THE TIME-COURSE OF INDUCED INTERPRETIVE BIASES IN HEALTHY INDIVIDUALS VARYING IN DEPRESSIVE SYMPTOMS

BY

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Abstract

Cognitive theories of depression posit that after a negative event or mood state, those vulnerable to the disorder automatically impose negative interpretations on ambiguous information. However, empirical research on depression-linked interpretive biases has yielded mixed results, likely due to flawed experimental paradigms and statistical techniques that do not adequately control for anxiety. Cognitive Bias Modification for Interpretation (CBM-I) is an innovative research paradigm that involves inducing interpretive biases in an experimentally controlled manner. The current study is the first to assess whether cognitive bias modification influences interpretation differently according to vulnerability to depression. Individuals scoring lower and higher on a depression inventory judged the relatedness of either neutrally valenced (e.g. *book-read*) or negatively valenced (e.g. *sick-vomit*) word-pairs. They then made judgements about homophone word-pairs, in which the first word could be interpreted as either neutral in meaning (e.g. *dye-ink*) or negative in meaning (e.g. *die-death*). At the later stages of processing all individuals, regardless of depression scores, resolved ambiguous word-pairs in a training-congruent manner, consistent with previous CBM-I studies. However, in the early stages of processing, those scoring higher, but not lower in the depression inventory, were uniquely receptive to negative context training, such that they were more likely to interpret ambiguous word-pairs in a negative as opposed to neutral manner. This finding is crucially important, as it helps to clarify theoretical debate in the literature.

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The Time-Course of Induced Interpretive Biases in Healthy Individuals Varying in Depressive Symptoms

You see your partner hugging an attractive stranger on the other side of the road – who do you suppose this person is? Life is full of scenarios that can be interpreted in different ways; yet without necessarily realising it we use cues to make sense of the world around us. Typically, healthy individuals interpret ambiguous information in a positive manner. For example, they might use context (it's the middle of the afternoon) and likelihood (their partner has always been faithful) to conclude that the attractive stranger is a long lost friend. However, our interpretation can be influenced by many factors, including our own emotional state, and may play a role in mood disorders.

Cognitive theories of depression suggest that following a negative event or mood state, some individuals are more likely to interpret ambiguous information in a negative manner, and that this negative bias plays a causal role in the onset of the disorder (e.g. Beck, 1976, 1987, 2008; Beck & Clark, 1988; Bower, 1981; DeRaedt & Coster, 2010; Pearsons & Miranda, 1992; Sheppard & Teasdale, 2004). However, empirical research on depression-linked interpretive biases has yielded mixed results (Bisson & Sears, 2007; Butler & Mathews, 1983; Dearing & Gotlib, 2009; Lawson & MacLeod, 1999; Lawson, MacLeod, & Hammond, 2002; Mogg, Bradbury, & Bradley, 2006; Sears, Bisson, & Neilson, 2010; Wenzlaff & Eisenburg, 2001). One reason for this inconsistency is that methodologies have not been driven by a theoretical understanding of how emotional ambiguity is processed in healthy individuals. The current study focuses on the nature of interpretive biases in healthy individuals, and relates this understanding to theories of depression. Several questions are explored. First, does prior access to negative information lead healthy individuals to interpret ambiguous information in a negative manner? Second, if so, are some individuals more sensitive to this manipulation than others? Lastly, what is the time-course of interpretive biases – do they reflect a rapid onset of activation of related concepts, or a slower, more controlled selection process?

Depression and Information Processing Biases

Depression is the most common psychiatric disorder in the world, estimated to affect around 121 million people (World Health Organization [WHO], 2011a). Individuals with Major Depressive Disorder (MDD) are affected by a constellation of cognitive, behavioural and emotional symptoms, including a pervasive negative mood, feelings of worthlessness and guilt, and loss of interest and pleasure in everyday activities. Individuals with MDD also experience changes in appetite and sleep patterns, suffer from fatigue, have little or no energy, and may exhibit psychomotor agitation (American Psychiatric Association [DSM-IV-TR], 2000). Of serious concern, depression is a major risk factor for suicide, which is one of the three leading causes of death, across the world, in individuals aged 15-44 (WHO, 2011b). Despite several treatment options, there is a high rate of relapse (Judd, 1997); in fact, depression is predicted to be the second leading contributor to the global burden of disease by the year 2020 (Murray & Lopez, 1996; WHO, 2011a). For these reasons, research in the area of depression is imperative. Several cognitive theories of depression exist; one of the most influential comes from Aaron Beck.

Beck's (1976) original cognitive theory stated that individuals who experience early childhood loss, failures, or rejections may develop dysfunctional belief systems. After a negative event or mood state, these individuals activate negative schema about the self, world, and future, which result in automatic and persistent information processing biases that can ultimately lead to depression. For example, imagine your partner breaks up with you. An individual with dysfunctional belief systems may activate maladaptive schemas such as, *I am not worthy of my partner, I will never be good enough for anyone, and my future is doomed*. These negative schemas might lead the individual to attend to negative information in the environment, show enhanced memory for negative events, and interpret ambiguous situations in a negative manner, which eventually results in depressive symptoms. Recent modifications to Beck's theory (e.g., Beck, 2008) acknowledge that vulnerability to depression does not simply arise from dysfunctional belief systems, but rather can involve an interaction between genetic (e.g. short variant of the serotonin transporter gene), neurochemical (e.g. hypersensitive amygdala), and cognitive factors (e.g. information processing biases).

In order to test key assumptions of cognitive theories, researchers have focused on the associations between depression and negative information processing biases, specifically in the domain of attention, memory, and interpretation (for a review see Gotlib & Joormann, 2010). Thus far, a negative attentional bias, that is, selectively attending to negative information, has been associated with clinical depression (Gotlib, Krasnopervoa, Yue, & Joormann, 2004) and dysphoria[1] (Koster, De Raedt, Leyman, & De Lissnyder, 2010). Negative attentional biases have also been reported in individuals vulnerable to depression (i.e. daughters of depressed mothers; Joormann, Talbot, & Gotlib, 2007) and individuals remitted from depression (Joormann & Gotlib, 2007), but only after they have been induced into a negative mood. Similarly, a negative memory bias, that is, enhanced memory for negative events, has been associated with clinical depression (Bradley, Mogg, & Williams, 1995; Gilboa-Schechtman, Erhard-Weiss, & Jeczemien, 2002; Ridout, Astell, Reid, Glen, & O'Carroll, 2003), dysphoria (Denny & Hunt, 1992, Ridout, Noreen, & Johal, 2009), and healthy individuals induced into a negative mood (Ridout et al., 2009). However, the association between negative interpretive biases (consistently resolving ambiguous information in a negative manner) and depression remains inconclusive.

Several problems arise when testing for depression-linked interpretive biases. First, is designing an appropriate task. Just because an individual consistently selects negative meanings of ambiguous information, does not necessarily mean they possess a negative interpretive bias. Rather, they could process all possible meanings, but have a greater tendency to report negative meanings (negative reporting bias). Researchers who test interpretive biases in mood disorders tend to use self-report, homophone-spelling, text comprehension, and semantic priming tasks. Each of these tasks has advantages and disadvantages, which will be extensively discussed. A second problem, that arises when testing for depression-linked interpretation biases, is accounting for anxiety (a problem in all depression specific studies; for a discussion see Beuke, Fischer, & McDowall, 2003). Depression and anxiety are highly co-morbid (Rapaport, 2001). That is, those who exhibit depressive symptoms are also highly likely to exhibit anxiety symptoms. The field of anxiety-linked interpretive biases is well established. Those with high levels of anxiety have consistently been shown to have a negative-interpretive bias, often specific to threat (e.g. Byrne & Eysenck, 1993; Calvo & Castillo, 1997; Hadwin, Frost, French, & Richards, 1997; MacLeod & Cohen, 1993; Mathews, Richards, & Eysenck, 1989; Richards & French, 1992; Russo, Patterson, Roberson, & Stevenson 1996). Therefore, if depression

[1] The term dysphoria is used to refer to non-diagnosed negative affect. For example, an individual who scores in the clinical range on a depression questionnaire would be referred to as dysphoric. Whereas an individuals who scores in the clinical range on a depression questionnaire *and* had been diagnosed with MDD by a clinician, would be referred to as depressed.

levels are measured but anxiety is not taken into consideration, there is no way of knowing whether interpretive biases obtained are due to depression, anxiety, or both.

Tasks Used to Assess Interpretive Biases in Depression

Self-report tasks.

The first studies to test for depression-linked interpretive biases tended to measure interpretation through self-report. Specifically, participants read ambiguous scenarios, and made subjective decisions in regard to which interpretations they believed were likely. One classic study of this type comes from Butler and Mathews (1983). Groups of anxious, depressed and control participants were presented with descriptions of ambiguous situations. For example, *you wake up with a startle in the middle of the night, thinking you heard a noise, but all is quiet*. They were then presented with an open ended question (e.g. *what do you think woke you up*) followed by three possible explanations. One of these explanations always included a threatening interpretation (e.g. *it could be a burglar*). Participants were required to rank the three possible explanations in order of likelihood. Butler and Mathews found that both anxious and depressed participants were more likely than controls to select the threatening interpretation of the ambiguous scenarios. The authors inferred that this was evidence of a negative interpretive bias. Self-report tasks, however, have been extensively criticized, as it is impossible to determine whether negative biases are actually interpretive or responsive (MacLeod & Mathews, 1991; Mogg, Bradley, Miller, & Potts, 1994). Responses are valenced, and participants are presented with all alternatives and given plenty of time to choose which one they prefer. They could, for example initially interpret the ambiguous scenario in a neutral or positive manner, but when shown all possibilities, choose to select the negative interpretation.

Homophone spelling tasks.

Another task used to assess interpretive biases in depression is the homophone spelling task. Words that are pronounced the same, but differ in semantic meaning and spelling are referred to as homophones; for example *carrot/carat*. In homophone spelling tasks, researchers typically select homophones that have an emotional meaning and a neutral meaning; for example *dye/die* (neutral & emotionally negative) and *piece/peace* (neutral & emotionally positive). In the task itself, participants hear the homophone, and after a delay, are asked to write down the word they heard. Responses are coded as neutral (neutral spelling) or emotional (emotional spelling). Homophone spelling tasks have been extensively tested in the field of anxiety, and have revealed consistent results. Negative biases have been associated with clinical anxiety (Mathews et al., 1989) and self-reported trait anxiety (Byrne & Eysenck, 1993; Hadwin et al., 1997; Richards & French 1992; Russo et al., 1996). Further, Barazzone and Davey (2009) have reported mood congruent effects after angry, anxious, happy, and neutral mood inductions. For example, those induced into an angry or anxious mood were more likely to interpret homophones in a negative manner. Notably, using a homophone spelling task, Blanchette and Richards (2003) have reported that when contextual cues become available to individuals (e.g. they see the word *death* before they hear the word *dye/die*), mood-congruent effects dissipate.

Only a handful of studies have used the homophone spelling task to test for depression-linked interpretive biases. Wenzlaff and Eisenburg (2001) modified the task in a group of non-dysphoric, previously dysphoric, and chronically dysphoric individuals. Neutral/negative and neutral/positive homophones were presented, for example *morning/mourning* and *suite/sweet*. Individuals were required to write down the word they heard. However, the authors attempted to control the time in which they had to respond. There were two conditions: immediate and delayed. In immediate trials, individuals were instructed to write down the word they heard as quickly as possible (words were presented every three seconds). In delayed trials, individuals were given more time to write down the word they heard (words were presented every thirteen seconds). Wenzlaff and Eisenberg reported that non-dsyphoric individuals exhibited a positive interpretive bias in both immediate and delayed conditions (i.e. less likely to write down negative, and more likely to write down positive meanings of homophones). In contrast, chronically dysphoric individuals exhibited a negative interpretive bias in both immediate and delayed conditions (i.e. more likely to write down negative, and less likely to write down positive meanings of homophones). Of particular interest were the results demonstrated by previously dysphoric individuals. In the immediate condition, they responded in a similar manner to chronically dysphoric individuals, whereas in the delayed condition they responded in a similar manner to non-dysphoric individuals. The authors inferred that previously depressed individuals do not lose the negative cognitions associated with their prior depressive episode; rather, they become better at controlling them. This finding is supportive of cognitive theories of depression that state that negative processing biases are persistent, and automatically activated in those vulnerable to the disorder (i.e. those who have previously suffered from an episode).

Using the homophone spelling task, Mogg et al. (2006) also reported a negative bias in clinically depressed individuals. That is, clinically depressed individuals were more likely to write down the negatively emotional as opposed to the neutral spelling of homophones (e.g. *die* as opposed to *dye*). Importantly, this negative bias remained when individuals with co morbid depression and anxiety were removed from the analyses. The authors pointed out that this result was consistent with previous studies inferring negative information processing biases in depression. However, as they failed to obtain similar results using a different task (discussed below), they suggested that the results from the homophone spelling task could be due to a reporting bias.

The homophone spelling task has been extensively criticised for its susceptibility to demand effects (MacLeod, 1990). Along with self report tasks, there is no way of determining the nature of obtained biases. In other words, there is no way of knowing whether an individual actually activates emotionally negative as opposed to neutral spellings first (interpretive bias), or whether they are simply more likely to write down emotionally negative as opposed to neutral spellings (response bias). In fact, Mogg et al., (1994) found some support for the hypothesis that during the second half of the homophone spelling task, individuals become increasingly aware that they are hearing words with two meanings, and adopt response strategies in order to try and present themselves in a more favourable way, or in a way consistent with experimenter expectations. The findings from Wenzlaff and Eisenberg (2001) also support this hypothesis (when given more time to respond, previously dysphoric individuals showed a conscious change in strategy).

Text comprehension tasks.

Another task used to assess interpretive biases in emotional disorders is the text comprehension task. In these tasks, participants are typically required to read an emotionally ambiguous sentence aloud, followed by a continuation sentence that is related to the neutral or negative meaning of the ambiguous sentence. The time taken to read the continuation sentence is used as the dependent measure. If, for example, participants are faster to read negative compared to neutral conclusions of ambiguous sentences, then negative interpretations are implied. This task was initially designed by anxiety researchers, and has been associated with anxiety-linked interpretive biases (e.g. MacLeod & Cohen, 1993).

In a slightly different variation to the original text comprehension task, Dearing and Gotlib (2009) tested cognitive theories of depression by examining whether negative interpretive biases were evident in those at risk for depression. They recruited daughters of depressed mothers (high risk group) and daughters of never depressed mothers (low risk group). As cognitive models of depression postulate that negative schemas are triggered by negative moods or events, participants were first induced into a negative mood. In their text comprehension task, participants read ambiguous stories about themselves. For example:

> *In PE, your teacher informs the class that she is starting a softball tournament. Your teacher picks four team captains and tells them to take turns picking teammates. You are certain that you will be picked _______.*

They were then shown a positive or negative probe word. For example, *first* (positive ending) or *last* (negative ending). Participants had to decide whether the probe word "fit" the story. Dearing and Gotlib found that daughters of depressed mothers were faster to respond to negative probes than daughters of never depressed mothers. No differences were found with positive probes. Thus, Dearing and Gotlib provided evidence in favour of a negative interpretive bias in those vulnerable to depression. Furthermore, supportive of cognitive theories of depression, this negative interpretive bias only emerged when negative schema were first activated (i.e. through negative mood induction).

Along with using the homophone spelling task (previously discussed), Mogg et al. (2006) also used a modified version of the text comprehension task to test for depression-linked interpretive biases. Participants were non-depressed and clinically-depressed individuals. Participants were first presented with an ambiguous, depressive or non-depressive cue. They were then required to read an ambiguous sentence, followed by a continuation sentence. For example, participants would see either *?????* (ambiguous cue), *death* (depressive cue), or *marriage* (non-depressive cue). They were then required to read the sentence *Carol cried throughout the service*, followed by either *funerals always made her cry* (depressive meaning) or *weddings always made her cry* (non-depressive meaning). The authors predicted that clinically depressed participants would be faster to read continuations preceded by the ambiguous and depressive cue conditions, compared to the non-depressive cue condition. However, their results told a different story. The authors reported that clinically depressed and non-depressed participants were faster to read continuation sentences preceded by ambiguous and non-depressive cue conditions, compared to the depressive-cue condition. Thus, no evidence in favour of a depression-linked interpretive bias was found. In fact, depressed individuals exhibited a non-depressed interpretive bias. However, it is possible that the text comprehension task used was not sensitive to depression-related interpretive biases because it relied heavily on statements about others (e.g., *Carol cried*). Depression has been linked with self-referential biases (e.g. Hertel & El-Messidi, 2006; Smallwood, 2004). That is, depressed individuals are particularly sensitive to information about themselves. Perhaps changing the sentences to include “I” and “me” statements would have allowed depression-related biases to emerge (as in Dearing & Gotlib, 2009). For example, *I cried throughout the service*.

Semantic priming tasks.

