The impact of cognitive control deficits and rumination on depressive symptoms and social cognition: implications for the postnatal period

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Table of contents

List of tables *4*

List of figures *5*

Abstract *6*

Papers associated with the thesis *8*

Acknowledgements *9*

Chapter 1. Introduction and background 10

Overview of the chapter *10*

Section A: General background *11*

Section B: Postnatal depression - background, a systematic review of rumination in the perinatal context and a cognitive model. *22*

Section C: Overview of the thesis *57*

Chapter 2. Does rumination mediate the relationship between attentional control and symptoms of depression? 61

Method *67*

Results *73*

Discussion *81*

Chapter 3. Attentional control, rumination and recurrence of depression 87

Method *93*

Results *99*

Discussion *113*

Chapter 4. Associations between depression, rumination and empathy: does gender make a difference? 118

Method *122*

Results *125*

Discussion *129*

Chapter 5. Examining the effects of induced rumination on attention performance and sensitivity to infant face and voice cues. 134

Method *138*

Results *143*

Discussion *154*

Chapter 6. Training cognitive control in individuals with high trait rumination 160

Method 168

Results 178

Discussion 191

Chapter 7. General discussion 199

Summary of key findings 199

Strengths and limitations 209

Remaining questions and future directions 212

Clinical applications 215

Conclusion 218

References 220

Appendices 246

Appendix A: Questionnaires 247

Appendix B: Ethical approvals 255

Appendix C: Publications associated with the thesis 258

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List of tables

Table 1.1 Summary of included studies 29
Table 2.1. Descriptive statistics for questionnaire measures and Attention Network Task (ANT) performance..... 74
Table 2.2. Correlations between depression, anxiety, rumination and attention measures 75
Table 2.3. Correlations between ACS scores and ANT performance 77
Table 2.4. Regression analysis: correlates of depression (PHQ-9 scores)..... 78
Table 2.5. Regression analysis: correlates of anxiety (GAD-7 scores)..... 79
Table 2.6. Regression analysis: correlates of brooding..... 79
Table 3.1 Remitted recurrent MDD patients versus controls at baseline..... 100
Table 3.2. ECT data by participant group (remitted patients, healthy controls) and trial type..... 103
Table 3.3. Baseline characteristics of rMDD patients recurrent versus resilient during follow up. 107
Table 3.4. rMDD patients recurrent versus resilient during follow-up: IST and ECT variables, and rumination..... 108
Table 4.1 Descriptive statistics for questionnaire measures 126
Table 4.2. Correlations between questionnaire measures 126
Table 4.3. Gender differences in questionnaire scores. 126
Table 4.4. Correlations between questionnaire measures, separated by gender..... 127
Table 4.5. Multiple linear regression examining predictors of empathy scores. 128
Table 5.1. Participant demographic and questionnaire data by group 144
Table 5.2. Descriptive data and group x time interactions for PANAS ratings..... 145
Table 5.3. Group differences in cognition following induction procedures. 146
Table 5.4. Attention Network Task (ANT) performance by group. 148
Table 5.5. Group comparisons of infant face and voice ratings..... 151
Table 5.6. Correlations between baseline questionnaire scores and infant face/voice ratings. ... 151
Table 6.1. Demographic characteristics by training group 179
Table 6.2. Baseline clinical characteristics by training group..... 179
Table 6.3. Training effects on Attentional Network Task indices and Running Span scores. 184
Table 6.4. Training effects on number of negative thoughts reported during breathing focus task. 185
Table 6.5. Training effects on social cognition tasks. 186
Table 6.6. Training effects on questionnaire measures. 187
Table 6.7. Correlations between change in PASAT performance with training and change in outcome measures..... 189

List of figures

Figure 1.1 PRISMA diagram displaying search and screening process 28
Figure 1.2 Cognitive model of rumination and its effects on parenting behaviour 49
Figure 2.1. Attentional Network Task displays and index calculations. 69
Figure 2.2. Models examined in the mediation analyses 72
Figure 3.1 Reaction times for switch and non-switch trials, comparing low and high ruminators 102
Figure 3.2. ECT reaction times (milliseconds) by participant group and trial type 104
Figure 3.3. Association between disengagement from angry faces and time to recurrence 111
Figure 3.4. Association between disengagement from happy faces and time to recurrence 112
Figure 6.1. Recruitment flow diagram 168
Figure 6.2. Change in median ISI on adaptive PASAT over training. 181
Figure 6.3. Ratings for ability to focus on instructed instrument over training. 182
Figure 6.4. Ratings for ability to ignore unattended instruments over training. 182
Figure 6.5 Scatter plot showing the association between change in PASAT performance over training, and change in negative thought reactivity on the breathing task from pre- to post-training 190
Figure 6.6 Scatter plot showing the association between change in PASAT performance over training, and change in ruminative thought reactivity on the breathing task from pre- to post-training 190

Abstract

Rumination is a maladaptive emotional regulation strategy that involves a negative and repetitive focus on one's self and one's thoughts. Ruminative thinking is often pervasive in the context of depression and is understood to play a role in the onset and maintenance of depressive symptoms. Two major themes are explored throughout the thesis: firstly, the idea that cognitive control deficits underpin rumination, which in turn increases vulnerability to depression; secondly, the proposed role that rumination plays in impairing social cognition. These themes are explored in relation to general adult depression, and also with reference to specific applications during the perinatal period.

Cognitive control refers to the set of processes involved in facilitating flexible and goal-driven behaviour, notably the ability to direct and control the focus of attention. Theoretical models posit that deficits in cognitive control promote rumination, as ruminative thought is more likely to occur and persist where there are difficulties with flexibly directing attention. Both cognitive control deficits and rumination have been consistently linked with increased vulnerability to depression. Rumination is hypothesised to mediate relationships between cognitive control and depression. In this thesis, associations between cognitive control, rumination and depressive symptoms are examined both concurrently (Chapter 2), and in a longitudinal design (Chapter 3). The impact of manipulating cognitive control using a cognitive training paradigm is also explored (Chapter 6), with rumination as a key outcome.

It has been suggested that rumination mediates the effects of depression on social functioning, as it involves a persistent, internally-directed focus of attention. It is thought that this may impair effective engagement with social cues and social cognitive processes. In the postnatal context, rumination is hypothesised to be a mechanism through which depression affects parenting, which can be conceptualised as a specific example of social functioning. In this thesis, associations between rumination and empathy are examined using questionnaire measures (Chapter 4), and the impact of induced rumination on processing of infant cues is assessed (Chapter 5).

In summary, the thesis begins with an introduction to the relevant concepts and literature, then presents findings from a systematic review (Chapter 1) and series of experimental studies (Chapters 2-6). Finally, remaining questions, directions for future research and possible clinical applications of the work are discussed (Chapter 7).

Declaration

This thesis is composed of work conducted by the candidate, Hannah DeJong, for the degree of Doctor of Philosophy at the University of Oxford. Several of the chapters contain content that is either published or under review in peer-reviewed journals (see page 8 for a list of associated papers). This work has been edited and formatted for inclusion in the thesis. The candidate is the first author, or joint first author, on all published and submitted papers.

Chapter 3 contains secondary analysis of data previously collected as part of a large cohort study. The candidate was responsible for generating the hypotheses examined, conducting the analysis and writing the chapter. The data reported in Chapter 6 were collected with support from research assistants, who were trained and supervised by the candidate. All other aspects of the thesis, including study design, data collection, statistical analysis and writing were completed by the candidate.

Papers associated with the thesis

DeJong, H., Fox, E., & Stein, A. (2016). Rumination and postnatal depression: A systematic review and a cognitive model. *Behaviour Research and Therapy, 82*, 38-49.[1]

DeJong, H., Fox, E., & Stein, A. (2019). Does rumination mediate the relationship between attentional control and symptoms of depression? *Journal of Behavior Therapy and Experimental Psychiatry, 63,* 28-35.

DeJong, H., Figueroa, C.[2], Mocking, R. J. T., Fox, E., Rive, M. M., Schene, A. H., Stein, A., Ruhe, H. G. (in preparation). Attentional control, rumination and recurrence of depression.

DeJong, H. Fox, E., & Stein, A. (in preparation). Associations between depression, rumination and empathy in a community sample: does gender make a difference?

DeJong, H. Fox, E., & Stein, A. (in preparation). Examining the effects of induced rumination on attention performance and sensitivity to infant face and voice cues.

DeJong, H. Fox, E., & Stein, A. (submitted). Training cognitive control in individuals with high trait rumination.

[1] See Appendix C for a copy of the full text of the published paper.
[2] Joint first authorship: H. DeJong and C. Figueroa

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Chapter 1. Introduction and background[3]

Overview of the chapter

The core theme of this thesis concerns the role played by rumination in the context of depression. Two key processes are explored throughout the thesis. Firstly, I examine the hypothesis that rumination mediates the relationship between underlying deficits in cognitive control and depressive symptoms. Secondly, I explore the links between rumination and deficits in social cognitive processing, and consider how this relationship may contribute to social functioning difficulties in the context of depression. Both these processes are considered in relation to depression in the general adult population, but also with specific reference to the perinatal context.

In this introductory chapter, I first define the core constructs with which the thesis is concerned and give an overview of the existing theoretical and empirical literature in this area. The second section of the chapter (Section B, page 22) provides background on perinatal depression and incorporates a systematic review of the literature on rumination during the perinatal period. A cognitive model is also presented, based on the extant literature, which provides an organising framework and highlights directions for future study. The final section of the chapter (Section C, page 57) provides an overview of the thesis, including the main processes and hypotheses addressed, and an outline of the studies and key methods employed.

[3] Sections of this chapter, including an earlier version of the systematic review and cognitive model have previously been published in: *DeJong, H., Fox, E., & Stein, A. (2016). Rumination and postnatal depression: A systematic review and a cognitive model. Behaviour Research and Therapy, 82, 38-49.* A full copy of the text of this paper is available in Appendix C.

Section A: General background

Depression and rumination

Depression is a psychological disorder typified by sadness, loss of interest or pleasure, feelings of guilt and low self-worth, disturbances in sleep and appetite, fatigue and cognitive impairments such as poor concentration (American Psychiatric Association, 2013). Depression is relatively common – a recent meta-analysis suggests lifetime and 12-month prevalence of around 11% and 7% respectively (Lim et al., 2018) – and the World Health Organisation ranks major depressive disorder as the largest contributor to global disability of any psychiatric disorder (World Health Organisation, 2017). Depression is associated with a range of adverse outcomes, including impact on educational performance, employment and productivity, relationship quality, as well as increased morbidity and mortality (Kessler & Bromet, 2013). Depression can often take a chronic course and recurrence following a period of recovery is high, with recurrence rates typically estimated at over 50% (Eaton et al., 2008; Hardeveld, Spijker, De Graaf, Nolen, & Beekman, 2013; Steinert, Hofmann, Kruse, & Leichsenring, 2014). There is then a pressing need to better understand the aetiology and maintenance of depression, and to use this knowledge to develop more effective interventions.

Rumination is a key cognitive feature of depression that may play an important role in both its onset and maintenance. Rumination is typically defined as "the process of thinking perseveratively about one's feelings and problems" (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008), or as "repetitive, prolonged and recurrent thoughts about one's self, one's concerns and one's experiences" (E. R. Watkins, 2008). Rumination is a type of repetitive negative thinking (RNT) and is understood to be closely related to other forms of RNT such as worry. It may

represent a transdiagnostic process, with relevance to both depression and anxiety disorders (De Raedt, Hertel, & Watkins, 2015; T Ehring & Watkins, 2008).

Ruminative thoughts are characterized by negative valence, a repetitive and pervasive quality, and are perceived as difficult to ignore or control (Nolen-Hoeksema et al., 2008; M. Pearson, Brewin, Rhodes, & McCarron, 2008; E. Watkins, Moulds, & Mackintosh, 2005). Rumination is of particular interest for researchers and clinicians because of its proposed role in conferring vulnerability to depression and in maintaining low mood (Nolen-Hoeksema et al., 2008). It has been suggested that rumination may be an important target for treatment (Martell, Dimidjian, & Herman-Dunn, 2013; E. Watkins et al., 2007) and also for preventative interventions in relation to depression (Topper, Emmelkamp, Watkins, & Ehring, 2017; Topper, Emmelkamp, & Ehring, 2010).

Rumination may be a trait vulnerability factor – elevated rumination is found in never-depressed offspring of depressed parents (Nolen-Hoeksema et al., 2008) and the tendency to ruminate remains high, even following remission from depression (Visted, Vøllestad, Nielsen, & Schanche, 2018). It has also been proposed that high trait rumination may be one factor that confers vulnerability to recurrence of depression; a small number of studies support this hypothesis (Figueroa et al., 2015; Michalak, Hölz, & Teismann, 2011; Timm et al., 2017) - see Chapter 3 for further discussion of this literature.

Factor analysis of rumination data suggests that rumination is composed of two components, labelled as brooding and reflective pondering (Schoofs, Hermans, & Raes, 2010; Treynor, Gonzalez, & Nolen-Hoeksema, 2003). Reflective pondering involves a purposeful focus on difficulties, in order to facilitate problem solving. In contrast, brooding involves making passive comparisons between one's current situation and some unachieved standard. The brooding component of rumination is thought to be particularly maladaptive, and in a number of studies

has been shown to be predictive of future depressive symptoms (K. A. Pearson, Watkins, & Mullan, 2010; Raes, Smets, Nelis, & Schoofs, 2012; Schoofs et al., 2010; Treynor et al., 2003). The predictive role of reflective pondering is less clearly established but it has typically been found to be either unrelated to future depression or to have a small protective effect.

Depression, rumination and cognitive control

Defining cognitive control

Both depression and rumination have been linked with impairments in cognitive control. Cognitive control refers to a set of processes that facilitate flexible responding to environmental stimuli, in line with current behavioural goals (Miller & Cohen, 2001). Cognitive control is closely related to executive functioning and includes processes such as controlling and shifting the focus of attention, inhibiting irrelevant information or unwanted responses, and updating working memory (Miyake et al., 2000). Attentional control – that is, the ability to direct attention flexibly, according to current goals (Derryberry & Reed, 2002) – is considered to be one of the core abilities supporting and serving cognitive control (M. W. Eysenck, Derakshan, Santos, & Calvo, 2007; Mackie, Van Dam, & Fan, 2013).

Impairments in cognitive control have clear implications for cognition, learning and daily functioning, but also for emotional regulation and the development of psychological disorder, including depression. Below I review evidence linking impairments in cognitive control to both depression and rumination, and outline models that seek to explain the associations between these three domains.

Associations between depression and cognitive control

There is substantial evidence that depression is associated with significant deficits in cognitive control. Self-reported difficulties with attentional control are consistently associated with elevated levels of negative affect, and with increased symptoms of anxiety and depression (Fajkowska & Derryberry, 2010; Pacheco-Unguetti, Acosta, Marqués, & Lupiáñez, 2011; Reinholdt-Dunne, Mogg, & Bradley, 2009, 2013; Tortella-Feliu et al., 2014). In addition, a large body of experimental evidence indicates that cognitive control impairments occur across a range of tasks in both clinically depressed groups and vulnerable populations, including individuals with subclinical symptoms and remitted groups (Grahek, Everaert, Krebs, & Koster, 2018; E. H. W. Koster, Hoorelbeke, Onraedt, Owens, & Derakshan, 2017; Snyder, 2013). There is some evidence that the degree of cognitive control impairment may be related to depression severity (Snyder, 2013).

Recent longitudinal studies demonstrate that cognitive control impairments are predictive of future depression (Demeyer, De Lissnyder, Koster, & De Raedt, 2012; Pe, Brose, Gotlib, & Kuppens, 2016), rather than merely being associated with current symptoms. Similarly, evidence from cognitive training studies is beginning to indicate a causal role for cognitive control deficits. Evidence from a number of studies now suggests that training cognitive control has transferable benefits in terms of depression outcomes, both in vulnerable and clinical groups (E. H. W. Koster et al., 2017; Motter et al., 2016). Findings have been inconsistent, and there is a need to further investigate how to optimise training and maximise transfer, as well as a need to identify moderators of training outcome (E. H. W. Koster et al., 2017). However, there is now a growing consensus that training cognitive control can improve depression outcomes.

Thus, there is considerable evidence that depression is associated with impairments in cognitive control, and that these impairments play a predictive and causal role in depression. However, a number of outstanding questions remain. Firstly, it is unclear whether the cognitive control impairments associated with depression are general deficits or are specific to cognitive control tasks requiring processing of emotional stimuli. It has been argued that while clinical populations may display general deficits, the impairments found in vulnerable groups are likely to be specifically related to processing of affective information (E. H. W. Koster et al., 2017), but this hypothesis requires further systematic testing. Similarly, given the multi-componential nature of cognitive control, questions remain regarding which components are impaired in depression and which are preserved. A related issue concerns which tasks are best suited to measuring changes in cognitive control in the context of depression or depression vulnerability. Finally, it has been proposed that, rather than representing an ability deficit, cognitive control impairments in the context of depression could instead be due to difficulties in deciding when and how to engage cognitive control (Grahek et al., 2018). Motivational and reward processing aspects of depression may then be important, as engaging cognitive control is an effortful, goal-directed process. This possibility has not to-date been thoroughly investigated.

Associations between rumination and cognitive control

It is suggested that emotional regulation strategies in large part rely on the effective use of cognitive control, and therefore deficits in cognitive control may predispose individuals to greater use of maladaptive strategies (Fajkowska & Derryberry, 2010; Joormann & D'Avanzato, 2010; E. H. W. Koster, De Lissnyder, Derakshan, & De Raedt, 2011). Several theoretical models particularly implicate cognitive control deficits in the tendency to engage in high levels of RNT, including rumination and worry (C. R. Hirsch & Mathews, 2012; E. H. W. Koster et al., 2011; Mor & Daches, 2015; E. R. Watkins & Nolen-Hoeksema, 2014).

Many models that seek to explain how rumination is triggered and maintained emphasise a role for cognitive control deficits (reviewed in Mor & Daches (2015)). Such models tend to implicate either absolute deficits in cognitive control, or biases in the deployment of cognitive control, such that processing of certain types of information (e.g. negative or self-referential information) is less effectively regulated. It is hypothesised that deficits or biases in these domains could account for difficulties in stopping ruminative thought processes once these are triggered. This may help to account for the prolonged and perseverative quality of rumination (E. H. W. Koster et al., 2011). Other, related models conceptualise rumination as being akin to a cognitive habit, which develops in the context of deficits in cognitive control. This idea was proposed by Hertel (2004) and has been further developed by Watkins & Nolen-Hoeksema (2014). These authors suggest that habitual, trait rumination develops through the repeated co-occurrence of rumination with contextual cues (e.g. low mood), such that rumination eventually becomes automatically cued by these contextual factors. They argue that deficits in cognitive control may confer vulnerability to habitual rumination, as cognitive control enables individuals to override pre-potent or habitual responses, in order to respond flexibly to situational demands. There is then an emerging consensus in the theoretical literature that cognitive control difficulties, whether absolute deficits or biases, are implicated in vulnerability to high trait rumination (Mor & Daches, 2015).

Difficulties with inhibition of irrelevant information and flexibly shifting the focus of attention have been particularly implicated in rumination, with a growing body of experimental evidence highlighting associations between high trait rumination and inhibition or attention-shifting deficits (Davis & Nolen-Hoeksema, 2000; E. De Lissnyder, Derakshan, De Raedt, & Koster, 2011; Joormann, 2006; Whitmer & Banich, 2007). A recent meta-analysis similarly concluded that rumination is particularly associated with impaired inhibition and set shifting, although it also noted that not all aspects of cognitive control have yet been thoroughly examined (Yang, Cao, Shields, Teng, & Liu, 2017).

Evidence that cognitive control deficits play a causal role in promoting rumination is starting to emerge from longitudinal studies, in which performance on cognitive control tasks is associated with later rumination (E. De Lissnyder, E. H. Koster, et al., 2012; Demeyer et al., 2012; Zetsche & Joormann, 2011). Experimental designs, such as cognitive training paradigms, have also provided evidence that increasing cognitive control produces significant reductions in rumination (Hoorelbeke, Koster, Demeyer, Loeys, & Vanderhasselt, 2016; Hoorelbeke, Koster, Vanderhasselt, Callewaert, & Demeyer, 2015; Mor & Daches, 2015; G. J. Siegle et al., 2014; Vanderhasselt et al., 2015). Thus, there is growing support for the hypothesis that cognitive control deficits are causally implicated in vulnerability to rumination. However, the reverse effect may also be present – a number of studies have found that state rumination impairs aspects of cognitive control, although there has been relatively little systematic research on this issue (Philippot & Brutoux, 2008; Roberts, Watkins, & Wills, 2016; E. Watkins & Brown, 2002; Whitmer & Gotlib, 2013). Thus, the relationship between rumination and cognitive control may in fact be bi-directional.

Depression, rumination and cognitive control: current models

Despite many outstanding questions, there is then substantial evidence that deficits in cognitive control are implicated in vulnerability to both high levels of rumination and depression. A mediation model has been proposed, in which deficits in cognitive control are proximally related to greater use of maladaptive emotional regulation strategies, including rumination, which in turn increase risk for depression (De Raedt & Koster, 2010; Joormann & Gotlib, 2010; Joormann & Vanderlind, 2014; E. H. W. Koster et al., 2011).

Several studies have now found evidence of a mediation effect. Demeyer et al. (2012) showed that cognitive control deficits on an attentional control task were associated with depressive

symptoms one year later and this relationship was mediated by rumination. In a cross-sectional study, Kertz et al. (2017) similarly demonstrated that self-reported deficits in attentional control and depressive symptoms were linked via an indirect pathway involving RNT and mood recovery. In another cross-sectional study, Hsu et al. (2015) showed that rumination mediated the relationship between self-reported attentional control and symptoms of depression/anxiety. Thus, there is some evidence that increased rumination may mediate the impact of cognitive control deficits on future depressive symptoms.

There is then a growing consensus that deficits in cognitive control are implicated in vulnerability to habitual rumination, and subsequent increased risk of depression. However, many of the existing studies are limited by use of cross-sectional designs and reliance on self-report measures, and various outstanding issues remain to be addressed. Throughout the thesis, these relationships will be explored through a number of approaches, including systematic review (Chapter 1, Section B), experimental work utilising cognitive control tasks in non-clinical and clinical populations (Chapters 2 and 3), and a cognitive training study (Chapter 6). More information on the approaches used and the hypotheses tested are outlined later in this chapter (Section C, page 57).

In the next section, I go on to describe the background literature relating to the second theme of the thesis – that is, the role that rumination may play in relation to social cognitive deficits and social functioning impairments in the context of depression.

Depression, rumination and social functioning: the role of social cognition

Depression

The social impairment associated with depression is pervasive, occurring across a wide range of domains (Kupferberg, Bicks, & Hasler, 2016). It is at least as severe as social impairments associated with other chronic health conditions (Hays, Wells, Sherbourne, Rogers, & Spritzer, 1995; K. B. Wells, Stewart, Hays, & et al., 1989) and may persist over many years, even after resolution of depressive symptoms (Hirschfeld et al., 2000; Rhebergen et al., 2010; Saris, Aghajani, van der Werff, van der Wee, & Penninx, 2017). Social impairments include problems with fulfilling social roles and participating in leisure activities, fewer and less satisfying social interactions, and increased interpersonal and relationship difficulties (Gadassi & Rafaeli, 2015; Hirschfeld et al., 2000). The impact of these social difficulties may in turn increase risk of chronic or recurrent depressive disorder.

It has been suggested that depression-related impairments in social functioning may partly result from underlying deficits in social cognition (Epa & Dudek, 2015; Gadassi & Rafaeli, 2015; Thoma, Friedmann, & Suchan, 2013). Social cognition is an overarching term for the cognitive processes that are involved in processing, storing and applying information about other people and social situations. A large body of research suggests that a range of deficits in social cognition can be observed in the context of depression, including deficits in emotion recognition, social decision making, empathy and theory of mind (Bora & Berk, 2016; Kupferberg et al., 2016). There is also evidence that some of these deficits persist after recovery (Ladegaard, Videbech, Lysaker, & Larsen, 2016), although there have been relatively few studies conducted in remitted groups.

Rumination

Rumination is also associated with significant difficulties in social functioning. Rumination, in comparison to other emotion regulation strategies, is associated with increased levels of interpersonal distress and more severe difficulties in intimate relationships (Lam, Schuck, Smith, Farmer, & Checkley, 2003), impaired social problem-solving (Donaldson & Lam, 2004) and excessive reassurance seeking (Weinstock & Whisman, 2007). Chronic rumination erodes social support and increases social friction over time (Nolen-Hoeksema et al., 2008). Furthermore, in a longitudinal study, brooding rumination in individuals remitted from depression was associated with lower relationship satisfaction both concurrently and over time (K. A. Pearson, Watkins, Kuyken, & Mullan, 2010).

Similar to depression, it has been proposed that rumination may be associated with impaired social cognition, although much less research has specifically examined this hypothesis. Tse and Bond (2004) suggest that rumination may be one of the key mechanisms through which depression impairs social cognition, as it consumes cognitive resources and increases self-focus, resulting in less attention to social cues and difficulty generating effective responses. Similarly, Joireman et al. (2002) have argued that as rumination is a maladaptive form of self-focused attention, it might be expected to impair empathy and understanding of others. Batson (2009) has specifically proposed that high levels of self-focus lead to an increase in personal distress when faced with the negative emotions of others, whereas lower levels of self-focus help promote empathic concern. This may in turn influence behavioural responses, with personal distress shown to increase social withdrawal, whilst empathic concern predicts greater engagement in prosocial behaviour (Grynberg & López-Pérez, 2018). Thus, high levels of rumination might be expected to be associated with less adaptive social responding.

There is direct evidence from a small number of studies that use of maladaptive emotion regulation strategies, including rumination, is negatively associated with social cognitive performance. In one study, dysphoric participants who were induced to ruminate generated less effective solutions on a social problem solving task than dysphoric participants in a distraction condition, or non-dysphoric controls (Lyubomirsky & Nolen-Hoeksema, 1995). Similar associations have been demonstrated between trait rumination and negative or avoidant responses on social problem-solving tasks (Hasegawa et al., 2015; McMurrich & Johnson, 2008). In another study, using a healthy participant group, Rowland et al. (2012) demonstrated that more frequent use of rumination, as well as catastrophizing and blaming others, was negatively associated with performance on a social inference task. A small literature also indicates changes in empathy associated with rumination, although these results are inconsistent (Boyraz & Waits, 2015; Grynberg & López-Pérez, 2018; Joireman et al., 2002; López-Pérez & Ambrona, 2015; Troyer & Greitemeyer, 2018) - see Chapter 4 for further discussion of these findings. Overall, relatively few studies have specifically addressed the relationship between rumination and social cognition, and many questions remain regarding the association between these constructs.

Researchers considering the perinatal context have also highlighted a possible role for rumination in impairing parenting responses (Moulds, Black, Newby, & Hirsch, 2018; Psychogiou & Parry, 2014; Stein, Lehtonen, Harvey, Nicol-Harper, & Craske, 2009). Parenting can be considered a specific example of social functioning, which is presumably supported by social cognitive processes. Indeed, a small number of studies have directly demonstrated associations between performance on social cognition tasks and measures of parenting sensitivity (MacKinnon et al., 2014; Rigby, Conroy, Miele-Norton, Pawlby, & Happé, 2016). It is proposed then that rumination may be a key cognitive process through which postnatal depression impairs parental responsiveness. Relevant theories and the current empirical evidence are discussed in more detail in the next section (Section B).

Section B: Postnatal depression - background, a systematic review of rumination in the perinatal context and a cognitive model

Postnatal depression (PND) is a psychological disorder, typically defined as involving an episode of depression during the first postnatal year. Point prevalence during the first three months post-partum is around 13% (Howard et al., 2014). Whilst many women will recover within a few months, around 30% experience more persistent depressive symptoms and there is a high risk of further depressive episodes (Howard et al., 2014). PND is considered to be phenomenologically equivalent to major depressive disorder (MDD) occurring at other times, and is highly similar in terms of symptoms, course and prognosis. Some studies have suggested that somatic and sleep-related symptoms may be somewhat more prevalent in PND e.g. (Williamson, O'Hara, Stuart, Hart, & Watson, 2014), leading to the development of perinatal assessment measures that exclude these features. However, in general these disorders are understood to be similar in symptomology and presentation. PND differs from MDD primarily in the timing of the depressive episode, and consequently its implications. PND has onset either during pregnancy or in the first year postnatally and thus has specific impacts, due to the importance of this developmental window for the infant and the uniqueness of the mother-infant relationship. During this period the infant is developing rapidly and is highly dependent on the parent.[4]

Postnatal depression represents an important target for support and intervention. It has a significant impact on maternal wellbeing, both immediately and over time, due to the risk of chronic or recurrent depression. In addition, PND carries both short-term and long-term risks for offspring development. A range of negative child outcomes associated with PND have been reported across cognitive, behavioural and emotional domains, and these persist across

[4] The majority of the research in this area has focused on mothers and so the mother-infant relationship is particularly emphasised throughout this chapter and throughout the thesis. However, there is a clear need for additional research focused on the role of fathers and the impact of paternal PND. Indeed, in recent years a growing body of work has begun to examine this issue (Glasser & Lerner-Geva, 2018).

development (Stein et al., 2014). One mechanism underlying the negative effect of PND on child outcomes is impact on parenting quality. Aspects of parenting quality that have been identified include reduced sensitivity and responsiveness to infant cues, as well as a tendency to interact in a way that is either excessively withdrawn or intrusive (Murray, Halligan, & Cooper, 2010). These parenting behaviours then confer risk for a range of negative child outcomes. Negative outcomes for the child seem to be particularly pronounced where maternal depression is severe and persistent or recurrent (Netsi et al., 2018; Stein et al., 2014).

It is recognised that early environmental and social input is vitally important for healthy development in infants, and that the mother-infant relationship provides a key part of this input. Whilst depression is understood generally to have negative impacts on relationships and social functioning (see page 19), which apply to the mother-infant relationship, there are also distinctive features. For example, social cues from the infant may be more ambiguous than from adult interactive partners, infants are extremely sensitive to the qualities of interaction and contingency of responding (Bigelow, MacLean, & MacDonald, 1996; Nadel, Carchon, Kervella, Marcelli, & Réserbat-Plantey, 2001; Striano, Henning, & Stahl, 2006), and infants rely on a close degree of contingency in order to make sense of the interaction, due to their limited ability to detect contingency over temporal delays (Bornstein & Manian, 2013; Keller, Lohaus, Völker, Cappenberg, & Chasiotis, 1999). The mother-infant relationship is also unusual in its intensity and the amount of time devoted to this dyadic interaction. The implications of depression during the perinatal period are therefore somewhat unique, in terms of impact on parenting, the mother-infant relationship and on various child development outcomes.

PND then is understood to exert effects on the child, at least in part, via its behavioural impact on parenting. However, the cognitive features of PND that are likely to mediate this relationship are not well understood. This section of the thesis outlines the existing literature on one specific

cognitive feature of PND, that is, rumination. Whilst the importance of rumination in the onset and maintenance of depression is increasingly recognised, and is starting to influence treatment approaches, these findings have not yet been broadly applied in the perinatal context. Integrating these developments into understanding PND may prove helpful in understanding the mechanisms through which maternal depression impacts on child development.

Consistent with a growing literature suggesting that rumination affects social cognition and social functioning (see page 20), several authors have suggested that rumination could be an important cognitive mechanism through which perinatal psychological disorders affect parenting (Moulds et al., 2018; Psychogiou & Parry, 2014; Stein et al., 2009). Stein and colleagues (2009) have hypothesised that rumination is a form of preoccupation, which affects mothers' ability to effectively process infant cues and results in reduced contingency and sensitivity in parenting behaviour. Whilst rumination has received considerable attention as a key cognitive feature in depression, it has been much less extensively characterised in the context of PND. Here, I seek to provide a systematic review of evidence relating to rumination in the perinatal context; this work has not previously been systematically reviewed. Drawing on this literature, as well as broader understandings of rumination, I then present a new framework for conceptualising the specific impact of rumination in the postnatal context. It is intended that this model can be used to generate hypotheses and to guide future research in this area. The model has also helped to guide the design and hypotheses of studies presented later in the thesis.

I focus specifically on rumination because of its recognised importance in depression, and because theoretical accounts propose that this may be a key process in explaining the impact of PND on parenting. This is not however intended to imply that this is the only area of cognition or emotional regulation that is important within PND. Similarly, whilst I focus here on PND, there are likely to be parallels with other perinatal psychological disorders, e.g. anxiety disorders, eating

disorders. Stein et al. (2009) argue that all these disorders are characterised by preoccupation, whether in the form of rumination, worry or obsessions, and that the mechanisms through which parenting is affected may then be similar across disorders. Closely related cognitive processes may therefore have broad applicability across a range of perinatal mental health conditions, but here I focus particularly on rumination in the context of depression.

Systematic review

Method

A systematic review of the literature was conducted, following the PRISMA guidelines (Moher et al. 2009). The search was conducted using several online databases: PsychInfo, Pubmed, MEDLINE and Scopus. The most recent search was completed in August 2018. Search terms included "*perinatal depression" OR "postnatal depression" OR "postpartum depression" OR "maternal depression",* in combination with "*rumination" OR "repetitive negative thought" OR "repetitive negative thinking" OR "perseverative thought".* Papers identified in this search were also used to check for additional results, by examining references and citations. In order to be included in the review, papers had to report data on some measure of rumination or RNT, or to report on the effects of a rumination induction. Results were limited to the perinatal period (i.e. measured during pregnancy or the first year postnatally). Review papers and opinion pieces were not included in the systematic review. Inclusion criteria also included publication in a peer reviewed journal, and availability in the English language.

Unpublished data was excluded from the review due to the difficulties of identifying and obtaining such data in a systematic way. Including unpublished data in systematic reviews has the advantage of limiting the impact of publication bias. However, it can introduce other sources of bias, in that the studies located may not be representative of all unpublished studies, and the inclusion of unpublished studies relies on the willingness and availability of the original researchers to provide this data. It has also been suggested that the methodological quality of unpublished studies may be lower than for published work, although the evidence for this is mixed (Hopewell et al, 2007). A decision was taken therefore to exclude unpublished literature, but I acknowledge that this may have resulted in the exclusion of some work with relevance to the review.

Search results were combined and duplicates removed, before titles and abstracts were screened. Full texts were then screened for relevance and fulfilment of the inclusion criteria. The search and screening process is shown in Figure 1.1.

Study selection and data extraction were performed by a single reviewer. Whilst single data extraction reduces the time and human resource requirement to undertake a review, there is some evidence that this approach can generate a somewhat higher level of errors compared to double data extraction (e.g. Buscemi et al, 2006). The current review data may therefore be subject to higher levels of bias and/or error than if multiple reviewers had been involved, and this is recognized as a limitation of the work. The provision of a clear search strategy and inclusion criteria may mitigate this risk to some degree, as it should be possible for other researchers to replicate these results.

Only a small number of papers were identified, addressing a variety of questions and using a wide range of methods and measures. Meta-analysis of the data was therefore not feasible or appropriate. Instead, a narrative synthesis of the findings is presented below.

Figure 1.1 PRISMA diagram displaying search and screening process

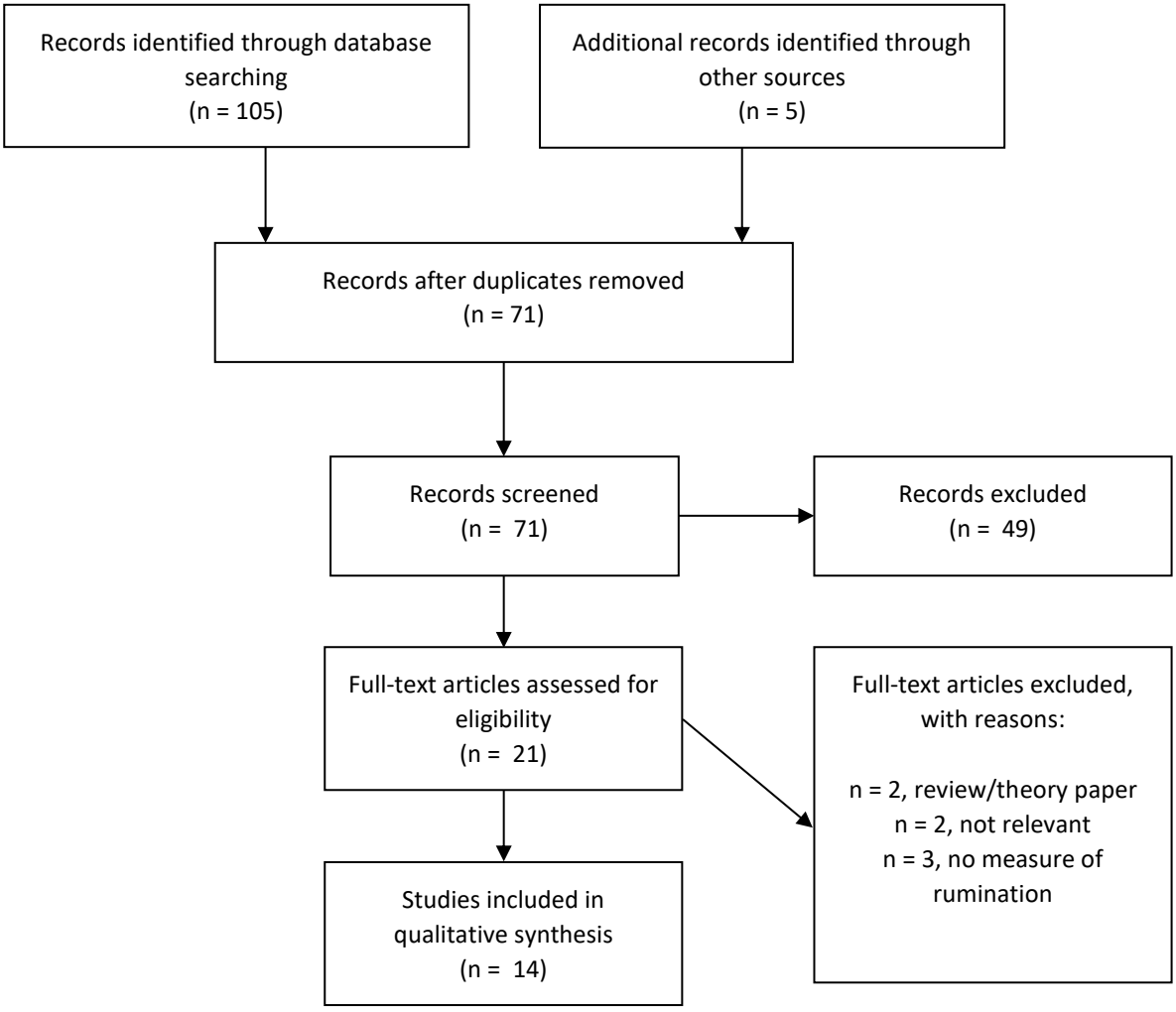


Table 1.1 Summary of included studies

Authors (year)	**Participants**	**Measures / procedure**	**Findings**
Questionnaire Studies			
Isa Alfaraj et al. (2009)	N=21 depressed, N-22 non-depressed (assessed by BDI) 2nd or 3rd trimester of pregnancy. UK.	Positive beliefs about rumination (PBRS) Perceived lack of social support over previous month (rating scale).	Positive beliefs about rumination higher in depressed group. Perceived social support lower in depressed group. Positive beliefs about rumination predict depression classification above perceived lack of social support.
O'Mahen et al. (2010)	N=110 scoring 10 or more on EPDS (N=65 at follow up) During pregnancy and 3mths later. USA.	Assessment via phone interview, including: Mood (EPDS) Rumination (RRS; 10 item version) Social functioning (SASS) Silencing the self (STSS)	For low social functioning: rumination related to later depression; silencing the self unrelated to rumination or mood. For high social functioning: social functioning buffers impact of rumination on future depressed mood; silencing beliefs associated with increased rumination and depressed mood.
Barnum et al. (2013)	N=101 3rd trimester of pregnancy to 8 weeks postpartum. USA.	Rumination (RRS; 3rd trimester) Negative inferential styles (Expanded Attributional Style Questionnaire; 3rd trimester). Depression (EPDS; 3rd trimester, 4 and 8 weeks postpartum)	Brooding rumination and negative inferential styles predict depression at 8 weeks, but not 4 weeks. Attributional style only predictive for women with already high levels of depression – may be predictor of maintenance.
Muller et al. (2013)	N=66. 2nd or 3rd trimester of pregnancy, up to 8 weeks postpartum. Germany.	Perseverative thinking (PTQ) Depression (BDI-II) Postpartum bonding (PBQ) Attachment Scale of PSI	PTQ does not predict postnatal depression. Unproductive subscale of PTQ predicts bonding and attachment (as does ante- and post-natal depression).

Authors (year)	Participants	Measures / procedure	Findings
Raes et al. (2014)	N=210 3rd trimester of pregnancy; follow up at 12 and 24 weeks postpartum. Belgium.	Depression (DASS; EPDS) History of depression (MDQ) Rumination (RRS) Dampening of positive emotions (RPA)	Depression during pregnancy and previous depressive episodes predict depression postpartum. Dampening also has predictive role, but rumination does not. Rumination highly related to previous depressive episodes. Similar findings at 12 and 24 months.
O'Mahen, Karl, Moberly & Fedock (2015)	N=55 depressed pregnant women, N=85 elevated low mood (not clinically depressed) pregnant women. M=23.27 weeks gestation. USA.	Mood (SCID-IV, EPDS, BDI-II). Childhood Trauma Questionnaire. Rumination (RRS). Behaviour activation (BADS).	Brooding rumination associated with depressed symptoms and also with history of neglect and abuse. Brooding partially mediated relationship between childhood emotional abuse and depression. Behavioural activation fully mediated relationship between childhood emotional neglect and depression. Brooding and behavioural activation inversely related.
Tester-Jones et al. (2015)	N=203 Infants 9-14 mths. UK.	Rumination (RRS) Depression (EPDS) Attunement and bonding (MIRI and PBQ) Perceived social support (SPS) Infant temperament (negative affect subscale of IBQ-R)	Brooding rumination mediated the effect of postnatal maternal depressive mood on maternal self-reported responsiveness to the infant when infants were low, but not high, in negative temperament. For infants with higher negative temperament, maternal depressive symptoms were directly related to self-reported responsiveness, as was perceived social support.

Authors (year)	Participants	Measures / procedure	Findings
Schmidt et al. (2016)	N=215 Seen in 1st and 3rd trimester. Germany.	Rumination (RRS) Worry (PSWQ-PW) Depression and anxiety (DASS items) Maternal-foetal bonding (MAAS)	Rumination in 1st trimester is predictive of MAAS intensity scores in 3rd trimester (when controlling for depression, anxiety and demographic variables at time 1). Worry in 1st trimester is predictive of depression and anxiety in 3rd trimester (when controlling for depression, anxiety and demographic variables at time 1). Small effects: 0.8-3% variance.
Denis & Luminet (2017)	Pilot: N=63. Recruited at birth, questionnaires at 1mth postpartum. Main study: N=124. Recruited within 2yrs of birth, from PND support groups. N=74 in first yr, N=50 in second yr postpartum. France.	Personality (revised abb. Eysenck Personality Questionnaire) Rumination (RRS) Maternal self-esteem (Maternal Self-Report Inventory) Alexithymia (Toronto Alexithymia Scale 20) Depression (EPDS)	Pilot: Brooding rumination and low maternal self-esteem associated with EPDS scores. Main study: In first year, neuroticism, brooding and low maternal self-esteem associated with EPDS scores. In second year, brooding, reflective rumination and alexithymia associated with EPDS scores.
Egan et al. (2017)	N=71. Assessed during 3rd trimester (T1) and 6 weeks after birth (T2). Australia.	Depression (EPDS) Perfectionism (Clinical Perfectionism Questionnaire) Repetitive negative thinking (RNT-10)	Used structural equation modelling. Best fit model indicates perfectionism is associated with RNT, which is then associated with antenatal depression, which in turn is associated with postnatal depression, i.e. RNT has a mediating role. Depression stable from T1 to T2.

Authors (year)	Participants	Measures / procedure	Findings
Schmidt, Seehagen, Hirschfeld, Vocks, Schnieder & Teismann (2017)	N=184 Assessed at 13 and 26 weeks of pregnancy, and 5 and 16 weeks after birth. Germany.	Perseverative thinking (PTQ) Depression (EPDS) Bonding (PBQ) Social support (F-SozU-K-14)	Used latent growth curve model to examine relationships of RNT (overall levels and trajectories) with postnatal depression and bonding. Overall higher levels of RNT related to impaired bonding and higher levels of depression. Increase in RNT over pregnancy also related to impaired bonding and increased postnatal depression.
Experimental Studies			
Stein et al. (2012)	N=253: (GAD n=90, MDD n=57; control n=106) Infants 10 mths old. UK.	Randomised to either worry/rumination prime (WRP, i.e. current topic of worry/concern) or neutral prime (NP, i.e. journey to appointment) and instructed to think about this topic for 5 mins. Live interactions with infant observed and coded, before and after prime.	WRP resulted in more negative thoughts, higher thought recurrence and more self-focus relative to NP. Compared with controls, WRP had a more negative impact on maternal responsiveness to infant vocalization for GAD, and to a lesser extent for MDD; WRP also led to decreased maternal vocalization for GAD. Across the whole sample, WRP was associated with increased child vocalization relative to NP.
O'Mahen, Boyd & Gashe (2015)	N=59 dysphoric (BDI-II score ≥14); N=39 non-dysphoric (BDI-II score <14). Infants aged 12mths or under. UK.	Depression (BDI-II) Randomly allocated to rumination or distraction condition – 8mins thought, guided by statements, e.g. rumination: "think about what your feelings might mean". Postnatal Parental Problem-Solving Task.	Dysphoric mothers in the rumination condition demonstrated poorer problem-solving effectiveness and less confidence in problem-solving compared to all other groups.

Authors (year)	Participants	Measures / procedure	Findings
Tester-Jones et al (2017)	N=79 women with infants aged 3-12 months. N=39 dysphoric (BDI >14) and N=40 non dysphoric (BDI < 10). UK.	Depression (BDI) Randomised to rumination induction (10mins thinking about unresolved goal-based problem, with prompts) or control condition (10mins thinking about resolved problem, with prompts). Interaction observed and coded during free play and infant stressor (adapted still-face paradigm).	More analytical thinking reported in rumination condition, compared to control. Mothers in rumination condition showed reduced sensitivity over time (i.e. post-induction and post-still-face procedure), whereas control condition did not. No moderation by dysphoria status.

Abbreviations: BADS = Behavioural Activation for Depression Scale; BDI = Beck Depression Inventory; DASS = Depression, Anxiety and Stress Scale; EPDS = Edinburgh Postnatal Depression Scale; IBQ-R = Infant Behaviour Questionnaire – Revised; MAAS = Maternal Antenatal Attachment Scale; MDQ = Major Depression Questionnaire; MIRI = Maternal Infant Responsiveness Instrument; PBQ = Postpartum Bonding Questionnaire; PBRS = Positive Beliefs about Rumination Scale; PSI = Parenting Stress Index; PSWQ-PW = Penn State Worry Questionnaire – Past Week; PTQ = Perseverative Thinking Questionnaire; RPA = Responses to Positive Affect questionnaire; RRS = Ruminative Response Scale; SASS = Social Adaptation Self-Evaluation Scale; SCID-IV= Structured Clinical Interview for DSM Disorders; SPS = Social Provisions Scale; STSS = Silencing the Self Scale.

Results

Fourteen papers were identified, addressing a range of questions about rumination within the perinatal context. Eleven of these papers examined whether rumination is predictive of other maternal outcomes, including depression and/or bonding with the infant, using questionnaire measures. Three papers described experimental studies examining the effects of induced rumination on some aspect of parenting behaviour. The key findings from each paper are described below and study details are summarised in Table 1.1.

Questionnaire studies

Seven papers using questionnaire measures examined whether rumination is associated with depression in the perinatal period, either alone or in combination with other variables. Denis and Luminet (2018) measured brooding and depression concurrently, along with various other related constructs. This study found that during the first year postnatally, brooding, neuroticism and low self-esteem were all associated with levels of depression. In the second year postnatally, brooding continued to be associated with depression, as were reflective rumination and alexithymia. Attributional style was also a predictor of later depressive symptoms, although only in women with pre-existing high levels of depression, suggesting it may be a maintenance factor. Egan et al. (2017) also showed an association between RNT and depression, such that RNT during pregnancy mediated the relationship between perfectionism and antenatal depression. Antenatal depression was further associated with postnatal depression, with symptoms remaining stable from pregnancy into the postnatal period. Barnum, Woody & Gibb (2013) showed that antenatal rumination, measured in the third trimester, was predictive of increased depressive symptoms at 8 weeks postpartum, although not at 4 weeks postpartum. In contrast, Raes et al. (2014) found that rumination in the third trimester did not predict depression at either 12 or 24 weeks, when controlling for previous

episodes of depression. This may be because previous depressive episodes were very highly correlated with rumination. Depression during pregnancy and previous depressive episodes were key predictors of postnatal depressive symptoms in this study, as was dampening of positive emotion.

