

THE INFLUENCE OF NEGATIVE AFFECT ON SELF-REFERENT  
SENTENCE PROCESSING AND MEMORY PERFORMANCE

BY

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### Specific Aims

The current study will investigate how a negative mood state affects sentence processing in individuals that have never experienced depression. Empirically, the goal of this research is to investigate how an induced negative mood state affects the judgment of plausible and implausible sentences that contain self-referent material. Past research in the domain of semantic processing has found evidence for a distinct attention bias for items that contain emotional content (Bradley et al., 2001; Lang, Bradley, & Cuthbert, 1997) and evidence supports that this bias is relevant to an individual's past experience with depression (Borod, Bloom, & Haywood, 1998; Atchley, Ilardi, & Enloe, 2003; Ilardi et al., 2007; Levin et al., 2007). More generally, there has been significant evidence to suggest that items having emotional significance affect cognition in the form of enhanced performance (Bradley et al. 2001; Kern et al., 2002; Atchley, Ilardi, & Enloe, 2003; Kensinger & Corkin, 2003). For the current study, enhanced cognitive performance will include faster lexical access, faster decision-making abilities, and improved recall accuracy due to the increased salience of emotional stimuli. Increased salience facilitates our ability to detect the meaning of an emotional stimulus, therefore, improving response time and correct response accuracy. More specifically, this study will explore the phenomenon of enhanced cognitive performance by measuring the occurrence of faster reading time and faster reaction time for making semantic decisions based on sentence content and better recall accuracy for emotional words in the sentences presented.

Researchers have suggested numerous influences that emotion has on memory performance, such as greater recall accuracy for emotionally-valent items and increased recall accuracy while in a valenced mood state (see review by Blaney, 1986; and also Buchanan, 2007). As this study will be assessing memory for emotion-related material and memory performance while in a negative mood state, a review of the influence of emotion on recall performance will be provided. Regarding recall performance for negatively-valent material, assumptions that negative emotional content drives attentional biases (Davidson, 1990; Levin et al., 2007) and emotion-related items increase physiological arousal (Bradley et al., 2001; Kensinger & Corkin, 2003) are well accepted explanations for why there is increased recall for emotion-related content. For example, research conducted by Kensinger and Corkin (2003) showed an advantage for remembering emotionally valent words over neutral words and a greater advantage for recalling words with high arousal content (eg. anger) over words with low arousal content (eg. shy). A study by Schupp et al. (2004) found an attentional bias for negative pictures with high arousal content and these researchers proposed that this effect to be due to motivated attention.

The theory of motivated attention argues that evolutionary significance is assigned to stimuli in our environment in the form of increased salience so that attention is guided toward information that is critical for survival (Lang, Bradley, & Cuthbert, 1997; Bradley et al., 2001). For these researchers, emotional content refers to the degree to which an environmental stimulus conveys semantic meaning that is relevant to survival. The degree to which a stimulus drives our

attention and innervates arousal systems in the brain are determined by the impact an emotional stimulus has pertaining to evolutionary significance. The level of emotion has been measured by Lang, Bradley, and colleagues according to arousal, which reflects the intensity of the stimulus, and valence, reflecting the degree to which a stimulus is negative or positive. The degree to which a word stimulus can be measured regarding its negative and positive valence is of particular interest to the current study as sentences will be presented that include positive, negative, and neutral words. The primary research goal of this study is to examine how the semantic aspects of emotional valence influence cognitive performance and so words rated high in arousal have been excluded from our stimulus lists.

The current study is concerned with the linguistic aspects of cognitive performance while processing emotional items. We will investigate how emotion impacts cognitive performance using sentences with emotion-related words, a method that has been shown to elicit emotional processing (Landis, 2006; Kissler et al., 2007; Herbert, Junghofer, & Kissler, 2008; Silvert et al., 2004; see also review by Shanahan, 2008). Attentional biases in decision-making tasks have been explored at length, providing evidence for the increased salience of emotional items and also evidence for increased performance when making a decision about words that convey emotional meaning (Borod et al., 1998; Atchley et al., 2003; Ilardi et al., 2007; Levin et al., 2007). Emotion researchers consider attentional biases toward emotion-related content a survival mechanism that produces an advantage when performing a cognitive task and several researchers

