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Depressive cognition: Self-reference and depth of processing

Blair E. Wisco *,1

Yale University, Department of Psychology, Box 208205, New Haven, CT, 06520-8205, United States

A B S T R A C T

Cognitive models of depression, which propose that depression is associated with negatively biased thinking, have typically focused on either the content or the processes of depressive cognition. Content-based models suggest that depressive thought is more negative for self-relevant than for externally-focused content. Process-based models propose that early, automatic processes are not negatively biased in depression, but that deeper processes are biased. The current review evaluates evidence for both the self-relevant content and depth of processing accounts, and concludes that there is substantial evidence for both models. I call for further research which integrates content and process-based approaches by using self-relevant stimuli and cognitive measures which precisely identify the specific attention, memory, and interpretation processes affected in depression.

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Cognitive theories of depression have been prominent for over forty years (Beck, 1967). Such theories have typically focused on either the content or the processes of depressive cognition. Early cognitive models specified the content of depressive thought as negative views of the self, the future, and the world (Beck, 1976). Since Beck's original formulation, theorists have argued that negative views of the world and the future are limited to one's world and one's future, and could be described as specific kinds of negative self-views (Haaga, Dyck, & Ernst, 1991). As I will review below, extensive evidence indicates that depressed individuals hold more negative self-views, blame themselves more than others for negative events, are more pessimistic for themselves than for others, and more adversely affected by self-reflection than nondepressed individuals.

More recent cognitive theories have focused on the process of depressive cognition, rather than its content (Williams, Watts, MacLeod, & Mathews, 1997). One influential model, proposed by Williams and colleagues, argues that early, automatic processes are not biased in depression, but that more strategic, elaborative

* Tel.: +1 203 432 4522; fax: +1 203 432 7172.
   E-mail address: Blair.wisco@yale.edu.

processes are negatively biased.[2] More recent process-based theories have suggested modifications to the Williams and colleagues' model (Mogg & Bradley, 2005; Watkins, 2002). Below, I describe the different process-based models in detail and offer a comprehensive review of the evidence in tests of memory, attention, and interpretation bias in depression. Most of the evidence for such process-based models has come from performance-based measures that are better able to isolate specific cognitive processes than self-report questionnaires. The research using such performance-based measures, however, has not included systematic investigation of self-relevant versus external content.

In the following review, I integrate content- and process-based approaches to depressive cognition.[3] First, I offer evidence that the self-relevance of stimuli affects the level at which these stimuli are processed, drawing upon basic research from the social cognitive and cognitive science literatures not concerned with differences between depressed and nondepressed individuals. I then argue that the effects of self-relevance and depth of processing are confounded in current tests of depressed versus nondepressed cognition. I discuss the negative self-reference effect in memory as one example of this confound. Next, I evaluate evidence from content-focused studies that depressed individuals are more negative for themselves than for others. I then review evidence for process-focused models that depressed and nondepressed people differ in elaborative, but not automatic, processing of negative information. I conclude that there is substantial evidence for both of these models, but that inferences regarding the contributing roles of self-relevance and depth of processing are limited by the confounded nature of most of the current literature. Finally, I discuss the importance of combining a focus on self-referential content with performance-based measures which more closely pinpoint specific cognitive processes.

1. Self-reference and social cognition

People in general, whether depressed or nondepressed, process self-referential stimuli differently from more external stimuli. The self-relevance of information has been found to affect speed of attention, facility of memory, and neurobiological correlates of processing. Some of the earliest evidence of these effects came from dichotic listening paradigms, during which individuals are instructed to attend to one stream of speech while another irrelevant stream of speech is presented in their other ear. Overall, participants recall few words presented in the unattended ear. When the stream of unattended speech contains their own name, however, they are more likely to recall this self-relevant stimulus than the other words presented (Moray, 1959; Wood & Cowan, 1995). This phenomenon is commonly

referred to as the "cocktail party effect." Similar effects have been found for other self-referential information, specifically words consistent with one's own self-descriptions. When these self-relevant words are presented in the stream of unattended speech, the task of attending to the target stream of speech requires more attentional resources, suggesting distraction by the self-relevant words (Bargh, 1982).

Similar findings have emerged using other measures of selective attention. One such measure is the Stroop task, in which participants are asked to name the color of words whose content varies. Participants take longer to identify the color of self-relevant words than neutral words, suggesting attentional interference by the self-relevant content (Geller & Shaver, 1976; Algom, Chajut, & Lev, 2004, for a discussion of limitations of this task). Likewise, when participants are asked to identify a name presented in the center of a computer screen, task-irrelevant pictures presented on the side of the screen are more distracting when the pictures are self-relevant (the participant's own face, rather than another face; Bredart, Delchambre, & Laureys, 2006). One's own name also holds attention more than other words when stimuli are presented in rapid succession, as they are in masking procedures (Shelley-Tremblay & Mack, 1999) and rapid serial visual presentation tasks (Shapiro, Caldwell, & Sorenson, 1997).

Neuroimaging results support the notion that self-referential information is processed differently from other kinds of information. In studies directly examining self-reflective thought, greater activation of the medial prefrontal cortex (MPFC) has been consistently associated with self-relevance across a variety of experimental tasks. Ratings of the self-descriptiveness of trait adjectives are associated with greater activation of the MPFC than judgments of how well the adjectives describe others (Craik et al., 1999; Kelley et al., 2002; Schmitz, Kawahara-Baccus, & Johnson, 2004). Self-descriptiveness ratings are also associated with greater activation of the MPFC than ratings of the positivity (Schmitz et al., 2004) or social desirability of words (Craik et al., 1999; Fossati et al., 2003). Even within self-descriptiveness ratings, greater MPFC activation is found when traits are judged to be self-descriptive than when they are judged not to be self-descriptive (e.g., when the answer is "yes" as opposed to "no;" Macrae, Moran, Heatherton, Banfield, & Kelley, 2004; Moran, Macrae, Heatherton, Wyland, & Kelley, 2006). Similarly, participants asked to engage in self-reflective thought demonstrate greater activation of the dorsomedial prefrontal cortex than those asked to consider external, non-self-relevant statements (Johnson et al., 2006), and participants show greater activation of the MPFC when asked to listen to statements that reflect one's own attributes (e.g., "I forget important things") than when they listen to statements of general, non-self-relevant, information (e.g., "Ten seconds is more than a minute;" Johnson et al., 2002). The neuroimaging data corroborate the behavioral evidence that differential processing occurs for self-relevant and non-self-relevant information.