In semantic priming paradigms, participants are presented with an ambiguous prime word or sentence. After a delay, they are then presented with a target word and / or non-word. The target word is either related to the prime (usually in a neutral or an emotionally negative / positive manner), or unrelated to the prime. Participants are typically required to (a) make a lexical decision judgement (decide whether the target is a word or non-word), (b) make a relatedness judgement (decide whether the prime and target are related or unrelated), or (c) read the target word aloud. Typically, participants are faster at responding to targets related to the prime than to targets unrelated to the prime. This is referred to as priming. Researchers studying emotional ambiguity are interested in individuals’ differences for priming of neutrally valenced words versus priming of negatively valenced words. Anxiety-linked interpretive biases have been extensively reported in semantic priming tasks (e.g. Calvo & Castillo, 1997; Calvo, Eysenck, & Castillo, 1997; MacLeod, 1990; Richards & French, 1992), but studies in depression remain rare.

Lawson and MacLeod (1999) were the first to test for a depression-linked interpretive bias using a semantic priming task. As cognitive theories of depression posit that negative schema only become active after a negative event or mood state, participants were low and high in depressive symptoms, but also induced into a positive or dysphoric mood. Participants were required to read aloud ambiguous sentences (e.g. *the doctor examined little Emma’s growth*). They then had to read a target word aloud that was either related to the neutral interpretation (e.g. *height*), or the negative interpretation (e.g. *tumour*). Response latencies were measured, and used as the dependent variable. Lawson and MacLeod reported no effects with their dysphoric and positive mood induction. However, they did report that those high in depressive symptoms exhibited priming for neutral interpretations of ambiguous sentences, whereas those in low in depressive symptoms exhibited priming for negative interpretations of ambiguous sentences. This, of course, was unexpected, and argued against their hypothesis.

There is, however, an alternative explanation for Lawson and MacLeod's (1999) counterintuitive findings. The authors selected individuals who scored in the top and bottom third of a depression scale, but in the middle third of an anxiety scale. Although at face value, this appears to be a reasonable way to control for anxiety, as discussed by Beuke et al. (2003) it comes with major concerns. The depression and anxiety scales administered both share properties of general negative affect (see Clark & Watson, 1991). The anxiety scale also shares properties associated with depression (Bieling, Antony, & Swinson 1998). Thus, the mood of an individual scoring in the middle range on their anxiety scale could actually take two different forms. Firstly: low negative affect + low depression + high anxiety. Secondly: high negative affect + high depression + low anxiety. So, in selecting two groups that scored similarly on their anxiety scale, Lawson and MacLeod may have constructed two groups that ironically differed in levels of *pure* anxiety. The fact that their two groups might have consisted of those high in depression and low in pure anxiety and low in depression and high in pure anxiety, actually provides a reasonable explanation of their results: the interpretive biases observed could have been driven by anxiety. Thus, Lawson and MacLeod's (1999, pp. 472) interpretation, specifically that they provided "*rather strong evidence for quite the reverse pattern of depression-linked interpretive bias*" is tentative at best.

Blink-reflex tasks.

In a later study Lawson et al. (2002) further assessed interpretive biases in those low and high in depression using a more sensitive task. Specifically, the blink reflex was used as their dependent measure (i.e. participants were startled with white noise, and the magnitude of their blink reflex was recorded). Large blink reflexes are associated with negatively valenced information, and small blink reflexes with neutrally valenced information. If an ambiguous stimulus is presented and associated with a large blink reflex, one can assume the negative as opposed to neutral interpretation was selected. Participants low and high in depressive symptoms heard neutral (e.g. *dress*), negative (e.g. *stress*) and ambiguous (e.g. an acoustic blend of *dress* & *stress,* in which the distinguishing phoneme was adjusted e.g. **ress*) words. They were required to imagine a situation evoked by the word, and were then startled with white noise after which their blink reflex was measured. Lawson et al. found that blink reflexes for ambiguous words in those high in depressive symptoms, were larger when compared to neutral words, but no different when compared to negative words. The opposite was found for those low in depressive symptoms. Blink reflexes were smaller when compared to negative words, but no different when compared to neutral words. Results combined suggested that those high in depressive symptoms interpreted ambiguous stimuli in a negative manner, and those low in depressive symptoms in a neutral manner. Lawson et al. were the first to show a depression-linked interpretive bias, using a methodology that did not rely on self report or homophone spelling tasks. Their results can also be uniquely attributed to depression, as the authors adequately controlled for anxiety. Specifically, anxiety was used as a covariate in all analyses. The authors also performed an additional statistical control in which they compared high and low anxious individuals using depression as a covariate. Under these conditions, no group effects were observed.

Time-Course of Interpretive Biases

An important factor to consider in tasks that assess interpretive biases through priming is the actual mechanism that gives rise to priming. Priming can be a result of initial automatic activation (e.g. through spreading of activation among related constructs; automatic processing), or as a result of controlled processes (e.g. participants generate a set of related constructs in anticipation of the target; controlled processing). The most common way to distinguish between automatic and controlled processing is to manipulate the time between the onset of the prime and the onset of the target. This is referred to as stimulus onset asynchrony (SOA). If priming effects are observed at short SOAs (typically less than 500ms), priming is attributed to automatic processes; however, if priming effects are observed at long SOAs (typically greater than 700ms), priming is attributed to controlled processes. Notably, there is debate in the word recognition literature in regard to the specific time that differentiates automatic from controlled processes (see Kutas & Federmeier, 2011). For this reason, the phrases *early stages of processing* (inclusive of automatic processes) versus *late stages of processing* (inclusive of controlled processes) will now be used, as they are more encompassing, and not tied to a specific theory.

The time course of priming in non-emotional ambiguity has been extensively studied (e.g Simpson, 1984; Simpson & Burgess, 1985; Simpson & Kang, 1994; Simpson & Krueger, 1991; Swinney, 1979). It appears that in the early stages of processing (typically less than 500ms) both meanings of an ambiguous word are primed, reflecting initial activation of all possible meanings. However at the later stages of processing (typically greater than 700ms) one is primed, while the other is inhibited. Context plays a vital role in disambiguating ambiguous information (see Gaskell & Marslen-Wilson, 2001). Nevertheless, there is still debate in the literature about whether context effects occur before (early) word identification or after (late). This being said, Lucas (1999) carried out a meta-analysis in which the early effects of context on lexical access were examined. Results suggested that contextually appropriate meanings are at least activated to a greater extent than contextually inappropriate meanings at early processing stages.

Using high- and low-trait anxious individuals, Richards and French (1992) were the first to examine the time course of interpretive biases in emotional ambiguity. They used a semantic priming paradigm with a lexical decision task. Emotional homographs were visually presented as primes (e.g. *arms*). After delays of 500ms, 750ms or 1200ms, target words or non-words were presented. Target words were either related to the non-threatening meaning of the prime (e.g. *legs)*, related to the threatening meaning of the prime (e.g. *weapons*) or unrelated to the prime. At the 500ms SOA, both high- and low-trait anxious individuals primed both threat and non-threat meanings. At the 700ms SOA, high-trait anxious individuals primed threat but not non-threat meanings, whereas no effects were observed with low- trait anxious individuals. At the 1200ms SOA, high-trait anxious individuals primed threat meanings and inhibited non-threat meanings, with the reverse pattern evident for low-trait anxious individuals. The results of Richards and French suggest that during the early stages of processing, threat and non-threat meanings are equally available to high- and low-trait anxious individuals. However, during the later stages of processing, high-trait anxious individuals allocate more resources to threatening meanings and low-trait anxious individuals allocate more resources to non-threat meanings. Using a text comprehension task, Calvo and collegues (Calvo & Castillo, 1997; Calvo, et al.,1997) also found that anxiety-linked interpretive biases were a result of late as opposed to early processes. Results from depression studies, however, tell a different story.

Bisson and Sears (2007) examined the time course of interpretive biases in depression. To assess interpretive bias, they used a cross-modal semantic priming task. Specifically, participants heard an ambiguous sentence, saw a target word or non-word, and made a lexical decision judgement. The target word was either related or unrelated to the ambiguous prime sentence. If related, it was related in a neutral, negative or positive manner. For example, participants would hear *Joan was stunned by her final exam results*, and see, *grades* (neutral related), *distress* (negative related) or *success* (positively related). In order to differentiate between early and late processes, the time between the offset of the prime sentence and the onset of the target was manipulated. This is referred to as inter stimulus interval (ISI). They found that those high and low in depression were equally likely to prime positive and negative interpretations of ambiguous sentences. Furthermore, this effect remained at the 0ms ISI (intended to tap into early processes) and the 1000ms and 2000ms ISIs (intended to tap into late processes). Bisson and Sears suggested that negative schema might have to be activated in those high in depression before a negative interpretive bias became apparent, as asserted by cognitive theories on the disorder. In order to explore this possibility they carried out a further experiment in which a negative mood was induced in both their low and high depression groups. Although the negative mood induction procedure appeared to be effective, results were similar to those of their previous experiments.

Bisson and Sears (2007) acknowledged that the lack of interpretative bias observed with their high-depressed group was consistent with Lawson and MacLeod's (1999) findings, and combined cast doubt on the robustness of the typically hypothesized effect (i.e. that depression is associated with a negative interpretive bias). However, as with Lawson and MacLeod (1999), there are some serious concerns with their results. Bisson and Sears made no mention of controlling for anxiety, and in fact, did not even administer an anxiety scale to their participants. Additionally, Bisson and Sears offered no explanation of the lack of priming differences observed during the early versus later stages of processing. For example, one would at least expect that individuals low in depression and induced into a positive mood would be more inclined to exhibit a positive bias at the later stages of processing (e.g. see Hirsch & Mathews, 1997). One explanation is that their task was not sensitive enough to pick up on priming differences during the early versus later stages of processing. Consider two of their ambiguous prime sentences: (a) *Jason's* *classmates laughed as he made his presentation* (b) *Carol cried throughout the service*. In each case, there is a target word that turns the sentence into an ambiguous statement. In the first sentence, *laughed* could refer to cheering or mocking. In the second sentence *service* could refer to marriage or funeral. Importantly, these words are presented at different points within the sentences. Nonetheless, target words were presented at specific ISI's (after the end of the sentence) with the expectation that they would differentially tap into the early versus later stages of processing. However, the type of processing tapped into will have depended on when the ambiguity within the sentence was presented. In fact, by varying the placement of target words in the ambiguous statements, the ISIs reported by Bisson and Sears are much longer than reported and therefore essentially meaningless. The only possible interpretation of their data is that, given sufficient time, individuals both high and low in depression can activate both positive and negative interpretations of ambiguous sentences.

In a follow up study, Sears et al. (2010) assessed interpretive biases in dysphoric and non-dysphoric individuals, using a relatedness judgement task. A relatedness judgement was chosen as they suggested that lexical decision tasks are perhaps not sensitive enough to detect interpretive biases in depression (because lexical decision responses are not necessarily related to participants' interpretation of ambiguity). Individuals listened to ambiguous prime sentences that were self referent in nature. For example *my boyfriend said that I am unlike his past girlfriends.* They then saw visually related and unrelated targets, and were required to make a yes or no response (yes – related; no – unrelated). Visual targets were either related to the negative (e.g. *jealous*), positive (e.g. *attractive*), or neutral (e.g. *relationship*) interpretation of the prime sentence. Like their previous study, Sears et al. manipulated the ISI (0ms or 1000ms). However in this study the manipulation was within subjects, with the reasoning that it would control for anticipatory responses. Sears et al. predicted that dysphoric individuals would be faster to respond to negative than to positive or neutral targets, thus implying they would be more likely to immediately impose negative as opposed to positive or neutral meanings on ambiguous sentences.

Sears et al's (2010) hypothesis was not supported. However, they did find significant effects in their accuracy data. According to Signal Detection Theory (MacMillan & Creelman, 2005), responses in tasks that require a relatedness judgement can be coded in four ways: as a hit (responding related to a related target), miss (responding unrelated to a related target), false alarm (responding related to an unrelated target), or correct rejection (responding unrelated to an unrelated target). The authors found no differences in false alarm or correct rejection rates between dysphoric and non-dysphoric individuals. They did, however, report that dysphoric individuals were less likely to miss negative targets and more likely to miss positive targets than non-dysphoric individuals. Sears et al. thus inferred that dysphoric individuals were more likely to ‘immediately’ impose negative as opposed to positive interpretations on the ambiguous sentences.

There are, however, several concerns with Sears et al.’s (2010) study. Firstly, their results were not fully analyzed according to Signal Detection Theory. Typically in signal detection tasks, hit and false alarm rates are transformed into measures of sensitivity and criterion (MacMillan & Creelman, 2005). Sensitivity (d’) can produce a measure of an individual’s ability to discriminate between related and unrelated prime-target pairs, and criterion (c) can measure whether individuals are more likely to respond “related” or “unrelated” when they are uncertain about prime-target pairs. Thus, Sears et al. should have obtained negative, positive and neutral sensitivity values as opposed to just looking at miss rates, as these would have provided measures of interpretive bias independent of response bias. Secondly, as with their previous study, Sears et al. manipulated ISI with prime sentences which in itself causes an array of issues (previously discussed). Furthermore, they reported no interactions involving ISI in their accuracy data, thus their miss rates were averaged across 0ms and 1000ms conditions. Sears et al. suggest that their task was assessing ‘immediate’ interpretations of ambiguous sentences (i.e. the early stages of processing); however, given the constraints of their task any claims about the time course of the interpretive biases obtained are unfounded. Thirdly, as with their previous study, Sears et al. failed to assess individuals’ anxiety levels, let alone attempt to control for them. For this reason, it cannot be concluded that the negative interpretive biases observed were linked with dysphoria. Despite these concerns, Sears et al’s findings were still informative to the field by verifying the use of relatedness judgement tasks in the assessment of depression-linked interpretive biases.

Cognitive Bias Modification for Interpretation (CBM-I)

As illustrated, although research on anxiety-linked interpretive biases is plentiful, studies on depression-linked interpretive biases are lagging behind. An innovative area in the anxiety field involves inducing interpretive biases in healthy individuals in an experimentally controlled manner. Why? Because in order to understand the cognitive mechanisms involved in the development and maintenance of anxiety-linked interpretive biases, one must first understand the processes involved in healthy individuals. Of course, the same principle applies to depression-linked interpretive biases. Over a series of four experiments Grey and Mathews (2000) investigated whether they could experimentally manipulate the way in which healthy individuals' interpreted ambiguous information through *training*. Training, now commonly known as Cognitive Bias Modification for Interpretation (CBM-I), is defined as "*controlled exposure to circumstances that lead to a systematic change*" (Grey & Mathews, 2000, pp. 1145). Specifically, Grey and Mathews wanted to see whether forcing participants to resolve ambiguous information in either a threatening or non-threatening manner would subsequently influence the way in which they resolved ambiguous information at the later stages of processing.

Grey and Mathews' (2000) first experiment consisted of two phases: a training phase and a test phase. Half of participants were trained to interpret ambiguous words in a non-threatening way, and half in a threatening way. Training involved solving related word fragments of ambiguous words. For example, the homograph *beat* would be shown on the computer screen. After a 750ms SOA (tapping into the later stages of processing) this was followed by either r_yt_m (*rhythm*; non-threat condition) or p_li_e (*police*; threat condition). Participants were required to generate the missing letters. In the test phase, the training contingency previously used was eliminated. Every participant was presented with threat and non-threat word fragment solutions to *old* and *new* homographs. Results showed that training with non-threat meanings only produced faster reaction times to non-threat fragments of old homographs. In contrast, training with threat meanings produced faster reaction times to threat fragments for both old and new homographs. In other words, when enough time was given for controlled processes to emerge, threat training produced a threat-induced interpretive bias (i.e. the training generalised to new homographs), but the same was not true of non-threat training (i.e. the training did not generalise to new homographs). The later finding is perhaps not surprising as "non-threat" is a less salient and cohesive emotional category than "threat".

Grey and Mathews (2000) suggested that in order to induce interpretive biases, it is possible that training needs to involve the active generation of valenced meanings. That is, it might require individuals to actively select one meaning over another (*active training*). In order to test this hypothesis, they carried out a further experiment. This time their training phase required participants to simply verify the association between two valenced words (*passive training*). They were first shown an associate of a homograph, for example, *water* (non-threat condition) or *break* (threat condition). They were then shown the homograph itself, in this case, *drop*. They were required to make a relatedness judgement (decide whether the two words were related or unrelated). Unlike the training phase in their previous experiment, the associate of the homograph was shown first in the hope that participants would be less likely to access alternative meanings of the homograph itself (i.e. active generation of one interpretation over another was not required). The test phase consisted of a lexical decision task (from Richards & French, 1992), with an SOA of 750ms (tapping into the later stages of processing). Results showed that participants who trained with threat meanings were faster to respond to old and new threat targets than old and new non-threat targets. This time the reverse effect was also evident for those who trained with non-threat meanings. These findings suggested that in order to induce an interpretive bias at the later stages of processing, generation of appropriately valenced words was not required.

