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***Understanding depressive rumination from a cognitive science perspective:
The impaired disengagement hypothesis***

Ernst H.W. Koster ^a, Evi De Lissnyder ^a, Nazanin Derakhshan ^b, and Rudi De Raedt ^a

^a Ghent University, Belgium

^b Birkbeck University of London, UK

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Corresponding author:

Ernst Koster
Ghent University
Dept. of Experimental-Clinical and Health Psychology
Henri Dunantlaan 2
B-9000 Gent
Belgium
Phone: 0032(0)9 2646446
Fax: 0032(0)9 2646489
E-mail: Ernst.Koster@UGent.be

Abstract

Persisting negative thoughts are considered a hallmark feature of depression. Recent information-processing approaches have begun to uncover the underlying mechanisms of depressive rumination. Despite marked advances in this area, there is a lack of integration between psychopathology and cognitive (neuro)science research. We propose the ‘impaired disengagement’ hypothesis as a unifying framework between both approaches. The core tenet of our model is that prolonged processing of self-referent material is due to impaired attentional disengagement from negative self-referent information. We discuss the empirical evidence for this framework and outline future ways in which the causal predictions of this model can be tested. The proposed framework can account for the effectiveness of various treatments for depression and may aid in devising new interventions to target depressive cognition.

Keywords: depression, cognition, rumination, attention, information-processing

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1. Introduction

Persistent negative cognition is a hallmark feature of depression and anxiety that is assumed to play an important role in the etiology and maintenance of affective disorders (Clark, Beck, & Alford, 1999; Watkins, 2008). Although engaging in prolonged and repetitive thinking about one's self in relation to the social environment, which could increase upon the encounter of stressful events or emotional states, is in essence a constructive and normative process, this process can become exaggerated and associated with detrimental effects in several forms of psychopathology (Watkins, 2008). In this article we focus on an important form of depressive cognition, rumination, and we propose a new theory based on information-processing and affective neuroscience research to account for heightened levels of rumination observed in depression. This new theory holds important implications with regard to strategies that can directly target the mechanisms underlying rumination.

It is important to mention that, at the outset, we clearly distinguish between cognitive processes and products, as proposed by Ingram and colleagues (Ingram, Miranda & Segal, 1998). Attentional control, as measured by experimental tasks, is considered a *process* influencing rumination as measured by questionnaires. Although definitions of rumination (see below) sometimes refer to rumination as “a process” of thinking, we regard rumination as a certain *style* of self-referential thinking. The negative cognitions associated with a ruminative thinking style are seen as cognitive *products*.

1.1 Depression and Negative Cognition

Cognitive theories have emphasized the role of negative cognitions in the etiology and maintenance of depression. According to Beck's influential cognitive theory (Beck, Rush, Shaw, & Emery, 1976), depression is characterized by the presence of negative *schemas*, defined as mental representations of past experiences, containing dysfunctional attitudes about

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the self (Beck, 1967, 1995). These underlying schemas have an important influence on the way information is processed, guiding one's interpretation, attention and memory for personally relevant negative experiences (Clark et al., 1999). The activation of the schemas in confrontation with stressful life events and negative mood states leads to specific negative automatic thoughts including negative cognitions about the self, the world and the future (the so called negative cognitive triad, Beck, 1995). The negative cognitions, in turn, further maintain and exacerbate negative affect, leading to a vicious cognitive-affective circle with enhanced depressive symptoms (Teasdale, 1988; Watkins, 2008).

Although the negative content of depressive cognition is proposed to play an important role in the vulnerability for depression (Alloy et al., 2000; Clark et al., 1999), recent theoretical models highlight the importance of underlying cognitive processes that might be responsible for elevated and persistent negative cognition and affect (Joormann, Yoon, & Zetsche, 2007). Research has demonstrated that the activation of negative cognitions or representations in working memory may not necessarily result in increased and prolonged negative affect. Instead, it is the ability to regulate negative affect that plays an instrumental role in determining which individuals are at risk to experience prolonged negative affect upon encounter of stress (Joormann et al., 2007). The regulation of negative mood however seems to be dependent upon the efficient exercise of working memory functions involved in the regulation of negative information. In a related manner, individual differences in the cognitive control functions are proposed to be related to a ruminative thinking style (Davis & Nolen-Hoeksema, 2000).

