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Review

Depression: A cognitive perspective☆

Joelle LeMoult[a,*], Ian H. Gotlib[b]

[a] University of British Columbia, Canada
[b] Stanford University, United States

HIGHLIGHTS

- Depression is characterized by negative cognitive biases and maladaptive emotion regulation strategies
- Depression-related deficits in cognitive control over mood-congruent material may underlie other cognitive processes
- Cognitive control deficits relate to maladaptive emotion regulation strategies, and negative biases in attention and memory
- We discuss empirical evidence and implications for theory, practice, and future research

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ABSTRACT

Cognitive science has been instrumental in advancing our understanding of the onset, maintenance, and treatment of depression. Research conducted over the last 50 years supports the proposition that depression and risk for depression are characterized by the operation of negative biases, and often by a lack of positive biases, in self-referential processing, interpretation, attention, and memory, as well as the use of maladaptive cognitive emotion regulation strategies. There is also evidence to suggest that deficits in cognitive control over mood-congruent material underlie these cognitive processes. Specifically, research indicates that difficulty inhibiting and disengaging from negative material in working memory: (1) increases the use of maladaptive emotion regulation strategies (e.g., rumination), decreases the use of adaptive emotion regulation strategies (e.g., reappraisal), and potentially impedes flexible selection and implementation of emotion regulation strategies; (2) is associated with negative biases in attention; and (3) contributes to negative biases in long-term memory. Moreover, studies suggest that these cognitive processes exacerbate and sustain the negative mood that typifies depressive episodes. In this review, we present evidence in support of this conceptualization of depression and discuss implications of research findings for theory and practice. Finally, we advance directions for future research.

1. Introduction

Major Depressive Disorder (MDD) is one of the most prevalent and debilitating forms of psychopathology (Kessler et al., 2005). Epidemiological surveys indicate that the lifetime prevalence of MDD is 16.6%, with estimates as high as 21.3% in women (Kessler, Berglund, et al., 2005; Kessler & Bromet, 2013); indeed, more than 30 million U.S. adults have met criteria for MDD in their lifetime (Haro et al., 2006). Importantly, MDD is a highly recurrent disorder; moreover, each depressive episode increases the likelihood that individuals will develop a subsequent episode of MDD (Solomon et al., 2000). Depression is also associated with enormous costs at both the individual and societal level; in fact, depression continues to be the leading cause of disability worldwide (World Health Organization, 2017), accounting for almost half of disability-adjusted life years (World Health Organization, 2012). Finally, in addition to documented adverse effects of depression on interpersonal relationships, educational attainment, and financial security (Kessler & Wang, 2009), MDD has been associated both concurrently and prospectively with poor physical health, cardiac problems, and cancer (Knol et al., 2006; Luppino et al., 2010).

Given the high prevalence and substantial burden of depression, it is not surprising that investigators have conducted a great deal of research with the goal of increasing our understanding of the onset, maintenance, and treatment of depressive episodes. In this review, we will examine how cognitive science, in particular, has promoted our understanding of depression. The current review advances our

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* Corresponding author at: Department of Psychology, University of British Columbia, 2136 West Mall, Vancouver BC V6T1Z4, Canada.
E-mail address: jlemoult@psych.ubc.ca (J. LeMoult).

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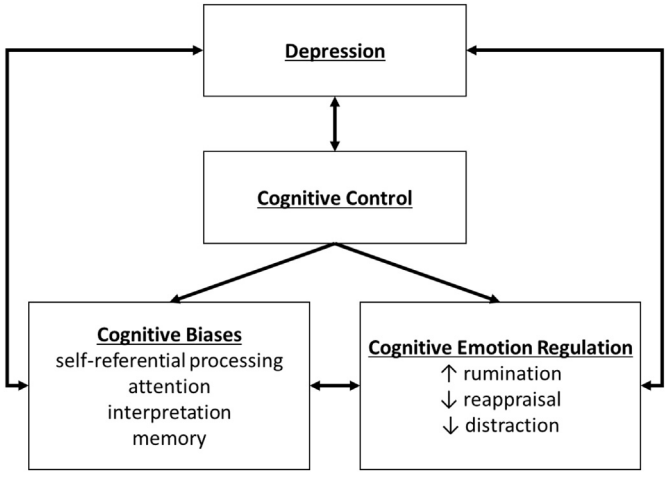

Fig. 1. Depression is associated with (1) cognitive biases in self-referential processing, attention, interpretation, and memory; (2) the use of maladaptive versus adaptive cognitive emotion regulation strategies; and (3) deficits in cognitive control over mood-congruent material, which in turn, contributes to cognitive biases and the use of maladaptive emotion regulation strategies, all of which exacerbate and sustain symptoms of depression.

understanding of cognition and depression by including recent research that capitalizes on methodological developments (e.g., eye tracking technology) and techniques (cognitive bias modification paradigms), by offering a theoretical model (Fig. 1) that depicts the relations among cognitive factors and depression, and by discussing in detail the clinical implications of this work. We begin by providing an historical overview of cognitive theories of depression. We then review major advances in our understanding of cognition and depression, focusing specifically on cognitive deficits in executive functioning, working memory, and processing speed; cognitive biases in self-referential processing, attention, interpretation, and memory; deficits in cognitive control over stimuli or information that is congruent with one's emotional state (i.e., mood-congruent material); and the cognitive emotion regulation strategies of rumination, distraction, and reappraisal. Fig. 1 depicts the relations among cognitive factors that are most strongly supported by empirical evidence. Next, we discuss the implications of empirical findings for theory and practice. Finally, we offer our perspective on what we think lies ahead for researchers in this area. Certainly, researchers have studied other aspects of cognition, including goal selection, response selection, performance monitoring, and language; however, because these are relatively less studied in relation to depression, they are outside the scope of this review.

2. Historical overview of cognitive theories of depression

Researchers and clinicians have long acknowledged that cognition plays a critical role in the onset and maintenance of depressive disorders. Fifty years ago, Beck (1967) posited that biased acquisition and processing of information influence the etiology and course of depressive episodes. Beck argued that internal mental representations, or schemas, affect how depressed individuals perceive themselves and the world around them. He contended that individuals with depression have mood-congruent schemas that are characterized by themes of loss, failure, worthlessness, and rejection that lead depressed individuals to have negative perceptions of themselves, the world, and the future (the cognitive triad) and to exhibit negative information-processing biases. These characteristics, in turn, contribute to negative mood states in depressed persons. Importantly, Beck posited that early life adversity confers vulnerability to MDD by promoting the development of depressive schemas that could be activated by internal or external negative events. Beck posited further that these negative schemas remain present, albeit 'latent,' even after recovery from the depressive episode, and trigger negative automatic thoughts and moods when they are activated by negative events, thereby explaining the onset of both first and subsequent depressive episodes.

Beck's original model was the impetus for decades of research and theory on cognition and depression. One major advance in this area came from Bower's (1981) seminal work on mood and memory. Bower postulated that cognition is influenced by an interconnected network of nodes, each of which contains semantic representations that can be activated by external stimuli. Activation of any single node partially activates adjacent nodes, resulting in an automatic spreading of activation. As a result, the schematic representations in the adjacent nodes require less environmental activation for them to be accessed, leading to a processing advantage for stimuli that are related to these primed representations. Like Beck, Bower argued for the persistence of biased cognition and posited that associative networks are stable constructs that endure beyond the depressive episode. In fact, building on Bower's work, Ingram (1984) and Teasdale (1988) argued that the onset, maintenance, and recurrence of depressive disorders is a result of biased processing of emotional information, evidenced by mood-congruent biases in self-referential processing, attention, memory, and interpretation. This formulation has led to a wealth of research examining the nature and role of cognitive biases in depression.

3. Empirical findings

Over the past several decades a significant methodological shift has taken place in the measurement of cognition, and in particular, cognitive biases. The field moved away from an exclusive reliance on self-report measures of cognition toward emphasizing objective indices and experimental manipulations. This methodological shift reflects investigators' increased awareness of the drawbacks of self-report measures, which, for example, are limited by individuals' introspective ability and are subject to recall, demand, and reference biases (Althubaiti, 2016). Given the consistent evidence of biased cognition associated with depression (Mathews & MacLeod, 2005), these biases are especially problematic in studies of participants who are currently depressed or who are at risk for developing depression, as we review below. Thus, by having relied primarily on self-report measures, the validity of researchers' assessments of cognitive functioning in depression was almost certainly limited by the very construct they were purporting to examine. The relatively recent utilization of computer-based information-processing tasks and eye-tracking technology has helped to overcome the limitations of self-report measures. That being said, it is also important to acknowledge that the psychometric properties of some information-processing tasks have been insufficiently tested or found to be poor (Brown et al., 2014; Schmukle, 2005). Variable scoring methods (e.g., Starzomska, 2017) can further complicate interpretation of results and can obfuscate true findings. Thus, while we are enthusiastic about the move toward more objective assessments of cognition, we also encourage researchers to take into account the limitations of existing measures when interpreting results presented below. A second methodological advancement involves the development of cognitive bias modification (CBM) methods (Hallion & Ruscio, 2011; Hertel & Mathews, 2011). Specifically, by experimentally manipulating the presence or intensity of information-processing biases, researchers are able to examine the effects of these alterations on mood, behavior, and other cognitive processes. Whenever possible, in this review of the literature we weigh more heavily studies that have used these stronger methodological approaches.