Grey and Mathews (2000) were the first to show that negative interpretive biases could be induced in healthy individuals by repeated exposure to emotionally valenced meanings of ambiguous words. In other words, they showed that interpretive biases were not invariant, and could be modified by means other than altering mood state. Using CBM-I, negative interpretive biases have also been trained in recognition memory tasks with passages of ambiguous text (Mathews & Mackintosh, 2000a; Salemink, van den Hout, & Kindt, 2010). These findings have been extended to show that induced interpretive biases are durable across delays, ranging from 20 minutes to 24 hours (Yiend, Mackintosh & Mathews, 2005) and are able to withstand changes in environmental contexts, for example transferring to different rooms, with different experimenters, and having material presented in different sensory modalities (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006). Additionally, in the most recent CBM-I study, Hoppitt, Matthews, Yiend, and Mackintosh (2010a) have shown that individuals need not train with ambiguous information in order to modify subsequent interpretation. Specifically, in one of their passive threat training conditions, participants saw negatively valent unambiguous words (e.g. *cancer*), and then completed threatening unambiguous word fragments (e.g. *tumour*). This method of training still led to training-congruent biases at the later stages of processing in a subsequent interpretation task.

Current Study

As previously mentioned, CBM-I originated from the anxiety field. In fact, no studies to date have assessed whether cognitive bias modification influences interpretation differently according to vulnerability to depression. In addition, although induced interpretive biases in CBM-I tasks have been detected at the later stages of processing (when enough time is given for controlled processes to emerge), it is unknown as to whether they are identifiable at the early stages of processing (as a result of automatic activation of related concepts). Thus, the current study aims to answer two questions. Firstly, do induced negative interpretive biases differ for those lower and higher in depressive symptoms? And secondly, are induced interpretive biases a result of early or later processes? Cognitive theories of depression posit that after negative schemas become active, those vulnerable to the disorder automatically active negative interpretations of ambiguous information. For this reason, compared to those scoring lower, those scoring higher on a depression scale might be uniquely receptive to negative context training during the early stages of processing. In order to address these questions a novel methodology was required.

A cross-modal priming paradigm with a relatedness judgement was used. Specifically, participants heard a word, then saw a word, and had to decide whether the auditory-visual word-pair was related or unrelated. A cross-modal semantic priming paradigm was chosen because it has notable advantages when it comes to exerting experimental control. Prime words were chosen over prime sentences, because it was essential that time intervals were rigidly manipulated in order to differentiate between early and late processes (i.e. see discussion on Bisson & Sears, 2007 and Sears et al. 2010). As the majority of prime words in the current study were one syllable, they did not drastically vary in spoken duration, allowing for the manipulation of SOA (as in Grey & Mathews, 2000 and Richard & French, 1992). A relatedness judgement was chosen over a lexical decision task for two reasons. Firstly, as pointed out by Sears et al. (2010), in lexical decision tasks participants simply have to decide whether what they see is a word or a non-word. This decision is not directly related to the participant's interpretation of ambiguity. In fact, participants could ignore the ambiguous prime word, and still successfully complete the task. In relatedness judgements, the participant has to decide whether the prime and target are related, or unrelated. This decision is more likely to be linked to the interpretation of ambiguity, and further encourages them to pay attention to the prime. Secondly, relatedness judgements allow for signal detection analysis. Signal detection analysis will be used to determine whether depression or context training affect sensitivity to emotionally valenced information independent of response biases.

The two experiments in the current study both consisted of two phases, a context training phase and an interpretive phase. There were two crucial differences between each phase. Firstly, every prime heard in the context training phase had one meaning (unambiguous), whereas every prime heard in the interpretive phase had two meanings (ambiguous). Secondly, the context training phase was manipulated between-subjects, and consisted of word pairs related in only one valence, neutral or negative. However, the interpretive phase was manipulated within-subjects, and consisted of ambiguous primes followed by targets of both neutral and negative valence. Like previous CBM-I studies (e.g. Grey & Mathews, 2000; Wilson, MacLeod, Mathews, & Rutherford, 2006), Experiment 1 used a long SOA (800ms), in order to tap into the late stages of processing. If participants use the context training as a cue to help guide the interpretation of ambiguous information in a controlled way, then those in negative context training will be faster and more accurate than those in the neutral context training to judge targets that are related to the negative interpretation of the ambiguous homophone (consistent with previous CBM-I studies e.g. Grey & Mathews, 2000; Wilson et al., 2006). Furthermore, if those vulnerable to depression are particularly sensitive at picking up on negative contextual cues and using them in a controlled way, then this effect will be larger for those higher in depressive symptoms. Experiment 2 used a short SOA (400ms), in order to tap into the early stages of processing. If context training leads to the automatic activation of related concepts, then those in negative context training will be faster and more accurate than those in neutral context training to judge targets that are related to the negative interpretation of the ambiguous homophone. Furthermore, if those vulnerable to depression are particularly sensitive to negative contextual cues in the early stages of processing (as predicted by cognitive theories on depression), then this effect will be larger for those higher in depressive symptoms.

Experiment 1

The aim of Experiment 1 was to determine whether repeated access to valenced unambiguous word-pairs would influence the subsequent interpretation of emotional homophones. There were two phases; a context training phase and an interpretive phase. During the context training phase, participants were randomly assigned to one of two context training conditions; neutral or negative. Those in neutral context training heard unambiguous neutral primes (e.g. *book*) followed by related or unrelated visual targets (e.g. *read* or *boat* respectively) and those in negative context training heard unambiguous negative primes (e.g. *sick*) followed by related or unrelated visual targets (e.g. *vomit* or *wreck* respectively). Participants made a relatedness judgement. During the interpretive phase, those in both neutral and negative context training heard homophone primes with both emotionally neutral and negative meanings (e.g. *sleigh/slay*). Of the related targets they saw, half were to the neutral interpretation (e.g. *sleigh-snow*) and half to the negative interpretation (e.g. *slay-murder*). Unrelated targets were similarly negative or neutral in valence. Again, participants were required to make a relatedness judgement. An SOA of 800ms was used in order to allow enough time for controlled processes to emerge (tapping into the later stages of processing).

If participants use context training as a cue to help guide the interpretation of ambiguous information, then those in negative context training will be faster and more accurate than those in neutral context training at saying ‘related’ to homophone-target pairs that are resolved in a negative as opposed to neutral manner (reflected in a word-pair valence x context training interaction). Furthermore, if those vulnerable to depression are particularly sensitive to negative contextual cues, then this effect will be greater for those scoring high in depression (reflected in a word-pair valence x context training x depression interaction). Alternatively, if vulnerability to depression is reflected in a bias towards negative interpretation in general, then compared to those low in depression, those high in depression should be faster and more accurate to negatively valenced targets overall, regardless context training (reflected in a word-pair valence x depression interaction).

Method

Participants

Participants were 32 undergraduate students enrolled in an introductory psychology course at Victoria University of Wellington, New Zealand, who received course credit for their inclusion in the experiment. Participants were 4 men, and 28 women, with a mean age of 19 (range 18-20) and 20 (range 17-43) respectively.

Participants were English speaking, and had no reported hearing loss or history of depression.

Stimuli

Questionnaires.

The Zung Self Rated Depression Scale (SDS; see Appendix A) was used to assess participants' current depressive symptoms (Zung, 1965). There are 20 questions in total, 10 questions are worded towards increasing depressive levels, and 10 towards decreasing depressive levels. For example, *I feel down-hearted and blue* and *I feel that I am useful and needed*. Participants answer on a 4-point Likert scale ("a little of the time", "some of the time", "a good part of the time", or "most of the time"). Possible scores range from 20-80. A score of less than 50 is considered to be within the normal range. Scores between 50-59 are reflective of minimal to mild depression, scores between 60-69 of moderate to severe depression, and scores above 70 of severe depression.

The Zung Self Rated Anxiety Scale (SAS; see Appendix A) was used to assess participants' current anxiety symptoms (Zung, 1971). There are 20 questions in total, 15 questions are worded towards increasing anxiety levels, and 5 questions towards decreasing anxiety levels. For example, *I feel afraid for no reason at all* and *I can breathe in and out easily*. Participants answer on a 4-point Likert scale ("a little of the time", "some of the time", "a good part of the time", or "most of the time"). Possible scores range from 20-80. Scores between 20-44 are considered to be within the normal range. Scores between 45-59 are reflective of mild to moderate anxiety, scores between 60-74 of severe anxiety, and scores between 75-80 of extreme anxiety.

The Zung scales correlate well with the Hamilton depression and anxiety scales (depression, $r = .76$, Biggs, Wylie, & Ziegler, 1978; anxiety, $r = .75$, Zung, 1971), and have good reliability (split-half $r = .73$, Zung, 1972; Chronbach's alpha = .79, Knight, Waal-Manning, & Spears, 1983).

Prime-target pairs in context training.

Sixty-four unambiguous primes (32 with a neutral meaning, 32 with a negative meaning) were taken from the Affective Norms for English Words (ANEW; Bradley & Lang, 1999). Each ANEW word has a valence rating between one and nine (negative – positive). Neutral primes were selected if they had a valence rating between five and six, and negative primes were selected if they had a valence rating between one and four. An independent t-test confirmed that the neutral primes

(*M*=5.36, *SD*=1.46) were rated significantly more positive than the negative primes (*M*=2.63, *SD*=1.62), $t(62) = 21.76$, $p < .001$, $d = 1.685$.

Sixty-four related targets were selected for the unambiguous primes (32 with a neutral meaning, 32 with a negative meaning). The majority were taken from the University of South Florida Free Association Norms (USFFAN; Nelson, McEvoy & Schreiber, 1998). Primes were searched, and the most frequent associate was chosen, as long as it was of similar valence to the prime. If the USFFAN could not provide an associate, primes were presented to six independent judges, who were asked to produce three associates. The most common associate was then selected, as long as it was of similar valence to the prime. Typically, unrelated targets are created by randomly re-pairing related primes and targets (e.g. Simpson & Burgess, 1985). However, this approach was not suitable for the current study, given that many prime-target pairs would have still been related. For example, the prime *burn* could relate not only to *fire*, but to *wreck*, *anger* and *victim*. For this reason, each prime was intentionally paired with an unrelated target. All targets were then matched to entires in the ANEW database in order to obtain valence ratings, but only 19 were found (8 neutral targets, and 11 negative targets). Nonetheless, a paired sample t-test confirmed that of those, the neutral targets (*M*=6.15, *SD*=0.90) were rated significantly more positively than the negative targets (*M*=2.87, *SD*=0.66), $t(17) = 9.15$, $p < .001$, $d = 3.644$. Negative and neutral targets were matched for word length and frequency (Kucera & Francis, 1967). For a full list of context prime-target pairs see Appendix B.

Homophones for interpretation.

A pool of emotionally-ambiguous homophones were obtained from various sources (Blanchette & Richards, 2003; Mathews et al., 1989; Nygaard, & Lunders, 2002). Forty-seven homophones, each with both a relatively neutral meaning and a relatively negative meaning, were selected as potential primes. Two questionnaires were then produced. Each questionnaire presented only one alternative spelling of the homophone (e.g. questionnaire 1 = *sleigh*, questionnaire 2 = *slay*). Approximately half of the homophones were spelled in their neutral form, and approximately half in their negative form. Positive words were also included as fillers (*sweet*, *hug*, *joy*, *love* and *peace*).

The two questionnaires were administered to a group of pre-test participants (*n*=16), who rated the words for valence on a 5-point Likert scale (1= negative, 2= more negative than neutral, 3= neutral, 4= more positive than neutral, 5= positive).

Thirty-two homophones were selected based upon their mean rating in both the neutral and negative form (neutral range = 2.63 – 3.63; negative range = 1.00 – 2.88), and the difference between their mean rating in the neutral and negative form. Homophones were excluded if the ‘neutral’ meaning was rated as too positive (e.g. *berry* / bury), too negative (e.g. *bald* / bawled), or if participants indicated they did not understand the meaning of the word (e.g. *lye* / lie). An independent t-test confirmed that of the 32 homographs selected, the valence ratings for the neutral spellings (M=3.11, SD=.29) were significantly higher than the valence ratings for the negative spellings (M=1.66, SD=.42), t(62)=16.20, p<.001, d = 3.452. For a full list of homophones and their mean ratings see Appendices C and D.

Homophone prime-target pairs for interpretation.

There were 32 homophone primes, but they were treated as 64 primes, 32 neutral in meaning, and 32 negative in meaning. The majority of targets were taken from the USFFAN (Nelson et al., 1998). Both spellings of each homophone prime were searched, and the most frequent associate was chosen, as long as it was congruent in valence to the homophone prime of interest (e.g. sleigh - *snow* = both neutral in meaning; slay - *kill* = both negative in meaning). If the USFFAN could not provide an associate, homophone primes were presented to six independent judges, who were asked to produce three associates. The most common associate was then selected, as long as it was congruent in valence to the homophone prime of interest. Each prime was intentionally paired with an appropriate unrelated target. Targets were then searched in the ANEW database in order to obtain valence ratings, but only 26 were found (12 neutral targets, and 14 negative targets). Nonetheless, an independent samples t-test confirmed that, of those, the neutral targets were rated significantly more positively (M=6.41, SD= 1.14) than the negative targets (M=2.86, SD=.99), t(24) = 8.43, p < .001, d = 3.114. Negative and neutral targets were matched for word length and frequency. For a full list of homophone prime-target pairs see Appendix E.

Recordings.

Prior to the experiment, the context and homophone primes were digitally recorded at a sound studio by a New Zealand voice actress, whose native language was English. Homophone primes were recorded twice – once with the actress reading the neutral spelling (e.g. *sleigh*) and once with her reading the negative spelling (e.g.

slay)[2]. A list of words was presented to the actress in random order, so that she did not read the two versions of the homophone one after the other. She was instructed to speak with as little emotion as possible, in order to portray a neutral tone. The recordings were made with a Neumann U87 microphone, in one channel (mono) at 24 bits and 44100kz. The sound editing software Audacity (version 1.2.6) was used to duplicate the mono recordings to make stereo files. It was also used to convert files to 16 bits, and equate them for peak amplitude. The mean duration of a homophone prime was 677ms, with a standard deviation of 93ms.

Procedure

After written consent was obtained, groups of participants (no greater than six) were seated at computer booths in a large testing room. Participants first completed the cross-modal priming task, and then filled out the depression and anxiety questionnaires. The cross-modal priming task consisted of two phases; context training (always the first block of trials), and interpretation (always the second block of trials). In both phases, participants heard a prime through stereo headphones, and then saw a related or unrelated target on the computer screen. For example, in the interpretive phase, participants would have heard *sleigh / slay*, and then seen either *snow* (neutral related), *kill* (negative related), *class* (neutral unrelated), or *deprived* (negative unrelated). Participants were required to make a relatedness judgement by pressing the 1 (related) or 2 (unrelated) key with the index or middle finger of their right hand.

The valence of the context training phase was manipulated between participants – half of participants were assigned to neutral context training (64 neutral prime-target pairs; 32 related, 32 unrelated), and half to negative context training (64 negative prime-target pairs; 32 related, 32 unrelated). The interpretive phase was manipulated within subjects - every participant was presented with 64 homophone prime-target pairs, 32 related (16 neutral, 16 negative) and 32 unrelated (16 neutral, 16 negative). The valence of the related and unrelated homograph prime-target pairs was counterbalanced between participants. For example, if participant 1 heard and saw *sleigh – snow* (neutral related) and *slay – deprived* (negative unrelated), participant 2 would hear and see *slay – kill* (negative related) and *sleigh – class*

[2] The experimenter listened to each spelling of the homophone carefully, to ensure the pronunciation was the same. Once this was established, one version was chosen (typically that with the best sound quality).

(neutral unrelated). Thus each participant heard each homophone twice, but only one with a related target (either neutral or negative). Across participants, each homophone was presented equally often with each type of target.

The time between the onset of the prime, and the onset of the target was 800ms. Targets were presented in black lower-case letters on a white background for 250ms, and there was a response-stimulus interval (RSI) of 1500ms. Participants responded to 128 trials which took no longer than 10 minutes to complete. Once everyone had finished, the depression and anxiety questionnaires were handed out. These took no longer than 10 minutes to complete. Participants were then verbally debriefed and given an informational handout to take home.

Results and Discussion

All participants met the criteria for sensitivity to distinguish between related and unrelated word-pairs. That is, they obtained sensitivity values of 1.0 or higher for both neutral and negative homophone word-pairs. Depression and anxiety scores are presented in Table 1. In order to include depression as a between subjects variable, a median split was performed on the SDS. Those scoring between 22 and 32 were classified as “lower depression” and those between 33 and 58 as “higher depression”. Note that no one scored in the range seen in those with major depression, and so the groups reflect variability in depressive symptoms within the normal range. As consistent with previous literature, depression and anxiety scales were highly correlated $r(30) = .68$, $p = <.001$. Anxiety was used as a covariate in all analyses. However, in order to ensure potential depression effects were solely attributable to the disorder, depression analyses were repeated with anxiety as a between-subjects factor and depression as a covariate. Therefore a median split was also performed on the SAS. Those scoring between 25 and 31 were classified as “lower anxiety” and those between 32 and 43 as “higher anxiety”.