1.2 Rumination

In recent years, *ruminat*ion has been defined as “behaviors and thoughts that focus one's attention on one's depressive symptoms and on the implications of those symptoms”

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(Nolen-Hoeksema, 1991, p. 569). The response style theory of depression (Nolen-Hoeksema, 1991) proposes that individuals differ in their reaction to negative mood states and that rumination is a trait-like response style to distress. Individuals are engaged in depressive rumination because they believe that ruminating about their mood and symptoms will help to understand themselves better. However, rather than leading to increased self-understanding, depressive rumination augments sad mood and negative thinking by focusing attention on current mood (Lyubomirsky & Nolen-Hoeksema, 1995). Later, it was proposed that the harmful effects of rumination stem not from attention to distress per se, but from self-focused attention that is negative, evaluative and judgmental (Rude, Maestas, & Neff, 2007).

To assess individual differences in the tendency to ruminate, Nolen-Hoeksema and Morrow (1991) developed the Ruminative Response Scale (RRS). This scale has high internal consistency and acceptable convergent validity (Butler & Nolen-Hoeksema, 1994; Nolen-Hoeksema & Morrow, 1991). Various versions of this 22-item scale have been used in numerous studies over the years. Factor analyses of the RRS have identified two distinct subtypes of rumination (Treynor, Gonzalez, & Nolen-Hoeksema, 2003). The first, reflective pondering, is a more adaptive form of rumination and reflects the degree to which individuals engage in cognitive problem solving to improve their mood. The second, depressive brooding, is a more maladaptive form of rumination and reflects the degree to which individuals passively focus on symptoms of distress and the meaning of those symptoms. Both rumination scales involve focusing on distress, but the brooding scale contains more self-critical, evaluative, and judgmental statements (Rude et al., 2007). Depression is specifically characterized by high levels of brooding (Burwell & Shirk, 2007; Joormann, Dkane, & Gotlib, 2006; Treynor et al., 2003).

Rumination in response to negative mood increases vulnerability to depression. Experimental studies testing the effects of rumination have generally used the rumination

induction procedure developed by Nolen-Hoeksema and Morrow (1993). This procedure increases ruminative thinking and has been shown to heighten and prolong negative mood and cognition in dysphorics (Morrow & Nolen-Hoeksema, 1990; Nolen-Hoeksema & Morrow, 1993) and in clinically depressed participants (Donaldson & Lam, 2004; Lavender & Watkins, 2004; Watkins & Moulds, 2005; Watkins & Teasdale, 2001). Induction of rumination also hampers problem solving and task performance (Watkins & Brown, 2002). In addition, numerous studies have demonstrated that rumination is associated concurrently with depressive symptoms (Treyner et al., 2003) and prospectively with the onset (Nolen-Hoeksema, 2000), severity (Just & Alloy, 1997; Nolen-Hoeksema & Morrow, 1991) and duration (Nolen-Hoeksema, 2000) of depression, and recovery from depression (Kuehner, & Weber, 1999; Schmaling, Dimidjian, Katon, & Sullivan, 2002).

2. The Impaired Disengagement Hypothesis

Despite marked progression in the understanding of the affective consequences of rumination, there is less clarity on the underlying mechanisms of rumination. We argue that information-processing factors play a crucial role in rumination. We will first outline a basic model of information-processing in rumination and will subsequently discuss the empirical evidence for each of its specific components.

2.1 Basic Assumptions of the Model

Engaging in rumination, be it pondering or brooding, in response to major life events, negative mood states, or relatively minor stressors (such as an awkward social encounter) is considered a normal, non-pathological process. This process of critical contextual and self-evaluation helps us make sense of events in our social environment or personal history (see Carver & Scheier, 1998). We refer to this process as ‘cued rumination’. We postulate

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difficulty to disengage attention as the central engine that puts individuals at risk for heightened levels of rumination and brooding in particular. That is, individuals who are characterized by a difficulty to exercise attentional control in response to negative thoughts are likely to experience persistent rumination. Attentional control is broadly conceived here and refers to the ability to selectively attend to task-relevant information and to inhibit distraction by task-irrelevant information.