3.1. Cognitive deficits

Before we discuss the substantial literature examining cognitive biases in the context of depression, we briefly review the evidence for general cognitive deficits in this disorder. Investigators have posited

that depression is associated with broad deficits in cognitive functioning, evidenced by difficulties in executive functioning, working memory, and processing speed (Ahern & Semkovska, 2017; Chakrabarty, Hadjipavlou, & Lam, 2016). Indeed, some cognitive deficits are reflected in depressive symptoms listed in the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013). Therefore, it is not surprising that almost 40% of currently or formerly depressed participants have been found to experience impairment in at least one cognitive domain (Gualtieri & Morgan, 2008). We briefly review evidence documenting depression-related impairment in the three cognitive deficits that have received the most consistent empirical support in the literature: executive functioning, working memory, and processing speed. For additional detail, we direct readers to recent reviews and meta-analyses of this literature (Ahern & Semkovska, 2017; Chakrabarty et al., 2016; McIntyre et al., 2013).

Executive functioning refers to the ability to plan, problem solve, and inhibit the processing of information. Researchers have postulated that executive functioning is impaired in depression (e.g., Levin, Heller, Mohanty, Herrington, & Miller, 2007; Nitschke, Heller, Imig, McDonald, & Miller, 2001); empirical evidence, however, has been mixed. Whereas some studies report significant deficits across multiple domains of executive functioning (e.g., Porter, Gallagher, Thompson, & Young, 2003), other investigators have found no significant differences between individuals with and without depression (Grant, Thase, & Sweeney, 2001). Moreover, evidence from several reviews yields only partial support for deficits in executive functioning in depression (DeBattista, 2005; Ottowitz, Dougherty, & Savage, 2002; Rogers et al., 2004; Veiel, 1997; Zakzanis, Leach, & Kaplan, 1998). In contrast, however, a more recent – and more comprehensive – meta-analysis concluded that compared to healthy control participants, depressed participants show deficits across numerous aspects of executive functioning, including updating, shifting, and inhibition (Snyder, 2013). Importantly, however, data suggest that aspects of executive functioning (e.g., shifting) return to baseline after remission (see systematic review and meta-analysis by Ahern & Semkovska, 2017), suggesting that executive functioning deficits are concurrent, rather than stable and residual, characteristics of depression. To the extent that depressed individuals do exhibit deficits in executive functioning, there is at least preliminary experimental evidence to indicate that these deficits underlie depression-related difficulties in other domains of cognitive functioning, including deficits in the domains of memory, attention, and rumination (e.g., Hertel, 1997; Levin et al., 2007; Nitschke, Heller, Etienne, & Miller, 2004; Whitmer & Gotlib, 2013). For example, Siegle, Ghinassi, and Thase (2007) experimentally tested the relations among executive functioning, rumination, and depressive symptoms in a group of severely depressed participants using a novel cognitive bias modification (CBM) protocol aimed at improving executive functioning, specifically cognitive control. Participants were assigned to receive six sessions of cognitive control training, which consisted of participants completing Wells (2000) Attention Control Training intervention and Gronwall's (1977) Paced Auditory Serial Attention Task. They documented that depressed participants who received cognitive control training exhibited significant improvement in behavioral indices of executive functioning and reported significant decreases in depressive symptoms and levels of rumination. Similarly, Hoorelbeke and Koster (2017) reported that 10 sessions of Siegle et al.'s (2007) cognitive control training procedure reduced levels of rumination, other maladaptive cognitive emotion regulation strategies, and depressive symptoms in formerly depressed participants.

Working memory is defined as the ability to maintain or manipulate information across a short delay (Baddeley, 1992, 1996). Several reviews suggest that depression is associated with deficits in working memory (e.g., Zakzanis et al., 1998), a conclusion that has been supported by the results of meta-analyses (Christensen, Griffiths, MacKinnon, & Jacomb, 1997; Snyder, 2013). Importantly, however, a closer examination of the literature suggests that the link between depression and impairments in working memory is observed almost exclusively when attention is not constrained by the task (e.g., Hertel & Rude, 1991) and, instead, could be allocated to personal concerns and task-irrelevant thoughts (e.g., Ellis & Ashbrook, 1989). In fact, providing depressed individuals with instructions that focused their thoughts on the task at hand eliminated depression-related deficits in working memory (Hertel, 1998). Hertel (2004) concluded that depressed individuals have the ability to perform at the level of healthy control participants in structured situations but have difficulty doing so when situations are unconstrained or when they are left to their own initiative. She argued that in these unconstrained situations, it is likely that the opportunity to ruminate will impair working memory performance in depressed individuals. Moreover, a recent meta-analysis reported that both visuospatial and auditory working memory performance did not differ between formerly depressed participants and healthy control participants (Ahern & Semkovska, 2017).

Processing speed deficits are among the most frequently replicated findings related to cognitive deficits in depression (McIntyre et al., 2013), and Mohn and Rund (2016) found that depressed participants exhibited larger deficits in processing speed than in working memory. Yet, studies of this construct, too, have yielded mixed results. For example, evidence from a recent meta-analysis suggested that impairments in processing speed were inconsistent and task-dependent (Ahern & Semkovska, 2017). Specifically, depression-related deficits in processing speed ranged from nonsignificant to large; tasks involving word reading were associated with the largest source of impairment. Importantly, deficits in processing speed have been found to improve during periods of remission and following effective treatment (Herrera-Guzmán et al., 2010); moreover, meta-analytic evidence suggests that processing speed does not differentiate formerly depressed participants from healthy control participants (Ahern & Semkovska, 2017). Thus, to the extent that deficits in processing speed are found in depressed individuals, they are more likely to be observed during a current depressive episode than during a period of episode remission.

3.1.1. Summary of cognitive deficits

Taken together, the presence of pervasive deficits in cognitive functioning remains a topic of considerable debate, with evidence to support both the presence and the absence of cognitive impairment in depression. Clearly, more data are needed before strong conclusions can be made regarding the extent of general cognitive deficits in depression. When cognitive deficits are present, however, they are likely to cause considerable interference and functional impairment in individuals' everyday life. For example, cognitive deficits may mediate the association between depression and psychosocial dysfunction (notably workforce performance; McIntyre et al., 2013). Cognitive deficits are also relevant in the context of cognitive biases in depression. For example, as we discuss in greater detail below, researchers have posited that deficits in processing speed are relevant when interpreting results of studies based on reaction times. Importantly, evidence from recent reviews and meta-analyses suggests that cognitive deficits (e.g., shifting) ameliorate during episode remission and cognitive functioning does not differ between formerly depressed participants and healthy control participants (Ahern & Semkovska, 2017). Thus, cognitive deficits are more likely to be observed during current depressive episodes than during periods of episode remission.

3.2. Cognitive biases

There is now consistent evidence that individuals with depression or who are at risk for depression exhibit preferential processing of mood-congruent material across multiple forms of cognition. Findings have largely supported theoretical models of depression in which negative schemas are posited to influence perceptions of the self, as well as biases in attention, memory, and interpretation. Based on these models,

we would expect to observe mood-congruent cognitive biases in depressed individuals, as well as in individuals at risk for depression or in individuals with a history of depression when they are in a dysphoric mood state. As we describe below, empirical evidence obtained over the last several decades has also helped to refine and extend the original cognitive models of depression in several important ways. In the following sections we review findings from studies of biases in self-referential processing, attention, interpretation, and memory.

3.2.1. Biased self-referential processing

Self-referential processing is posited to reflect individuals' underlying negative cognitive schemas (Beck, 1967), and is often measured using the self-referential encoding task (SRET). In the SRET, participants are asked to judge whether or not emotional adjectives describe them. Participants' memory of those adjectives is then tested in an incidental recall paradigm. A meta-analysis concluded that negative schemas, as measured with the SRET, were associated with depression more strongly than were any other cognitive processes that were assessed (Phillips, Hine, & Thorsteinsson, 2010). Findings from adult, adolescent, and child samples indicate that depressed participants exhibit more negative self-referential biases than do healthy control participants; more specifically, they endorse more negative and fewer positive adjectives as self-descriptive, endorse negative adjectives and reject positive adjectives more quickly, and recall more negative and fewer positive adjectives, regardless of whether or not they were endorsed (Auerbach, Stanton, Proudfit, & Pizzagalli, 2015; Connolly, Abramson, & Alloy, 2016; Derry & Kuiper, 1981; Gilboa, Roberts, & Gotlib, 1997; Gotlib, Kasch, Traill, Joormann, & Arnow, Johnson, 2004; Joormann & Siemer, 2004; Kuiper & Derry, 1982). Taken together, this pattern of negatively biased self-referential processing has been interpreted to reflect the presence of negative self-schemas in depression (Davis & Unruh, 1981; Derry & Kuiper, 1981; Dobson & Shaw, 1987). Moreover, prospective studies show that more negatively biased self-referential processing predicts a more pernicious course of depression, evidenced by longer-lasting (Davis & Unruh, 1981) and more severe (Disner, Shumake, & Beevers, 2017) symptoms.

Although the literature examining self-referential processing in at-risk and formerly depressed individuals is less established than is research assessing self-referential processing in currently depressed persons, this area of research is growing. For example, several investigators have found that children at risk for depression exhibit negative self-referential biases following a negative mood induction, suggesting that cognitive biases are evident before the onset of the disorder and can be primed by a negative mood state (Hammen et al., 1987; Hayden et al., 2013; Taylor & Ingram, 1999). Moreover, euthymic individuals with a history of depression exhibit negatively biased self-referential processing after experiencing a negative mood induction (Fritzsche et al., 2010; Kircanski, Mazur, & Gotlib, 2013; LeMoult, Kircanski, Prasad, & Gotlib, 2017), which has been found to prospectively predict episode relapse (LeMoult, Kircanski, et al., 2017).