O'Mahen et al. (2010) found a complex relationship between rumination during pregnancy and later depression, such that rumination was predictive of later depression scores but only for women who reported poor social functioning. This suggests that effective social support may buffer the impact of rumination on future depressed mood. In contrast 'silencing the self' was predictive of rumination and depressed mood in women high in social functioning, but not those low in social functioning. These findings suggest that rumination may have a rather complex predictive relationship with perinatal depression, interacting with other risk and protective variables, both within the individual and her social/environmental context.

O'Mahen, Karl, Moberly & Fedock (2015) examined links between childhood maltreatment, emotional regulation and depression in a group of women assessed during pregnancy. These women were either depressed or had elevated but non-clinical symptoms of depression. The data showed that brooding rumination was associated with higher levels of childhood maltreatment and with higher levels of depressive symptoms during pregnancy. Modelling showed that brooding rumination was a partial mediator of the relationship between childhood emotional abuse and current depressive symptoms. This suggests that rumination, particularly the brooding form, may be a pathway through which childhood maltreatment increases risk of depression later in life, including during the perinatal period. The authors hypothesise that this effect may be mediated through attachment style – emotional abuse has been shown to be linked to the development of anxious attachment, which in turn predicts higher levels of rumination. Thus, they suggest that attachment styles emerge from

experiences of abuse or maltreatment and lead to distinctive emotional regulation strategies, including rumination, which then confer increased risk of depression.

Finally, one study examined positive beliefs about rumination, comparing these across depressed and non-depressed pregnant samples. Positive beliefs about the utility of rumination, for example as a strategy for problem solving or resolving unmet goals, are thought to be important as they may promote engagement in rumination (Papageorgiou & Wells, 2001, 2003). Isa Alfaraj et al. (2009) showed that positive beliefs about rumination were higher in a depressed than a non-depressed group, and that these beliefs predicted depression classification. This predictive relationship existed over and above the effect of perceived lack of social support.

Four of the questionnaire-based studies examined impact of rumination on later bonding, attachment or self-reported maternal responsiveness. Müller et al. (2013) reported that rumination during pregnancy predicted mother-reported difficulties in bonding and attachment, even when controlling for pre- and post-natal depressive symptoms. The 'unproductiveness' subscale of the Perseverative Thinking Questionnaire (PTQ) (T. Ehring et al., 2011) was particularly predictive of mother-infant bonding and attachment. This subscale includes items such as 'my thoughts take up all my attention' and 'I keep asking myself questions without finding an answer'. These findings are consistent with a proposed role for rumination in capturing attention and impeding effective engagement with infant cues, resulting in interactive difficulties. However, as rating of the mother-infant relationship was self-reported, it is also possible that the effect of rumination is to impact maternal *perceptions* of bonding and attachment. Scores on the PTQ did not predict postnatal depressive symptoms.

Schmidt et al. (2016) examined changes in rumination, worry, depression, anxiety and maternal-foetal bonding from the first to the third trimester of pregnancy. Maternal-foetal bonding is considered an important index because it is predictive of later mother-infant attachment and maternal sensitivity (Shin, Park, & Kim, 2006; Siddiqui & Hägglöf, 2000). Schmidt and colleagues showed that rumination in the first trimester had a small negative effect on intensity of maternal preoccupation with the foetus in the third trimester. Rumination was not predictive of later depression or anxiety symptoms, when controlling for baseline depression and anxiety. However, worry did have a small predictive effect for both depression and anxiety. In another paper, Schmidt and colleagues extended this work to consider effects of RNT on postnatal bonding (Schmidt et al., 2017). They considered both overall levels of RNT during pregnancy, and trajectories of RNT during this period. Both overall levels of RNT and increase in RNT over pregnancy were associated with mother-reported impairments in bonding with the infant. Similarly, both overall levels of RNT and an increase in RNT over pregnancy were associated with higher levels of depression during the postnatal period.

The role of rumination may differ depending on infant factors. The final questionnaire study identified by the review indicated that rumination mediated the relationship between maternal depression and self-reported responsiveness to the infant, but only where infants displayed low levels of negative affect. Where infants had high levels of negative affect, depression was instead directly related to responsiveness (Tester-Jones, O'Mahen, Watkins, & Karl, 2015). This finding was based on self-report measures and therefore it is unclear whether these relationships would also hold for observed maternal responsiveness. It does however highlight the possible impact of infant variables, and the complex interplay of these factors with maternal mood and cognitions. It is unclear why rumination appears to be implicated only for infants low in negative affect. However, the authors speculate that rumination may be

more prevalent under conditions where mood is low in the absence of infant difficulties. Rumination is often used as a strategy to gain insight or resolve ambiguity, and therefore may be utilised in this causally ambiguous situation, i.e. where the parent is unhappy and finding parenting challenging but does not perceive the infant to be particularly difficult to manage or high in negative affect.

Experimental studies

Three experimental studies were identified – in each case a rumination induction procedure was used prior to examining performance on some measure of parenting ability. Stein et al. (2012) tested whether inducing rumination or worry affected maternal responsiveness to 10 month old infants. This question was explored in a large sample composed of healthy controls and women meeting criteria for Generalised Anxiety Disorder (GAD) or Major Depressive Disorder (MDD). Mother-infant interactions were examined both before and after a priming condition – either a worry/rumination prime, or a neutral prime. Worry/rumination was readily induced, using a procedure in which mothers were asked to spend 5 minutes thinking about either a current worry or a negative life event. Mothers in this condition reported more negative thoughts, more repetitive thoughts and more difficulty controlling thoughts, compared to the neutral prime condition; they also reported more negative affect. The impact of priming was particularly strong for the clinical groups (GAD, MDD). This suggests that ruminative thinking styles were readily accessible and easily triggered in these groups, using a brief, simple priming procedure.

I focus here particularly on findings for the MDD group, although the full analysis included comparisons between GAD, MDD and controls. At baseline, the only difference between groups was that mothers with MDD followed their child's focus of attention less than controls.

Following the rumination prime, responsiveness to infant vocalisation was lower in MDD than controls; this was not the case for the neutral prime. Also, across the MDD group, maternal responsiveness to infant vocalisation was lower following the rumination prime than following the neutral prime. These were largely trend-level effects, with similar but somewhat stronger effects found for the GAD group. None of these effects was moderated by remission status, suggesting that both recently recovered and currently anxious/depressed mothers responded similarly to the priming condition, and differed significantly from the control group. These findings therefore suggest that maternal cognitions, including rumination, have causal, observable effects on mother-infant interactions in the context of postnatal depression and anxiety. It is interesting to note that the main effects of the worry/rumination prime were on maternal responsiveness to *vocalisation* specifically. It has been suggested that worry and rumination are primarily verbal in modality (T. Ehring & Watkins, 2008) and therefore may particularly impact on processing of concurrent auditory/verbal stimuli.

In a similar study, Tester-Jones et al. (2017) examined the effect of a rumination induction on parenting sensitivity and considered whether the effects of this induction differed between dysphoric and non-dysphoric mothers. Rumination was induced by asking participants to think about an unresolved goal for 10 minutes; this process was supported by a series of prompts during the induction period (e.g. 'Focus on how this problem bothers and troubles you.' 'Think about how this problem is still unresolved.'). In the control condition, participants were asked to spend a matched period of time thinking about a problem that had previously bothered them but had since been resolved. A similar set of prompts was used during this period (e.g. 'Think about how this problem is now resolved.'). The induction procedure was based on the hypothesis that rumination is triggered by the occurrence of a goal discrepancy, and persists until the goal is either abandoned or resolved (Roberts, Watkins, & Wills, 2013; E. R. Watkins, 2008). Thus, the active induction was expected to trigger rumination while the control

condition was not. A manipulation check indicated that participants in the rumination induction condition reported a higher level of analytical thinking than did controls. Maternal sensitivity was examined at three timepoints: pre-induction during a period of free play with the infant, post-induction during a second period of free play, and following an adapted still-face procedure (30 second withdrawal of responding/interaction). Results showed that mothers in the rumination condition demonstrated a reduction in sensitivity over time, i.e. sensitivity was lower post-induction and reduced further following the still-face procedure. Mothers in the control condition did not show any reduction in sensitivity. These results were not moderated by dysphoria status, suggesting that the induction had a similar effect in both dysphoric and healthy mothers. The authors argue that this demonstrates a causal effect of rumination in impairing the quality of mother-infant interactions, which occurs regardless of current depressive symptoms. The larger reduction in interaction quality following the still-face procedure suggests that the effects of rumination may be particularly pronounced during stressful or challenging interactions.

In the final study identified, O'Mahen, Boyd, & Gashe (2015) examined the impact of rumination on parental problem solving. Rumination in general is known to affect problem solving and is associated with difficulties both in generating solutions and implementing them effectively (Nolen-Hoeksema et al., 2008). Dysphoric and non-dysphoric women with an infant under 12 months were randomised to either a rumination or distraction condition. Problem solving effectiveness was then assessed using a parenting-specific problem solving measure, which involved generating solutions for problem scenarios in order to reach a specified outcome. (e.g. *Problem* - New to area, attend baby-mum class, baby cries uncontrollably, 2-year old bites another child. *Outcome* - I make some friends). The results showed that, compared to all other groups, dysphoric mothers in the rumination condition demonstrated less effective problem solving and rated themselves as less confident in their problem solving.

The authors hypothesise that rumination captures attention and cognitive resources, and so impedes the ability to notice and engage with key features of the environment, resulting in lack of accurate information on which to base problem-solving strategies.

Discussion of systematic review findings

The review highlights the somewhat mixed evidence as to whether rumination predicts later depression in the perinatal context, particularly after controlling for the effects of previous and current depression (Raes et al., 2014; Schmidt et al., 2016). Given the strong correlations of rumination with both current depression and history of depression, this may partly result from use of small studies with limited power to test predictive models and disentangle these effects. However, several papers indicate that rumination may interact with other variables including mother, infant and social/environmental factors (Egan et al., 2017; H. A. O'Mahen et al., 2010; H. A. O'Mahen, Karl, et al., 2015), suggesting that rumination has a complex role in predicting future depression, which depends on the presence of other factors. Two studies suggest that rumination may act as a mediator between some other risk factor (e.g. childhood maltreatment, perfectionism) and depression (Egan et al., 2017; H. A. O'Mahen, Karl, et al., 2015). The review also indicates that the time course over which rumination is examined may play a role; for example, in one study rumination was predictive of later (2 months postnatal) but not earlier (1 month postnatal) depression (Barnum et al., 2013). In addition, positive beliefs about the utility of rumination may be important (Isa Alfaraj et al., 2009), although this was examined only concurrently with mood, and not in a longitudinal design.

The current review indicates that rumination is consistently associated with relational outcomes such as bonding and attachment, with higher rumination predicting later difficulties with bonding and attachment (Müller et al., 2013; Schmidt et al., 2017; Schmidt et al., 2016;

Tester-Jones et al., 2015). However, there are very few studies examining this question and although the existing studies are longitudinal, they do not allow definite causal conclusions to be drawn. Critically, these studies have considered only mother-reported indices of bonding and attachment, rather than objective measures. The use of objective measures seems particularly important given the likely impact of low mood and rumination on *perception* of these outcomes. As discussed in relation to prediction of later depression, rumination is likely to interact with other factors such as social support and infant temperament to predict relational outcomes (Tester-Jones et al., 2015). Given these findings, it will be important to extend current work by establishing under what circumstances, or in the context of what other variables, rumination is predictive of later maternal outcomes (e.g. depression) and mother-infant outcomes (e.g. bonding).

The existing experimental evidence suggests that inducing rumination (or similar cognitive processes, such as worry) has a significant impact on maternal responsiveness (Stein et al., 2012; Tester-Jones et al., 2017) and effectiveness of parenting-related problem solving (H. A. O'Mahen, Boyd, et al., 2015). Experimental designs provide a more robust test of causality and suggest that rumination may indeed have a causal, mechanistic role. However, there are many remaining questions about the pathways through which rumination operates on parenting responses, the specific changes it causes, and subsequent impact on infants; further experimental research is clearly required. The current studies also provide inconsistent evidence as to the interaction between rumination and clinical status. Two studies showed an impact of the rumination induction only for depressed or dysphoric participants (H. A. O'Mahen, Boyd, et al., 2015; Stein et al., 2012), whereas in the third study the effects of the rumination induction were not moderated by dysphoria status (Tester-Jones et al., 2017). It therefore remains unclear whether rumination in itself is a risk to effective parenting, or only when combined with current depressive symptomology.

The current review highlights some surprising gaps in the existing research. For example, there is currently no research examining issues such as the prevalence, chronicity and content of rumination in the perinatal context. Some qualitative research into women's experiences of PND has indicated themes that resemble rumination, but these are not typically labelled as such and therefore were not included in the systematic review. For instance, qualitative themes identified include: "obsessive thoughts of being a bad mother", "wondering what was happening to them", and "loss of control over thoughts" (Beck, 1992). Qualitative studies also frequently identify themes of loss, and incongruity between expectations and realities of motherhood (Beck, 2002). These ideas closely match the primary content of ruminative thought, that is, themes of loss and discrepancy between current and desired states (Nolen-Hoeksema et al., 2008; E. R. Watkins, 2008). However, there is little systematic evidence regarding themes of rumination in PND, and how closely these parallel the content of rumination in depressive disorder more broadly. There is similarly no published literature on the prevalence or frequency of ruminative thought in PND, or indeed in healthy perinatal populations. Recently, experience sampling methodology has been used to examine and characterise rumination in daily life (Kircanski, Thompson, Sorenson, Sherdell, & Gotlib, 2015; Kircanski, Thompson, Sorenson, Sherdell, & Gotlib, 2017; Timm et al., 2017); this method may be useful for beginning to address some of these questions in the perinatal period.

This systematic review therefore provides information about the potential role of rumination in predicting later outcomes, including maternal depression and mother-infant outcomes such as bonding and attachment. There is some initial evidence that rumination plays a causal role in impairing parenting quality. However, the review also highlights many remaining questions and areas where this work could be extended (see also *Remaining questions and future directions*, page 55).

To date, the literature on rumination in the perinatal period has lacked a theoretical model or organising framework. Therefore, in the next section of this chapter, I develop and present a new cognitive model which seeks to account for the specific effects of rumination on parenting behaviour in the postnatal context.

Developing a cognitive model of rumination, PND and parenting

Theoretical Models of Rumination and Related Cognitive Processes

As outlined above, a number of information-processing models have been proposed that seek to explain how rumination is triggered and maintained, and which emphasise the role of underlying cognitive control deficits (Mor & Daches, 2015) (see Section A, page 15). I have drawn on these existing models in seeking to develop a specific perinatal model.

Forms of repetitive negative thinking, including rumination, are increasingly recognised as transdiagnostic phenomena (De Raedt et al., 2015; T. Ehring & Watkins, 2008), with relevance to both anxiety and depressive disorder. Various accounts of anxiety and worry have been proposed that have clear parallels with the models of rumination outlined above in terms of an emphasis on the role of cognitive biases and cognitive control deficits. Therefore, in addition to models from the depression literature, the cognitive model presented here is also informed by existing models of anxiety and worry. I have particularly drawn on Attentional Control Theory (Michael W. Eysenck & Derakshan, 2011; M. W. Eysenck et al., 2007) and a key model of worry (C. R. Hirsch & Mathews, 2012). These accounts are similar in that they integrate 'bottom up' biases in attentional processing with 'top down' cognitive control processes. They may therefore have utility in guiding the development of an integrative model of rumination, cognitive biases and cognitive control.

Cognitive biases in perinatal depression

Cognitive biases are prevalent in depression (Gotlib & Joormann, 2010; Mathews & MacLeod, 2005) and have been clearly implicated in the development and maintenance of rumination (Everaert, Koster, & Derakshan, 2012; Mathews & MacLeod, 2005). However, much less work

has been conducted specifically in perinatal populations. In a recent review, Webb and Ayers (2015) identified 14 studies examining cognitive biases in women with perinatal mental health problems, including depression, anxiety and PTSD[5]. Various study designs were employed, but in each case the stimuli examined were either adult or infant facial expressions. Webb and Ayers concluded that women who are depressed perinatally tend to show attentional biases towards sad infant faces, and to a lesser extent show similar biases towards sad adult faces. There is also evidence that this group are more likely to interpret neutral or ambiguous infant faces as negative. These biases seem likely to negatively affect contingent, sensitive parenting because this relies on an ability to accurately interpret infant cues, in order to respond in an appropriately matched way. If a mother is biased towards detection of negative cues, she may miss important positive or neutral cues, such as happiness or interest, which would otherwise have guided her responses. Infant cues also provide critical feedback that allows mothers to continually evaluate and adjust their parenting responses as required. Cognitive biases in infant cue perception may therefore affect mothers' evaluations of their parenting, and ability to adjust their behaviour to meet the infant's needs.

The existing perinatal literature is therefore small but broadly consistent with the general depression literature in suggesting negative cognitive biases in attention and interpretation. Various questions have not yet been addressed, including whether memory biases are present and how these different cognitive biases relate to one another. Biases in attention, interpretation and memory are likely to interact (Everaert et al., 2012); for example, an attentional bias towards negative information may lead to more negative information being recalled later (memory bias). Therefore, in interaction with one another, these biases may have wide-ranging impacts on perception of the infant (e.g. affect, temperament), the self (e.g.

[5] A search for recent work on cognitive biases in the perinatal period did not identify any additional papers since the publication of this review.

self-efficacy, evaluation of parenting ability), and the parent-infant relationship (e.g. bonding, attunement). It is also unclear from the current literature in PND whether cognitive biases operate on a range of stimuli, including facial expressions other than sadness (e.g. anger, fear) and vocal stimuli; this may be a useful direction for future research.

Cognitive control deficits in perinatal depression

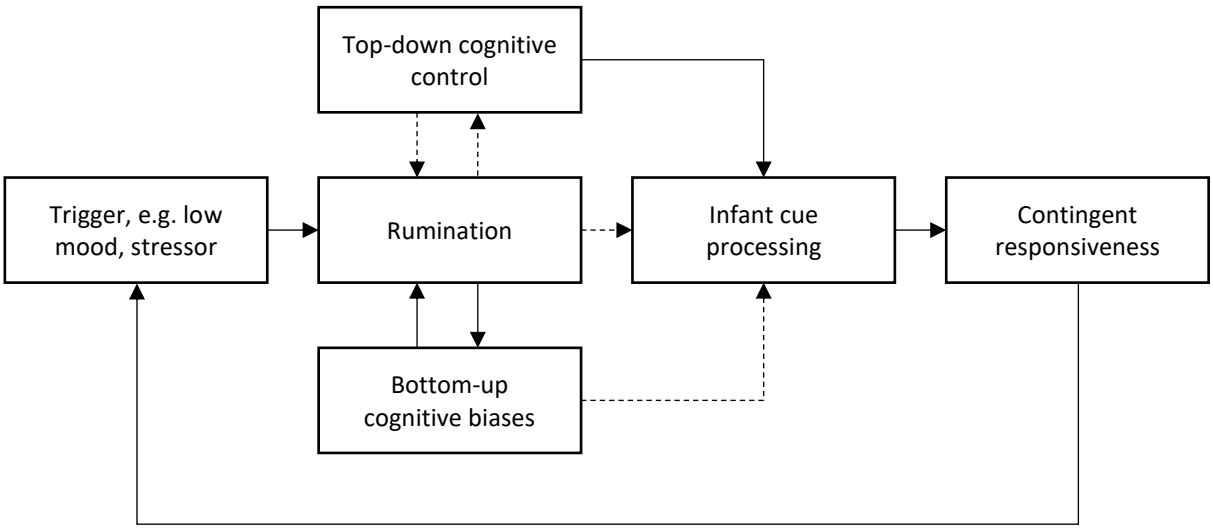
As outlined above (Section A, page 15), cognitive control deficits are associated with rumination and considered to play an important role in vulnerability to habitual rumination. Impairments in cognitive control are perhaps particularly relevant for postnatal populations, given the demands that parenting places on executive functions. Barrett and Fleming (2011) note that mothers: "must be flexible and be able to focus when appropriate and switch attention when the situation changes… planning, attention, flexibility and working memory are essential for adequate mothering". A recent review of the neuroimaging evidence in PND highlighted consistent findings of changes in brain regions implicated in executive functioning (Duan, Cosgrove, & Deligiannidis, 2017). A small number of studies using neuropsychological measures have also found evidence of impaired executive function in the context of PND. Pio de Almeida et al. (2012) report evidence of impaired working memory and short-term memory in depressed mothers. Messinis et al. (2010) report poorer performance on a learning task and an attention switching task by postnatally depressed women, compared to controls. There is also some evidence that depressive symptoms during pregnancy are associated with deficits in visuospatial working memory (Hampson et al., 2015; Kataja et al., 2017). However, there has been little work in this area and a more thorough examination of cognitive control in PND is indicated. It would also be of interest to explore links between cognitive control in PND and changes in parenting behaviour, particularly those features of parenting that are critical to child development, such as contingency.

Applying a Theoretical Model to Postnatal Depression

There are then several theoretical models that seek to explain rumination, or related cognitive processes such as worry, with reference to underlying cognitive biases and/or cognitive control deficits. The literature in PND, reviewed above, is broadly consistent with findings from research in depression and rumination more broadly. However, the perinatal literature has not typically been guided by a specific theoretical framework and there are many gaps in the current research evidence. Use of a clearer theoretical framework may provide a focus for future research and advance understanding in this field.

Whilst the models of rumination and worry described earlier in this chapter provide a helpful starting point for a theoretical framework, they require adaptation in order to account for particular effects in the context of PND. I propose an information-processing model of rumination in PND, guided by general models of rumination and worry, and extended to include processes that are specific to the postnatal context. The model is intended to provide an initial theoretical framework that may illuminate some of the underlying cognitive mechanisms and provide testable hypotheses for future research. The model is described below and illustrated in Figure 1.2. The description of the model begins with an account of rumination, and its relation to cognitive biases and cognitive control deficits, based on existing models from the broader depression and anxiety literature. I then go on to discuss how these processes may specifically affect the postnatal period, with reference to their impact on infant cue processing and parenting behaviour.

Figure 1.2 Cognitive model of rumination and its effects on parenting behaviour[6]



A cognitive model of rumination and parenting

I propose that rumination is associated with both top-down cognitive control deficits and bottom-up cognitive biases; these components of the model are hypothesised to have bidirectional links with rumination. The model posits that rumination is preceded by an initial trigger, which may be internal, such as mood or an intrusive negative thought, or could be an external event such as an everyday stressor. In the postnatal context, this may include parenting related triggers, such as managing multiple demands or encountering infant negative affect. Following this trigger, rumination is established and maintained though the combined effects of cognitive biases and cognitive control deficits.

Firstly, it is suggested that in the context of depression or low mood, cognition is biased in favour of negative information. Negative information is therefore more likely to enter awareness and thus influences the content of ruminative thought, such that this is pervasively

[6] Where solid lines indicate positive links and dotted lines indicate negative/inhibitory links.

negative. Rumination, which involves repetition and elaboration of this content, likely also reinforces cognitive biases via rehearsal. These biases are therefore strengthened, and it becomes increasingly likely that negative content and ruminative processes will be activated when future triggers are encountered.

Secondly, deficits in cognitive control are hypothesised to impair the ability to reappraise or redirect attention away from negative thoughts once triggered. Cognitive control incorporates voluntary, executive processes that facilitate directing attention towards task-relevant information in a goal-directed manner, by flexibly shifting the focus of attention and inhibiting distracting information. Typically then, cognitive control processes enable people to override negative, ruminative thought processes once triggered, and to redirect attention onto alternative topics or task-relevant information. However, in the context of cognitive control deficits, there may be insufficient control to override ruminative processes once these are activated. These thoughts are therefore subject to continued attention and develop into a repetitive and persistent thought process. When this occurs repeatedly, a pattern of high trait rumination is established. Rumination is also likely to exert reciprocal effects on cognitive control, as it is an activity that consumes cognitive resources (Roberts et al., 2016). This may mean that during rumination, with cognitive control directed towards processing of the ruminative content, it becomes increasingly difficult to redirect attention. The ruminative state is therefore maintained and becomes prolonged.

The combined effects of negative cognitive biases and cognitive control deficits may therefore help explain vulnerability to rumination. This type of model is consistent with the characteristics of ruminative thought, particularly the reported experience that it is repetitive and uncontrollable. Within the model, rumination also acts to reinforce cognitive deficits and

biases, thus increasing the likelihood that rumination will be triggered in future. This is consistent with the stability and persistence of trait rumination over time.

In the postnatal context, I propose that these cognitive processes will have important effects on infant cue processing. Cognitive biases are hypothesised to affect attention to and interpretation of infant emotional cues. Cognitive control deficits are hypothesised to affect the ability to appropriately direct cognitive resources towards infant cues. Biases and control deficits may therefore directly impair infant cue processing, potentially resulting in slower and/or less accurate perception of infant cues. In addition, it is proposed that cognitive biases and control deficits impair cue processing indirectly, via their actions on rumination. The combination of cognitive biases and control deficits leads to rumination becoming highly prevalent and persistent. It thus captures attentional and cognitive resources so that external cues, including infant cues, are likely to be less effectively or less rapidly attended. This is consistent with the proposed role of preoccupation as an important mechanism through which maternal psychiatric disorder affects parenting (Stein et al., 2009). Given the frequency and persistence of ruminative thinking in depression, it is hypothesised that its effects on parental sensitivity to infant cues may be pervasive.

Failure to rapidly and accurately perceive infant cues is likely to have a significant impact on parent-infant interaction, particularly contingent responsiveness. Continent responsiveness refers to a pattern of responding to the infant in which the parent's behaviours are closely matched to the infant's cues, both in terms of timing and selection of response (Bornstein & Tamis-LeMonda, 1989). The mother's ability to deliver an appropriate and timely response, and so maintain contingency, is dependent on accurate and efficient processing of infant cues. I hypothesise that information processing deficits and biases, along with the preoccupation inherent in rumination, impair mothers' ability to process infant cues accurately and

efficiently; contingent responding is thus impaired. Infants are highly sensitive to deviations from contingency (Bigelow et al., 1996; Mesman, van Ijzendoorn, & Bakermans-Kranenburg, 2009; Tronick, Als, Adamson, Wise, & Brazelton, 1978), and can perceive contingency only over short latencies (Keller et al., 1999). Therefore, even subtle mismatches or delays in responding may have significant implications for child outcomes.

Psychogiou and Parry (2014) have suggested that unstructured interactions (e.g. play) may be particularly affected by parental depression, as parental response in such situations is highly dependent on self-directed attention. In contrast, more structured situations may be less affected, as the externally imposed structure may help to focus and direct parental responses. In addition, it has been shown that parenting difficulties associated with maternal psychopathology are mainly observed under conditions of stress or challenge (Ginsburg, Grover, Cord, & Ialongo, 2006). Within the model, this is consistent with the role of stress or challenge as a trigger for rumination, which then has effects on cue processing and interaction. Lack of contingency is likely to result in difficult or mismatched interactions with the infant, which may in fact act as a trigger to further rumination. Impairments in contingent responding may also impact on the mother's experience of parenting and sense of competence as a parent.

Implications for Child Development

Contingent responsiveness is thought to be a key aspect of effective parenting, which promotes the infant's development. If rumination, and related attentional processes, have effects on contingent responding therefore, this may be an important mechanism through which maternal mood impacts on child developmental outcomes. It has been suggested that contingent responsiveness is particularly implicated in child *cognitive* development.

Contingent responsiveness in mothers with depression is predictive of children's attention and cognitive functioning (Murray et al., 2010), which in turn predicts later intellectual functioning (Bornstein, 2014; Stanley, Murray, & Stein, 2004). It could therefore be hypothesised that high levels of maternal rumination might be particularly associated with risk of negative attentional and cognitive outcomes for the infant. PND in general is associated with a range of risks for child development, including behavioural and emotional, as well as cognitive outcomes (reviewed in Stein et al. (2014)). It is possible that rumination, and subsequent changes in infant cue processing and contingency, play an important role in mediating some or many of these risks. There is a need for longitudinal, developmental studies to examine these questions. Finally, whilst the research to date has primarily focused on mothers, there is no reason to believe that similar processes might not also apply to fathers; this should be a focus of future work in this area.

Implications for Intervention

The model presented here has implications for intervention design, as it highlights specific cognitive features of PND that may be key mechanisms through which depression affects parenting and therefore child development. Interventions that target these cognitive mechanisms are therefore likely to have benefits both for maternal mental health, and for child outcomes.

Although rumination has not often been examined as an outcome in treatment trials, there is some evidence that cognitive behavioural therapy does not effectively reduce rumination (Schmaling, Dimidjian, Katon, & Sullivan, 2002), that high levels of rumination predict poorer therapeutic outcomes (Jones, Siegle, & Thase, 2008), and that rumination at end of treatment predicts depressive relapse (Michalak et al., 2011). There is therefore increasing interest in

treatments that are hypothesised to specifically target rumination, including mindfulness approaches (e.g. MBCT (Segal, Williams, & Teasdale, 2013)), acceptance-based approaches (S. C. Hayes, Strosahl, & Wilson, 2003), behavioural activation (Martell et al., 2013) and metacognitive therapy (A. Wells, 2009). Given that residual rumination seems to confer risk for future depressive episodes, clinicians and researchers have suggested that more effectively targeting this aspect of depressive cognition may improve treatment outcomes and reduce relapse. In the postnatal context, treating depression alone often does not seem to be sufficient to ameliorate negative effects on parent-infant interactions and child outcomes (Poobalan et al., 2007). One hypothesis is that residual rumination may be a factor underlying this effect; if ruminative thinking remains a habitual response that is triggered when low mood or stressors are encountered, then this would continue to affect parental attention to infant cues, and therefore negatively impact on parent-child interactions.

The model outlined above generates several testable predictions regarding the type of interventions that may be helpful. In particular, it suggests that interventions that shift the balance of competition between bottom-up biases and top-down control processes should be beneficial in reducing rumination. This could involve directly targeting 'top-down' attention control processes, 'bottom-up' attention biases, or a combination of both these factors. Interventions that target the 'bottom-up' cognitive biases in the model could include attention bias modification (ABM) procedures and cognitive bias modification procedures that target interpretation biases (CBMi). These procedures are designed to change biases through repeated rehearsal of a more positive or neutral bias (Hertel & Mathews, 2011). 'Top-down' interventions may include cognitive remediation (Porter, Bowie, Jordan, & Malhi, 2013) or other training procedures, such as working memory training (E. H. W. Koster et al., 2017). There may be particular benefits to a 'top-down' approach, as increased cognitive control is likely to facilitate greater *flexibility* of responding. This flexibility of responding has been

proposed to be important for effective emotional regulation (Ochsner & Gross, 2005) and resilience (Genet & Siemer, 2011), and is likely to play a key role in facilitating sensitive and contingent parenting behaviour.

Remaining Questions and Future Directions

The review and theoretical framework presented here highlight many remaining questions about the role of rumination in PND and suggest several potential avenues for future research. Firstly, there is a need for studies that better characterise rumination in the context of PND, including prevalence, frequency and persistence of rumination, as well as content and themes. More consistent use of terminology and better alignment with the general depression literature may be helpful in developing understanding of the role of rumination in the postnatal context. Inclusion of rumination measures in treatment trials and epidemiological studies would also facilitate exploration of the role of rumination as a proposed vulnerability factor and mechanism of change.

Secondly, the suggested role of cognitive biases and cognitive control in the model could be tested directly. Experimental designs, which manipulate either cognitive biases or cognitive control, and examine impact on rumination, would provide a particularly robust test of the model. There are a small number of studies addressing these processes in non-perinatal groups, although to date findings have been mixed (Mor & Daches, 2015). As the literature on rumination and cognitive control in depression continues to develop, this may support or suggest refinements to the model.

Thirdly, the impact of rumination on infant cue perception and subsequent parenting behaviour requires further examination. Whilst there is evidence that rumination affects maternal responsiveness (Stein et al., 2012; Tester-Jones et al., 2017), the precise effects of

rumination on infant cue processing are unclear. It may be that the effects of rumination differ according to the emotional tone of cues (e.g. happy, sad or neutral expressions), or that certain modalities (e.g. visual, auditory) are more affected than others. As rumination is thought to be a predominantly verbal phenomenon (T. Ehring & Watkins, 2008), it might be expected that responsiveness to auditory/vocal cues would be particularly affected. Experimental studies using standardised infant cue stimuli, in combination with induced rumination procedures, could be used to address these questions. In addition, examining infant cue perception and live mother-infant interaction in the same group would facilitate a test of the hypothesised links between these components in the model. Longitudinal designs would also be of use in extending this work to include measures of infant developmental outcomes.

Some of these outstanding questions and suggestions for future study are addressed later in the thesis. For example, one chapter reports on an experimental study examining the impact of induced rumination on infant cue processing (Chapter 5); another reports on the impact of a cognitive training procedure on rumination (Chapter 6). A more detailed overview of the contents of the thesis and the main methods employed is provided in the next section.

Section C: Overview of the thesis

As described above, the core theme of this thesis is the role of rumination in the context of depression. In particular, I consider two key processes: firstly, the proposed role that rumination plays in mediating the relationship between cognitive control deficits and vulnerability to depression and secondly, the impact of rumination on social cognitive processing. These processes have broad implications for understanding of depression, as they may contribute to depressive vulnerability and to the significant social functioning deficits that occur in the context of depressive illness.

In addition, these processes have specific implications for depression occurring during the perinatal period. Rumination and underlying cognitive control deficits may play a role in onset and severity of depression during the perinatal period, similarly to depression occurring at other times. Indeed, the systematic review reported above found some evidence for this, although findings were mixed and appear to be moderated by other key variables. In addition, the proposed impact of rumination on social cognition has implications for parenting behaviour. It is likely that a high level of social cognitive performance is required to facilitate effective responding to infant cues, with a number of studies showing associations between performance on social cognition tasks and parenting sensitivity (MacKinnon et al., 2014; Rigby et al., 2016). There is also now experimental evidence indicating that rumination plays a causal role in impairing parenting sensitivity (Stein et al., 2012; Tester-Jones et al., 2017). Deficits in parenting sensitivity during the postnatal period have significant impacts on infant development (Stein et al., 2014) and these effects are particularly pronounced where depression is severe and prolonged (Netsi et al., 2018). Thus, rumination could be a key cognitive mechanism through which PND affects infant outcomes, both via its impact on the

severity and duration of maternal depression and via impacts on social cognition and parenting behaviour.

Cognitive control deficits, rumination and depression

The relationships between cognitive control deficits, rumination and depression are examined in three of the following thesis chapters. Chapter 2 describes a study in which associations between these constructs are examined in a community population. I specifically test the hypothesis that rumination mediates the relationship between deficits in cognitive control and symptoms of depression. The study makes use of both self-report and performance measures of cognitive control and considers how they relate to one another, as well as their relationship to rumination and concurrent depressive symptoms. Chapter 3 extends this work and reports on a study in which cognitive control and rumination are examined as possible predictors of later depressive recurrence, in a remitted clinical sample. This work comprised of secondary data analysis of an existing dataset from a large cohort study, designed to examine predictors of depressive recurrence in a high risk population. Again, an experimental approach was used, with cognitive control measured using two standardised cognitive tasks. I test the hypothesis that cognitive control performance and rumination will predict depressive recurrence, with rumination mediating the relationship between cognitive control and time to recurrence. I also examine whether there are differences in performance on the cognitive control task between remitted patients and healthy controls.

Finally, Chapter 6 reports on a cognitive training study, conducted in a sample of participants selected for high trait rumination. Cognitive training designs have potential utility as clinical interventions, but also provide a means of addressing causal questions regarding the role of cognitive control deficits in conferring vulnerability to psychological disorder. This study

specifically examines whether two different forms of cognitive training can be used to increase cognitive control, and whether any improvements in cognitive control are associated with reductions in state rumination. Impact on a range of more distal outcomes is also examined, including change in depressive symptoms, trait rumination and social cognition. In addition to the use of cognitive training procedures, this study makes use of standardised measures of cognitive control performance, including attention and working memory tasks. An innovative measure of state rumination is also used, to give an objective measure of ruminative thought within the experimental session.

Rumination and social cognition

The remaining two empirical chapters examine the relationship between rumination and social cognition. In Chapter 4, I report on the associations between depression, rumination and empathy, using data from an online questionnaire study in a community population. I test the hypothesis that both depression and rumination will be associated with impaired empathy and consider whether the relationships between these constructs differ by gender.

Chapter 5 utilises a rumination induction procedure to examine the causal role of rumination in impairing social cognitive processing. The social cognitive task used in this study was an infant face and vocal cue processing task, and therefore was designed to assess aspects of social cognitive performance that are specifically relevant to parenting in the perinatal period. By comparing the rumination induction to a control condition, I test whether current rumination has effects on the processing of infant cues and consider whether any such effects differ according to the modality and valence of those cues. Interactions between the rumination induction and trait rumination/current depressive symptoms are also considered. In addition, I examine whether induced rumination impacts on performance of a cognitive

control task, given the hypothesised bidirectional relationship between rumination and cognitive control (Roberts et al., 2016).

In this thesis then, I argue that cognitive control deficits confer vulnerability to rumination, and that rumination then confers dual vulnerability to a) depressive symptoms, b) social cognitive deficits. These themes are explored both in relation to general adult depression and with reference to specific applications in the perinatal context. The studies primarily make use of analogue populations, with subclinical levels of depression, or populations selected for a key vulnerability factor (e.g. high trait rumination). The exception is the study reported in Chapter 3, which concerns a remitted clinical sample. The studies employ a range of experimental methods to address the hypotheses of interest, including use of standardised measures of cognitive control, questionnaire measures of rumination and depressive symptoms, induced rumination and cognitive training procedures. The studies are thus designed to examine a range of associative and causal questions regarding the links between rumination, depression, cognitive control and social cognition. The methods used, and results of the empirical work, are described in Chapters 2 to 6. Chapter 7 provides a summary and discussion of these findings, including the limitations and strengths of the studies, and consideration of their implications both for future research and for clinical practice.

Chapter 2. Does rumination mediate the relationship between attentional control and symptoms of depression?

As outlined in Chapter 1, attentional control (AC) refers to the ability to direct and focus attention, and is considered to be an important component of executive functioning and cognitive control (Derryberry & Reed, 2002; M. W. Eysenck et al., 2007). Impairments in AC have been particularly linked to risk for developing affective disorder, via their impact on emotional regulatory processes, including proneness to rumination (Joormann & D'Avanzato, 2010; Joormann & Vanderlind, 2014; E. H. W. Koster et al., 2011). In this chapter, I explore the specific links between AC, rumination and symptoms of depression in a cross-sectional design.

Measuring attention functioning

One widely used measure of attention performance is the Attention Network Task (ANT) (Fan, McCandliss, Sommer, Raz, & Posner, 2002). The task is based on Posner and colleagues' model of attention (Posner & Petersen, 1990; Posner & Rothbart, 2007), which proposes that attention functioning can be divided into three distinct but interrelated networks: alerting, orienting and executive attention. Alerting is involved in maintaining sensitivity to incoming information. Orienting is implicated in directing attention to relevant information in the environment. Executive attention is primarily involved in resolving conflicts between competing sources of information. The ANT combines a spatial cueing task with a flanker paradigm and is designed to assess the functioning of all three networks in a single task, by comparing reaction times across different trial types.

Self-report measures of AC are also commonly used, most notably the Attentional Control Scale (ACS) (Derryberry & Reed, 2002). This is a questionnaire measure of attention performance, with items framed in terms of everyday functioning, e.g. 'It's hard for me to concentrate on a difficult task when there are noises around'. Subsequent factor analyses of this measure have indicated that it contains two components: focusing and shifting (Judah, Grant, Mills, & Lechner, 2014; Ólafsson et al., 2011). Focusing is defined as the ability to maintain attention, particularly in the face of distraction or competing stimuli. Shifting involves the flexible allocation of attention, and the ability to move attentional resources between different tasks or sources of information.

The relationship between self-report measures of AC and performance measures has been addressed in relatively few studies, with mixed findings (Judah et al., 2014; Pacheco-Unguetti et al., 2011; Reinholdt-Dunne et al., 2009, 2013; Tortella-Feliu et al., 2014; Williams, Rau, Suchy, Thorgusen, & Smith, 2017). It therefore remains unclear how these are related and whether this differs across different populations. Comparisons between self-reported attention and the ANT specifically have either shown no significant correlation between these measures (Reinholdt-Dunne et al., 2009; Williams et al., 2017), or correlations only between focusing and the conflict index of the ANT (Reinholdt-Dunne et al., 2013). Notably, many of the existing studies have examined only total ACS scores, and have not considered possible differences between the focusing and shifting components. Distinguishing between these subscales may help to clarify some of the inconsistent findings in this area.

There is also some evidence that self-report measures of cognitive functioning may be more influenced by mood and personality factors than are performance measures (Buchanan, 2016; Meltzer et al., 2016). Self-report measures and performance tasks are then likely to provide somewhat differing and perhaps complementary measures of AC.

Attentional control and depression

There is evidence that poor AC is significantly associated with vulnerability to affective disorder. Self-reported difficulties with AC appear to be associated with high levels of negative affect, and with elevated symptoms of anxiety and depression (Fajkowska & Derryberry, 2010; Pacheco-Unguetti et al., 2011; Reinholdt-Dunne et al., 2009, 2013; Tortella-Feliu et al., 2014). It is proposed that the two components of AC (focusing and shifting) may have specific differential associations with anxiety and depression, such that poor focusing is most strongly correlated with anxiety symptoms, whilst impaired shifting ability is more closely correlated with depressive symptoms (Judah et al., 2014; Reinholdt-Dunne et al., 2013; Ólafsson et al., 2011). However, to date few studies have specifically addressed this hypothesis.

Studies utilising performance measures also indicate consistent evidence that depression is associated with broad impairments in cognitive control, including AC, and that this is apparent for both clinical groups and vulnerable populations (e.g. subclinical or remitted groups, high trait ruminators) (E. H. W. Koster et al., 2017; Snyder, 2013). This is consistent with the suggestion that AC deficits may represent a vulnerability factor for affective disorder, rather than resulting from the impact of current affective symptoms. For this reason, associations between AC and depressive symptoms are of interest in healthy and/or vulnerable populations, as well as clinical samples.

Relatively few studies have specifically used the ANT to examine associations between AC, depression and anxiety. Where this has been examined, some studies have found no associations between ANT performance and depression or anxiety (Reinholdt-Dunne et al., 2013). However, others have found reduced executive network performance and changes in orienting function associated with higher anxiety (Pacheco-Unguetti, Acosta, Callejas, & Lupiáñez, 2010; Pacheco-Unguetti et al., 2011). These relationships therefore require further

examination and clarification. There is particular debate as to whether the cognitive deficits associated with depression apply to the processing of emotionally neutral information, as presented in the ANT, or whether these deficits are more specific to the processing of affective information. One view is that general deficits may be present for clinical populations, whereas impairments in vulnerable populations may be more restricted to conditions requiring processing of emotional material (E. H. W. Koster et al., 2017; Snyder, 2013). However, this has rarely been systematically examined.

Attentional control and rumination

Emotion regulation strategies are of considerable interest in the context of affective disorder, as they appear to play a role in the development and maintenance of these disorders. For example, as outlined in Chapter 1, use of rumination as an emotional regulation strategy has been strongly related to the onset and severity of depression (Nolen-Hoeksema et al., 2008). It has been suggested that ER strategies in large part rely on the effective use of AC, and therefore deficits in AC may predispose individuals to greater use of maladaptive strategies (Fajkowska & Derryberry, 2010; Joormann & D'Avanzato, 2010; E. H. W. Koster et al., 2011). Several theoretical models particularly implicate AC deficits in the tendency to engage in high levels of worry and rumination (C. R. Hirsch & Mathews, 2012; E. H. W. Koster et al., 2011; Mor & Daches, 2015; E. R. Watkins & Nolen-Hoeksema, 2014). Various evidence suggests that worry and rumination are associated with impairments in inhibition and attention shifting, although in common with the literature on depression, there is not clear consensus about whether these impairments apply to neutral as well as affective stimuli (E. De Lissnyder et al., 2011; Vanderhasselt, Kühn, & De Raedt, 2011; Whitmer & Banich, 2007). One somewhat divergent model has proposed that rumination is associated not with AC deficits as such, but with a narrowed focus of attention (Whitmer & Gotlib, 2013). It is proposed that a narrowed

focus of attention could predispose individuals to rumination, by promoting a persistent focus on negative thoughts. It is hypothesised that a narrow attentional focus could confer advantages on particular tasks, for example avoiding distraction by irrelevant stimuli, but also confer disadvantages where task performance requires attentional flexibility or a broadly distributed focus of attention.

One previous study has specifically examined associations between ANT performance and rumination, finding that poorer functioning of the orienting network explained increases in brooding, even after controlling for trait anxiety (Tortella-Feliu et al., 2014). Several studies have also linked self-reported AC to levels of repetitive negative thinking (RNT), including rumination and worry. These studies consistently indicate that poorer AC is associated with higher levels of RNT (Cox, Ebesutani, & Olatunji, 2016; Hsu et al., 2015; Mills et al., 2016).

Researchers have recently started to explore hypothesised three-way relationships between AC, RNT and affective disorder, in particular the suggestion that AC deficits may predispose individuals to depressive symptoms, via an increase in maladaptive emotional regulation strategies. Hsu et al. (2015), using path analysis, showed that rumination mediates the relationship between self-reported AC and depression/anxiety symptoms. Similarly, Kertz et al (2017) demonstrated a relationship between AC deficits and depression, mediated by an indirect pathway involving RNT and mood recovery. However, these studies relied on cross-sectional data and used only self-report measures of AC. One previous study has examined the longitudinal relationship between performance on an AC task and later depressive symptoms. This study showed that AC deficits at baseline were associated with higher depressive symptoms at one year, and this relationship was fully mediated by rumination (Demeyer et al., 2012). In addition, a number of relevant cognitive training studies, in both clinical and selected vulnerable populations, provide evidence that increasing AC via cognitive training has benefits

in terms of reductions in rumination and depressive symptoms (E. H. W. Koster et al., 2017; Mor & Daches, 2015). These findings are consistent with the suggestion that AC deficits play a causal role in vulnerability to depressive symptoms. There is then growing support for a model in which AC deficits increase vulnerability to depression, via increases in rumination or other forms of RNT.

Aims and hypotheses

AC impairments appear to reflect a vulnerability factor for the development of maladaptive emotion regulation strategies and subsequent affective disorder. This study examined a number of key outstanding questions regarding the relationships among attentional performance, self-reported AC, depression, anxiety and rumination in a community sample. Firstly, the study examined the relationship between attention performance and self-reported AC. It was hypothesised that self-report and performance measures would be largely unrelated, with the exception of a possible association between focusing and ANT conflict performance. Secondly, the study tested whether depression and anxiety symptoms are related to a) attention performance on the ANT, b) self-reported AC. Thirdly, the study investigated whether rumination is related to a) attention performance on the ANT, b) self-reported AC. It was hypothesised that depression, anxiety and rumination would all be associated with poorer conflict performance (ANT) and poorer self-reported AC. It was further predicted that, consistent with previous findings, depressive symptoms would be particularly associated with shifting impairments and generalised anxiety symptoms with focusing impairments. Finally, I tested the hypothesis that brooding rumination would mediate relationships between AC measures and depressive symptoms.

Method

Participants

81 participants were recruited through a combination of posters, email newsletters and online advertising. To ensure a range of depressive symptoms within this non-clinical sample, the study was advertised for participants who had been experiencing recent sadness or low mood, lasting at least 2 weeks. However, participants who were currently receiving or seeking treatment for any psychological disorder were not included in the study. One participant was excluded after reporting current treatment for a mental health condition, resulting in a final sample of N = 80. Inclusion criteria included age between 18-35 years, normal or corrected-to-normal vision and hearing, and fluent English language. The study was reviewed and approved by the University research ethics committee (reference: MS-IDREC-C1-2015-038)[7].

Measures[8]

Ruminative Responses Scale (RRS) (Nolen-Hoeksema & Morrow, 1991)

The RRS is a 22-item measure of proneness to ruminative thinking when feeling sad or low. Participants are asked to rate how likely they are to engage in a range of behaviours and thought processes 'when you feel down, sad or depressed', e.g. "think about how alone you feel", "think about a recent situation, wishing it had gone better". Each item is rated on a scale from 1 (almost never) to 4 (almost always). A total score can be calculated (range 22-88), as well as subscale scores for 'brooding' (5 items, range 5-20) and 'reflective pondering' (5 items, range 5-20) (Treynor et al., 2003). Brooding is conceptualised as involving passive comparisons between one's current situation and some unachieved goal or standard; it has been strongly

[7] For ethical approval, see Appendix B.
[8] For copies of questionnaire measures, see Appendix A.

linked to both current and future depressed mood. In contrast, reflective pondering is understood to involve purposeful engagement in cognitive problem solving.

Attentional Control Scale (ACS) (Derryberry & Reed, 2002)

The ACS is a 20 item self-report measure of the ability to control and direct attention, and to resist distraction. Items are framed in terms of everyday situations, e.g. "When I am reading or studying, I am easily distracted if there are people talking in the same room" and rated according to frequency, from 1 (almost never) to 4 (always). A total score is calculated (range 20-80), as well as two subscale scores for 'focusing' (9 items, range 9-36) and 'shifting' (11 items, range 11-44) attention (Ólafsson et al., 2011). Focusing refers to the ability to maintain attention, particularly in the face of distraction. Shifting refers to the ability to direct attention flexibly, and to move attention between different tasks or stimuli.