Finally, a large body of literature has examined the "self-reference effect" (SRE) in memory, which refers to the phenomenon that encoding words in reference to the self (by indicating whether or not the word describes oneself) leads to better recall of those words than almost any other kind of encoding strategy. In one of the earliest studies examining the SRE, Rogers, Kuiper, and Kirker (1977) compared self-referential encoding of words to three other encoding conditions (indicating whether the word is presented in uppercase letters, whether it rhymes with another word, or whether its meaning is the same as another word). Participants were more likely to recall self-referentially encoded words than words encoded in any of the other conditions. Since this original study, there have been over one hundred studies examining the presence of the SRE in memory. A meta-analysis found that self-referentially encoded words are remembered better than words encoded according to semantic properties (e.g., "Does the word mean the same as X?") or in reference to someone else (Symons & Johnson, 1997).

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[2] The vast majority of the depressive cognition literature relies upon examinations of relative differences between depressed and nondepressed groups. When the depressed group shows relatively more negative thinking, it is often referred to as "negatively biased." Because the bias terminology is commonly used in this literature, I adopt it for this review as well. This terminology has come into question because such group differences could be explained by either a negative bias in the depressed group or a positive bias in the nondepressed group, relative to some objective standard. In fact, several studies have found that such differences are best explained by a lack of positive bias in the depressed group (Alloy & Ahrens, 1987; McCabe & Gotlib, 1995). However, objective standards are difficult to determine for much this research which concerns participants' subjective attitudes and beliefs. For this reason, I use the bias terminology to refer to any thinking that is more negative in depressed individuals than nondepressed individuals, regardless of its relationship to objective truth.

[3] For the purposes of this review, I conducted separate PsycINFO searches including the keywords "Depression" or "Major Depression" or "Depression (Emotion)" and each of the following combinations of keywords, in turn "cognitive bias," "attentional bias" or "attention bias" or "attention," "memory bias" or "memory," "interpretation bias," "self-reference" or "self-relevance." I reviewed the abstracts generated by these searches to identify relevant articles, and conducted a manual search of the reference lists of identified studies.

Self-referential encoding is thought to enhance memory by promoting both greater elaboration and organization of material (Klein & Loftus, 1988; Symons & Johnson, 1997). Because of its relevance to depressive biases, I focus on the role of elaboration here. Elaboration of a stimulus refers to the creation of associations between that stimulus and existing material stored in memory. For example, elaboration of the word "sad" might include associations with other words, (e.g., "crying"), an autobiographical memory (e.g., that bad break-up last spring), or other concepts stored in memory (e.g., the concept "death of a loved one"). Greater elaboration promotes memory by allowing multiple routes for later recall (Craik, 1979; Klein & Loftus, 1988). Returning to our example, by creating multiple associations with the word "sad," one is able to call on any of these related constructs when trying to remember the word. The more associations one creates, the more likely one will be able to use these associations to facilitate recall. Self-referential encoding allows for greater elaboration precisely because the self is such a highly familiar concept, which makes a greater number of associations possible. Tasks that assess the degree of elaboration of stimuli have consistently found that self-referential encoding does promote greater elaboration than other forms of encoding (Klein & Loftus, 1988).

2. Implications for depressive cognition

Self-referential information, therefore, is processed differently from non-self-referential information in both attention and memory tasks. In particular, evidence from the SRE memory task suggests that self-referential encoding encourages more elaborative processing. This basic research has important implications for the study of self-relevance in depressive cognition. For example, the SRE effect has been found to differ between depressed and nondepressed individuals. When the valence of the encoded adjectives is taken into account, depressed individuals show better memory for negative words that have been self-referentially encoded than either positive words that have been self-referentially encoded or any words that have been encoded in reference to others (D'Argembeau, Comblain, & Van der Linden, 2005; Denny & Hunt, 1992; Derry & Kuiper, 1981; Dozois & Dobson, 2001; Kuiper, & Derry, 1982). This effect is reversed for nondepressed individuals, who show the best memory for positive words that have been self-referentially encoded, compared to negative self-referentially encoded words or any other-referentially encoded words. In fact, depressed individuals only show a negative memory bias in the self-referential condition, with similar memory for negative and positive words in the other-referential conditions. Therefore, the negative memory bias associated with depression appears to be limited to self-referentially encoded words, at least on this task.

This pattern of SRE results has been explained in two different ways. First, some researchers have argued that negatively biased thinking in depression is limited to self-referential content (Derry & Kuiper, 1981; Kuiper & Derry, 1982). Although depressed individuals think negatively about themselves, such negativity does not extend to their thinking about others. However, other theorists have pointed out that the self-referential condition also encourages more elaborative processing than the other-referential condition, as described above (Williams et al., 1997). It may be that depressed individuals show a negative bias in conditions which encourage elaboration, but not in conditions which do not encourage elaboration. Because the self-referential condition is both more self-relevant *and* more elaborative than the other-referential condition, either explanation is plausible. Unfortunately, few tests of depressive cognition have systematically varied both self-relevance and degree of elaboration. Therefore, I consider these two potential moderators of depressive cognition in turn, first examining the evidence that depressed individuals think more negatively about themselves than about others.

3. Self-relevant content in depression

Negative self-views are one of the defining features of depression. The symptoms of Major Depressive Disorder include "feelings of worthlessness," according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 1994), and negative associations with the self are central to most theories of depression. Freud defined depression as "anger turned inward," and psychodynamic theorists argue that depression is marked by excessive self-criticism (Blatt, 1974). Aaron Beck's cognitive model of depression includes the cognitive triad, which he defined as negative views of the self, the future, and the world (Beck, 1976). Later theorists have argued that negative views of the world and the future are limited to one's world and one's future, and could be conceptualized as specific kinds of self-views (Haaga, Dyck, & Ernst, 1991). Haaga and colleagues note that negative views of the future are often assessed with measures which only assess self-relevant future events, like the Hopelessness Scale (Beck, Weissman, Lester, & Trexler, 1974) or the Crandell Cognitions Inventory (Crandell & Chambless, 1986). A factor analysis of one commonly used measure of the cognitive triad (the Cognitive Triad Questionnaire; Beckham, Leber, Watkins, Boyer, Cook, 1986), revealed a one-factor solution which the authors labeled "self-relevant negative attitude" (McIntosh & Fischer, 2000). Therefore, Beck's original model included negative self-views, and later theorists have further emphasized the importance of self-relevance. The reformulated helplessness theory of depression also assigns an important role to internal attributions, or self-blame, for negative events (Abramson, Seligman, & Teasdale, 1978). The hopelessness theory of depression deemphasized the role of internal attributions but argued that one proximal cause of depression is inferring negative consequences about the self in response to negative life events (Abramson, Metalsky, & Alloy, 1989). Nolen-Hoeksema's response styles theory of depression highlights the role of a specific form of self-reflection known as rumination in the development of depression (Nolen-Hoeksema, 1991). Finally, integrative models incorporating cognitive and interpersonal theories of depression emphasize cognitive appraisals of personal unworthiness and incompetence in the development of depression (Gotlib & Hammen, 1992).