Interestingly, consistent with cognitive models of depression (Beck, 1967), researchers have posited that negative self-referential schemas are related to other cognitive biases. Initial evidence supports this formulation. For example, Disner et al. (2017) found that a more negative self-referential processing bias associated with a more negative attentional bias. As we discuss in more detail below, however, few investigators have examined the nature of the relations among different cognitive processes; thus, this is an important area for future research.

3.2.1.1. Summary of biased self-referential processing. As depicted in Fig. 1, negative self-referential biases are one of the cognitive biases reported in at-risk, currently, and formerly depressed individuals (Auerbach et al., 2015; Hayden et al., 2013; Kircanski et al., 2013); these findings have been interpreted as reflecting the presence of negative self-schemas in these populations (Davis & Unruh, 1981; Derry & Kuiper, 1981). In addition, prospective studies indicate negatively biased self-referential processing predicts the onset of new depressive episodes (LeMoult, Kircanski, et al., 2017), and initial evidence suggests that biased self-referential processing is associated with attentional biases (Disner et al., 2017).

3.2.2. Attentional biases

Whether depressed individuals are characterized by negative biases in attention has been a topic of considerable debate. Historically, researchers examining attentional biases in depression have generally used the emotional Stroop task or the dot-probe task. In the emotional Stroop task, participants are asked to name the color of an emotionally valenced word; a negative attentional bias is inferred if participants take longer to name the color of negative versus neutral words. Overall, studies using the emotional Stroop task to assess attentional biases in depression have yielded equivocal results; indeed, a meta-analysis by Peckham and colleagues found only marginally significant differences between depressed and control participants' performance on this task (Peckham, McHugh, & Otto, 2010). These mixed results may be due to the limitations of the emotional Stroop task. For example, researchers have argued that this task yields an ambiguous measure of attention because longer response latencies could reflect biases either in initial attention or in subsequent response selection (Mogg, Millar, & Bradley, 2000).

An alternative measure of attentional bias is the dot-probe task. In this task participants are asked to detect the location of a dot that has been presented behind either a neutral or an emotional (e.g., happy, sad) stimulus; in most studies, words or faces are used as stimuli. Attentional allocation is determined based on participants' reaction time to detect the location of the dot once the stimuli have been removed from the display. Based on cognitive models of depression, one would expect that depressed individuals would exhibit negative attentional biases, operationalized as shorter response latencies to detect the dot when it appears behind sad versus happy stimuli. Findings from empirical studies, however, suggest that delineating the nature of attentional biases in depression is more complicated than was originally thought. On one hand, depressed individuals have been found to show the expected pattern of negative attentional bias that is specific to sad versus angry or happy stimuli (e.g., Gotlib, Krasnoperova, Yue, & Joormann, 2004). On the other hand, results differ as a function of the duration for which stimuli are presented. When stimuli are presented for short or subliminal durations, researchers have failed to find evidence of a negative attentional bias in depression (Mogg, Bradley, & Williams, 1995). In contrast, when stimuli are presented for longer durations (i.e., > 1000 ms), the predicted negative attentional bias is observed (e.g., Donaldson & Lam, 2004; Gotlib, Krasnoperova, et al., 2004; Joormann & Gotlib, 2007; see meta-analysis by Peckham et al., 2010) and further, predicts the onset of depression in at-risk youth (Jenness, Young, & Hankin, 2017). Moreover, more consistent evidence of negative attentional bias is obtained when faces rather than words are used as stimuli (see Armstrong & Olatunji, 2012, for a review). This pattern of results has led researchers to conclude that depression is characterized not by biases in the initial orienting toward negative stimuli, as is often observed in anxiety disorders, but rather, by difficulty disengaging from negative stimuli that has captured depressed individuals' attention (Mathews & MacLeod, 2005).

In this context, researchers have recently pointed out that a limitation of the dot-probe task is its lack of precision in being able to differentiate initial orienting from subsequent disengagement (Grafton & MacLeod, 2014; Grafton, Watkins, & MacLeod, 2012). This limitation is due to the fact that the dot-probe task typically assesses attention at only one point in time on each trial: at the time the dot is displayed. Prior to the dot being displayed, participants may shift their attention between the two stimuli any number of times, which reduces the sensitivity and validity of the task to assess different components of attention. Although alternative computer-based tasks have been used to address this limitation of the dot-probe task (e.g., Grafton, Southworth,

Watkins, & MacLeod, 2016; Koster, De Raedt, Goeleven, Franck, & Crombez, 2005; Rinck & Becker, 2005), a particularly promising approach to overcoming this limitation of the task comes from the use of eye-tracking technology, which continuously monitors the focus of visual attention and, thus, provides measures of attention the entire time stimuli are displayed. Using this information, researchers can extract data concerning initial gaze location (i.e., initial engagement) and the speed with which participants shift their attention away from a stimulus following fixation (which has been used as a marker of subsequent disengagement). Findings of studies using tasks that have been carefully designed for assessment of eye tracking support the conclusion that depressed individuals have difficulty disengaging their attention from negative material (Caseras, Garner, Bradley, & Mogg, 2007; Eizenman et al., 2003) and, further, that this difficulty is associated with more maladaptive responses to stress (Sanchez, Vazquez, Marker, LeMoult, & Joormann, 2013). Research conducted using eye trackers (Kellough, Beevers, Ellis, & Wells, 2008) also add to a growing body of evidence (Deveney & Deldin, 2004; LeMoult, Joormann, Sherdell, Wright, & Gotlib, 2009; Surguladze et al., 2004) that depressed participants differ from healthy control participants in the way they process positive information. For example, Kellough et al. (2008) found that compared to healthy control participants, depressed participants not only spent more time viewing dysphoric images, but also spent less time viewing positive images.

Several studies have used CBM paradigms to conduct causal tests of effects of attentional biases on symptoms and on other cognitive biases in depression. These studies, too, however, have yielded equivocal findings. For example, using a CBM version of the dot-probe task, investigators have reported that multiple (between four and eight) sessions of attention bias training reduce attention to negative stimuli and increases attention to neutral stimuli in depressed college students (Wells & Beevers, 2010; Yang, Ding, Dai, Peng, & Zhang, 2015) and depressed youth (Yang, Zhang, Ding, & Xiao, 2016). In addition, Beevers, Clasen, Enock, and Schnyer (2015) examined depressed adults' pre- to post-training change in attentional bias following eight sessions of a CBM version of the dot-probe task. Not only did Beevers et al. find the expected changes in attentional biases, but they also found that greater improvement in negative biases from pre- to post-training was correlated with greater reduction in depressive symptoms, suggesting that negative attentional biases play a causal role in the maintenance of depressive episodes. Moreover, Browning, Holmes, Charles, Cowen, and Harmer (2012) found that 28 sessions of a dot-probe-based attention bias training benefited currently euthymic individuals with a history of depression by reducing the magnitude of predictors of risk for recurrence, specifically depressive symptoms and cortisol responses to stress. Other researchers, however, have failed to replicate these results. For example, Kruijt, Putman, and Van Der Does (2013) found that one session of the visual-search CBM paradigm had no effect on attentional biases or mood in a group of dysphoric adults. Similarly, Baert, De Raedt, Schacht, and Koster (2010; experiment 2) found no effects of 10 sessions of attention training using a CBM version of the spatial cueing task with word stimuli in a sample of depressed in- and out-patients. Moreover, even with successful training, the benefits have not transferred consistently to other domains of functioning (see Hallion & Ruscio, 2011). There is evidence that studies using multiple sessions of CBM training are more likely to find changes in attentional biases (although see Baert et al., 2010, for an exception); however, the type of training task might also influence training effectiveness, with dot-probe tasks being superior to spatial-cueing or visual-search tasks. Moreover, attentional biases might be more easily modified in individuals with less severe depressive symptoms (Baert et al., 2010).

Importantly, depressed children and adolescents have also been found to exhibit attentional biases to negative stimuli (see Jacobs, Reinecke, Gollan, & Kane, 2008, for a review), as have youth at familial risk for depression following a negative mood induction (Joormann, Talbot, & Gotlib, 2007; Kujawa et al., 2012). Moreover, attentional biases to negative stimuli have been found to predict the subsequent onset of depressive symptoms (Beevers & Carver, 2003). Finally, there is now evidence from CBM studies that six sessions of dot-probe based attention bias training can modify attentional biases in youth at familial risk for depression and, further, that doing so modulates the heightened emotional and physiological responses to stress that are otherwise observed in high-risk youth (LeMoult, Joormann, Kircanski, & Gotlib, 2016).