Patient Health Questionnaire (PHQ-9) (Spitzer, Kroenke, & Williams, 1999) and GAD-7 (Spitzer, Kroenke, Williams, & Lowe, 2006)

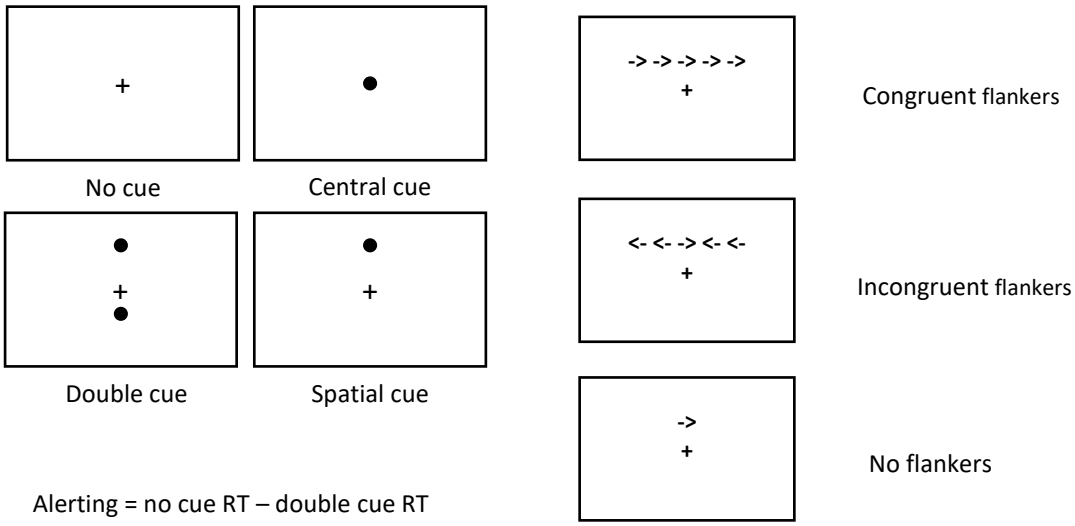
The PHQ-9 and GAD-7 are brief questionnaires that assess the presence of symptoms of depression and generalised anxiety disorder over the preceding 2 weeks. These scales have good reliability and validity, and are frequently used as screening tools in both clinical and research settings (Kroenke, Spitzer, & Williams, 2001; Spitzer et al., 2006). In both cases, each item is rated on a 4-point scale from 0 (not at all) to 3 (nearly every day). All items are added to give a total score; the possible range of scores is therefore 0-27 for the PHQ-9 and 0-21 for the GAD-7.

Attentional Network Task (ANT) (Fan et al., 2002)

The ANT is designed to assess 3 aspects of attentional performance – alerting, orienting and conflict resolution (executive attention). On each trial, participants are asked to indicate the

direction of a central arrow, which appears in one of two positions. On some trials the arrow appears with either congruent or incongruent flankers. Target displays are preceded by a cue display with one of 4 configurations: no cues, central cue, double cue, or spatial cue (see Figure 2.1).

Figure 2.1. Attentional Network Task displays and index calculations.



The task was presented on a laptop, using Inquisit presentation software. Participants completed a practice block (28 trials) during which they received feedback, followed by two experimental blocks of 96 trials. Mean reaction times for all trials with a correct response were used to calculate the attention indices, as shown in Figure 2.1. Lower values for alerting and orienting indicate poorer performance whereas for conflict, higher values indicate poorer conflict resolution. In common with previous studies using the ANT (e.g. Fan et al, 2002; Fan et al, 2005), responses occurring outside the 1700msec response window were excluded by the presentation program, but no further outliers were excluded from the analysis.

Procedure

Participants attended for a single session of testing and gave written consent to participation. The rationale given to participants was that the study was designed to examine whether rumination affects how people respond to infant cues. Participants received either a small financial payment to compensate them for their time, or alternatively received credits as part of a university research participation scheme. All research appointments took part in a quiet laboratory in the University department. Demographic data and questionnaire measures were completed, followed by the ANT[9].

Statistical analysis

Analysis was conducted using SPSS version 22.0. Distribution of the data was checked for normality and outliers >3 standard deviations from the mean were removed. This resulted in removal of a small percentage of ANT index scores (0.01%). Pearson's correlations were used to examine relationships between questionnaire measures and ANT performance indices. Hierarchical linear regressions were used to examine potential correlates of depression, generalised anxiety and brooding. As differential relationships have previously been shown for depression and anxiety with AC (Judah et al., 2014; Reinholdt-Dunne et al., 2013; Ólafsson et al., 2011), each model included other affective symptoms at Step 1, followed by ACS subscales at Step 2. For example, to examine correlates of depression, generalised anxiety was entered at Step 1, and both ACS subscales entered at Step 2.

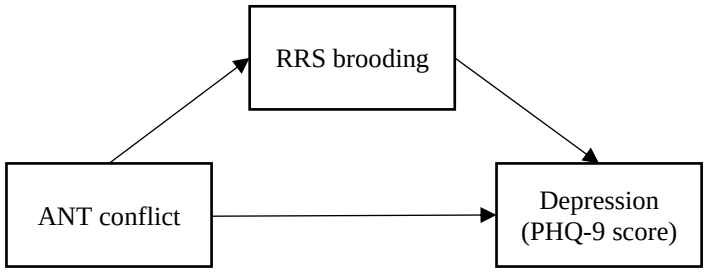
Mediation analyses were conducted using the PROCESS macro for SPSS (A. F. Hayes, 2013) (processmacro.org). This method assesses both the direct and indirect paths between the

[9] Following these tasks, participants completed a rumination induction and several other measures, which are reported in Chapter 5.

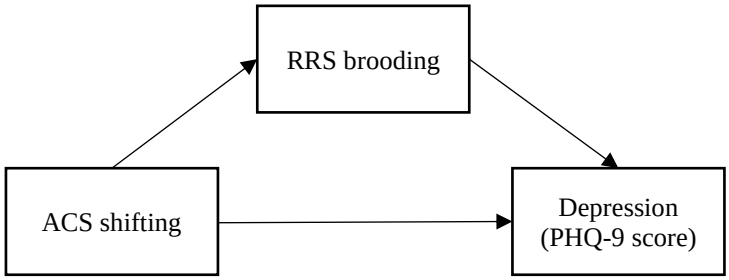
independent variable and the dependent variable. In this case, the direct path in each model involved the effects of AC on depression, while the indirect path tested concerned the effects of AC on depression through the hypothesised mediating variable (brooding). The analyses focused specifically on brooding, as this is the aspect of rumination theorised to be most strongly predictive of depression. Analyses were conducted with 10,000 bootstrap samples, and bias-corrected bootstrap confidence intervals are reported for all indirect effects. Completely standardised effects are also reported for all indirect effects, as an indicator of effect size. Three models were tested, each including one of the AC variables of interest (ACS attentional shifting, ACS attentional focusing, ANT conflict index) as the independent variable, depression score as the dependent variable, and brooding as the hypothesised mediator (see *Figure 2.2)*

Figure 2.2. Models examined in the mediation analyses

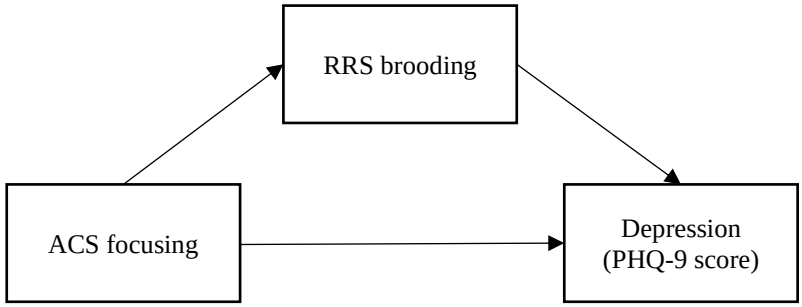
a)



b)



c)



ANT=Attention Network Task, ACS=Attentional Control Scale, RRS=Ruminative Responses Scale, PHQ-9=Patient Health Questionnaire.

Results

Participant Characteristics

The sample was composed of 80 participants (27; 33.8% male), with a mean age of 22.82 years (SD=4.10, range 18-34 years). The ethnicity of the sample was predominantly white (N=57, 71.3%), and most participants were university students (N=58, 72.5%).

Descriptive Statistics

Descriptive statistics for questionnaire scores and ANT performance are shown in Table 2.1. Although there are no established population norms for the ANT, these values appear to be broadly similar to previous studies in undergraduate samples (Reinholdt-Dunne et al., 2013).

Correlation of attention measures with depression, anxiety and rumination

Depression, anxiety and rumination were negatively correlated with self-reported AC, such that higher levels of depression, generalised anxiety symptoms and rumination were associated with poorer reported AC (see Table 2.2). This was true for both subscales of the ACS (focusing, shifting) and for the total score.

Table 2.1. Descriptive statistics for questionnaire measures and Attention Network Task (ANT) performance.

Measure	*Mean (SD)*	*95% CI*
PHQ-9 score	10.28 (5.55)	9.06, 11.50
GAD-7 score	9.49 (4.46)	8.51, 10.47
RRS Total	48.54 (10.98)	46.13, 50.95
RRS Brooding	11.14 (3.21)	10.44, 11.84
RRS Reflective Pondering	10.81 (3.36)	10.07, 11.55
ACS Total	49.00 (8.73)	47.09, 50.91
ACS Focusing	21.35 (4.59)	20.34, 22.36
ACS Shifting	27.65 (5.34)	26.48, 28.82
	Mean RT, msec (SD)	*95% CI*
ANT: No cue trials	553.16 (79.37)	535.77, 570.55
Centre cue trials	508.07 (65.11)	493.80, 522.34
Double cue trials	501.17 (61.93)	487.60, 514.74
Spatial cue trials	484.70 (67.12)	469.99, 499.41
Congruent flanker trials	490.85 (69.74)	475.57, 506.13
Incongruent flanker trials	573.74 (75.20)	557.26, 590.22
No flanker trials	474.50 (71.94)	458.49, 490.50
Alerting	50.36 (29.84)	43.82, 56.90
Orienting	23.46 (20.08)	19.06, 27.86
Conflict	84.55 (31.74)	77.59, 91.51

PHQ-9= Patient Health Questionnaire, GAD-7=Generalised Anxiety Disorder scale, RRS = Ruminative Responses Scale, ACS = Atttentional Control Scale, ANT=Attention Network Task.

Table 2.2. Correlations between depression, anxiety, rumination and attention measures

	ACS Total		ACS Focus		ACS Shift		ANT Alerting		ANT Orienting		ANT Conflict	
	r (p)	95% CI	*r (p)*	*95% CI*	*r (p)*	*95% CI*	*r (p)*	*95% CI*	*r (p)*	*95% CI*	*r (p)*	*95% CI*
PHQ-9	-.47 (<.001)**	-.63, -.28	-.26 (.022)*	-.45, -.04	-.54 (<.001)**	-.68, -.36	-.08 (.477)	-.30, .14	.09 (.438)	-.13, .30	-.28 (.014)*	-.47, -.06
GAD-7	-.42 (<.001)**	-.59, -.22	-.31 (.006)**	-.50, -.10	-.42 (<.001)**	-.59, -.22	-.07 (.568)	-.29, .15	.06 (.622)	-.16, .28	-.25 (.027)*	-.45, -.03
RRS Total	-.49 (<.001)**	-.64, -.30	-.35 (.002)**	-.53, -.14	-.49 (<.001)**	-.64, -.30	-.05 (.665)	-.27, .17	-.11 (.320)	-.32, .11	-.18 (.119)	-.39, .04
RRS Brooding	-.45 (<.001)**	-.61, -.26	-.38 (.001)**	-.55, -.18	-.40 (<.001)**	-.57, -.20	-.02 (.842)	-.24, .20	-.03 (.829)	-.25, .19	-.29 (.011)*	-.48, -.08
RRS Reflective Pondering	-.30 (.007)**	-.49, -.09	-.25 (.028)*	-.45, -.03	-.28 (.013)*	-.47, -.06	-.02 (.879)	-.24, .20	-.32 (.005)*	-.50, -.11	.01 (.932)	-.28, .29

ACS = Attentional Control Scale, ANT = Attention Network Task, PHQ-9= Patient Health Questionnaire, GAD-7=Generalised Anxiety Disorder scale, RRS = Ruminative Responses Scale.

Depression, generalised anxiety and rumination were uncorrelated with the alerting index of the ANT. Only reflective pondering was correlated with orienting, such that higher reflective pondering was associated with poorer orienting. Depression, generalised anxiety and brooding were all negatively correlated with the ANT conflict index. This indicates that higher depression, generalised anxiety and brooding were associated with *better* conflict performance, i.e. reaction times were less affected by the presence of incongruent flankers (see Table 2.2).

The reaction time difference between congruent trials and no flanker trials was also examined, to determine whether the presence of flankers was associated with a facilitation effect and whether any such effect would correlate with depression, anxiety or brooding. Reaction times were in fact slightly slower on congruent flanker trials, compared to no flanker trials [t=2.73, p=.008; see Table 2.1 for descriptive statistics]. The difference in reaction times between congruent and no flanker trials was not significantly correlated with depression [r=-.04, p=.724], anxiety [r=-.17, p=.132] or brooding [r=-.07, p=.550].

To test the possibility that the relationships between questionnaire measures and the ANT conflict index resulted simply from differences in overall reaction times, correlations between RT's for congruent, incongruent and no flanker trials on the ANT and depression, anxiety and brooding were examined. All these relationships were non-significant (all p's >.05). Performance metrics were also examined; accuracy was high [M=123.6 of 128 trials correct, SD=4.3, i.e. 95.6% accuracy] and response accuracy was not correlated with RT for any trial type. Neither was accuracy correlated with depression or generalised anxiety symptoms, or with rumination scores (all p's>.05). Thus, it does not appear that effects were driven by trade-offs between speed and accuracy.

Correlations between self-report and performance measures of attention

There were no significant correlations between self-reported AC, as measured by the ACS, and any of the ANT performance indices (see Table 2.3).

Table 2.3. Correlations between ACS scores and ANT performance

	ANT Alerting		ANT Orienting		ANT Conflict	
	r (p)	*95% CI*	*r (p)*	*95% CI*	*r (p)*	*95% CI*
ACS Total	.17 (.150)	-.05, .38	.13 (.280)	-.09, .34	.14 (.222)	-.08, .35
ACS Focus	.15 (.189)	-.07, .36	.07 (.526)	-.15, .29	.14 (.225)	-.08, .35
ACS Shift	.14 (.222)	-.08, .35	.12 (.318)	-.10, .33	.20 (.080)	-.02, .40

ACS = Attentional Control Scale, ANT = Attention Network Task.

Associations of attentional control with depression and anxiety

In order to examine correlates of depression (PHQ-9 scores), a linear regression model was tested with anxiety (GAD-7 score) entered in the first step, and ACS focusing and shifting entered in the second step. At Step 1, anxiety was positively associated with depression, accounting for 51.5% of the variance in depression. Adding focusing and shifting at Step 2 significantly improved the model, explaining an additional 8% of the variance. At this stage, both anxiety [β=.61, t=7.42, p<.001] and poorer shifting [β=-.35, t=-3.82, p<.001] were associated with depression. Focusing was not significantly correlated with depression [β=.12, t=1.32, p=.193] (see Table 2.4).

In order to examine correlates of generalised anxiety symptoms (GAD-7 scores), a model was tested with depression (PHQ-9 score) entered in the first step, and ACS focusing and shifting entered in the second step. This model indicated that at Step 1, depression was significantly correlated with anxiety [β=.72, t=9.05, p<.001], explaining 51.5% of the variance in generalised

anxiety. Adding the ACS subscales at Step 2 did not improve the model fit [$\triangle R^2$=.02, F(2, 75)=1.34, p=.269] (see Table 2.5).[10]

Associations of attentional control with brooding (see Table 2.6)

In order to examine correlates of brooding, a linear regression model was tested with depression and anxiety scores entered in the first step, and ACS focusing and shifting entered in the second step. At Step 1, depression [β=.32, t=2.77, p=.007] and anxiety [β=.46, t=4.04, p<.001] were both significantly associated with brooding, together explaining 52.1% of the variance. Adding the ACS scores at Step 2 did not significantly improve the model fit [$\triangle R^2$=.03, F(2, 74)=2.21, p=.117].[11]

Table 2.4. Regression analysis: correlates of depression (PHQ-9 scores)

	B	SE B	β	*t*	*p*	*95% CI for B*
Step 1. $\triangle R^2 = .515$						
GAD-7 score	.902	.100	.718	9.049	<.001**	.70, 1.10
				F(1, 77) = 81.881, p<.001, R^2 = .515, adj. R^2 = .509		
Step 2. $\triangle R^2$ = .080, $\triangle$ F(2,75)=7.452, p=.001						
GAD-7 score	.760	.102	.605	7.418	<.001**	.56, .96
ACS focusing	.138	.105	.115	1.315	.193	-.07, .35
ACS shifting	-.359	.094	-.350	-3.824	<.001 **	-.55, -.17
				F(3, 75) = 36.835, p<.001, R^2 = .596, adj. R^2 = .580		

GAD-7=Generalised Anxiety Disorder scale, ACS = Attentional Control Scale.

[10] Controlling for age and sex of participants did not alter the findings for either of these models; the uncorrected models are reported here.

[11] Controlling for age and sex of participants did not alter these findings; the uncorrected model is reported here.

Table 2.5. Regression analysis: correlates of anxiety (GAD-7 scores)

	B	SE B	β	*t*	*p*	*95% CI for B*
Step 1. △ R^2 = .515						
PHQ-9 score	.571	.063	.718	9.049	<.001**	.45, .70
					F(1, 77) = 81.88, p<.001, R^2 = .515, adj. R^2 = .509	
Step 2. △ R^2 = .017, △F(2, 75) = 1.336, p=.269						
PHQ-9 score	.557	.075	.700	7.418	<.001**	.41, .71
ACS focusing	-.139	.089	-.146	-1.561	.123	-.32, .04
ACS shifting	.029	.088	.036	.333	.740	-.15, .20
					F(3, 75) = 28.422, p<.001, R^2 = .532, adj. R^2 = .513	

PHQ-9 = Patient Health Questionnaire, ACS = Attentional Control Scale.

Table 2.6. Regression analysis: correlates of brooding

	B	SE B	β	*t*	*p*	*95% CI for B*
Step 1. △ R^2 = .521						
GAD-7 score	.336	.083	.461	4.043	<.001**	.17, .50
PHQ-9 score	.183	.066	.315	2.765	.007**	.05, .32
					F(2, 76) = 41.313, p<.001, R^2 = .521, adj. R^2 = .508	
Step 2. △ R^2 = .027, △ F(2, 74) = 2.207, p=.117						
GAD-7 score	.304	.083	.417	3.646	<.001**	.14, .47
PHQ-9 score	.188	.071	.324	2.635	.010**	.05, .33
ACS focusing	-.131	.065	-.189	-2.009	.048*	-.26, -.001
ACS shifting	.027	.063	.046	.433	.667	-.10, .15
					F(4, 74) = 22.416, p<.001, R^2 = .548, adj. R^2 = .523	

PHQ-9 = Patient Health Questionnaire, ACS = Attentional Control Scale.

Mediation analyses

A series of mediation analyses were conducted to examine the potential mediating effect of brooding in the relationships between the attentional measures and depressive symptoms. Firstly, the effect of attentional conflict performance (ANT conflict index) on depression was examined, using single-step mediation with brooding as the potential mediator (*Figure 2.2a).* There was no significant direct effect of conflict performance on depression (B = -.02, t(77)=-1.11, p=.272, 95%CI [-.05, .01]). However, there was a significant indirect effect via brooding (B = -.03, 95% CI [-.05, -.01]). The completely standardized indirect effect was B = -.18 (95%CI [-.29, -.05]); that is, for every 1 SD change in the ANT conflict index, there was a -0.18 SD change in depression score via the indirect pathway.

Secondly, the effect of attentional shifting on depression was tested, with brooding entered as the potential mediator (*Figure 2.2b*). There was a significant direct effect of attentional shifting on depression (B = -.34, t(78)=-3.79, p<.001, 95%CI [-.52, -.16]). The indirect path was also significant, i.e. brooding rumination significantly mediated the relationship between attentional shifting and depression (B = -.22, 95% CI [-.36, -.11]). The completely standardized indirect effect was B = -.21 (95%CI [-.33, -.11]).

Finally, the effect of attentional focusing on depression was examined, with brooding as a potential mediator (Figure 2.2c). There was no significant direct effect of attentional focusing on depression (B = -.02, t(77)=-.18, p=.856, 95%CI [-.25, 21]). There was however a significant indirect effect via brooding (B = -.29, 95% CI [-.46, -.13]). The completely standardized indirect effect was B = -.24 (95%CI [-.38, -.11]).[12]

[12] All indirect effects remained significant when age, gender and generalised anxiety symptoms were added to the mediation models as covariates. The uncorrected models are reported here.

Discussion

This study examined several questions regarding the relationships between attentional performance, self-reported AC, depression, anxiety and rumination.

Self-reported attention, depression and rumination

The results indicate that depression, generalised anxiety and rumination are associated with impairments in both the shifting and focusing components of self-reported AC. Regression analyses indicated that, after controlling for generalised anxiety, depression was specifically associated with impairments on the shifting subscale of the ACS. This is consistent with previous findings indicating a specific relationship between depression and this component of AC (Judah et al., 2014; Reinholdt-Dunne et al., 2013; Ólafsson et al., 2011). ACS scores did not correlate with generalised anxiety after controlling for depression. Similarly, ACS scores were not significantly associated with brooding after controlling for depression and anxiety. However, the relationships between self-reported AC and depression were mediated by brooding, which is consistent with the hypothesis that AC difficulties confer risk for depression because they increase use of rumination as an emotional regulation strategy. This increase in rumination, in turn, increases risk for depression (Joormann & D'Avanzato, 2010).

Attentional performance, depression and rumination

Against predictions, depression, anxiety and rumination were associated with better conflict performance on the ANT, i.e. at higher levels of psychopathology performance was *less* affected by the presence of incongruent flankers. A mediation analysis confirmed an indirect association between ANT conflict performance and depression, mediated by brooding.

The finding that *enhanced* conflict performance is associated with depression, anxiety and rumination is contrary to the initial study hypotheses. However, it is consistent with several previous studies indicating that participants with high depression and rumination can demonstrate preserved or even enhanced ability to inhibit or ignore distracting information (Joormann et al., 2010; Krompinger & Simons, 2011; Meiran et al., 2011; Zetsche et al., 2012). As outlined in the introduction to this chapter, one prominent theoretical model has sought to explain these findings, proposing that rumination is associated with a *narrowed* focus of attention (Whitmer & Gotlib, 2013). This has advantages for particular tasks, for example avoiding distraction by irrelevant stimuli, but also confers disadvantages where performance requires attentional flexibility or a broadly distributed focus of attention. It is proposed that a narrowed focus of attention may predispose people to rumination, as it facilitates a narrow and persistent focus on negative thoughts. Habitual rumination is then hypothesised to confer risk for developing depressive symptoms. The results of the mediation analysis reported here are consistent with this model, with the association between ANT conflict performance and depression being mediated by brooding.

The difference in reaction times between congruent and no flanker trials was also calculated and correlated with depression, anxiety and brooding. If these symptoms are indeed associated with narrowed attention, it could be hypothesised that they would be associated with smaller differences between congruent and no flanker trials (i.e. less influence by the presence of flankers). Overall, participants showed a statistically significant increase in reaction times when flankers were present, compared to when the target was presented alone. However, there was no association between this reaction time difference and depression, anxiety or brooding. This result does not then confirm the hypothesis that a narrowed focus of attention, resulting in less influence from flankers, might account for the relationships between ANT conflict performance and depression, anxiety and brooding. However, in common with validation studies of the ANT

(Fan et al., 2002), participants in general did not seem to be strongly influenced by the presence of congruent flankers, with very small reaction time differences between congruent and no flanker trials. Thus, this index may not be a good measure of attentional breadth, and further studies are required to test the hypothesis that the current results could be attributable to attentional narrowing. Specific behavioural measures of attentional scope are available (Bosmans, Braet, Koster, & De Raedt, 2009) and could facilitate testing this hypothesis in future empirical studies.

Relationships between self-report and performance measures

In this study, self-reported AC and ANT performance were not correlated with one another. This suggests that these measures assess somewhat different constructs. The ANT is a highly controlled test, with simple stimuli, whilst the ACS enquires about performance in complex, everyday situations, which may have rather different attentional demands. In addition, while the ANT assesses several components of attention, it is not considered to be a comprehensive assessment of all aspects of attention performance. The lack of correlation between these measures could also suggest that participants are relatively poor at evaluating their own attention performance, or are influenced by factors other than performance, e.g. personality, mood (Buchanan, 2016; Meltzer et al., 2016; Williams et al., 2017). These findings suggest that self-report and performance measures of attention contribute different information, and there may be benefits to including both types of measure in studies of this kind. The possible reasons for a lack of correspondence between these measures could also be usefully explored in future research, for example by examining additional performance measures, or by manipulating variables that may affect self-assessment of performance.

Strengths, limitations and future directions

Whilst previous work has linked AC to affective disorder and to emotional regulation strategies, few studies have examined the three-way interactions between these constructs. This study therefore helps to extend previous work in this area, and to establish a model for how these variables may be related. The mediation models presented are consistent with previous studies in this area (Demeyer et al., 2012; Hsu et al., 2015; Kertz et al., 2017), and extend earlier work by including both performance and self-reported measures of attention.

There are several limitations of the current study that should be recognised. The sample was primarily composed of university students and, although mean levels of generalised anxiety and depression were in the 'moderate' range (Spitzer et al., 1999; Spitzer et al., 2006), it was a non-clinical sample. It is unclear therefore how these findings would generalise to other populations, including clinical groups. All measures were taken concurrently, and therefore it was not possible to examine causal relationships between variables, or to be confident about the directionality of effects. For theoretical reasons, effects were examined in one direction (i.e. deficits in AC as vulnerability factors for rumination and subsequent depression). However, it is possible that these relationships are in fact bidirectional or mutually reinforcing (Roberts et al., 2016). The use of longitudinal and experimental designs in future studies may help to better elucidate these relationships.

In addition, as state rumination was not manipulated or measured, it was not possible to examine interactions between state and trait effects. Whilst the effects of anxiety were considered (using the GAD-7), there was no specific measure of worry (e.g. Penn State Worry Questionnaire (Meyer, Miller, Metzger, & Borkovec, 1990)) included in the current study. It is unclear then whether these findings are specific to rumination, or whether they apply more broadly to other

forms of RNT. Similarly, other types of emotional regulation (e.g. distraction, reappraisal) were not examined in this study. It is of interest that rumination was associated with enhanced ability to ignore incongruent flankers, which I have argued may reflect a narrowed and inflexible focus of attention. This AC profile could be similarly associated with use of other emotional regulation strategies, for example difficulties using distraction and reappraisal, which require flexible shifting of attention.

Clinical implications

These findings are consistent with a model in which specific AC deficits predispose individuals to developing maladaptive emotional regulation styles and, via these effects, increase risk of affective disorder. AC deficits may then be a useful marker of vulnerability to affective disorder and a potential target for preventative interventions. In addition, there is some evidence that current treatments do not adequately ameliorate either the AC deficits or high levels of rumination associated with depression, which may increase risk of recurrence (E. H. W. Koster et al., 2017). Addressing AC deficits may therefore provide a valuable adjunct to existing treatments. One approach to targeting AC is via cognitive training procedures, such as working memory training. A number of studies have now demonstrated benefits of such interventions, including reductions in rumination and depressed mood, although findings of transfer are mixed (E. H. W. Koster et al., 2017; Mor & Daches, 2015). These interventions then require refinement and optimisation but have significant potential for benefit, both for reducing vulnerability in high risk populations and for increasing treatment efficacy. Cognitive training paradigms also provide a robust means of testing hypothesised causal mechanisms, in order to better establish the factors that are implicated in the aetiology and maintenance of depressive symptoms. The use of cognitive training to target rumination will be explored further in Chapter 6.

Conclusions

Both depression and rumination were associated with impairments in self-reported AC. Depression was specifically associated with poorer attentional shifting. Depression and brooding were also associated with *better* performance on the conflict component of the ANT, perhaps indicating an association with a narrowed focus of attention. Importantly, the relationships of ANT conflict and self-reported AC to depression were mediated by brooding. These findings are consistent with models that suggest AC deficits are associated with increased use of maladaptive emotional regulation strategies, including rumination, which in turn increases vulnerability to depression.

Chapter 3. Attentional control, rumination and recurrence of depression

This study expands on the themes introduced in Chapter 2. However, rather than examining the relation of cognitive control (CC) and rumination to current symptoms, the focus is on their relation to depressive recurrence. This study also makes use of a clinical sample and longitudinal study design, allowing an examination of whether CC and rumination are prospectively associated with time to recurrence. The data used here are drawn from the DELTA study (Mocking et al., 2016), a large cohort study designed to examine various potential predictors of recurrence within a high-risk group of patients – that is, patients remitted from at least two previous episodes of Major Depressive Disorder.

Depression and recurrence

Of all psychiatric disorders, Major Depressive Disorder (MDD) is ranked as the single largest contributor to global disability (World Health Organisation, 2017). A major factor that adds to the large burden of MDD, is the high risk of recurrence after remission from a depressive episode. Although estimates vary between studies, MDD recurrence rates are typically reported to be at least 50% (Eaton et al., 2008; Hardeveld et al., 2013; Steinert et al., 2014), with rates as high as 90% in clinical samples with three or more previous episodes (Beshai, Dobson, Bockting, & Quigley, 2011; Bockting et al., 2015). Clinical characteristics such as the number of previous episodes and residual symptoms have been identified as among the strongest predictors of recurrence (Hardeveld, Spijker, De Graaf, Nolen, & Beekman, 2010; Kessing, Hansen, Andersen, & Angst, 2004).

Whether cognitive and psychological processes associated with MDD (e.g. habitual maladaptive thinking patterns, deficits or biases in cognitive processing), predict the long-term course of MDD is less well established. In the current study, I consider the potential role of two key factors in predicting depressive recurrence: rumination and deficits in CC. Examining the role of CC deficits and rumination in depression is theoretically important in understanding vulnerability to onset and recurrence of this disorder. These models also have potential clinical utility, as both CC deficits and rumination have been identified as possible targets for treatment and/or preventative interventions (E. H. W. Koster et al., 2017; Martell et al., 2013; Mor & Daches, 2015; Topper et al., 2017; Topper et al., 2010; E. Watkins et al., 2007).

The role of rumination

High levels of rumination have been consistently shown to predict the onset, severity and maintenance of depressive episodes (Nolen-Hoeksema et al., 2008; E. R. Watkins, 2008), and residual rumination following treatment is considered a risk factor for recurrence of depression (E. R. Watkins, 2009). A small number of studies have specifically examined a possible role for rumination in predicting depressive recurrence. Michalak, Hölz and Teismann (2011) found that higher levels of rumination predicted shorter time to recurrence within 12 months of completing a mindfulness based treatment. In a large cohort study, scores on a cognitive reactivity measure (Leiden Index of Depression Sensitivity; LEIDS (Van der Does, 2002, 2005)), including the rumination subscale, were associated with time to recurrence of depression (Figueroa et al., 2015). In contrast, Timm et al. (2017) did not show a relationship between trait rumination and time to recurrence, but did find that rumination predicted levels of residual symptoms at 6 and 30 months after treatment. Instability in levels of momentary daily rumination (i.e. high amplitudes and high frequency of changes in rumination over time) also predicted a shorter time to recurrence.

The role of cognitive control deficits

As outlined in the previous chapters, CC refers to a broad set of cognitive processes that facilitate flexible responding, in line with current goals. Attentional control is a closely related construct, with the ability to direct and focus attention serving to facilitate and support CC (Mackie et al., 2013). Several theoretical models have proposed that CC deficits increase vulnerability to rumination and similar processes, such as worry, by reducing the degree to which individuals are able to exert control over these thought processes and impairing use of other emotional regulation strategies, such as reappraisal or distraction (C. R. Hirsch & Mathews, 2012; E. H. W. Koster et al., 2011; Mor & Daches, 2015; E. R. Watkins & Nolen-Hoeksema, 2014). Many empirical studies indicate that rumination is closely associated with deficits in CC, particularly impairments in attentional inhibition and attentional shifting (E. De Lissnyder et al., 2011; Mor & Daches, 2015; Vanderhasselt et al., 2011; Whitmer & Banich, 2007). Similarly, many studies utilising both self-report and performance measures indicate that CC impairments are present both in clinically depressed and vulnerable groups (E. H. W. Koster et al., 2017; Snyder, 2013). CC impairments are thus considered a key vulnerability underlying both depression and rumination, although there is a lack of clear evidence as to whether depression and rumination are associated with general deficits in CC, or with deficits that are mainly apparent when processing (negative) emotional stimuli (E. H. W. Koster et al., 2017; Mor & Daches, 2015).

It has been suggested that deficits in CC are proximally related to greater use of maladaptive emotional regulation strategies, including rumination, which then increase risk for depression (De Raedt & Koster, 2010; Joormann & Gotlib, 2010; Joormann & Vanderlind, 2014; E. H. W. Koster et al., 2011). As outlined in Chapter 2, a small number of studies have now demonstrated a mediating role for rumination or other forms of repetitive negative thinking (RNT) in the relationship between attentional control and depressive symptoms (Demeyer et al., 2012; Hsu et

al., 2015; Kertz et al., 2017). However, possible relationships between attentional control deficits, rumination and depressive *recurrence* have been less well examined. Many existing studies are also limited by reliance on self-report measures of CC and use of cross-sectional designs.

Study design and measures

In the current study, predictors of recurrence were examined in a group of patients remitted from at least two previous episodes of MDD. Two CC tasks were examined: firstly, a version of the exogenous cueing task (ECT), and secondly the Internal Shift Task (IST).

The ECT was developed by Fox and colleagues (Fox, Russo, Bowles, & Dutton, 2001), as an adaptation of an earlier paradigm (Posner, Inhoff, Friedrich, & Cohen, 1987). The task was designed to address limitations of tasks previously used to assess attentional biases in the context of affective disorder. In particular, the ECT allows researchers to disentangle attentional engagement effects from attentional *dis*engagement. This development was driven by the hypothesis that, rather than being associated with attentional capture by threat cues, anxiety may in fact be associated with maintained attention to threatening information and difficulties disengaging attention from such stimuli (Fox et al., 2001). The ECT was further developed by Koster and colleagues, who applied this task to understanding attentional effects in the context of depression (E. H. Koster, De Raedt, Goeleven, Franck, & Crombez, 2005). In two studies, these authors demonstrated that dysphoric participants showed maintained attention for negative words, likely due to difficulties with attentional disengagement. In contrast, control participants maintained attention more strongly towards positive words. Similarly, another study from this group showed maintained attention for negative words in dysphoric participants, which was most pronounced for those participants with moderate to severe (rather than mild) depressive symptoms (Baert, De Raedt, & Koster, 2010). Other studies using alternative versions this task

demonstrate that clinically depressed participants show stronger attentional engagement with, and slower disengagement from, angry faces compared to healthy controls (Leyman, De Raedt, Schacht, & Koster, 2007). Effects are typically evident at longer presentation durations, consistent with the suggestion that depression is related to biases at later, more elaborative stages of information processing. However, not all studies using the ECT have shown significant differences related to depressive symptoms. For example, one study in healthy participants demonstrated no associations between ECT task performance using facial stimuli and symptoms of depression, anxiety or stress (Ernst H. W. Koster, Leyman, De Raedt, & Crombez, 2006). There has been a lack of previous research using this task in remitted depressed groups.

The IST was developed as a measure of cognitive control, as exerted over internally-represented information, i.e. stimuli held in working memory (E. De Lissnyder, Koster, & De Raedt, 2012). It has been suggested that depression might specifically be associated with difficulties with *internal* cognitive control, as such difficulties are hypothesized to contribute to impairments in regulating negative affect, including habitual engagement in rumination (Joormann & D'Avanzato, 2010; E. H. W. Koster, De Lissnyder, & De Raedt, 2013). Thus, a measure that requires participants to exert cognitive control over internally-represented information is of particular interest when considering relations between cognitive control, depression and rumination. Previous work using the IST has demonstrated that patients with MDD show general impairments in attentional shifting across emotional and neutral conditions, and levels of rumination are associated with the degree of shifting impairment (E. De Lissnyder, E. H. W. Koster, et al., 2012). In adolescents, there is evidence that dysphoria is associated with specific difficulties with shifting under emotional conditions, particularly when shifting from negative to neutral information (Wante, Mueller, Demeyer, Naets, & Braet, 2017). High ruminators also display attentional shifting impairments in the emotional condition, particularly when shifting away from negative information; the brooding component of rumination is particularly strongly associated with this shifting impairment (E. H.

W. Koster et al., 2013). Larger shift costs on the IST have similarly been associated with increased rumination in response to future stress in healthy controls (E. De Lissnyder, E. H. Koster, et al., 2012). In one longitudinal study, shifting impairments were associated with later depressive symptoms and this effect was mediated by rumination (Demeyer et al., 2012). There is then consistent evidence that depressive symptoms and rumination are associated with impaired shifting on the IST. This is particularly true of the emotional condition, although in clinical groups there is evidence of a more general impairment across both emotional and non-emotional trials (E. De Lissnyder, E. H. W. Koster, et al., 2012). However, there are few existing studies in clinical groups and, as with the ECT, there has been a lack of previous research in remitted patients.

The combination of these two tasks in the current study thus provides an index of CC processes, particularly attentional disengagement and shifting. These processes are assessed as applied to both internally and externally represented stimuli, and under both neutral and emotional conditions.

Aims and hypotheses

The aim of the current study was to examine performance on two CC tasks (ECT, IST) in a remitted patient group, and to consider how CC performance is related to both rumination and time to depressive recurrence. It was hypothesised that CC would be poorer in the remitted patient group compared to controls. Within the remitted patient group, it was hypothesised that higher rumination would be associated with difficulties in disengaging and shifting attention, particularly when processing negatively-valenced emotional stimuli. It was also hypothesised that both high rumination and CC deficits would be associated with shorter time to recurrence of depression, with rumination mediating the relationship between CC performance and recurrence.

Method

Participants

Participants were recruited from across the Netherlands, via general practitioners, adverts, patient organizations, and other research projects, in the context of the DELTA cohort study (Mocking et al., 2016). The study was approved by a local research ethics committee (University of Amsterdam; reference AMC-METC-Nr.:11/050) and written informed consent was obtained from all participants. Remitted depressed (rMDD) patients had experienced ≥2 major depressive episodes and were in stable remission for at least 8 weeks, based on the Structured Clinical Interview for DSM-IV Axis I Disorders Patient Edition (SCID-I/P) and a Hamilton Depression Rating Scale (HDRS) score ≤7. Patients were not currently taking any psychotropic medication. Only controls without personal or first-degree familial psychiatric history were included. Exclusion criteria were as follows: alcohol/drug dependency; psychotic/bipolar disorder; primary anxiety disorder; personality disorder; electroconvulsive therapy within 2 months of recruitment to the study; history of severe head injury; neurological disease; severe physical illness; lack of Dutch language proficiency.

Study design and procedure

At the baseline visit, the neuropsychological tests were conducted in two blocks with a break in between, in the context of a larger study. After this baseline visit, all participants received a booklet including the Ruminative Response Scale (RRS – see Measures, page 97) to complete before the second visit, which was an MRI session. Mean time from baseline visit to the second visit was 39.8 days [SD=24.1]. To prospectively assess recurrence, follow up assessments of the rMDD participants were conducted every 4 months by phone. These assessments included administration of the SCID-I/P and HDRS. To maximize detection of recurrence, participants were

also instructed to contact the study team if they subjectively experienced a recurrence, and to inform a person close to them of these instructions. A protocol containing details of the full study has been published (Mocking et al., 2016).

Measures

Depression measures

Primary outcome was the occurrence of a major depressive episode, assessed using the SCID-I/P, in the 2.5-year follow-up period. Number of previous episodes was also assessed using the SCID-I/P. Severity of residual symptoms in the rMDD group and depressive symptoms in the control group were measured using the HDRS.

The SCID (First et al, 1996) is a structured diagnostic interview that is considered to be the gold standard for assessing DSM-IV defined disorders in psychiatric research. A number of psychometric studies have demonstrated good reliability and validity of this instrument (Lobbestael et al, 2011; Zanarini et al, 2000).

The HDRS (Hamilton, 1960) is a widely-used depression assessment scale. It is clinician-rated and composed of 17 items regarding symptoms of depression over the previous week. A meta-analysis of the psychometric properties of the HDRS indicates that it provides a reliable assessment of depression, with good levels of internal consistency, inter-rater reliability and test-retest reliability (Trajkovic et al, 2011). Scores between 0 and 7 are considered to be within the normal range.

Internal Shift Task (IST) *(E. De Lissnyder, E. H. Koster, et al., 2012; E. De Lissnyder, E. H. W. Koster, et al., 2012)*

The IST is a working memory task involving updating and shifting functions, executed on internally represented stimuli. The task includes two conditions: a gender and an emotion condition. These are completed sequentially, with order of conditions counterbalanced across participants. For each condition, participants completed 3 practice blocks and 12 experimental blocks, with a random number of 10 to 14 trials per block. Each trial consists of presentation of a single face in the centre of the screen. Participants were asked to keep a mental count of the number of faces seen across two categories. In the gender condition, this equates to the number of male and female faces. In the emotion condition, this is the number of neutral and angry faces. Angry faces are specifically used due to the salience of social threat and interpersonal evaluation in depression (E. De Lissnyder, E. H. W. Koster, et al., 2012). As each face is presented, participants are asked to press the space bar as quickly as possible when they have updated their internal counts. This provides a reaction time measure for each trial. The next stimulus is then presented, following an inter-stimulus interval of 200ms. At the end of each block, participants are asked to enter the number of faces seen from each category. This provides an accuracy measure for each block.

Blocks therefore contain both switch and non-switch trials, i.e. trials in which the category to be updated is different from or the same as the preceding trial. The design of the task thus allows examination of switching costs under both emotional and non-emotional conditions. Switch costs are calculated as the difference in reaction time between switch and no-switch trials and provide an index of the efficiency of shifting between representations in working memory.

The IST was programmed using E-prime 2.0 and displayed on a Windows 7 desktop with a 60Hz, 22-inch colour monitor. The face stimuli used were extracted from the Karolinska Directed

Emotional Faces picture set (Lundqvist, Flykt, & Ohman, 1998). The stimuli included 24 angry and 24 neutral faces, selected on the basis of a previous validation study (Goeleven, De Raedt, Leyman, & Verschuere, 2008). Images were presented at a consistent size (326 x 326 pixels) and adjusted to remove external features, such as hair.

Exogenous Cueing Task (ECT) *(E. H. W. Koster et al., 2006)*

This task is based on the exogenous cueing paradigm (Posner, 1980), and designed to investigate attentional effects when processing emotional stimuli. Emotional facial expressions of four different valences (angry, sad, happy, neutral) were used as cue stimuli. All face stimuli were extracted from the Karolinska Directed Emotional Faces picture set (Lundqvist et al., 1998) and adjusted to the same size (326 x 326 pixels). Sixteen pictures were selected from each emotional category. During the task, participants are asked to respond to the location of a visual target, presented to either the left or right of a central fixation point. This target is preceded by a visual cue, which can occur either in the same location as the target (valid cue) or in the opposite location (invalid cue). Several key indices can be calculated based on the reaction times for different cue types. Attentional engagement for each valence can be examined by comparing reaction times for validly cued emotional trials to validly cued neutral trials. Similarly, attentional disengagement for each valence can be calculated by comparing reaction times for invalidly cued emotional trials to invalidly cued neutral trials.

The ECT was programmed using E-prime 2.0 and presented as described for the IST. Participants completed 10 practice trials and 256 test trials. There were therefore 16 test trials of each type (2 presentation durations [200, 1000msec], 2 validity conditions [valid, invalid cue], 4 face valences [angry, sad, happy, neutral]). Order of trial types and location of the target were randomised across the task. Each trial began with two white frames, presented at either side of a fixation cross for 500msec. The cue stimulus was then presented in the location of one of these frames,

for either 200 or 1000msec, and followed by white mask presented for 50msec. The target (black square) then appeared in one of the frames and participants were asked to respond to its location as quickly as possible, by pressing the left or right arrow key on a standard keyboard. To minimise anticipatory responding, 12 'catch trials' were also included. These are trials in which a cue stimulus is presented but not followed by a target stimulus. On these trials participants were required to withhold making a response.

RRS-NL (Raes, 2012; Raes & Hermans, 2007; Raes, Hermans, & Eelen, 2003; Raes et al., 2009)

The Dutch adaptation of the original RRS is a self-report rumination measure, which consists of 22 items that describe possible responses to depressed mood (Nolen-Hoeksema & Morrow, 1991). Items are rated on a 4-point scale (from 1 almost never to 4 almost always; range 22-88) based on the extent to which respondents engage in these thoughts or actions when feeling sad, down or depressed. In a previous study, Cronbach's α for the total RRS-NL was .92 (Schoofs et al., 2010); in the current study, Cronbach's α was 0.96. The introductory statement was reframed so that, instead of asking participants what they generally do when depressed, the focus was on their responses in the past week.

Statistical analysis

Group differences

All analyses were conducted using SPSS version 22.0. In order to compare performance of patients and controls on each cognitive task, a mixed ANOVA was conducted. For the IST, this included condition (emotion, gender) and switch type (switch, no switch) as within subject factors, and group (remitted patients, controls) as a between subject factor. For the ECT, the mixed ANOVA included cue valence (angry, sad, happy, neutral), cue duration (short, long), and cue validity (valid, invalid) as within subject factors and group (remitted patients, controls) as a

between subject factor. Relationships between task performance and rumination were then examined in the remitted patient group only. Two participants with outlier scores (RRS total ≥70) were removed from these analyses. The remaining participants were classified as high or low ruminators using a median split (RRS total ≤35 and >35 respectively). A mixed ANOVA was conducted for each task, as described above, but with rumination group (high/low) as the between-subject factor.

Survival Analysis

Cox proportional hazard regression models were used, with time to first recurrence as the endpoint. Participants lost to follow-up or without relapse during follow-up were considered censored. Based on previous literature, specific indices of IST (overall shift costs, emotion shift cost) and ECT (engagement and disengagement for each duration and valence) task performance were selected as possible predictors of recurrence. Firstly, the associations of IST and ECT performance and rumination with recurrence were investigated with simple Cox regression models. Secondly, for variables that were associated with time to recurrence in the simple models, additional Cox regression models, adjusted for age, sex and established predictors of depressive recurrence (residual depressive symptoms at baseline, previous episodes of MDD) were conducted.

It was planned that mediation analysis would proceed only if assumptions for mediation were met in the simple and corrected Cox models. The possibility that rumination modified relationships between ECT/IST scores and recurrence was also examined, by adding a rumination interaction term to the Cox regression models. These models were tested both with and without adding established predictors of recurrence (residual symptoms, previous episodes).

Results

Participant characteristics

The full cohort included 73 rMDD patients and 45 controls. Of these, 69 rMDD patients and 43 controls participated in the neuropsychological test battery. Of the 69 rMDD patients, 64 (92.8%) had at least one follow-up measurement and 52 (75.4%) completed the planned 2.5 years of follow-up assessments.

The groups did not differ significantly on age, gender, IQ, education, or living situation (see Table 3.1). However, rMDD patients were significantly less likely to be employed and had significantly higher HDRS scores than controls. Total RRS scores were significantly higher in rMDD patients than controls[13].

[13] The data displayed in Table 3.1 includes all participants who participated in at least part of the neuropsychological test battery. However, the pattern of group differences did not change when restricting the sample to only those participants who completed each of the tasks examined here (IST and ECT).

Table 3.1 Remitted recurrent MDD patients versus controls at baseline

		rMDD (n = 69)	HC (n = 43)	χ^2	t	U	p
Female	N (%)	45 (65.8%)	30 (69.8%)	0.25			0.68
Age (yrs)	Mean (SD)	53.4 (7.7)	51.5 (8.2)		1.20		0.23
Education	Categories[a]	0/0/0/4/22/27/16	0/0/0/1/16/18/8	1.25			0.76
IQ	Mean (SD)	108.8 (8.2)	106.3 (9.6)		1.43		0.16
Living situation	Categories[b]	29/0/19/17/2/0/2	12/0/16/11/4/0/0	5.52			0.24
Employment status	Categories[c]	26/27/16/0	21/17/5/0	2.68			0.26
Currently employed	Yes (%)	46 (68.7)	37 (86.0)	4.28			0.04
Age of onset (yrs)	Mean (SD)	26.7 (10.8)	-				-
Episodes							
- last 10yrs	Median (IQR)	2 (1-2)	-				-
- lifetime		4 (2-7)	-				-
HDRS	Median (IQR)	2 (0-5)	1 (0-1)			2317	.001
RRS total	Mean (SD)	38.07 (12.21)	26.07 (4.44)		-6.09		<.001

HC=healthy control; HDRS=Hamilton Depression Rating Scale; rMDD=remitted major depressive disorder; RRS=Ruminative Response Scale.
[a] Level of educational attainment: primary school not finished/primary school finished/primary school + ≤2 years of lower level secondary school finished/lower level secondary school finished/medium level secondary school finished/high level secondary school finished/pre-university or university degree).
[b] Living situation: alone/living with parents/cohabiting/cohabiting with children/single living with children/other/unknown.
[c] Employment status: low/middle/high income/never worked.