In addition to these theoretical views, substantial empirical evidence suggests that depression is marked by negative associations with the self. Relative to their nondepressed counterparts, depressed individuals report more negative views of themselves on self-report measures, make more pessimistic predictions for themselves than for others, and respond to self-reflection with more negative mood and thinking. Depressed individuals consistently endorse more negative thoughts about themselves on questionnaires such as the Automatic Thoughts Questionnaire (Hollon & Kendall, 1980), the Crandell Cognitions Inventory (Crandell & Chambless, 1986) and the self-scale of the Cognitive Triad Questionnaire (Beckham et al., 1986) than nondepressed individuals (Dobson & Shaw, 1986; Dohr, Rush, & Bernstein, 1989; Hollon, Kendall, & Lumry, 1986; Lam, Brewin, Woods, & Bebbington, 1987). Depressed individuals report lower self-esteem than nondepressed individuals (Metalsky, Joiner, Hardin, & Abramson, 1993; Parry & Brewin, 1988; Prosen, Clark, Harrow, & Fawcett, 1983; Roberts & Kendler, 1999). When asked to rate adjectives, depressed participants choose more negative words as self-descriptive than nondepressed participants (Bradley & Mathews, 1988; Derry & Kuiper, 1981; Dobson & Shaw, 1987; Rude, Krantz, & Rosenhan, 1988).

Depressed individuals are also more likely to blame themselves when negative events happen to them. There is substantial evidence supporting the learned helplessness theory that depression is marked by a tendency to attribute negative events to internal, stable, and global causes (Abramson et al., 1978). The internal dimension of attributional style refers to the extent to which an individual believes an event is caused by him, as opposed to by others or circumstances. For example, an individual who attributes job loss to his own failings, as opposed to

economic circumstances, would be making an internal attribution. Hundreds of studies investigating attributional style have been conducted, and meta-analytic reviews have found that negative attributional styles, including internal attributions for negative events, are associated with depression in both children (Gladstone & Kaslow, 1995) and adults (Mezulis, Abramson, Hyde, & Hankin, 2004). However, when assessing causes of events that happen to others, including strangers and close friends, dysphoric individuals are not more likely to make internal, stable, or global attributions for negative events than nondysphoric individuals (Schlenker & Britt, 1996; Sweeney, Shaeffer, & Golin, 1982).[4] Therefore, attributional style associated with depression is specific to negative events that happen to the self.

Depressive symptoms are also associated with more pessimistic predictions for one's own future. Compared to nondysphorics, dysphoric individuals predict worse performance for themselves, but not for others, on a motor skills task (Garber & Hollon, 1980). When predicting likelihood of future life events, nondysphoric individuals predict that positive events are more likely to occur than negative events for both themselves and for others. Dysphoric individuals also predict that positive events are more likely than negative events for others, but think that positive and negative events are equally likely for themselves (Pyszczynski, Holt, & Greenberg, 1987). Alloy and Ahrens (1987) found that dysphoric individuals made more pessimistic predictions than nondysphoric individuals both for themselves and for hypothetical others, but this effect was more pronounced for their self-predictions. Taken together, this evidence suggests that dysphoria is associated with a more pessimistic view of the future for oneself but not consistently for others.

Given the negative self-views associated with depression, it is not surprising that thinking about the self would have different consequences for depressed and nondepressed individuals. Indeed, self-reflection exacerbates negative mood and increases negative thinking for depressed but not for nondepressed individuals. Much of the research on self-reflection in depression has focused on the construct of rumination, or the tendency to dwell on one's depressive symptoms and the causes and consequences of those symptoms (Nolen-Hoeksema, 1991). A ruminative response style, or a predisposition to respond to distress with rumination, increases risk for the development of depressive symptoms in the future (Nolen-Hoeksema, 1991; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008; Wisco & Nolen-Hoeksema, 2008). Additionally, experimental research consistently finds that asking participants to ruminate enhances negative thinking, impairs problem solving, and interferes with instrumental behavior for dysphoric and depressed but not for nondysphoric or nondepressed individuals (Donaldson & Lam, 2004; Lyubomirsky & Nolen-Hoeksema, 1993, 1995; Nolen-Hoeksema & Morrow, 1993; Watkins & Baracaia, 2002; Watkins & Moulds, 2005). This pattern of results is generally attributed to content of ruminative thought, which would be expected to be more negative in dysphoric individuals who hold negative views of the self.

However, self-referential thought can be detrimental to dysphoric individuals even when it is positive in content. When explicitly instructed to recall positive memories, nondysphoric individuals show elevated mood. Currently depressed participants, however, exhibit worsened mood, and remitted depressed and dysphoric participants show no mood benefit (Joormann & Siemer, 2004; Joormann, Siemer, & Gotlib, 2007). Depressed and dysphoric participants are able to recall positive memories, as ratings of the positivity of the memories do not

differ by dysphoria or depression status. The mood effect is not due to a global inability to repair mood, because dysphoric and depressed participants showed elevated mood following externally-focused distraction exercises. The self-referential nature of the memory recall task had negative mood effects for depressed but not nondepressed individuals, even thought the content of the self-reflection was similarly positive across all groups. Taken together, this literature suggests that depressive thought is more negative for self-relevant than non-self-relevant information, in terms of self-views, attributional style, predictions for the future, and the effects of self-reflection.