Important to note here, rumination is influenced by factors other than information-processing. Clearly, heightened levels of negative affect and/or the frequent encounter of stressful events are associated with enhanced attempts to understand these feelings and events (see also Martin & Tesser, 1996). However, these factors cannot explain why rumination persists despite the absence of highly stressful events or other unmet goals. The latter can be observed in individuals with recurrent depression who develop new depressive episodes upon encounter of relatively mild stressors (Monroe et al., 2006) and have high levels of rumination. Given that information-processing factors related to attention and executive function determine to a large extent the contents of working memory (Hasher & Zacks, 1988), these factors may play an important role. It is noteworthy that we are not the first to suggest that information-processing factors contribute to rumination. For instance, Linville (1996) proposed that deficient inhibition is a risk factor for heightened levels of intrusions in working memory. However, our proposal goes beyond this prediction in being more specific on the factors involved in integrating cognitive as well as affective neuroscience data. First, we will describe the nature of this attentional problem in more detail. We will then review the extant research that has investigated the association between rumination and information processing deficits.

INSERT FIGURE 1 ABOUT HERE

2.2 Impaired Disengagement Hypothesis

A schematic outline of the impaired disengagement hypothesis is provided in Figure 1. We assume that certain internal (e.g., negative affect or memories) or external stressors that conflict with an individual's goals cue ruminative thoughts. For instance, being confronted with a stressor such as a job loss, an argument with one's spouse or receiving criticism will elicit thoughts about the causes of these stressors. Clearly, the nature of such thinking is analytical and self-critical in looking at one's contribution to the problem, and this is likely to elicit a negative mood state. This is a normal process that is crucial in the deliberate regulation of one's behavior. This critical thinking is terminated when a solution to the problem is reached or, in the absence of a solution, when the individual engages in either automatic or deliberate emotion regulation.

In most individuals self-critical negative thoughts typically are not in line with existing positive self views. Therefore after some time these thoughts (or the affiliated negative mood) will cause the signaling of cognitive conflict. In line with emerging literature on emotion regulation, this signaling of conflict can occur at the automatic as well as at the strategic level (see Mauss, Bunge, & Gross, 2007). In most individuals this conflict signaling is followed by the disengagement of attention from negative thoughts. The successful disengagement of attention from negative thoughts then allows to reappraise the situation or distract from the situation altogether by focusing attention on other (task-relevant) stimuli or more positive distracters. Note that avoidance of negative information is quite frequently observed in non-depressed, control participants (see De Raedt & Koster, 2010, for a review).

There are multiple ways in which this initial stage of conflict signaling and attentional allocation can be disrupted. This may be due to either impaired conflict signaling or intact conflict signaling but reduced attentional control. In the first option (i.e., impaired conflict signaling), in individuals with negative self schemas (cf. Clark et al., 1999), negative thoughts

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about oneself will elicit less cognitive conflict and therefore attentional resources will not be reallocated. Indeed, there is emerging evidence that conflict signaling is reduced for negative material when individuals are in a negative mood state (Foti & Hajcak, 2010). The absence of conflict signaling will be associated with a sustained attentional focus on self-referring negative information. Interestingly, recent neurophysiological data show that conflict monitoring reduces with increasing number of depressive episodes (Vanderhasselt & De Raedt, 2010).