Internal shift task performance

65 rMDD patients and 40 controls were included in the IST analyses[14]. A block was scored as correct if the reported number of faces was correct for both categories. Using this criterion, average accuracy was 73% (M=17.6 correct, SD=4.71). Accuracy did not differ by condition [t(104)=-.88, p=.281] or by group (remitted patients/controls) [t(103)=.212, p=.832]. As with previous reports using the IST (e.g. De Lissnyder et al, 2012; Demeyer et al, 2012; Koster et al,

[14] 6 rMDD patients and 2 controls patients did not complete the IST; data from a further 2 rMDD patients and 3 controls was excluded because the task stopped prematurely due to technical error.

2013), for all reaction time analyses, median scores for each trial type were used in order to reduce possible the influence of outliers in the within-subject data.

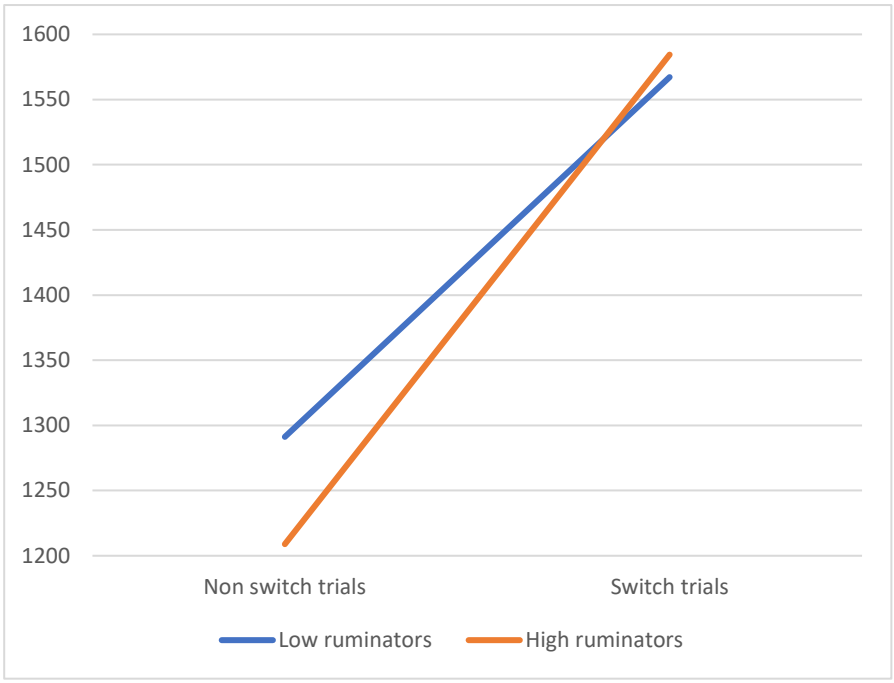
Comparison between remitted patients and controls

A mixed ANOVA showed a main effect of condition [F(1, 103)=4.48, p=.037], with faster responses for gender trials [M=1368.94, SD=428.09] than for emotion trials [M=1454.56, SD=433.98]. There was also a main effect of switch type [F(1, 103)=271.83, p<.001], with faster responses on no switch trials [M=1229.11, SD=367.68], than on switch trials [M=1563.73, SD=444.13]. There was however no main effect of group [F(1, 103)=.003, p=.954] and no significant interaction effects [all p's >.05]. There was therefore no evidence of differences in IST performance between remitted patients and controls.

Relationships between rumination scores and IST performance

A mixed ANOVA analysis with rumination (high/low) as the between subject factor similarly indicated significant main effects of condition [F(1, 55)=5.55, p=.022] and switch type [F(1, 55)=164.68, p<.001], and a significant interaction between switch type and rumination group [F(1, 55)=5.62, p=.021] (see *Figure 3.1*). This interaction was further explored by comparing shift costs for each group using independent sample t-tests. This analysis indicated that shift costs were larger for high ruminators [M=375.54msec, SD=222.88] than for low ruminators [M=275.98msec, SD=158.06], although this effect was just below the significance threshold [t(55)=-1.95, p=.056].

Figure 3.1 Reaction times for switch and non-switch trials, comparing low and high ruminators



Exogenous cueing task performance

68 rMDD patients and 43 controls were included in the ECT analysis[15]. Trials with incorrect responses were excluded from analysis (0.4% of trials). Trials were screened for very fast (<200msec) or slow (>750msec) responses, but no such trials were identified. Analyses were therefore conducted on the remaining 99.6% of trials. Performance on catch trials was highly accurate (N=7 participants made 1 catch-trial error; the remaining participants made no such errors), indicating low levels of anticipatory responding. Mean reaction times for each trial type are shown in Table 3.2 and these data are illustrated in Figure 3.2.

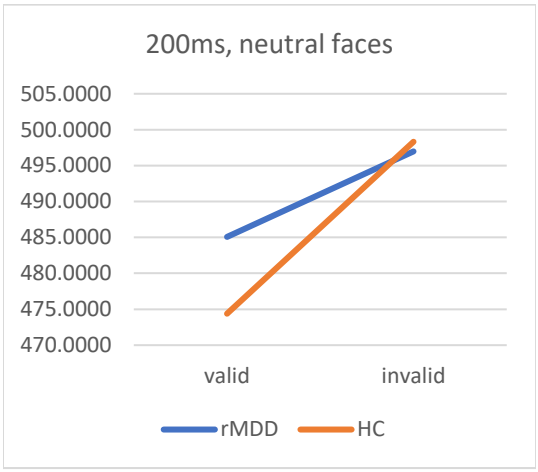
[15] 4 remitted MDD patients and 2 controls patients did not complete the ECT; data from 1 remitted MDD patient was excluded because the task stopped prematurely due to technical error.

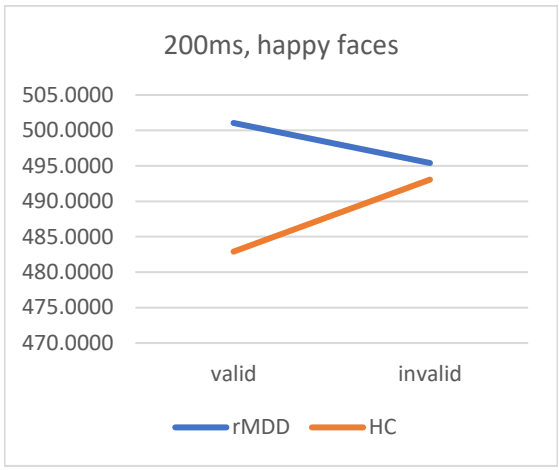
Table 3.2. ECT data by participant group (remitted patients, healthy controls) and trial type

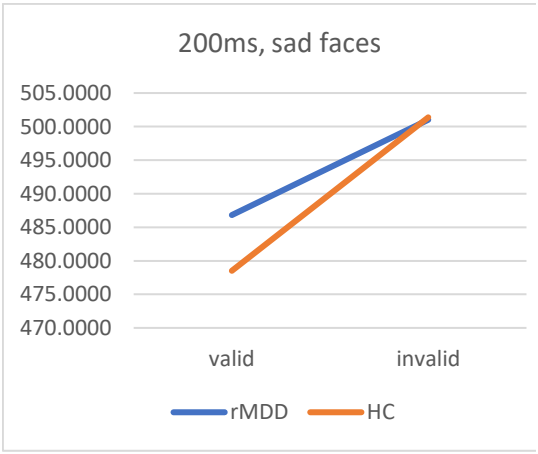
Trial type			rMDD (N=68)		HC (N=43)	
			Mean (ms)	SD	Mean (ms)	SD
200ms	Valid cue	Neutral	485.07	122.46	474.38	70.83
presentation		Happy	501.05	116.67	482.89	76.10
		Sad	486.82	119.74	478.51	77.40
		Angry	495.33	118.70	484.45	80.64
	Invalid cue	Neutral	496.97	121.49	498.32	92.11
		Happy	495.40	120.76	493.05	97.40
		Sad	501.02	121.07	501.38	106.36
		Angry	499.54	123.51	501.42	111.54
1000ms	Valid cue	Neutral	506.75	117.22	490.80	76.58
presentation		Happy	492.97	119.30	487.18	83.12
		Sad	492.52	115.83	489.54	87.16
		Angry	506.60	120.41	493.04	82.62
	Invalid cue	Neutral	494.79	119.48	494.51	88.15
		Happy	482.89	113.49	477.65	89.14
		Sad	492.25	111.58	482.98	80.67
		Angry	494.17	120.65	486.53	74.34

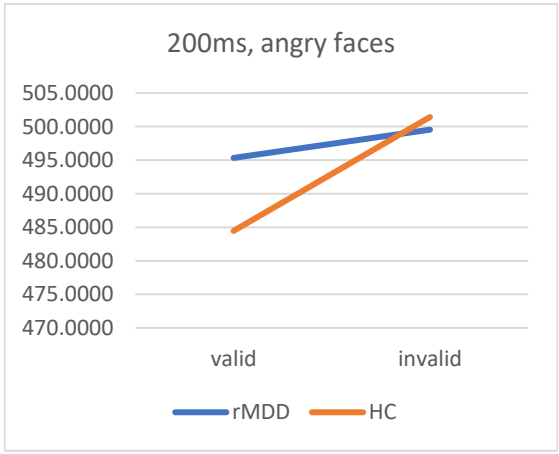
HC=healthy controls, rMDD = remitted Major Depressive Disorder, ms = milliseconds

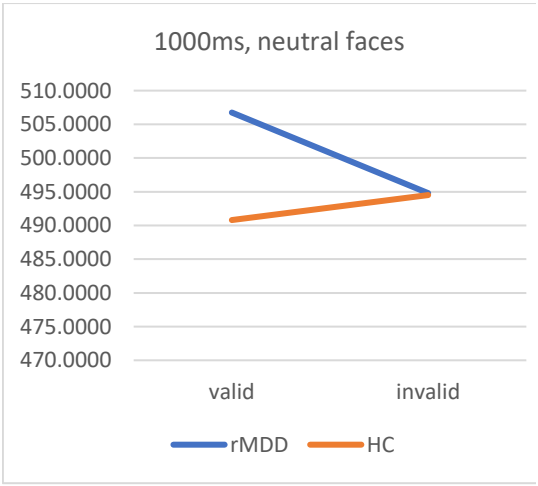
Figure 3.2. ECT reaction times (milliseconds) by participant group and trial type











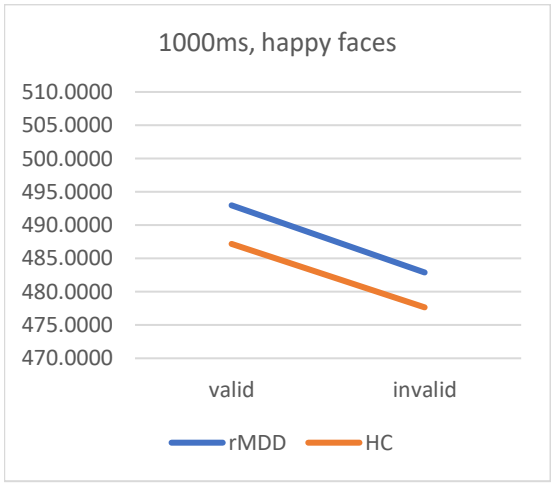
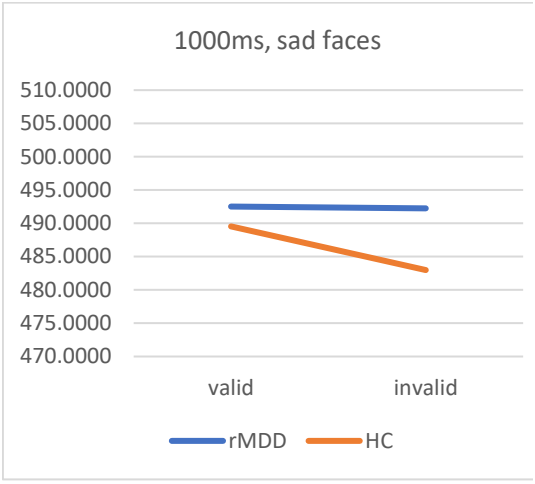
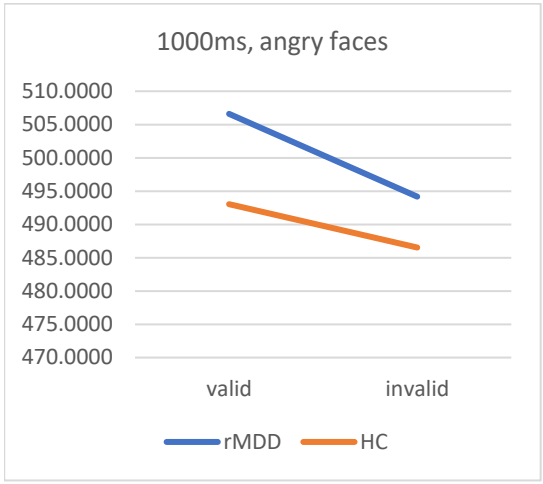


Figure 3.2 (continued). ECT reaction times (milliseconds) by participant group and trial type





HC=healthy controls, rMDD = remitted Major Depressive Disorder, ms = milliseconds, ECT = Exogenous Cueing Task

Comparison between remitted patients and controls

The mixed ANOVA analysis indicated no main effect of group and no significant interactions involving group [all p's >.05][16]. There was therefore no evidence of differences between remitted patients and controls in ECT performance.

Relationships between rumination scores and ECT performance

When examining ECT performance of high and low ruminators, there was no main effect of group and no interactions involving group [all p's>.05]. These analyses therefore suggest no evidence of differences in ECT performance between participants with high and low rumination scores.

IST/ECT performance and rumination as predictors of recurrence

Baseline characteristics of rMDD participants who experienced a recurrence during the study period, versus those who were resilient (no recurrence during the study period) are shown in Table 3.3. The groups did not differ on most demographic and clinical characteristics; the recurrent group had an earlier age of onset and greater number of depressive episodes in the preceding 10 years. Rumination scores, ECT and IST performance indices for the recurrent and resilient groups are shown in Table 3.4.

[16] Main effects and interaction effects not involving group are not reported here, as they are not relevant to the main study hypotheses.

Table 3.3. Baseline characteristics of rMDD patients recurrent versus resilient during follow up

		Recurrent (n = 35)	Resilient (n = 29)	χ^2	T	U	p
Female	N (%)	25 (71.4%)	19 (65.5%)	0.26			0.61
Age	Years; mean (SD)	52.8 (7.1)	54.7 (8.6)		0.98		0.37
Education	Levels[1]	0/0/0/2/15/13/5	0/0/0/2/6/12/9	4.52			0.21
IQ	Mean (SD)	108.0 (7.5)	110.0 (9.5)		0.90		0.37
Living situation	Levels[2]	15/0/9/7/2/0/2	11/0/9/9/0/0/0	4.34			0.40
Employment status	Levels[3]	15/15/5/0	9/10/10/0	3.64			0.16
Currently employed	Yes (%)	22 (64.7)	20 (71.4)	0.32			0.60
Age of onset	Years; mean (SD)	24.2 (10.7)	30.1 (11.0)		2.16		0.04
Episodes							
-last 10 years	Median (IQR)	2 (1-3)	1 (1-2)			746	0.01
-lifetime		4 (2-12.5)	5 (2-5.5)			606	0.18
HDRS	Median (IQR)	2 (1-5)	2 (0-4.5)			521	0.85

For notes and abbreviations, see Table 3.1.

Table 3.4. rMDD patients recurrent versus resilient during follow-up: IST and ECT variables, and rumination

				Cox statistics			
				Exp (B)	Wald	95 CI	p
Exogenous Cueing Task (ms)		**Recurrent (n=34)**	**Resilient (n=29)**				
Disengage sad short	Mean (SEM)	-6,81 (5.25)	9.31 (4.94)	0.984	4.03	0.975-1.00	0.045
Disengage angry short	Mean (SEM)	-0.67 (5.98)	7.21 (4.42)	0.984	8.33	0.974-0.995	0.004
Disengage happy short	Mean (SEM)	-10.94 (6.45)	6.45 (4.13)	0.983	9.61	0.972-0.994	0.002
Disengage sad long	Mean (SEM)	-6.79 (6.72)	-1.94 (3.72)	0.995	0.69	0.985-1.006	0.41
Disengage angry long	Mean (SEM)	-1.93 (6.49)	-2.93 (6.01)	1.001	0.02	0.991-1.010	0.89
Disengage happy long	Mean (SEM)	-16.8 (4.77)	-11.35 (4.55)	0.995	0.29	0.985-1.006	0.59
Engage sad short	Mean (SEM)	-3.75 (-3.76)	3.33 (5.33)	0.996	0.59	0.984-1.007	0.44
Engage angry short	Mean (SEM)	-14.5 (5.38)	-4.77 (6.09)	0.996	0.66	0.986-1.006	0.42
Engage happy short	Mean (SEM)	-22.3 (6.88)	-3.91 (5.84)	0.991	4.36	0.983-0.999	0.037
Engage sad long	Mean (SEM)	7.05 (6.46)	20.7 (5.14)	0.989	3.81	0.977-1.0	0.051
Engage angry long	Mean (SEM)	-3.3 (6.03)	4.60 (5.64)	0.994	1.08	0.98-1.01	0.299
Engage happy long	Mean (SEM)	8.9 (5.07)	20.11 (5.67)	0.994	1.36	0.983-1.004	0.237
Internal Shift Task (ms)		**Recurrent (n=34)**	**Resilient (n=27)**				
Global shift cost	Mean (SEM)	314.9 (39.4)	331.7 (34.2)	1.000	0.003	0.998-1.002	0.95
Emotional shift cost	Mean (SEM)	330.2 (45.1)	341.5 (28.6)	1.000	0.001	0.999-1.001	0.97
Rumination		**Recurrent (n=35)**	**Resilient (n=29)**				
RRS total score	Mean (SEM)	40.9 (2.1)	34.2 (2.22)	1.027	5.01	1.0-1.05	0.025

ms = milliseconds, RRS = Ruminative Responses Scale

In the Cox regression models, three ECT performance measures predicted time to recurrence of depression: disengagement from angry faces, sad faces and happy faces, all at a short duration (HR_{SD} = 0.984 [CI, 0.974-0.995]; Wald = 8.33; p=0.004, HR_{SD} = 0.983 [CI, 0.972-0.994]; Wald = 9.61; p=0.003; and HR_{SD} = 0.984 [CI, 0.975-1.00]; Wald = 4.03; p=0.045, respectively). For angry and happy faces, these associations remained significant when correcting for age, sex, residual symptoms and previous depressive episodes (HR_{SD} =0.99 [CI, 0.98-0.99]; Wald = 8.34; p=0.004; and HR_{SD} =0.98 [CI, 0.97-0.99]; Wald = 8.9; p=0.003 respectively). In both cases, faster disengagement was associated with a shorter time to recurrence (see Figure 3.3 and Figure 3.4). For sad faces however, this association was no longer significant after correcting for age, sex, residual symptoms and previous depressive episodes (HR_{SD} =0.989 [CI, 0.879-1.175]; Wald = 2.97; p=0.085). These effects were not driven by differences in overall reaction times – raw reaction times for responding to invalidly cued angry, sad, happy and neutral face trials were not associated with recurrence (all p's >.05).

To further explore the relationship between disengagement and time to recurrence, comparisons were made between patients with relatively rapid disengagement from angry and happy faces to those with relatively slow disengagement (1 SD above and below median scores). These analyses showed that participants with relatively rapid disengagement from angry faces had a greater than 2-fold increase in risk of recurrence, compared to participants with relatively slow disengagement (HR_{SD}= 2.11 [95% Cl= 1.003-4.44], Wald=3.88; p=.049). Participants with more rapid disengagement from happy faces had an almost 3-fold increase in risk of recurrence compared to participants with slower disengagement (HR_{SD}= 2.96 [95% Cl= 1.41-6.22], Wald=8.23; p=.004).

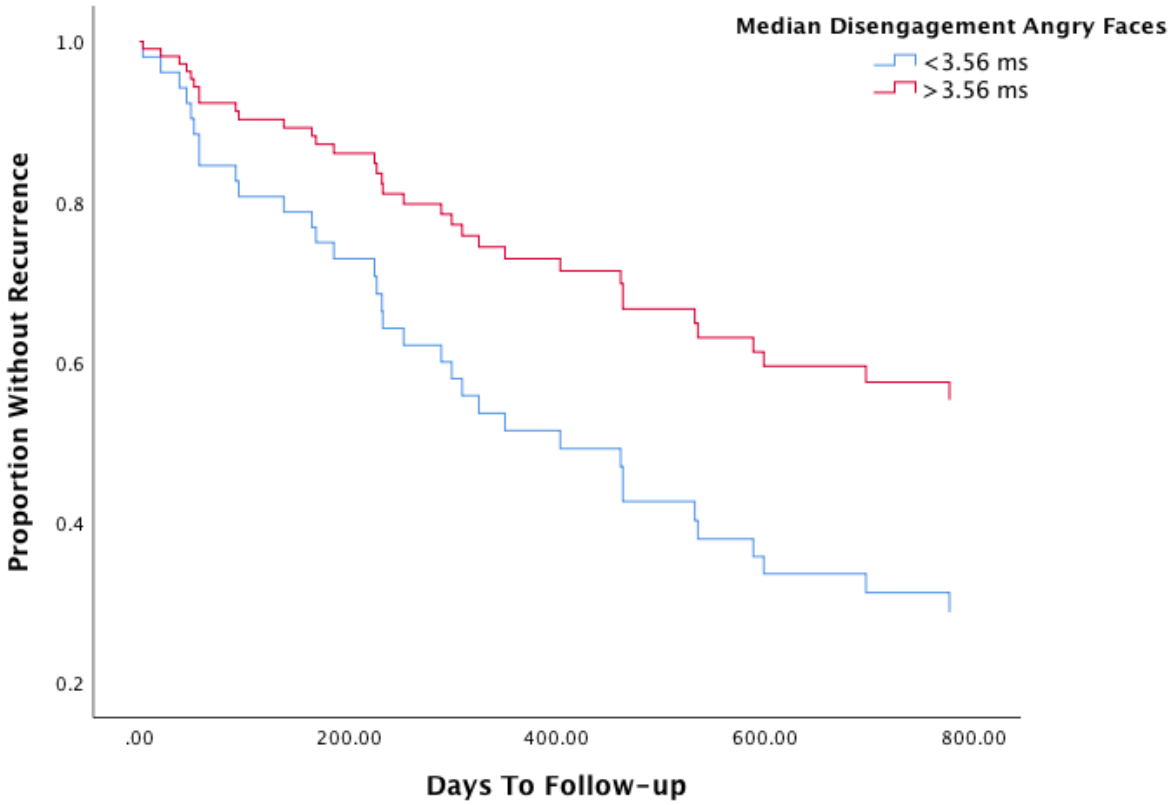
Engagement with happy faces at short duration also predicted recurrence (HR_{SD} = 0.991 [CI, 0.983-0.999]; Wald = 4.36 ; p=0.037) but this relationship was no longer significant after correcting for age, sex, residual symptoms and previous depressive episodes (HR_{SD} = 0.993 [CI,

0.984-1.002]; Wald = 2.38 ;p=0.123). Engagement with angry and sad faces was not associated with time to recurrence.

Rumination was associated with time to recurrence in a simple Cox regression model (HR_{SD} = 1.027 [CI, 1.003-1.051]; Wald = 5.01; p=0.025). However, this relationship was no longer significant when correcting for age, sex, residual symptoms and previous depressive episodes (HR_{SD} = 1.026 [CI, 0.997-1.055]; Wald = 3.18; p=0.075).

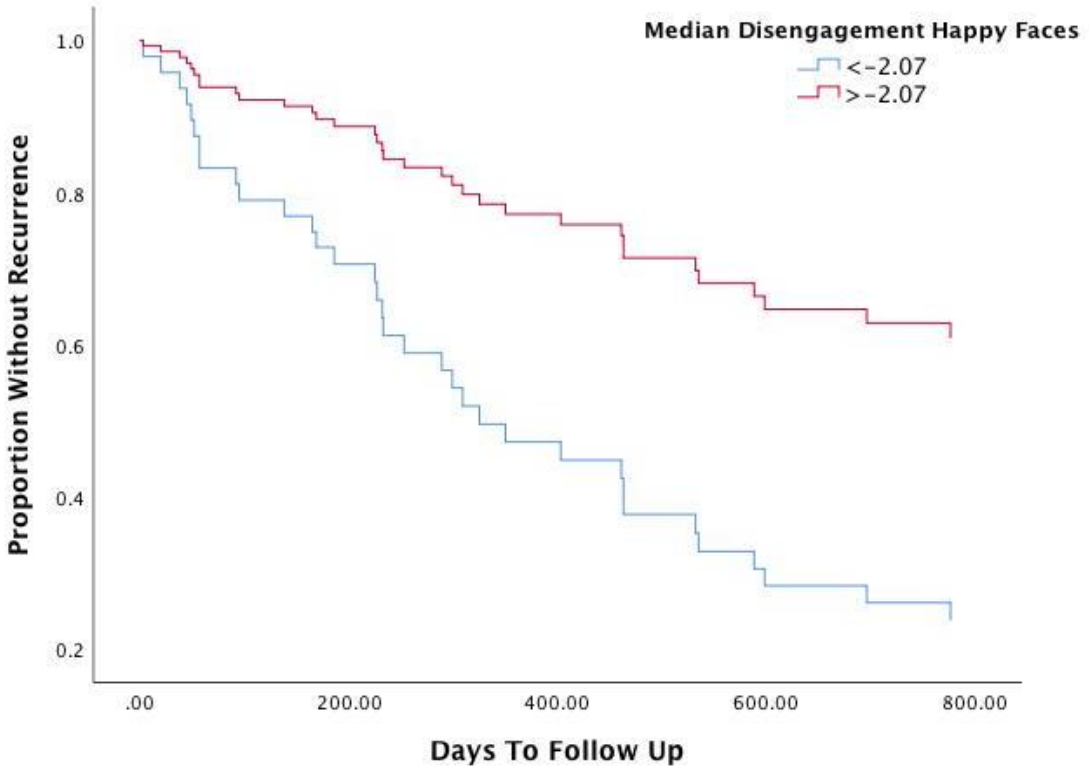
Mediation analyses were not conducted due to assumptions for mediation not being met – although some ECT performance indices were associated with recurrence, these were not associated with rumination, and rumination was not associated with recurrence in the corrected model. Rumination*disengagement interaction terms were added to the significant regression models (disengagement from angry and happy faces at short durations) to check for moderation effects. In neither of these models was the interaction term significant (HR_{SD} = 0.999 [CI, 0.998-1.001], Wald = 1.47, p=0.225 and HR_{SD}=1.00 [CI, .999-1.001], Wald=.012, p=.913 respectively).

Figure 3.3. Association between disengagement from angry faces and time to recurrence



Survival curves for time to recurrence of participants with disengagement from angry faces RT ≤ 3.56 ms (n = 30; upper red line) vs > 3.56 ms (n=33; blue line) while controlling for age, sex, residual symptoms and number of previous depressive episodes.

Figure 3.4. Association between disengagement from happy faces and time to recurrence



Survival curves for time to recurrence of participants with disengagement from happy faces RT ≤ 2.07 ms (n = 30; upper red line) vs > 2.07 ms (n=33; blue line) while controlling for age, sex, residual symptoms and number of previous depressive episodes.

Discussion

This study investigated associations between cognitive control (CC) and rumination in patients remitted from depression and tested whether these factors predicted time to depressive recurrence. Evidence as to the persistence of attentional and CC deficits during the remitted phase of depression is inconsistent (Kanske, Heissler, Schönfelder, & Wessa, 2012; Marchetti, Shumake, Grahek, & Koster, 2018), but this study found no evidence of differences in task performance between remitted patients and controls. There were also few differences in task performance between high and low ruminators, with the exception that switch costs on the IST appeared to be slightly larger for high ruminators.

IST performance was not associated with time to recurrence. However, on the ECT rapid disengagement from emotional (angry and happy) faces, compared to neutral faces, was associated with shorter time to recurrence over a 2.5 year follow up. Importantly, the associations between disengagement from emotional faces and recurrence remained significant after correcting for known risk factors for recurrence, namely residual depressive symptoms and number of previous episodes. The predictive effect was not due to differences in raw reaction times, but specifically related to differences in reaction time between emotional and neutral faces. To my knowledge, these are novel findings, as very few studies have previously examined whether performance on CC tasks is associated with depressive recurrence.

It has previously been demonstrated that both depressed patients and vulnerable groups show impaired attentional disengagement, particularly for negative information (Gotlib & Joormann, 2010). Therefore, it had been hypothesised that difficulties with disengaging would be predictive of rumination and depressive vulnerability. The finding was in fact in the opposite direction to that hypothesised – that is, participants who most rapidly disengaged from emotional faces had

the shortest time to depressive recurrence. This suggests that an avoidance of emotional stimuli, resulting in rapid disengagement, might be a vulnerability factor for recurrence. Although this effect was not as hypothesised, it is notable that other studies have shown links between speeded disengagement and affective disorder. Yiend et al (2015) found evidence in two studies that patients with generalised anxiety disorder show speeded disengagement from negative faces. This effect is opposite to what these authors had predicted, given evidence in subclinical populations of delayed disengagement from such stimuli. The authors note that caution is warranted in extrapolating findings across populations. Similarly here, it may be that changes in attentional processing differ across subclinical, clinical and remitted depressed populations. This issue requires further systematic investigation. Whilst much previous research has focused specifically on responding to negative emotional stimuli, in this case both positive (happy) and negative (angry) emotional faces demonstrated a similar effect. This pattern of findings could then suggest that some remitted patients demonstrate a general avoidance of affect (both positive and negative) and that this broad pattern of avoidance carries risk for recurrence. Study designs employing a wider range of emotional stimuli, both positive and negative, could be used to further examine this possibility.

Only attentional disengagement from stimuli presented for short intervals (200ms) as opposed to longer intervals (1000ms) was associated with time to recurrence. Previous studies in depression have typically demonstrated that attention biases exist at longer presentations, suggesting that such biases occur at more elaborative stages of information processing (Gotlib & Joormann, 2010). However, previous work has primarily considered currently depressed and/or vulnerable populations, and it may be that attentional responses differ during remission. Also, it is notable that at longer stimulus presentations on the ECT, the pattern of results found here does not suggest significant facilitation by valid cues, and may even be indicative of an inhibition of return effect (Klein, 2000) (i.e. at longer delays, valid cues inhibit rather than facilitate responding to the

target, resulting in longer reaction times). Therefore, responding at the longer presentation used here may reflect the operation of somewhat different attentional processes.

It has recently been argued that early life stress can result in divergent cognitive styles, including both vigilant and unemotional phenotypes. These phenotypes are associated with increased attention towards negative or threatening stimuli, and avoidance of negative/threatening stimuli respectively (Del Giudice, Ellis, & Shirtcliff, 2011; England-Mason, Khoury, Atkinson, Hall, & Gonzalez, 2018). There is some evidence that these phenotypes are related to emotional regulation (ER), such that the unemotional (avoidant) phenotype is more likely in the presence of poor ER, whereas the vigilant phenotype is more likely where ER is good (England-Mason et al., 2018). The current findings indicate that remitted patients who show a more rapid disengagement from negative and positive emotional stimuli have shorter time to relapse. Rapid disengagement from emotional facial expressions could be interpreted as being consistent with an avoidant response style. This response style, perhaps in combination with associated ER difficulties, could then confer vulnerability to depressive recurrence. This interpretation of the results is speculative; future studies that systematically examine the relationships between attentional measures, ER and recurrence vulnerability could begin to address these hypotheses.

Cognitive deficits or response styles, including avoidance of emotional stimuli, may also be amendable to change via cognitive training procedures. A number of studies have now shown beneficial effects of cognitive training on depressive symptoms (E. H. W. Koster et al., 2017), including in remitted groups (Hoorelbeke, Faelens, Behiels, & Koster, 2015; Hoorelbeke & Koster, 2017). However, there is a lack of previous studies that have used time to recurrence as an outcome. The use of cognitive training designs may be an interesting direction for future research, particularly as a means of testing the hypothesized causal role for CC deficits in recurrence vulnerability.

Consistent with recent reviews (Visted et al., 2018), rumination was significantly higher in the remitted group than in controls. High levels of rumination were associated with larger shift costs on the IST, but not with performance on the ECT. Higher levels of rumination were also associated with shorter time to recurrence, but this relationship was no longer significant after controlling for other known risk factors (residual symptoms, number of previous episodes). This is a relatively common finding in this area, given the high degree of association between rumination and depressive history/symptoms. Contrary to the study hypotheses then, the relationship between attentional performance and recurrence was not mediated by rumination in this sample. Nor did rumination moderate relationships between ECT disengagement and time to recurrence.

Strengths and limitations

Strengths of the current study include the use of a clinical sample and long-term follow up of participants, with repeated assessments to determine timing of recurrence. Relatively few studies have used longitudinal designs to assess the role of cognitive and psychological risk factors for recurrence in this way. The sample was well-defined and controlled, for example excluding participants currently taking psychotropic medication, or with comorbid psychiatric disorder. The inclusion of a matched comparison group of healthy controls facilitates interpretation of the results. The use of objective measures of CC is also a strength of the design.

The study is limited by the relatively modest sample size, particularly the small number of patients with a recurrence during the follow up period. These findings are novel and require replication in future studies. This is particularly important given concerns about the reliability of attentional tasks that rely on reaction time measurement, and evidence that results of studies

using these tasks are highly sensitive to small changes in task methodology (e.g. stimulus timing and intensity) (Cisler, Bacon, & Williams, 2009).

Conclusions

On the tasks examined (IST, ECT), there was no evidence of impaired CC in patients in stable remission from MDD compared to healthy controls. However, individual differences in attentional disengagement were associated with time to recurrence within the remitted MDD group. Rapid disengagement from emotional (angry and happy) faces was a significant predictor of shorter time to recurrence, even after correcting for other known predictors. If these findings are replicated in other samples, disengagement from emotional stimuli may be an interesting target for screening to establish who is at higher risk of recurrence within remitted populations. These cognitive characteristics may also be amenable to change via intervention, for example through cognitive training approaches. This would be of substantial interest to explore in future studies, given the significant problem posed by high recurrence rates in MDD and the need to develop more effective treatments that address this issue.

Chapter 4. Associations between depression, rumination and empathy: does gender make a difference?

The focus of this chapter moves to the second major theme of the thesis, namely the hypothesised relationship between rumination and impaired social cognition. Below, I report on the findings from a large online questionnaire study, examining the links between depression, rumination and empathy, and considering the role of gender differences. As described in Chapter 1 (page 19), depression and rumination are both associated with significant difficulties in social functioning. It is proposed that these difficulties, at least in part, result from underlying deficits in social cognition. A large body of previous research indicates that various social cognitive deficits can be observed in the context of depression, and a small number of studies are beginning to indicate that rumination is associated with similar deficits (Kupferberg et al., 2016; Ladegaard et al., 2016; Rowland et al., 2012). A growing line of research suggests that both rumination and depression are specifically associated with changes in empathy, but very few studies have examined the interactions between these three variables simultaneously. This study was designed to begin to address this gap in the current literature.

Defining empathy

Empathy is a complex aspect of social cognition, which involves the ability to understand and respond to others' emotions (Spreng, McKinnon, Mar, & Levine, 2009). It has been argued that empathy is multi-dimensional, and it is often considered to have separable emotional and cognitive components. Emotional empathy is defined as the ability to experience a vicarious response to another person's emotional state, which generates concern for the other person and/or personal distress. Cognitive empathy involves the ability to understand another person's

perspective and is closely related to concepts such as mentalising and theory of mind. It encompasses an understanding of the beliefs, intentions, desires and emotional states of others (Thoma et al., 2013).

Empathy and depression

Previous studies using self-report measures suggest that depression is associated with reported impairments in empathy, particularly a reduced awareness of other people's emotions and difficulties with perspective taking. There is some evidence that these difficulties increase with chronicity or additional episodes of depression (Cusi, Macqueen, Spreng, & McKinnon, 2011; Domes et al., 2016; Donges et al., 2005). However, other studies have not found changes in reported empathic ability and instead suggest that depression is mainly associated with increased personal distress in response to the emotions of others (Thoma et al., 2013). Findings from self-report measures are then somewhat mixed, perhaps in part due to the range of empathy measures used and lack of consensus about how best to define and assess this construct (Spreng et al., 2009). When experimental measures are examined, there is more consistent evidence that depression at both clinical and subclinical levels is associated with impaired empathy, including changes in emotion perception, theory of mind and perspective taking (Epa & Dudek, 2015; Gadassi & Rafaeli, 2015; Schreiter, Pijnenborg, & Aan Het Rot, 2013). There is also some evidence that depression-related deficits in cognitive empathy may be larger for women (Gadassi & Rafaeli, 2015; Schreiter et al., 2013), although relatively few studies have examined gender effects.

Empathy and rumination

Several studies have now examined associations between rumination and empathy, with rather mixed results. As predicted, some studies show reduced perspective taking in participants with a

higher tendency to engage in rumination (Joireman et al., 2002). However, in a recent longitudinal panel study, rumination and empathy were shown to have a positive reciprocal relationship over time, i.e. higher rumination was associated with increased empathy over time and vice versa (Boyraz & Waits, 2015). These contradictory findings may be explained by the use of varied measures of empathy, which emphasize different aspects of this construct. For example, one recent study showed differential relationships between rumination and affective versus cognitive aspects of empathy, such that rumination and affective empathy were positively associated, but a small negative association was found between rumination and cognitive empathy (Troyer & Greitemeyer, 2018). Experimental studies have also generated mixed findings. In one study, participants instructed to ruminate experienced higher levels of personal distress when viewing images of a child in pain, whereas participants instructed to use reappraisal experienced higher empathic concern (López-Pérez & Ambrona, 2015). However, in another study, habitual rumination was associated with both increased personal distress and increased empathic concern when viewing a video of a person describing an emotionally distressing situation (Grynberg & López-Pérez, 2018). It appears then that rumination can then be either positively or negatively associated with empathy, depending on the study design and measures used, and the aspect of empathy that is emphasized.

Study design

The current study was designed to examine the three-way associations between depression, rumination and empathy in a single design. The existing literature suggests a robust relationship between rumination and depression, and provides some evidence that both may be associated with changes in empathy. The study was designed to further examine these associations. Empathy was measured using a self-report questionnaire, the Toronto Empathy Questionnaire (TEQ) (Spreng et al., 2009). This is a single-scale questionnaire, designed to capture consensus

about the construct of empathy, and was developed via an exploratory factor analysis of existing measures. It is considered to primarily measure the ability to demonstrate accurate insight into the affective states of others.

The study was also designed to explore the possible effects of gender on the relationships between depression, rumination and empathy, as previous findings suggest some gender differences. Specifically, there appears to be a stronger association between depression and impaired social cognition in women than in men, suggesting that gender may moderate these relationships (Gadassi & Rafaeli, 2015; Schreiter et al., 2013). In addition, the prevalence of depression differs by gender, with women around twice as likely to experience an episode of major depression (Sprock & Yoder, 1997; Weissman & Klerman, 1977). Rumination is also typically higher in women (Johnson & Whisman, 2013). There are therefore several indicators that these variables and the relationships between them may show important gender differences, although this has rarely been addressed in the existing literature.

Aims and hypotheses

The aims of the study then were to: 1) examine relationships between depression, rumination and empathy in a community sample, 2) examine whether these relationships differ by gender. It was hypothesised that depression and rumination would be highly positively correlated and that both these variables would be negatively correlated with empathy. Previous findings suggest that the association between depression and empathy is moderated by gender, with greater empathic impairments found in women when depressed (Gadassi & Rafaeli, 2015; Schreiter et al., 2013). It was hypothesised therefore that depression and rumination would be more strongly negatively correlated with empathy in women than in men.

Method

Participants and procedure

A community sample of N = 618 participants aged 18-35 years were recruited through a combination of posters, e-newsletters and online advertising. Advertising was designed to target local residents, primarily from the student community. A small number of participants reported non-fluency in English (N = 5) and were removed from further analysis. The final sample was therefore N = 613. All recruitment and data collection procedures were completed online. Participants were presented with written information about the study and asked to provide consent to participation. They then provided basic demographic and screening information, before completing the study questionnaires. The study was approved by the local university ethics committee (ref: R37551/RE001)[17].

The study was presented as a screening study, designed to select participants for a further cognitive training study (see Chapter 6). Participants were told that the training study was designed to examine the effects of two types of attention training, in a group of participants prone to rumination. Participants in the screening study were entered in a prize draw to win shopping vouchers, and were also aware that they would be compensated for their time and travel expenses if they were subsequently selected for and participated in the follow-on training study.

Measures

Three questionnaires were used to assess the key variables of interest[18]:

[17] For ethical approval, see Appendix B.
[18] For copies of the questionnaire measures, see Appendix A.

Patient Health Questionnaire (PHQ-9) (Spitzer et al., 1999)

For description of this measure, see Chapter 2, page 68.

Ruminative Responses Scale (RRS) (Nolen-Hoeksema & Morrow, 1991)

For description of this measure, see Chapter 2, page 67.

Toronto Empathy Questionnaire (TEQ) (Spreng et al., 2009)

The TEQ is a 16-item, self-report measure of empathy that has good reliability and validity, and a robust single factor structure with high internal consistency [Cronbach's α = .85 in a validation study (Spreng et al., 2009)]. The TEQ was designed to capture underlying consensus about the concept of empathy and was developed via exploratory factor analysis of items from existing empathy measures. The TEQ primarily measures the ability to accurately demonstrate insight into the affective states of others. Items include: 'I find that I am 'in tune with other people's moods'' and 'I enjoy making other people feel better'. Each item is scored on a 5-point scale (from 0 never to 4 always). Half the items are reverse scored and all item scores are then summed to derive a total score (range 0-64). The TEQ correlates highly with other self-report measures of empathy and shows moderate associations with behavioural performance on social cognition tasks (Spreng et al., 2009).

Statistical analysis

All analysis was performed using SPSS Version 22.0. Descriptive statistics were examined for all key variables. Depression and rumination data were both found to be non-normally distributed, with a strong positive skew. Non-parametric statistics were therefore used where appropriate. Correlations between questionnaires were examined using Spearman's rank correlation coefficients, both across the whole sample and for men and women separately. Gender differences were examined using Mann Whitney *U* tests, with effect sizes reported as eta squared

values. Multiple linear regression was used to examine potential correlates of empathy, with gender, depression and brooding entered simultaneously as independent variables. Additional hierarchical linear regressions were used to examine whether gender moderated the relationship between depression and empathy, or between brooding and empathy.

Results

Participant characteristics and descriptive statistics

613 participants were included in the analyses. There were N = 135 male (22%) and N = 478 female (78%) participants, with an average age of 25.5 years [SD=5.09].

Descriptive statistics for the questionnaires are shown in Table 4.1. PHQ-9 scores were also categorized according to recommended clinical cut-offs[19], and indicated that 444 participants (72.4%) reported no or minimal signs of depression, 103 (16.8%) reported mild symptoms, 52 (8.5%) reported moderate symptoms and 14 (2.3%) reported severe symptoms. N = 70 (11.4%) participants reported current treatment for a mental health condition. As in the validation studies, the TEQ displayed high internal consistency [Cronbach's α=.84].

Correlations between depression, rumination and empathy

Correlations between questionnaire scores are presented in Table 4.2. As predicted, PHQ-9 and RRS scores were highly positively correlated, with stronger correlations for total RRS score and brooding than for reflective pondering. Depression and brooding scores were significantly negatively correlated with empathy.

Gender differences in questionnaire scores were examined and indicated that men and women did not significantly differ in depression or rumination scores. However, there was a significant gender difference in empathy, with women scoring higher on the TEQ than men (see Table 4.3).

[19] Where scores <9 indicate no or minimal symptoms, 10-14 mild symptoms, 15-19 moderate symptoms and >20 severe symptoms (Kroenke et al., 2001).

Table 4.1 Descriptive statistics for questionnaire measures

Measure	Median (IQR)
PHQ-9 total score	6 (2-10)
RRS total score	41 (32-52)
RRS brooding	9 (7-12)
RRS reflective pondering	9 (6-11)
TEQ total score	48 (44-53)

Table 4.2. Correlations between questionnaire measures

	1	2	3	4
1. PHQ-9 total score				
2. RRS total score	.75**			
3. RRS brooding	.65**	.88**		
4. RRS reflective pondering	.51**	.82**	.64**	
5. TEQ total score	-.11**	-.07	-.11**	-.02

** = p<.01

Table 4.3. Gender differences in questionnaire scores.

Measure	Median (IQR)		*U*	*p*	*η2*
	Males (N=135)	Females (N=478)			
PHQ-9 total score	6 (2-11)	6 (2-10)	31336.50	.381	.00
RRS total score	41 (30-52)	40.5 (32-52.25)	31316.00	.635	.00
RRS brooding	9 (6-12)	9 (7-12)	30580.50	.335	.001
RRS reflective pondering	9 (6-11)	9 (6-11)	31170.50	.371	.001
TEQ total score	46 (41-51)	49 (44-54)	24742.50	<.001**	.028

PHQ-9 = Patient Health Questionnaires, RRS = Ruminative Responses Scale, TEQ = Toronto Empathy Questionnaire

Gender differences in the associations between measures were then considered (see Table 4.4). In most cases, the pattern of correlations appeared similar for men and women. However, for men there was a significant correlation between depression and empathy which was not present for women. Conversely, there was a significant relationship between brooding and empathy in women, which was not significant for men. This latter effect may be related to lack of statistical power in the smaller sample of men, as the magnitude of the correlation appears to be similar.

Table 4.4. Correlations between questionnaire measures, separated by gender

Male		1	2	3	4
	1. PHQ-9 total score				
	2. RRS total score	.79**			
	3. RRS brooding	.70**	.89**		
	4. RRS reflective pondering	.58**	.82**	.66**	
	5. TEQ total score	-.19**	-.14	-.15	-.10
Female		1	2	3	4
	1. PHQ-9 total score				
	2. RRS total score	.74**			
	3. RRS brooding	.64**	.88**		
	4. RRS reflective pondering	.49**	.82**	.63**	
	5. TEQ total score	-.07	-.06	-.11**	.00

** p<.01, * p<.05

PHQ-9 = Patient Health Questionnaires, RRS = Ruminative Responses Scale, TEQ = Toronto Empathy Questionnaire

Regression and moderation analyses

A multiple linear regression was used to examine correlates of empathy (for full statistics, see Table 4.5), with gender, depression and brooding entered simultaneously. The model showed that gender and brooding were significantly associated with empathy scores, with similar

associative strength (*β*= .17 and -.15 respectively). Depression scores were not significantly associated with empathy. The full model accounted for around 5% of variance in empathy.

Table 4.5. Multiple linear regression examining predictors of empathy scores.

Full model: $F(3, 609)=10.96$, $p<.001$, $R^2=.051$, *adj* $R^2=.049$			
	t	*p*	*β*
Gender	4.34	<.001**	.172
PHQ-9 score	-.23	.818	-.012
RRS brooding score	-2.78	.006**	-.145

Gender was also examined as a possible moderator of the relationship between: a) brooding and empathy, b) depression and empathy. In each case, gender and the questionnaire measure (RRS brooding or PHQ-9 score) were entered in the first step of a linear regression model, with the interaction term (brooding*gender or depression*gender) entered in a second step. Interaction terms were calculated using centred questionnaire scores.

Gender did not moderate the relationship between brooding and empathy. At Step 1, brooding and gender were both associated with empathy (β=-.15, t=-3.87, p<.001 and β=.17, t=4.38, p<.001 respectively). Adding the interaction term at step 2 did not improve the model (Δ F=.40, p=.525) and the interaction term was not significantly associated with empathy (β=.11, t=.64, p=.525). Similarly, gender did not significantly moderate the relationship between depression and empathy. At Step 1, depression and gender were both associated with empathy (β=-.11, t=-2.69, p=.007 and β=.16, t=4.11, p<.001 respectively). Adding the interaction term did not improve the model (Δ F=2.37, p=.124) and the interaction term was not significantly associated with empathy (β=.25, t=1.54, p=.124).

Discussion

Self-report measures of depression, rumination and empathy were completed by a large community sample, in an online study design. The sample presented with primarily low levels of depression. However, there was a wide range of scores including moderate to severe levels in around 11% of participants. Rumination scores were consistent with those found in previous studies utilizing similar populations (Vergara-Lopez, Lopez-Vergara, & Roberts, 2016), and mean empathy score was consistent with initial validation studies of the TEQ in similar populations (Spreng et al., 2009). No significant differences between men and women were identified in levels of depression or rumination reported. However, women did report significantly higher empathy scores than men, with small to medium effect size. This gender difference in TEQ scores is consistent with previous studies using this measure (Spreng et al., 2009), as well as the broader literature on gender effects on empathy and affective social cognition e.g. (Baron-Cohen & Wheelwright, 2004; McClure, 2000; Thompson & Voyer, 2014).

As hypothesised, the total rumination score and rumination subscales were positively correlated with depression. This correlation was stronger for brooding than for reflective pondering. There were small but significant negative correlations between rumination and empathy, and between depression and empathy, such that higher levels of brooding and depression were associated with lower reported empathy. In a regression model, with gender, depression and brooding entered simultaneously, only gender and brooding were significantly related to empathy. Being male and having a higher brooding score were both associated with lower empathy.