4. Elaborative processing in depression

The studies reviewed above offer strong evidence that depression is associated with more negative thinking for self-relevant than non-self-relevant information. However, this literature has tended to use self-report measures that cannot identify specific cognitive processes. Later theorists have suggested that some processes, but not others, are negatively biased in depression and have encouraged the use of performance-based measures that pinpoint specific cognitive processes. As described earlier, the influential model proposed by Williams and colleagues argues that early, automatic processes are not biased in depression, but that more strategic, elaborative processes are negatively biased. Williams and colleagues predicted that depressive biases would emerge on tests of explicit memory, but not on tests of attention or implicit memory, which do not require elaboration.

Since proposal of their model, some evidence of attention and implicit memory biases in depression has emerged (Caseras, Garner, Bradley, & Mogg, 2007; Eizenman et al., 2003; Gotlib, Kasch, et al., 2004; Gotlib, Krasnoperova, Yue, & Joormann, 2004; Rinck & Becker, 2005; Ruiz-Caballero & Gonzalez, 1997; Watkins, Vache, Verney, Muller, & Mathews, 1996). Later theorists have noted that when depressive biases emerge in attention and implicit memory, it tends to be on tasks which require deeper levels of processing (Mogg & Bradley, 2005; Watkins, 2002). Depth of processing was originally defined as the degree to which the semantic content of a verbal stimulus was processed (Craik & Tulving, 1975). In the current review, I define tasks as allowing for deeper levels of processing if they encourage processing of the semantic content of verbal stimuli or the emotional meaning of pictorial stimuli. When processing occurs in a sequential fashion, I define processes which occur later in the sequence as "deeper" than earlier processes.

Below, I review the current state of the literature on degree of elaboration and depressive biases in memory, attention, and interpretation, and suggest an expansion of the model proposed by Williams et al. (1997). I argue that depressive biases emerge in deeper levels of processing which include, but are not limited to, the strategic elaboration of material in memory. Explicit memory tasks, which generally encourage deep, elaborative processing, find consistent evidence of depressive biases. When implicit memory biases are found in depressed individuals, they tend to be at deeper, conceptual levels of implicit memory (Watkins, 2002). When attention biases are found, they tend to be at longer presentation times and on tasks which assess the dwell of attention, rather than the initial allocation of attention (Mogg & Bradley, 2005). In interpretation, biases tend to be found at deeper levels of processing, but not in the early activation of interpretations. In general, deeper levels of processing are more consistently associated with depressive biases. However, I argue that the conclusions drawn from this literature are limited by the nature of the stimuli used in these studies, which are often not self-relevant in tests of less elaborative processes.

4.1. Memory biases

Depressed individuals demonstrate "mood congruence" on many memory tests, meaning that they are more likely than nondepressed individuals to recall negative material and less likely to recall positive

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[4] Much of the research on depressive cognition has included participants who score highly on a self-report measure of depressive symptoms, such as the Beck Depression Inventory (Beck, Steer, & Brown, 1996), but do not necessarily meet full criteria for major depression. When describing a specific study, I refer to the participants as dysphoric if they were chosen based solely on their self-report of depressive symptoms, and as depressed if the participants met full criteria for Major Depression. When making generalizations from the literature, I do not distinguish between dysphoria and depression.

material (Blaney, 1986; Matt, Vasquez, & Campbell, 1992). Strong evidence for mood congruence in depression emerges on tests of explicit memory, or the conscious recollection of previous events or experiences. Depressed individuals consistently recall more negative autobiographical memories than nondepressed individuals (Fogarty & Hemsley, 1983; Lloyd & Lishman, 1975; Mayo, 1983; Rottenberg, Hildner, & Gotlib, 2006; Stone, 1981). When asked to read and recall a list of words, depressed individuals are more likely to recall negative words and less likely to recall positive words than nondepressed individuals (Bradley & Mathews, 1988; Breslow, Kocsis, & Belkin, 1981; Derry & Kuiper, 1981; Dunbar & Lishman, 1984; Finkel, Glass, & Merluzzi, 1982; Ingram, Smith, & Brehm, 1983; Kuiper & Derry, 1982; Ramel et al., 2007). Similarly, when participants are asked to recall their performance on a task, depressed individuals are more likely to recall failure and less likely to recall success than nondepressed individuals (DeMonbreun & Craighead, 1977; Dobson & Shaw, 1981; Gotlib, 1981, 1983; Lyubomirsky, Caldwell, & Nolen-Hoeksema, 1998; Nelson & Craighead, 1977). Although some failures to find these effects have been reported (Craighead, Hickey, & DeMonbreum, 1979), mood congruent memory has been well-replicated within the literature (Blaney, 1986) and at least one meta-analytic review has estimated the mood congruent memory effect to be robust (Matt, Vasquez, & Campbell, 1992).

In contrast to the explicit memory literature, tests of implicit memory in depression have yielded mixed results. Implicit memory refers to the transfer of previous learning to performance on later tasks (Schacter, 1987). Implicit memory does not require conscious re-collection of learning, and often occurs outside of awareness. Evidence of implicit memory is seen on priming tasks, where individuals are faster to identify briefly presented words if they have seen the words previously. Implicit memory effects can also be seen when individuals are asked to finish incomplete words (e.g., word stem completion) or solve anagrams. For example, if individuals have previously seen the word "cape," they are more likely to complete the word fragment "ca_ _" as "cape" than as "cake," and more likely solve the anagram "apec" as "cape" than as "pace." If such priming effects are larger for negative than positive words in depressed, but not nondepressed, individuals, this would suggest a bias associated with depression.

Several studies have failed to find evidence of such depressive biases in implicit memory (Banos, Medina, & Pascual, 2001; Danion, Kauffmann-Muller, Grange, Zimmermann, & Greth, 1995; Denny & Hunt, 1992; Ilsley, Moffoot, & O'Carroll, 1995; Lim & Kim, 2005; Tarsia, Power, & Sanavio, 2003; Watkins, Mathews, Williamson, & Fuller, 1992). Some of these studies did find clear evidence of depressive biases in explicit memory within the same participants, suggesting that mood congruent memory is limited to explicit memory recall (Denny & Hunt, 1992; Lim & Kim, 2005; Watkins et al., 1992). More recently, however, evidence of depressive biases in implicit memory has been demonstrated on tasks including priming of lexical decision (by responding to the question: "is this a word or not?"), word stem completion, and anagram solving (Bradley, Mogg, & Williams, 1994, 1995; Rinck & Becker, 2005; Ruiz-Caballero & Gonzalez, 1994, 1997; Watkins et al., 1996).