have linked this phenomenon to increased levels physiological arousal driven by emotion stimuli (Tucker, 1981; Derryberry & Tucker, 1992; Bradley et al., 2001; Schupp et al., 2004). Schupp et al. (2004) suggests that levels of physiological arousal can be modulated by the level of emotional-arousal present in a stimulus and that emotion content, particularly content rated high in arousal, requires more mental resources. Considering that physiological arousal can be modulated by emotional content, neuroimaging evidence demonstrates that both cortical and subcortical areas play a large role in emotion processing (Damasio et al., 2000) and that processing at both the cortical and subcortical level can play a large role in determining emotional significance. In the following review, a discussion of the substantial amount of evidence supporting the role of specific subcortical structures in processing emotional information (Derryberry and Tucker, 1992) will be considered.

Within the literature pertinent to particular anatomical structures being involved in emotion processing, there is evidence for activation in the left and right hemispheres being influenced by whether this information is aversive or appetitive (Tucker, 1981; Davidson, 1990; Davidson, 2000; Landis; 2006). Other researcher, such as recent work done by Atchley, Ilardi, and Enloe (2003), suggests that the right hemisphere plays a highly specific role in emotional language processing. Using depressed and remitted-depressed patients, this research provides behavioral aspects of semantic processing that are not mood-state specific, but rather trait-specific. In thinking of how mood dependent cognition is related to more enduring trait-like aspects of personality, research

presented by Levin et al. (2007) suggests that depression can result from a prolonged negative mood state. The current study has implications for investigating the mechanisms that underlie transient mood and how this can influence semantic access for emotional words. Currently, theories related to the processing of emotion require more evidence to differentiate between the effect of a transient mood state and the experience of prolonged negative affect, as suggested by researchers such as Levine and Burgess (1997). The current research intends to provide evidence for how valenced emotional states influence the processing of emotional stimuli in never-depressed individuals.

This research also will explore the effects of word valence on recall for emotional and neutral sentences with a particular interest in how a self-referent context can affect emotion processing (see review by Ingram, 1990). Emotion and memory researchers such as Kern et al. (2002; 2005) have found that a negative mood state aids the availability of negative memories and that negative mood results in enhanced memory performance. Somewhat incompatible findings are presented by Davidson (2003), who suggests overall poor memory performance while in a negative mood state. The current research intends to provide further evidence of the influence of a negative mood on memory performance and sentence processing.

How the judgment of valenced sentences changes after the induction of a negative mood is the primary aim of the current research and this will provide insight into how never-depressed individuals process emotion. This research could also influence our understanding of emotion processing in clinically

depressed populations regarding semantic organization in a negative mood. Positive, negative, and neutral sentences that include self-referent material will be used to test whether an induced negative mood state affects reading time, aspects of judging of sentence plausibility, and memory performance. To help us interpret the current research, an outline of past research related to our current goals from the perspective of emotion research in cognitive neuroscience and how emotion is related to language comprehension and memory processing is provided. We also will provide background considerations relevant to an investigation of how emotion is processed while in a valenced mood state.

In summary, the primary theoretical goal of this research is to study the impact of emotion on higher order cognition. Numerous models of emotion that have been developed are applicable to this research. Thus, many of the researchers who have developed these models will be discussed, with a particular focus on the domains of language comprehension, memory, and emotion in cognitive neuroscience. The following review provides a targeted discussion of the research theories related to emotional cognition that have led to the current research goals. We will begin with a general outline of the dominant models of emotion processing in the domain of cognitive neuroscience.

### Emotion in Cognitive Neuroscience

Before the turn of the 20<sup>th</sup> century, emotion was considered a brain mechanism activated after the emergence of an exciting stimulus (James, 1884), although the emotion model established by William James and later developed by Carl Lange specified that emotion was not the cause of physiological change

(Lange, 1922). These researchers suggested that the emotional response is a brain reaction to the physiological changes that take place in the body. Emotion did not occur after the presentation of an arousing stimulus, but only after physiological elements manifested in behavior such as crying, trembling with fear, or an increase in heart rate. James and Lange referred to emotion as our perception of the physiological systems that activate in response to our environment (Lange, 1922).