The patterns of correlations between variables differed between men and women. In particular, a significant correlation between depression and empathy was present only for men; these variables were not significantly related in women. The correlation between brooding and

empathy was of similar magnitude for men and women, but statistically significant only for women. However, formal moderation analyses did not indicate any significant interaction effects involving gender.

These findings may help to explain why several previous studies have found that the social cognitive impairments associated with depression appear to be larger in women. This study indicates that rumination and empathy are significantly negatively correlated, and we know from previous meta-analyses that levels of rumination are typically somewhat higher in women (Johnson & Whisman, 2013). The combination of these effects then could account for the higher level of social cognitive impairment typically found in women when depressed.

The current findings also generate predictions regarding possible impairments in social cognition and social functioning in groups who are vulnerable to, or remitted from, depression. Rumination appears to be a relatively stable trait that confers vulnerability to depression (Nolen-Hoeksema et al., 2008) and tends to remain high during remission of mood symptoms (Visted et al., 2018). It could therefore be predicted that individuals with high levels of rumination (including vulnerable and remitted groups), might experience a significant degree of related social impairment even in the absence of current depressive symptoms. There is indeed some recent evidence that social cognitive functioning does not return to baseline levels following remission from depression (Ladegaard et al., 2016). A possible direction for future work in this area would be to examine whether elevated levels of rumination help to account for ongoing social cognitive deficits in remitted groups.

It would be of interest to further examine the relationships tested here in selected samples of participants with clinical or subclinical depression. As discussed in the introduction to this paper, both positive and negative correlations between rumination and empathy have previously been

reported. These relationships therefore require further elaboration, particularly to explore possible dissociations between different aspects of empathy (Troyer & Greitemeyer, 2018). However, the use of a single factor empathy measure in the current study does not permit me to explore this issue further here.

Another important extension of this work would be to examine whether depression and brooding show similar associations with other social cognitive measures, including performance on behavioural tasks. Given the reliance on self-report measures in this study, it is possible that the relationships reported here are specific to self-perception and reporting of empathy, rather than to empathic or social cognitive ability per se. How these findings might relate to social functioning also remains to be tested, although it could be hypothesised that deficits in social cognition are likely to be associated with some degree of social functioning impairment (Epa & Dudek, 2015; Gadassi & Rafaeli, 2015; Thoma et al., 2013).

Limitations

There are several limitations of the current study. The use of a single measure of empathy does not allow dissociation of different aspects of this multidimensional construct. The study also did not include objective measures of social cognitive performance or a measure of social functioning. The sample represents a broad, community population and these findings require replication in clinical and selected vulnerable populations to more fully understand the implications of these relationships in the context of depression. This study did not collect data on history of depression, which may be relevant both to levels of rumination and residual social impairment. In common with many student/community samples, there is an overrepresentation of women and so the sample of men is more limited in size.

Given the single time point for data collection, this study was not able to address issues of causality or relationships between variables over time. It seems likely that rumination and empathy may have reciprocal relationships. Whilst rumination could be predicted to impair empathy via increased self-focus and difficulty attending to the feelings of another, impairments in empathy and related social functioning difficulties may also increase vulnerability to rumination. Longitudinal study designs could be utilized in future research to explore these relationships more fully.

There are also other variables of interest that may help to further elucidate these findings. For example, early life experiences and attachment style have been linked to both rumination and social cognition (Lanciano, Curci, Kafetsios, Elia, & Zammuner, 2012; Ruijten, Roelofs, & Rood, 2011; Troyer & Greitemeyer, 2018). Examination of these variables and their interactions over time may be a useful direction for future research. As the associative relationships described here account for only a small proportion of the variation in empathy, it is likely that many other predictive factors are also involved.

Conclusions

In summary, both depression and rumination (particularly brooding) are negatively correlated with self-reported empathy. Reported empathy is somewhat lower in men, but gender does not significantly moderate the relationships between empathy and depression or brooding. These findings generate several hypotheses regarding the role rumination may play in impaired social functioning in depression, but further work is required to replicate these findings and extend them into clinical populations. Understanding the factors that confer vulnerability to social impairment in the context of depression is vital for developing interventions that effectively address these difficulties. The significant association with rumination, independent of current

depressive symptoms, also suggests a possible need to intervene with vulnerable and remitted groups, for whom rumination is often high even in the absence of current affective symptoms. Whilst this study did not find evidence of moderation by gender, it will be important to continue to consider possible gender differences in mood disorder and related cognitive processes. Failure to examine gender effects may obscure meaningful differences in mechanisms and relationships between variables.

In the next chapter (Chapter 5), I examine associations between rumination and social cognitive processes, with a focus on potential applications in the perinatal period. Specifically, the effects of rumination on processing of infant stimuli (facial and vocal expressions) are examined. An experimental design was used, with rumination manipulated via an induction procedure. The impact on social cognitive performance was then explored, in order to examine whether rumination plays a causal role in impairing processing of social information.

Chapter 5. Examining the effects of induced rumination on attention performance and sensitivity to infant face and voice cues.

In this chapter, I move towards a more specific focus on the perinatal period, and particularly the role that rumination may play in mediating the effects of PND on parenting. These processes are examined here using an experimental design, in which rumination was manipulated via an induction procedure, in order to examine impact on attentional performance and processing of infant social cues.

As outlined in Chapter 1 (Section B, page 22), postnatal depression (PND) is a relatively prevalent mental health condition, affecting around 15% of women in the year following birth (Howard et al., 2014) and is understood to carry a range of risks, including for various aspects of child development (Stein et al., 2014). These effects are understood to be mediated in part through the impact of PND on parenting behaviour. Whilst the behavioural impact of PND is well established, the cognitive mechanisms that presumably underlie and mediate these impacts are less understood. It has been proposed that rumination may be an important cognitive feature of PND that helps to account for the impact of PND on parenting (Moulds et al., 2018; Psychogiou & Parry, 2014; Stein et al., 2009). Research on rumination in the perinatal context has to-date been limited, but initial findings suggest that rumination may be associated with future low mood, and also difficulties with mother-infant bonding and maternal responsiveness (see '*Discussion of systematic review findings'*, Chapter 1, page 41). A small number of experimental studies using induced rumination procedures indicate that rumination may have a causal role, negatively affecting the sensitivity and contingency of maternal responding (Stein et al., 2012; Tester-Jones et al., 2017).

The role of cognitive control and rumination in postnatal depression

I have proposed in the introductory chapter of this thesis that rumination, in combination with associated cognitive control deficits and cognitive biases, may be a key mechanism through which PND affects parenting behaviour. In summary, the model (Figure 1.2, page 49) proposes that cognitive control deficits, in combination with cognitive biases, increase risk of rumination as negative themes are more likely to be attended and elaborated. Rumination also reinforces these cognitive features, as it impairs cognitive control by consuming executive resources and reinforces biases through rehearsal. The model further proposes that cognitive control deficits, cognitive biases and rumination impair the accuracy and/or efficiency of infant cue processing. Impaired infant cue processing in turn is hypothesised to limit capacity for contingent responding.

Study design

In the work described here, several hypotheses generated by this model are tested, using standardised measures of cognitive control and infant cue processing, and a rumination induction procedure. Firstly, this study examines the extent to which current rumination affects attention performance, particularly tasks requiring top-down cognitive control. Several studies have suggested that rumination depletes cognitive control, as it consumes cognitive resources, making redirection of attention difficult (S. Hayes, Hirsch, & Mathews, 2008; Stefanopoulou, Hirsch, Hayes, Adlam, & Coker, 2014; E. Watkins & Brown, 2002). Specifically in this study, the effects of an induced rumination procedure on performance of a standardised attention task, the Attention Network Task (ANT) (Fan et al., 2002) were examined.

Secondly, the effects of current rumination on infant cue processing were examined. A small number of studies have tested whether inducing rumination affects maternal sensitivity during live interaction tasks (Stein et al., 2012; Tester-Jones et al., 2017). However, the hypothesis that

changes in parental sensitivity are mediated by changes in infant cue processing is currently untested. In the current study therefore, standardised infant stimuli were used to test whether induced rumination was associated with changes in ratings of these stimuli.

Participant selection

In the current study, a community sample was used. Participants were recruited on the basis of reporting current low mood, as it was hypothesised that this might facilitate the rumination induction; however, participants were not required to meet criteria for an episode of depression. Whilst rumination is particularly relevant to depression, including PND, it is a cognitive process occurring to some degree throughout the population. There is also some evidence that rumination affects parenting responses regardless of diagnostic status. Tester-Jones et al. (2017) showed that mothers induced to engage in rumination were less sensitive towards their infant in a subsequent interaction period and this effect was not moderated by pre-existing dysphoria status. This finding suggests that rumination may impair interactions in both depressed and non-depressed groups. Findings in non-clinical groups may then still have relevance for PND. In addition, the effects of rumination on parenting behaviour may be important in the postnatal period generally, regardless of clinical status. The current study employed a group of participants who were largely non-parents and with little previous childcare experience. Whilst there is some evidence that parents have enhanced responding to infant-related stimuli (Nishitani, Doi, Koyama, & Shinohara, 2011; Stallings, Fleming, Corter, Worthman, & Steiner, 2001; Thompson-Booth et al., 2014), infant faces are highly motivating and capture attention even in non-parent groups (Brosch, Sander, & Scherer, 2007; Glocker, Langleben, Ruparel, Loughead, Gur, et al., 2009; Glocker, Langleben, Ruparel, Loughead, Valdez, et al., 2009; Parsons, Young, Kumari, Stein, & Kringelbach, 2011). The current study therefore provides an initial examination of these

processes, using a series of novel methods. However, there will also be a need for future studies to examine these questions directly in clinical groups and with participants who are parents.

Aims

The aims of the current study were to explore the effects of induced rumination on a) attentional performance and b) ratings of standardised infant face and voice cues. Analyses also examined whether any effects on infant cue processing differed by valence and/or modality of cues. A secondary aim was to explore how baseline characteristics, including trait rumination and symptoms of depression and anxiety, interact with induced rumination to affect performance on these tasks.

Method

Participants[20]

81 participants who self-identified as experiencing current sadness or low mood were recruited via posters and online advertising. Inclusion criteria included age between 18-35 years, normal or corrected-to-normal vision and hearing, and fluent English language. People currently receiving or seeking treatment for a mental health condition were excluded from participation (n = 1), resulting in a final sample of N = 80.

Measures

Questionnaires

Questionnaires included in this study were the Ruminative Responses Scale (RRS) (Nolen-Hoeksema & Morrow, 1991), the Attentional Control Scale (ACS) (Derryberry & Reed, 2002), the Patient Health Questionnaire (PHQ-9) (Spitzer et al., 1999) and the GAD-7 (Spitzer et al., 2006). For a description of these questionnaire measures, see Chapter 2 (page 67)[21].

Manipulation checks

Short Positive and Negative Affect Scale (PANAS)

A 12 item PANAS was used to assess affect at various points throughout the study, including measuring changes in affect from pre- to post-induction. Each item was rated on a 5-point scale from 1 (very slightly or not at all) to 5 (extremely). Composite scores for positive and negative affect were calculated using 10 items, as described by Kercher (1992), i.e. positive affect: excited,

[20] The participants included here are the same sample as described in Chapter 2.
[21] For a copy of these questionnaire measures, see Appendix A.

enthusiastic, alert, inspired and determined; negative affect: distressed, upset, scared, nervous and afraid.

Cognitive rating scales

A series of rating scales were administered following the rumination induction, as a manipulation check. These included ratings of the valence of thoughts (-9 very negative to 9 very positive), intrusiveness, repetitiveness, and degree of attention to thoughts. The rating scales were based on a set previously used with a similar induction procedure (Stein et al., 2012). These rating scales were also administered at two further time points, to assess whether any changes in cognition that occurred following induction persisted over time.

Performance tasks

Attentional Network Task (ANT) (Fan et al., 2002)

The ANT was used as described in Chapter 2, page 68.

Infant face and voice rating task

A computerised task was used to examine ratings of infant face and voice stimuli, according to emotional valence. All items were presented on a laptop with headphones, using Presentation software. For each item, the participant was asked rate how happy or sad they thought the infant depicted was. Ratings were made on a vertical visual scale (range -4 to +4), which was adjusted using the arrow keys. The task began with 6 practice items, using non-infant stimuli, to familiarise participants with the procedure and rating system.

The face stimuli consisted of 50 greyscale images of infant faces, including 10 individuals. For each infant, there was an image in each of the following categories: very negative, muted

negative, neutral, muted positive, very positive. The development and standardisation of these images is described in Stein et al. (2010). Each image was presented for 1500ms. Participants then had up to 2500ms to make their rating, before the next stimulus was presented. The voice stimuli consisted of 50 sound clips, each 1500ms long. These vocal sounds were collected during home recordings of infants, and have been standardised and validated (Parsons, Young, Craske, Stein, & Kringelbach, 2014). The vocal sounds were organised into 5 categories - very negative, muted negative, neutral, muted positive, very positive – with 10 stimuli in each category. Following presentation of the sound stimulus, participants had up to 2500ms to make their rating, before the next item was presented. All face stimuli were presented in one block, with voice stimuli in a separate block. The order of presentation of these blocks was counterbalanced across participants. Within each block, each stimulus was presented once, in a randomised order.

Rumination induction and control induction

The rumination induction consisted of 5 minutes spent thinking about a current life difficulty. The specific instructions used were:

> *"Please think about a current difficulty in your life. It should be something that you have been worrying about, or that has been on your mind recently. You don't have to tell me what that is, but I'd like you to now close your eyes and concentrate on those negative thoughts, as intensely as you can, until I ask you to stop. I'll tell you when the time is up."*

Similar procedures have previously been used (Roberts et al., 2013; Stein et al., 2012) and shown to successfully induce a ruminative thinking style, and accompanying changes in mood. In the equivalent control condition, participants were asked to spend 5 minutes thinking about their journey to the appointment. This topic was chosen as it was likely to provide emotionally neutral content but contain enough detail to occupy the participant's thoughts for the required period of

time. It has been successfully used as a control condition in a previous induced rumination study (Stein et al., 2012). The specific instructions used were:

> *"Please think about how you got here this morning/afternoon. I'd like you to close your eyes and think about your journey here, in as much detail as you can. Concentrate on this as intensely as you can, until I ask you to stop. I'll tell you when the time is up."*

Procedure

The rationale given to participants was that the study was designed to examine whether rumination affects how people respond to infant cues. Participants were randomised to either the rumination condition or the control condition using a computer-generated random number sequence. Uneven groups were created (rumination group: 50, control: 30) to facilitate use of follow-on tasks within the rumination group[22]. Participants attended a laboratory in the University department for a single session of testing and provided written informed consent to participation. Questionnaires were administered first, followed by the ANT. Participants were then asked to complete either the rumination induction or the control condition. This was followed by the infant face and voice rating task, and a second administration of the ANT.

All participants were debriefed at the end of the testing session, and the researcher checked that there were no lasting mood effects following the rumination induction. Participants received a small cash payment, or alternatively received course credits as part of a University research participation scheme. The research was approved by the local University research ethics committee (ref. MS-IDREC-C1-2015-038)[23].

[22] These tasks are not reported as part of this thesis.
[23] For ethical approval, see Appendix B.

Statistical analysis

All statistical analysis was conducted using SPSS 22.0. A small number of outlier variables (i.e. data points >3 SD from the mean) were removed from the analysis. There was also a small amount of missing data, due to participants misunderstanding task instructions, technical errors, and time constraints. All analyses were conducted using all available data. Descriptions of the specific analyses conducted are incorporated in the *Results* section.

Results

Participant characteristics and group matching

Participant demographic and clinical characteristics are presented in Table 5.1. Groups were generally well matched, except that a greater proportion of the rumination group had previous childcare experience. To account for this group difference, analysis of the infant cue task was conducted both including and excluding participants with previous childcare experience (see below). Clinical characteristics were well matched across groups, and mean levels of depression and anxiety were in the moderate range.

Effects of induction on mood and cognition

A mixed ANOVA with a 2 (time) x 2 (group) design was conducted, to examine the effects of the induction on reported affect (PANAS positive and negative composite scores). The primary outcome of interest was any time x group interactions, which would suggest that the control and rumination inductions had differential effects. Time x group interactions were significant for both positive and negative affect. The groups diverged over time so that following the induction the rumination group had higher negative affect and lower positive affect compared to the control group (see Table 5.2).

Table 5.1. Participant demographic and questionnaire data by group

	Rumination condition (N=50)	*Control group (N=30)*	*t / χ^2*	*p*
Gender (M/F)	18 / 32	9 / 21	.302	.583
Age - mean (SD)	22.90 (4.10)	22.70 (4.17)	-.210	.834
Ethnicity			3.212	.523
White	34	23		
Mixed/multiple ethnic group	2	0		
Asian/Asian British	11	7		
Black/African/Caribbean/	2	0		
Black British				
Other ethnic group	1	0		
Highest level education			3.671	.299
No formal qual.	0	0		
GCSE	1	2		
A level	25	15		
Undergraduate	10	9		
Masters degree or higher	14	4		
Current occupation			1.057	.788
Paid employment	7	6		
Student	37	21		
Full time parent/carer	1	0		
Unemployed	5	3		
Other	0	0		
Parent (yes/no)	2 / 48	0 / 30	1.231	.267
Live with infants (yes/no)	0 / 50	0 / 30		
Childcare experience (yes/no)				
	8 / 42	0 / 30	5.333	.021*
GAD-7	9.88 (4.23)	8.83 (4.82)	-1.016	.313
PHQ-9	9.98 (5.06)	10.77 (6.34)	.611	.543
RRS total	48.88 (10.34)	47.97 (12.14)	-.358	.721
ACS total	48.98 (9.49)	49.03 (7.40)	.027	.979

GAD-7=Generalised Anxiety Disorder scale, PHQ-9=Patient Health Questionnaire, RRS=Ruminative Responses Scale, ACS=Attentional Control Scale

Table 5.2. Descriptive data and group x time interactions for PANAS ratings.

	Rumination group Mean (SD)		Control group Mean (SD)				
	Pre induction	Post induction	Pre induction	Post induction	*F*	*p*	η_p^2
Positive affect	10.06 (3.41)	7.47 (2.61)	10.53 (3.74)	10.27 (3.79)	9.76	.003**	.112
Negative affect	7.16 (2.70)	11.33 (3.63)	7.87 (3.62)	7.30 (3.44)	49.77	<.001**	.393

Reported cognitive style following induction was compared across groups using independent sample t-tests (see Table 5.3). The groups differed significantly in valence of thoughts, with the rumination group reporting more negative thoughts. Consistent with the theorised characteristics of rumination, the rumination group also reported more repetitive thoughts, less mental imagery, less focus on the environment, and greater focus on themselves and their thoughts. The groups did not differ in terms of focus on the task, intensity of thoughts, concentration, ease of directing thoughts, or verbal cognition (thoughts in words/sentences).

Table 5.3. Group differences in cognition following induction procedures.

	Rumination group Mean (SD)	Control group Mean (SD)	*t*	*p*	*g*
Valence of thoughts.	-4.71 (1.52)	.77 (3.05)	9.16	**<.001***	2.46
Time spent focused on task.	7.38 (1.52)	6.87 (1.68)	-1.41	.164	0.32
Intensity of thoughts.	7.12 (1.44)	6.83 (1.66)	-.81	.418	0.19
Ease of directing thoughts.	4.76 (2.06)	4.57 (2.08)	-.41	.686	0.09
Ease of concentrating.	4.74 (2.33)	5.40 (2.42)	1.21	.230	0.28
Repetitiveness of thoughts.	6.70 (1.93)	5.17 (2.35)	-3.17	**.002***	0.73
Time spent thinking in words/sentences.	5.42 (2.86)	4.37 (3.61)	-1.45	.152	0.33
Time spent thinking in images.	5.60 (2.71)	7.27 (2.61)	2.70	**.008***	0.63
Time spent focusing on environment.	2.78 (1.92)	5.17 (2.94)	4.40	**<.001***	1.02
Time spent focused on self and thoughts.	7.70 (1.46)	6.23 (2.33)	-3.10	**.003***	0.82

To examine whether group differences following induction were sustained over time, the groups were compared on mood and cognitive ratings at two further time points. Following the infant rating task (approx. 10 minutes post-induction), there were no significant differences between groups for PANAS composite scores [positive affect: t=.35, p=.730, M_R=9.5, SD_R=3.44, M_C=9.8, SD_C=4.21; negative affect: t=-.45, p=.651, M_R=7.46, SD_R=3.02, M_C=7.13, SD_C=3.28]. There was one significant difference in cognition ratings, such that the rumination group reported *greater* focus on the infant task than did the control group [t=-3.09, p=.003, g=0.71; M_R=8.46, SD_R=1.13, M_C=7.40, SD_C=1.94]. Across the whole sample, focus on the infant task was positively associated with mood recovery (i.e. change in affect from post-induction to post-infant task) such that higher task focus was correlated with greater increase in positive affect [r=.25, p=.028] although not with change in negative affect [r=-.154, p=.173]. When the rumination group alone was

examined, correlations between task focus and change in affect were of similar magnitude, although neither was significant [positive affect: r=.20, p=.168; negative affect: r=-.10, p=.501].

Following the attention task (approx. 25 minutes post-induction), there were no group differences in PANAS composite scores [positive affect: t=1.50, p=.138, M_R=7.98, SD_R=3.06, M_C=9.13, SD_C=3.75; negative affect: t=-.15, p=.882, M_R=6.80, SD_R=2.83, M_C=6.90, SD_C=3.07]. There were also no significant differences on any of the cognition ratings at this time point [all p's >.05].

Group differences in attentional performance

Performance on the ANT was examined using a mixed ANOVA, with a 2 (time) x 2 (group) design. Descriptive statistics are shown in Table 5.4. For alerting, there was a main effect of group [F(1, 70)=8.41, p=.005, $\eta_p^2 = .820$] such that the rumination group showed a larger alerting effect than the control group. Neither the main effect of time [F(1, 70)=1.96, p=.166, $\eta_p^2 = .027$], nor the interaction of group x time [F(1, 70)=.37, p=.544, $\eta_p^2 = .005$] were significant. For orienting, there was a main effect of time [F(1, 70)=6.71, p=.012, $\eta_p^2 = .087$], such that the orienting value was smaller at Time 2 for both groups. There was no main effect of group [F(1, 70)=.12, p=.74, $\eta_p^2 = .002$], and no significant interaction effect [F(1, 70)=.29, p=.59, $\eta_p^2 = .004$]. For conflict, there was no main effect of time [F(1, 70)=2.28, p=.135, $\eta_p^2 = .032$] or group [F(1, 70)=.32, p=.572, $\eta_p^2 = .005$], and no significant interaction effect [F(1, 70)=.03, p=.867, $\eta_p^2 < .001$].

Table 5.4. Attention Network Task (ANT) performance by group.

	Rumination group (N=47)		Control group (N=25)	
	Time 1: Mean (SD)	Time 2: Mean (SD)	Time 1: Mean (SD)	Time 2: Mean (SD)
ANT alerting	56.37 (28.80)	64.93 (31.71)	42.04 (26.39)	45.40 (27.52)
ANT orienting	24.24 (19.86)	13.92 (18.57)	21.23 (21.75)	14.46 (20.71)
ANT conflict	83.10 (30.49)	77.95 (26.23)	86.40 (33.76)	82.27 (30.54)

Where time 1 indicates pre- rumination induction and time 2 indicates post- rumination induction.

Interactions between induction and baseline variables

Possible interactions between baseline variables and induction group on ANT performance were examined using hierarchical linear regressions. For each baseline variable, scores were centred and combined with induction group (rumination/control) to create an interaction term. Baseline ANT performance was entered at Step 1, baseline questionnaire score and group were entered at Step 2, and the interaction term was entered in Step 3. A regression analysis was conducted separately for each ANT outcome variable (alerting, orienting, conflict) and for each baseline measure (RRS brooding, PHQ-9, GAD-7).

RRS brooding

Alerting: The model was significant at Step 1 [$F(1, 76)=7.40$, $p=.008$, $R^2=.09$, $R^2_{adjusted}=.078$], with baseline alerting being significantly associated with alerting following induction [$\beta=.30$, $t=2.72$, $p=.008$]. Adding group and brooding to the model did not significantly improve the model fit [change $R^2=.06$, change $F=2.38$, $p=.100$], although the model remained significant. At this step, both baseline alerting [$\beta=.26$, $t=2.40$, $p=.019$] and group were significantly associated with post-induction alerting [$\beta=.22$, $t=2.02$, $p=.047$], but brooding was not [$\beta=.08$, $t=.78$, $p=.440$]. Adding the interaction term at Step 3 did not improve model fit, and the interaction term was not a significant.

Orienting: The model was non-significant at every step, and none of the entered variables were significantly associated with post-induction orienting.

Conflict: The model was significant at Step 1 [$F(1, 75)=64.73$, $p<.001$, $R^2=.47$, $R^2_{adjusted}=.46$], with baseline conflict performance significantly associated with conflict performance following induction [$\beta=.68$, $t=8.05$, $p<.001$]. Adding group and brooding to the model at Step 2 did not improve the model fit, and neither of the added variables was significantly associated with conflict performance. Similarly, adding the interaction term did not improve the model and the interaction term was not significant.

PHQ-9 scores and GAD-7 scores

Findings for PHQ-9 scores presented a similar pattern. Alerting was best described by the model at Step 2; baseline alerting [$\beta=.25$, $t=2.33$, $p=.023$] and group [$\beta=.22$, $t=2.04$, $p=.045$] were significantly associated with post-induction alerting, whilst depression was not [$\beta=-.17$, $t=-1.56$, $p=.122$]. Adding the interaction term did not improve the model. Orienting was not significantly associated with any of the variables entered. Conflict was associated only with baseline conflict. Similarly for analyses with GAD-7 scores: alerting was associated only with baseline alerting [$\beta=.26$, $t=2.36$, $p=.021$] and group [$\beta=.23$, $t=2.03$, $p=.046$]. Orienting was not associated with any of the variables entered. Conflict performance was associated only with baseline conflict performance [$\beta=.66$, $t=7.52$, $p<.001$].

Group differences in infant cue processing

The ratings of the two groups on the infant cue processing task were compared using independent sample t-tests. Face and voice ratings were analysed separately, as was each valence category. There were no significant differences between groups in mean ratings for any

of the stimulus categories. Means, standard deviations and t-test statistics are shown in Table 5.5.. The pattern of findings remained the same when participants with previous childcare experience were removed from the analysis.

Interactions between induction and baseline variables

Correlations between baseline variables (RRS brooding, PHQ-9, GAD-7) and infant face/voice ratings were examined. This indicated some correlations with GAD-7 scores, such that people with higher anxiety scores tended to rate negative items more negatively. This was significant for very negative faces, muted negative faces and very negative voices (see Table 5.6*).* None of the correlations between infant cue ratings and RRS or PHQ-9 scores reached significance. The pattern of findings remained similar when participants with previous childcare experience were removed from the analysis, with the exception that the correlation between very negative faces and GAD-7 score became non-significant [r=-.18, p=.130].

Table 5.5. Group comparisons of infant face and voice ratings.

Stimuli	Rumination group Mean (SD)	Control group Mean (SD)	*t*	*p*	*g*
Faces: very negative	-2.45 (.61)	-2.43 (.63)	.157	.875	0.04
Faces: muted negative	-1.42 (.39)	-1.42 (.56)	.007	.995	<0.01
Faces: neutral	-.45 (.42)	-.32 (.40)	1.26	.211	0.29
Faces: muted positive	.64 (.48)	.80 (.57)	1.39	.169	0.32
Faces: very positive	1.84 (.62)	1.89 (.72)	.37	.712	0.09
Voices: very negative	-2.20 (.82)	-2.12 (.78)	.43	.667	0.10
Voices: muted negative	-1.55 (.76)	-1.48 (.73)	.44	.663	0.10
Voices: neutral	.33 (.65)	.31 (.71)	-.16	.876	0.04
Voices: muted positive	.68 (.68)	.86 (.63)	1.15	.252	0.27
Voices: very positive	1.36 (.60)	1.43 (.54)	.52	.604	0.12

Table 5.6. Correlations between baseline questionnaire scores and infant face/voice ratings.

Stimuli	GAD-7 score	PHQ-9 score	RRS total score	RRS brooding
Faces: very negative	-.23 **(.045)***	-.01 (.384)	-.12 (.296)	-.19 (.088)
Faces: muted negative	-.24 **(.031)***	-.11 (.259)	-.09 (.459)	-.20 (.078)
Faces: neutral	-.10 (.394)	.001 (.990)	.05 (.682)	.00 (.98)
Faces: muted positive	-.09 (.404)	-.14 (.211)	-.15 (.187)	-.09 (.454)
Faces: very positive	-.01 (.961)	-.08 (.498)	-.10 (.390)	-.03 (.810)
Voices: very negative	-.30 **(.008)***	-.20 (.083)	-.11 (.327)	-.17 (.129)
Voices: muted negative	-.19 (.099)	-.14 (.227)	-.02 (.871)	-.10 (.397)
Voices: neutral	-.08 (.468)	-.17 (.139)	-.09 (.439)	-.02 (.897)
Voices: muted positive	-.04 (.701)	-.04 (.699)	-.08 (.463)	-.09 (.440)
Voices: very positive	.10 (.380)	-.004 (.974)	-.02 (.881)	.06 (.586)

Possible interactions between baseline variables and induction condition on infant cue processing were examined using hierarchical linear regressions. For each baseline variable (RRS brooding, PHQ-9, GAD-7), scores were centred and combined with the induction group to create an interaction term. The baseline variable and group were entered in the first block of the regression, with the interaction term entered in a second block. A regression was conducted separately for each category of face/voice stimulus and for each baseline measure (RRS brooding, PHQ-9, GAD-7).

None of the analyses for RRS brooding effects were significant – that is, neither group, RRS scores, nor the RRS*group interaction term were associated with ratings for any of the face/voice stimulus categories. Similarly, with PHQ-9 entered as the baseline variable, none of the models were significant. For GAD-7 scores and very negative voices, the model was significant at Step 1 [$F(2, 78)=3.72$, $p=.029$, $R^2=.089$, $R^2_{adjusted}=.065$] and GAD-7 was a significantly negatively associated with voice rating [$\beta=-.297$, $t=-2.69$, $p=.009$]. Group was not a significant predictor [$\beta=-.011$, $t=-.10$, $p=.922$] and adding the interaction term did not improve the model. The GAD-7 models for all other face and voice stimuli were non-significant.

When participants with previous childcare experience were removed from the analysis, two of the models became significant. Firstly, the model examining PHQ-9 scores as a possible correlate of neutral voice ratings was significant: $F(3, 69)=2.84$, $p=.045$, $R^2=.114$, $R^2_{adjusted}=.074$. Neither PHQ-9 score [$\beta=.027$, $t=.18$, $p=.860$] nor group [$\beta=-.052$, $t=-.45$, $p=.658$] were significantly associated with neutral voice ratings, but the interaction term of PHQ-9 score*group was significantly correlated with ratings [$\beta=-.355$, $t=-2.34$, $p=.022$]. This interaction reflects the fact that PHQ-9 scores were negatively correlated with neutral voice ratings for participants in the rumination condition [$r=-.44$, $p=.003$] but not participants in the control condition [$r=.03$, $p=.874$].

Secondly, the model examining GAD-7 scores as a possible predictor of neutral voice ratings was also significant: $F(3, 69)=4.17$, $p=.009$, $R^2=.159$, $R^2_{adjusted}=.121$. Neither GAD-7 score [$\beta=.176$, $t=1.13$, $p=.264$] nor group [$\beta=-.035$, $t=-.31$, $p=.760$] were significantly associated with neutral voice ratings, but the interaction of GAD-7 score*group was significantly correlated with ratings [$\beta=-.499$, $t=-3.20$, $p=.002$]. This interaction reflects the fact that GAD-7 scores were negatively correlated with neutral voice ratings, for participants in the rumination condition [$r=-.50$, $p=.001$] but not participants in the control condition [$r=.20$, $p=.319$].

Discussion

Participants recruited to this study in general represented a subclinical group, with mean levels of anxiety and depression in the moderate range (Kroenke et al., 2001; Spitzer et al., 1999; Spitzer et al., 2006). Groups were largely well matched on demographic and clinical variables, with the exception of previous childcare experience. The possible effects of this group difference were explored by repeating all analyses of the infant cue task whilst excluding those participants with previous childcare experience.

The rumination induction had the expected effects on reported mood and cognitive style. The induction increased negative affect, reduced positive affect and induced more negative, self-focused and repetitive thoughts, compared to the control condition. However, whilst these effects were evident following the induction procedure, they did not appear to be well sustained. This may be due to use of compensatory or self-regulatory strategies on the part of the rumination group – this group reported greater focus on the infant rating task than did controls. As this task immediately followed the induction procedure, it could be hypothesised that this reflects a strategy to reduce or avoid further rumination, through distraction or re-orienting of attention to an external task. The correlation between task focus and mood recovery (increase in positive affect across the task) seems consistent with this suggestion.

The induction procedure did not appear to have any effect on performance on the attention task, with no interactions between group and time for alerting, orienting or conflict performance. Attention performance was also not associated with interactions between baseline anxiety, depression or rumination and induction condition. Similarly, there were no significant group differences in ratings of face or voice stimuli on the infant cue perception task. Induction group was not associated with face or voice ratings and baseline variables (brooding rumination,

depression) were not associated with face and voice ratings, either alone or in interaction with induction group. There were however some correlations between anxiety and infant cue ratings, such that participants with higher anxiety scores gave more negative ratings to negatively-valenced face and voice stimuli. Caution is warranted in interpreting these findings, as they would no longer reach statistical significance if corrections for multiple testing were applied. However, this finding is consistent with many previous studies that have demonstrated an association between anxiety and negative interpretive biases (MacLeod & Mathews, 2012; Mathews & MacLeod, 2005; Ouimet, Gawronski, & Dozois, 2009).

When participants with previous childcare experience were removed, in order to better match the groups, two significant interaction effects emerged. The interaction between depression score and induction group, and the interaction between anxiety score and induction group, were both associated with neutral voice ratings. In both cases, depression and anxiety scores were negatively correlated with neutral voice ratings, specifically for participants in the rumination induction group. This suggests that for affectively neutral voice stimuli, baseline depression and anxiety biased ratings towards more negative scores, but only when participants were also exposed to an induced rumination procedure. In contrast, following the control procedure, baseline levels of anxiety and depression did not affect these ratings. This may suggest that the induction has the effect of 'activating' negative biases in participants with higher levels of baseline depression or anxiety.

These interactions were specific to the neutral voice stimuli, which is consistent with previous findings that perception of emotionally neutral or muted stimuli are more affected in depression than perception of prototypical emotional expressions (Joormann & Gotlib, 2006). It is also of note that these interaction effects emerged for vocal stimuli only, and not for facial stimuli. This may parallel the finding from Stein and colleagues (Stein et al., 2012) that rumination induction

has particular effects on responsiveness to infant *vocalization*. Given the suggestion that rumination is a primarily verbal process, it may be that tasks requiring processing of auditory material are particularly affected by current rumination. This possibility could usefully be explored in further work. It is unclear why the interaction effects reported here emerge only when excluding the subgroup of participants with previous childcare experience. These findings require replication, and systematic comparisons of participants with and without previous childcare experience would help to further elucidate these effects.

Strengths and limitations

The use of a rumination induction procedure and randomised group assignment in this study allowed the examination of a possible causal role for rumination in impairing attentional processes and infant cue perception. The use of an induction procedure is a strength of the study design and is likely to be a useful approach for future work in trying to elucidate causal effects. Relatedly, the use of both an induction procedure and a questionnaire measure of rumination allowed some exploration of interactions between trait and state effects of rumination. This has received relatively little attention in the existing literature, and many questions remain about how these processes interact. The study also made use of well-established and validated measures of attention and infant cue processing, facilitating an examination of objective performance on these tasks.

There were however several limitations to the current study. Firstly, whilst the rumination procedure was effective immediately following induction, its effects were apparently not sustained and may not have reliably persisted through the subsequent tasks. There is a need to explore whether induction methods can be refined, to achieve stronger and more sustained effects. For example, it has been suggested that induction procedures requiring participants to

focus on unmet goals may be an effective means of inducing powerful and long-lasting ruminative effects (Roberts et al., 2013; Tester-Jones et al., 2017). Alternatively, using a clinical sample may facilitate stronger induction effects and would also aid generalisation of the findings to clinical groups. The use of a sub-clinical, non-parent sample allowed me to perform an initial test of several hypotheses but does not allow generalisation of these findings to clinical groups with PND. As discussed in the introduction, there appear to be differences in infant processing between parent and non-parent participants; indeed, the results of the current study showed some key differences when participants with previous childcare experience were removed from the analysis. Future work will therefore require use of parent participants to rigorously examine these effects. Similarly, although rumination, independent of clinical status, may be relevant to parental sensitivity and responsiveness (Tester-Jones et al., 2017), exploring the effects of rumination specifically in the context of clinical depression is likely to be important. It is increasingly clear that the greatest effects of PND on child development occur in the context of severe and sustained depression (Netsi et al., 2018) and so examining these effects in relevant clinical populations is likely to provide clearer insights into the cognitive processes that account for this impact.

This study did not directly examine parent-infant interactions, and the stimuli included in the infant cue task were of unfamiliar infants. The advantage of this design is that it allows for an objective measure of performance with standardised stimuli. However, it is not clear how performance on these tasks, using non-self-relevant stimuli, relates to performance during live interactions with one's own infant. Computerised tasks with unfamiliar infants are likely to differ substantially from live interaction, in terms of their salience and their affective and motivational effects, although relationships between standardised infant task performance and live interaction have rarely been examined. It is unclear then how closely related task performance is to live parent-infant interaction. Whilst experimental studies demonstrate that rumination plays a

causal role in impairing sensitivity during live interaction (Stein et al., 2012; Tester-Jones et al., 2017), it is not yet clear whether this effect is mediated by changes in infant cue processing. It may be that other processes are (also) implicated, for example impairments in planning and executing an appropriate behavioural response.

Conclusions

This study builds on previous work utilising rumination induction procedures and suggests that these approaches have utility for examining causal questions relating to the role of rumination in affecting mother-infant interaction quality. Relatively brief, simple induction procedures appear to have measurable effects on affect and cognition, which are consistent with an induced pattern of ruminative thought. However, there may be challenges with attempting to induce effects that are long-lasting enough to affect subsequent tasks, particularly in non-clinical populations. In the current study, the rumination induction did not appear to have robust effects on subsequent attentional performance or infant cue processing. This may be due to the use of self-regulatory strategies by participants, such as redirecting attention to external tasks following the rumination period. Future studies should continue to explore the effects of rumination on both live mother-infant interactions, and on related measures such as infant cue processing tasks. Similarly, continued examination of the associations between rumination and attentional performance, using a range of attentional measures, will help to further elucidate these relationships. It will be important in future studies to examine these effects in parent groups and clinical populations, as well as making use of analogue samples where appropriate.

Given the prevalence of PND and accumulating evidence of its effects on child development, there is an urgent need to better understand the mechanisms through which PND affects mother-infant interactions and so confers risk for negative child outcomes. Rumination is a promising

mechanism that is amenable to study via experimental designs and provides a possible target for prevention and intervention efforts (Mor & Daches, 2015; Topper et al., 2010; E. R. Watkins & Nolen-Hoeksema, 2014). Such interventions have the potential to provide benefits not only for maternal mental health, but also for the mother-infant relationship and child developmental outcomes.

In the next chapter (Chapter 6), I explore the potential utility of cognitive training interventions as a means of targeting rumination. The chapter describes findings from a cognitive training study in a group of individuals with high trait rumination, and examines whether increasing cognitive control via training procedures is an effective means of reducing rumination. Training designs facilitate testing of hypotheses regarding the causal role of underlying cognitive control deficits, and may also have potential clinical applications.

Chapter 6. Training cognitive control in individuals with high trait rumination

Cognitive control, depression and rumination

As described in previous chapters, many cognitive models of rumination highlight a key role for cognitive control deficits. It is hypothesised that deficits or biases in cognitive control have the effect of impairing effective regulation of ruminative thought processes, such that these become prolonged and perseverative, and are easily triggered in the presence of negative mood (Joormann & D'Avanzato, 2010; E. H. W. Koster et al., 2011; E. R. Watkins & Nolen-Hoeksema, 2014). Deficits in cognitive control have been consistently demonstrated in individuals with depression and vulnerable groups (Grahek et al., 2018; E. H. W. Koster et al., 2017; Snyder, 2013). Recent reviews indicate that high levels of rumination are similarly associated with impairments in cognitive control (Mor & Daches, 2015). Theoretical accounts suggest that deficits in cognitive control affect selection of emotional regulation strategies, for example promoting greater use of rumination, which then confers increased risk for depression (E. H. W. Koster et al., 2017). Several studies have now found evidence of this mediating effect (see Chapters 2 and 3).

Cognitive training designs

The development of cognitive training designs has made it possible to test the hypothesised causal role of cognitive control deficits in depression, by training cognitive control and examining subsequent effects on depressive symptoms. There is considerable interest in cognitive training procedures, both as a tool for examining causal mechanisms and as potential interventions. Recent reviews of studies in this field have concluded that there is some evidence for cognitive training as an effective intervention in individuals with clinical depression or individuals who are vulnerable to depression, although findings are somewhat mixed and questions remain regarding

how best to optimise and target such interventions (E. H. W. Koster et al., 2017). There is also increasing interest in using cognitive training to target hypothesised proximal maladaptive emotional regulation strategies, such as worry and rumination. It has been suggested that targeting these processes may have considerable utility for both treatment and preventative efforts, as well as providing a robust test of the hypothesised role of these processes in depression vulnerability.

Cognitive training tasks target cognitive processes such as attentional control and working memory, as a means of producing improvement on some clinically relevant outcome. It is proposed that improvements in cognitive performance can 'transfer' to other untrained outcomes, thus potentially providing broad benefits. Various cognitive training tasks have been used to target depression, rumination and other repetitive negative thought processes (e.g. worry, intrusive thoughts). Key common features of such tasks are a requirement for sustained focus on target stimuli and/or the ability to ignore irrelevant or no-longer-relevant stimuli. Use of a large number of training trials, often over several sessions of training, and adaptive task designs (i.e. tasks that increase/decrease in difficulty depending on performance) appear to be important features of many of these training paradigms (E. H. W. Koster et al., 2017).

Whilst there has been considerable interest in cognitive training in recent years, this remains a controversial area – findings are mixed in terms of the effectiveness of training and many questions remain regarding how best to optimise and target such interventions. Although there is now broad consensus that multiple sessions of training tend to be more effective than single-session training (Hallion & Ruscio, 2011; E. H. W. Koster et al., 2017), it remains unclear what constitutes a minimum effective dose of training and how variation in training schedules (e.g. number, length, timing of sessions) impacts on training effectiveness. Similarly, questions remain regarding how best to optimise training, e.g. through the design of training tasks, selection of task

stimuli, and content of task instructions/rationale. There is growing evidence that significant individual differences are evident in response to training, with some participants demonstrating greater gains than others (Grol et al., 2018; Hotton, Derakshan, & Fox, 2018). There is therefore considerable interest in identifying moderators of training outcome, including both factors related to the study design and individual differences between participants. This issue has to-date received relatively little systematic investigation (E. H. W. Koster et al., 2017).

Other key considerations for cognitive training studies include selection of outcome measures and length of follow-up. In most cases, outcome is only assessed immediately following training and therefore the longer-term impact of training remains largely unexamined. Brief follow-up periods may affect the likelihood of demonstrating change on some clinical measures; for example, assessments of depressive symptoms and trait rumination are unlikely to show substantial change over short time frames. There is then a need to identify outcome measures that are more appropriate for assessing change over short periods. The design of appropriate control conditions also requires careful consideration in cognitive training designs, with options including sham training and no-training/wait-list conditions. Sham training has the advantage of controlling for general factors (e.g. rationale/expectancy effects, adherence to a training schedule), but can often be conceptualised as effectively providing 'low dose' training. Such designs may then make it difficult to demonstrate between-group differences in outcome, but provide strong evidence of the specific benefits of training where group differences are found (Melby-Lervag, Redick, & Hulme, 2016).

The mechanisms of change for cognitive training also require further elucidation. It is hypothesised that any clinical benefits result from improvements in cognitive control. However, several studies have failed to demonstrate near-transfer (i.e. change in performance on closely related cognitive tasks) or have failed to show associations between cognitive improvements and

clinical change (E. H. W. Koster et al., 2017; Mor & Daches, 2015); in other studies, these mechanisms have not explicitly been tested.

There are then various outstanding methodological and theoretical issues that remain to be addressed in relation to cognitive training designs. In addition, relatively few studies have specifically assessed the impact of cognitive training on rumination. The current study begins to address some of these outstanding issues.

Study design and training tasks

The current study examined the effects of two specific training tasks: the adaptive Paced Auditory Serial Addition Task (PASAT) (Gronwall & Sampson, 1974) and an innovative music-listening task based on the Attention Training Task (ATT) (A. Wells, 1990, 2009). The effects of these tasks were compared to an active control condition, in a population characterised by high levels of trait rumination. The PASAT involves sequentially adding numbers, presented at a fixed speed, and is a highly challenging task involving substantial demands on attention and working memory. In the adaptive training version of this task, the speed of presentation of the numbers is varied according to the number of consecutive correct/incorrect responses made – it is thus adapted to the performance of each participant. The task uses emotionally neutral stimuli, but the task context is thought to be stressful, due to the challenging task demands and high number of errors inevitably committed (G. Siegle, Ghinassi, & Thase, 2007). The task may therefore also contain a requirement for active emotional regulation. The ATT is a selective listening task that involves attending to a specified target from a complex array of simultaneously presented environmental sounds (e.g. bells, water, traffic noise). Over the course of the task, participants are asked to listen selectively to specific sounds, switch their attention between different sounds, and finally

to divide their attention across the full array. Repeated training on this task is hypothesised to reduce self-focus and improve attentional control (Papageorgiou & Wells, 2000).

The adaptive PASAT and ATT have been used either independently or in combination in several previous training studies. The combination of both tasks has been trialled for treating depression, in both inpatient and outpatient clinical populations, with evidence that training reduces negative affect and rumination (Calkins, McMorran, Siegle, & Otto, 2015; G. Siegle et al., 2007). The adaptive PASAT has also been used as a stand-alone intervention in various populations including healthy students, students with high levels of rumination, and current and remitted depressed patients (Hoorelbeke & Koster, 2017; Hoorelbeke et al., 2016; Hoorelbeke, Koster, et al., 2015; Vanderhasselt et al., 2015). These studies have demonstrated training-related reductions in rumination, and in some cases also improvement in mood or depressive symptoms. In most of these studies, transfer of training gains to untrained cognitive control tasks was also demonstrated, confirming the hypothesised mechanism of action. In a case series, ATT training alone was associated with reductions in rumination, depression and anxiety in patients with recurrent major depression (Papageorgiou & Wells, 2000). In addition, the ATT has been tested in the context of traumatic/stressful life events, and shown to reduce the frequency of intrusions and negative affect associated with participants listening to a narrative of their traumatic experience. Participants also reported changes in attention, including reduced self-focus and increased attention flexibility (Callinan, Johnson, & Wells, 2014; Nassif & Wells, 2014).

There is then some evidence that both the adaptive PASAT and the ATT can be utilised to reduce rumination and depressive symptoms. It is hypothesised that symptom change following training occurs via increases in cognitive control. In several studies, transfer of training gains to untrained cognitive control tasks supports this mechanistic model. Also in support of this account, a common finding across cognitive training studies is that engagement with training or degree of

improvement on the training task are associated with size of improvement in clinical outcomes (Calkins et al., 2015; Hotton et al., 2018; Sari, Koster, Pourtois, & Derakshan, 2016; G. J. Siegle et al., 2014; Vanderhasselt et al., 2015). However, this association has not been replicated across all studies and in many cases has not been examined (E. H. W. Koster et al., 2017). Studies utilising the PASAT or combined PASAT + ATT protocol have typically involved 3 to 10 sessions of training, delivered over 1 to 2 weeks, with some studies showing benefit in vulnerable groups after as few as 3 sessions (E. H. W. Koster et al., 2017). However, there has been no systematic evaluation of the dose/intensity of training required to reliably improve cognitive control or to produce benefit on clinical outcomes. In the current study therefore, a pragmatic decision was made to include 5 sessions of training, delivered over one week.

It has previously been suggested that it may be possible to adapt and enhance the ATT by using musical stimuli (Graham, 2010), but to my knowledge there are no published reports utilising this approach. There are several potential advantages to using musical stimuli in this context. Musical training is known to have benefits that extend beyond the specific trained skills and may confer broad benefits via its effects on motivation, reward and mood. It has also been argued that the rhythmic qualities of music may have specific attentional effects, perhaps 'scaffolding' the development of attention and other executive processes (Miendlarzewska & Trost, 2013). It has been proposed that these effects on executive functions may account for transfer of benefit to various, apparently unrelated, domains (Moreno & Farzan, 2015). There are then several reasons to suggest that using music as a training stimulus may be an interesting adaptation of the ATT, with potential benefits for transfer of training and for the acceptability of training. However, these hypotheses remain untested. One of the aims of the current study was to test such an adaptation and compare this to a more established training task (adaptive PASAT), as well as to a control training condition.