As one explanation for these contradictory findings, some theorists have argued that depressive biases will only emerge if there is a match between the type of encoding strategy and the kind of implicit memory test used (Barry, Naus, & Rehm, 2004). They distinguish between conceptual processing, which requires processing of the semantic content or meaning of a word, and perceptual processing, which does not require awareness of a word's meaning. Conceptual processing would be considered "deeper" than perceptual processing. Barry and colleagues argue that a match is necessary so that the same processes (conceptual or perceptual) are activated at both encoding and retrieval, which is referred to as transfer-appropriate processing. Conceptual encoding includes tasks such as rating the pleasantness or self-descriptiveness of words. Conceptual tests of implicit memory

include tasks such as free association, when participants are asked to identify associates of cue words, and word recognition, in which participants are given a definition and asked to provide the corresponding word. Perceptual encoding strategies include tasks such as counting the number of letters in the word, and perceptual tests include tasks such as word stem completion. Barry and colleagues argue that implicit memory biases emerge in both perceptual and conceptual processes for depressed individuals, but only when the same kind of processing is activated at both encoding and retrieval.

However, some of the evidence for implicit memory biases on perceptually-driven tasks has come into question. Much of the evidence for perceptual effects has been found using lexical decision tasks, in which participants are asked to identify whether or not a string of letters is a word (Bradley et al., 1994, 1995). Because the semantic content of words has been shown to influence performance on lexical decision tasks (Neely, 1977), such tasks do not isolate perceptual memory processes. Philip Watkins (2002) has argued that implicit memory biases will emerge only in conceptually-driven processing, on tasks in which conceptual processing is required at both encoding and at test. Studies that have failed to find evidence of implicit memory biases have typically used either perceptually-driven encoding strategies (Lim & Kim, 2005) or perceptually-driven tests (Watkins et al., 1992; Denny, & Hunt, 1992). At least one study has found evidence of implicit memory bias in depression using both perceptually-driven encoding (counting the number of letters in the word) and a perceptual test (word stem completion), contradicting Watkins' claim (Ruiz-Caballero & Gonzalez, 1997). However, most of the studies that have found clear evidence of implicit memory biases have included both conceptual encoding and retrieval tasks (Rinck & Becker, 2005; Watkins et al., 1996, 2000).

Therefore, explicit memory in depression is marked by mood congruency, such that depressed individuals are more likely than nondepressed individuals to preferentially recall negative information. While early studies failed to find evidence of similar biases in implicit memory in depression, more recent research has offered evidence of such effects. This pattern of results contradicts Williams and colleagues' model, which predicted biases in explicit but not implicit memory. The majority of the evidence suggests that implicit memory biases are found in conceptual but not perceptual processing, offering preliminary support that depressive biases are more likely to occur at deeper levels of processing. Thus, depressive biases can occur without elaboration (on implicit memory tasks), but are limited to deeper levels of processing.

4.2. Attentional biases

Similar to the findings in implicit memory, evidence for attentional biases in depression has been mixed. While several studies have failed to find evidence of attentional biases in depression, more recent evidence suggests that such biases do emerge under certain circumstances. When evidence of attentional biases does emerge, it tends to be when stimuli are presented for relatively longer periods of time or in processes that involve disengagement of attention (Mogg & Bradley, 2005). The current evidence suggests that depressed individuals are not more likely to initially attend to such information, but may be more likely than nondepressed individuals either to dwell on negative information for longer periods of time, or to return their attention more frequently to such information. This pattern of results contradicts Williams et al. (1997) contention that depressive biases would not emerge on tests of attention, but is consistent with an expanded model that predicts depressive biases at deeper levels of processing.

4.2.1. Emotional Stroop/dot probe tasks

The emotional Stroop task is one of the most commonly used measures of attention to emotion associated with psychopathology. In the emotional version of the Stroop, emotional and neutral words are

presented in various colors, and individuals are asked to name the color in which the words are presented. Interference by the emotional content of the word is implied by longer RTs to name emotional than neutral words. The evidence for depressive biases in Stroop performance is equivocal. Several studies using the emotional Stroop have found that dysphoric or clinically depressed individuals take longer to name the color of depression-related words than neutral words or positive words (Dudley, O'Brian, Barnett, McGuckin, & Britton, 2002; Gotlib & Cane, 1987; Gotlib & McCann, 1984; Lim & Kim, 2005). However, several studies have failed to replicate this effect of Stroop interference in dysphoria and depression (Dalgleish et al., 2003; Grant & Beck, 2006; Gotlib, Kasch, et al., 2004; Hedlund & Rude, 1995; Hill & Knowles, 1991; Yovel & Mineka, 2004, 2005). The reliability of Stroop interference by negative words in depression is therefore unclear. However, the Stroop task has been criticized for collapsing multiple cognitive processes into a single variable (Algom et al., 2004; Gotlib, Kasch, et al., 2004). If depression is marked by biases only in deeper levels of processing, this could explain the mixed results.

Another cognitive task commonly used to investigate attention in depressed individuals is the dot probe. In dot probe tasks, two stimuli are presented on the screen for a short period of time (~14–1500 ms), the stimuli offset, and a dot appears in the location that one of the stimuli previously held. In the emotional version of the task, critical trials include one emotional stimulus and one neutral stimulus. The participant is asked to identify the location of the dot, and response time (RT) is measured. Shorter RTs when the dot appears in the previous location of the emotional stimulus, relative to when it replaces the neutral stimulus, indicate an attentional bias for emotion. If depressed individuals are negatively biased in their initial allocation of attention, one would expect to find effects even at very short stimulus presentation times. However, if depressed individuals do not initially attend to but tend to dwell on negative information, one might expect to find effects only at relatively long presentation times.

There is some evidence of attentional bias for depression-related words presented for relatively long durations (1000 ms or longer; Mogg & Bradley, 2005). Bradley, Mogg, and Lee (1997) found that self-report inventories of depressive symptoms correlated with attentional bias for negative words presented for 1000 ms, even after controlling for levels of trait anxiety. No relationship was found between depressive symptoms and bias for negative words presented for 500 ms or 14 ms. Similarly, Mogg, Bradley, and Williams (1995) found evidence of an attentional bias in depressed individuals for words presented for 1000 ms, but not for negative words presented for 14 ms. Using a shorter presentation time of 750 ms, Hill and Dutton (1989) found no evidence of attentional bias to self-esteem threatening words in depressed individuals.