Contemporary theory of emotion perception hypothesizes that emotion processing activates upon the perception of emotional significance in our environment, as in the case of seeing a face (Tracy & Robins, 2008). The stimulus elicits a particular bodily response as the physiological reactions related to the nature of that emotional stimulus are activated (Lange, 1922). James and Lange made a controversial assumption of which instance occurred first, the emotion or the behavior. Today, emotion research assumes that cognitive processing activates these physiological body states, though many researchers are elaborating upon the James-Lange theory of emotion by investigating the interaction between the brain and other parts of the body. The James-Lange theory of emotion was certainly a motivating idea to begin considering the phenomenon of emotion more exclusively.

Over the course of a century, cognitive neuroscience and research in physiology have built on this operational definition of emotion. For example, Damasio and colleagues consider emotion to be the unconscious physiological system that activates after an evolutionarily significant stimulus is presented

(Damasio, 1998; Damasio et al., 2000). Damasio and colleagues present much of their emotion research based on a brain-body feedback loop, a system that takes into account that emotion is not merely the conscious perception of the physiological change that is taking place. These researchers tell us that unconscious feedback from the body is essential to emotional perception.

Evidence for the unconscious perception of emotion presented by Damasio et al. (2000) suggests that feeling an emotion draws upon both cortical and subcortical structures that belong to patterns of neural activity that have developed throughout the evolution of our species. These researchers posit that emotion be considered a whole-body regulation mechanism closely related to maintaining homeostasis, as feeling an emotion draws upon brain structures that both receive internal signals, via the peripheral nervous system, and distribute these signals, via the spinal cord. Considering basic emotion processes as related to homeostasis is important for the theory that has driven much of the work done by Damasio and colleagues and Damasio's somatic-marker hypothesis considers the regulatory nature of emotion as an example of how integrative emotion systems affect more than conscious perception, as in cases of how stress can lead to fatigue and heart disease.

With the somatic-marker hypothesis, Bechara and Damasio (2006) suggest that emotion systems are integrated at the level of decision-making. In this article, Bechara and Damasio propose that distinct bodily feedback systems associated with emotional states such as joy and fear are drawn upon when making economic decisions. The basis of this theory suggests the significant influence that emotion

has on all of cognition while also contributing to the operational definition of emotion.

Rainville et al. (2006) provided further evidence that distinct cardiorespiratory patterns can be elicited by discrete emotions. In this case, the same neural systems that influence behaviors associated with homeostasis are accessed when basic emotional states are elicited. The relationship between the neural activation for emotion and bodily responses is a key component of the somatic-marker hypothesis. Damasio and colleagues continue to find evidence suggesting that bioregulatory feedback is essential to the nature of emotion processing. The involvement of homeostatic mechanisms in a feedback loop with neural systems activated by emotion processing suggests that emotion has greatly impacted the evolution of our visceral systems.

Damasio et al. (2000) found distinct patterns of activation for the elicitation of sadness, happiness, anger, and fear. This and other more recent models introduce anatomical structures functioning synchronously with the perception of discrete emotions and these models contribute to the modern approach to studying emotion processing. With some information about the history of emotion and how research on emotion has changed with the emergence of cognitive neuroscience, we will next consider more specific approaches to studying emotion that take into account the functions of the limbic system and the impact of subcortical structures on emotion processing.

## Subcortical Models of Emotion

While researchers such as William James, Carl Lange, and Antonio Damasio draw their attention to how emotion functions outside the central nervous system, other researchers have focused more on the subcortical brain structures that play a critical role in emotion processing. Among them, one of the most influential approaches has come from the work of Don Tucker, whose research has had a great influence on unraveling the influence of subcortical arousal systems on cognition (Tucker, 1981; Tucker & Williamson, 1984; Derryberry & Tucker, 1992).