Outcomes assessed

The main outcome of interest was change in performance on a behavioural task designed to assess in-session rumination. This task was adapted from a worry measure developed by Hirsch and colleagues, known as the Breathing Focus Task (C. R. Hirsch, Hayes, & Mathews, 2009) (see *Method*, page 171, for a description). Other outcomes assessed included: improvement on the trained task, near transfer effects (change on untrained measures of cognitive control and working memory) and far transfer effects (change in symptoms of depression and anxiety, trait rumination). Change on measures of social cognition were also examined from pre- to post-training. Recent reviews have noted that depression is associated with broad impairments in social cognition, including deficits in empathy and theory of mind (Bora & Berk, 2016; Kupferberg et al., 2016). These deficits may partially account for the difficulties in social functioning associated with depression (Bora & Berk, 2016; Gadassi & Rafaeli, 2015). High levels of rumination are similarly associated with social impairment, including difficulties in relationships, interpersonal distress and poorer social problem-solving (Donaldson & Lam, 2004; Lam et al., 2003; Nolen-Hoeksema et al., 2008). The association between rumination and changes in social cognition is less well established, but a small number of studies have shown rumination-related changes in processes such as empathy (Joireman et al., 2002; Troyer & Greitemeyer, 2018). Theoretical models conceptualise rumination as a form of preoccupation, which may impair social cognition by promoting an internal focus of attention and making attending to social cues challenging (Stein et al., 2009; Tse & Bond, 2004). Improvements in attentional control derived from training, and associated reductions in intrusive rumination, could then potentially confer benefits for social cognitive performance. Social cognitive outcomes have however rarely been examined in cognitive training studies.

Aims and hypotheses

The aims of the study then were to examine the effects of two forms of cognitive training – a musical selective listening task (musical ATT) and the adaptive PASAT – in a sample of participants selected for high trait rumination. Several outcomes were measured, including improvement in performance on the training task, near transfer effects (other tasks measuring attention and working memory) and far transfer effects (state and trait rumination, symptoms of depression and anxiety, social cognitive performance).

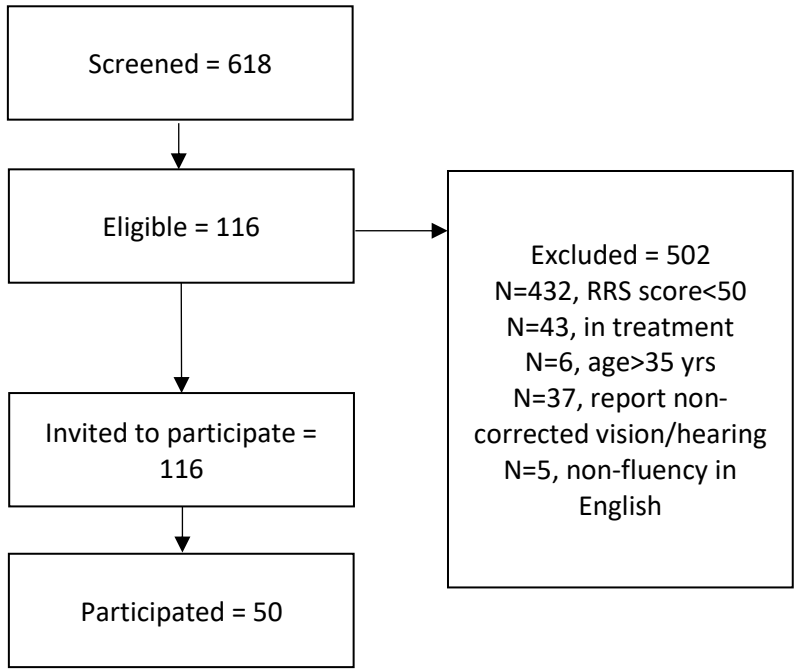
It was hypothesised that completion of the active training tasks, compared to the control condition, would lead to improved performance on the trained task, improved attention and working memory performance on other (untrained) tasks, and fewer negative intrusive thoughts during the breathing-focus task (i.e. reductions in state rumination). It was also hypothesised that individual differences in training-related improvement would be associated with change on these outcome measures, such that participants who showed the greatest gains on the training tasks would also show the largest change on transfer measures.

Method

Participants

50 participants with high levels of rumination were recruited using a combination of social media advertising, e-newsletters and posters. Initial screening for the study was completed online, and included questionnaire measures of depressive symptoms, rumination and empathy[24]. Participants meeting inclusion criteria were then invited to participate in the training study. Inclusion criteria included total rumination score ≥ 50 (Ruminative Responses Scale; RRS), age 18-35 years, normal or corrected-to-normal vision and hearing, and English language fluency. RRS score ≥ 50 was set as a cut-off, as this is approximately 1 SD above the mean in previous non-clinical samples (Nolen-Hoeksema, Larson, & Grayson, 1999; Schoofs et al., 2010). Participants who reported current treatment for a mental health condition were excluded from participation. The screening and recruitment process are depicted in Figure 6.1.

Figure 6.1. Recruitment flow diagram[25]



[24] See Chapter 4 for analysis of these data.
[25] More than one reason for exclusion may apply to the same participant.

Measures

Questionnaires[26]

Patient Health Questionnaire (PHQ-9) (Spitzer et al., 1999) & Generalised Anxiety Disorder Questionnaire (GAD-7) (Spitzer et al., 2006)

For description of these questionnaires, see Chapter 2, page 68.

Ruminative Responses Scale (RRS) (Nolen-Hoeksema & Morrow, 1991)

For description of this measure, see Chapter 2, page 67.

Penn State Worry Questionnaire (PSWQ) (Meyer et al., 1990)

The PSWQ is a 16-item self-report measure of trait worry, with high validity and good test-retest reliability. Items are scored on a 5-point scale from 1 (not at all typical of me) to 5 (very typical of me). Several items are reversed scored, and all items added to give a total score ranging from 16 to 80. A measure of worry was included due to the high degree of similarity between, and high co-occurrence of, different forms of repetitive negative thinking (T. Ehring & Watkins, 2008).

IQ measure

National Adult Reading Test (NART) (Nelson, 1982)

The NART is a brief reading test that is widely used to provide an estimate of IQ. The task involves reading aloud a list of 50 words, which are 'irregular' (i.e. do not follow typical pronunciation rules) and therefore require prior knowledge of the word to pronounce correctly. Participants' performance was audio-recorded and each recording was scored for accuracy. Data for 13(26%) of the participants was scored by two researchers, in order to calculate inter-rater reliability.

[26] For copies of the questionnaire measures, see Appendix A.

Error scores for each participant were used to generate an estimate of verbal IQ, using the equation: *estimated Verbal IQ = 129.0 – 0.919 × no. of errors*.

Verbal IQ was included as a baseline comparator between groups, as verbal intelligence is known to correlate highly with working memory ability (Ackerman, Beier, & Boyle, 2005) and is also associated with social cognitive performance, particularly as measured by the Reading the Mind in the Eyes task (RMET – see below, page 172) (Peterson & Miller, 2012).

Attention and working memory measures – near transfer

Attentional Network Task (ANT) (Fan et al., 2002)

For a description of the ANT, including task design, administration and calculation of key indices, see Chapter 2, page 68.

Running Span task (Broadway & Engle, 2010)

Running span tasks are working memory tasks that require participants to recall the last n items from a list of items that is m + n items long. In this version, sequences of letters were visually presented. Participants were asked to recall sequences of between 3 and 6 letters. Trials included 3 to 8 items in total, with between 0 and 2 distractor items. Each letter was presented for 300ms, with a 200ms blank screen between items. Participants were asked to recall the last n items of a trial, in the correct order. Responses were made by selecting letters from a visual display. There was an option to insert 'blank' items in the response sequence if needed. Participants completed 4 practice trials, followed by 12 experimental trials. Two scores were generated: the total number of correctly recalled items, and the total number of correctly recalled items from partial recall trials only (i.e. trials with at least one distractor present)[27].

[27] The task script is available online at: www.millisecond.com/download/library/RunningSpan/

State rumination measure – far transfer

The state rumination measure was adapted from a worry task, developed by Hirsch and colleagues (C. R. Hirsch et al., 2009). The task consists of 3 sequential periods, each lasting 5 minutes: 1) breathing focus, 2) rumination focus, 3) breathing focus.

During the breathing focus periods, participants were asked to close their eyes and try to focus their attention on their breathing only. A computer-generated sound at random intervals of 20-30 seconds, acted as a cue to report current thoughts. Participants were asked to report whether they were still focused on their breathing, or if another thought had come to mind. Brief thought content and valence (positive, negative, neutral) were also collected. There were 12 probes in each breathing focus period. Following the breathing focus period, participants were asked to rate their mood during this time on 3 visual analogue scales (depressed, anxious, happy) and to rate how much of the time they spent focused on their breathing, how difficult this was, and how much time they spent ruminating.

During the rumination period, participants were instructed to spend 5 minutes with their eyes closed focusing on a current problem or concern, "dwelling on or ruminating about this problem, in the way you would normally ruminate about an unresolved problem". They were instructed that this should be an unresolved problem, which had been coming to mind recently and making them feel sad, down or stressed. The participant was asked to briefly state the problem/concern selected, in order to check compliance with instructions. The instructions for this section were adapted from the rumination induction procedure reported by Roberts et al. (2013). Following the final period of breathing focus, participants were asked to think back to the rumination period and rate their mood during this time on 3 visual analogue scales (depressed, anxious, happy) and to report on the contents of their thoughts (time spent ruminating, difficulty focusing on rumination, proportion of positive/negative/neutral thoughts).

Social cognition measures – far transfer

Frith-Happé Animations (Castelli, Happé, Frith, & Frith, 2000)

This task utilised a set of 4 brief animations, developed to assess implicit understanding of social interactions and mental states. During the animations, two triangles interact with one another, depicting complex social processes such as 'tricking' and 'persuading' through patterns of movement. Participants were asked to watch each animation and describe what they saw happening. Descriptions were audio recorded and scored for intentionality and appropriateness. Intentionality is scored from 1-5 and indicates the degree of complexity of social/mental state descriptions provided. Appropriateness is scored from 0-3 and indicates the accuracy with which the participant described the scenario depicted in the animation. N = 12 (24.5%) descriptions were double scored in order to assess inter-rater reliability.

Reading the Mind in the Eyes task (RMET) (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001)

The RMET is an explicit measure of advanced theory of mind, which asks participants to view photographs of eyes and to decide what the person depicted is thinking or feeling. It consists of 36 greyscale photos, each presented with a choice of 4 response options. A word list is available for participants to look up definitions as needed. For each item, one option is considered correct, based on a panel consensus during the initial psychometric study. Test-retest reliability is acceptable and the test shows good correspondence with other theory of mind measures, as well as expected differences between clinical and non-clinical groups.

Training tasks and training evaluation

Training tasks were completed at home, using the Inquisit online presentation software. Participants were given a rationale for training during the first research appointment, before

completing a short practice version of each training task. Participants were asked to complete 5 sessions of training over the following week, each comprising approximately 20 minutes training in total (10 minutes PASAT, 10 minutes musical ATT). Participants were randomised to one of 3 training conditions using a random number generator:

a) Musical ATT condition: active musical ATT; sham PASAT
b) PASAT condition: sham musical ATT; active PASAT
c) Control condition: sham musical ATT; sham PASAT

Participants were blind to treatment allocation but researchers[28] were aware of each participant's training condition, due to the need to provide instructions and practice training during the initial research appointment.

Musical ATT

The musical training task was developed for this study, and was adapted from Wells' (1990) Attention Training Task (ATT). In the adapted version, the neutral environmental sounds used in the original task were replaced with music. The pieces of music used were two movements from Brahm's trio for clarinet, cello and piano (Op.114) - Andantino grazioso (III) and Allegro (IV). Participants in the active condition were instructed to listen selectively to different instruments (~2.5 minutes), then to switch attention rapidly between instruments (~1 minute), and finally to divide their attention between all the instruments (~1 minute). Listening instructions were presented visually onscreen throughout the task. This procedure was repeated for the second piece of music. At the end of both pieces, participants were asked to answer several questions, presented on the screen, regarding: degree of focus on the music, ability to listen selectively to a

[28] The majority of the data collection was completed by the D.Phil candidate, but a small number of assessment sessions were conducted by research assistants who were trained and supervised by the candidate.

particular instrument whilst ignoring other instruments, degree of distraction by thoughts or environmental stimuli, and enjoyment of the music.

Participants in the sham condition were instructed to simply listen to the music and try to focus their attention on it throughout. At the end of the music, participants were asked to rate: their degree of focus on the music, degree of distraction by thoughts or environmental stimuli, and enjoyment of the music.

Paced Auditory Serial Addition Task (PASAT) training (Calkins et al., 2015; Gronwall & Sampson, 1974; G. Siegle et al., 2007)

The PASAT is a numerical task, in which participants are presented with a sequence of numbers and after each item are asked to add the previous two numbers. Numbers were presented audibly, and participants were asked to respond by selecting the correct response from a visual numerical display (1 to 18), using a mouse click. The task was adaptive, such that the speed of presentation increased if participants gave 4 correct consecutive responses and decreased if participants gave 4 incorrect consecutive responses. The starting speed was 3000 msec between numbers, with increasing/decreasing speed increments of 100 msec. Participants completed 180 trials each session, in 3 blocks. Measures of performance included: number of correct responses, longest consecutive sequence of correct responses, minimum inter-stimulus interval (ISI) and median ISI.

For the sham condition, the same stimuli were used, but participants were asked simply to respond after each item by selecting the last number presented. The task was adaptive, with ISI increasing and decreasing in a similar way to the active version.

Training credibility/expectancy questionnaire (Devilly & Borkovec, 2000)

A credibility/expectancy questionnaire was used to assess participants' beliefs about the credibility of the training, and likelihood of it affecting their levels of rumination. The original questionnaire was designed to measure treatment expectancy and rationale credibility in clinical outcome studies. The wording of several items was therefore slightly adapted to make it suitable for use in a training study, rather than a treatment study[29].

Procedure

Participation in the study involved attending for two research appointments, as well as completing five sessions of at-home training during the week between appointments. Research appointments were scheduled seven days apart and took part in a quiet room at the University department. The study was approved by the local university ethics committee (ref: R37551/RE001). The rationale given to participants was that the study was designed to test two different procedures for training attention control, and to examine their effects in a group of participants who are prone to rumination.

The initial appointment began with collection of demographic information and completion of questionnaires. Participants then completed the NART and responses were audio recorded for scoring. The ANT and Running Span tasks were administered, followed by the state rumination task and related rating scales. Participants were then asked to complete the Animations and RMET tasks. Finally, the training tasks were explained and a short practice version of each task was completed. Participants were shown how to access the training at home and asked to complete five sessions of training over the following week. Participants then completed the training expectancy measure.

[29] A copy of the questionnaire is available in Appendix A.

The follow up appointment was scheduled for one week after the initial appointment. This appointment began with completion of questionnaires, followed by the attention and working memory tasks (ANT, Running Span), state rumination task, and social cognition tasks (Animations, RMET). At the end of the appointment, participants were debriefed and compensated for their time and travel expenses.

Statistical analysis

All analyses were performed using SPSS version 22.0. There was a small amount of missing data due to experimenter/participant error, or technical difficulties. All analyses were conducted using all available data. Analysis of training outcomes was conducted using an intent to treat (ITT) approach. In order to explore whether level of adherence to treatment was important for outcomes, the analysis was also repeated including only those participants who completed at least 4 of 5 scheduled training sessions (N=46). Whilst it is unclear what would be an adequate dose of training, it was decided a priori that 80% compliance would be used as a reasonable indicator of engagement with the training protocol. The pattern of results remained the same when only this adherent subgroup was examined, and so only ITT analyses are reported here.

Baseline demographics, clinical characteristics and sessions of training were compared across groups using ANOVA and Chi square tests as appropriate. Effects of training were examined using mixed ANOVA, with training group as a between subject variable and time (pre-, post-training) as a within subject variable. Improvement on the training tasks was first examined, followed by near transfer (untrained attention and WM tasks) and far transfer effects (state rumination, social cognition, questionnaire measures). Partial eta squared effect sizes are reported throughout.

There have been several reports from cognitive training studies that size of training gains are associated with degree of clinical improvement (Calkins et al., 2015; Hotton et al., 2018; Sari et al., 2016; Vanderhasselt et al., 2015). For the PASAT condition, changes in task performance over training were therefore correlated with change on other tasks and questionnaires. Correlations were examined using Pearson's correlation coefficients. No similar analysis was conducted for the music condition, due to the lack of clear improvement on the training task in this condition (see Results).

Results

Baseline characteristics and group matching

A total of 50 participants were included in the study, with 40 female and 10 male participants. The sample was primarily white (N = 40, 80%), with a mean age of 25.72 years [SD=5.80]. All participants were either University students (N = 29, 58%) or currently employed (N = 21, 42%). NART scores indicated that mean estimated verbal IQ for the participants in this study was 112.07, with a relatively narrow range of scores [SD=5.99, min=97.75, max=124.41]. Thirteen (26%) of the NART assessments were double scored and interrater reliability was found to be high [ICC=.908, p<.001].

Sex distribution, estimated verbal IQ, education, ethnicity and age were all matched across training conditions, with no significant differences between groups (see Table 6.1).

By design, rumination (RRS total) was high across the sample [M=61.00, SD=6.20]. Similarly, high levels of worry were reported [PSWQ: M=61.56, SD=9.31]. Mean depression [PHQ-9: M=11.18, SD=6.24] and anxiety scores [GAD-7: M=10.36, SD=4.74] were in the moderately severe and moderate ranges respectively. Baseline clinical characteristics were generally well matched across training conditions. Anxiety and worry did appear to be somewhat lower in the PASAT training group, compared to the other conditions, although this effect did not reach statistical significance (see Table 6.2).

Table 6.1. Demographic characteristics by training group

	Training condition			
	Music (n=17)	PASAT (n=15)	Control (n=18)	χ^2 (p) / *F* (p)
Sex				
- Male	2	5	3	2.512 (.285)
- Female	15	10	15	
Ethnicity				
- White British	9	9	6	25.417 (.114)
- White other	5	1	10	
- Other	3	5	2	
Education				
- GCSE	0	0	1	5.929 (.431)
- A level	5	8	5	
- Undergraduate	8	3	6	
- Masters or higher	4	3 [1 missing]	6	
Age	26.06 (4.562)	24.13 (5.705)	26.72 (6.858)	.855 (.432)
Estimated verbal IQ	113.05 (5.67)	111.17 (6.42)	111.90 (6.12)	.40 (.676)

Table 6.2. Baseline clinical characteristics by training group

	Training condition			
	Music training	PASAT training	Control training	F (p)
RRS total	62.41 (4.56)	59.53 (3.52)	60.89 (8.78)	.859 (.430)
RRS brooding	13.94 (1.98)	12.47 (2.92)	13.83 (2.55)	1.703 (.193)
RRS reflection	13.35 (2.57)	12.93 (2.28)	12.89 (2.70)	.173 (.842)
PSWQ	63.82 (6.15)	56.73 (11.78)	63.44 (8.40)	3.140 (.052)
GAD-7	11.47 (4.64)	7.93 (4.89)	11.33 (4.16)	3.051 (.057)
PHQ-9	12.71 (5.79)	9.93 (5.93)	10.78 (6.92)	.839 (.439)

GAD-7=Generalised Anxiety Disorder scale, PHQ-9=Patient Health Questionnaire, RRS=Ruminative Responses Scale, PSWQ=Penn State Worry Questionnaire, PASAT=Paced Auditory Serial Addition Task.

Study retention, training compliance and expectancy measures

49 participants returned for a follow up appointment [N = 1 from the control group lost to follow up]. Mean time to follow up was 7.12 days [SD=0.60], with a range from 6 to 10 days. Time to follow up did not differ across training conditions [F(2, 48)=.78, p=.464]. Mean number of sessions of training completed was 4.73 [SD=.88] and number of sessions completed did not differ across conditions [F(2, 46)=.13, p=.875].

Prior to training, there were no group differences in perceived credibility of the training or expectancies about training (all p's >.05). The rationale for training appeared to be well understood by participants, and scores for perceived logicalness of training were high [M=7.08, SD=1.47, rated from 1-10]. There was however a wide range of expectancy, with predicted improvement in rumination ranging from 0 to 80% [M=34.0%, SD=20.70%].

Improvement on training task

PASAT: For the PASAT group, median ISI for each session was used as the key indicator of task performance. An ANOVA analysis of this variable indicated a main effect of time [F=20.74, p<.001], suggesting a significant improvement over the sessions of training. Mean values decreased from M=2164.29msec [SD=310.35msec] in session 1, to M=1742.86msec [SD=297.98msec] in session 5 (see Figure 6.2).

Musical ATT: For the musical ATT condition, two self-report scales were used as key indicators of task performance: 1) ability to focus on the instructed instrument [i.e. the instrument to be attended], 2) difficulty ignoring the other instruments. ANOVA analyses suggested no main effects of time on either of these variables [F(4, 40)=.614, p=.655 and F(4, 40)=.824, p=.518 respectively] (see Figure 6.3 and Figure 6.4), suggesting that there was no robust training effect

on this task. Mean scores for ability to maintain attention to the task ranged from 1.44 [SD=.96] to 2.12 [SD=1.17] across sessions of training (where 1 indicates ability to maintain attention to the task 'some of the time' and 2 indicates 'about half the time'). This suggests that participants struggled to consistently engage with the task, which may account for the apparent lack of improvement with training.

Control: The control group performance on the sham PASAT was high across sessions, with mean accuracy of 87.49% [SD=2.54]. Accuracy did not differ between the first [M=86.88, SD=3.41] and final session [M=88.19, SD=2.82] of training [t(15)=1.89, p=.079]. This suggests that for the control group, engagement with training was sustained across sessions. Reported ability to maintain attention to the sham musical task was similar to that reported by the active group. Mean ratings for this item ranged from 1.62 [SD=.99] to 2.27 [SD=1.03] across sessions of training and did not significantly differ from those of the active training group at any point.

Figure 6.2. Change in median ISI on adaptive PASAT over training.

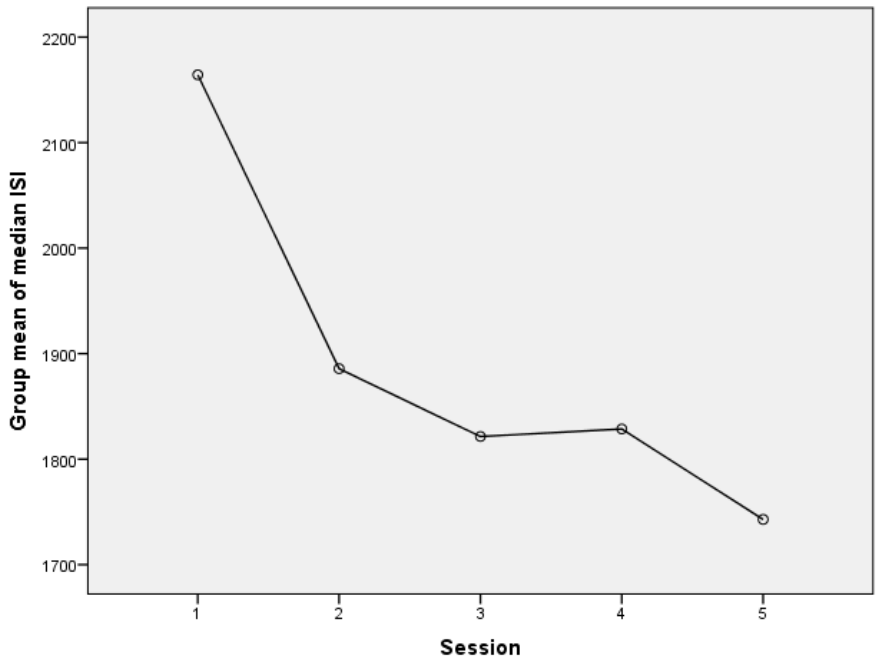


Figure 6.3. Ratings for ability to focus on instructed instrument over training.

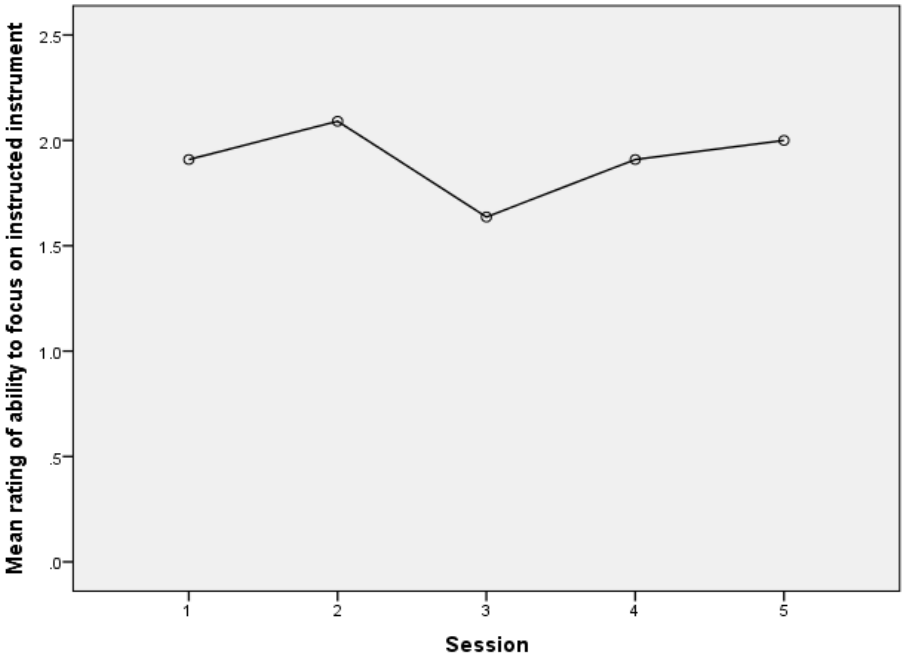
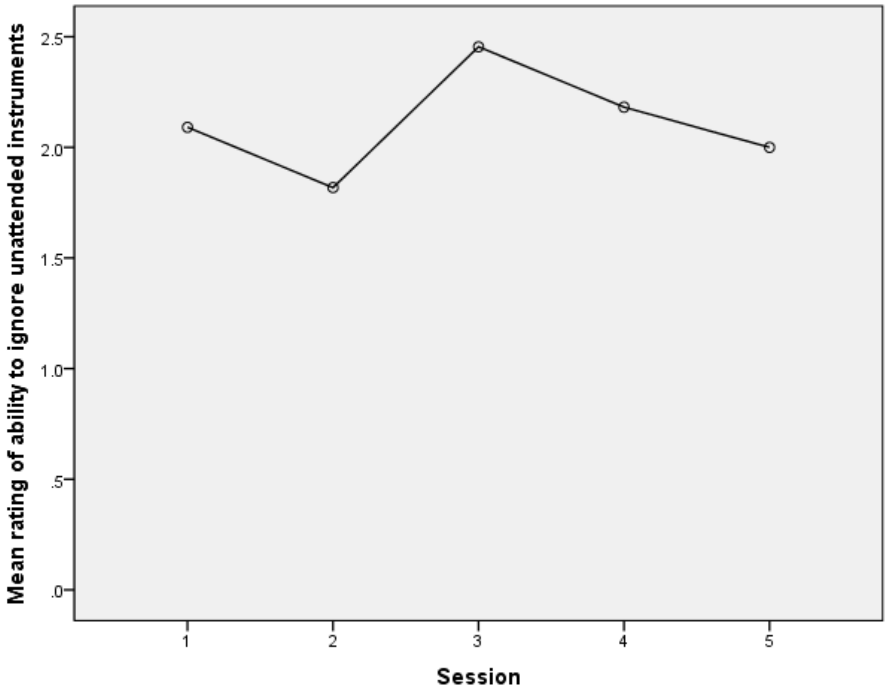


Figure 6.4. Ratings for ability to ignore unattended instruments over training.



Training effects on attention and working memory tasks

For the ANT, mixed ANOVA analyses indicated that there were no main effects of group or time on any of the ANT indices (alerting, orienting, conflict) and no interaction effects. For the Running Span, there was a significant main effect of time, with participants across all conditions demonstrating improved performance at Time 2 (post-training). There was no significant main effect of group, and no significant interaction effect (see Table 6.3).

Training effects on state rumination (breathing task)

A mixed ANOVA was conducted with within subject variables period (pre-/post rumination) and time (pre-/post training) and between-subject variable of group (training condition). The outcome examined was total number of negative thoughts during each breathing period.

As expected, there was a main effect of period, with an increase in negative thoughts following the instructed rumination period. There was also a main effect of time, with participants reporting fewer negative thoughts during breathing periods at the follow up session, compared to the baseline session. There was also a significant a time x period interaction effect, as the change from pre- to post-rumination was larger at baseline [$t(48)=-5.26$, $p<.001$, $d=-0.78$, $M_{pre}=1.86$, $SD_{pre}=1.57$, $M_{post}=3.43$, $SD_{post}=2.18$] than at follow up [$t(48)=-2.34$, $p=.023$, $d=-0.34$, $M_{pre}=1.10$, $SD_{pre}=1.43$, $M_{post}=1.73$, $SD_{post}=1.45$]; i.e. increase in intrusive negative thoughts following the rumination period was smaller following training.

There were no significant main effects of training group, and no interaction effects involving training group, suggesting no differential effects of training condition on state rumination (see Table 6.4).

Table 6.3. Training effects on Attentional Network Task indices and Running Span scores.

	Music training	PASAT training	Control training	Time F, p, η^2	Group F, p, η^2	Interaction F, p, η^2
Alerting t1	39.80(21.76)	56.33 (18.92)	40.81 (15.32)	.07, .792, .002	2.55, .089, .100	1.23, .301, .051
Alerting t2	36.77 (27.33)	49.34 (23.25)	47.85 (25.67)			
Orienting t1	25.82 (18.64)	22.02 (21.67)	22.05 (12.33)	.19, .662, .004	2.49, .094, .100	1.16, .322, .049
Orienting t2	24.55 (14.75)	26.69 (12.07)	14.23 (13.63)			
Conflict t1	67.61 (24.26)	75.59 (29.07)	80.36 (31.24)	1.31, .258, .028	.474, .625, .020	2.14, .129, .085
Conflict t2	74.15 (19.06)	63.55 (22.75)	72.67 (25.11)			
Running Span total t1	32.94 (9.93)	36.67 (5.46)	37.12 (10.08)	**6.39, .015*, .122**	.78, .465, .033	.44, .650, .019
Running span total t2	37.41 (9.00)	38.87 (6.91)	39.29 (8.89)			
RS score t1	18.41 (6.79)	21.80 (4.63)	22.00 (9.05)	**6.90, .012*, .130**	.41, .667, .017	2.21, .121, .088
RS score t2	23.29 (7.11)	22.40 (5.48)	23.47 (7.07)			

Table 6.4. Training effects on number of negative thoughts reported during breathing focus task.

	Music training		PASAT training		Control training	
	Pre-rumination M(SD)	Post-rumination M(SD)	Pre-rumination M(SD)	Post-rumination M(SD)	Pre-rumination M(SD)	Post-rumination M(SD)
Negative thoughts T1	2.06 (1.56)	3.76 (1.75)	2.00 (1.89)	3.47 (2.47)	1.53 (1.28)	3.06 (2.36)
Negative thoughts T2	1.24 (1.48)	2.00 (1.54)	1.20 (1.42)	1.80 (1.37)	.88 (1.45)	1.41 (1.46)

Mixed ANOVA analysis: main effects and interactions

	F	p	η^2
Time	**25.08**	**<.001***	**.353**
Period	**27.98**	**<.001***	**.378**
Group	1.17	.319	.048
Time x period	**5.28**	**.026***	**.103**
Group x time	.03	.969	.001
Group x period	.11	.896	.005
Group x period x time	.01	.991	.000

T1= pre-training, T2=post-training, PASAT=Paced Auditory Serial Addition Task.

Training effects on social cognition

Twelve (24.5%) of scripts for the Animations/Triangles task were double scored. Interrater reliability was examined using intra-class correlation coefficients and indicated high reliability for both the Appropriateness ratings [ICC=.898, p<.001] and the Intentionality ratings [ICC=.792, p=.001]. For the Appropriateness index of the Animations task, there was a main effect of time with performance improving from pre- to post-training. There was no main effect of group and no interaction effect. For the Intentionality index of the Animations task, there was no main effect of either group or time, and no interaction effect. For RMET performance, there were no significant

effects of training group or time (pre/post training), and no interaction effects. There was therefore no evidence of training transfer to any of the social cognition tasks (see Table 6.5).

Table 6.5. Training effects on social cognition tasks.

	Music group M (SD)	PASAT group M (SD)	Control group M (SD)	Time F, p, η^2	Group F, p, η^2	Interaction F, p, η^2
RMET T1	28.25 (2.54)	28.53 (3.54)	28.00 (4.10)	.002, .964, .000	.53, .592, .024	1.18, .317, .051
RMET T2	28.06 (2.14)	29.27 (3.41)	27.50 (3.92)			
Triangles Appropriateness T1	2.23 (.53)	2.17 (.48)	1.77 (.67)	**4.89, .032* .100**	2.98, .061, .119	.87, .428, .038
Triangles Appropriateness T2	2.27 (.54)	2.47 (.48)	2.00 (.82)			
Triangles Intentionality T1	3.50 (.85)	3.72 (.72)	3.63 (.76)	1.39, .245, .031	.34, .716, .015	.33, .720, .015
Triangles Intentionality T2	3.73 (.64)	3.87 (.82)	3.65 (.67)			

T1= pre-training, T2=post-training, RMET = Reading the Mind in the Eyes Test

Training effects on questionnaire measures – depression, anxiety, rumination and worry.

Similar ANOVA analyses were conducted for all questionnaire measures. There were main effects of time on anxiety (GAD-7), depression (PHQ-9) and rumination (RRS total), with all these scores decreasing from baseline to follow up. The reduction in total rumination score appeared to be due to change in reflection [trend effect of time, p=.051], with no evidence of significant change in brooding [p=.704]. There was no main effect of time on worry (PSWQ). Across all questionnaires, there were no main effects of group and no interaction effects. This suggests that

there was no significant transfer of training effects to any of the self-reported questionnaire outcomes (see Table 6.6).

Table 6.6. Training effects on questionnaire measures.

		Music training	PASAT training	Control training	Time F, p, η^2	Group F, p, η^2	Interaction F, p, η^2
GAD-7							
-	t1	11.47 (4.64)	7.79 (5.04)	11.71 (3.96)	**4.42, .041*,**	2.43, .100,	1.57, .219,
-	t2	9.29 (4.30)	7.93 (4.10)	10.41 (5.22)	**.090**	.097	.065
PHQ-9							
-	t1	12.81 (5.96)	9.93 (5.93)	11.12 (6.98)	**4.35, .043*,**	.428, .654,	1.49, .236,
-	t2	10.75 (5.31)	9.67 (5.09)	10.59 (7.20)	**.088**	.019	.062
RRS total							
-	t1	62.41 (4.56)	59.503(3.52)	60.35 (8.74)	**5.04, .030*,**	.594, .556,	.031, .969,
-	t2	59.00 (10.39)	56.93 (8.43)	57.12(11.19)	**.099**	.025	.001
RRS brooding							
-	t1	13.94 (1.98)	12.47 (2.92)	13.71 (2.57)	.15, .704,	1.343, .271,	.064, .938,
-	t2	13.58 (3.54)	12.47 (3.11)	13.59 (2.69)	.003	.055	.003
RRS reflection							
-	t1	13.35 (2.57)	12.93 (2.28)	12.82 (2.77)	4.03, .051,	.255, .776,	.026, .975,
-	t2	12.59 (3.06)	12.20 (3.38)	11.88 (3.31)	.080	.011	.001
PSWQ							
-	t1	63.82 (6.15)	56.73 (11.78)	63.65 (8.61)	.05, .817,	2.66, .081,	.39, .677,
-	t2	63.41 (7.70)	57.73 (12.05)	63.53 (8.31)	.001	.104	.017

PASAT=Paced Auditory Serial Addition Task, GAD-7=Generalised Anxiety Disorder scale, PHQ-9=Patient Health Questionnaire, RRS=Ruminative Responses Scale, PSWQ=Penn State Worry Questionnaire.

Associations between training improvement and change measures

Change scores on the PASAT (median ISI in session 1 – median ISI in session 5) were calculated for each participant in the PASAT training group. Change scores for each of the main outcome variables were also calculated (score at follow up – score at baseline). Correlations between PASAT change score and outcome change scores within the PASAT training group were then examined[30].

In most cases, correlations were not statistically significant (see Table 6.7). However, change in negative thought reactivity was significantly negatively correlated with improvement in PASAT performance over training. That is, participants who had larger improvements in training also showed greater reductions in negative thought reactivity from pre- to post-training. Negative thought reactivity was calculated as the difference in the number of negative thoughts reported during the post-rumination breathing period, versus the pre-rumination breathing period (see Figure 6.5). In order to confirm this association, the same analysis was conducted using the percentage of time reported ruminating during the breathing periods (i.e. change in rumination reactivity). This index showed a similarly large and significant correlation between reactivity and improvement in PASAT performance over training [r=-.71, p=.009] (see Figure 6.6).

[30] One participant did not complete any training, and therefore there was no change score available. One participant was excluded due to a negative change score on the PASAT, suggesting a lack of engagement with training. One participant who had an unusually large deterioration in mood (increase of 12 points on PHQ-9 score) from baseline to follow up was also excluded. Correlation analyses were therefore conducted on data from the remaining 12 participants in the PASAT group.

Table 6.7. Correlations between change in PASAT performance with training and change in outcome measures.

Correlations of change in PASAT performance with:	*r (p)*
Change ANT alerting	-.39 (.207)
Change ANT orienting	.43 (.161)
Change ANT conflict	.11 (.729)
Change Running Span total	.14 (.659)
Change Running Span score	.21 (.506)
Change GAD-7	.12 (.723)
Change PHQ-9	.30 (.351)
Change RRS total score	.37 (.253)
Change RRS brooding	.38 (.256)
Change RRS reflective pondering	.25 (.454)
Change PSWQ	.13 (.685)
Change RMET	-.01 (.977)
Change Triangles Appropriateness score	-.18 (.580)
Change Triangles Intentionality score	.05 (.881)
Change negative thought reactivity[31]	**-.58 (.046)***

PASAT=Paced Auditory Serial Addition Task, ANT=Attention Network Task, GAD-7=Generalised Anxiety Disorder scale, PHQ-9=Patient Health Questionnaire, RRS=Ruminative Responses Scale, PSWQ=Penn State Worry Questionnaire, RMET=Reading the Mind in the Eyes Task.

[31] Negative thought reactivity was calculated as the difference in the number of negative thoughts reported during the post-rumination breathing period, versus the pre-rumination breathing period. The change measure reflects the difference in this index from pre- to post-training.

Figure 6.5. Scatter plot showing the association between change in PASAT performance over training, and change in negative thought reactivity on the breathing task from pre- to post-training.

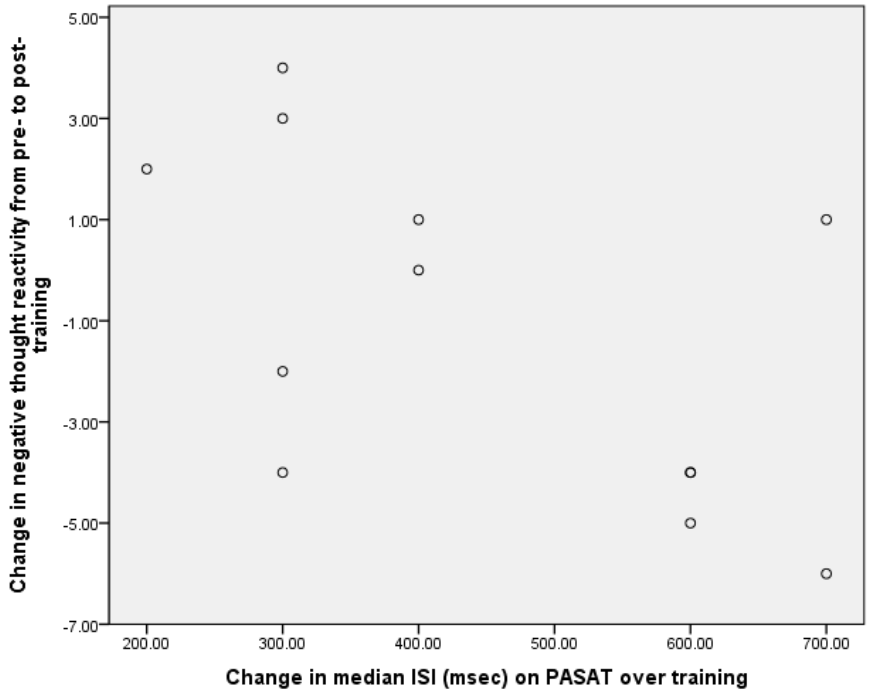
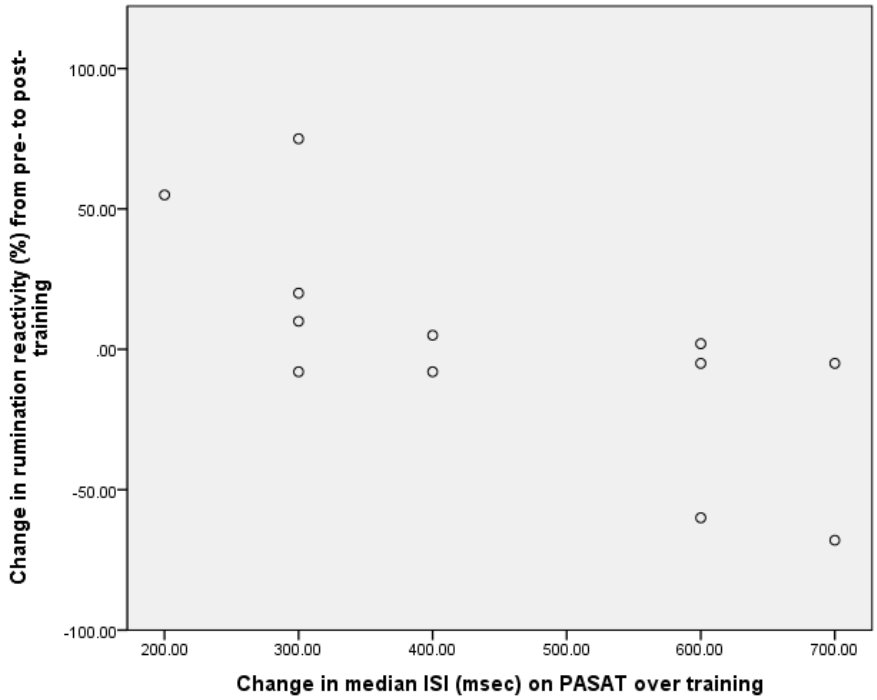


Figure 6.6. Scatter plot showing the association between change in PASAT performance over training, and change in ruminative thought reactivity on the breathing task from pre- to post-training.



Discussion

This study aimed to investigate how training attentional control would affect the tendency to ruminate in individuals with high baseline levels of trait rumination. Training-related improvement was demonstrated for the adaptive PASAT training, but not for a novel musical training task. There was no evidence of differences between groups in state rumination during a behavioural assessment (breathing-focus task). Nor was there any evidence of transfer to other attention or working memory measures, to self-reported trait rumination, symptoms of depression or anxiety, or to social cognitive performance. However, individual differences in response to training in the PASAT training arm were associated with changes in rumination during the breathing focus task. Specifically, a moderate relationship was found between improvement in PASAT performance over training, and reduction in negative thought reactivity and rumination reactivity from pre- to post-training. These results provide evidence that performance on the PASAT can be successfully improved with training, and that at an individual level, these improvements are associated with reductions in state rumination in a sample characterised by high levels of trait rumination. This is consistent with the hypothesised role that deficits in cognitive control may play in conferring vulnerability to rumination. Successfully increasing cognitive control via training seems to help participants exert greater control over intrusive ruminative thoughts.

These findings parallel those of Grol and colleagues (2018), who examined the effects of working memory training in a sample of participants characterised by high trait worry. In that study, there were similarly no group differences in outcome between training conditions. However, inter-individual differences in increases in working memory capacity were associated with reduction in negative thought reactivity during a breathing-focus task. The findings from these two studies suggest that the breathing-focus task may be particularly sensitive to training-related change over

brief intervention periods, at least at an individual level. However, not all studies using this measure have reported such associations (Hotton et al., 2018).

In the current study, individual gains in training were not related to change in performance on near transfer tasks (i.e. untrained attention and working memory tasks, ANT and Reading Span). This could suggest that the mechanism of change following training was not in fact via changes in cognitive control. However, it may be that these tasks were not sufficiently sensitive to detect training-related change and/or that these analyses are underpowered. Given the complexity of cognitive control, it is also possible that tasks measuring different aspects of this construct might have been more optimally targeted to detect training related changes. Several previous studies have reported transfer using alternative cognitive control measures, such as the dual n-back or flanker tasks (Hoorelbeke et al., 2016; Sari et al., 2016), although other studies have failed to demonstrate evidence of near transfer.

Several cognitive training studies have now demonstrated significant individual variation in the degree of benefit derived from training, and have shown that engagement with training and/or training progress is correlated with efficacy of training (E. H. W. Koster et al., 2017). However, it is not clear what factors moderate individual differences in response. Previous findings suggest that these may include beliefs about training, motivational and effort effects, baseline performance and personality traits. The need for further exploration of moderators has recently been identified as a key area to be addressed by future studies (E. H. W. Koster et al., 2017).

There are several aspects of the study design that may account for the lack of transfer effects at a group level. Given the relatively small sample size, and high inter-individual differences in response to training, the study is underpowered to detect small group-level differences. Another limiting factor may be the number of sessions of training, which in this study was relatively low, in

comparison to the 10 session protocol used in several recent studies (Hoorelbeke, Faelens, et al., 2015; Hoorelbeke et al., 2016; Hoorelbeke, Koster, et al., 2015). The dose of training may then not have been adequate to facilitate transfer of benefits at a group level. It remains unclear what constitutes a minimum necessary dose of training in these types of studies, and whether this varies depending on the population studied and outcome measure examined. The selection of measures and the brief timescale may also have limited the ability to detect transfer effects; it seems unlikely that outcomes such as depression severity and trait rumination would show significant change over only a week period. Future work utilising optimised training schedules and longer follow up periods may be able to more adequately test whether training confers benefit for outcomes such as symptoms of depression, trait rumination and social cognitive performance.

In the music training arm, participants did not show any clear improvement on the trained task, and there was no evidence of benefit on any other outcome when groups were compared. The lack of task improvement and transfer is perhaps surprising, particularly given the close similarity to the ATT. However, the music task differed from the original ATT in several key respects, including use of visual rather than verbal prompts and use of musical stimuli rather than environmental sounds. It is unclear to what extent each of these factors may have contributed to the failure to detect any training-related benefit. Of note, previous work using the original ATT has typically used a therapist-supported procedure, in which the therapist provides verbal instructions and prompts throughout the task. The lack of therapist support in this study could also then have contributed to the lack of improvement over training on the musical ATT. In addition, many of the previous studies testing the ATT have used it in combination with other tasks, such as the PASAT, or as one component of metacognitive therapy (A. Wells, 2009). The participant group in this study differs from previous work using the ATT, which has included both clinical and subclinical populations, but has not previously targeted samples selected on the basis of high rumination scores. In addition, focus on the music task was reported to be fairly low

across training, suggesting non-optimal engagement with this task. This may be related to the highly repetitive nature of this task (utilising the same pieces of music in each training session), or to the lack of requirement for a clear behavioural response. It is also possible that the self-rating scales may have been too blunt to detect small changes in performance over time, or that participants found it difficult to recognise and evaluate such changes.

One strength of this study is the inclusion of the breathing-focus task, which allowed an objective measure of training effects on state rumination during the experimental session. Studies more typically rely on self-rated questionnaire measures of rumination, which may make detection of change following brief interventions challenging. Indeed, in the current study it was changes on the breathing-focus task that showed associations with training-related gains. A similar task has been utilised in relation to worry in several previous studies (C. R. Hirsch et al., 2009), including cognitive training studies (Grol et al., 2018; Hotton et al., 2018), and this was adapted for the current study in order to examine rumination. The pattern of findings here was consistent with that reported in previous studies using this measure. In particular, participants reported an increase in the number of negative thoughts experienced in the post-rumination breathing period, as compared to the pre-rumination period. As described above, reductions in this reactivity effect were associated with training gains.

The use of a behavioural measure of state rumination in the current study provides a useful means of examining change in rumination over a short time period. It seems likely that this is more sensitive to change after relatively brief training than trait measures, such as rumination questionnaires. Future training studies targeting rumination may then benefit from the inclusion of this task. It would also be of interest to examine whether the changes in negative thought reactivity reported here can be replicated in studies using these or similar training protocols. Alternatively, it has been proposed that experience sampling methods may be a helpful means of

tracking changes in ruminative thought during and following training. These may be more sensitive than questionnaire measures, may have higher ecological validity than experimental measures and provide rich data including information on change over time (Hoorelbeke et al., 2016; E. H. W. Koster et al., 2017).