Gotlib, Joormann, and colleagues have used a version of the dot probe with emotional faces presented for 1000 ms that has yielded consistent results. They found evidence of biases for sad faces in currently (Gotlib, Kasch, et al., 2004; Gotlib, Krasnoperova, et al., 2004) and formerly (Joormann & Gotlib, 2007) depressed adults, and in girls at high risk of developing depression (Joormann, Talbot, & Gotlib, 2007). These biases were specific to sad faces, with no evidence of selective attention for angry or happy faces (Gotlib, Kasch, et al., 2004; Gotlib, Krasnoperova, et al., 2004; Joormann & Gotlib, 2007; Joormann et al., 2007). In addition to greater attention to sad faces, there is some evidence that depression is associated with reduced attention to happy faces. Self-reported depressive symptoms correlate with avoidance of happy faces on dot probe tasks, e.g., longer RTs when the dot replaces a happy than a neutral face. This effect has been found at stimulus durations of 1250 ms (Bradley, Mogg, Falla, & Hamilton, 1998), and at the relatively short 500 ms (Bradley, Mogg, & Millar, 2000; Bradley et al., 1998).

Overall, biases on the dot probe tend to be found when the stimuli are presented for relatively long durations. In contrast to this pattern, a series of studies has failed to find an attentional bias for depression-

related words presented for 1500 ms. These studies have all been conducted with children and adolescents who are diagnosed with current major depression (Dalgleish et al., 2003; Neshat-Doost, Moradi, Taghavi, Yule, & Dalgleish, 2000), or mixed anxiety-depressive disorder (Taghavi, Neshat-Doost, Moradi, Yule, & Dalgleish, 1999). The developmental stage of these participants might be related to the different pattern of results found. Additionally, one study has failed to find evidence of attentional bias to sad faces presented for 1000 ms in depressed individuals (Mogg, Millar, & Bradley, 2000). However, in that study, the majority of depressed participants had comorbid GAD, which may have obscured the results. Overall, there is more robust evidence for depressive biases on the dot probe at longer, rather than shorter, stimulus presentation durations.

4.2.2. Other attention tasks

The pattern of results on the dot probe is consistent with the theory that depressive biases will emerge only at deeper levels of processing, in that attentional biases are more likely to emerge for longer presentation times. However, these tasks are limited in that they cannot distinguish between different subcomponents of attentional processing, including the initial orienting of attention, dwell of attention, and return of attention to particular stimulus (Weierich, Treat, & Hollingworth, 2008). One technique that can more precisely measure subcomponent processes of attention is eye movement tracking. With eye tracking, one can monitor the eye movements of participants as they view multiple stimuli and measure both fixations, or movements from one location to another, and glance durations, or the amount of time the eyes remain fixated on a particular location. Location of first fixation, and number of total fixations to a particular stimulus offer measures of orienting of attention, and glance duration offers a measure of attentional dwelling. Matthews and Antes (1992) presented pictures with happy and sad regions (e.g., a picture in which one child is smiling and another is crying). They found that dysphoric individuals fixated the sad regions of the pictures more frequently than nondysphoric individuals, but there were no differences between the groups in the location of the first fixation. Dysphoric and nondysphoric participants also made a similar number of fixations to the happy regions of the pictures and showed similar glance durations. Eizenman et al. (2003) assessed eye movements while viewing presentations of 4 different pictures, containing threatening, sad, neutral, and positive content, displayed on the screen at the same time. Depressed individuals displayed longer average glance duration for pictures with sad content than nondepressed individuals, but did not differ for any of the other three stimulus types, suggesting a tendency to dwell on sad pictures. Depressed and nondepressed individuals did not differ in fixation frequency for any of the stimulus types, suggesting no greater tendency to initially orient attention to or return attention more frequently to sad pictures. A more recent eye-tracking study replicated these results, finding that dysphoric individuals were more likely to maintain gaze on negative pictures than nondysphoric individuals, but showed no greater tendency to initially fixate negative pictures (Caseras et al., 2007).

Visual search tasks can also discriminate between initial allocation and dwell of attention. Visual search tasks involve the presentation of multiple stimuli, one of which is different from the rest. The task for the participant is to identify the discrepant stimulus as quickly as possible. When the participant is faster to identify discrepant stimuli (or targets) that are depression-relevant, this offers evidence of initial allocation of attention to sadness. When the participant is slower to identify a neutral target when the other stimuli are depression-relevant, this indicates a tendency to dwell on sad information (Weierich et al., 2008).

Depressed individuals are not faster to initially attend to sad information on such visual search tasks. Depressed and nondepressed individuals pick sad faces (Karparova, Kersting, & Suslow, 2005) and depression-relevant words (Rinck & Becker, 2005) out of neutral

backgrounds at similar rates. However, Suslow et al. (2004) found that depressed participants with comorbid anxiety were slower to find positive faces in neutral crowds than depressed participants without comorbid anxiety, or nondepressed controls. This could be explained by the anxiety symptoms of the comorbid group, or because they exhibited greater severity of depressive symptoms than either of the other two groups. There is some evidence that depressed individuals tend to dwell on negative information in the background. Rinck and Becker (2005) found that depressed individuals were slower than nondepressed individuals to identify neutral target words in backgrounds of depressive words, and that this effect was not found for social phobia-related or positive words. Karparova et al. (2005), however, found no differences between depressed and nondepressed individuals on their speed to detect positive faces out of a crowd of sad faces, suggesting no attentional dwell on sadness. Therefore, the limited evidence from these few studies is broadly consistent with the depth of processing hypothesis, in that attentional biases for sad information, when found, were found for attention dwell only.

Another task which can discriminate between initial allocation of attention and attentional dwell is the Posner cueing paradigm. The cueing paradigm distinguishes between two aspects of the covert allocation of attention, or attentional processes that occur without moving one's eyes. Specifically, the cueing paradigm can distinguish the engagement of attention to a stimulus, and disengagement of attention away from that stimulus. Fox, Russo, Bowles, and Dutton (2001) used a typical cueing paradigm to assess difficulty disengaging from emotional stimuli in anxious individuals. In the cueing task, a single stimulus (cue) is presented to the left or right of a fixation cross, the cue offsets, and a target appears in the same location as the cue (valid trials), or in the opposite location as the cue (invalid trials). Difficulty disengaging attention is given by the difference in RTs between invalid trials and valid trials for emotional compared to neutral cues. Koster, De Raedt, Goeleven, Franck, and Crombez (2005) used a similar cueing paradigm to assess disengagement from emotional words in dysphoric and nondysphoric individuals. They presented words for 250, 500, or 1500 ms, and examined participants' RTs to identify the location of a target that either appeared in the same location or different location from the cue stimulus. They found that dysphoric individuals were slower than nondysphorics to identify the location of a target following an invalid negative cue that was presented for 500 or 1500 ms, offering preliminary evidence of difficulty disengaging from sad stimuli in depressed individuals. Koster, Leyman, De Raedt, and Crombez (2006) failed to replicate this effect, but this study may have been underpowered to detect this effect because only seven participants scored in the clinical range on their inventory of depressive symptoms.