In order to set aside the long-standing view that emotional states and biological substrates related to emotion are nonspecific and result in general arousal, Derryberry and Tucker (1992) suggested that the initial processing of information in our environment gives an advantage to emotional stimuli, so that our behavior serves either our appetitive goals or our interest to withdrawal from an environmental stimulus, as in the case of danger or threat. The structures that contain the neural pathways that these researchers suggest as the foundation of emotional processing consist of the brainstem and limbic system structures. They state that emotion systems are necessary in the response systems that can orchestrate a coordinated effort to evaluate and react to the environment. These systems are highly distributed in the brain and specific response patterns have developed in order to achieve goal states that we perceive as emotional experience. What has been discussed in the review by Derryberry and Tucker (1992) has also been supported by work presented by researchers such as

Damasio and colleagues that have found highly distributed brain activation while participants reported feeling emotion (Damasio et al., 2000).

The activation of subcortical structures can emerge upon the presentation of auditory or visual sensory information or this activation can be generated from within the individual. An interesting example of internal sensory generation is found by eliciting emotion using declarative memory, as evidenced by Philippot et al. (2003) by asking participants to recall personal memories. Derryberry and Tucker (1992) designed a model of the neural pathways that are activated upon the presentation of emotional information coming from an external source. These researchers theorize that, through evolution, our ability to process emotion has developed brain structures that are efficiently organized in order to allocate our mental resources to stimuli that are more significant to survival. Their argument provides a fundamental framework for a discussion of discrete emotions and provides assumptions as to why we have evolved in a way that gives priority to emotional information in our environment.

Interpreting evidence from brain imaging techniques that reveal the activation sites in response to emotional-related environmental stimuli, Derryberry and Tucker (1992) speculate that the subcortical structures specific to the initial processing of emotion have developed directly from more primitive structures that perform basic regulatory as well as basic motor and arousal functions essential for homeostasis and the fundamental aspects of survival, such as our level of consciousness and our amount of hunger. These emotional structures, including the hypothalamus and the limbic system, are organized so

that appraisal and judgment can be most efficient. For example, Derryberry and Tucker discuss structures within the hippocampus that play a large role in emotion processing through the application of long-term memory stores.

Derryberry and Tucker (1992) suggest that as our species evolved with more complex neural circuitry than other species. They claim that the structures crucial for emotion processing, such as those involved in homeostatic responses and memory, developed patterns of activation that are more efficient due to their close proximity. The authors suggest that due to the particular location of these structures and the specific roles that they undertake, their activation appears to be critical for our response to an emotional stimulus. The structures critical for emotion processing require access to highly distributed neural networks in order to fulfill their function, as the brain is capable of activating a global response to an emotional stimulus. The involvement of these areas in emotion processing and memory demonstrate the importance of the interaction between these two cognitive abilities and the impact that arousal systems can have on memory and information processing more generally.

The model developed by Derryberry and Tucker (1992) functions according to how appetitive or aversive the qualities of a stimulus might appear. For example, we may react according to the degree which an environmental stimulus generates physiological arousal. The emotional structures involved in the initial appraisal are suggested to be essential in the evolution of our species, as these structures have become integrated among all of our cognitive processes by elaborating on fundamental mechanisms of perception. For example, emotion

contributes to the perceptual modality of vision through the activation of express saccades. This can be seen in the case of the thalamus filtering sensory information to be sent via the ventral pathway before sending information to cortical structures involved in higher order cognitive processing. Due to the complex nature of the neural pathways involved in processing emotional stimuli, higher cognitive functions such as memory and learning are often regarded as automatic functions influenced by our ability to discern emotional cues within our environment so that more emotional information is given priority, as this information could be detrimental to our survival.

The concept of survival mechanisms was also addressed by Tucker and Williamson (1984) in a review of the neurotransmitter systems that underlie motor readiness. By changing the qualitative nature of the information perceived in our environment, subcortical substrates can give priority to emotional information and cue the activation systems related to perceptual arousal and motor readiness. Evidence that dopaminergic pathways can be traced to the basal ganglia is suggested as the foundation of postural readiness and motivated attention, two crucial components of the fight or flight response (Tucker & Williamson, 1984). Dopamine is an excitatory neurotransmitter related to motor performance generated in the basal ganglia and it is shown to innervate cortical areas of the left hemisphere that are involved in reward systems. This evidence demonstrates how specific neurotransmitters operating on the level of motor behavior are integrated with our neural systems involved in emotion processing.

Here, Tucker and Williamson suggest that reward systems use dopamine to initiate approach behavior.