3.2.2.1. Summary of attentional biases. Evidence of biased attention in depression has been equivocal; however, data from a growing number of studies support the proposition that at-risk, currently, and formerly depressed individuals experience difficulty disengaging attention from negative stimuli that has captured their attention, which is depicted in the theoretical model that we present in Fig. 1. It is important to note that the majority of past studies have assessed attentional biases using the dot-probe task, which has been found to have poor psychometric properties (Schmukle, 2005) that may contribute to the equivocal findings in this area. With this in mind, we encourage researchers to develop and use alternative tasks to measure attentional biases; creating emotional modifications of existing tasks from cognitive psychology may be a promising path toward this goal. CBM studies aimed at modifying attentional biases have been found to be most effective when multiple training sessions are administered using dot-probe tasks and when targeting either individuals with less severe depressive symptoms (Baert et al., 2010) or adolescents at risk for depression (LeMoult, Joormann, et al., 2016). Even when attention biases are modified, however, evidence of transfer of training has been inconsistent. It is possible that these inconsistencies will be resolved through the use of more effective CBM paradigms (Vazquez, Blanco, Sanchez, & McNally, 2016).

3.2.3. Interpretation bias

One of the core tenets of cognitive models of depression is that depressed individuals interpret ambiguous information in a negative manner. Historically, evidence of negatively biased interpretation in depression has been equivocal. In recent years, however, increasing evidence suggests that people with depression do, in fact, tend to make negative interpretations of ambiguous information (Lee, Mathews, Shergill, & Yiend, 2016; Orchard, Pass, & Reynolds, 2016). For example, compared to their nondepressed peers, depressed individuals exhibit more negative interpretations on homophone tasks (Mogg, Bradbury, & Bradley, 2006), questionnaires (Voncken, Bögels, Peeters, Bogels, & Peeters, 2007), ambiguous scenarios tasks (Butler & Mathews, 1983), and eye-blink tests (Lawson, MacLeod, & Hammond, 2002). Researchers have found negative interpretation biases in both adult and adolescent depressed samples (Orchard et al., 2016), and in both social and non-social situations (Voncken et al., 2007). Moreover, negative interpretation biases have been shown to vary as a function of symptom severity (Lee et al., 2016), with severely depressed individuals interpreting emotionally ambiguous information more negatively than do their mildly or moderately depressed counterparts.

Evidence of negative interpretation bias has also been reported outside of a depressive episode. For example, Dearing and Gotlib (2009) documented a negative interpretation bias in never-depressed girls at risk for depression. In addition, Wenzlaff and Bates (1998) reported that, under high cognitive load, euthymic individuals with a history of depression demonstrate negative interpretation biases; moreover, results from prospective studies indicate that negative interpretation biases predict the onset of a depressive episode 18-28 months later (Rude, Valdez, Odom, & Ebrahimi, 2003). These findings provide support for the formulation that interpretation biases are risk factors for the onset of future depressive episodes.

It is important to note, however, that there have been several notable exceptions to the results described above. For example, Lawson and MacLeod (1999) examined depressed participants' response

latencies to target words that were presented after ambiguous sentences and found no interpretation bias. Bisson and Sears (2007) used a similar task and also failed to find evidence of an interpretation bias in depression, even following a negative mood induction. Lawson et al. (2002) argued that the lack of consistent evidence for interpretation biases in depression may stem from a reliance on response latencies as the dependent variable. Although negative interpretation biases have been found using reaction-time based tasks (Hindash & Amir, 2012), depression is associated both with slowed reaction time to execute voluntary responses and with increased variability of such response latencies (Azorin, Benhaïm, Hasbroucq, & Possamaï, 1995; Byrne, 1976); thus, reaction-time based assessments may yield insensitive and inconsistent indices of cognitive processing in this disorder (Moretti et al., 1996).

Interestingly, findings from other researchers suggest that depressed participants are more accurate in their interpretations and judgments than are healthy control participants, who may be more likely to see the world through "rose-colored glasses" (McKendree-Smith & Scogin, 2000). These findings are consistent with a growing literature documenting that depressed participants fail to show the positive cognitive biases that are exhibited by healthy control participants (Alloy & Abramson, 1979; Canli et al., 2004; Gotlib, Jonides, Buschkuehl, & Joormann, 2011). For example, Alloy and Abramson (1979) concluded that, at times, depressed individuals are "sadder but wiser" than are individuals without a history of psychopathology. They observed that nondepressed individuals exhibited cognitive biases that facilitated positive interpretations of themselves and the world, whereas depressed persons maintained a realistic, albeit negative, perspective that likely contributed to their negative mood.

Studies using CBM to alter interpretation biases have been useful in testing the proposed link between interpretation biases and depressed mood. Several studies have documented that positive interpretation biases can be trained through one or two training sessions and lead to more positive interpretations of novel ambiguous information (Joormann, Waugh, & Gotlib, 2015; Möbius, Tendolkar, Lohner, Baltussen, & Becker, 2015; Yiend et al., 2014). Importantly, after one or two CBM training sessions, corresponding changes have also been observed in depressed mood (Blackwell & Holmes, 2010; Holmes, Lang, & Shah, 2009), memory biases, and responses to stress (Joormann et al., 2015); evidence of transfer to other tasks, however, has been inconsistent (Möbius et al., 2015; Yiend et al., 2014), even when multiple sessions of training have been administered (LeMoult, Colich, et al., 2017). For example, Yiend et al. (2014) found that one session of positive interpretation bias training had little effect on mood or responses to stress in a sample of depressed adults. Similarly, LeMoult, Colich, et al. (2017) found that six interpretation bias training sessions led to more positive interpretation biases in depressed adolescents, but the benefits of did not transfer to other tests of interpretation bias or influence reactivity to stress.

Related to biases in interpretation are biases in the identification of emotion, and like biases in interpretation, mood-congruent biases in the identification of facial expressions of emotion have been documented in depressed individuals (Surguladze et al., 2004). For example, Joormann and Gotlib (2006) examined depressed individuals' ability to identify the emotional expression displayed in a series of faces as they progressed from neutral to 100% emotional intensity. Depressed participants required significantly greater intensity of emotion than did participants with social anxiety disorder and healthy control participants to correctly identify happy expressions, and less intensity to identify sad than angry expressions. Moreover, biases in the identification of facial expressions of emotion have been found to remain even after individuals recovered from a depressive episode (LeMoult et al., 2009). Specifically, formerly depressed participants in whom a negative mood was induced required significantly greater emotional intensity to identify happy expressions.

Difficulty accurately identifying subtle expression of emotion may hinder effective interpersonal interactions and, thereby, impair social support. Individuals use facial expressions to monitor emotional reactions, to determine others' opinions and to adjust their behavior to avoid conflict (e.g., Hess, Kappas, & Scherer, 1988). Thus, the ability to accurately and quickly identify others' emotional facial expressions is important in social interactions. Results of a growing number of studies suggest that deficits in social skills and interpersonal interactions play an important role in risk for depression (Joiner & Timmons, 2009), and it is possible that biased processing of social cues, evidenced via negative biases in the identification of facial expressions of emotion, contributes to these impairments.

3.2.3.1. Summary of interpretation biases. Although evidence of negative interpretation biases in depression has been mixed, researchers have documented the presence of negative interpretation biases in depression (Mogg et al., 2006), especially when using non-reaction-time-based tasks (Lawson et al., 2002), as we have depicted in Fig. 1. Moreover, depressed individuals may also differ from healthy control participants in their lack of a positive interpretation bias (Alloy & Abramson, 1979; McKendree-Smith & Scogin, 2000) and in their ability to identify subtle happy emotional expressions (Joormann & Gotlib, 2006; LeMoult et al., 2009). CBM studies designed to alter interpretation biases have shown that interpretation biases can be modified in depressed adolescents and adults (Joormann et al., 2015; LeMoult, Colich, et al., 2017); evidence of transfer of training, however, has been inconsistent (Joormann et al., 2015; Yiend et al., 2014).

3.2.4. Memory bias

One of the most robust findings in the depression literature is that depressed individuals exhibit mood-congruent biases in memory, evidenced by preferential recall for negative information (Mathews & MacLeod, 2005). Memory biases are found most consistently when investigators are assessing explicit memory – i.e., overtly asking participants to recall previously encoded information. Not only do depressed individuals preferentially recall negative versus neutral stimuli, but they also fail to show the pattern of preferential recall of positive versus neutral stimuli exhibited by individuals without a history of psychopathology (see Gotlib, Roberts, & Gilboa, 1996, for a review; or Matt, Vázquez, & Campbell, 1992 for a meta-analysis). Moreover, explicit memory biases in depression appear to be specific to depression-relevant stimuli, rather than to negative stimuli more generally (Gotlib et al., 1996). Interestingly, emerging evidence suggests that, at least for positive stimuli, memory biases might be related to how the information was initially encoded. Specifically, whereas healthy control participants preferentially encode positive information, depressed individuals fail to show this bias (Gotlib et al., 2011). These findings underscore the need to separate biases in encoding from biases in memory, and highlight an important area for future research.

Although less consistent, researchers have also provided evidence of implicit memory biases in depression. Implicit memory is a form of long-term memory that is not influenced by conscious thought or intentional effort (Graf & Schacter, 1985). Biases in implicit memory are defined as the preferential recall or recognition of emotional information that occurs in the absence of any intention to remember the information or its emotional content. Thus, examinations of implicit biases provide an important, and arguably more accurate, representation of memory biases in that they are not influenced exclusively by intentional recall. Consistent with cognitive theories of depression, depressed individuals exhibit preferential implicit memory for negative versus positive information (Bradley, Mogg, & Millar, 1996; Ruiz-Caballero & González, 1997; Taylor & John, 2004; Watkins, Martin, & Stern, 2000; Watkins, Vache, Verney, & Mathews, 1996). Moreover, Vrijsen et al. (2014) found better memory for negative versus positive stimuli on an incidental recall task in individuals with a history of depression. There is also inconsistent evidence, however, particularly when memory is assessed through recall rather than through

recognition tasks. For example, Tarsia, Power, and Sanavio (2003) failed to find implicit memory biases in a sample of depressed adults. In addition, evidence from a recent meta-analysis (Gaddy & Ingram, 2014) suggests that inconsistencies in mood-congruent memory biases are due to the different types of stimuli used. Gaddy and Ingram (2014) found that mood-congruent memory biases were especially strong when the stimuli were self-relevant.