In the second option, sustained attention for self-referring negative information is observed due to impaired attentional control. At this point there are important reciprocal relations between rumination, attentional control, and depression. First, depressive episodes are characterized by a general reduction in attentional control. Many studies have documented an overall reduction of attentional control in depression (e.g., Merriam, Thase, Haas, Keshavan, & Sweeney, 1999). It is noteworthy though that this reduced attentional control is not of very large magnitude and mostly found in severely depressed individuals (see for a review, Joormann et al., 2007). However, depression is characterized by valence-specific impaired attentional control. Attentional control is markedly lower in the presence of self-relevant negative information. There now is converging evidence to show that clinical as well as sub-clinical depression is characterized by an attentional bias in favor of negative material. This effect is mainly observed when self-relevant negative information is presented for longer durations (see De Raedt & Koster, 2010, for a review). Finally, there is evidence suggesting reduced functional connectivity between neural structures involved in conflict signaling and the implementation of attentional control (Holmes & Pizzagalli, 2008). An more extensive overview of the neural mechanisms associated with impaired attentional control.

Importantly, previous research has shown that such persistent rumination is associated with impaired problem solving (Watkins & Moulds, 2005), reduced performance on other

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tasks (e.g., Lyubomirsky, Kasri, & Zehm, 2003), and with negative affect (Thomsen, Jorgensen, Mehlsen, & Zachariae, 2004). In previous theories it is held that hyper-accessibility of negative thought content reduces the effectiveness of executive functions and depletes attentional resources from problem solving (e.g., Watkins & Brown, 2002). At this point more specific hypotheses can be formulated based on research into the influence of emotion on cognition. It is thought that negative mood narrows the attentional focus, which may cause an attentional funneling effect (see Clore & Gasper, 2000). That is, the narrowing of attention is associated with heightened importance of the emotional information that is within the focus of attention, which in turns intensifies the emotional state causing a further reduction of goal space. These three factors nicely explain why enhanced self-focused attention is associated with impaired problem solving and executive functioning. Indeed, there is evidence that sad compared with positive mood is associated with a more focused attention and less creative thinking (Rowe, Hirsh, & Anderson, 2007).

There is an important reciprocal relation between the affective and cognitive consequences of rumination. That is, negative affect, impaired problem solving and task impairments can become important cues that trigger further negative cognitions and rumination.

A final but crucial proposal is that if individuals become trapped in this vicious cycle, rumination becomes a habitual mode of thinking. Where initially rumination may be goal-directed and engage attentional resources, persistent rumination is characterized by reduced quality of thinking with attention being deployed to negative thoughts in a less constructive way (Nolen-Hoeksema et al., 2008). This observation may be caused by the combination of attentional funneling and the strengthening of associative thinking along similar in the context of reduced attentional control. This persistent rumination is related to depressive rumination or brooding. As this becomes an habitual form of thinking, we propose that this type of

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rumination is associated with a large reduction in deliberate allocation of attentional resources. The empirical research on several elements of our proposal is discussed in the subsequent sections.

2.3 Research Findings

In this section we will review the literature on the association between rumination, attention, and depressive symptoms. Note that many of the studies included here have examined individuals (undergraduates) with elevated depressive symptoms, who generally show elevated levels of rumination. It has been demonstrated that individuals who show heightened levels of subclinical depressive symptoms are at risk for developing clinical depression (Fergusson, Horwood, Ridder & Beautrais, 2005). In most of the studies we discuss below, statistical procedures have been used to examine the association between rumination and attentional control functions, while controlling for depression scores.

2.3.1 Rumination and General Attentional Control

With regard to the specific cognitive operations related to attentional control, factor analysis of tasks measuring facets of attentional control revealed three functions that are moderately correlated with one another but are clearly separable: (1) monitoring and updating of working memory representations, (2) inhibition and (3) mental set shifting (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). The functions most frequently related to depression and rumination are inhibition and set shifting. Cognitive inhibition refers to the ability to effectively inhibit the processing of previously relevant or irrelevant distracting information. The set shifting function concerns the ability to shift back and forth between multiple tasks, operations or mental sets (Monsell, 1996).