In the current study, several outcomes showed significant change over time, irrespective of training group, including increased performance on the Running Span task and reduced scores for depression, anxiety and rumination. Participants across all groups also demonstrated reduced negative thought reactivity after training on the breathing-focus task. There are various possible reasons for these changes. Running Span improvements and breathing-focus changes may reflect practice effects. This raises the interesting possibility that the breathing-focus task in itself may have potential as an intervention/training task. There are also likely to be significant demand and expectancy effects at work, as participants in all arms were aware that the training was designed to target rumination, were presented with a rationale, and actively participated in several sessions of training. The use of an active training arm has the benefit of controlling for general effects to some extent, but is not truly inactive – participants are still required to comply with a training schedule and to maintain attention to the training tasks, all of which could conceivably confer some benefits (Klingberg, 2010). The use of an active control condition may therefore make it more difficult to detect group differences. Selection of appropriate control conditions is recognised as a challenge for training interventions (Grol et al., 2018; E. H. W. Koster et al., 2017). One possible direction for future studies may be to include both active and passive (e.g. wait list) control conditions, in order to better disentangle specific and general training effects.

Limitations

In common with many cognitive training studies, a weakness of the current study is the small sample sizes, and therefore limited power to detect modest group effects or to robustly examine inter-individual differences. Future studies would benefit from use of larger samples. The feasibility of delivering the training online should facilitate conducting such studies and holds promise for efficient delivery of interventions clinically, should benefit be reliably demonstrated. There is also a need for more long term follow up, both to examine whether any training benefits are maintained, and to test whether changes in state rumination transfer over time to more distal outcomes such as trait rumination and mood.

A further limitation of the current study is the use of a non-clinical sample. The participants in this study can be considered to have increased vulnerability for depression, due to elevated trait rumination scores, and many had depression scores in the moderate to high range. However, the extent to which any findings may generalise to clinically depressed individuals is unclear and requires direct testing in appropriate populations.

Clinical applications

Cognitive training studies provide a strong test of hypothesised causal mechanisms, and future studies using these designs have the potential to further elucidate the role of cognitive control deficits in conferring vulnerability to rumination and depression. A clear understanding of causal and maintenance mechanisms is likely to be vital for developing and refining effective treatments for depression (Holmes et al., 2018).

It is also suggested that training procedures in themselves may have clinical utility for treatment and prevention, either delivered alone or as an adjunct to other treatment approaches. Online training designs are highly resource efficient and can be delivered remotely and flexibly. Repetitive negative thinking, including rumination and worry, is a common psychological feature of many mood and anxiety disorders, and is understood to play a maintaining role in these conditions (T. Ehring & Watkins, 2008). Developing reliably effective training procedures therefore has potential for broad, transdiagnostic application.

However, existing training designs do not show reliable transfer to clinical outcomes and so the potential for clinical application is currently limited (Grol et al., 2018). An important direction for future research is to examine how to maximise training benefit. Key variables that could be manipulated to increase effectiveness may include the rationale given to patients, the training schedule and dosage. It may also be necessary to consider who is likely to benefit most from training, and to target interventions accordingly. Whilst innovative training tasks such as the music task tested here are of interest, it is likely that refining tasks that have already shown evidence of benefit (e.g. PASAT, n-back tasks) (E. H. W. Koster et al., 2017) will more rapidly lead to advances in this field.

Conclusion

This study demonstrates that improvements in performance on a working memory task (PASAT) over training are associated with reductions in rumination reactivity. This is consistent with the hypothesised causal role of attentional control deficits in conferring vulnerability to ruminative thinking. However, the results also suggest that transfer of benefit from training to other outcomes is inconsistent, and dependent on the degree of improvement over training. At a group level, there were no differences in outcome between the active training procedures used and a

control training condition. Therefore, there is a need to refine existing training procedures to maximise the benefit derived from these interventions, and to consider for whom these interventions are most effective.

Although the current findings are largely negative, some participants did appear to benefit from training and recent findings from other cognitive training studies provide indications that such approaches can have significant impact on clinically relevant outcomes including rumination (Hoorelbeke & Koster, 2017; Hoorelbeke et al., 2016; Hoorelbeke, Koster, et al., 2015; E. H. W. Koster et al., 2017). With modification then, such approaches may have potential to both increase understanding of the cognitive mechanisms underlying vulnerability to and maintenance of mood disorders, and to contribute to treatment and prevention efforts.

Chapter 7. General discussion

Throughout the thesis, two key themes have been explored through a systematic review and series of experimental studies. Firstly, I have considered the role of cognitive control deficits and rumination in predicting depressive symptoms, with rumination as a hypothesised mediator between cognitive control impairments and depression. Secondly, I have examined the impact of rumination on social cognition and discussed the possible implications for social functioning, including parenting. Both themes are examined in relation to general adult depression and depression vulnerability, but also with reference to specific applications in the perinatal period.

This chapter provides a broad overview of the thesis and discussion of the issues raised in earlier chapters. I summarise the key findings and draw links between the results from each of the empirical chapters. Strengths and limitations of the work are discussed, along with suggestions for refining some of the methods used. I consider how the findings relate to existing theory and research evidence, and highlight important remaining questions and directions for future study. Finally, possible clinical applications of the work are considered.

Summary of key findings

In this section, I summarise the key findings from the thesis, grouped according to the two major themes.

Cognitive control, rumination and depression

The first major theme concerns the role that rumination may play in mediating relationships between cognitive control and vulnerability to depression. Here, I highlight pertinent findings

from the systematic review in Chapter 1 and summarise the results of the relevant empirical chapters (Chapters 2, 3 and 6).

Several of the studies identified in the systematic review (Chapter 1, Section B) address the role that rumination may play in predicting future depression, specifically within the perinatal period. Overall, these studies indicate rather mixed evidence as to whether rumination is predictive of later depression, with a number of both positive and negative findings. It appears that the role of rumination may depend on interactions with many other variables including factors related to the mother and her social/environmental context, and factors related to the infant (Egan et al., 2017; Heather A. O'Mahen et al., 2010; H. A. O'Mahen, Karl, et al., 2015). The timing of measurements may also be important, with some studies indicating a predictive role for rumination on depression at some timepoints but not others (Barnum et al., 2013). Finally, rumination is highly correlated with other clinical characteristics, such as previous episodes of depression, and in studies correcting for these characteristics, rumination is often no longer significantly associated with future depression (Raes et al., 2014; Schmidt et al., 2016). Small sample sizes and lack of statistical power may mean that use of corrected models obscures the potential role of rumination. Thus, there is evidence from the review that under some circumstances, rumination is predictive of future depression, but this relationship is likely to be moderated by various factors and may differ depending on the time course considered. Change in rumination over time may also be important, with one study indicating associations between trajectories of rumination over pregnancy and later depression (Schmidt et al., 2017). However, few studies have considered change in rumination over time, with most utilising measures at a single timepoint. Use of repeated measures and consideration of patterns of change may be an interesting avenue for future study, both in relation to the perinatal period and depression more broadly.

Chapter 2 reports on an experimental study in which self-report and performance measures of cognitive control were examined, and related to concurrent measures of depression and rumination in a community sample. Results showed that depression and rumination were associated with increased difficulties in attentional control, as measured by a self-report questionnaire. Depression and rumination were also associated with performance on the conflict index of the Attentional Network Task. However, this effect was in the opposite direction to that hypothesised, with higher depression and rumination being associated with better conflict performance (i.e. less interference from incongruent flankers). In Chapter 2 (page 64) I discuss these results with reference to the 'narrowed attentional scope' model (Whitmer & Gotlib, 2013), which suggests that rumination is associated with a narrowed and inflexible attentional focus, which can actually promote performance on certain tasks, e.g. avoiding distraction by irrelevant distractors/flankers. Thus, although not as predicted, the results of this study are consistent with some previous theoretical accounts and a number of previous empirical studies. The results highlight the need for a nuanced account of the role of cognitive control deficits in depression, including a consideration of which aspects of cognitive control are impaired and which may be preserved or even enhanced. It is likely that use of batteries of measures that encompass a broad range of cognitive processes will be required to address these questions effectively, given the multi-componential nature of cognitive control. It will also be important to consider that self-report and performance measures likely assess somewhat different constructs and may at times produce conflicting results.

In addition to the above findings, a mediation analysis was conducted, which indicated that relationships between the cognitive control measures (both self-report and performance) and depression were mediated by brooding rumination. These findings are consistent with the suggestion that deficits in cognitive control confer vulnerability to depression, via their impact on emotional regulation strategies, including rumination. However, as the measures were taken

concurrently, it is not possible to confidently infer directionality or causality from these results. Longitudinal and experimental studies are needed to further elucidate these relationships.

In Chapter 3, these findings are extended to consider the role of cognitive control and rumination in predicting depressive recurrence. This issue is of considerable clinical interest, as recurrence of depression is high and contributes substantially to the overall burden of this disorder (Mocking et al., 2016). Recurrence was examined in a high-risk clinical population, that is patients who had experienced two or more previous episodes of depression but were currently in remission. The aspects of cognitive control specifically examined were attentional disengagement and shifting, both of which have been previously related to depression and rumination. The tasks examined were the Internal Shift Task (IST) (E. De Lissnyder, E. H. Koster, et al., 2012; E. De Lissnyder, E. H. W. Koster, et al., 2012) and a version of the Exogenous Cueing Task (ECT) using facial expression stimuli (E. H. W. Koster et al., 2006). Overall, there were no differences in task performance between remitted patients and controls. There were few associations between task performance and rumination, except a small increase in overall shift costs on the IST for participants with high rumination scores compared to those with low rumination scores. This is consistent with previous reports of reduced flexibility/shifting ability associated with high trait rumination (Yang et al., 2017).

Individual differences in performance on the ECT by remitted patients were associated with time to recurrence. Specifically, more rapid disengagement from angry and happy facial expressions was associated with shorter time to recurrence. This predictive effect was in the opposite direction to that hypothesised – several previous studies have indicated that slowed disengagement is associated with depression and a similar effect had been expected in this study (Gotlib & Joormann, 2010). However, there is some prior evidence that clinical groups can demonstrate avoidance of emotional stimuli, resulting in speeded disengagement from affective

cues. For example, Yiend et al. (2015) demonstrated this in two studies with patients diagnosed with Generalised Anxiety Disorder. These patients showed speeded disengagement from threat cues, in contrast to the enhanced attention towards threat typically seen in sub-clinically anxious groups. The current findings may reflect a similar effect. Of note, there has been very little previous research in remitted groups, and it is possible that cognitive control performance differs in remitted individuals compared to clinical and subclinical populations. Thus, these findings indicate that attentional avoidance of emotional stimuli (both positive and negative) may be associated with risk of future depressive recurrence in remitted populations. Recent theoretical accounts have argued that an emotionally avoidant attentional style may occur particularly where individuals also have difficulties with emotional regulation (Del Giudice et al., 2011; England-Mason et al., 2018). It would be of interest in future studies to assess emotional regulation more broadly, and to assess whether this is indeed associated with changes in attentional performance and with risk of depressive recurrence.

In this study (Chapter 3), rumination at baseline was predictive of future depressive recurrence, but the relationship was no longer significant when controlling for other known predictors, e.g. residual symptoms, number of previous episodes. Therefore, whilst disengagement on the ECT was predictive of recurrence, this relationship was not mediated by rumination. This is in contrast to a number of previous studies which have shown that rumination mediates the relationship between cognitive control deficits and future depression (Demeyer et al., 2012; Hsu et al., 2015; Kertz et al., 2017). However, the timing of assessment may be important – for example, Demeyer et al. (2012) showed that rumination at follow up was a mediator of this relationship, whilst rumination at baseline was not. The focus on a remitted clinical group and use of time to recurrence as the key outcome also differs from much of the previous research.

Whilst shift costs on the IST were higher for individuals with high trait rumination, performance on the IST was not related to recurrence. This is perhaps surprising, particularly given arguments that cognitive control over *internally* represented stimuli may be particularly implicated in rumination and depression (E. De Lissnyder et al., 2012). Previous studies have shown concurrent associations between IST performance and depressive symptoms, as well as longitudinal associations with depressive symptoms (E. De Lissnyder, E. H. W. Koster, et al., 2012; Demeyer et al., 2012). However, to my knowledge, no previous studies have examined the relationship between IST performance and time to recurrence; it may then be the case that the IST is less associated with risk of recurrence than it is associated with level of depressive symptoms. These relationships could also differ between clinical and subclinical groups, as discussed in relation to the ECT data.

Chapter 6 assesses the causal influence of cognitive control deficits on rumination by using a cognitive training procedure to enhance cognitive control and assessing the impact of this on state rumination. Two cognitive training tasks were used and compared to control training. Outcomes assessed included a measure of state rumination, as well as changes in performance on related cognitive tasks (attention and working memory tasks, i.e. near transfer) and more distal outcomes (trait rumination and worry, symptoms of depression and anxiety, social cognition). Participants in the active Paced Auditory Serial Addition Task (PASAT) condition demonstrated clear improvements in PASAT performance over the course of training. It was less clear that the musical attention training task had any training effect, with participants reporting no significant change in self-rated performance over training. At a group level, there was no evidence of transfer to any of the outcome measures, with no significant group differences on any outcome. However, individual differences in response to PASAT training were related to individual improvements on the state rumination measure. Specifically, participants who demonstrated greater improvement in PASAT performance over training had the largest

decreases in negative though reactivity and rumination reactivity from baseline to post-training. Given the lack of training-related change on the other cognitive tasks examined, the mechanisms of this effect are somewhat unclear. However, it suggests that training cognitive control can, at least for some participants, enhance ability to avoid intrusive and perseverative ruminative thinking. Similar results have recently been demonstrated in relation to the impact of cognitive training on proneness to worry (Grol et al., 2018). As with several other recent findings in this field, these results highlight the need to consider individual differences in response to training and potential moderators of training response (Grol et al., 2018; Hotton et al., 2018; E. H. W. Koster et al., 2017). The study is limited by various issues common to the cognitive training field, including questions about selection of appropriate control conditions (e.g. active sham training versus waiting-list / no training) and lack of clarity regarding the minimum effective dose for training (see also *'Strengths and Limitations'*, page 209).

Overall then, the thesis provides some evidence that changes in cognitive control are associated with rumination and with depressive symptoms. However, it appears that this is a complex picture and there is a need to establish more precisely which aspects of cognitive control are implicated, and the direction of effect in each case. Developing a better understanding of these effects requires a systematic approach and careful selection and specification of tasks, in order to distinguish between different components of cognitive control. Of note, there may be important differences in cognitive control between clinical and sub-clinical groups, and between currently depressed and remitted participants. There is then a need for caution in generalising results across different populations. The thesis provides some initial evidence that individual differences in cognitive control performance may be associated, not only with concurrent symptoms, but also with risk of future recurrence. However, this preliminary work requires replication and further study. It would be of interest to examine a wider range of cognitive control tasks, in order to better establish which aspects of cognitive control are most strongly predictive of recurrence. The

thesis also provides mixed evidence as to whether rumination acts as a mediator of the relationship between cognitive control deficits and depression, with both positive and negative findings. It is likely that, in characterising this relationship, future studies particularly need to consider the effects of outcome selection (e.g. depressive symptoms, time to recurrence), the timing of measurements (e.g. concurrent versus longitudinal designs) and the ability to detect small effects, particularly when statistically controlling for other predictive variables.

Rumination and social cognition

The second major theme of the thesis concerns the links between rumination and social cognition. Here I highlight pertinent findings from the systematic review in Chapter 1 and summarise the results from the relevant empirical chapters (Chapters 4 and 5).

The systematic review reported in Chapter 1 highlights several studies examining relationships between rumination and future bonding or attachment. These studies consistently indicate that higher levels of rumination during pregnancy are associated with poorer bonding with the foetus/infant, although bonding/attachment is usually mother-reported and therefore could more accurately be described as maternal *perceptions* of bonding/attachment (Müller et al., 2013; Schmidt et al., 2017; Schmidt et al., 2016; Tester-Jones et al., 2015). Thus, there is growing evidence that rumination in the perinatal period is associated with impaired relational outcomes. In addition, experimental evidence indicates that rumination has a causal and negative effect on observed parenting sensitivity and parental problem solving (H. A. O'Mahen, Boyd, et al., 2015; Stein et al., 2012; Tester-Jones et al., 2017). I have hypothesised that changes in social cognition may be a plausible mechanism through which rumination impacts parenting outcomes (see *Figure 1.2*, page 49). However, there is a lack of previous work directly addressing this possibility.

In Chapter 4, I report on associations between depression, rumination and empathy, using data from a large online questionnaire study. The results indicate that both depression and rumination are associated with reported reductions in empathy, with the strongest association between brooding and empathy. There was some evidence that associations between these constructs differed by gender – depression was significantly associated with empathy only for men and not women. However, gender was not a statistical moderator of these relationships. Overall, the results of this study indicate that rumination is associated with impairments in empathy, even when accounting for the impact of current depressive symptoms. This is consistent with the hypothesised role of rumination in impairing social cognition, perhaps via increased self-focus and difficulty in appropriately directing attention to social cues (Tse & Bond, 2004). However, many questions remain regarding whether the role played by rumination is causal and which aspects of social cognition, besides empathy, might be affected. The study is limited by a reliance on a self-report measure of empathy and a lack of objective measures of social cognitive performance.

The study reported in Chapter 5 was designed to examine whether changes in perception of infant cues may be a mechanism through which rumination impairs parenting sensitivity. A rumination induction procedure was used, and the effects on infant cue processing examined. Infant facial and vocal cues were presented using standardised stimuli, and participants were asked to rate the valence of these cues. The results of this study did not indicate that the rumination induction, as compared to a control condition, had any overall effect on ratings of infant cues. There were however some important interaction effects – depression and anxiety scores were both associated with more negative ratings of neutral infant vocal cues, but only for participants in the rumination induction condition. This finding suggests that the effects of state rumination may interact with current depression and anxiety symptoms to predict processing of infant cues.

The lack of clear overall differences in infant ratings across conditions could indicate that the established effects of rumination on parenting sensitivity are not in fact mediated via changes in processing of infant cues. It may be that other processes, e.g. selection and/or execution of an appropriate response, are instead implicated. However, interpretation of these results is complicated by the fact that the rumination induction used in this study appeared to have limited efficacy, in that the effects of the induction on mood and cognitive style were not well sustained beyond the induction period. This could be related to methodological limitations of the induction procedure used and/or to the use of a non-clinical sample of participants, who may be less susceptible to experiencing perseverative rumination following a brief induction. Indeed, the interaction effects described above suggest that the effects of the induction may have been more pronounced for those participants already experiencing higher levels of depressive and/or anxious symptoms. There is a need for future studies to refine the induction methods used (see also *Discussion* in Chapter 5, page 154, and '*Strengths and Limitations'* below, page 209), and to examine these processes in clinical participants. Although there are limitations in this particular study, use of similar experimental approaches is likely to be helpful in seeking to establish a clearer mechanistic model of the impact of rumination on parenting.

Overall then, the thesis provides some evidence that rumination is associated with changes in social cognition, including empathy and infant cue processing. However, there are likely to be important interactions with current depression and anxiety symptoms, which need to be considered in seeking to assess the specific impact of rumination. Further experimental work, for example utilising performance-based measures of social cognition and rumination induction procedures, will help to better elucidate the potential role of rumination, both in the perinatal context and in depression more broadly.

Strengths and limitations

The thesis has primarily made use of an experimental psychopathology approach, in order to examine the processes of interest. The use of experimental designs, including application of standardised tasks, cognitive manipulations (e.g. rumination induction) and cognitive training procedures, is now widespread within depression research. This approach provides a means of better understanding causal and maintenance mechanisms, which in turn may facilitate development of more targeted and effective interventions (Holmes et al., 2018). However, experimental designs have been underutilised in relation to understanding cognitive processes in perinatal depression. The need to develop more effective interventions is particularly pressing in the perinatal period, where results of intervention trials have often been disappointing, particularly in relation to long-term outcomes and child outcomes (Cooper, Murray, Wilson, & Romaniuk, 2003; Forman et al., 2007; Murray, Cooper, Wilson, & Romaniuk, 2003; O'Hara, Stuart, Gorman, & Wenzel, 2000). Developing a clearer account of the key processes and mechanisms linking depression to parenting behaviour and subsequent child outcomes is likely to be important for developing more effective interventions.

The application of an experimental approach, with studies designed to address a number of important questions within this field, is then a strength of the thesis. Another strength is the use of current theory and existing empirical evidence to develop the study questions and hypotheses. In particular, recent developments in theoretical accounts of vulnerability to rumination, and related processes such as worry, e.g. (C. R. Hirsch & Mathews, 2012; E. H. W. Koster et al., 2011; Mor & Daches, 2015; E. R. Watkins & Nolen-Hoeksema, 2014) have helped to guide the development and interpretation of these studies. The application of these models to the perinatal context is particularly novel.

However, several limitations of the work are also recognised. The sample sizes in general are relatively small, and samples are principally composed of non-clinical/subclinical participants and non-parent participants. There are benefits to the use of analogue samples, including greater ease of recruitment and fewer practical difficulties with data collection. Barriers to participation can be a particular issue for postnatal populations, and may include difficulties with transportation and childcare, need to accommodate variable infant feeding/sleep routines, and perceived stigma about postnatal depression (Goodman, 2009; H. A. O'Mahen & Flynn, 2008). The use of analogue populations here facilitated exploration of a number of relevant processes and provided a starting point for developing and refining the experimental designs used. However, there is clearly a need for future studies that test these processes in selected populations, including individuals with clinical depression, parents, and parents with postnatal depression. Whilst depressive symptomology can be considered to be dimensional, there may also be discrete differences between clinical and subclinical populations, particularly in relation to attentional affects (E. H. W. Koster et al., 2017; Yiend et al., 2015). In addition, there is evidence that processing of infant cues does differ in some respects between parent and non-parent participants (Nishitani et al., 2011; Stallings et al., 2001; Thompson-Booth et al., 2014). There is then a need to examine these processes directly in relevant clinical groups, and to be cautious about extrapolating from findings in subclinical or analogue samples, and from non-parent samples.

Perhaps due to the novelty of several of the experimental procedures, these were not always entirely successful, and the methods employed require refinement. For example, the rumination induction (Chapter 5) was not well sustained in the sample used here, with evidence that mood and thinking style rapidly returned to baseline after the induction period. This suggests that the induction procedure may need to be enhanced, particularly for use in non-clinical populations who may be less susceptible to perseverative rumination. An alternative induction procedure that

has now been employed by a number of researchers uses both a longer induction period (10 minutes) and the addition of prompts to promote ruminative thinking during this period (Roberts et al., 2013; Tester-Jones et al., 2017). There is evidence of impairments in mother-infant interaction following this procedure, even in non-dysphoric participants (Tester-Jones et al., 2017). This may then be a useful alternative induction procedure for future studies in this area.

There were also some methodological limitations to the training procedures used in the cognitive training study (Chapter 6). Firstly, the musical attention training task was novel and did not appear to result in improvements over training. Any future work using such a training design will require further development of the task to determine whether this method can be used to effectively train attentional control, and if so in what ways the procedure needs to be altered and refined. In addition, it is unclear whether the dose of training (5 sessions) was adequate, and this may have contributed to the lack of transfer effects found in this study. There is now consensus that multiple sessions of training are more likely to be effective than a single session, but it is not clear what represents a minimum effective dose or an optimal length of training (E. H. W. Koster et al., 2017). A number of recent similar studies have made use of 10 sessions of training (Grol et al., 2018; Hoorelbeke & Koster, 2017; Hoorelbeke et al., 2016; Hoorelbeke, Koster, et al., 2015), with some evidence of group transfer effects at this dose of training. Ten sessions may then be a useful benchmark for future study designs, although a more systematic examination of dose effects and training schedules is also warranted.

In relation to the effects of depression and rumination on parenting behaviour, it has been proposed that unstructured tasks (e.g. play) and/or stressful situations are more likely to be negatively affected (Ginsburg et al., 2006; Psychogiou & Parry, 2014). Unstructured tasks may place greater requirements on cognitive control, as attention and behavioural responses are less constrained by the task structure, and stressful situations have a greater requirement for

engagement of emotional regulatory processes. The design of experimental studies, particularly the use of standardised tasks may therefore minimise the effects of rumination, as these tasks are typically highly structured and exert limited emotional demands. Such tasks may then underestimate the impact of rumination under more naturalistic conditions. This possibility could be usefully explored in future studies employing a range of measures with varying task demands, and by examining the associations between performance on such tasks and parenting behaviour during various live interactions.

Remaining questions and future directions

In general, the study findings across the thesis point to the need for a more nuanced account of the role played by cognitive control deficits in vulnerability to rumination and depression. Whilst there is growing evidence that cognitive control deficits do play a role, there are many remaining questions regarding the aspects of cognitive control that are particularly implicated and whether these impairments are general or restricted to processing of (negative) emotional material. Questions also remain regarding the timescales over which such deficits may impact on depression, with differences between studies examining concurrent symptoms, future symptoms and recurrence.

In relation to the association between rumination and social cognitive performance, there is a need to better establish when and how social cognition is affected. Current evidence regarding the relationship between rumination and empathy is somewhat conflicting and little evidence is currently available regarding the impact of rumination on other aspects of social cognition (e.g. emotion recognition, theory of mind). Systematic work is also needed to adequately parse out specific associations between social cognition and rumination, as distinct from associations with concurrent depressive symptoms. This field would benefit from further experimental work, for

example using induced rumination, in order to more clearly establish the specificity and directionality of these relationships. In the perinatal context, a handful of studies now strongly suggest a causal role for rumination in impairing parenting behaviour (H. A. O'Mahen, Boyd, et al., 2015; Stein et al., 2012; Tester-Jones et al., 2017) but the precise mechanisms through which this occurs remain to be elucidated. I have argued that changes in social cognition, including processing of infant cues, may be one such mechanism but additional experimental evidence is required to support or refute this hypothesis. There may also be other mechanisms implicated, such as difficulties with selecting, planning or executing an appropriate behavioural response. These possibilities have not yet been examined.

In terms of methodological directions, refining and continuing to use rumination induction as an experimental tool has potential to further elucidate the role of rumination, in particular allowing exploration of possible causal impact. Expanding the range of measures used to assess rumination is also potentially informative; research to date has heavily relied on self-report questionnaires assessing trait rumination. The study reported in Chapter 6 made use of a novel in-session measure of state rumination that may have utility for future research, including as an outcome for cognitive training studies and in other experimental designs. In addition, experience sampling is beginning to be used as a means of assessing moment-to-moment rumination (Kircanski et al., 2015; Kircanski et al., 2017; Timm et al., 2017). This may be an interesting method to explore further, with advantages over questionnaire measures in terms of the richness of data generated, ability to track rumination over time and reduced reliance on retrospective reporting. Future studies should also consider differences between state and trait rumination, and potential interactions between these constructs – these issues have rarely been considered in the existing literature.

With ongoing refinements, cognitive training designs will continue to provide a means to examine causal questions about the role of cognitive control, as well as having possible clinical utility as interventions or adjuncts to treatment. The cognitive training literature would benefit from a more systematic approach to some of the remaining methodological issues, including design and selection of training tasks, minimum effective doses and optimum training schedules, design of control conditions, moderators of training outcome and selection of outcome measures (E. H. W. Koster et al., 2017). Use of larger samples in these studies is likely to facilitate detection of transfer effects, and to allow examination of individual difference effects and moderators of training outcome. It will also be important to begin to assess the long-term outcomes of training, as to-date few studies have addressed this issue.

As indicated above, other key directions for future research include the need to examine these processes in relevant selected populations (e.g. parents, individuals with clinical depression) as well as utilising analogue and subclinical samples where appropriate. It would be of interest to continue to explore gender differences (see Chapter 4), given evidence of gender differences in both rumination and social cognition (Johnson & Whisman, 2013; Proverbio, 2017). These differences are of significant clinical interest, as they may help to explain gender differences in prevalence of depression (Sprock & Yoder, 1997; Weissman & Klerman, 1977), and emerging evidence that the impact of depression on social functioning differs by gender (Gadassi & Rafaeli, 2015; Schreiter et al., 2013). Of note, much of the perinatal literature has been focused on the role of mothers and research investigating the impact of perinatal depression on fathers, although growing, is currently more limited (Glasser & Lerner-Geva, 2018). Given possible gender differences in the processes of interest, caution in generalising research findings and theoretical models from mothers to fathers is warranted.

An important additional consideration for future research in this area is the consistent use of terminology. Rumination and 'repetitive negative thinking' (RNT) are commonly used terms within the depression literature, but in perinatal psychology/psychiatry a wide variety of terms are used to identify these and closely related constructs. As noted in relation to the systematic review (Chapter 1, page 43), qualitative work in particular has noted the presence of several themes that appear to be related to ruminative thinking but are not labelled as such, e.g. loss of control over thoughts, incongruity between expected/desired states and realities of motherhood (Beck, 1992, 2002). Similarly, other studies have examined the role of self-focus in maternal depression, and its relation to parenting behaviour. For example, in one recent study depressive symptoms were shown to be associated with higher self-focus and increased self-focus was further associated with less warmth in maternal interactions with the infant, with self-focus mediating the relationship between depressive symptoms and maternal warmth (Humphreys, King, Choi, & Gotlib, 2018). This finding appears to be closely aligned to studies indicating an effect of rumination on parental sensitivity. Greater use of consistent terminology and definitions would then facilitate integration of this literature, and help to establish better links between perinatal research and general depression research.

Clinical applications

Given the proposed role of rumination in maintenance and recurrence of depression, interventions targeting rumination may have important benefits for long-term mental health. There is some evidence that current treatments, including cognitive behavioural therapies and medication, do not effectively target rumination, with trait rumination remaining high during remission (Schmaling et al., 2002; Visted et al., 2018). Residual rumination seems to increase vulnerability to future depression (Michalak et al., 2011; E. R. Watkins, 2009). A number of psychological therapies have then been developed in recent years, which more specifically

address rumination. These include Rumination-Focused Cognitive Behavioural Therapy (RF-CBT) (E. Watkins et al., 2007; E. R. Watkins et al., 2011), Behavioural Activation (BA) (Martell et al., 2013), metacognitive therapy (A. Wells, 2009) and mindfulness-based approaches, such as mindfulness-based cognitive therapy (MBCT) (Segal et al., 2013). However, there have been a relatively small number of studies directly assessing change in rumination following treatment, and subsequent impact on depressive symptoms/depressive recurrence. Continued assessment of these therapies, with a focus on whether reduction in rumination is a core mechanism of change, has potential to further elucidate the role of rumination in the onset, maintenance and recurrence of depression. In the perinatal context, the addition of measures of rumination, parenting behaviour and child outcomes to treatment trials is one means of continuing to evaluate the hypothesised role of rumination in PND. Comparing treatments specifically designed to target rumination with treatments thought to target depression through other mechanisms may also provide a way of assessing the long-term impact of rumination on parenting and child outcomes.

Growing evidence that rumination is prospectively associated with depression raises the possibility that measures of rumination may provide a helpful means of screening for depression risk, and that rumination may be a useful target for preventative work (Topper et al., 2010). Screening for perinatal depression is a routine part of perinatal care in the UK and many other countries; however, use of rumination measures for screening could provide a means of identifying women with elevated risk *before* any significant increase in depressive symptoms. Preventative work targeting rumination is beginning to be trialled, with initial evidence that targeting RNT through an online cognitive behavioural intervention has benefits in terms of reduced RNT, reduced symptoms of depression and anxiety, and reduced 12-month prevalence of depression and generalized anxiety disorder (Topper et al., 2017). To my knowledge, similar preventative studies specifically targeting RNT in perinatal populations have not yet been

conducted. However, there is some evidence that MBCT, used preventatively during pregnancy, reduces postnatal depressive symptoms and depressive recurrence in a high-risk group (Dimidjian et al., 2016). Thus, there is broad initial evidence that preventative interventions for targeted groups may have clinical utility. Increased contact with health services and motivation to make lifestyle changes during pregnancy and the postnatal period may make this a particularly suitable time for preventative work.

Cognitive training approaches may have clinical utility for prevention or treatment of depressive disorder, although as discussed previously significant further work is needed to maximise the effectiveness of such interventions and to identify moderators of the treatment effect (Grol et al., 2018; E. H. W. Koster et al., 2017). If such refinements can be made, cognitive training of sufficient efficacy and intensity has substantial potential, either as a stand-alone intervention or as an adjunct to other treatments. Benefits of cognitive training interventions include the ability to deliver interventions remotely (e.g. through online platforms or apps) and minimal requirement for input from trained therapists/clinicians. These interventions potentially then provide an accessible and cost-effective means of targeting putative vulnerability factors for depression. In perinatal populations particularly, the potential to deliver interventions remotely and at flexible times is highly desirable. A number of recent intervention studies have explored use of online therapies in the perinatal context for these reasons, with positive initial evidence of effectiveness, at least in the short term (Milgrom et al., 2016; H. A. O'Mahen et al., 2014; Pugh, Hadjistavropoulos, & Dirkse, 2016).

The proposed role of rumination in social functioning difficulties also has clinical implications. Deficits in social functioning associated with depression are severe and pervasive (Kupferberg et al., 2016) and tend to persist following recovery (Hirschfeld et al., 2000; Rhebergen et al., 2010; Saris et al., 2017). It is suggested that rumination may be a key mechanism through which

depression affects social cognition, and subsequently social functioning (Tse & Bond, 2004). Thus, targeting rumination in both currently depressed and remitted groups has the potential to ameliorate social cognitive impairments, and to improve social functioning. A greater understanding of the specific impacts of rumination on social cognition may facilitate development of such interventions. In addition, in the perinatal context, rumination appears to be implicated as one pathway through which postnatal depression impacts on parenting behaviour (Stein et al., 2012; Stein et al., 2009; Tester-Jones et al., 2017). Interventions designed to target rumination may then have utility both for reducing the severity and duration of perinatal depressive episodes, and for reducing the impact of depression on parenting behaviour and subsequent child outcomes. This possibility remains to be tested in clinical trials and intervention designs, as rumination has rarely been examined as an outcome of treatment in the perinatal context.

Conclusion

Rumination appears to confer risk both through its role in promoting depressive symptoms, and via its impact on social cognition. These processes are of importance for depression occurring in the adult population in general and also have specific applications for the perinatal context. Underlying deficits in cognitive control are a key vulnerability factor for depression, and evidence suggests that their relationship to depression is at least partially mediated by rumination. Rumination is therefore likely to be an important target for treatment, either directly or indirectly through targeting underlying cognitive control deficits. An experimental psychopathology approach has the potential to further elucidate the role of cognitive control deficits and ruminative processes. This approach has been widely employed in relation to depression broadly, but various questions remain to be addressed, and similar experimental designs have to-date been underutilised in the perinatal context. It will be important to continue to refine the methods

used and to apply these approaches in relevant clinical samples and parent samples. Ultimately, a better understanding of the key mechanisms involved will be valuable in the design of treatment approaches that effectively target these key processes. Interventions that effectively target cognitive control and/or rumination have wide potential benefit, with possible outcomes including improvements in depression chronicity and severity, and reduced risk of recurrence, as well as improvements in social cognition and social functioning. In the perinatal context, interventions targeting rumination hold potential for improved current and future maternal mental health, increased parental responsiveness and subsequently improved child outcomes across a range of domains.

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Appendices

Appendix A: Questionnaires **247**

GAD-7 and PHQ-9 248

Ruminative Responses Scale 249

Penn State Worry Questionnaire 250

Attentional Control Scale 251

Toronto Empathy Questionnaire 252

Credibility/expectancy questionnaire 253

References for questionnaire measures 254

Appendix B: Ethical approvals **255**

Study A approval (Chapters 2 & 5) 256

Study B approval (Chapters 4 & 6) 257

Appendix C: Publications associated with the thesis **258**

DeJong, H., Fox, E. & Stein, A. (2016) 259

Appendix A: Questionnaires

GAD-7 and PHQ-9. (Spitzer et al, 1999; Spitzer et al, 2006)

Over the last 2 weeks, how often have you been bothered by the following problems? (please circle your answer)	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Feeling nervous, anxious or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3
Over the last 2 weeks, how often have you been bothered by the following problems? (please circle your answer)	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself, or that you are a failure, or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowing that other people could have noticed, OR the opposite—being so fidgety and restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

Ruminative Responses Scale. (Nolen-Hoeksema & Morrow, 1991)

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

	Almost never	Sometimes	Often	Almost always
1. Think about how alone you feel				
2. Think "I won't be able to do my job if I don't snap out of this"				
3. Think about your feelings of fatigue and achiness				
4. Think about how hard it is to concentrate				
5. Think "What am I doing to deserve this?"				
6. Think about how passive and unmotivated you feel.				
7. Analyze recent events to try to understand why you are depressed				
8. Think about how you don't seem to feel anything anymore				
9. Think "Why can't I get going?"				
10. Think "Why do I always react this way?"				
11. Go away by yourself and think about why you feel this way				
12. Write down what you are thinking about and analyze it				
13. Think about a recent situation, wishing it had gone better				
14. Think "I won't be able to concentrate if I keep feeling this way."				
15. Think "Why do I have problems other people don't have?"				
16. Think "Why can't I handle things better?"				
17. Think about how sad you feel.				
18. Think about all your shortcomings, failings, faults, mistakes				
19. Think about how you don't feel up to doing anything				
20. Analyze your personality to try to understand why you are depressed				
21. Go someplace alone to think about your feelings				
22. Think about how angry you are with yourself				

Penn State Worry Questionnaire. (Meyer et al, 1990)

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

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

Attentional Control Scale. (Derryberry & Reed, 2002)	Almost never	Sometimes	Often	Always
1. It's very hard for me to concentrate on a difficult task when there are noises around. (R)				
2. When I need to concentrate and solve a problem, I have trouble focusing my attention. (R)				
3. When I am working hard on something, I still get distracted by events around me. (R)				
4. My concentration is good even if there is music in the room around me.				
5. When concentrating, I can focus my attention so that I become unaware of what's going on in the room around me.				
6. When I am reading or studying, I am easily distracted if there are people talking in the same room. (R)				
7. When trying to focus my attention on something, I have difficulty blocking out distracting thoughts. (R)				
8. I have a hard time concentrating when I'm excited about something. (R)				
9. When concentrating I ignore feelings of hunger or thirst.				
10. I can quickly switch from one task to another.				
11. It takes me a while to get really involved in a new task. (R)				
12. It is difficult for me to coordinate my attention between the listening and writing required when taking notes during lectures. (R)				
13. I can become interested in a new topic very quickly when I need to.				
14. It is easy for me to read or write while I'm also talking on the phone.				
15. I have trouble carrying on two conversations at once. (R)				
16. I have a hard time coming up with new ideas quickly. (R)				
17. After being interrupted or distracted, I can easily shift my attention back to what I was doing before.				
18. When a distracting thought comes to mind, it is easy for me to shift my attention away from it.				
19. It is easy for me to alternate between two different tasks.				
20. It is hard for me to break from one way of thinking about something and look at it from another point of view. (R)				

Toronto Empathy Questionnaire. (Spreng et al., 2009)

Below is a list of statements. Please read each statement *carefully* and rate how frequently you feel or act in the manner described. Circle your answer on the response form. There are no right or wrong answers or trick questions. Please answer each question as honestly as you can.

1.	When someone else is feeling excited, I tend to get excited too	Never	Rarely	Sometimes	Often	Always
2.	Other people's misfortunes do not disturb me a great deal	Never	Rarely	Sometimes	Often	Always
3.	It upsets me to see someone being treated disrespectfully	Never	Rarely	Sometimes	Often	Always
4.	I remain unaffected when someone close to me is happy	Never	Rarely	Sometimes	Often	Always
5.	I enjoy making other people feel better	Never	Rarely	Sometimes	Often	Always
6.	I have tender, concerned feelings for people less fortunate than me	Never	Rarely	Sometimes	Often	Always
7.	When a friend starts to talk about his\her problems, I try to steer the conversation towards something else	Never	Rarely	Sometimes	Often	Always
8.	I can tell when others are sad even when they do not say anything	Never	Rarely	Sometimes	Often	Always
9.	I find that I am "in tune" with other people's moods	Never	Rarely	Sometimes	Often	Always
10.	I do not feel sympathy for people who cause their own serious illnesses	Never	Rarely	Sometimes	Often	Always
11.	I become irritated when someone cries	Never	Rarely	Sometimes	Often	Always
12.	I am not really interested in how other people feel	Never	Rarely	Sometimes	Often	Always
13.	I get a strong urge to help when I see someone who is upset	Never	Rarely	Sometimes	Often	Always
14.	When I see someone being treated unfairly, I do not feel very much pity for them	Never	Rarely	Sometimes	Often	Always
15.	I find it silly for people to cry out of happiness	Never	Rarely	Sometimes	Often	Always
16.	When I see someone being taken advantage of, I feel kind of protective towards him\her	Never	Rarely	Sometimes	Often	Always

Credibility/expectancy questionnaire. Adapted from Devilly & Borkovec (2000)

We would like you to indicate below how much you believe, right now, that the training you are going to complete will help to reduce your rumination. Belief usually has two aspects to it: (1) what one *thinks* will happen and (2) what one *feels* will happen. Sometimes these are similar; sometimes they are different.

Please answer the questions below. In the first set, answer in terms of what you *think*. In the second set answer in terms of what you *really and truly feel*.

<u>Set I</u>

1. At this point, how logical does the training offered to you seem?

1 2 3 4 5 6 7 8 9

not at all logical somewhat logical very logical

2. At this point, how successful do you think this training will be in reducing the amount you ruminate?

1 2 3 4 5 6 7 8 9

not at all useful somewhat useful very useful

3. How confident would you be in recommending this training to a friend who ruminates a lot?

1 2 3 4 5 6 7 8 9

not at all confident somewhat confident very confident

4. By the end of the training, how much reduction in your rumination do you think will occur?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

<u>Set II</u>

For this set, close your eyes for a few moments, and try to identify what you really feel about the training and its likely effects. Then answer the following questions.

1. At this point, how much do you really feel that the training will help you to reduce the amount you ruminate?

1 2 3 4 5 6 7 8 9

not at all somewhat very much

2. By the end of the training, how much reduction in your rumination do you really feel will occur?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

References for questionnaire measures

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Appendix B: Ethical approvals

Study A approval (Chapters 2 and 5)

CONFIDENTIAL

Ref: MS-IDREC-C1-2015-038

Dr Hannah DeJong
Department of Psychiatry
University of Oxford
Warneford Hospital
Oxford

27th February 2015

Dear Dr DeJong

CUREC checklist

I am writing to acknowledge receipt of your CUREC-1 form for your project: **Investigating responses to infant cues during induced rumination**

On the basis of the information you have provided this has now been approved by the Medical Sciences IDREC **subject to:**

a) **your agreeing to follow Protocol 9**

b) **it is your responsibility to comply with the requirements for administering any tests or questionnaires and if in doubt to contact the publisher of those tests or questionnaires.**

The reference number for this project is **MS-IDREC-C1-2015-038** and is valid for a period of **4 months** from the CUREC 1 approval date, **15th March 2015**. Please may I remind you that your project may be reviewed at some stage during an annual audit of projects.

Amendments

Should you at some stage alter some of the techniques or procedures then you should first undertake a checklist (CUREC-1) to see whether these changes alter the ethics of the research. If these remain the same then the committee will require notification of the changes to lodge with the project. If they do not remain the same then you may need to complete a CUREC-2 form and undergo further scrutiny by the committee.

Please do not hesitate to contact me if you have any queries about this.

Yours sincerely

Gill Halstead

Gill Halstead
Research Ethics Co-ordinator, Medical Sciences

Study B approval (Chapters 4 and 6)

MEDICAL SCIENCES
INTER-DIVISIONAL RESEARCH ETHICS COMMITTEE

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CONFIDENTIAL

Ref: R37551/RE001

Dr Hannah DeJong
Department of Psychiatry
University of Oxford
Warneford Hospital
Oxford

2nd March 2016

Dear Dr DeJong

Research Ethics Approval - CUREC 1

Project title: Training attentional control in high ruminators

The above application has been considered on behalf of the Medical Sciences Inter-divisional Research Ethics Committee (IDREC) in accordance with the procedures laid down by the University for Ethical Approval of all research involving human participants.

I am pleased to inform you that, on the basis of the information provided to the IDREC, the proposed research has been judged as meeting appropriate ethical standards, and approval has been granted for a period of **8 months**, commencing on **2nd March 2016**. The reference number for this project is **R37551/RE001**.

This is **subject to:**

a) **your following the BPS guidelines for online research**
b) **your agreeing to follow Approved Procedure 9**
c) **it is your responsibility to comply with the requirements for administering any tests or questionnaires and if in doubt to contact the publisher of those tests or questionnaires.**
d) **if new staff are engaged MS IDREC should be informed of their names, status and ethics training.**

Please may I remind you that your project may be reviewed at some stage during an annual audit of projects.

Amendments

Should there be any subsequent changes to the project, which raise ethical issues not covered in the original application, you should submit details to the IDREC for consideration and approval.

Please do not hesitate to contact me if you have any queries.

Yours Sincerely

H. Barnby-Porritt

Dr. Helen Barnby-Porritt
Research Ethics Manager, Medical Sciences

Appendix C: Publications associated with the thesis

DeJong, H., Fox, E. & Stein, A. (2016).

Rumination and postnatal depression: a systematic review and a cognitive model. *Behaviour Research and Therapy, 82*, 38-49.

doi: 10.1016/j.brat.2016.05.003

Abstract

Postnatal depression (PND) confers risk for a range of negative child developmental outcomes, at least in part through its impact on parenting behaviour. Whilst the behavioural effects of depression on parenting are well established, the cognitive mechanisms that may mediate this effect are less well understood. The current paper proposes that rumination may be a key cognitive mechanism through which parenting is affected in PND, and provides a systematic review of the existing literature on rumination in the context of perinatal depression. The review identifies ten relevant papers. Eight are questionnaire-based studies examining the role of rumination in predicting future depression and/or mother-infant relationship outcomes, such as bonding. Two are experimental studies examining the effects of induced rumination on parenting behaviours. The results of the review are discussed, and remaining questions highlighted. We then present a new theoretical model, developed specifically for the perinatal context, and informed by existing models of rumination and worry. Our cognitive model emphasises the relationship between rumination, cognitive biases and cognitive control, and the impact of these variables on infant cue processing and subsequent parenting responses. The model provides a potential framework for future work in this area, and to guide the development of treatment interventions.

Keywords

Postnatal depression; rumination; contingent responsiveness; parenting; cognitive control; cognitive biases.

Rumination and postnatal depression: a systematic review and a cognitive model

Postnatal depression (PND) is a psychological disorder, typically defined as involving an episode of depression during the first post-natal year. Point prevalence during the first three months post-partum is around 13% (Howard et al., 2014). Whilst many women will recover within a few months, around 30% experience more persistent depressive symptoms and there is a high risk of further depressive episodes (Howard et al., 2014). PND is considered to be phenomenologically equivalent to major depressive disorder (MDD) at other times, and is highly similar in terms of symptoms, course and prognosis. Some studies have suggested that somatic and sleep-related symptoms may be somewhat more prevalent in PND (e.g. Williamson, O'Hara, Stuart, Hart, & Watson, 2014), leading to the development of perinatal assessment measures that exclude these features. However, in general these disorders are understood to be similar in symptomology and presentation. PND differs from MDD primarily in the *timing* of the depressive episode, and consequently its *implications*. PND has onset either during pregnancy or in the first year postnatally, and thus has specific impacts due to the importance of this developmental window for the infant, and also due to the uniqueness of the mother-infant relationship. During this period the infant is developing rapidly, and is highly dependent on the parent.[32]

Post-natal depression represents an important target for support and intervention, not only because of the impact on maternal mental health but because PND also carries long-term risks for offspring. A range of negative child outcomes associated with PND have been reported across cognitive, behavioural and emotional domains (Stein et al., 2014). One potential mechanism underlying the negative impact on child outcomes is difficulties with parenting quality. Aspects of parenting quality that have been identified include reduced sensitivity and responsiveness to infant cues, as well as a tendency to interact in a way that is either excessively withdrawn or intrusive (Murray, Halligan, & Cooper, 2010). These parenting behaviours then confer risk for a range of negative child outcomes. Negative outcomes for the child seem to be particularly pronounced where maternal disorder is persistent or recurrent (Stein et al., 2014).

It is recognised that early environmental and social input is vitally important for healthy development in infants, and that the mother-infant relationship provides a key part of this input.

[32] The majority of the research in this area has focused on mothers and so the mother-infant relationship is particularly emphasised throughout this review. However, we recognise that fathers are also involved in parenting, and similar processes are likely to apply. There is a clear need for additional research to examine this directly.

Whilst depression is understood generally to have negative impacts on relationships and social functioning, which apply to the mother-infant relationship, there are also distinctive features. For example, social cues from the infant may be more ambiguous than from adult interactive partners; infants are extremely sensitive to the qualities of interaction and contingency of responding (e.g. Bigelow, & Rochat, 2009; Nadel et al., 2001; Striano, Henning, & Stahl, 2006); infants rely on a close degree of contingency in order to make sense of the interaction, due to their limited ability to detect contingency over temporal delays (Keller et al., 1999; Bornstein & Manian, 2013). The mother-infant relationship is also unusual in its intensity and the amount of time devoted to this dyadic interaction. The implications of depression during the perinatal period are therefore somewhat unique, in terms of impact on parenting, the mother-infant relationship and on various child development outcomes.