Depressed individuals also differ from healthy control participants in their recall of autobiographical memories, which has been observed across cultural groups (Dritschel, Kao, Astell, Neufeind, & Lai, 2011). Specifically, when asked to recall autobiographical memories, depressed individuals exhibit more generic memories than do healthy control participants. Autobiographical memory is most frequently assessed via the autobiographical memory test (AMT), in which participants are asked to provide a specific memory triggered by positive and negative cue words. Compared to individuals without a history of psychopathology, depressed individuals provide memories that summarize a category of similar events (e.g., taking vacations with my family) rather than a specific event (e.g., the time my brother and I kayaked on the lake). Raes et al. (2005) documented that overgeneral memories are associated with difficulties in problem solving, deficits in imagining specific future events, and longer duration of depressive episodes. Biases in autobiographical memory have also been observed during periods of episode remission, and have been found to predict the subsequent onset of depressive episodes in the context of postpartum depression (Mackinger, Pachinger, Leibetseder, & Fartacek, 2000).

Importantly, mood-incongruent processing has been identified as an adaptive mood regulation strategy, and difficulties in mood-incongruent memory recall are posited to impair depressed individuals' ability to use positive memories to improve negative mood states (Joormann & Siemer, 2004; Joormann, Siemer, & Gotlib, 2007). Moreover, recent evidence suggests that mood-incongruent processing – measured by the proportion of positive emotion words used to describe a sad memory – predicted fewer symptoms of depression six months later and a shorter time to recover from a depressive episode (Brockmeyer, Kulessa, Hautzinger, Bents, & Backenstrass, 2015). Biased memory has also been linked to the onset of depressive symptoms. For example, overgeneral autobiographical memory was found to moderate the effect of daily hassles in predicting increased depressive symptoms over time in a college-age sample. Further, Rawal and Rice (2012) documented that overgeneral autobiographical memory increased risk for depression in adolescents. These findings are consistent with the formulation that depressed individuals' overgeneral autobiographical memories limit their ability to use these memories to repair negative mood (Chen, Takahashi, & Yang, 2015; Joormann, Siemer, & Gotlib, 2007).

More recently, several investigators have attempted to modify negative memory biases through the use of CBM methods (Arditte Hall, De Raedt, Timpano, & Joormann, 2018; Eigenhuis, Seldenrijk, van Schaik, Raes, & van Oppen, 2017; Vrijsen et al., 2014). For example, Arditte et al. (2018) examined the impact of one session of positive memory enhancement training (PMET) on the memories and subjective experiences of individuals with MDD, and found that participants assigned to PMET showed improved memory specificity, increased ability to "relive" positive memories, and enhanced emotion regulation. In addition, Raes, Williams, and Hermans (2009) developed MEmory Specificity Training (MEST) to reduce overgeneral memory. These investigators administered MEST on a weekly basis for 4 consecutive weeks to 10 inpatients with depressive symptoms. Whereas other investigators have found that memory specificity does not improve with treatment as usual in depression, Raes and colleagues documented that participants' retrieval style became significantly more specific following MEST. Watkins, Baeyens, and Read (2009) also targeted overgeneral memory, but did so using eight sessions of a concreteness training paradigm. They demonstrated that training dysphoric participants to hold more concrete and less overgeneral memories significantly decreased both depressive symptoms and their frequency of rumination. Interestingly, evidence suggests that the relation between rumination and memory is bidirectional; specifically, following a one-time rumination induction depressed participants exhibited increased overgeneral autobiographical memories (Watkins & Teasdale, 2001) and improved memory for negative self-referential material (Moulds, Kandris, & Williams, 2007).

3.2.4.1. Summary of memory biases. Evidence of negatively biased memory may be related to how information was initially encoded (Gotlib et al., 2011) and is more commonly observed when explicit versus implicit memory is assessed and when stimuli are self-relevant (Gaddy & Ingram, 2014). Depressed individuals also differ from healthy control participants in their recall of autobiographical memories: depressed individuals tend to recall more overgeneral positive autobiographical memories, which may underlie the difficulties in emotion regulation that have been documented in MDD, as we depicted in Fig. 1 (Joormann & Siemer, 2004; Joormann, Siemer, & Gotlib, 2007). CBM-memory studies are in relatively early stages, but initial evidence suggests that training depressed participants to hold less overgeneral memories decreases levels of both depressive symptoms and rumination.

3.3. Cognitive control

As depicted in Fig. 1, difficulty controlling the content of negative information in working memory is posited to underlie many of the cognitive biases described earlier as well as the cognitive emotion regulation strategies that we discuss later in this paper (Everaert, Koster, & Derakshan, 2012; Joormann, 2006; Joormann & Gotlib, 2010; Joormann & Tanovic, 2016). Cognitive control plays a central role in determining the contents of working memory, the part of short-term memory that reflects current cognitions and awareness. Importantly, working memory is a limited-capacity system; therefore, efficient working memory functioning requires flexible control over the contents of working memory by limiting the initial access of information into working memory (inhibiting) and expelling information that is no longer relevant (updating).

Depressed individuals have been found to have difficulty inhibiting negative information from entering working memory. In order to assess inhibition in the processing of emotional information, Joormann (2004) designed the negative affective priming task, which examines participants' ability to intentionally ignore (i.e., inhibit from working memory) positive and negative material. Using the negative affective priming task, researchers have found that dysphoric, currently depressed, and formerly depressed participants experience difficulty inhibiting negative, but not positive, information from working memory (Goeleven, De Raedt, Baert, & Koster, 2006; Joormann, 2004; Joormann & Gotlib, 2010). Further, difficulty inhibiting negative information from working memory was associated with the use of more maladaptive emotion regulation strategies (i.e., rumination; Joormann & Gotlib, 2010) which has also been found by De Lissnyder, Derakshan, De Raedt, and Koster (2011). Bootstrapping analysis also documented that difficulty inhibiting negative information in working memory was associated with negative attentional biases, which in turn was associated with negative interpretation biases and symptoms of depression (Everaert, Grahek, & Koster, 2017).

Updating, a second component of cognitive control, involves effectively revising the contents of working memory by discarding no-longer-relevant information. Using an affective version of the Sternberg task, Joormann and Gotlib (2008) examined whether depressed individuals had difficulty removing emotionally valenced material from working memory. Compared to individuals without a history of psychopathology, depressed individuals had difficulty removing negative, but not positive, words from working memory. Moreover, greater difficulty discarding negative information was related to higher levels of

rumination. Researchers have also assessed individuals' ability to update the contents of working memory using a directed forgetting task, in which participants are asked to intentionally forget a subset of information that they recently learned (Bjork, 1972). Consistent with findings obtained using the affective Sternberg task, depressed individuals show greater facilitation, or less successful updating, for negative than for positive words learned in a self-relevant manner (Power, Dalgleish, Claudio, Tata, & Kentish, 2000); further, they have been found to incorrectly recall negative words that had never been presented in the task (Joormann, Teachman, & Gotlib, 2009). Interestingly, similar results were found in individuals who scored high on a trait measure of rumination; high trait-ruminators exhibited reduced forgetting of negative material (Joormann & Tran, 2009). Further evidence of reduced cognitive disengagement from negative material comes from a series of studies using Anderson and Green's (2001) think-no-think task. Researchers found that depressed individuals had difficulty discarding from working memory recently learned negative, but not positive, nouns (Joormann, Hertel, Brozovich, & Gotlib, 2005), which has been related to increased reactivity to stress (LeMoult, Hertel, & Joormann, 2010). Moreover, Everaert and colleagues provided cross-sectional evidence that the relation between difficulty updating negative information in working memory and depressive symptoms was mediated by negative interpretation biases (Everaert, Grahek, Duyck et al., 2017).

Building on this work, several researchers have begun to examine the potential benefits of cognitive control training over emotional information. For example, using a training version of Anderson and Green's (2001) think-no-think task, Joormann et al. (Joormann, Hertel, Lemoult, & Gotlib, 2009) showed that depressed participants could be trained in one session to forget negative material. In addition, depressed participants performed particularly well when they were given a strategy of how to remove no-longer-relevant material from working memory (i.e., by using thought substitutes). Moreover, training using an emotional working memory training task improved performance on the affective Stroop task (Schweizer, Hampshire, & Dalgleish, 2011) and improved emotion regulation after multiple training sessions (Schweizer, Grahn, Hampshire, Mobbs, & Dalgleish, 2013). Additional evidence for the association between cognitive control and cognitive emotion regulation strategies can be found in the Relation Between Cognitive Emotion Regulation Strategies and Other Cognitive Processes section below.

3.3.1. Summary of cognitive control

As depicted in Fig. 1, compared to healthy control participants, depressed individuals have difficulty both inhibiting and updating negative information in working memory. Importantly, this has been linked to rumination and is associated with increased reactivity to stress. Findings from CBM studies are consistent with the proposition that depressed individuals can compensate for cognitive control biases when given explicit strategies, which may have promising implications for interventions.