Additionally, Tucker and Williamson (1984) discuss noradrenergic pathways initiated by the locus coeruleus as the basis for perceptual awareness, which is necessary for regulating arousal. More specifically, norepinephrine is described as having the ability to regulate neural systems by using an advanced filtering mechanism in order to find novel stimuli in our environment. This subcortical model based on evolutionary significance, motor readiness, and arousal advanced by Tucker and colleagues is consistent with another subcortical model of emotion referred to as the theory of Motivated Attention.

The theoretical construct of Motivated Attention has been of particular interest to the research of Bradley and Lang (Lang et al., 1997; Bradley et al., 2001; Bradley et al., 2003; Schupp et al., 2004; Hillman et al., 2004). This theory states that evolutionarily significant stimuli in our environment activate the subcortical arousal networks necessary in order for the resources of cognitive mechanisms such as attention and memory to be allocated to a particular stimulus (Lang et al., 1997; Cuthbert et al. 2003). Bradley and colleagues have put forth distinct sets of stimuli that allow Motivated Attention to be tested. Among their methodological tools, the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention [CSEA], 1999; Lang, Bradley, & Cuthbert, 1999) has been shown to be an efficient tool used to stimulate appetitive or defensive responses significant to the evolutionary mechanisms regarded as emotion. The theory behind this method of emotion elicitation is that salient

pictures containing emotionally significant material will activate the same neural circuitry related to appetitive and defensive action that is required to assess stimuli in our natural environment (Bradley et al, 2001). In this research, it is assumed that the semantic content of the pictures (i.e. the situation depicted) elicits a physiological response comparable to encountering the real life event.

The research conducted in Schupp et al. (2004) is a typical example of research in emotional picture processing. Emotional imagery was found to be effective due to informational salience and its ability to capture attentional resources by depicting highly motivating cues containing evolutionarily significant material. An example of this material could be hunger, inspired by the evolutionary significance of energy consumption, which could be depicted through the image of a delicious piece of cake. This research investigated the effectiveness of imagery to elicit an emotional response. The researchers anticipated that the quality of content-specific imagery within pleasant and unpleasant categories would have a significant effect on emotional perception. Pictures of erotica and human threat are considered highly arousing and capable of eliciting the most significant responses as they depict moments personally relevant to survival, thus encouraging a more thorough evaluation. The research by Schupp et al. (2004) tested whether attentional resources are limited and whether the emotional content of the pictures would significantly occupy these resources.

Schupp et al. (2004) presented subjects with emotional pictures previously indexed according to their degree of valence and arousal (IAPS: Bradley & Lang,

1995), respectively. Content of the emotional imagery was selected as an independent variable and physiological responses were recorded as dependent variables. At the onset of each picture, ERP responses were recorded with special consideration for the late positive potential (LPP), a component associated with increased and prolonged attention. Irrelevant to valence, the LPP was found according to the arousal levels of the pictures, with the highest LPP found in response to human mutilation (i.e. highly arousing, highly negative). Startle probes elicited P300 responses, providing further evidence of motivated attention while also providing a measure of attentional resources that are being assigned to stimuli of evolutionary value. Smaller P300 responses during the viewing of arousing pictures provided evidence of attentional resources being occupied and prolonged for significant periods of time compared to neutral pictures. Pleasant pictures caused the smallest P300 responses compared to unpleasant pictures, with highly arousing erotic pictures causing the smallest overall response.

This electrophysiological evidence of sustained attention for stimuli with high levels of arousal suggests the potential of evolutionarily significant material to access our attentional and emotional motivation. Furthermore, this evidence demonstrates the motivational significance of highly arousing emotional stimuli, with a particular significance for high arousal content (i.e. erotica) to engage mental resources conceivably due to the evolutionary implications for reproduction. This study also illustrates how the P300 component can be modified as a function of valence.