There is converging evidence showing that higher levels of rumination are negatively correlated with attentional control. An early study by Davis and Nolen-Hoeksema (2000)

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showed that ruminators versus non-ruminators committed more perseverative errors on the Wisconsin Card Sorting Task. The aim of the WCST is to determine what rule should be used to sort target cards to match key cards that vary in stimulus dimensions. Feedback is given to participants about correct and incorrect matches and they must be able to adjust their performance when the rule unexpectedly changes. Ruminators persisted in performing the task according to the old rule despite receiving feedback that their matches were incorrect, suggesting a lack of cognitive flexibility. In this study, ruminators did not differ from non-ruminators on other measures of working memory or task switching, such as a backward digit span. However, these tasks were all administered in a non-selected undergraduate sample, which potentially reduced the chance to find large differences between ruminators and non-ruminators.

Using a mixed antisaccade paradigm with neutral stimuli, a recent study examined whether rumination was related to inhibition and shifting impairments (De Lissnyder, Derakshan, De Raedt, & Koster, submitted). In a typical antisaccade paradigm participants are instructed to inhibit an eye-movement in response to an abrupt peripheral cue and to simultaneously generate a volitional saccade to its mirror position on the screen. Performance on antisaccade trials is compared with prosaccade trials where participants are instructed to simply look at the cue and so inhibition is not required. Ruminators compared with non-ruminators found it difficult to inhibit orienting towards the abrupt cue as indicated by their longer antisaccade latencies. Interestingly, these inhibition impairments were specifically related to depressive brooding. No effects of rumination were observed on shifting capacity.

A recent study by Whitmer and Banich (2007) investigated inhibition and set shifting in relation to different types of rumination. They used a task switching paradigm to determine if attentional control impairments in ruminators were associated with inhibition or set shifting impairments in the context of non-emotional information. Participants had to

perform an odd-one-out search based on a stimulus dimension (color, motion, orientation) that was cued prior to a stimulus display. Through presentation of specific trial sequences, the authors could disentangle between inhibition of previous task settings and task switching. It was found that the two types of rumination, reflective pondering and brooding, were associated with different attentional control dysfunctions. Brooding was specifically associated with impaired inhibition. In a recent extension of this study (De Lissnyder, Koster, Derakhshan, & De Raedt, 2010) using a modified task that examined set shifting and inhibition in response to non-emotional as well as emotional information, it was shown that brooding was related to valence-specific inhibitory problems as well as set-shifting impairments (see below).

2.3.2 Rumination and Valence-specific Attentional Bias

The association between rumination and valence-specific attentional bias has been investigated in a number of studies. One interesting study used the dot probe task for this purpose for (Donaldson, Lam, & Mathews, 2007). In the dot probe task, pairs of stimuli – with one neutral and one emotional stimulus - are presented at separate spatial locations and one of these stimuli is replaced by a task-relevant probe (e.g., a dot). The logic of this task is that if individuals systematically orient towards an emotional stimulus, responding to probes presented at the location of the emotional stimulus is faster than responding to probes that appear at the opposite location of the emotional stimulus. This task was included with negative words as stimuli and was presented to a sample of depressed patients. The results showed that trait rumination was associated with an attentional bias for negative words, even when depressive symptoms were statistically controlled for (Donaldson et al., 2007).

Another line of studies used an affective variant of the negative priming paradigm (Joormann, 2004) to investigate valence-specific inhibitory deficits in keeping information

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from entering working memory. In this paradigm, participants must ignore the emotional valence of an irrelevant stimulus on a first trial. On a subsequent trial this ignored emotional information either becomes task-relevant or is not task-relevant. The idea is that it takes longer to respond to a previously ignored stimulus because one has to overcome inhibition. If this response slowing is not observed than this indicates impaired inhibition. Such inhibition impairments for negative information have been observed in dysphoric (Joormann, 2004) as well as clinically depressed individuals (Goeleven, De Raedt, Baert, & Koster, 2006). Joormann (2006) found that an increased tendency to depressively ruminate was associated with impaired inhibition of negative words. Thus, it could be that the impaired inhibition of negative information enhances the amount of negative information that enters working memory. The study by De Lissnyder et al. (2010) confirmed this hypothesis as impaired inhibition of negative information was best predicted by depressive rumination. Although, no association between rumination and inhibition of negative faces was found in a depressed sample (Goeleven et al., 2006), this may be explained by the fact that rumination is a verbal processes with a stronger linkage to verbal compared with pictorial material.