Therefore, depressed individuals tend to show preferential attention for sad stimuli at longer, but not shorter, presentation times on the dot probe task. The consistently null results at shorter presentation times of stimuli in these tasks suggest that depressed individuals are not more likely to allocate attention initially to negative stimuli (Mogg & Bradley, 2005, for a detailed discussion). This is consistent with evidence from visual search and eye-tracking studies, which show no tendency to identify sad targets more quickly or to initially fixate on a sad stimulus (Caseras et al., 2007; Eizenman et al., 2003; Karparova et al., 2005; Rinck & Becker, 2005). The findings at longer stimulus presentation times on the dot probe could be due to an increased likelihood to dwell on, or to return attention more frequently to, negative stimuli in depressed relative to nondepressed individuals. Another study offers preliminary evidence that depressed individuals have difficulty disengaging from a sad stimulus on a modified cueing task (Koster et al., 2005). Therefore, when attention biases are found, they tend to be at longer presentation times or in processes that involve the dwell of attention, rather than the initial allocation of attention. This pattern of results is consistent with the theory that depressive biases will emerge at deeper levels of processing.

4.3. Interpretation biases

There is wide literature suggesting that depressed and dysphoric individuals interpret ambiguous information more negatively than nondepressed individuals. One widely used measure of interpretation bias is the Cognitive Bias Questionnaire (CBQ, Krantz & Hammen, 1979). The Cognitive Bias Questionnaire presents potentially distressing anecdotes, and asks participants to choose one response indicating how they would react in that situation. Dysphoric and clinically depressed individuals are more likely to choose depressive-distorted reactions to these hypothetical situations, suggesting a more negative interpretation of the anecdote (Carver, Ganellen, & Behar-Mitrani, 1985; Haley, Fine, Marriage, Moretti, & Freeman, 1985; Krantz & Hammen, 1979; Miller & Norman, 1986).

Other researchers have investigated interpretation bias by comparing dysphoric individuals' evaluations of their own performance to the evaluations of independent observers. In such experiments, individuals are asked to participate in an experimentally controlled social interaction or performance task, and then to rate their own performance. Dysphorics agree more with negative feedback about their performance in social situations than nondysphorics (Cane & Gotlib, 1985). Similarly, depressed women rate videotaped social interactions as more negative than nondepressed women (Hoehn-Hyde, Schlottmann, & Rush, 1982). Individuals induced to experience negative mood also rate their social performance as more negative than individuals put in a happy mood (Forgas, Bower, & Krantz, 1984).

However, evidence described above all comes from self-report measures, which have a number of limitations. Specifically, self-report measures are subject to response bias and cannot distinguish between various subcomponent processes of interpretation. Response bias refers to the tendency to generate or endorse a certain type of response. Depressed individuals might not make negative interpretations, but rather be more likely to generate or choose negative responses. Either an interpretation bias or a response bias could explain the pattern of results found on self-report interpretation measures. Additionally, interpretation involves several different processes, including the activation of various explanations, the choice of a single explanation as most likely, and reporting this response. Similar to the attention literature, the most commonly used measures of interpretation cannot distinguish between these processes.

Lawson, MacLeod, and Hammond (2002) used a psychophysiological measure, which is unaffected by response biases, to examine interpretation biases in depressed and nondepressed individuals. Participants in this study were asked to imagine situations evoked by ambiguous words, and their interpretation was measured indirectly by their eyeblink responses to bursts of white noise. Neutral, negative, and ambiguous words were included in the study. Ambiguous words were created by altering the auditory signal, and could be resolved with either a negative or neutral interpretation (e.g., gloom/bloom). When eyeblink responses are similar to the ambiguous and to the negative words, this suggests a negative interpretation bias. In this study, depressed participants demonstrated similar eyeblink responses to ambiguous words and to negative words, whereas nondepressed individuals demonstrated similar eyeblink responses to ambiguous and neutral words, offering evidence of a negative interpretation bias associated with depression. Because participants did not have to generate or choose a response, these results cannot be explained by a response bias. However, this paradigm cannot distinguish between the activation and selection of interpretations. Because participants in this study were instructed to imagine situations associated with the words for a period of 8 seconds, several interpretations may have been activated before participants chose one to imagine. A bias in either the initial activation or the selection of interpretation could have led to the observed pattern of results.

Other studies have used measures which can more precisely isolate the activation of interpretations. In contrast to the robust evidence of

negative interpretation biases at later levels of processing, there is little evidence of such biases when the activation of interpretations is isolated. Such measures present ambiguous sentences which could have either a neutral or negative interpretation (e.g., "The doctor examined little Emily's growth"). Participants first read the ambiguous sentence then either a single word or second sentence that is related to the negative or neutral interpretation of the ambiguous sentence (e.g., "tumor" or "height"). Unrelated words/sentences are included as a control (e.g., "apple"). Priming is measured by comparing response times (RTs) for related and unrelated stimuli, with faster RTs for related stimuli indicating successful priming. Negative interpretation bias would be indicated by greater priming of negative than neutral words following ambiguous sentences in the depressed relative to the nondepressed group. Studies investigating the activation of interpretations in dysphoric (Lawson & MacLeod, 1999; Bisson & Sears, 2007) and clinically depressed (Mogg, Bradbury, & Bradley, 2006) individuals have found no evidence of negative interpretation bias compared to nondepressed individuals.[5] In fact, Lawson and MacLeod (1999) found the opposite pattern, with dysphoric individuals exhibiting greater priming for neutral than negative words. The results relating to interpretation activation may be limited because the stimuli used in these studies were not self-relevant. Given the robust evidence that negative self-views are an integral part of depression, interpretation biases might be expected to be limited to self-relevant content, in which case these tasks would not constitute an appropriate test of depressive interpretation biases.