PND then is understood to exert effects on the child, at least in part, via its behavioural impact on parenting. However, the cognitive features of PND that are likely to mediate this relationship are not well understood. This paper seeks to outline the existing literature on one specific cognitive feature of PND, that is, rumination. Recent developments have highlighted the important role played by rumination in the onset and maintenance of depression. These findings are beginning to influence treatment approaches within the adult mental health field, but have not yet been broadly applied in the perinatal context. We suggest that integrating these developments into understanding PND provides helpful clues as to the mechanisms through which maternal depression may impact on child development.

Rumination is a key cognitive feature of depression and is defined as 'a mode of responding to distress that involves repetitively and passively focusing on the symptoms of distress and the possible causes and consequences of these symptoms' (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Loss is hypothesised to be the core theme of rumination, and it is characterised by sustained and repetitive processing of negative emotional material. People who frequently ruminate when distressed are more likely to develop depression and are likely to remain depressed for longer. Rumination therefore confers risk for prolonged episodes and for future depressive episodes. The tendency to ruminate is trait-like and appears to remain fairly stable, even as depression improves. It has also been suggested that rumination is a trait vulnerability factor, as elevated rumination is found in never-depressed offspring of depressed parents (Nolen-Hoeksema et al., 2008).

Several authors have suggested that rumination may be an important cognitive mechanism through which perinatal psychological disorders affect parenting (Stein, Lehtonen, Harvey, Nicol-Harper, &

Craske, 2009; Psychogiou, & Parry, 2014). Stein and colleagues in particular have hypothesised that rumination is a form of preoccupation, which affects mothers' ability to effectively process infant cues and results in reduced contingency and sensitivity in parenting behaviour. Whilst rumination has received considerable attention as a key cognitive feature in depression, it has been much less extensively characterised in the context of PND. In this paper, we seek to provide the first systematic review of evidence relating to rumination in the perinatal context. Drawing on this literature, as well as broader understandings of rumination, we then present a new framework for conceptualising the specific impact of rumination in the postnatal context. It is intended that this model can be used to generate hypotheses and to guide future research in this area.

We focus specifically on rumination because of its recognised importance in depression, and because theoretical accounts propose that this may be a key process in explaining the impact of PND on parenting. This is not however intended to imply that this is the only area of cognition or emotional regulation that is important within PND. Similarly, whilst we focus here on PND, there are likely to be parallels with other perinatal psychological disorders, e.g. anxiety disorders, eating disorders. Stein et al (2009) argue that all these disorders are characterised by preoccupation, whether in the form of rumination, worry or obsessions, and that the mechanisms through which parenting is affected may then be very similar across disorders. Similar cognitive processes may therefore have broad applicability across a range of perinatal mental health conditions, but here we focus particularly on rumination in the context of depression.

Method

A systematic review of the literature was conducted, following the PRISMA guidelines (Moher et al. 2009). The search was conducted using several online databases: PsychInfo, Pubmed, MEDLINE and Scopus. The most recent search was completed in March 2016. Search terms included "*perinatal depression" OR "postnatal depression" OR "postpartum depression" OR "maternal depression",* in combination with "*rumination" OR "repetitive negative thought" OR "repetitive negative thinking" OR "perseverative thought".* Papers identified in this search were also used to check for additional results, by examining references and citations. In order to be included in the review, papers had to report data on some measure of rumination, or to report on the effects of a rumination induction. Results were limited to the perinatal period (i.e. measured during pregnancy or the first year

postnatally). Review papers and opinion pieces were not included in the systematic review. Inclusion criteria also included publication in a peer reviewed journal, and availability in the English language.

Search results were combined and duplicates removed, before titles and abstracts were screened. Full texts were then screened for relevance and fulfilment of the inclusion criteria. The search and screening process is shown in *Figure 1*. There were only a small number of papers identified, with varied questions addressed and a wide range of methods and measures used. A qualitative synthesis or meta-analysis of the data is therefore not feasible or appropriate. Instead, a narrative synthesis of the findings is presented below.

Figure 1. PRISMA diagram displaying search and screening process

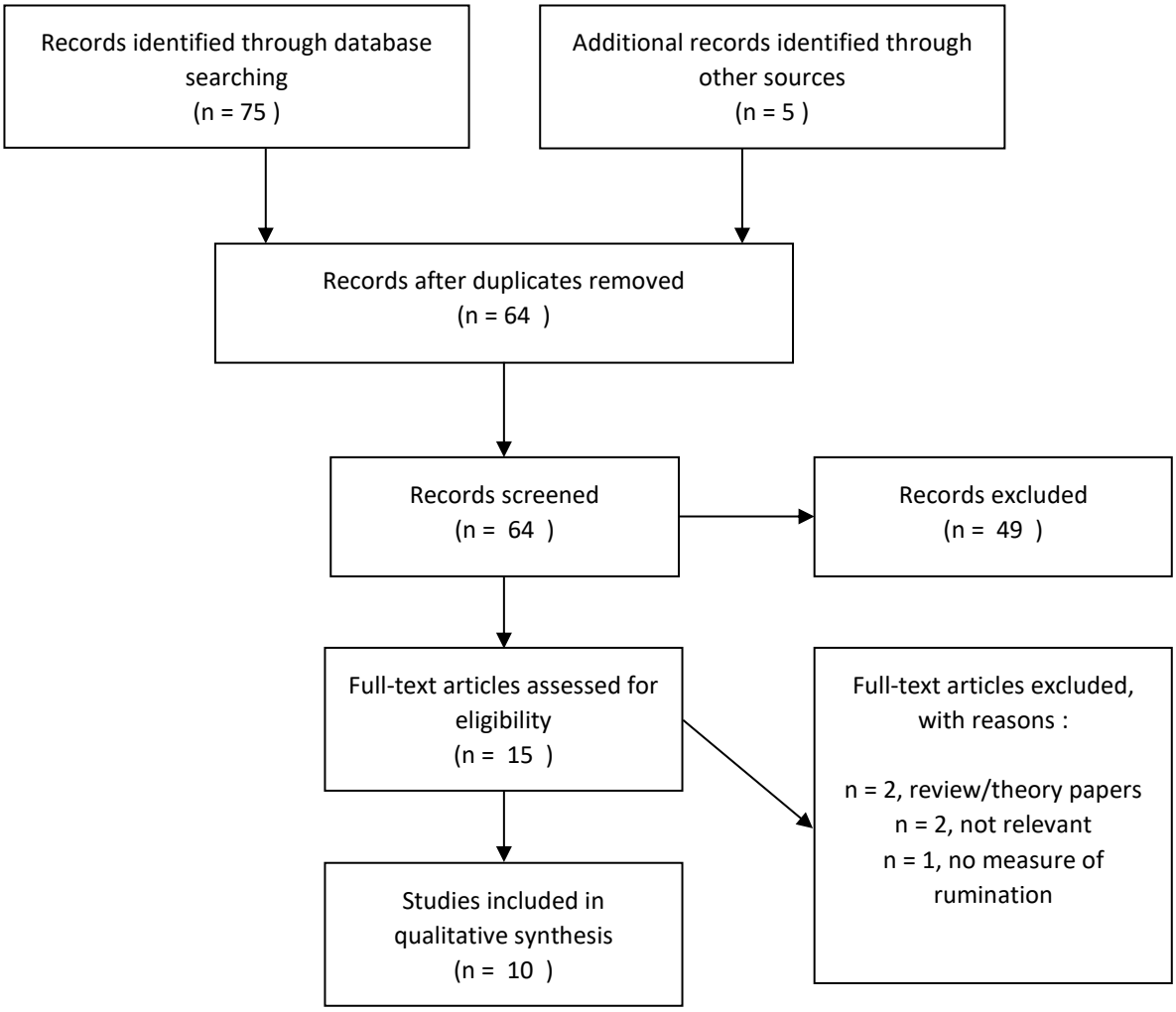


Table 1. Summary of included studies

Authors (year)	Participants	Measures / procedure	Findings
Questionnaire Studies			
Barnum et al. (2013)	N=101 3rd trimester of pregnancy to 8 weeks postpartum. USA.	Rumination (RRS; 3rd trimester) Negative inferential styles (Expanded Attributional Style Questionnaire; 3rd trimester) Depression (EPDS; 3rd trimester, 4 and 8 weeks postpartum)	Brooding rumination and negative inferential styles predict depression at 8 weeks, but not 4 weeks. Attributional style only predictive for women with already high levels of depression – may be predictor of maintenance.
Isa Alfaraj et al. (2009)	N=21 depressed, N-22 non-depressed (assessed by BDI) 2nd or 3rd trimester of pregnancy. UK.	Positive beliefs about rumination (PBRS) Perceived lack of social support over previous month (rating scale).	Positive beliefs about rumination higher in depressed group. Perceived social support lower in depressed group. Positive beliefs about rumination predict depression classification above perceived lack of social support.
Muller et al. (2013)	N=66 2nd or 3rd trimester of pregnancy, up to 8 weeks postpartum. Germany.	Perseverative thinking (PTQ) Depression (BDI-II) Postpartum bonding (PBQ) Attachment Scale of PSI	PTQ does not predict postnatal depression. Unproductive subscale of PTQ predicts bonding and attachment (as does ante- and post-natal depression).
O'Mahen et al. (2010)	N=110 scoring 10 or more on EPDS (N=65 at follow up) During pregnancy and 3mths later. USA.	Assessment via phone interview, including: Mood (EPDS) Rumination (RRS; 10 item version) Social functioning (SASS) Silencing the self (STSS)	For low social functioning: rumination related to later depression; silencing the self unrelated to rumination or mood. For high social functioning: social functioning buffers impact of rumination on future depressed mood; silencing beliefs associated with increased rumination and depressed mood.
O'Mahen, Karl, Moberly & Fedock (2015)	N=55 depressed pregnant women, N=85 elevated low mood (not clinically depressed) pregnant women. M=23.27 weeks gestation. USA.	Mood (SCID-IV, EPDS, BDI-II). Childhood Trauma Questionnaire. Rumination (RRS). Behaviour activation (BADS).	Brooding rumination associated with depressed symptoms and also with history of neglect and abuse. Brooding partially mediated relationship between childhood emotional abuse and depression. Behavioural activation fully mediated relationship between childhood emotional neglect and depression. Brooding and behavioural activation inversely related.
Tester-Jones et al. (2015)	N=203 Infants 9-14 mths. UK.	Rumination (RRS) Depression (EPDS) Attunement and bonding (MIRI and PBQ)	Brooding rumination mediated the effect of postnatal maternal depressive mood on maternal self-reported responsiveness to the infant when infants were low, but

Authors (year)	Participants	Measures / procedure	Findings
		Perceived social support (SPS) Infant temperament (negative affect subscale of IBQ-R)	not high, in negative temperament. For infants with higher negative temperament, maternal depressive symptoms were directly related to self-reported responsiveness, as was perceived social support.
Raes et al. (2014)	N=210 3rd trimester of pregnancy; follow up at 12 and 24 weeks postpartum. Belgium.	Depression (DASS; EPDS) History of depression (MDQ) Rumination (RRS) Dampening of positive emotions (RPA)	Depression during pregnancy and previous depressive episodes predict depression postpartum. Dampening also has predictive role, but rumination does not. Rumination highly related to previous depressive episodes. Similar findings at 12 and 24 months.
Schmidt et al. (2016)	N=215 Seen in 1st and 3rd trimester. Germany.	Rumination (RRS) Worry (PSWQ-PW) Depression and anxiety (DASS items) Maternal-foetal bonding (MAAS)	Rumination in 1st trimester is predictive of MAAS intensity scores in 3rd trimester (when controlling for depression, anxiety and demographic variables at time 1). Worry in 1st trimester is predictive of depression and anxiety in 3rd trimester (when controlling for depression, anxiety and demographic variables at time 1). Small effects: 0.8-3% variance.
Experimental Studies			
Stein et al. (2012)	N=253: (GAD n=90, MDD n=57; control n=106) Infants 10 mths old. UK.	Randomised to either worry/rumination prime (WRP) or neutral prime (NP) and instructed to think about this topic for 5 mins. Live interactions with infant observed and coded, before and after prime.	WRP resulted in more negative thoughts, higher thought recurrence and more self-focus relative to NP. Compared with controls, WRP had a more negative impact on maternal responsiveness to infant vocalization for GAD, and to a lesser extent for MDD; WRP also led to decreased maternal vocalization for GAD. Across the whole sample, WRP was associated with increased child vocalization relative to NP.
O'Mahen, Boyd & Gashe (2015)	N=59 dysphoric (BDI-II score ≥14); N=39 non-dysphoric (BDI-II score <14). Infants aged 12mths or under. UK.	Randomly allocated to rumination or distraction condition – 8mins thought, guided by statements, e.g. rumination: "think about what your feelings might mean", distraction: "think about a double-decker bus driving down a street". Postnatal Parental Problem-Solving Task.	Dysphoric mothers in the rumination condition demonstrated poorer problem-solving effectiveness and less confidence in problem-solving compared to all other groups.

Abbreviations:

BADS = Behavioural Activation for Depression Scale; BDI = Beck Depression Inventory; DASS = Depression, Anxiety and Stress Scale; EPDS = Edinburgh Postnatal Depression Scale; IBQ-R = Infant Behaviour Questionnaire – Revised; MAAS = Maternal Antenatal Attachment Scale; MDQ = Major Depression Questionnaire; MIRI = Maternal Infant Responsiveness Instrument; PBQ = Postpartum Bonding Questionnaire; PBRS = Positive Beliefs about Rumination Scale; PSI = Parenting Stress Index; PSWQ-PW = Penn State Worry Questionnaire – Past Week; PTQ = Perseverative Thinking Questionnaire; RPA = Responses to Positive Affect questionnaire; RRS = Ruminative Response Scale; SASS = Social Adaptation Self-Evaluation Scale; SCID-IV= Structured Clinical Interview for DSM Disorders; SPS = Social Provisions Scale; STSS = Silencing the Self Scale.

Results

Ten papers were identified, addressing a range of questions about rumination within the perinatal context. Eight of these papers examined whether rumination is predictive of other maternal outcomes, including mood/depression and bonding with the infant, using questionnaire measures. Two papers described experimental studies examining the effects of induced rumination on some aspect of parenting behaviour. Each paper is described briefly below and study details are presented in *Table 1.*

Questionnaire Studies

Five papers using questionnaire measures examined whether rumination is predictive of depression in the perinatal period, either alone or in combination with other variables. Barnum, Woody & Gibb (2013) showed that antenatal rumination, measured in the third trimester, was predictive of increased depressive symptoms at 8 weeks postpartum, although not at 4 weeks postpartum. Attributional style was also a predictor of later depressive symptoms, although only in women with pre-existing high levels of depression, suggesting it may be a maintenance factor. In contrast, Raes et al. (2014) found that rumination in the third trimester did not predict depression at 12 or 24 weeks, when controlling for previous episodes of depression. This may be because previous depressive episodes were very highly correlated with rumination. Depression during pregnancy and previous depressive episodes were key predictors of postnatal depressive symptoms, as was dampening of positive emotion.

O'Mahen et al (2010) found a more complex relationship during pregnancy, such that rumination was predictive of later depression scores but only for women who reported poor social functioning. This suggests that effective social support may buffer the impact of rumination on future depressed mood. In contrast 'silencing the self' was predictive of rumination and depressed mood in women high in social functioning, but not those low in social functioning. These findings suggest that rumination may have a rather complex predictive relationship with perinatal depression, interacting with other risk and protective variables, both in the woman and in her social/environmental context.

O'Mahen, Karl, Moberly & Fedock (2015) examined links between childhood maltreatment, emotional regulation and depression in a group of women assessed during pregnancy. These women were either depressed or had elevated (but non-clinical) symptoms of depression. The data

showed that brooding[33] rumination was associated with higher levels of childhood maltreatment and with higher levels of depressive symptoms. Modelling showed that brooding rumination was a partial mediator of the relationship between childhood emotional abuse and current depressive symptoms. This suggests that rumination, particularly the brooding form, may be a pathway through which childhood maltreatment increases risk of later depression. The authors hypothesise that this effect may be mediated through attachment style – emotional abuse has been shown to be linked to the development of anxious attachment, which in turn predicts higher levels of rumination. Thus they suggest that attachment styles emerge from experiences of abuse or maltreatment and lead to distinctive emotional regulation strategies, including rumination, which then confer increased risk of depression.

Finally, one study examined positive beliefs about rumination, comparing these across a depressed and non-depressed pregnant sample. Beliefs about the utility of rumination, for example as a strategy for problem solving or resolving unmet goals, are thought to be important as they may promote engagement in rumination (Papageorgiou & Wells, 2001, 2003). Isa Alfaraj et al (2009) showed that positive beliefs about rumination were higher in a depressed than a non-depressed group, and that these beliefs predicted depression classification. This predictive relationship existed over and above perceived lack of social support.

The remaining three questionnaire-based studies examined impact of rumination on later bonding, attachment or self-reported maternal responsiveness. Müller et al. (2013) reported that rumination during pregnancy predicted mother-reported difficulties in bonding and attachment, even when controlling for pre- and post-natal depressive symptoms. The 'unproductiveness' subscale of the Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011) was particularly predictive of mother-infant bonding and attachment. This subscale includes items such as 'my thoughts take up all my attention' and 'I keep asking myself questions without finding an answer'. These findings are consistent with the proposed role for rumination in capturing attention and impeding effective engagement with infant cues, resulting in interactive difficulties. However, as rating of the mother-infant relationship was self-reported, it is also possible that the effect of rumination is to impact maternal *perceptions* of bonding and attachment. Scores on the PTQ did not predict postnatal depressive symptoms.

[33] Brooding is a component of rumination that involves making passive comparisons between one's current situation and some unachieved standard, and is considered to be a particularly maladaptive subtype of rumination. This is contrasted with reflective rumination, which involves a more purposeful focus on difficulties in order to facilitate problem solving (Treynor, Gonzalez, & Nolen-Hoeksema, 2003).

In a recent study, Schmidt et al. (2016) examined changes in rumination, worry, depression, anxiety and maternal-foetal bonding from the first to third trimester of pregnancy. Maternal-foetal bonding is considered an important outcome because it is predictive of later mother-infant attachment and maternal sensitivity (Siddiqui, & Hägglöf, 2000; Shin et al., 2006). Schmidt and colleagues showed that rumination in the first trimester had a small negative effect on intensity of maternal preoccupation with the foetus in the third trimester. Rumination was not predictive of later depression or anxiety symptoms, when controlling for baseline depression and anxiety. However, worry did have a small predictive effect for both depression and anxiety.

The role of rumination may also differ depending on infant factors. The final questionnaire study identified in the review indicated that rumination mediated the relationship between maternal depression and self-reported responsiveness to the infant, but only where infants displayed low levels of negative affect. Where infants had high levels of negative affect, depression was instead directly related to responsiveness (Tester-Jones, O'Mahen, Watkins, & Karl, 2015). This finding was based on self-report measures and therefore it is unclear whether these relationships would also hold for observed maternal responsiveness. It does however highlight the possible impact of infant variables, and the complex interplay of these factors with maternal mood and cognitions. It is unclear why rumination appears to be implicated only for infants high in negative affect. However, the authors speculate that rumination may be more prevalent under conditions where mood is low in the absence of infant difficulties. Rumination is often used as a strategy to gain insight or resolve ambiguity, and therefore may be utilised in this causally ambiguous situation, i.e. where the parent is unhappy and finding parenting difficult but does not perceive the infant to be difficult or high in negative affect.

Experimental Studies

Two experimental studies were identified – in both cases a rumination induction procedure was used before examining performance on some measure of parenting ability. Stein et al. (2012) tested whether inducing rumination or worry affected maternal responsiveness to 10 month old infants. This question was explored in a large sample composed of healthy controls and women meeting criteria for Generalised Anxiety Disorder (GAD) or MDD. Mother-infant interactions were examined both before and after a priming condition – either a worry/rumination prime, or a neutral prime. Worry/rumination was readily induced, using a simple procedure in which mothers were asked to spend 5 minutes thinking about either a current worry or a negative life event. Mothers in this

condition reported more negative thoughts, more repetitive thoughts and more difficulty controlling thoughts, compared to the neutral prime condition; they also reported more negative affect. The impact of the priming was particularly strong for the clinical groups (GAD, MDD). This suggests that ruminative thinking styles were readily accessible and easily triggered in these groups, using a brief, simple priming procedure.

We focus here particularly on findings for the MDD group, although the full analysis included comparisons between GAD, MDD and controls. At baseline, the only difference between groups was that mothers with MDD followed their children's attention less than controls. Following the rumination prime, responsiveness to infant vocalisation was lower in MDD than controls; this was not the case for the neutral prime. Also, across the MDD group, maternal responsiveness to infant vocalisation was lower following the rumination prime than following the neutral prime. These were largely trend-level effects, with somewhat stronger effects found for the GAD group. None of these effects was moderated by remission status, suggesting that both recently recovered and currently anxious/depressed mothers responded similarly to the priming, and differed significantly from the control group. These findings therefore suggest that maternal cognitions, including rumination, have causal, observable effects on mother-infant interactions in the context of postnatal depression and anxiety. It is interesting to note that the main effects of the worry/rumination prime were on maternal responsiveness to *vocalisation* specifically. It has been suggested that worry and rumination are primarily verbal in modality (Ehring, & Watkins, 2008), and therefore may particularly impact on processing of concurrent auditory/verbal stimuli.

In the final study identified, O'Mahen, Boyd, & Gashe (2015) examined the impact of rumination on parental problem solving. Rumination in general is known to affect problem solving and is associated with difficulties both in generating solutions and then implementing these (Nolen-Hoeksema et al., 2008). Dysphoric and non-dysphoric women with an infant under 12 months were randomised to either a rumination or distraction condition. Problem solving effectiveness was then assessed using a parenting-specific problem solving measure, which involved generating solutions for problem scenarios in order to reach a specified outcome. (e.g. *Problem* - New to area, attend baby-mum class, baby cries uncontrollably, 2-year old bites another child. *Outcome* - I make some friends.) The results showed that, compared to all other groups, dysphoric mothers in the rumination condition demonstrated less effective problem solving and also rated themselves as less confident in their problem solving. The authors of this paper hypothesise that rumination captures attention and

cognitive resources, and so impedes the ability to notice and engage with key features of the environment, resulting in lack of accurate information on which to base problem-solving strategies.

Discussion

The review highlights the rather mixed evidence as to whether rumination predicts later depression in the perinatal context, particularly after controlling for the effects of previous and current depression (e.g. Raes et al., 2014). Given the strong correlations of rumination with both current depression and history of depression, this may partly be because small studies have limited power to test predictive models and disentangle these effects. However, several papers indicate that rumination may interact with other variables including mother, infant and social/environmental factors (O'Mahen et al., 2010, 2015), suggesting that rumination has a complex role in predicting future depression, which depends on the presence of other factors. The review also indicates that the time course over which rumination is examined may play a role, with for example rumination predicting later (2 months postnatal) but not earlier (1 month postnatal) depression (Barnum et al., 2013). Positive beliefs about the utility of rumination may also be important (Isa Alfaraj et al., 2009), although this was examined only concurrently with mood, and not in a longitudinal design.

The current review also indicates that rumination has an impact on relational outcomes such as bonding and attachment, with higher rumination predicting later difficulties with bonding and attachment (Muller et al., 2013; Schmidt et al., 2016; Tester-Jones et al., 2015). However, there are very few studies examining this question and the existing studies are longitudinal but do not allow definite causal conclusions to be drawn. Critically, these studies have considered only mother-reported indices of these outcomes, rather than objective measures. The use of objective measures seems particularly important given the likely role of low mood and rumination on *perception* of these outcomes. As discussed in relation to prediction of later depression, rumination is likely to interact with other factors such as social support and infant temperament to predict relational outcomes (Tester-Jones et al., 2015). Given these findings, it is important to extend this work by establishing under what circumstances, or in the context of what other variables, is rumination predictive of later maternal outcomes (e.g. depression) and mother-infant outcomes (e.g. bonding).

The existing experimental evidence suggests that inducing rumination (or similar processes, such as worry) has an impact on maternal responsiveness (Stein et al., 2012) and effectiveness of infant-related problem solving (O'Mahen et al, 2015). Experimental designs provide a more robust test of

causality and suggest that rumination may indeed have a causal, mechanistic role. However, there are many remaining questions about the pathways through which rumination operates on parenting responses, the specific changes it causes, and subsequent impact on infants; further experimental research is clearly required.

The current review highlights some surprising gaps in the existing research. For example, there is currently no research examining issues such as the prevalence, chronicity and content of rumination in the perinatal context. Some qualitative research into women's experiences of PND has indicated themes that resemble rumination, but these are not typically labelled as such and therefore were not included in the systematic review. For instance, qualitative themes identified include: "obsessive thoughts of being a bad mother", "wondering what was happening to them", and "loss of control over thoughts" (C. T. Beck, 1992). Qualitative studies also frequently identify themes of loss, and incongruity between expectations and realities of motherhood (C. T. Beck, 2002). These ideas closely match the primary content of ruminative thought, that is, themes of loss and discrepancy between current and desired states (Nolen-Hoeksema et al., 2008). However, there is little systematic evidence regarding themes of rumination in PND, and how closely these parallel the content of rumination in depressive disorder more broadly. There is similarly no published literature on the prevalence or frequency of ruminative thought in PND. Recently, experience sampling methodology has been used to examine rumination in daily life (Kircanski et al., 2015), and this method may be useful for addressing some of these questions in the perinatal period.

This systematic review therefore provides some information about the potential role of rumination in predicting later outcomes, including maternal depression and mother-infant outcomes such as bonding. There is also some initial evidence that rumination plays a causal role in impairing parenting quality in clinical populations. However, the review also highlights many remaining questions and areas where this work could be extended. We have briefly outlined some possible future directions here and discuss this in more detail later in the paper *(see 'Remaining questions and future directions'*).

To date, the literature on rumination in the perinatal context has lacked a theoretical model or organising framework. Therefore, for the remainder of this paper, we develop and present a new cognitive model which seeks to account for the specific effects of rumination in the postnatal context. This model is informed by the literature identified in the systematic review, particularly initial findings that inducing rumination has measurable effects on parenting quality. We have also

built upon existing theories and models of rumination, taken from the broader depression literature, and so a brief overview of the frameworks and theories that have most influenced our model is presented below.

Theoretical Models of Rumination and Related Cognitive Processes

Various information-processing models have been proposed that seek to explain how rumination is triggered and maintained in the context of depression. Many of these models emphasise the role of cognitive biases and cognitive control deficits (reviewed in Mor & Daches, 2015). These models of rumination tend to implicate either absolute deficits in cognitive control or biases in the deployment of cognitive control, such that processing of certain types of information (e.g. negative or self-referential information) is less effectively regulated. Cognitive control refers to a set of processes that facilitate flexible cognition and behaviour, in line with moment-to-moment goals. This concept is closely related to executive functions, and is generally held to include processes such as overriding pre-potent responses and inhibiting processing of irrelevant information, switching the focus of attention, and updating working memory (Miyake et al., 2000). Difficulties with inhibition of irrelevant information and flexibly shifting the focus of attention have been particularly implicated in rumination (Davis & Nolen-Hoeksema, 2000; De Lissnyder, Derakshan, De Raedt, & Koster, 2011; Joormann, 2006; Whitmer & Banich, 2007). It is hypothesised that deficits or biases in these domains could account for difficulties in terminating ruminative thought processes once these are triggered. This may help to account for the prolonged and perseverative quality of rumination. There is then an emerging consensus that cognitive control difficulties, whether absolute deficits or biases, are implicated in rumination. It has been suggested that cognitive control deficits or biases may in fact play a causal role in rumination and depression. Evidence for this is starting to emerge from longitudinal studies (Demeyer, De Lissnyder, Koster, & De Raedt, 2012) and experimental designs (Mor & Daches, 2015). However, this relationship may be bi-directional, as there is evidence that inducing rumination impairs aspects of cognitive control (Philippot & Brutoux, 2008; E. Watkins & Brown, 2002; Whitmer & Gotlib, 2013).

Other, related models conceptualise rumination as being akin to a cognitive habit, which develops in the context of deficits in cognitive control. This idea was proposed by Hertel (2004) and has been further developed in a recent model from Watkins & Nolen-Hoeksema (2014). Watkins & Nolen-Hoeksema suggest that habitual, trait rumination develops through the repeated co-occurrence of rumination with contextual cues (e.g. low mood), such that rumination eventually becomes

automatically cued by these contextual factors. They argue that deficits in cognitive control may confer vulnerability to habitual rumination, as cognitive control enables people to override pre-potent or habitual responses, in order to respond flexibly to situational demands. Similarly, Segal and colleagues (e.g. Segal et al., 2013) have proposed that during repeated episodes of depression, a strong connectivity develops between depressed mood and depressogenic cognition, including rumination. This connectivity creates a heightened cognitive vulnerability, meaning that when low mood is experienced in future this triggers high levels of depressogenic cognition, and so increases the risk of further episodes of depression.

Forms of repetitive negative thinking, such as rumination, are increasingly recognised as transdiagnostic phenomena (De Raedt, Hertel, & Watkins, 2015), with relevance to both anxiety and depressive disorder. Various accounts of both anxiety and worry have been proposed that have clear parallels with the models outlined above in terms of the emphasis on the role of cognitive biases and cognitive control deficits. Therefore, in addition to models from the depression literature, our cognitive model is also informed by existing models of anxiety and worry. We have particularly drawn on Attentional Control Theory (Eysenck & Derakshan, 2011; Eysenck, Derakshan, Santos, & Calvo, 2007) and a key model of worry (Hirsch & Matthews, 2012). These accounts are similar in that they integrate 'bottom up' biases in attentional processing with 'top down' cognitive control processes. They may therefore have utility in guiding the development of an integrative model of rumination, cognitive biases and cognitive control.

Cognitive biases in perinatal depression

Cognitive biases have been clearly implicated in the development and maintenance of rumination (Everaert, Koster, & Derakshan, 2012; Mathews & MacLeod, 2005), but much less work has been conducted specifically in perinatal populations. In a recent review, Webb and Ayers (2014) identified 14 studies examining cognitive biases in women with perinatal mental health problems, including depression, anxiety and PTSD. Various study designs were employed, but in each case the stimuli examined were either adult or infant facial expressions. There is a particular interest in attention to and interpretation of emotional facial expressions in this population, as it has been argued that the ability to interpret infant emotion accurately is a prerequisite for sensitive parenting behaviour. Webb and Ayers concluded that women who are depressed tend to show attentional biases towards sad infant faces, and to a lesser extent show similar biases towards sad adult faces. There is also evidence that this group of mothers are more likely to interpret neutral or ambiguous infant faces as negative. These biases seem likely to negatively affect contingent, sensitive parenting because this

relies on an ability to accurately detect infant cues, in order to respond in an appropriately matched way. If a mother is biased towards detection of negative cues, she may miss important positive or neutral cues, such as happiness or interest, which would otherwise have guided her responses. Infant cues also provide critical feedback that allows mothers to continually evaluate and adjust their parenting responses as required. Cognitive biases in infant cue perception may therefore affect mothers' evaluations of their parenting, and ability to adjust responses to meet the infant's needs.

The perinatal literature is therefore small but broadly consistent with the general depression literature in suggesting negative cognitive biases in attention and interpretation. Various questions have not yet been addressed, including whether memory biases are present and how these different cognitive biases relate to one another. Biases in attention, interpretation and memory are likely to interact with one another; for example an attentional bias towards negative information may lead to more negative information being recalled later (memory bias). Therefore, in interaction with one another, these biases may have wide-ranging impacts on perception of the infant (e.g. affect, temperament), the self (e.g. self-efficacy, evaluation of parenting ability), and the parent-infant relationship (e.g. bonding, attunement). It is also unclear from the current literature in PND whether cognitive biases operate on a range of stimuli, including facial expressions other than sadness (e.g. anger, fear) and vocal stimuli; this may be a useful direction for future research.

Cognitive control deficits in perinatal depression

As outlined above, cognitive control deficits are associated with rumination and considered to be important for understanding vulnerability to rumination. Impairments in cognitive control are perhaps particularly relevant for postnatal populations, given the demands that parenting places on executive function. Barrett & Fleming (2011) note that mothers "must be flexible and be able to focus when appropriate and switch attention when the situation changes… planning, attention, flexibility and working memory are essential for adequate mothering". A handful of studies using neuropsychological measures have found evidence of impaired executive function associated with postnatal depression. For example, Pio de Almeida et al. (2012) report evidence of impaired working and short-term memory in depressed parents; Messinis et al. (2010) report poorer performance on a learning task and an attention switching task by postnatally depressed women compared to controls. However, there has been little work in this area and a more thorough examination of cognitive control in PND is indicated. It would also be of interest to explore links between cognitive control in PND and changes in parenting behaviour, particularly the features of parenting that are critical to child development, such as contingency.

Applying a Theoretical Model to Postnatal Depression

There are then several theoretical models that seek to explain rumination, or related cognitive processes such as worry, with reference to underlying cognitive biases and/or cognitive control deficits. The literature in PND, reviewed above, is broadly consistent with findings from research in depression and rumination more broadly. However, the perinatal literature has not typically been guided by a specific theoretical framework and therefore there are many gaps in our knowledge. Use of such a framework may provide a focus for future research and advance understanding in this field.

Whilst the models of rumination and worry outlined above provide a helpful starting point for a theoretical framework, they require adaptation in order to account for particular effects in the context of PND. We propose an information-processing model of rumination in PND, guided by more general models of rumination and worry, which incorporates a focus on cognitive biases and cognitive control deficits, and the role of low mood/associated cues in triggering rumination. Importantly, our model also includes processes that are specific to the postnatal context, that is, effects on infant cue processing and parenting responses.

Our cognitive model of rumination in postnatal depression is intended to provide an initial theoretical framework that may illuminate some of the underlying cognitive mechanisms. These pathways provide testable hypotheses for future research and may also indicate possible intervention routes. Findings from attention bias modification and cognitive bias modification research suggest that cognitive biases and cognitive control deficits are potentially modifiable pathways, and therefore suitable targets for intervention. The model is described below and illustrated in *Figure 2*. The description of the model begins with an account of rumination, and its relation to cognitive biases and cognitive control deficits, which is based on existing models from the broader depression literature. We then go on to discuss how these processes may specifically affect the postnatal period, with reference to their impact on infant cue processing and parenting behaviour.

A cognitive model of rumination and parenting

We propose that rumination is associated with both top-down cognitive control deficits and bottom-up cognitive biases. These components of the model are hypothesised to have bidirectional links with rumination. Within the model, rumination is preceded by an initial trigger, which may be internal, such as mood or an intrusive negative thought, or could be an external event such as an

everyday stressor. In the postnatal context, this may include parenting related triggers, such as managing multiple demands or encountering infant negative affect. Following this trigger, rumination is established and maintained though the combined effects of cognitive biases and cognitive control deficits.

Firstly, it is suggested that in the context of depression or low mood, cognition is biased in favour of negative information. Negative information is therefore more likely to enter awareness and thus influences the content of ruminative thought, such that this is pervasively negative. Rumination, which involves repetition and elaboration of this content, likely also reinforces cognitive biases via rehearsal. These biases are therefore strengthened and it becomes increasingly likely that negative content and ruminative processes will be activated when future triggers are encountered.

Secondly, deficits in cognitive control are hypothesised to impair the ability to reappraise or redirect attention away from negative thoughts once triggered. Cognitive control incorporates voluntary, executive processes that facilitate directing attention towards task-relevant information in a goal-directed manner, by flexibly shifting the focus of attention and inhibiting distracting information. Typically then, cognitive control processes enable people to override negative, ruminative thought processes once triggered, and to redirect attention onto alternative topics or task-relevant information. However, in the context of cognitive control deficits, there may be insufficient control to override ruminative processes once these develop. These thoughts are therefore subject to continued attention and develop into a repetitive and persistent thought process. When this occurs persistently, a pattern of high trait rumination is established. Rumination is also likely to exert reciprocal effects on cognitive control, as it is an activity that consumes cognitive resources (S. Hayes, Hirsch, & Mathews, 2008; Stefanopoulou, Hirsch, Hayes, Adlam, & Coker, 2014; E. Watkins & Brown, 2002). This may mean that during rumination, with cognitive control directed towards processing of the ruminative context, it becomes increasingly difficult to redirect attention. The ruminative state is therefore maintained and becomes prolonged.

The combined effects of negative cognitive biases and cognitive control deficits may therefore help explain vulnerability to rumination. This type of model is consistent with the characteristics of ruminative thought, particularly the reported experience that it is repetitive and uncontrollable. Within this model, rumination also acts to reinforce cognitive deficits and biases, thus increasing the likelihood that rumination will be triggered in future. This is consistent with the stability and persistence of trait rumination over time.

In the postnatal context, we propose that these cognitive processes will have important effects on infant cue processing. Cognitive biases are hypothesised to affect attention to and interpretation of infant emotional cues. Cognitive control deficits are hypothesised to affect the ability to appropriately direct cognitive resources towards infant cues. Biases and control deficits may therefore directly impair infant cue processing, potentially resulting in slower and/or less accurate perception of infant cues. In addition, it is proposed that cognitive biases and control deficits impair cue processing indirectly, via their actions on rumination. The combination of cognitive biases and control deficits leads to rumination becoming highly prevalent and persistent. It thus captures attentional and cognitive resources so that external cues, including infant cues, are likely to be less effectively or less rapidly attended. This is consistent with the proposed role of preoccupation as an important mechanism through which maternal mental health disorders affect parenting (Stein et al., 2009). Given the frequency and persistence of ruminative thinking in depression, it is hypothesised that its effects on parenting behaviour may be pervasive.

Failure to rapidly and accurately perceive infant cues is likely to have a significant impact on parent-infant interaction, particularly contingent responsiveness. Continent responsiveness refers to a pattern of responding to the infant in which the parent's behaviours are closely matched to the infant's cues, both in terms of timing and selection of response (Bornstein & Tamis-LeMonda, 1989). The mother's ability to deliver an appropriate and timely response, and so maintain contingency, is dependent on accurate and efficient processing of infant cues. We hypothesise that information processing deficits and biases, along with the preoccupation inherent in rumination, impair mothers' ability to process infant cues accurately and efficiently. Contingent responding is thus impaired. Infants are highly sensitive to deviations from contingency (Bigelow, MacLean, & MacDonald, 1996; Mesman, van Ijzendoorn, & Bakermans-Kranenburg, 2009; Tronick, Als, Adamson, Wise, & Brazelton, 1978), and can perceive contingency only over short latencies (Keller, Lohaus, Völker, Cappenberg, & Chasiotis, 1999). Therefore, even subtle mismatches or delays in responding may have significant implications for child outcomes.

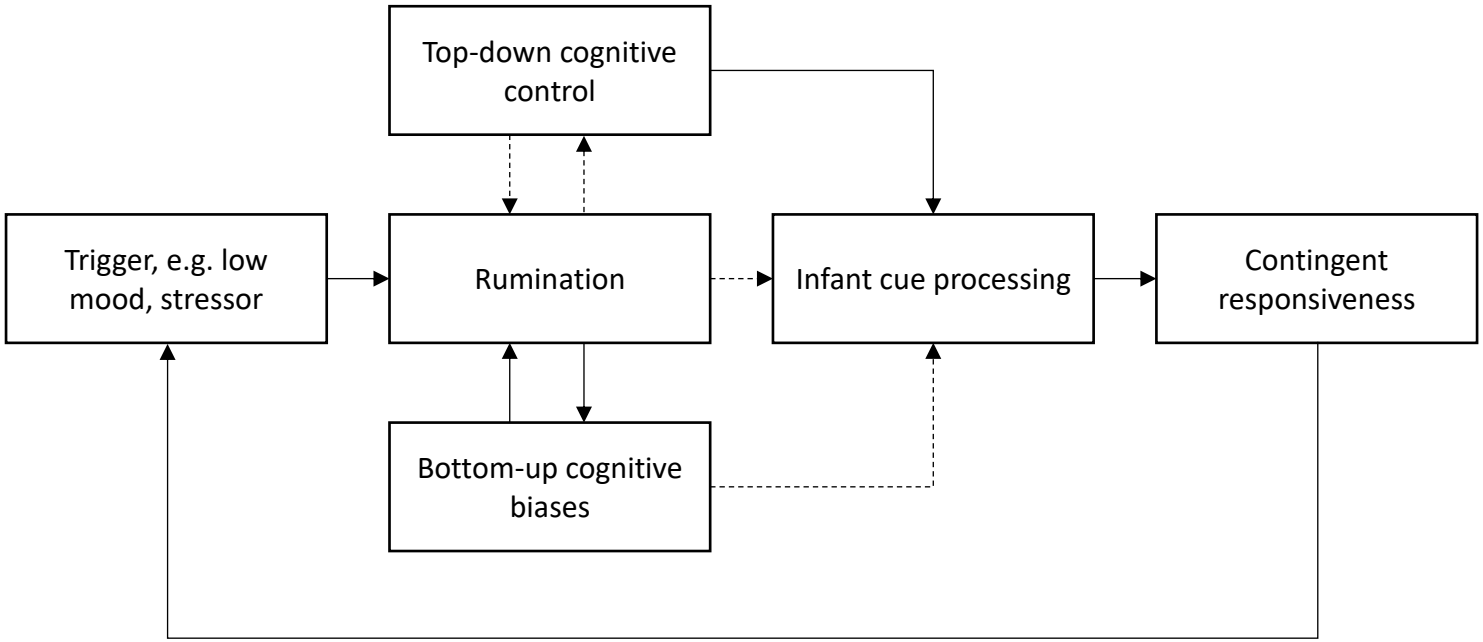
Psychogiou and Parry (2014) have suggested that unstructured interactions (e.g. play) may be particularly affected as parental response is highly dependent on self-directed attention. In contrast, more structured situations may be less affected, as the externally imposed structure may help to focus and direct parental responses. Similarly, it has been shown that parenting difficulties associated with maternal psychopathology are mainly observed under conditions of stress or challenge (Ginsburg, Grover, Cord, & Ialongo, 2006). Within the model, this is consistent with the

role of stress or challenge as a trigger for rumination, which then has effects on cue processing and interaction. Impairments in contingent responding are likely to impact on the mother's experience of parenting and sense of competence as a parent. Lack of contingency is likely to result in difficult or mismatched interactions with the infant, which may in fact act as a trigger to further rumination.

Implications for Child Development

Contingent responsiveness is thought to be a key aspect of effective parenting, which promotes the infant's development. If rumination, and related attentional processes, have effects on contingent responding therefore, this may be an important mechanism through which maternal mood impacts on child developmental outcomes. It has been suggested that contingent responsiveness is particularly implicated in child *cognitive* development. Contingent responsiveness in mothers with depression is predictive of children's attention and cognitive functioning (Murray et al., 2010), which in turn predicts later intellectual functioning (Bornstein, 2014; Stanley, Murray, & Stein, 2004). It could therefore be hypothesised that high levels of maternal rumination might be particularly associated with risk of negative attentional and cognitive outcomes for the infant. PND in general is associated with a range of risks for child development, including behavioural and emotional, as well as cognitive outcomes (reviewed in Stein et al., 2014). It is possible that rumination, and subsequent changes in infant cue processing and contingency, play an important role in mediating some or many of these risks. There is a need for longitudinal, developmental studies to examine these questions. Finally, whilst the research to date has focused on mothers, there is no reason to believe that similar processes might not also apply to fathers; this should be a focus of future work in this area.

Figure 2. Information processing model of rumination and effects on parenting behaviour[34]



[34] Where solid lines indicate positive links and dotted lines indicate negative/inhibitory links

Implications for Intervention

The model presented here has implications for intervention design – it highlights specific cognitive features of PND that we argue are key mechanisms through which depression affects parenting and therefore child development. Interventions that target these cognitive mechanisms are therefore likely to have benefits both for maternal mental health, and for child outcomes.

Although rumination has rarely been examined as an outcome in treatment trials, there is some evidence that cognitive behavioural therapy does not effectively reduce rumination (Schmaling, Dimidjian, Katon, & Sullivan, 2002), that high levels of rumination predict poorer outcomes (Jones, Siegle, & Thase, 2008), and that rumination at end of treatment predicts depressive relapse (Michalak, Hölz, & Teismann, 2011). There is therefore increasing interest in treatments that are hypothesised to specifically target rumination, including mindfulness approaches (e.g. MBCT; Segal, Williams, & Teasdale, 2013), acceptance-based approaches (S. C. Hayes, Strosahl, & Wilson, 2003), behavioural activation (Martell et al., 2010) and metacognitive therapy (A. Wells, 2009). Given that residual rumination seems to confer risk of future depressive episodes, clinicians and researchers have suggested that more effectively targeting this aspect of depressive cognition may improve treatment outcomes and reduce relapse.

In the postnatal context, treating depression alone does not seem to be sufficient to ameliorate negative effects on parent-infant interactions and child outcomes (Poobalan et al., 2007). One hypothesis is that residual rumination may be a factor underlying this effect; if ruminative thinking remains a habitual response that is triggered when low mood or stressors are encountered, then this would continue to effect parental attention to infant cues, and therefore negatively impact on parent-child interactions.

The model outlined above generates several testable predictions regarding the type of interventions that may be helpful. In particular, it suggests that interventions that shift the balance of competition between bottom-up biases and top-down control processes should be beneficial in reducing rumination. This could involve directly targeting 'top-down' attention control processes, 'bottom-up' attention biases, or some combination of both these factors. Interventions that target the 'bottom-up' cognitive biases in the model could include attention bias modification (ABM) procedures and cognitive bias modification procedures that target biases in interpretation of ambiguity (CBMi). These precedures are designed to change biases through repeated rehearsal of a more positive or neutral bias (Hertel & Mathews, 2011). 'Top-down' interventions may include cognitive remediation

(Porter et al., 2013) or other training procedures, such as working memory training (e.g. Owens et al., 2014). There may be particular benefits to a 'top-down' approach as increased cognitive control is likely to facilitate greater *flexibility* of responding. This flexibility of responding has been proposed to be important for effective emotional regulation (Ochsner & Gross, 2005) and resilience (Genet & Siemer, 2011), and is likely to play a key role in facilitating sensitive and contingent parenting behaviour. The model presented here provides a framework to direct hypothesis generation and future systematic investigation of these questions.

Remaining Questions and Future Directions

The review and theoretical framework presented here highlight many remaining questions about the role of rumination in PND, and suggest several potential avenues for future research. Firstly, there is a need for studies that better characterise rumination in the context of PND, including prevalence, frequency and persistence of rumination, as well as content and themes. More consistent use of terminology and better alignment with the general depression literature may be helpful in developing our understanding of the role of rumination in the postnatal context. Inclusion of rumination measures in treatment trials and epidemiological studies would also facilitate exploration of the role of rumination as a proposed vulnerability factor and mechanism of change.

Secondly, the proposed role of cognitive biases and cognitive control in the model could be tested directly. Experimental designs, which manipulate either cognitive biases or cognitive control, and examine impact on rumination, would provide a particularly robust test of the model. There are a small number of studies addressing these processes in non-perinatal groups, although to date findings have been mixed (Mor & Daches, 2015). As the literature on rumination and cognitive control in depression continues to develop, this may support or suggest refinements to the model.

Thirdly, the impact of rumination on infant cue perception and subsequent parenting behaviour requires further examination. Whilst there is evidence that rumination affects maternal responsiveness (Stein et al., 2012), the precise effects of rumination on infant cue processing are unclear. It may be that the effects of rumination differ according to the emotional tone of cues (e.g. happy, sad or neutral expressions), or that certain modalities (e.g. visual, auditory) are more affected than others. As rumination is thought to be predominantly verbal phenomena (Ehring, & Watkins, 2008), it might be expected that responsiveness to auditory/vocal cues would be particularly affected. If rumination does indeed affect responsiveness to particular cues, this may be demonstrated by changes in either accuracy or reaction time, or both of these parameters.

Experimental studies using standardised infant cue stimuli, in combination with induced rumination procedures, could be used to address these questions. In addition, examining infant cue perception and live mother-infant interaction in the same group would facilitate a test of the hypothesised links between these components in the model. Longitudinal designs would also be of use in extending this work to include direct measures of developmental outcomes for the infant.

Conclusions

There is a general need to better understand the mechanisms through which PND affects child outcomes. This is critical, in order to guide the design of more efficacious interventions that ameliorate these effects. The cognitive features of PND, including rumination and related cognitive deficits and biases, provide promising and relatively under-explored possible pathways. Increasing evidence from the broader treatment literature in depression suggests that these mechanisms are modifiable, either using psychotherapy or specific training interventions (e.g. ABM, working memory training). Interventions targeting these mechanisms therefore have potential to improve mother-infant interaction and child developmental outcomes. Given the role of rumination in conferring risk for future episodes of depression, interventions targeting this process may also have important benefits for long-term maternal mental health. In addition, it has been suggested that screening for and treating rumination may have potential as a preventative intervention (Topper, Emmelkamp, & Ehring, 2010). Increased contact with health services and motivation to make lifestyle changes during pregnancy and the postnatal period may make this a particularly suitable time for such preventative work. Given the proposed similarities between rumination and other repetitive negative thought processes (e.g. worry, preoccupation), interventions targeting rumination may also have broader applicability, for example in anxiety disorders or other parental mental health conditions.

The theoretical framework outlined here may have utility in guiding future research and in the development of improved interventions for PND. It provides a theoretical account of potential maintenance mechanisms, and suggests several pathways that may be modifiable. Understanding of these mechanisms is likely to benefit from ongoing experimental and clinical studies of rumination more broadly. However, there is also a need to test these mechanisms directly in postnatal groups in order to examine the hypothesised effects on processing of infant cues and contingent responding, and ultimately on child developmental outcomes.

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