3.4. Cognitive emotion regulation strategies

Cognitive emotion regulation strategies describe what people think about following an emotion-eliciting event in order to consciously or unconsciously cope with the event or influence the experience, magnitude, or duration of the resulting emotional response (Campbell-Sills & Barlow, 2007; Rottenberg & Gross, 2003; Thompson, 1994; Williams, Bargh, Nocera, & Gray, 2009). Research examining cognitive emotion regulation strategies has been instrumental in helping us gain a better understanding of depression and has been increasingly integrated into recent cognitive models of depression (Everaert et al., 2012; Joormann, 2010; Joormann & Vanderlind, 2014) given evidence that cognitive emotion regulation strategies are associated both with symptoms of depression and with the cognitive biases described earlier (Joormann & Gotlib, 2010; Meiran, Diamond, Toder, & Nemets, 2011; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Unlike the research presented earlier in this paper examining cognitive biases, the majority of work examining emotion regulation in depression continues to rely on self-report measures. Nevertheless, researchers have benefited by experimentally inducing various emotion regulation strategies and examining the results on cognition, mood, and/or behavior. Numerous emotion regulation strategies have been implicated in psychopathology (see Aldao, Nolen-Hoeksema, & Schweizer, 2010, and Schäfer et al., 2017, for recent meta-analytic reviews). In this review, we focus on three cognitive emotion regulation strategies that have received particular attention in depression: rumination, distraction, and reappraisal.

3.4.1. Rumination

Rumination is traditionally considered a maladaptive emotion regulation strategy defined as thinking repetitively and passively about negative mood states or about the causes and consequences of negative mood (Nolen-Hoeksema et al., 2008). Led by the theoretical and empirical contributions of Susan Nolen-Hoeksema, a number of researchers have examined the association between rumination and depressive symptoms. Taken together, the findings of this body of research suggest that higher levels of rumination are associated with higher levels of depressive symptoms both concurrently and prospectively (see reviews by Lyubomirsky, Layous, Chancellor, and Nelson (2015) and Nolen-Hoeksema et al. (2008); although note conflicting evidence regarding the effect of rumination on the maintenance of depressive episodes (Lyubomirsky et al., 2015; Nolen-Hoeksema et al., 2008)). Nonetheless, consistent evidence documents that rumination both predicts the onset of depressive episodes and mediates the sex differences in depression prevalence (Nolen-Hoeksema, 2000; Nolen-Hoeksema, Stice, Wade, & Bohon, 2007). Several studies have found that, across ages, females are more likely to ruminate than are males (Grant et al., 2004; Nolen-Hoeksema, Larson, & Grayson, 1999). In addition, data from longitudinal studies indicate that this sex difference in the prevalence rate of rumination contributes to females being more vulnerable to depressive symptoms than males (e.g., Nolen-Hoeksema et al., 1999).

Some researchers have posited that the association between rumination and depression is driven by the fact that the most commonly used measure to assess rumination, the Ruminative Response Scale (RRS) of the Response Styles Questionnaire (Nolen-Hoeksema & Morrow, 1991), contains overlapping content about both depression and rumination (Treynor, Gonzalez, & Nolen-Hoeksema, 2003). In response to these concerns, Treynor et al. (Treynor et al., 2003) examined the distinct components of the RRS and isolated two unique components of rumination – brooding and reflection. Researchers examining these subcomponents have found that brooding is particularly elevated among currently (e.g., Joormann, Dkane, & Gotlib, 2006) and formerly depressed individuals (e.g., D'Avanzato, Joormann, Siemer, & Gotlib, 2013).

Moreover, experimentally induced rumination is associated with prolonged emotional and biological response to stress, particularly for depressed individuals (Donaldson & Lam, 2004; Lavender & Watkins, 2004; LeMoult & Joormann, 2014; LeMoult, Yoon, & Joormann, 2015; Rimes & Watkins, 2005; Watkins & Brown, 2002). Rumination has also been shown to impede individuals' use of adaptive emotion regulation strategies; specifically, rumination interferes with effective problem solving and engagement in instrumental behavior (Lyubomirsky & Nolen-Hoeksema, 1995; Lyubomirsky, Tucker, Caldwell, & Berg, 1999). In addition, rumination may be linked with poor mood recovery because of its association with isolation; correlational evidence indicates that, although individuals who ruminate reach out for social support more often than do nonruminators, they are less likely to receive emotional support (Nolen-Hoeksema & Davis, 1999) and are more likely to experience higher levels of social exclusion and victimization (McLaughlin & Nolen-Hoeksema, 2012).

3.4.2. Distraction

In contrast to rumination, distraction is typically considered an adaptive emotion regulation strategy. Researchers have found that depressed participants are less likely to use distraction than are their nondepressed peers, even though they report it would likely help alleviate their negative mood (Lyubomirsky & Nolen-Hoeksema, 1993). Lyubomirsky and Nolen-Hoeksema (Lyubomirsky & Nolen-Hoeksema, 1993) argue that depressed individuals avoid distraction because it interferes with their attempts to gain insight into their problems. Nevertheless, depressed and dysphoric individuals are able to successfully use distraction when instructed to do so and, further, compared to rumination inductions, distraction inductions reduce subjective and objective markers of distress in depressed and dysphoric samples (Joormann, Siemer, et al., 2007; LeMoult et al., 2015; Lyubomirsky & Tkach, 2008). Specifically, adults and adolescents who distract themselves by completing an emotionally neutral task or thinking about externally focused items report lower levels of sad mood.

Despite these positive results, researchers have questioned the benefits of distraction. For example, Kross and Ayduk (2008) found that, compared to participants in a control condition, participants in a distraction condition reported lower depressed mood immediately after the mood induction, but higher depressed mood one day and seven days later. The authors concluded that distraction does not change individuals' ability to cope with future situations, and that the utility of distraction is limited to the short term (Kross & Ayduk, 2008). This interpretation is consistent with Campbell-Sills' perspective that distraction is no more than a short-term "band-aid," and not a long-term solution to symptoms of psychopathology (Campbell-Sills & Barlow, 2007). Other researchers go further to suggest that distraction is actually maladaptive in the long run; consistent with this possibility, avoidance-related coping strategies such as distraction are associated with adult and adolescent depression (Aldao et al., 2010; Schäfer et al., 2017). In order to reconcile these discrepant views of distraction, it will be important to also consider the timing and context of its use. In fact, more recent conceptualizations of emotion regulation argue that the ability to flexibly select and implement emotion regulation strategies may be more adaptive than is the use of any single strategy (Aldao & Nolen-Hoeksema, 2013; Bonanno & Burton, 2013). Indeed, depression has been associated with "stereotyped and inflexible responses" to emotional contexts (Rottenberg, Kasch, Gross, & Gotlib, 2002, p. 136).

3.4.3. Reappraisal

Reappraisal is an antecedent-focused strategy consisting of reinterpreting the meaning or interpretation of an emotion-eliciting situation in order to modify the emotional experience. Individuals with depression report using reappraisal less frequently than do formerly depressed individuals and those without a history of psychopathology (D'Avanzato et al., 2013). Importantly, however, when depressed participants are induced to reappraise in the laboratory, their negative mood is improved and, further, the amount of improvement does not differ from the improvement reported by healthy control participants (Ellis, Vanderlind, & Beevers, 2013; Millgram, Joormann, Huppert, & Tamir, 2015; Smoski, LaBar, & Steffens, 2014). Given this, it is surprising that researchers have found that levels of cognitive reappraisal do not predict recovery from a depressive episode (Arditte & Joormann, 2011) or improvement in depressive symptoms (Chambers et al., 2015). Additional research is needed to examine more explicitly the discrepancy between findings obtained in the laboratory versus naturalistic settings.

3.4.4. The relation between cognitive emotion regulation strategies and other cognitive processes

Researchers have now begun to examine the association between cognitive emotion regulation strategies and the cognitive biases described earlier. This is an important area of research as the ability to identify cognitive mechanisms underlying cognitive emotion regulation strategies may offer valuable avenues for intervention. The majority of work in this area has focused on understanding the association between rumination and cognitive biases – particularly difficulties in cognitive control. Increasing correlational evidence supports the proposition that rumination is associated with biases across multiple aspects of cognitive control, including difficulties inhibiting negative information from entering working memory (Joormann, 2006; Joormann & Gotlib, 2010) and updating information in working memory (Meiran et al., 2011), including removing irrelevant negative material from working memory (Joormann & Gotlib, 2008). In addition, individuals' ability to update information in working memory was found to moderate the effects of reappraisal and rumination on high-arousal negative emotions (Pe, Raes, & Kuppens, 2013). Specifically, whereas reappraisal was associated with decreased experience of these emotions for those with high, but not with low, updating ability, rumination was associated with greater experience of negative emotions for those with low, but not with high, updating ability. Difficulty flexibly shifting between different tasks has also been associated with higher levels of rumination, particularly brooding, in both depressed (De Lissnyder et al., 2012) and nonclinical samples (Beckwé, Deroost, Koster, De Lissnyder, & De Raedt, 2014; Koster, De Lissnyder, & De Raedt, 2013; Owens & Derakshan, 2013). Tentative evidence that cognitive control might underlie ruminative responses to stress comes from work by Demeyer, De Lissnyder, Koster, and De Raedt (2012). These investigators found that, in formerly depressed individuals, the prospective association between shifting impairments and depressive symptoms was fully mediated by rumination (Demeyer et al., 2012). The association between cognitive control and rumination was further investigated by Cohen, Mor, and Henik (2015). These researchers examined the experimental effects of one session of cognitive control training on rumination in a nonclinical sample and found that participants who were trained to control the content of negative information in working memory reported less rumination following training than did participants who were trained to control neutral information in working memory. Interestingly the relation between cognition and rumination may be bidirectional; for example, Whitmer and Gotlib (2012) found that depressed individuals who completed a rumination induction performed more poorly on a switching task than did depressed and healthy control participants who completed a distraction induction.