Table 1.

Depression and Anxiety Scores for Individuals in Experiment 1(800ms SOA).

	Neutral Context Training		Negative Context Training	
	Lower SDS	Higher SDS	Lower SDS	Higher SDS
*	N = 6	N = 10	N = 9	N = 7
	M(SD)	*M(SD)*	*M(SD)*	*M(SD)*
SDS	29.00(2.76)	40.30(5.27)	28.56(2.13)	38.71(3.50)
SAS	30.17(6.70)	34.70(5.58)	29.22(4.21)	35.57(2.37)

Note. SDS, Zung Self-Rated Depression Scale; SAS, Zung Self-Rated Anxiety Scale.
* Group numbers are unequal as individuals were randomly assigned to context training conditions before they completed the mood questionnaires.

Although participants completed a context training block and an interpretation block, only performance on the latter was analysed, as it was the critical block of interest. The cross-modal relatedness task was essentially a signal detection task; therefore, accuracy was transformed into measures of sensitivity (d'; a measure of participant's ability to discriminate between related and unrelated word pairs) and criterion (c; a measure of participant's bias to respond "related" or "unrelated" under conditions of uncertainty). Sensitivity (d') was calculated based on the Hit Rate (response of "related" to a related word pair) and the False Alarm Rate (response of "related" to an unrelated word pair) according to the formula:

$$d' = z(\text{Hit Rate}) - z(\text{False Alarm Rate})$$

with the correction for rates of 0 and 1 to .025 and .975 respectively (MacMillan & Creelman, 2005). The criterion measure (c) was calculated as:

$$c = -0.5(z(\text{Hit Rate}) + z(\text{False Alarm Rate})).$$

Positive values of c reflect a conservative criterion; that is, a bias to report word pairs as unrelated. Negative values of c reflect a lax criterion; that is, a bias to report word pairs as related. All response time analyses were based on median response times to concordant responses; that is, responses of "related" to related word pairs.

Accuracy

Sensitivity (d') and criterion (c) values were separately analysed in a 2 (word-pair valence: neutral, negative) x 2 (context training: neutral, negative) x 2 (depression: lower, higher) mixed model ANOVA, with word-pair valence as a within-subject variable and context training and depression as between-subject variable (see Table 2). Anxiety was used as a covariate.

Table 2.

Accuracy of Homophone Prime-Target Pairs for Individuals in Experiment 1 (800ms SOA).

	Neutral Context Training		Negative Context Training	
	Lower SDS	Higher SDS	Lower SDS	Higher SDS
*	N=6	N=10	N=9	N=7
	M(SD)	*M(SD)*	*M(SD)*	*M(SD)*
Neutral Homophones				
Hit / 16	7.00(1.26)	7.20(1.62)	6.33(1.22)	6.14(2.54)
False Alarm / 16	0.75(0.27)	1.05(0.83)	1.22(0.75)	0.79(0.57)
d'	1.55(0.23)	1.46(0.41)	1.27(0.48)	1.41(0.58)
c	0.91(0.14)	0.82(0.24)	0.86(0.18)	0.99(0.26)
Negative Homophones				
Hit / 16	11.00(1.79)	10.50(2.17)	11.44(1.67)	10.57(1.13)
False Alarm / 16	4.00(1.55)	3.30(1.57)	2.61(2.45)	0.85(0.55)
d'	1.24(0.52)	1.37(0.47)	1.76(0.59)	2.15(0.46)
c	0.05(0.13)	0.20(0.35)	0.22(0.37)	0.58(0.12)

In the sensitivity analysis, there was a marginal main effect of context training, $F(1, 27) = 3.08$, $p = .072$, $\eta_p^2 = .115$, qualified by the predicted interaction between word-pair valence and context training, $F(1, 27) = 11.70$, $p = .002$, $\eta_p^2 = .302$, (see Figure 1). For the discrimination of neutral word-pairs, those in the neutral context training ($M = 1.49$, $SD = .35$) were non-significantly better than those in the negative context training ($M = 1.33$, $SD = .50$), $t(30)=1.07$, $p = .295$, $d = 0.320$. However for the discrimination of negative word-pairs, those in the negative context training ($M = 1.93$, $SD = 0.55$) were significantly better than those in the neutral context training ($M = 1.32$, $SD=0.47$), $t(30) = -3.360$, $p = .002$, $d = 1.109$. This indicates that access to negative meanings of ambiguous homophones was facilitated by negative context training in which participants repeatedly made judgements about unambiguous negative words. Note that context training did not require resolution of ambiguity, and therefore suggests that repeated access to negative meanings is sufficient to induce an interpretive bias (consistent with passive training conditions in Hoppitt et al. 2010a). Additionally, as a long SOA was used, it can be inferred that the induced negative interpretive biases observed were at least evident during the later stages of processing, when opportunities for controlled or strategic processes became available (consistent with Grey & Mathews, 2000; Hoppitt et al., 2010a). Importantly, there were no main effects or interactions involving depression, indicating that the context training manipulation affected those higher and lower in depressive symptoms equally.

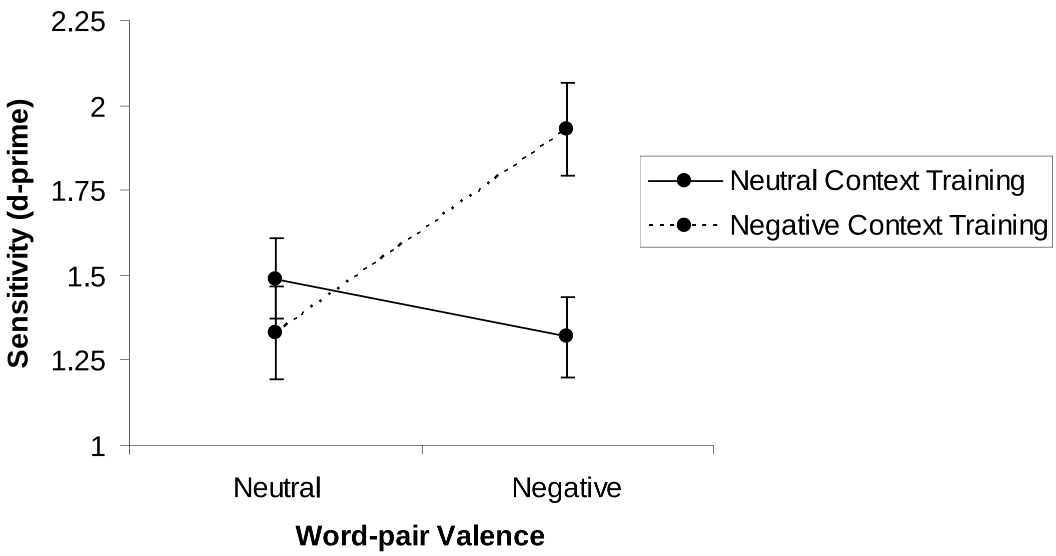

Figure 1. Sensitivity (d') to homophone prime-target pairs at the 800ms SOA, for individuals in neutral and negative context training.

A similar ANOVA on criterion values revealed a marginal main effect for context training, $F(1, 27) = 4.16$, $p = .051$, $\eta_p^2 = .133$, that was qualified by a word-pair valence x context training interaction, $F(1, 27) = 4.91$, $p = .035$, $\eta_p^2 = .154$ (see Figure 2). For neutral word-pairs, criterion values did not differ between neutral (M = 0.85, SD = 0.21) and negative (M = 0.92, SD = 0.22) context training, $t(30) = -.872$, $p = .39$, $d = 0.297$. However for negative word-pairs, those in neutral context training (M = 0.15, SD = 0.21) were less conservative (more likely to say "related") than those in negative context training (M =.38, SD = .34), $t(30) = -2.08$, $p = .046$, $d = 0.685$. This is likely because those in the neutral context training had no prior experience with negative information. For this reason, they were not as good as those in the negative context training at classifying negative word-pairs (i.e. they were more likely to say "related" to negative word-pairs, but not more likely to be correct in this decision).

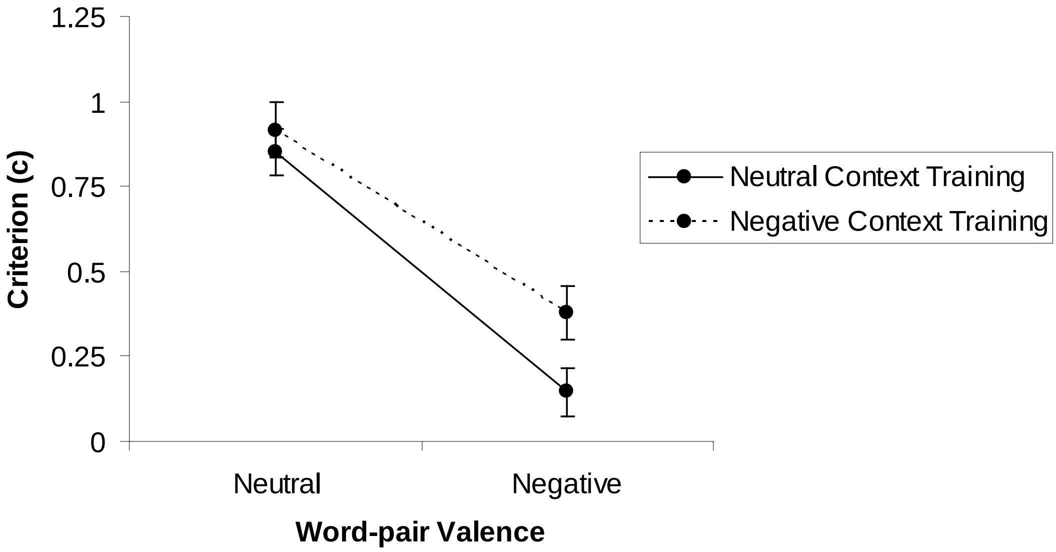

Figure 2. Criterion values (c) for homophone prime-target pairs at the 800ms SOA, for individuals in neutral and negative context training.

There was also a word-pair valence x depression group interaction, $F(1, 27) = 9.82$, $p = .004$, $\eta_p^2 = .267$ (see Figure 3). For neutral word-pairs, criterion values did not differ between individuals lower in depression ($M = 0.88$. $SD = 0.16$) or higher in depression ($M = 0.89$, $SD = 0.26$), $t(30) = -.124$, $p = .902$, $d = .038$. However, for negative word-pairs, those in the lower depression group ($M = 0.15$, $SD = 0.31$) tended to be less conservative (more likely to say related) than those in the higher depression group ($M = 0.36$, $SD = .33$), $t(30) = -1.772$, $p = .087$, $d = .615$. In order to determine whether the latter effect was solely attributable to depression, the criterion analysis was repeated with anxiety as a between subjects factor, and depression as a covariate. The only effect observed was a word-pair valence x anxiety group interaction, $F(1, 27) = 5.36$, $p = .028$, $\eta_p^2 = .166$; however, none of the follow up analyses were significant, even marginally so. Thus, the word-pair valence x depression group interaction observed was likely unique to depression, and strongly argues against a negative response bias for those who are higher in symptoms.

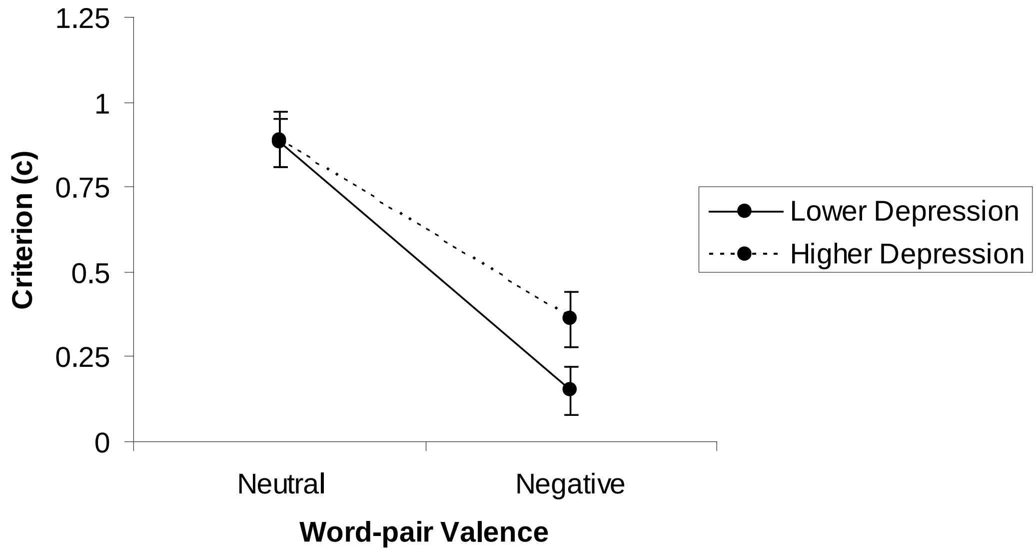

Figure 3. Criterion values (c) for homophone prime-target pairs at the 800ms SOA, for individuals lower and higher in depression.

Response Times

Response times for related trials were analysed in a 2 (word-pair valence: neutral, negative) x 2 (context training: neutral, negative) x 2 (depression: lower, higher) mixed model ANOVA, with word-pair valence as a within-subjects variable, and context training and depression as between-subjects variables (see Table 3). As with the criterion analysis anxiety was included as a covariate. The 3-way interaction between word-pair valence, context and depression group approached significance, $F(1, 27) = 3.520$, $p = .066$, $\eta_p^2 = .119$. Because this interaction was of theoretical interest, it was explored further. However, none of the follow-up analyses were significant. No other significant effects were observed.

Unrelated trials were not analysed, specifically because they would not have provided a sufficient baseline for comparison. Firstly, in a relatedness judgement, the unrelated condition leads to a different response (no) than in the related condition (yes), and therefore its use as a baseline is problematic. Secondly, in the current study the criterion analyses revealed that deciding whether a word-pair was unrelated was actually affected by context and depression (see Table 2).

Table 3.

Reaction Times to Correctly Identified Related Targets for Individuals in Experiment 1 (800ms SOA).

	Neutral Context Training		Negative Context Training	
	Lower SDS N = 6	Higher SDS N = 10	Lower SDS N = 9	Higher SDS N = 7
	M(SD)	*M(SD)*	*M(SD)*	*M(SD)*
Neutral Homophones	798(186)	675(15)	695 (67)	780(309)
Negative Homophones	728(165)	704(40)	699(113)	678(129)

Experiment 2

Experiment 1 indicated that for individuals in negative context training, those lower and higher in depressive symptoms performed equally on the interpretation task. Specifically, both groups exhibited a negative interpretive bias. Experiment 1 used a long SOA of 800ms, allowing for controlled or strategic processes to become available. However, cognitive theories on depression posit that exposure to negative information automatically activates negative schema in those vulnerable to the disorder, and that this in turn results in a negative interpretive bias (see, Beck, 1976, 1987, 2008; Beck & Clarke, 1988; Bower, 1981; DeRaedt & Coster, 2010; Pearsons & Miranda, 1992; Sheppard & Teasdale, 2004). In order to test this hypothesis and tap into the early stages of processing, Experiment 2 was run at an SOA of 400ms.

If context leads to the automatic activation of related concepts, then those in negative context training will be faster and more accurate at deciding that an ambiguous homophone-target pair is related when resolved in a negative as opposed to neutral manner (reflected in a word-pair valence x context training interaction). Furthermore, if those scoring higher in depression are biased towards negative interpretation in general, then compared to those lower in depression, those higher in depression should be faster and more accurate at negatively valenced targets overall (reflected in a word-pair valence x depression interaction). Alternatively, if those scoring higher in depression have greater reactivity to emotional context, then compared to those lower in depression, those higher in depression should be faster and more accurate at negatively valenced targets, but only when in the negative context condition (reflected in a word-pair valence x context training x depression interaction).

Method

Participants

Participants were 50 undergraduate students enrolled in a 200-level cognitive psychology course at Victoria University of Wellington, New Zealand. They voluntarily took part in the experiment during one of their weekly labs. Participants consisted of 13 men, and 36 women, with mean ages of 21 (range 18-37) and 20 respectively (range 18-23)[3].

Stimuli

Stimuli were identical to Experiment 1.

Procedure

The procedure was identical to Experiment 1, except that a 400ms SOA was used instead of a 800ms SOA. Additionally, given the nature of the testing situation, large groups of participants (between 10 –20) were run at a time.

Results and Discussion

All participants met the criteria for distinguishing between related and unrelated word-pairs. That is, their sensitivity values were above 0.8 for both neutral and negative homophone pairs. This criteria differed slighter from Experiment 1, as the task was much harder (due to the 400ms SOA) and participants were perhaps more susceptible to distraction (as they were tested in larger groups). This also meant that the number of participants in neutral and negative context training slightly differed (neutral context training, n = 27; negative context training n = 23). Depression and anxiety scores are presented in Table 4.

[3] One participant did not disclose their demographic information.

Table 4.