In addition to the ability to keep emotional material from entering working memory, the ability to remove emotional information from working memory is also of major importance in rumination. Joormann and Gotlib (2008) used an affective modification of the Sternberg task to study this phenomenon. In their study, participants first memorized two short lists of emotional words. A cue then indicated that only one of the two lists would be relevant. The design implicated that participants had to remove the irrelevant (emotional) information from working memory. Shortly after the cue, a probe word appeared and participants had to indicate whether it was from the relevant list. Depressed individuals had more difficulty removing negative words from working memory. Interestingly, a regression analysis showed

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that the difficulty in inhibiting negative words was associated with depressive rumination even when depression scores were controlled for.

Taken together, the evidence discussed above (see also Burwell & Shirk, 2007; Joormann, 2006) indicates that rumination and brooding in particular are associated with impairments and valence-specific biases in attentional control functions. It is interesting to note that, in most of the studies discussed below, the association between rumination and attentional control remained significant even when depression scores were controlled for. This finding is in line with the idea that information-processing impairments make it difficult for ruminators to disengage from negative content. This could mean that such cognitive control deficits may be causally related to the persistence of depressive cognition. Obviously, given the correlational nature of the empirical data we cannot draw any firm conclusions about the causal relationship between rumination and information-processing. Thus, it could still be the case that rumination leads to impaired attentional control, instead of attentional impairments being causally involved in the emergence and maintenance of rumination.

In a recent prospective study, we examined whether inter-individual differences in cognitive control ability, measured in a task where individuals had to switch between emotional and non-emotional material held in working memory, plays a moderating role in the association between the occurrence of a stressful event and the tendency to ruminate (De Lissnyder, Koster, Goubert, Onraedt, & De Raedt, submitted). Results revealed that impaired cognitive control measured at time one, reflected in larger switch costs, moderated the association between stress and increased rumination during a stressful period later in time. Interestingly, a larger switch cost when processing emotional material was associated with increased depressive brooding in response to stress. The prospective nature of the design also allows the interpretation that the association between rumination and information-processing

is not simply due to rumination depleting cognitive resources. Instead, our results are in line with the idea that impaired cognitive control contributes to rumination.

Moreover, there are also clues from affective neuroscience pointing towards a strong association between rumination and attentional control impairments, and that depressive rumination is not linked to top-down attempts to understand negative life events and mood but to the depletion of attentional resources. We will now turn to this literature.

3. Rumination and Attentional Control: Clues from Affective Neuroscience

Depression is associated with hypoactivation in cortical structures involved in attentional control which can be related to impaired emotion regulation. There is a wealth of research showing an enhanced amygdala activity upon the encounter of stress in depression, with the amygdala being primarily implicated in processing of negative emotions. In a study by Siegle and colleagues (Siegle, Steinhauer, Thase, Stenger, & Carter, 2002) depressed individuals showed sustained amygdala responses to negative words that lasted during a following task that involved non-emotional processing. The difference in sustained amygdala activity to negative versus positive words was related to rumination. This increased amygdala activity has been linked to impaired cognitive control exerted by specific regions of the prefrontal cortex (Davidson, Pizzagalli, Nitschke, Putnam, 2002; Holmes & Pizzagalli, 2008) onto limbic emotion processing, as reflected by lower regulatory activity in the frontal cortices as well as a reduced connectivity between the amygdala and these frontal cortex regions during emotion processing in depression. The reciprocal interplay between cognitive control and emotion has been underpinned by many neuro-imaging studies, demonstrating emerging evidence for a widely distributed and functionally interactive network of cortical-limbic pathways that play a central role in the regulation of sustained negative mood (Johnstone, Van Reekum, Urry, Kalin, & Davidson, 2007; Ochsner & Gross, 2008; Wager,

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Davidson, Hughes, Lindquist, & Ochsner, 2008). With regard to depression, it has been proposed that a deficient regulation of sustained negative affect is related to a failure to recruit the dorsal top-down control over the amygdala due to excessive bottom-up suppression by the ventral system and a primary dorsal system pathology (Taylor & Fragopanos, 2002; Phillips, Drevets, Rauch & Lane, 2003).