Rumination has also been associated with other cognitive biases. Everaert et al. (2017) for example, found that the relation between cognitive biases (particularly biases in interpretation) and depressive symptoms was mediated by brooding and reappraisal. In addition, higher levels of rumination have been associated with more negative autobiographical memories (e.g., Lyubomirsky & Tucker, 1998) and with greater difficulty using positive autobiographical memories to repair a negative mood state (Joormann & Siemer, 2004; Joormann et al., 2007). Moreover, trait rumination has been associated with an attentional bias for negative words (Donaldson, Lam, & Mathews, 2007) that is specific to biases in attentional disengagement (Grafton et al., 2016); similarly, state ruminative (i.e., ruminative response to a laboratory stressor) has been associated with difficulty disengaging from emotional expressions (LeMoult, Arditte, D'Avanzato, & Joormann, 2013).

Although the association between cognitive biases and reappraisal has not been examined extensively, initial evidence suggests that difficulty shifting and updating negative information in working memory undermines participants' use of reappraisal and its effectiveness. Malooly, Genet, and Siemer (2013) found that difficulty shifting between different sorting rules during an affective switching task was associated with poorer down-regulation of negative affect through the use of reappraisal. Moreover, Joormann and Gotlib (2010) documented that difficulty inhibiting negative information from working memory was associated with less frequent use of reappraisal.

3.4.5. Summary of emotion regulation

Considerable evidence suggests that depression is associated with more frequent use of rumination and less frequent use of reappraisal (D'Avanzato et al., 2013; Nolen-Hoeksema et al., 2008), as is depicted in the Cognitive Emotion Regulation box of Fig. 1. Although depression might also be associated with less frequent use of distraction, researchers have questioned the benefits of distraction as an adaptive long-term emotion regulation strategy (Aldao et al., 2010; Campbell-Sills & Barlow, 2007; Kross & Ayduk, 2008; Schäfer et al., 2017). In more recent conceptualizations of emotion regulation, the ability to flexibly select and implement emotion regulation strategies is posited to be a more important determinant of wellbeing then is the use of any single strategy (Aldao & Nolen-Hoeksema, 2013; Bonanno & Burton, 2013). Importantly, researchers are beginning to examine the relations among cognitive emotion regulation strategies and cognitive biases. Findings from this work are incorporated in the theoretical model depicted in Fig. 1 and support the formulation that difficulties disengaging attention from negative stimuli and controlling negative information in working memory are associated with higher levels of rumination and, possibly, with lower levels of reappraisal and distraction (Joormann, 2010; Koster, De Lissnyder, Derakshan, & De Raedt, 2011).

4. Implications for theory

Findings over the last several decades have largely supported the cognitive models of depression formulated by Beck, Bower, and Teasdale by providing evidence of the role of cognitive biases in the onset, maintenance, and recurrence of depressive episodes. Importantly, however, empirical findings have also served to expand and refine those early cognitive theories of depression in several important ways that are depicted in Fig. 1. For example, studies have highlighted the important role that cognitive emotion regulation strategies play in depression; whereas rumination contributes to the onset and maintenance of depressive episodes, reappraisal, and to a lesser extent distraction, are more adaptive alternatives that facilitate stress recovery. In addition, research suggests that cognitive models of depression should take into account the consistent finding that depression is associated with particular difficulty disengaging from negative material that has been captured by attention or has entered working memory. Moreover, experimental evidence supports the importance of cognitive control biases as a mechanism underlying other cognitive biases and maladaptive emotion regulation strategies (Cohen et al., 2015; Joormann, Hertel, et al., 2009; Schweizer et al., 2013, 2011). Below we describe other more recent cognitive models of depression that have incorporated the evidence presented above.

The response styles theory of rumination (Nolen-Hoeksema et al., 2008; Nolen-Hoeksema & Morrow, 1991) posits that individuals differ in their response to negative mood states and that certain response styles – in particular, rumination – exacerbate depressed mood and negative cognition. The harmful effects of rumination are posited to be due not to the increased attention to distress or the negative content of individuals' thoughts, but rather to the passive and repetitive "recycling" of these thoughts. The response styles theory predicts that rumination will be associated with higher levels of depressive symptoms and increased onset of depressive episodes. It also attributes sex differences in the prevalence of depression to sex differences in the use of rumination.

Building on Nolen-Hoeksema's response styles theory and on cognitive models of depression (Beck, 1978; Bower, 1981; Ingram, 1984; Teasdale, 1988), Joormann (2010) posited a model of depression in which deficits in cognitive control are central to both cognitive biases and cognitive emotion regulation strategies. Specifically, Joormann argued that difficulty inhibiting access of negative information into working memory and removing no-longer-relevant negative content from working memory underlie both rumination and problems disengaging attention from negative information. In turn, negative content is preferentially stored in long-term memory, explaining the negative memory biases that typify depression.

Koester and colleagues (Koster et al., 2011) formulated the 'impaired disengagement' hypothesis to explain the persistence of negative thoughts in depression. Koester et al. argue that prolonged cognition of self-referent material stems from impaired attentional disengagement from negative self-referent information. In fact, they posit that difficulties in attentional disengagement also underlie the decreased use of adaptive emotion regulation strategies, including reappraisal and distraction.

Finally, in addition to the cognitive models of depression presented here, we suggest that researchers attend closely to recent integrative models of depression that are aimed at understanding how cognitive-biological interactions contribute to the pathophysiology and course of depression. Although a detailed summary of these models is outside of the scope of this review, interested readers are referred to Beck and Bredemeier (2016) and Disner, Beevers, Haigh, and Beck (2011).

5. Clinical implications

At present, fewer than 40% of individuals who are treated for MDD achieve symptom remission with initial treatment (Gaynes et al., 2009; Holtzheimer & Mayberg, 2011). Given evidence that cognitive biases and emotion regulation strategies influence the onset, maintenance, and recurrence of depressive symptoms, cognition is an important target for intervention. Both theoretical models of depression and empirical findings suggest that ameliorating maladaptive cognition can reduce depressive symptomatology. Consistent with this possibility, Cognitive Behavior Therapy (CBT) has been shown to have beneficial effects on cognitive biases and emotion regulation strategies. For example, several studies have examined the effects of CBT on cognitive biases and have found significant reductions in biases in attention (e.g., Davis et al., 2016; Lazarov et al., 2018), interpretation (e.g., Williams et al., 2015), and perceived control (Pereira et al., 2017). Moreover, reappraisal is a fundamental component of cognitive restructuring, which is a central therapeutic technique in CBT (Beck, Rush, Shaw, & Emery, 1979; Beck, 2011). CBT has been associated with increased use of reappraisal (Goldin et al., 2014; Moscovitch et al., 2012), and in turn, self-efficacy of reappraisal has been shown to mediate the effect of CBT on symptoms, such that increases in reappraisal self-efficacy predicted decreases in symptoms one year post CBT (Goldin et al., 2012). In addition, several treatment-outcome studies have demonstrated that CBT reduces rumination (e.g., Price & Anderson, 2011).

In addition, several investigators have begun to apply recent cognitive science theories and findings to create alternatives or extensions to CBT. Indeed, results of CBM studies indicate that reducing negative cognitive biases improves depressive symptoms and attenuates emotional and biological responses to stress (for a review see Hallion & Ruscio, 2011; Hertel & Mathews, 2011). Although the effectiveness of CBM has been called into question, it is possible that researchers will be able to refine CBM methods for improved therapeutic effect. For example, by targeting the core cognitive biases underlying other cognitive risk factors or by improving our implementation of CBM training methods, CBM tasks may serve as an adjunct or alternative to existing treatments.

Increasing evidence documents the benefits of mindfulness-based cognitive therapy (MBCT) for depression (Dimidjian, Kleiber, & Segal, 2009; Segal, Williams, Teasdale, & Gemar, 2002). MBCT uses a combination of psychoeducation about depression, mindfulness meditation practices, and cognitive-behavioral strategies. Several large randomized trials documented reductions in depressive symptoms and relapse rates following MBCT (Ma & Teasdale, 2004; Teasdale et al., 2000). Although the literature examining the effects of MBCT for depression on changes in cognitive processes is small, initial evidence suggests that MBCT is associated with reduced overgeneral autobiographical memory,

negative attentional biases, and rates of rumination (Dimidjian et al., 2009; Teasdale, Segal, & Soulsby, 2000; van Vugt, Hitchcock, Shahar, & Britton, 2012).