Depression and Anxiety Scores for Individuals in Experiment 2.

	Neutral Context Training		Negative Context Training	
	Lower SDS	Higher SDS	Lower SDS	Higher SDS
*	n = 18	n = 9	n = 9	n = 14
	M(SD)	*M(SD)*	*M(SD)*	*M(SD)*
SDS	28.83(4.19)	48.00 (3.64)	30.56(3.43)	41.64(5.96)
SAS	28.89(4.61)	44.56(10.90)	28.89(4.48)	35.57(7.93)

*As with experiment 1, group numbers are unequal as context training was randomly assigned before participants completed the mood questionnaires.

As with Experiment 1, a median split was performed on the SDS. Those scoring between 22 and 34 were classified as “lower depression” and those between 35 and 58 as “higher depression”. Consistent with previous literature, depression and anxiety scales were highly correlated $r(48) = .834$, $p = <.001$. Anxiety was used as a covariate in all depression analysis. However, in order to ensure that any potential depression effects were solely attributed to depression, depression analyses were run with anxiety as a between subjects variable and depression as a covariate. Therefore a median split was also performed on the SAS. Those scoring between 21 and 31 were classified as “lower anxiety” and those between 32 and 58 as “higher anxiety”. Although participants completed a context training block and an interpretation block, only the latter was analysed, as it was the critical block of interest. Related response times and accuracy were analysed in the same way as Experiment 1.

Accuracy

Sensitivity (d’) and criterion (c) values were separately analysed in a 2 (word-pair valence: neutral, negative) x 2 (context training: neutral, negative) x 2 (depression: lower, higher) mixed model ANOVA, with word-pair valence as a within-subject variable and context and depression as between-subject variables (see Table 5). Anxiety was used as a covariate.

Table 5.

Accuracy of Homophone Prime-Target Pairs for Individuals in Experiment 2 (400ms SOA).

	Neutral Context Training		Negative Context Training	
	Lower SDS N=18	Higher SDS N=9	Lower SDS N=9	Higher SDS N=14
	M(SD)	*M(SD)*	*M(SD)*	*M(SD)*
Neutral Homophones				
Hit / 16	7.39(1.38)	7.67(2.00)	7.78(1.86)	7.14(1.75)
False Alarm / 16	1.00(0.69)	1.05(1.49)	0.94(0.92)	0.89(0.92)
d'	1.54(0.39)	1.64(0.31)	1.65(0.41)	1.58(0.30)
c	0.82(0.18)	0.83(0.37)	0.83(0.29)	0.88(0.28)
Negative Homophones				
Hit / 16	9.83(1.89)	9.67(2.29)	9.44(2.79)	11.00(1.75)
False Alarm / 16	1.69(1.03)	2.61(1.50)	1.89(1.87)	1.50(0.92)
d'	1.60(0.35)	1.35(0.28)	1.58(0.63)	1.89(0.40)
c	0.48(0.28)	0.35(0.41)	0.52(0.45)	0.39(0.30)

The only effect observed was the predicted word-pair valence x context training x depression interaction, $F(1, 45) = 5.27$, $p = .026$, $\eta_p^2 = .105$. For participants in the lower depression group (see Figure 4), the word-pair x context training interaction was not significant, $F(1,24) = .41$, $p = .528$, $\eta_p^2 = .017$. In other words, discrimination of related from unrelated word-pairs was equal for negative and neutral targets, regardless of context training. This indicated that training with negative word pairs did not facilitate access to negative meanings of ambiguous words for lower depression participants. This finding is consistent with theories of non-emotional ambiguity resolution, that posit automatic activation of all word meanings in the early stages of processing (Simpson, 1984; Simpson & Burgess, 1985; Simpson & Kang, 1994; Simpson & Krueger, 1991; Swinney, 1979). However, the word-pair x context training interaction was significant for those in the higher depression group, $F(1, 20) = 5.74$, $p = .026$, $\eta_p^2 =.223$ (see Figure 3). For higher depression participants, discrimination of related from unrelated neutral word-pairs was not affected by context training, $t(21) = .51$, $p = .618$, $d = .211$. In contrast, discrimination of related from unrelated negative word-pairs was significantly better following negative context training than neutral context training, *t*(21) = -3.53, *p* = .002, *d* = 1.366. In other words, for participants high in depressive symptoms, negative context training automatically activated related concepts, such that participants were better able to identify emotionally ambiguous homophones that were resolved in a negative as opposed to neutral manner. The criterion analysis did not reveal any significant effects.

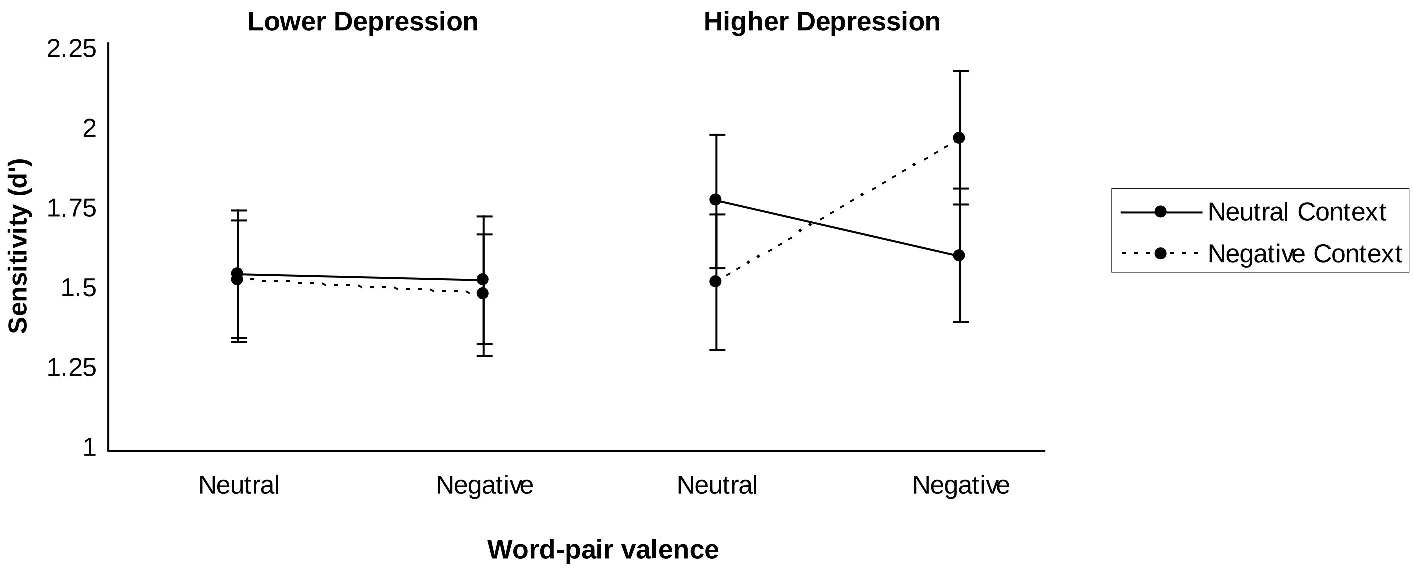

Figure 4. Sensitivity (d') to homophone prime-target pairs at the 400ms SOA, for individuals lower and higher in depression, and in neutral and negative context training.

In order to determine whether the negative interpretive bias observed for those scoring high in depression was specific to depression, sensitivity (d') and criterion (c) values were separately analysed in a 2 (word-pair valence: neutral, negative) x 2 (context training: neutral, negative) x 2 (anxiety: lower, higher) mixed model ANOVA, with word-pair valence as a within-subject variable and context training and anxiety as between-subject variables. Depression was used as a covariate. No significant effects were observed in the sensitivity analyses, including the word-pair valence x context training x anxiety interaction, $F(1, 45) = .01$, $p = .949$, $\eta_p^2 = .001$. Similarly, no significant effects were observed in the criterion analyses. This indicates that the depression effect observed in the sensitivity analysis can be specifically attributed to depression, as not only was anxiety adequately controlled for, but when the same analyses was run with anxiety as a between-subjects variable and depression as a covariate, no significant effects were observed. Thus, the sensitivity results combined suggest that vulnerability to depression is reflected in greater reactivity to emotional context.

Response Times

Response times for related word pairs were analysed in a 2 (word-pair valence: neutral, negative) x 2 (context training: neutral, negative) x 2 (depression: lower, higher) mixed model ANOVA, with word-pair valence as a within-subjects variable, and context group and depression as between-subjects variable (see Table 6). No significant effects were observed. For the same reasons in Experiment 1, response times to unrelated word-pair trials were not analysed.

Table 6.

Reaction Times to Correctly Identified Related Targets for Individuals in Experiment 2 (400ms SOA).

	Neutral Context Training		Negative Context Training	
	Lower SDS N=18	Higher SDS N=9	Lower SDS N=9	Higher SDS N=14
	M(SD)	*M(SD)*	*M(SD)*	*M(SD)*
Neutral Homophones	759(153)	745 (62)	838(151)	774(126)
Negative Homophones	773(190)	742(140)	779(106)	768(72)

General Discussion

Cognitive theories of emotional disorders suggest that anxious and depressed individuals consistently interpret ambiguous information in a negative manner, and that this negative interpretive bias might play a role in the cause and maintenance of their disorder (see, Beck, 1976, 1987, 2008; Beck & Clarke, 1988; Bower, 1981; DeRaedt & Coster, 2010; Pearsons & Miranda, 1992; Sheppard & Teasdale, 2004). While anxiety-linked interpretive biases have been well established (Byrne & Eysenck, 1993; Calvo & Castillo, 1997; Hadwin et al., 1997; MacLeod & Cohen, 1993; Mathews et al., 1989; Richards & French, 1992), empirical research on depression-linked interpretive biases has yielded mixed results (Bisson & Sears, 2007; Butler & Mathews, 1983; Dearing & Gotlib, 2009; Lawson & MacLeod, 1999; Lawson et al., 2002; Mogg et al., 2006; Sears et al., 2010; Weinzlaff & Eisenberg, 2001). This is likely due to differing methodologies and the use of statistical techniques that do not adequately control for anxiety.

The aim of the current study was to use a cognitive bias modification procedure to detect induced interpretive biases in healthy individuals. As there was large variability in depression scores, a median split was used create two groups: lower depression and higher depression. Although individuals in the *higher depression* group were not depressed, it is fair to say that they were likely more vulnerable to depression compared to those in the *lower depression* group. It was also of primary interest to determine the time-course of induced interpretive biases. Individuals in the lower and higher depression groups were allocated to either neutral or negative context training conditions, in which they repeatedly made relatedness judgements about valenced words. They then completed an interpretation block, in which they were required to make relatedness judgements about ambiguous homophones. Experiment 1 used an SOA of 800 ms, and Experiment 2 an SOA of 400ms. However, Experiment 2 will be discussed first, as it assessed the early stages of processing, followed by Experiment 1, in which the later stages of processing were assessed.

Experiment 2 showed that, in the early stages of processing, negative context training induced a negative interpretive bias in the higher but not the lower depression group. In other words, after repeatedly making judgments about unambiguous negative word-pairs, individuals in the higher depression group obtained higher sensitivity values for negative than neutral interpretations of ambiguous words, whereas sensitivity values did not differ for individuals in the lower depression group. Conversely, Experiment 1 showed that, in the later stages of processing, negative context training induced negative interpretive biases in all individuals, regardless of depression scores. In other words, after repeatedly making judgements about unambiguous negative word-pairs, individuals in lower and higher depression groups obtained higher sensitivity values for negative as opposed to neutral interpretations of ambiguous words. In regard to response bias, results indicated that in the early (Experiment 2) and later stages (Experiment 1) of processing all individuals were conservative in their responses. That is, when faced with a homophone prime-target pair they were more likely to say "unrelated" than "related". This finding in itself illustrates how difficult the task was. Overall, the results suggest that, given sufficient time, healthy individuals successfully use context as a cue to guide the interpretation of ambiguous information. However, those vulnerable to depression are uniquely receptive to negative contextual cues in the earlier stages of processing.

Previous Research

Although not directly comparable, findings are consistent with depression-linked interpretive biases observed in self-report (Butler & Mathews, 1983) homophone spelling (Mogg et al., 2006; Wenzlaff & Eisenberg, 2001) text comprehension (Dearing & Gotlib, 2009), semantic priming (Sears et al., 2010) and blink reflex tasks (Lawson et al. 2002). Notably, self-report and homophone spelling tasks have been extensively criticised for their susceptibility to response bias. That is, rather than showing an enhanced sensitivity to negative interpretations, individuals in these tasks might have been more inclined to report negative as opposed to neutral interpretations. This possibility can be ruled out in the current study, as accuracy was analysed according to Signal Detection Theory and thus provided a measure of interpretive bias (sensitivity) independent of response bias (criterion).

Early stages of processing.

The current study contributes to the literature in the assessment of the time-course of depression-linked interpretive biases. Only a handful of studies have assessed whether depression-linked interpretive biases are detectable at the early stages of processing. In a study by Wenzlaff and Eisenberg (2001), chronically dysphoric, previously dysphoric, and non-dysphoric individuals completed a modified version of the homophone spelling task. That is, after hearing neutral/negative (e.g. *dye/die*) and neutral/positive (e.g. *piece/peace*) homophones, they were required to write down the word they heard. In one condition, individuals only had three seconds to respond, thus their immediate interpretations were assessed. In this condition, Wenzlaff and Eisenberg found that both chronically dysphoric and previously dysphoric individuals were more likely to write down negative spellings of neutral/negative homophones, and neutral spellings of neutral/positive homophones. The opposite effect was reported for non-dysphoric individuals. Thus, the authors inferred that chronically dysphoric and previously dysphoric individuals displayed a negative interpretive bias at the early stages of processing.

Blanchette and Richards (2003) examined the role of context on anxiety-linked interpretive biases at early stages of processing. This is relevant to the current study, as it is the only other study to have directly assessed the role of context in emotional vulnerability. State-anxious and non-anxious participants heard emotional homophones (e.g. *dye/die*) and then saw contextual cues (e.g. *death*). In one of their experiments, contextual cues were presented subliminally, thus tapping into the early stages of processing. Participants were simply required to write down the word they heard (e.g. *dye* or *die*). Thus rather than contextual cues being presented in a training block, as in the current study, they were presented before each interpretation trial. Nevertheless, Blanchette and Richards reported that anxious participants were particularly sensitive to contextual cues (neutral, negative and positive valence) when they were presented subliminally (tapping into the early stages of processing), whereas non-anxious participants were not.

In a semantic priming task by Sears et al. (2010), dysphoric and non-dysphoric individuals heard ambiguous sentences, and related (neutral, negative or positive) and unrelated targets. Rather than making a lexical decision (as in Bisson & Sears, 2007; Lawson & MacLeod, 1999), individuals were required to judge the relatedness of the prime-target pairs. Reaction time and accuracy was assessed. Further, accuracy was split into 'hits' (responding related to a related target), false alarms (responding related to an unrelated target), correction rejections (responding unrelated to an unrelated target), and misses (responding unrelated to a related target). Although Sears et al. did not report any significant effects in their reaction time data, they did report that dysphoric individuals were more likely to 'miss' positive targets, and less likely to 'miss' negative targets. The authors manipulated ISI (0ms & 1000ms), but did not obtain any interactions with this variable. Thus, miss rates were averaged across 0ms and 1000ms ISI conditions. Nevertheless, Sears et al. still concluded that dysphoric individuals displayed a negative interpretive bias at the early stages of processing.

In the current study, Experiment 2 (with a 400ms SOA) showed that after negative context training, individuals in the higher depression group were more likely to select negative than neutral interpretations of ambiguous words. The same was not true for individuals in the lower depression group, or individuals in the higher depression group and in neutral context training. Thus, only after negative schemas were activated (through repeated access to negatively valenced word-pairs) did individuals vulnerable to depression exhibit a negative interpretive bias at the early stages of processing. Results from Experiment 2 are consistent with previous research that has assessed depression-linked interpretive biases at the early stages of processing (Blanchette & Richards, 2003; Sears et al. 2010; Wenzlaff & Eisenburg, 2001). However, unique to the current study, anxiety was adequately controlled for, and the measure of interpretive bias obtained (sensitivity) was independent of response bias (criterion). In fact, from a methodological standpoint, it appears that accuracy is a more sensitive measure of interpretation than reaction time, at least in semantic priming paradigms. Like the current study, Sears et al. only obtained significant effects in their accuracy as opposed to reaction time data. Furthermore, Lawson et al (2002) have already raised concerns about solely relying on the speed of responses in interpretation tasks, especially in depression whereby reaction times can be slower (Azorin, Benhaïm, Hasbroucq, Possamaï, 1995) and more variable (Byrne, 1976).