Two additional dependent measures implemented by Schupp et al. (2004) were blinks, which were also elicited with a startle probe, and skin conductance response (SCR). Blink response amplitudes were most pronounced for unpleasant pictures, with the largest blinks caused by images of human threat and mutilation. Pleasant pictures showed blink inhibition with the most inhibition for erotic pictures. This measure again supports evidence of the appetitive and defensive mechanisms involved in emotion processing, as the most pronounced blink responses were caused by high arousal emotional stimuli. More importantly, this measure provides further evidence for an effect of valence, which revealed a trend significant for distinguishing between these appetitive and defensive systems. Blinking has obvious implications for avoidance strategies, while approach strategies are reasonably suggested by blink inhibition. Lastly, the largest changes in SCR were found when participants viewed high arousal pictures. This effect was found in both pleasant and unpleasant valence categories. The SCR measure was not found to be significantly modified by picture valence, though there was a slightly larger change in SCR for unpleasant pictures compared to the pleasant pictures. For Schupp et al. (2004), imagery elicitation efficiently isolated specific attributes of the emotional processing of highly arousing pictures of sex and violence, all of which are most likely relevant to the processing of evolutionarily relevant stimuli.

In a different lab, Davidson (2000) also measured eye blinks as participants viewed negative pictures from the IAPS. In this study, some interesting individual differences were measured and Davidson concluded that his

results show evidence of distinct emotion regulation strategies. In this case, a strategy of emotion regulation refers to an individual's ability to cope with an environmental stressor. Startle probes were presented while participants viewed emotional pictures and this measure gauged the extent to which an emotional response was elicited. Startle probes given at the offset of the pictures reflected the participant's ability to regulate the experience of negative emotion. A larger magnitude of blink responses to negative pictures was found in participants with greater right side activation displaying an inability to suppress affective influence. Participants that showed stronger left-lateralized activation were successfully able to regulate affect and showed a less magnified blink response.

These findings of Schupp et al. (2004) and Davidson (2000) demonstrate how imagery is considered a technique highly capable of inducing an acute emotional state with the potential to effectively modify the perception of valence and intensity (i.e. level of arousal). Whereas using pictures has the ability to motivate a general response to emotional cues according to valence and arousal, researchers are investigating the ability of other elicitation techniques to induce discrete emotional responses.

Presenting motion pictures as a medium of elicitation of valence and arousal is also common and researchers are investigating whether this medium has the ability to elicit a more discrete emotional response due its dynamic nature (Gross & Levenson, 1995; Rottenberg, 2007). Unlike static imagery, film elicitation has the advantage of more closely simulating perception in our environment. However, film also carries the disadvantage of producing unreliable

responses, as the viewer can attend to different stimuli and several viewers could interpret film content in different ways. Therefore, a dependable set of film stimuli has yet to be established that is as effective as the IAPS. Gross and Levenson (1995) successfully attempted the objective of gathering a sample of existing films that would consistently elicit discrete emotional responses. Working from a collection of 248 commercial films and two neutral film segments, these researchers identified 16 films that successfully demonstrate specific categories of emotion where one type of emotion predominated over the others. The experiment resulted in 7 films with the ability to reliably elicit a discrete emotional response.

In order to identify these films, 78 films were shown to 31 different groups out of a total of 494 participants. After each film, participants were asked to rate their emotional experience during each film according to an inventory that contained an 8 point Likert scale of intensity for each of the following possibilities: amusement, anger, intensity, confusion, contempt, contentment, disgust, embarrassment, fear, happiness, interest, pain, relief, sadness, surprise, and tension. Films varied in their reliability to elicit an isolated emotion and films in the categories of amusement, disgust, and sadness were most consistent as 80% of the participants submitted an isolated response. Anger, contentment, fear, and surprise were somewhat successful in their ability to create consistent response. The category of intensity was significant with disgust, which elicited the highest intensity response, followed in order of strength by amusement, anger, sadness, surprise, fear, and contentment. However, these results did not correlate with

ratings of discreteness or how distinct these emotions are when defining them individually. The level of discreteness demanded by empirical researchers in the field may decide how effective these films are. Gross and Levenson concluded that finding completely isolated emotional responses using motion pictures is an arduous task and have not further developed their film set.

This study provides evidence for the potential of film elicitation to allow for more complex emotional feedback in the case of particular emotions, but exercising the full potential of this technique will be far from complete until an effective set of films is established and replicated. Many of the films used in this study were commercially available and viewed previously by some participants; these participants showed more intense responses. This issue of individual differences may have significantly affected the ability of this technique to elicit a reliable emotional response, though this technique is endowed with the potential to induce emotion at an advanced level as the visual and auditory perceptions when viewing motion pictures closely resemble that of an ecologically valid experience similar to our perception of reality.