Another promising therapeutic development is emotion regulation therapy (ERT). ERT is a recently developed treatment that integrates components of CBT, acceptance, mindfulness, and experiential, emotion-focused therapeutic techniques (Mennin, Fresco, Ritter, & Heimberg, 2015; Renna, Quintero, Fresco, & Mennin, 2017). It was designed originally for Generalized Anxiety Disorder (GAD) but has been applied to individuals with GAD and comorbid depression. ERT focuses on training three emotion regulation skills: allowance, distancing, and reframing. Despite its relatively recent development, researchers have documented the efficacy of ERT (Mennin et al., 2015; Renna et al., 2017). Specifically, patients receiving ERT showed improvement in symptom severity, impairment, quality of life, mindful attending/acceptance, and cognitive reappraisal (Mennin et al., 2015).

Work by Watkins and colleagues provides another example of researchers applying recent cognitive science theories and findings to improve clinical practice. These researchers adapted CBT to specifically target rumination via a rumination-focused CBT protocol, and documented significant reductions in symptoms and remission rates that were mediated by reductions in rumination (Watkins et al., 2007, 2011). Over the next decade, we envision researchers will continue to develop and refine therapeutic approaches that target other cognitive processes that are related to depression.

As we consider the current state of the treatment outcome literature, we would like to make two additional points. First, we believe that the field can now move toward targeted and person-specific interventions that are informed by cognitive and biological markers. At present, person-centered variables are rarely used to inform intervention approaches, and we know little about which interventions work best for which individuals and why. Second, we urge investigators to move toward early identification of risk for depression so that we can make the transition from a reactive- to a proactive-based approach to treatment. Although we have made progress in identifying individuals at greatest risk for depression on the basis of demographic, environmental, and developmental risk factors (e.g., sex, family history of the disorder, early life stress, and/or the onset of puberty), we still need preventive interventions that reduce the rates of the onset of depression in these at-risk populations.

6. Future directions

Over the past several decades we have made exciting progress in our understanding of depression. What should we work towards and expect over the next several years? First and foremost, despite considerable progress in the measurement of cognition in depression, the psychometric properties of many information-processing tasks are still unknown or poor (Brown et al., 2014; Schmukle, 2005). It is critical that researchers use experimental methods and tasks with strong psychometric properties. Therefore, we encourage researchers to evaluate and report the psychometric properties of the tasks that they are using so that other researchers can select tasks with the strongest psychometrics, can interpret inconsistencies in the literature in light of potential variability in task psychometrics, and can identify when new tasks with stronger psychometric properties should be developed.

Second, there has been a trend toward the development of more integrative models of depression that aim to describe how biological, emotional, and cognitive components interact to precipitate and exacerbate depressive symptoms (e.g., Disner, Beevers, Haigh, & Beck, 2011). We think that it is critical that researchers continue to pursue this line of inquiry in order to move the field forward. Specifically, the integration of cognitive science with biology will allow us to identify the biological factors that influence and are influenced by negative cognitive biases and maladaptive emotion regulation strategies.

Third, we anticipate that the NIMH's Research Domain Criteria (RDoC) will continue to shape the way we define and study psychopathology. RDoC, a system for classifying mental disorders based largely on a dimensional framework encompassing biology and behavior, posits that mechanisms that underlie problematic behaviors and symptoms are transdiagnostic. RDoC was formulated to identify and utilize biomarkers that can reliably predict the onset, course, and outcome of mental illness. Importantly, the RDoC approach has the potential to improve methods and systems used in the prevention and treatment of psychiatric disorders. The Cognitive Systems domain, which includes constructs such as attention, memory, and cognitive control, is particularly relevant to consider in attempting to understand the nature of the association between cognition and depression. Moreover, two of the major domains of the RDoC approach, the Positive Valence System and the Negative Valence System, most strongly capture the aberrant processing that may be common to depression and related disorders; studying these domains is a promising avenue for future investigation.

Fourth, there is currently a relative gap in our understanding of individual-difference factors (e.g., ethnicity, race, sex) that interact with cognitive processes to affect depressive symptomatology. This gap is particularly surprising given evidence that prevalence rates of depression differ across ethnicity, race, and sex (Kessler, 2003; Kessler et al., 2003; Kessler et al., 2005) and that perceived discrimination is associated with negative mental health outcomes, such as depression (Chou, Asnaani, & Hofmann, 2012). Initial work in this area suggests that ethnic and racial factors and sex differences can influence the association between cognitive factors and depression. For example, there is considerable evidence that women are more likely to ruminate than are men, and some studies find that sex differences in rumination mediate sex differences in the prevalence of depression (Nolen-Hoeksema et al., 2008). In addition, Kwon, Yoon, Joormann, and Kwon (2013), found that the association between reappraisal and depressive symptoms was stronger in a Korean than in a US sample, but that, across both countries, women were more likely to ruminate than were men. In contrast, however, Dritschel and colleagues (Dritschel et al., 2011) documented similar autobiographical memory biases in depressed individuals from Britain and Taiwan. This finding suggests that there are circumstances when culture does not influence cognitive processes, and it highlights the importance of identifying when and for whom individual-difference factors influence the role of cognition in depression.

Fifth, we think initial findings regarding the role of mental imagery biases in depression are promising. Mental imagery, or the ability to imagine a past, current, or future event, is a central feature of cognition. Although its role in depression has been largely overlooked, researchers have documented that, compared with healthy control participants, depressed participants have more intrusive negative mental images, less vivid positive images, and overgeneral images of past events (for a review see Holmes, Blackwell, Burnett Heyes, Renner, & Raes, 2016). For example, Holmes, Crane, Fennell, and Williams (2007) reported that intrusive mental images of suicide (termed flash-forwards) are associated with depression and suicidal ideation. Moreover, several investigators have found reduced vividness for positive future events in dysphoric than in non-dysphoric participants (Anderson & Evans, 2015; Holmes, Lang, Moulds, & Steele, 2008; Szollosi, Pajkossy, & Racsmány, 2015) and in formerly depressed participants compared to healthy control participants (Werner-Seidler & Moulds, 2011); this reduced vividness may limit individuals' ability to imagine future positive events and increase negatively biased affective forecasts. Less vivid processing of positive memories may also hinder individuals' ability to use positive memories to repair or protect against negative mood states. Consistent with this possibility, researchers have shown that experimentally inducing concrete, imagery-focused processing when currently or formerly depressed individuals recall a positive memory leads to greater improvement in mood than does an abstract, verbal processing style (Werner-Seidler & Moulds, 2012). Thus, although the role of mental

imagery biases in depression has been understudied, initial evidence suggests that this is a promising approach for future research.

Finally, it is increasingly apparent that any single form of cognition does not operate in isolation. Although investigators have begun to examine the relations among cognitive biases and emotion regulation strategies (these initial findings inform the theoretical model depicted in Fig. 1), additional research is needed to understand how different components of cognition interact and influence one another. Similarly, by including multiple forms of cognition together in the same model, researchers are able to test the relative and differential contribution of different cognitive factors in the onset and maintenance of depression. These are important and exciting goals in the coming years.

7. Take-home points

Over the last several decades, researchers have made major advances in elucidating factors involved in the onset and maintenance of depression, and have generated a number of important conclusions that have influenced the field; these findings are depicted in the model presented in Fig. 1. First, investigators have documented that depression is characterized by both general cognitive deficits (e.g., impairments in executive functioning and memory) and negative cognitive biases (i.e., the negatively biased processing of emotional information). Moreover, not only do depressed individuals exhibit negative cognitive biases, but they also fail to show the positive cognitive biases that likely serve as protective factors for healthy control participants. Specifically, depression is characterized by negatively biased interpretation of ambiguous information, difficulty disengaging from negative material that has captured their attention or has entered working memory, and overgeneral positive autobiographical memories that interfere with depressed persons' ability to use positive memories to repair negative mood states. Interestingly, whereas the majority of evidence on cognitive deficits suggests they are not frequently observed outside of acute episodes, cognitive biases have been found to persist during periods of episode remission and to emerge even prior to the onset of depressive episodes. Second, cognitive emotion regulation strategies (e.g., rumination, reappraisal) are increasingly being recognized as important in understanding the development and course of depressive disorders. Research suggests that depression is characterized by (1) increased use of maladaptive emotion regulation strategies (e.g., rumination); (2) decreased use of adaptive emotion regulation strategies (e.g., reappraisal); and (3) decreased flexibility in the selection and implementation of emotion regulation strategies. Third, there is growing experimental evidence indicating that biases in cognitive control underlie the other cognitive biases and the use of maladaptive (rumination) versus adaptive (reappraisal) emotion regulation strategies (Cohen et al., 2015; Joormann, Hertel, et al., 2009; Schweizer et al., 2013, 2011). Although there is some initial experimental evidence that cognitive biases and cognitive emotion regulation strategies perpetuate difficulty controlling negative information in working memory, this is relatively understudied and, thus, is not included in Fig. 1.

We have made significant progress in understanding the role and importance of cognition in depression. As we look forward, we hope to see a continuation of interdisciplinary, integrative research aimed at identifying risk factors and improving approaches to the prevention of depression. We believe that this work will be critical to further refining cognitive models of depression and, ultimately, to decreasing the prevalence, severity, and duration of episodes of this debilitating disorder.

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Contributors

JL and IHG discussed the focus of the current review. JL wrote the first draft of the manuscript, and IHG contributed to and approved the final manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.

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Joelle LeMoult is currently an Assistant Professor in the Department of Psychology at the University of British Columbia. The overarching goal of her research is to further our understanding of the onset, maintenance, and recurrence of Major Depressive Disorder (MDD). Using a multimodal approach, she examines the cognitive, emotional, and biological responses to environmental stressors that contribute to symptoms of depression and comorbid anxiety disorders.