First, emotional stimuli activate the amygdala (Zald, 2003), which in turn signals to the Anterior Cingulate Cortex (ACC). The ACC can be seen as a bridge between subcortical emotion processing and cognitive control, integrating signals from the ventral ACC and the dorsal ACC (Bush, Luu & Posner, 2000), the latter being involved in conflict monitoring and the facilitation of task-appropriate response selection (Macdonald, Cohen, Stenger & Carter, 2000). The ACC in turn sends signals to the DLPFC to increase attentional control and modify the distribution of processing resources (Hopfinger, Buonocore & Mangun, 2000; Macdonald et al., 2000). Previous research in depression has found despite signaling of cognitive control in an error detection paradigm, the adjustment to errors was impaired in depressed individuals because of reduced connectivity between the ACC and the prefrontal cortex (Holmes & Pizzagalli, 2007). Due to these reasons there may remain an inward focused attention, with persistent rumination. In the case of normal connectivity, the DLPFC can initiate emotion regulation, inhibiting the amygdala (Davidson et al., 2002) via connections with other frontal regions such as the orbitofrontal (OFC) cortex (Taylor & Fragopanos, 2005).

The neural underpinnings of specific habitual thinking styles such as rumination can also be linked to the broader default-mode-network (DMN), a set of brain regions with consistently decreased neural activity during goal-oriented tasks (Shulman et al., 1997). The brain structures involved in the default mode network (DMN) include precuneus/posterior cingulate cortex, medial prefrontal cortex and medial, lateral and inferior parietal cortex

(Raichle, 2001). Although deactivated during task performance, this network is active in the resting brain with a high degree of functional connectivity between regions. This resting state activity has been termed the default-mode of brain activity to denote a state in which an individual is awake and alert, but not actively involved in an attention demanding or goal-directed task (Raichle, MacLeod, Snyder, Powers, Gusnard, & Shulman, 2001). The DMN has in several studies been linked to psychological functions of introspective and self-referential thought (Gusnard, Akbudak, Shulman, & Raichle, 2001; Mason, Norton, Van Horn, Wegner, Grafton, & Macrae, 2007). For the present purposes it is noteworthy to mention that the negative correlation between the DMN and the task positive network (the brain network activated during tasks) has led to the idea that there is a switching between introspective and extrospective attention, this being linked to the DMN and the task-positive network, respectively (Broyd, Demanuele, Debener, Helps, James, & Sonuga-Barke, 2009).

In recent years, the DMN has been linked to several forms of psychopathology, including depression. The ruminative, self-referential focus of depressed patients has led to predictions of differences between this clinical group and controls in terms of DMN connectivity (Greicius, Flores, Menon, Glover, Solvason, Kenna, et al., 2007). Following analysis of resting state fMRI data, the ventral subgenual ACC was found to contribute disproportionately to the connectivity of the DMN in this patient group, with increases in connectivity associated with the length of the current depressive episode (Greicius et al., 2007). There was also increased functional connectivity in the thalamus during rest. Greicius et al. (2007) suggest that increased connectivity in 'affective' regions may detrimentally affect connectivity in regions associated with cognitive processing such as the dorsal ACC. In a recent study examining the default mode network in depression comparing resting conditions (looking at negative and positive pictures) with an active reappraisal condition has shown that depression is characterized by a failure to regulate activity in neural structures (amygdala,

parahippocampus, hippocampus), associated with the DMN (Sheline, Barch, Price, Rundle, Vaishnavi, Snyder, et al. 2009).

Taken together, the finding that self-reflective thoughts are associated with the DMN which is anti-correlated with areas involved in attentional control suggests that ruminative thought may be a habitual mode of thinking in depressed individuals, going over negative events past repeatedly, without marked difficulties to control this type of thinking, or to engage in the active reappraisal of events past. These findings are not in line with the idea that depressive rumination is driven by top-down processes, related to attempts to make sense of negative events and mood. Instead these data provide some indication for the inability to or absence of effortful control over depressive cognition as rumination depletes attentional resources.