Importantly, the fact that depression-linked interpretive biases were detected at the early stages of processing helps provide clarity on controversial debate in the literature. Although automatic and persistent depression-linked interpretive biases are predicted by the majority of cognitive theories on depression (e.g. Beck, 1976, 1987, 2008; Beck & Clark, 1988; Bower, 1981; DeRaedt & Coster, 2010; Pearsons & Miranda, 1992; Sheppard & Teasdale, 2004) there has been little empirical support for this notion, specifically in studies that use behaviour measures. This has led researchers to question whether, in fact, depression-linked interpretive biases are effortful and controlled (e.g. Williams, Watts, MacLeod & Mathews, 1988, 1997).

Integrating both theories, Shestyuk and Deldin (2010) have recently proposed that self-referential processing biases in depression result from abnormalities in both automatic and controlled processes. They recorded Event Related Potentials (ERPs) during the encoding stages of self-referent or other-referent words. Automatic processing biases were indexed by the P2 component (see Crowley & Colrain, 2004), and controlled processes by the late positive component (see Johnson, 1995; Naumann, Bartussek, Diedrich, & Laufer, 1992). Shestyuk and Deldin found that currently depressed and previously depressed participants exhibited greater P2 activation during the encoding of negative relative to positive self-referent words, where as the opposite was true of controls. Furthermore, whereas currently depressed individuals showed greater activation of the late positive component during the encoding of negative as opposed to positive self-referent words, the opposite was true of previously depressed participants. That is, like controls, previously depressed participants exhibited greater activation of the late positive component during the encoding of positive relative to negative self-referent words. Shestyuk and Deldin thus suggested that automatic processing biases reflect vulnerability to depression, whereas controlled processing biases reflect a mood dependant feature of the disorder. This theory fits nicely with Wenzlaff and Eisenberg's (2002) data, and is also consistent with the findings reported in the current study.

Later stages of processing.

Two of the studies aforementioned also assessed whether depression-linked interpretive biases were detectable at the later stages of processing. Wenzlaff and Eisenberg (2001) assessed individuals' delayed interpretations of ambiguous homophones. In this condition, individuals were given thirteen seconds (as opposed to three seconds) to write down the word they heard. Wenzlaff and Eisenberg found that chronically dysphoric individuals continued to display a negative interpretive bias. However, previously dysphoric individuals did not. Instead, like non-dysphoric individuals, previously dysphoric individuals displayed a positive interpretive bias at the later stages of processing. Combining their time-course findings, Wenzlaff and Eisenberg suggested that previously dysphoric individuals do not lose the negative cognitions associated with a prior dysphoric episode, but rather become better at controlling them.

In another of Blanchette and Richards (2003) experiments, state-anxious and non-anxious individuals heard emotional homophones (e.g. *dye/die*). However, this time contextual cues were presented supraliminally (thus tapping into controlled processes). Soon after, a target appeared. The target was one of the spellings of the homophone (e.g. *dye* or *die*) or a non-word. Participants were required to make a lexical decision on the target. Blanchette and Richards found that state anxious individuals were still faster to respond to contextually congruent targets; however, this time, the same effect was evident for non-anxious individuals. Blanchette have since replicated this finding in naturally occurring state-anxiety (i.e. with individuals awaiting dental treatment; Blanchette, Richards & Munjiza, 2007). Combining subliminal and supraliminal priming findings, Blanchette and Richards concluded that state anxiety was linked to an automatic enhanced sensitivity to emotional context, and later referred to this as the "context hypothesis".

Interestingly, although the current study focused on depression as opposed to anxiety, results are also consistent with the “context hypothesis”. In Experiment 1, all individuals, regardless of depression scores, were sensitive to negative contextual cues at the later stages of processing (consistent with effects observed in Blanchette and Richard’s, 2003 supraliminal priming experiment). On the other hand, in Experiment 2, individuals scoring high but not low in depression showed an enhanced sensitivity to negative contextual cues in the early stages of processing (consistent with the effects observed in Blanchette and Richards subliminal priming experiment). However, in order to determine whether those scoring relatively higher as opposed to lower in depression were uniquely receptive to contextual cues in *general,* a positive training condition would need to be included. Nevertheless, along with the findings from Wenzlaff and Eisenberg (2001), and Blanchette and Richards (2003), results from the current study suggest that at the later stages of processing interpretive biases are not invariant; that is, under the right experimental conditions, they are malleable to change. This notion is supported in studies that modify interpretive biases through training.

In the current study, results observed at the later stages of processing are directly comparable to studies utilising cognitive bias modification procedures. In a series of studies, Grey and Mathews (2000) examined the effects of active and passive training on the subsequent interpretation of ambiguous information. During active training participants were required to actively generate appropriate valenced targets. For example, after being presented with an ambiguous word (e.g. *beat*), participants in threat training were required to generate the threat as opposed to non-threat meaning by completing a word fragment (e.g. *police* / p _li _ e as opposed to *rhythm*/ r_yt_m). During passive training participants were exposed to appropriate valenced targets, but did not have to generate training-congruent meanings. For example, those in threat training had to verify the association between *police-beat* whereas those in non-threat training had to verify the association between *rhythm-beat* (i.e. the ambiguous word was presented as a target, to prevent participants from accessing both meanings). Grey and Mathews reported that after both active and passive training participants were more likely to interpret ambiguous words in a training-congruent manner. Notably, in their interpretation phases, an SOA of 750ms was used, thus tapping into the later stages of processing.

In the current study, individuals partook in neutral or negative context training. That is, they either had to verify the association between unambiguous neutral word-pairs (e.g. *cat-dog*) or unambiguous negative word-pairs (e.g. *depressed-lonely*). This is equivalent to what the CBM-I literature refers to as passive training. Like findings from Grey and Mathews (2000), during the later stages of processing, individuals in the current study were more likely to resolve ambiguous words in a training-congruent manner. Importantly, this effect did not interact with depression, suggesting that at the later stages of processing vulnerability factors are not solely responsible for inducing negative interpretive biases. Potential mechanisms for the replicable training-congruent effect, at the later stages of processing, are now discussed. There are four possible contenders: demand effects, undetected mood changes, emotional category priming and transfer of processing.

Potential Mechanisms Underlying Strategically Induced Biases

Demand effects.

Demand effects could have been responsible for inducing interpretive biases at the later stages of processing. Specifically, it could be that individuals were aware of the purpose of the task, and performed in a way consistent with experimenter expectations. However, this possibility is highly unlikely. Feedback to the experimenter indicated that many participants did not even notice that some of the words they heard were ambiguous. Furthermore, the task itself was difficult. It required participants to make speeded judgements to prime-target pairs that were presented less than a second apart. The window of time to respond was no greater than 1750ms. In fact, the difficulty of the task was confirmed by the number of individuals who did not meet sensitivity requirements, and were consequently excluded from the data analysis (i.e. their ability to distinguish related word-pairs from unrelated word-pairs was not above chance). The task difficulty was also confirmed in criterion values. All participants were conservative in their responses. That is, they were more likely to say “unrelated” than “related’ when faced with a homophone prime-target pair. Thus, it is unlikely that participants had the cognitive resources available to respond to perceived demand.

Undetected mood changes.

It is also possible that induced negative interpretive biases at the later stages of processing were a result of undetected mood changes arising from negative context training. Specifically, repeated access to negatively valenced word-pairs might have induced a negative mood-state in individuals, which led them to interpret homophones in a negative as opposed to neutral manner. To rule out this possibility, mood-state should have been assessed before and after training. Nonetheless, this explanation still seems unlikely. In CBM-I tasks, where training involves *passages of text*, mood state has been reportedly modified in a training-congruent manner (e.g. Mathews & Mackintosh, 2000b); however, such an effect is typically absent in CBM-I tasks, like the current study, where training involves *single words* (e.g. Hoppitt et al., 2010a; Wilson et al., 2006). This seems logical, as individuals who participate in experimental tasks are skilled readers, who come across negatively valenced single words everyday. These negative valenced single words do not typically evoke noticeable feelings of sadness etc.

It is important to note, that although training with negatively valenced single words might not directly affect an individuals' mood state, it may affect their emotional reactivity to stressful events. For example, Wilson et al. (2006) conducted a CBM-I task that consisted of three phases: training, interpretation, and emotional reactivity. In the training phase, healthy individuals were trained to interpret ambiguous information in either a non-threatening or threatening manner. In the interpretation phase, individuals in threat-training were more likely to interpret ambiguous information in a negative as opposed to neutral manner (consistent with the findings reported in Experiment 1 of the current study). Importantly, threat-training did not affect mood state after training. However, in the emotional reactivity phase, individuals were required to watch a potentially stressful video. Wilson et al. found that after viewing this video, individuals in threat training reported greater increases in negative mood, than individuals in non-threat training. Thus, Wilson et al's results showed that valence training did not affect individuals' current mood state, but it did affect their later emotional reactivity to stressful events; This effect has been extensively replicated (see, Hirsch, Mathews & Clark, 2007; Hoppitt et al., 2010a, Hoppitt et al., 2010b; Mackintosh et al., 2006; Mathews & MacLeod, 2002).

Emotional category priming.

The interpretive biases reported in the current study could also have been due to emotional category priming (Higgins, 1989; Hill & Kemp Wheeler, 1989). That is, repeated access to negatively valenced meanings (i.e. negative context training) might have primed an entire category of negative interpretations, such that when presented with ambiguous information, negatively related meanings were more readily available than neutrally related meanings. In fact, this is the mechanism that Grey and Mathews (2000) deemed the most plausible explanation of the training-congruent biases observed in their studies. However, Wilson et al. (2006) have shown that emotional category priming cannot be the only factor responsible for training congruent biases.

As previously mentioned, Wilson et al. (2006) carried out a CBM-I task with three phases: training, interpretation and emotional reactivity. In the training phase, participants were actively trained to interpret ambiguous information in either a threatening or non-threatening manner. Crucially, in the interpretation phase, they were presented with ambiguous word-pairs and unambiguous word-pairs (threat and non-threat). Wilson et al. reported that while individuals responded to ambiguous prime words in a training-congruent manner, the same was not true of unambiguous prime words. In other words, individuals in threat training were no faster at responding to unambiguous threatening word-pairs, than individuals in non-threat training. This suggested that active threat training did not simply prime threat related meanings in general, but rather uniquely influenced the ability to access negative interpretations of ambiguous word meanings. Notably, as all participants in Wilson et al's study completed active training, their study could not determine whether the same mechanism was responsible for passive training.

Transfer of processing.

The first study to tease apart the mechanisms involved in active and passive training came from Hoppitt et al. (2010a). They suggested that in active training, training-congruent biases emerged due to transfer of processing (other wise known as the learning of an implicit production rule). Specifically, participants learn to select training-congruent interpretations through practice, and transfer this rule to novel ambiguous information. Thus, they suggested that active training uniquely influences the ability to access training-congruent meanings of ambiguous information. If this hypothesis were correct, then as in Wilson et al. (2006), in an interpretation phase individuals in active threat training should be faster to respond to threatening targets, but only if preceded by an ambiguous prime. Alternatively, they suggested that in passive training, training-congruent biases emerged due to the priming of an entire category of training-congruent meanings (i.e. emotional category priming). For example, after repeatedly accessing threatening words, all threat related meanings become available, and thus individuals are primed to respond to all subsequently presented threatening information. If this hypothesis were correct, then in an interpretation phase, individuals in passive threat training should be faster to respond to threatening targets preceded by ambiguous primes and unambiguous threatening primes.

Hoppitt et al. (2010a) actually found that both active and passive threat training resulted in faster responses to threatening targets preceded by ambiguous and unambiguous primes. This finding alone suggested to the authors that the same mechanism was responsible for active and passive training, namely emotional category priming. However, Hoppitt et al. (2010a) added the same third phase to their experiment as Wilson et al. (2006). Individuals were required to watch a potentially stressful video, after which their mood was assessed. Results showed that individuals in active threat training reported greater increases in anxiety after the video than individuals in passive threat training. The question then remained, if threat biases were induced via the same mechanism, then why were individuals in active training more emotionally reactive to the potentially stressful video than individuals in passive threat training? Hoppitt et al. (2010a) suggested that the most parsimonious explanation had to be that active training did indeed result from transfer of processing. Individuals in active threat training must have become practiced at resolving ambiguous information in a threatening manner, thus when presented with subsequent stressful videos (e.g. of a man drowning and being rescued by a police officer), they focused on the threatening (e.g. the man could have died) as opposed to non-threatening (e.g. the heroic save) aspects, which in turn affected their mood state.

As the current study did not include unambiguous word-pairs in the interpretation block, it is difficult to determine whether interpretive biases at the later stages of processing resulted from transfer of processing or emotional category priming. On the one hand, in negative context training individuals were required to repeatedly make judgments about negative word-pairs. Neither primes nor targets were ambiguous, thus individuals could not have become practiced at selecting negative as opposed to neutral interpretations of ambiguous information. In conjunction with the fact that training was most consistent with the requirements of passive than active training, it is entirely possible that interpretive biases occurred due to emotional category priming.

On the other hand, in the current study, the actual task requirement in the context training phase and the interpretation phase did not differ. That is, in both phases participants heard a word, saw a word, and had to decide whether or not they were related. Thus, it is plausible that individuals in negative context training transferred some learning from context training to the interpretation phase. Negative valenced words form a tight cohesive category, so deciding whether or not two negatively valenced words are related or unrelated is a hard task. For example, consider the word-pairs *crash-wreck* (related) and *crash-bitter* (unrelated). Although *crash-wreck* is obviously related, deciding the relatedness of *crash-bitter* is not as clear. This is not because this particular word-pair was ineffectively matched, but rather because any two negatively valenced words can be seen as related, even distantly so. For example *crash-argue*, *crash-lonely*, *crash-evil*, *crash-wrong*, *crash-ugly* etc. Thus, individuals in negative context training would have likely come into the interpretation phase with a criterion of what they considered negatively related, and negative unrelated. For this reason, when faced with homophones (e.g. *steel/steal*), they might have been better at discriminating negative (e.g. *steal-rob* = related; *steal-mean* = unrelated) than neutral interpretations (e.g. *steel-iron* = related; *steel-fog* = unrelated). This of course is compared to individuals in neutral context training, who had no prior experience discriminating negatively valenced word-pairs. In summary, the mechanisms responsible for induced training-congruent biases, at the later stages of processing, in the current study, remain unclear. The pattern of results observed is consistent with both emotional category priming and transfer of processing mechanisms.

Future Directions

First, it is important to note, that the sample sizes in the current study (especially Experiment 1) were relatively small, and thus potentially under powered. It is possible, for example, that compared to those scoring lower in depression, individuals scoring higher in depression were more sensitive to detect negative homophones at both the early (Experiment 2) and later stages (Experiment 1) of processing.

A further limitation of the current study is that context training might have altered participants' responses on the mood questionnaires, which were always administered at the end of the task. In other words, after repeatedly making judgements about negatively valenced words (e.g. *loser-jerk; rape-victim; sick-vomit*), some individuals (perhaps those particularly susceptible to demand effects) might have been more inclined to answer depression-related questions in a slightly more pessimistic manner. For example, when asked the question *I feel down-hearted* *a blue* some individuals might have responded *some of the time* as opposed to *a little of the time*. These slight variations in responses could have shifted an individual from being in the lower depression group to the higher depression group, especially as this decision was simply based off a median-split. This of course could have obscured any depression effects observed at the early stages of processing. In fact, there is data to support this hypothesis. In Experiment 2, individuals scoring relatively higher as opposed to lower in depression were disproportionately split across context training conditions (neutral context training, n=9; negative context training, n=14). Similarly, individuals scoring relatively lower compared to relatively higher in depression were also disproportionately spilt across context training conditions (neutral context training, n=18; negative context training, n=9). In future, the order in which mood questionnaires are administered should be counterbalanced – half of individuals should fill them out before the cross-modal priming task, and the other half after the cross-modal priming task. This counterbalance could then be added as a between-subjects factor in the analysis of results. Furthermore, rather than classifying individuals as low or high in depression based off a median split, upper and lower quartiles could be used, as individuals scoring closer to the middle range would be the ones that would shift from the lower depression group to the higher depression group.

Second, in the current study, the context training and interpretation phases were identical in task requirements. That is, in both blocks participants heard and saw words and were required to make a relatedness judgment (decide whether the two words were related or unrelated). In order to test the boundaries of passive training in CBM-I, it would be beneficial to change the context training task from a relatedness judgement to a lexical decision. For example, in negative context training, individuals would hear a negative prime (e.g. *rage*), and then see a negative related target (e.g. *anger*), a negative unrelated target (e.g. *grave*) or a non-word target (e.g. *anter*). They would then be required to decide whether the target was a word or a non-word. Thus, participants would still be exposed to negatively valenced information, and thus meet the requirements of passive training, but would only be required to access the lexical content of the target, not necessarily its semantic meaning or its semantic relationship with the prime. Findings from this task would shed light on the level of access required to induce interpretive biases. It would also help to clarify the cognitive mechanism involved in inducing interpretive biases. Specifically, if a lexical decision task was used in context training and a relatedness judgement in the interpretation phase, individuals might be less likely to transfer learning (as the tasks would be fundamentally different).