Therefore, depression is marked by a negative interpretation bias, but only on measures which include later stages of processing. Measures which isolate the initial activation of various explanations have yet to find any evidence of interpretation bias associated with depression, but few studies have been conducted to date, and the studies that have been conducted have not utilized self-relevant stimuli. Therefore, depression is characterized by an interpretation bias at later stages of processing, and may or may not be characterized by a bias in the initial activation of interpretation, offering some evidence for the depth of processing model of depressive biases.

5. Conclusions

Studies of memory, attention, and to a lesser extent, interpretation, suggest that information processing in depression is marked by biases in deeper levels of processing (see Table 1 for a summary). The levels of processing affected by depression include, but are not limited to, the strategic elaboration of stimuli in memory. Therefore, Williams and colleagues' predictions that depressive biases would not emerge on tasks of attention or implicit memory have not born out, but the evidence is consistent with an expanded version of their model. Because self-referential encoding encourages this kind of elaboration, self-relevant stimuli may exacerbate depressive biases through this mechanism. Both the content, which is more negative for depressed and nondepressed individuals, and the process, which is the deeper level of processing most affected in depression, of self-referential thought might be expected to lead to negative biases in depression. In terms of both thought content and process, self-referential stimuli offer the most sensitive test of information processing biases in depression.

However, self-relevance of stimuli and depth of processing are often confounded in existing studies. Tests of deeper levels of

Table 1
Depth of processing and depressive cognition.

Process type/ stimuli	Process depth	
	Early processes	Later processes
Memory	Little evidence of perceptually-driven implicit memory biases.	Robust evidence of explicit memory biases in depression. Some evidence of conceptually-driven implicit memory biases in depression.
Self-referential stimuli used?	*Rarely*	*Often*
Attention	Little evidence for bias in initial allocation of attention.	Tendency to return to or to dwell on negative information in depression. More likely with longer presentation times.
Self-referential stimuli used?	*Rarely*	*Rarely*
Interpretation	No evidence of early activation of negative interpretations in depression.	Greater selection of negative interpretations in depression.
Self-referential stimuli used?	*None to date*	*Often*

processing, such as explicit memory, are more likely to use self-referential stimuli. Explicit memory tasks often use self-referential encoding of stimuli, and autobiographical memory is necessarily self-relevant. Tests of implicit memory and attention, however, often use single words or pictures of emotional faces, which are not inherently self-referential. In studies of interpretation bias, depth of processing and self-relevance are completely confounded because no studies investigating more automatic processing have utilized self-relevant stimuli. Given the current state of the literature, either the content (non-self-relevant) or the process (relatively shallow) could explain the lack of depressive biases in perceptually-driven implicit memory and activation of interpretations, and could explain the somewhat mixed state of the attention bias literature.

Despite limitations of this research, there are important implications for treatment research and development. More precise measures of attention, memory, and interpretation processes could be examined as possible mechanisms of change in cognitive therapy for depression, in addition to the self-report measures of cognitive change currently in use. Even more exciting are the possibilities for treatment development. To a certain extent, the self-relevance of cognitions is already incorporated into cognitive therapy. Of course, psychotherapy tends to focus on self-relevant topics. Additionally, when challenging automatic thoughts, cognitive therapists will often urge a client to consider what he would think if the same situation happened to a friend, with the rationale that we're easier on others than we are on ourselves (Greenberger & Padesky, 1995). However, cognitive therapy has yet to incorporate advances in basic research on depth of processing. As it is currently practiced, cognitive therapy for depression focuses primarily on interpretation, in the identification and challenging of automatic thoughts. Despite the robust evidence for mood congruent memory, aversive memories are not typically a focus in cognitive therapy, which explicitly focuses on the present (Beck, 1967). By incorporating research on the specific memory and attention processes affected in depression, we can begin to develop techniques which target these processes directly, to supplement cognitive restructuring of interpretations.

Therefore, self-referential processing is biased in depression, with self-reference effects in memory limited to negative stimuli in depressed individuals and limited to positive stimuli in nondepressed individuals. The negative self-reference effect could be due to negative associations with the self, because there is extensive evidence suggesting that depressed individuals hold more negative self-views than nondepressed individuals. The negative self-reference effect could also be due to the type of processing encouraged by self-

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[5] Mogg et al. (2006) included another task on which they did find evidence of negative interpretation biases. When asked to listen to homophones that could have either a negative or neutral interpretation (e.g., "die/dye"), depressed individuals were more likely to write down the negative version of the words than nondepressed individuals. However, homophone tasks cannot isolate the activation of interpretation because multiple interpretations could be activated before participants choose one to report. Therefore, a bias in either the activation or the selection of interpretations could lead to differential performance on this task. Additionally, the homophone task is subject to response biases because participants must generate their responses.

referential encoding, which is the kind of deep processing that is most consistently associated with negative information processing biases in depression. Early research identified the content of depressive thought as restricted to themes of loss and sadness, and further specified this content to be limited to self-relevant cognition. These tests offered evidence that depressive biases were exacerbated by self-relevance, but were limited in that they used self-report measures of cognition that could not identify the specific attention, memory, and interpretation processes affected in depression. Therefore, we do not know whether certain cognitive processes are more affected by the self-relevance of stimuli than others in depressed individuals.

More recently, researchers have adopted information processing tasks to begin to identify the specific cognitive processes in which depressive biases emerge. These tests have offered preliminary evidence that depressive biases emerge at deeper levels of processing. The evidence for depth of processing effects in depression is limited, however, by use of imprecise content, which is often not self-relevant. Because self-relevant stimuli offer the most sensitive test of cognitive biases in depression, shallower processes including the initial allocation of attention, perceptually-driven implicit memory, and the activation of interpretations should be tested with self-relevant stimuli before concluding that they are unbiased in depression. Interpretation activation is typically tested with ambiguous sentences that could be easily modified to be self-relevant by translating them from third into first person. Similarly, the verbal stimuli used in tasks assessing the initial allocation of attention and perceptually-driven implicit memory could be determined to be high or low in self-relevance by having participants make self-relevance ratings of the stimuli after completing the cognitive task. If depressive biases in these processes do not emerge despite the use of self-relevant stimuli, this would further strengthen the depth of processing argument. More generally, future research which manipulates both the self-relevance of stimuli and the depth of processing is necessary in order to clarify the contributing roles of thought content and process in depressive cognition.

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