The issue of individual differences has received considerable notice within the domain of emotion. Cortical structures and, in particular, the lateralization of cerebral hemisphere activation has been an important contributor to how individuals process information differently. Emotional information can significantly initiate lateralized activation of the cortex and the issue of individual differences plays a significant role in the cortical models of emotion literature.

A summary of this section on subcortical systems suggests that the organization of the brainstem and subcortical systems is critically important for the components of activation and arousal to meet their evolutionary goals and influence global emotion systems throughout the body (Tucker & Williamson, 1984; Derryberry & Tucker, 1992; Bradley et al., 2001). The appetitive and withdrawal behaviors that are influenced by these subcortical systems are often thought of as automatic and the patterns of lower-level activation can also be considered primarily to be the unconscious experience of emotion (Derryberry & Tucker, 1992; Damasio, 1998; Damasio, 2000).

The global aspects of emotion processing may subsequently allow whole brain responses that are better prepared to manage spontaneous and changing stimuli found in our environment. However, the complex environmental stimuli that communicate emotion likely require the activation of structures necessary for more than basic cognition, as survival strategies often require more thorough processing undertaken by the cerebral cortex. In particular, the cerebral right hemisphere (RH) is likely to participate relative to the emotional intensity of the stimulus (Tucker, 1981; Borod, Bloom, & Haywood, 1998), as will be illustrated in the following section. Theories that discuss hemispheric processing will play a key role in establishing the contribution of cortical structures to emotion processing. We will now direct our focus to the literature that considers cortical structures more directly.

## Cortical Models of Emotion

Whereas subcortical models originated from the James-Lange theory of emotion that is concerned with perceived bodily changes, cortical models of emotion diverge with the argument that emotion is the cause of change in the body. The theories based on underlying, unconscious mechanisms of emotion are important for understanding behavior, but in order to lead an extensive discussion of the nature of emotion, we must also consider the fact that conscious perception and that emotion can be initiated by cortical tissue. As an alternative to the James-Lange theory of emotion, Walter Cannon and Philip Bard (1920) asserted that the cortex initiates emotion-related behavior. Their theory suggests that conscious awareness plays a critical role in emotion processing.

Though we assume that subcortical structures are organized according to their responsibilities specific to processing incoming stimuli that require an assessment of emotionality, we must also consider the possibility that this organization is a coincidence. Given this possibility, it is essential to gather evidence from other domains in cognitive neuroscience to further establish the order of emotional brain systems. Support for organized emotional networks have been found elsewhere and, when considering research on the emotional functionality of the cerebral cortex, we find further evidence that our brain anatomy is organized for appraising specific stimulus attributes hemispherically (Davidson, 2000).

In a review of his work on laterality, Richard Davidson (2003) considers the effects of emotion on language processing using evidence from brain imaging

and electrophysiological techniques. His work has found that the efficiency of eliciting an emotional reaction from participants in his lab is influenced by individual differences in emotion processing (Davidson, 2003). His elicitation measures, such as watching an emotional film or viewing emotional imagery, are used as a means of identifying the underlying patterns of individual biases in attention and susceptibility to the content of an emotional stimulus (Davidson et al., 1990; Wheeler, 1993; Davidson, 2003). Unique circumstances arise when dealing with emotionality and personal experience and Davidson's term "affective style" refers to a reaction that is unique to each participant as a result of his or her adaptation to the environment and the individual's ability to regulate emotion (Davidson, 1994; Davidson et al., 2000; Davidson, 2003). Davidson speculates that the differences in how we process emotional information individually are influenced by amygdala and activity in the prefrontal cortex (PFC), a brain region assumed to play an important role in higher order cognition (Wheeler, 1993; Davidson, 2001; Davidson, 2002).

Anticipation and inhibition are important roles undertaken by subcortical structures, but specific areas located within the PFC are also involved in these cognitive functions (Wheeler, 1993; Davidson, 2001; Davidson, 2002).