Third, although individuals in the current study varied in degree of symptoms, they were still in the healthy range for depression. Thus, it remains unclear as to whether results from the present study generalise to (sub)clinical populations (e.g. Haaga & Solomon, 1993; Kendall, Hollon, Beck, Hammen, & Ingram, 1987). Furthermore, despite the fact individuals who partook in the study were not currently depressed, it is unknown as to whether individuals in Experiment 2 (400ms SOA) had been depressed in the past, as they consisted of a different population sample that Experiment 1 (800ms SOA). As previously discussed, Wenzlaff and Eisenberg (2001) reported that in the *early* stages of processing, previously dysphoric individuals were reminiscent of currently dysphoric individuals (negative interpretive bias), whereas in the *later* stages of processing they were more reminiscent of non-dysphoric individuals (positive interpretive bias). Thus, it would be advantageous to test the current research paradigm on previously depressed individuals, and individual's vulnerable to depression that have never been depressed in the past. This would determine whether enhanced sensitivity to negative contextual cues at the early stages of processing is attributable to the cognitions associated with vulnerability or a depressive episode. Along with neutral and negative context training, a no-training condition should also be included, in order to provide a baseline measure. For example, in the early stages of processing, previously depressed individuals might display a negative interpretive bias without any prior training (as in Wenzlaff and Eisenberg).

Finally, in the current study, neutral context training only produced non-significant neutral interpretive biases. This is likely because 'neutral' is not a salient emotion, and similarly forms less of a cohesive category than 'negative'. Future studies should explore the effect of positively valenced information on subsequent interpretation in depression. Individuals would repeatedly make judgements about unambiguous positive word-pairs (e.g. *happy-smile*; *hug-kiss*; *trophy-win*), then make judgements about positive/neutral homophones (e.g. *piece/peace*). It would be of particular interest to look at how previously depressed individuals responded to positive context training at the early and later stages of processing. For example, if previously depressed individuals sustain the negative cognitions associated with a prior depressive episode, but have developed strategies to counter them (Wenzlaff &

Eisenburg, 2001), then after positive context training they might be more likely to interpret ambiguous information in a positive (e.g. *peace-love*) as opposed to neutral (e.g. *piece-portion*) manner, but only at the later stages of processing.

Promising results from recent CBM-I studies confirm the need to expand the current research paradigm to include positively valenced information. Blackwell and Holmes (2010) found that after repeated CBM-I training sessions involving positive imagery, four out of seven clinically depressed individuals reported substantial improvements in interpretation and / or general mental health. Similar findings have been reported in the anxiety field. Individuals with Generalised Anxiety Disorder have been successfully trained to interpret novel ambiguous information in a benign as opposed to negative manner, subsequently reducing their negative thought intrusions (Hayes, Hirsch, Krebs, & Mathews, 2010). Furthermore, benign interpretations have been induced in adults (Mathews, Ridgeway, Cook, & Yiend, 2007) and children (Vassilopoulos, Banerjee, & Prautzalou, 2009) with high trait anxiety scores, and individuals reporting high levels of worry (Hirsch, Hayes & Mathews, 2009). These studies are reassuring, as they validate the potential therapeutic value of CBM-I in (sub)clinical populations.

Conclusions

The current study is the first to show evidence in favour of a depression-linked interpretative bias at the early stages of processing. At the 400ms SOA (early stages of processing), individuals in the higher depression group showed enhanced sensitivity to homophones resolved in a negative as opposed to neutral manner. This depression-linked interpretive bias is likely attributable to vulnerability factors, and is predicted by cognitive theories of depression (see, Beck, 1976, 1987, 2008; Beck & Clarke, 1988; Bower, 1981; DeRaedt & Coster, 2010; Pearsons & Miranda, 1992; Sheppard & Teasdale, 2004). However, the mechanisms responsible for inducing training-congruent biases at the 800ms SOA (later stages of processing) remain unclear. Vulnerability factors are unlikely to be the only cause, as all individuals, regardless of whether they were low or high in depression, showed enhanced sensitivity to homophones resolved in a training congruent manner. In order to differentiate between the two likely mechanisms (emotional category priming and transfer of processing) subtle changes to the research paradigm are required. For example, adding unambiguous prime-target pairs to the interpretation phase would allow the researcher to assess the possibility of emotional category priming. Further, changing the training task to a lexical decision would shed light on the level of access required to induce interpretive biases. Nonetheless, the present study opens the door for future CBM-I studies in (sub)clinical depressed populations.

References

American Psychiatric Association. (2000). Diagnostic and statistical manual of mental disorders (4th ed., text revision). Washington, DC: Author

Azorin, J.-M., Benhaïm, P., Hasbroucq, T., Possamaï, C.-A. (1995). Stimulus preprocessing and response selection in depression: A reaction time study. *Acta Psychologica*, *89*(2), 95-100. doi: 10.1016/0001-6918(94)00024-B

Barazzone, N., & Davey, G. C. L. (2009). Anger potentiates the reporting of threatening interpretations: An experimental study. *Journal of Anxiety Disorders*, *23*(4), 489-495. doi: 10.1016/j.janxdis.2008.10.007

Beck, A. T. (1976). *Cognitive therapy and the emotional disorders*. Oxford, UK: International Universities Press.

Beck, A. T. (1987). Cognitive models of depression. *Journal of Cognitive Psychotherapy*, *1*(1), 5-37.

Beck, A. T. (2008). The evolution of the cognitive model of depression and its neurobiological correlates. *The American Journal of Psychiatry*, *165*(8), 969-977. doi: 10.1176/appi.ajp.2008.08050721

Beck, A. T., & Clark, D. A. (1988). Anxiety and depression: An information processing perspective. *Anxiety Research*, *1*(1), 23-36.

Beuke, C. J., Fischer, R. & McDowall, J. (2003). Anxiety and Depression: why and how to measure their separate effects. *Clinical Psychology Review*, *23*(6), 831-848. doi: 10.1016/S0272-7358(03)00074-6

Bieling, P. J., Antony, M. M., & Swinson, R. P. (1998). The state-trait anxiety inventory, trait version: Structure and content re-examined. *Behaviour Research and Therapy*, *36*, 777-788. doi: 10.1016/S0005-7967(98)00023-0

Biggs, J. T., Wylie, L. T., & Ziegler, V. E. (1978). Validity of the Zung self-rating depression scale. *British Journal of Psychiatry*, *132*, 381–385. doi: 10.1192/bjp.132.4.381

Bisson, S., & Sears, C. R. (2007). The effect of depressed mood on the interpretation of ambiguity, with and without negative mood induction. *Cognition and Emotion*, *21*, 614-645. doi: 10.1080/02699930600750715

Blackwell, S. E., & Holmes, E. A. (2010). Modifying interpretation and imagination in clinical depression: A single case series using cognitive bias modification. *Cognitive Psychology*, *24*(3), 338-350. doi: 10.1002/acp.1680

Blanchette, I., & Richards, A. (2003). Anxiety and the interpretation of ambiguous information: Beyond the emotion-congruent effect. *Journal of Experimental Psychology: genera*l, *132*, 294-309. doi: 10.1037/0096-3445 .132.2.294

Bower, G. H. (1981). Mood and memory. *American Psychologist*, *36*, 129-148. doi: 129-148 10.1037/0003-066X .36.2.129

Bradley, B. P., Mogg, K., & Williams, R. (1995). Implicit and explicit memory for emotion-congruent information in clinical depression and anxiety. *Behaviour Research and Therapy*, *33*(7), 755-770. doi: 10.1016/0005-7967(95)00029-W

Bradley, M. M., & Lang, P. J. (1999). Affective norms for English words (ANEW): Instruction manual and affective ratings. Florida: The Center for Research in Psychophysiology, University of Florida.

Butler, G., & Mathews, A. (1983). Cognitive processes in anxiety. *Advances in Behaviour Research and Therapy*, *5*, 51-62. doi: 10.1016/0146-6402(83)90015-2

Byrne, A., & Eysenck, M. W., (1993). Individual differences in positive and negative interpretive biases. *Personality and Individual Differences*, *14*(6), 849-851. doi: 10.1016/0191-8869(93)90100-H

Byrne, D. G. (1976) Choice reaction times in depressive states. *British Journal of Clinical Psychology*, *15*, 149-156.

Calvo, M. G., & Castillo, M. D. (1997). Mood-congruent bias in interpretation of ambiguity: Stratic processes and temporary activation. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, *50*, 163-182. doi: 10.1080/027249897392279

Calvo, M. G., Eysenck, M. W., & Castillo, M. D. (1997). Interpretation bias in test anxiety: The time course of predictive inferences. *Cognition and Emotion*, *11*, 43-63. doi: 10.1080/026999397380023

Clark, L. A., & Watson, D. (1991). Tripartite model of anxiety and depression: Psychometric evidence and taxonomic implications. *Journal of Abnormal Psychology*, *100*, 316-336.

Crowley, K. E., & Colrain, I. M. (2004). A review of the evidence for P2 being an independent component process: age, sleep and modularity. *Clinical Neurophysiology, 115*, 732-744.

Dearing, K. F., & Gotlib, I. H., (2009). Interpretation of ambiguous information in girls at risk for depression. *Journal of Abnormal Child Psychology: An official publication of the International Society for Research in Child and Adolescent Psychopathology*, *37*, 79-91. doi: 10.1007/s10802-008-9259-z

De Raedt, R. & Koster, E. H. W. (2010) Understanding vulnerability for depression from a cognitive neuroscience perspective: A reappraisal of attentional factors and a new conceptual framework. *Cognitive, Affective & Behavioral Neuroscience*, *10*, 50-70. doi: 10.3758/CABN.10.1.50

Denny, E. B., & Hunt, R. R. (1992). Affective valence and memory in depression: Dissociation of recall and fragment completion. *Journal of Abnormal Psychology*, *101*(3), 575-580. doi: 10.1037/0021-843X.101.3.575

Gaskell, M. G., Marslen-Wilson, W. D. (2001). Lexical ambiguity resolution and spoken word recognition: Bridging the gap. *Journal of Memory and Language*, *44*(3), 325-349. doi: 10.1006/jmla.2000.2741

Gilboa-Schechtman, E., Erhand-Weiss, D., & Jeczemien, P., (2002). Interpersonal deficits meet cognitive biases: Memory for facial expressions in depressed and anxious men and woman. *Psychiatry Research, 113*(3), 279-293. doi: 10.1016/S0165-1781(02)00266-4

Gotlib, I. H. & Joorman, J. (2010). Cognition and depression: Current status and future directions. *Annual review of clinical psychology*, *6*, 285 – 312. doi: 10.1146/annurev.clinpsy.121208.131305

Gotlib, I. H., Krasnopervoa, E., Yue, D. N., & Joormann, J. (2004). Attentional biases for negative interpersonal stimuli in clinical depression. *Journal of Abnormal Psychology*, *113*(1), 127-135. doi: 10.1037/0021-843X.113.1.121

Grey, S., & Mathews, A. (2000). Effects of training on interpretation of emotional ambiguity. *Quarterly Journal of Experimental Psychology, 53A*, 1143-1163. doi: 10.1080/02724980050156335

Haaga, D. A., & Solomon, A. (1993). Impact of Kendall, Hollon, Beck, Hammen, and Ingram (1987) on treatment of the continuity issue in “depression” research. *Cognitive Therapy and Research*, *17*, 313-324. doi: 10.1007/BF01177657

Hadwin, J., Frost, S., French, C. C., & Richards, A. (1997). Cognitive processing and trait anxiety in typically developing children: Evidence for an interpretive bias. *Journal of Abnormal Psychology*, *106*(3), 486-490. doi: 10.1037/0021-843X.106.3.486

Hayes, S., Hirsch, C. R., Krebs, G., & Mathews, A. (2010). The effects of modifying interpretation bias on worry in generalized anxiety disorder. *Behaviour Research and Therapy*, *48*, 171-178. doi: 10.1016/j.brat.2009.10.006

Hertel, P. T., & El-Messidi, L. (2006). Am I blue? Depressed mood and the consequences of self-focus for the interpretation and recall of ambiguous words. *Behavior Therapy*, *37*, 259-268. doi: 10.1016/j.beth.2006.01.003

Higgins, E. T. (1989). Knowledge accessibility and activation: Subjectivity and suffering from unconscious sources. In J. S. Uleman & J. A. Bargh (Eds.), *Unintended Thought* (pp 75-123). New York: Guilford Press.

Hirsch, C. R., Hayes, S., & Mathews, A. (2009). Looking on the bright side: accessing benign meanings reduces worry. *Journal of Abnormal Psychology*, *118*, 44–54. doi: 10.1037/a0013473

Hirsch, C. R., & Mathews, A. (1997). Interpretative inferences when reading about emotional events. *Behaviour Research and Therapy, 12,*1123–1132. doi: 10.1016/S0005-7967(97)00069-7

Hirsch, C. R., Mathews, A., & Clark, D. M. (2007). Inducing an interpretation bias changes self-imagery: A preliminary investigation. *Behaviour Research and Therapy*, *45*(9), 2173-2181. doi: 10.1016/j.brat.2006.11.001

Hoppitt, L., Mathews, A., Yiend, J., & Mackintosh, B. (2010a). Cognitive mechanisms underlying the emotional effects of bias modification. *Applied Cognitive Psychology*, *24*(3), 312-325. doi: 10.1002/acp.1678

Hoppitt, L., Mathews, A., Yiend, J., & Mackintosh, B. (2010b). Cognitive bias modification: The critical role of active training in modifying emotional responses. Behavior Therapy, 41, 73–81. doi:10.1016/j.beth.2009.01.002

Johnson, R. Jr (1995). Event-related potentials insights into the neurobiology of memory systems, in *Handbook of Neuropsychology*, vol 10. Edited by Boller F, Grafman J. New York, Elseveir, pp135-163.

Joormann, J., & Gotlib, I. H., (2007). Selective attention to emotional faces following recovery from depression. *Journal of Abnormal Psychology*, *116*(1), 80-85. doi: 10.1037/0021-843X.116.1.80

Joormann, J., Talbot, L., & Gotlib, I. H., (2007). Biased processing of emotional information in girls at risk for depression. *Journal of Abnormal Psychology*, *116*(1), 135-143. doi: 10.1037/0021-843X.116.1.135

Judd, L. L. (1997). The clinical course of unipolar major depressive disorder. *Archives of General Psychiatry*, *54*(11), 989-991.

Kendall, P. C., Hollon, S. D., Beck, A. T., Hammen, C. L., & Ingram, R. E. (1987). Issues and recommendations regarding use of the Beck Depression Inventory. *Cognitive Therapy and Research*, *11*, 289-299. doi: 10.1007/BF01186280

Knight, R. G., Waal-Manning, J., & Spears, G. F. (1983). Some norms and reliability data for the state-trait anxiety inventory and the Zung self-rating depression scale. *British Journal of Clinical Psychology*, *22*, 245–249.

Koster, E. W., De Raedt, R., Leyman, L., & De Lissnyder, E. (2010). Mood-congruent attention and memory bias in dysphoria: Exploring the coherence among information-processing biases. *Behaviour Research and Therapy*, *48*(3), 219-225. doi: 10.1016/j.brat.2009.11.004

Kucera and Francis, W.N. (1967). *Computational Analysis of Present-Day American English.* Providence: Brown University Press.

Kutas, M., & Federmeier, K. D. (2011). Finding meaning in the N400 component of the event-related brain potential (ERP). *Annual Review of Psychology*, *62*, 621-647. doi: 10.1146/annurev.psych.093008.131123

Lawson, C., & MacLeod, C. (1999). Depression and the interpretation of ambiguity. *Behaviour Research and Therapy*, *37*, 463-474. doi: 10.1016/S0005-7967 (98)00131-4

Lawson, C., MacLeod, C., & Hammond, G. (2002). Interpretation revealed in the blink of an eye: Depressive bias in the resolution of ambiguity. *Journal of Abnormal Psychology, 111*(2), 321-328. doi: 10.1037/0021-843X.111.2.321

Lucas, M. (1999). Context effects on lexical access: A meta-analysis. *Memory and Cognition*, *27*(3), 385-398.

Mackintosh, B., Mathews, A., Yiend, J., Ridgeway, V., & Cook, E. (2006). Induced biases in emotional interpretation influence stress vulnerability and endure despite changes in context. *Behavior Therapy*, *37*(3), 209-222. doi: 10.1016/j.beth.2006.03.001

MacLeod, C., (1990). Mood disorders and cognition. In M. W. Eysenck (Ed.), *Cognitive psychology: An international review* (pp. 9-56) Oxford: Wiley.

MacLeod, C., & Cohen, I. L. (1993). Anxiety and the interpretation of ambiguity: A comprehension study. *Journal of Abnormal Psychology*, *102*(2), 238-247.doi: 10.1037/0021-843X.102.2.238

MacLeod, C., & Mathews, A. (1991). Biased cognitive operations in anxiety: Accessibility of information or assignment of processing priorities. *Behaviour Research and Therapy*, *29*(6), 599-610. doi: 10.1016/0005-7967(91)90009-R

Macmillan, N. A., & Creelman, C. D. (2005). *Detection Theory: A User's Guide (2nd ed.).* Mahwah, N.J.: Lawrence Erlbaum Associates.