4. Clinical Implications

Conceptualizing rumination as being mainly driven by information-processing deficiencies has specific implications for clinical treatment of rumination. With regard to psychological treatments, traditional cognitive therapy for depression which is considered one of the most efficacious treatments for depression (Hollon & Dimidjian, 2009) would use verbal interventions that target negative thinking through challenging some of the core beliefs that are reported by the depressed individual. Other well-investigated forms of psychotherapy, such as interpersonal therapy also mainly use verbal techniques to improve depressive cognition. From our perspective, it might be unrealistic to assume that verbal interventions can readily change a habitual thinking style if attentional control is not improved first, and this could be the reason for the important problem of relapse. Therefore, it could be more sensible to aim at improving and restoring attentional control when trying to improve depressive cognition. Recently, important advances have been made in the area of cognitive methodology

that allows to improve either attentional control functioning (see Siegle, Ghinassi, & Thase, 2007) or valence-specific processing biases (see MacLeod, Koster, & Fox, 2009).

Interestingly, there is also emerging research suggesting that several biological interventions that are commonly used to treat depression may operate in part through influences on attentional control. Importantly, several studies have shown that therapeutic effects of antidepressant medication are related to changes in cognitive processing of emotional information, with some of these studies showing that changes in cognitive processing of emotional information precede and predict the affective effects of antidepressant medication (see Browning, Holmes, & Harmer, 2010). Similar findings have been found in relation to repetitive Transcranial Magnetic Stimulation over the DLPFC, which is a relatively new intervention (Avery, Holtzheimer, Fawaz, Russo, Neumaier, Dunner, et al. 2006; Bortolomasi, Minelli, Fuggetta, Perini, Comencini, Fiaschi, et al. 2007). Research indicates that the effectiveness of multi-session rTMS in reducing depressive symptoms is preceded by increased attentional control (Vanderhasselt et al., 2009). Thus, there is increasing evidence suggesting that existing treatments for depression and depressive cognition may operate through influences on attentional control.

As an increasing number of depressive episodes is associated with lower stress reactivity (Monroe & Hakness, 2005) and increasing risk of developing new depressive episodes (Keller, 2003), it could be useful to target attentional control as a proximal risk factors for the development of first or recurrent depressive episodes. Computerized programs to improve attentional control are relatively easy to disseminate and may have protective effects in at-risk individuals (see Baert, De Raedt, & Koster, 2001; Siegle et al., 2007). It is important that future research addresses the clinical potential of such prevention or treatment programs.

5. Future Challenges

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The impaired disengagement hypothesis provides a useful framework for understanding the persistence of rumination in depression. At a broader level there is emerging cognitive as well as biological research pointing to the relevance of attentional factors in depression (De Raedt & Koster, 2010). Despite the wealth of correlational data indicating the link between attentional control and rumination, an important area of investigation will be to test the directional hypothesis that attentional factors contribute to the persistence of rumination. Although this is a plausible hypothesis given the available literature, further research is necessary to stringently test this hypothesis. This requires more prospective studies as well as research where attentional control is experimentally manipulated.

In addition, besides highly focused research examining the specific relation between attentional control and rumination, it will also be important to investigate this association in a broader framework to understand these factors in relation to depression. That is, it is conceivable that certain risk factors for depression have direct or indirect relations to attentional control and rumination. For instance, sleep disturbances are a well-established risk factor for depression, that are not only present during depressive episodes but also precede these episodes (Fichter, Kohlboeck, Quadflieg, Wyschkon, & Esser, 2009). In relation to the framework presented here, one could hypothesize that sleep disturbances may be related to depression through its influence on attentional control and rumination. In order to investigate such functional relations between, large-scale research is needed to carefully map the temporal relations between different aspects of psychological functioning.

In sum, we have argued that attentional control plays an important role in explaining depressive rumination. The present framework may assist in deriving new and focused hypotheses about risk factors for depression and their treatment.

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Figure caption

Figure 1. A schematic outline of the impaired disengagement model of rumination