Mathews, A., & Mackintosh, B. (2000a). Take a closer look: emotion modifies the boundary extension effect. *Emotion*, *4*(1), 36-45. doi: 10.1037/1528-3542.4.1.36

Mathews, A., & Mackintosh, B. (2000b). Induced emotional interpretation bias and anxiety. *Journal of Abnormal Psychology*, *109*, 602-615.

Mathews, A., & MacLeod, C. (2002). Induced processing biases have causal effects on anxiety. *Cognitive and Emotion*, *16*(3), 331-354. doi: 10.1080/02699930143000518

Mathews, A., Richards, A. & Eysenck, M. (1989). Interpretation of homophones related to threat in anxiety states. *Journal of Abnormal Psychology*, *98*, 31-34. doi: 10.1037/0021-843X.98.1.31

Mathews, A., Ridgeway, V., Cook, E., & Yiend, J. (2007). Inducing a benign interpretational bias reduces trait anxiety. *Journal of Behavior Therapy and Experimental Psychiatry*, *38*, 225–236. doi: 10.1016/j.jbtep.2006.10.011

Mogg, K., Bradbury, K. E., & Bradley, B. P. (2006). Interpretation of ambiguous information in clinical depression. *Behaviour Research and Therapy*, *44*, 1411-1419. doi: 10.1016/j.brat.2005.10.008

Mogg, K., Bradley, B. P., Miller, T., Potts, H. (1994). Interpretation of homophones related to threat: Anxiety or response bias effects? *Cognitive Therapy and Research*, *18*(5), 461-477. doi: 10.1007/BF02357754

Murray C, Lopez A. (1996). Evidence-based health policy—lessons from the Global Burden of Disease Study. *Science, 274,* 740–43.

Naumann, E., Bartussek, D., Diedrich, O., & Laufer, M. E. (1992). Assessing cognitive and affective information processing functions of the brain by means of the late positive complex of the eventrelated potential. J Psychophys, 6, 285-298.

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (1998). The University of South Florida word association, rhyme, and word fragment norms. Retrieved from: http://www.usf.edu/FreeAssociation

Nunn, J. D., Matthews, A., & Trower, P. (1997). Selective processing of concern-related information in depression. *British Journal of Clinical Psychology, 36*, 489-503.

Nygaard, L. C., & Lunders, E. R. (2002). Resolution of lexical ambiguity by emotional tone of voice. *Memory and Cognition*, *30*(4), 583-593.

Persons, J. B., & Miranda, J. (1992). Cognitive theories of vulnerability to depression: Reconciling negative evidence. *Cognitive Therapy and Research. Special Issue: Cognitive vulnerability to psychological dysfunction*, *16,* 485-502. doi: 10.1007/BF01183170

Rapaport, M. H. (2001). Prevalence, recognition, and treatment of comorbid depression and anxiety. *Journal of Clinical Psychiatry*, *62*, 6-10.

Richards, A., Blanchette, I., & Munjiza, J. (2007). Contextual influences in the resolution of ambiguity in anxiety. *Cognition and Emotion*, *21*(4), 879-890. doi: 10.1080/02699930601054018

Richards, A., & French, C. C. (1992). An anxiety-related bias in semantic activation when processing threat/neutral homographs. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, *45A*, 503-525.

Ridout, N., Astell, A. J., Reid, I. C., Glen, T., & O'Carroll, R. E., (2003). Memory bias for emotional facial expressions in major depression. *Cognitive and Emotion*, *17*(1), 101-122. doi: 10.1080/02699930302272

Ridout, N., Noreen, A., & Johal, J. (2009). Memory for emotional faces in naturally occurring dysphoria and induced sadness. *Behaviour Research and Therapy*, *47*(10), 851-860. doi: 10.1016/j.brat.2009.06.013

Russo, R., Patterson, N., Roberson, D., Stevenson, N (1996). Emotional value of information and its relevance in the interpretation of homophones in anxiety. *Cognition and Emotion*, *10*(2), 213-220. doi: 10.1080/026999396380349

Salemink, E., van den Hout, M., & Kindt, M. (2010). Generalisation of modified interpretation bias across tasks and domains. *Cognition and Emotion*, *24*(3), 453-464. doi: 10.1080/02699930802692053

Shestyuk, A. Y. & Deldin, P. J. (2010). Automatic and strategic representation of the self in major depression: Trait and state abnormalities. *The American Journal of Psychiatry*, *167*(5), 536-544.

Sears, C. R., Bisson, S., & Neilson, K. E. (2010). Dysphoria and the immediate interpretation of ambiguity: Evidence for negative interpretive bias in error rates but not response latencies. *Cognitive Therapy and Research*, Online First™, 15 May, 2010. doi: 10.1007/s10608-010-9314-2

Sheppard, L. C. & Teasdale, J . D. (2004). How does dysfunctional thinking decrease during recovery from major depression? *Journal of Abnormal Psychology*, *113*(1), 64-71. doi: 10.1037/0021-843X.113.1.64

Simpson, G. B. (1984). Lexical ambiguity and its role in models of word recognition. *Psychological Bulletin*, *96*(2), 316-340. doi: 10.1037/0033-2909.96.2.316

Simpson, G. B., & Burgess, C. (1985). Activation and selection processes in the recognition of ambiguous words. *Journal of Experimental Psychology*, *11*(1), 28-39. doi: 10.1037/0096-1523.11.1.28

Simpson, G. B., & Kang, H. (1994). Inhibitory proceses in the recognition of homograph meanings. In D. Dagenbach & T.H. Carr (Eds), *Inhibitory processes in attention, memory and language.* San Diego, C.A.: Academic Press.

Simpson, G. B., & Krueger, M. A. (1991). Selective access of homograph meanings in sentence context. *Journal of Memory and Language*, *30*, 627-642.

Smallwood, J. (2004). Brief Report: Self-reference, ambiguity, and dysphoria. *Cognition and Emotion*, *18*(7), 999-1007. doi: 10.1080/02699930341000293

Swinney, D. (1979). Lexical access during sentence comprehension: (Re) considering of context effects. *Journal of Verbal Learning and Verbal Behavior*, *18*, 645-659.

Vassilopoulos, S. P., Banerjee, R., & Prautzalou, C. (2009). Experimental modification of interpretation bias in socially anxious children: Changes in interpretation, anticipated interpersonal anxiety, and social anxiety symptoms. *Behavior Research and Therapy*, *47*, 1085-1089.

Wenzlaff, R. M., & Eisenberg, A. R. (2001). Mental control after dysphoria: Evidence of a suppressed, depressive bias. *Behavior Therapy*, *32*(1), 27-45. doi: 10.1016/S0005-7894(01)80042-3

Williams, J. M. G., Watts, F. N., MacLeod, C., Mathews, A. (1988). Cognitive psychology and emotional disorders. Chichester, UK: Wiley.

Williams, J. M. G., Watts, F. N., MacLeod, C., Mathews, A. (1997). Cognitive psychology and emotional disorders (2nd ed). Chichester, UK: Wiley.

Wilson, E. J., MacLeod, C., Mathews, A., & Rutherford, E. M. (2006). The causal role of interpretive bias in anxiety reactivity. *Journal of Abnormal Psychology*, *115*(1), 103-111. doi: 10.1037/0021-843X.115.1.103

World Health Organization, (2011a), *Depression*. Retrieved from: http://www.who.int/mental_health/management/depression/definition/en/

World Health Organization, (2011b), *Suicide prevention* (*SUPRE*). Retrieved from: http://www.who.int/mental_health/prevention/suicide/suicideprevent/en/

Yiend, J., Mackintosh, B., & Mathews, A. (2005). Enduring consequences of experimentally induced biases in interpretations. *Behaviour Research and Therapy*, *43*(6), 779-797. doi: 10.1016/j.brat.2004.06.007

Zung, W. W. (1965). A self-rating depression scale. *Archives of General Psychiatry*, *12*(1),63–70. Retrieved from: http://healthnet.umassmed.edu/mhealth/ZungSelfRatedDepressionScale.pdf

Zung, W. W. (1971). A rating instrument for anxiety disorders. Psychosomatics: *Journal of Consultation Liaison Psychiatry*, *12*(6), 371–379. Retrieved from: http://healthnet.umassmed.edu/mhealth/ZungSelfRatedAnxietyScale.pdf

Zung, W. W. (1972). The depression status inventory: An adjunct to the self rating *depression scale. Journal of Clinical Psychology*, *28*, 539–543.

Appendix A

Zung Self-Rating Depression and Anxiety Scales
(Depression questions = 1-20; Anxiety questions = 21-40)

Read each sentence carefully. For each statement, select the response that best corresponds to how often you have felt that way in the last 2 weeks.

	A little of the time	**Some of the time**	**Good part of the time**	**Most of the time**
1. I feel down-hearted and blue				
2. Morning is when I feel the best				
3. I have crying spells or feel like it				
4. I have trouble sleeping at night				
5. I eat as much as I used to				
6. I still enjoy sex				
7. I notice that I am losing weight				
8. I have trouble with constipation				
9. My heart beats faster than usual				
10. I get tired for no reason				
11. My mind is as clear as it used to be				
12. I find it easy to do the things I used to				
13. I am restless and can't keep still				
14. I feel hopeful about the future				
15. I am more irritable than usual				
16. I find it easy to make decisions				
17. I feel that I am useful and needed				
18. My life is pretty full				
19. I feel that others would be better off if I were dead				
20. I still enjoy the things I used to do				
21. I feel more nervous and anxious than usual				
22. I feel afraid for no reason at all				
23. I get upset easily or feel panicky				
24. I feel like I'm falling apart and going to pieces				
25. I feel that everything is all right and nothing bad will happen				
26. My arms and legs shake and tremble				
27. I am bothered by headaches neck and back pain				
28. I feel weak and get tired easily				
29. I feel calm and can sit still easily				
30. I can feel my heart beating fast				
31. I am bothered by dizzy spells				
32. I have fainting spells or feel like it				
33. I can breathe in and out easily				
34. I get feelings of numbness and tingling in my fingers and toes				
35. I am bothered by stomach aches or indigestion				
36. I have to empty my bladder often				
37. My hands are usually dry and warm				
38. My face gets hot and blushes				
39. I fall asleep easily and get a good night's rest				
40. I have nightmares				

Appendix B

Context prime-target pairs

Prime	Target		Prime	Target	
Neutral	Related	Unrelated	*Negative*	Related	Unrelated
arm	leg	green	abuse	beat	vomit
black	white	bacon	blind	deaf	argue
book	read	boat	burn	fire	deaf
cat	dog	hammer	crash	wreck	bitter
chair	table	brush	cruel	evil	scold
clock	watch	drink	debt	owe	lonely
cork	screw	road	depressed	lonely	owe
cow	milk	open	fat	ugly	cut
door	open	animal	fight	argue	dirt
egg	bacon	dog	fraud	fake	disease
elbow	knee	diary	germs	disease	dislike
farm	animal	head	gloom	dull	evil
foot	shoe	driver	greed	selfish	dull
frog	green	jacket	grief	sorrow	fake
hard	soft	leg	hate	dislike	fire
hat	head	light	loser	jerk	squeeze
journal	diary	knee	pinch	squeeze	garbage
jug	drink	lock	rage	anger	grave
key	lock	elephant	rape	victim	waste
lamp	light	pebble	scar	cut	conceited
month	year	rubber	scorn	scold	selfish
paint	brush	milk	scum	dirt	smack
pencil	rubber	tall	sick	vomit	wreck
rock	pebble	read	sin	wrong	beat
ship	boat	shoe	slap	smack	ugly
spray	squirt	white	snob	conceited	sting
street	road	squirt	sour	bitter	victim
tool	hammer	year	stink	garbage	anger
tower	tall	soft	stupid	dumb	sorrow
truck	driver	screw	tomb	grave	jerk
trunk	elephant	watch	trash	waste	dumb
vest	jacket	table	wasp	sting	wrong

Note: Context primes were primarily one syllable words, as the homophone primes were primarily one syllable words.

Appendix C

Valence ratings of selected homophones

Neutral			Negative			Neutral - Negative
	M	SD		M	SD	
Bale	3.13	0.83	Bail	2.38	0.92	0.75
Band	3.63	0.92	Banned	1.75	0.46	1.88
Blew	2.88	0.35	Blue	2.00	0.76	0.88
Board	3.13	0.83	Bored	1.38	0.52	1.75
Brake	3.00	0.53	Break	1.88	0.64	1.13
Brews	3.00	0.00	Bruise	1.63	0.52	1.38
Chute	3.00	0.00	Shoot	1.25	0.46	1.75
Course	3.13	0.64	Coarse	2.25	0.46	0.88
Dam	3.00	0.00	Damn	1.63	0.74	1.38
Dye	3.25	0.46	Die	1.00	0.00	2.25
Find	3.50	1.07	Fined	1.25	0.46	2.25
Floor	3.13	0.35	Flaw	1.63	0.52	1.50
Flew	3.63	0.74	Flu	1.13	0.35	2.50
Fort	3.25	0.46	Fought	1.88	0.64	1.38
Fowl	2.63	0.74	Foul	1.25	0.46	1.38
Grown	3.50	0.53	Groan	1.50	0.53	2.00
Hertz	2.75	0.71	Hurts	1.25	0.46	1.50
Mall	3.38	0.52	Maul	2.00	1.51	1.38
Mist	3.25	0.46	Missed	2.13	0.64	1.13
Morning	3.38	1.06	Mourning	1.38	0.74	2.00
Mown	2.75	0.46	Moan	1.63	0.74	1.13
Pane	2.88	0.35	Pain	1.38	0.74	1.50
Pour	2.88	0.35	Poor	1.38	0.52	1.50
Sell	3.13	0.35	Cell	2.88	0.64	0.25
Sleigh	3.50	0.76	Slay	1.63	0.74	1.88
Soar	3.25	0.89	Sore	1.38	0.74	1.88
Steel	2.88	0.35	Steal	1.75	1.39	1.13
Tees	3.00	0.00	Tease	2.25	1.30	0.75
Tents	3.00	0.00	Tense	1.38	0.52	1.63
Vein	2.63	0.52	Vain	1.25	0.46	1.38
Week	2.75	0.71	Weak	2.00	0.00	0.75
Whale	3.63	0.74	Wail	1.63	0.74	2.00

Appendix D

Valence ratings of excluded homophones.

Neutral	M	SD	Negative	M	SD	Neutral - Negative
Bald	1.63	0.92	Bawled	1.25	0.71	0.38
Berry	4.00	0.76	Bury	2.13	0.64	1.88
Flee	2.25	0.89	Flea	1.13	0.35	1.13
Hose	3.13	0.35	Hoes	2.38	0.74	0.75
Know	3.75	0.71	No	2.25	0.89	1.50
Lone	1.88	0.35	Loan	1.75	0.71	0.13
Lye	2.33	0.82	Lie	1.38	0.52	0.96
Patience	4.00	0.53	Patients	2.88	0.83	1.13
Raw	2.25	0.71	Roar	2.63	1.06	-0.38
Scull	2.63	0.74	Skull	2.38	0.52	0.25
Cereal	2.75	0.46	Serial	2.38	0.74	0.38
Steak	3.50	0.76	Stake	2.75	0.46	0.75
Earn	3.63	0.92	Urn	2.13	0.64	1.50
Wine	4.38	0.52	Whine	1.13	0.35	3.25

Appendix E

Homophone prime-target pairs.

Prime		Target			
		Related		Unrelated	
Neutral /	Negative	Neutral	Negative	Neutral	Negative
bale	bail	hay	court	camping	nervous
band	banned	music	forbidden	sky	ache
blew	hurts	wind	harms	bird	sick
blue	hertz	volts	sad	discover	sigh
bored	board	game	tired	boils	rough
brake	break	stop	smash	sale	tired
brews	briuse	boils	cut	ink	fault
cell	sell	sale	jail	tunnel	harms
chute	shoot	tunnel	gun	river	curse
course	coarse	obstacle	rough	snow	death
damn	dam	river	curse	stop	gun
die	dye	ink	death	night	ticket
find	fined	discover	ticket	ground	sad
flaw	floor	ground	fault	blood	lost
flu	flew	bird	sick	grass	smash
fought	fort	treehut	fight	spill	deprived
fowl	foul	chicken	smell	glass	agony
groan	grown	old	grunt	shopping	maim
mall	maul	shopping	maim	old	grunt
mist	missed	fog	lost	volts	jail
morning	mourning	night	grief	game	murder
mown	moan	grass	sigh	day	frail
pain	pane	glass	agony	chicken	smell
pour	poor	spill	deprived	treehut	fight
slay	sleigh	snow	murder	obstacle	grief
sore	soar	sky	ache	music	forbidden
steal	steel	iron	rob	fog	mean
tees	tease	shirt	mean	iron	rob
tense	tents	camping	nervous	hay	court
vein	vain	blood	arrogant	ocean	cry
wail	whale	ocean	cry	shirt	arrogant
weak	week	day	frail	wind	cut