Davidson's claim is that a specific hemisphere of the PFC is activated under circumstances that involve decisions on whether approach or withdrawal from a particular object or behavior, and lateral activation is especially necessary when goals are inconsistent with the initial information appraised from a stimulus, such as when pain from an injury is encountered while eating a delicious fruit or

potential food can be made of a dangerous animal (Davidson et al., 2000; Davidson, 2003). The PFC influences reactions when faced with uncertainty or when a novel response is necessary for more elaborate goals (Davidson, 2003). Davidson focuses on individual biases in emotion responses localized in the PFC and how hemispheric specificity can influence these particular reactions.

Davidson has found more activation in a particular hemisphere relevant to the valence of emotional stimuli and his laterality hypothesis has successfully predicted whether individuals will respond with a valence bias, as in when stronger activation for negative information is observed among certain individuals. Much of Davidson's work shows a laterality bias for positive stimuli in the left hemisphere (LH), while the right hemisphere (RH) seems to be activated by negative material and Davidson has attributed each hemisphere with its respective valence processing bias. There is a considerable amount of literature documenting hemispheric differences in PFC activity as a function of emotional valence (Davidson, 1992; Davidson, 2003; Heller, 1993).

Possible alternatives to Davidson's valence theory of hemispheric specificity have suggested that the LH serves an inhibitory role over the RH in emotion processing (Tucker, 1981; Tucker & Williamson, 1984). For example, when enhanced activation of the RH is found in response to negative stimuli, this alternative explanation indicates this is due to a lack of LH inhibition over the RH. Research presented by Don Tucker also has implications for research related to hemispheric processing (Tucker, 1981; Tucker & Williamson, 1984; Derryberry & Tucker, 1992) and his reviews encourage researchers to consider

the interaction of the two cerebral hemispheres. More specifically, Tucker emphasizes that, regardless of asymmetry, a natural balance between the cerebral hemispheres is necessary for normal, unbiased cortical activation and accurate information processing.

Tucker (1981) and Tucker and Williamson (1984) also raise the issue of whether the emotional processing contribution of PFC in the left and right hemispheres is due to activation or inhibition. More specifically, the inhibition theory suggests that the LH plays a large role in emotion processing as an inhibitory mechanism over the emotional activation of the RH. The LH has shown enhanced activation in cases of anxiety, while the RH has been shown to have less activation in cases of clinical depression and somewhat less activation in the case of individuals exposed to negative mood induction (Tucker, 1981). Furthermore, in what could be called Tucker's state-dependent theory of mood, he suggests that the reduced activation of the RH in depression is due to the transient nature of depression-related behavior. Lack of inhibition, hence, lack of activation in the LH is proposed as the actual cause of depression, as this is similar to the inhibitory influence of cortical structures on responses taken on by the limbic system.

Derryberry and Tucker (1992) discuss how the RH is more capable of applying integrative strategies involving global connections between different brain structures. They suggest that this hemisphere is more capable in the communication of emotion as the RH has stronger connections with areas outside the brain. At the neuronal level, overlapping axonal connections are prevalent in

the RH, suggesting networks that are more highly distributed. The RH also is more responsive to stimulus-induced physiological responses that distribute activation more generally across the brain as opposed to focused, localized motor responses more common in the LH. Tucker's theory of laterality is further supported by evidence of the primarily inhibitory nature of dopamine and its prevalence in the LH. The evidence provided by Don Tucker to support his inhibition theory does not specifically make a distinction between subcortical and cortical structures.

Subcortical anatomy is also considered by Davidson (2001; 2002; 2003) as he illustrates the importance of the amygdala and its crucial function in the motivation of further processing so that attentional resources can be directed in proportion to the emotional significance of a stimulus. Davidson assumes a general role of the amygdala in emotion processing, though his evidence suggests a negativity bias in this structure that is reasonably due to an evolutionary proclivity to react aversively when confronted with novel stimuli as a defensive precaution (Davidson, 2003). After initial assessment of an environmental stimulus and the immediate reactions necessary are considered, a more complete evaluation can make sense of ambiguous properties. Therefore, Davidson's position regards cortical processing as playing a larger role in evaluating emotional stimuli, as emotional information requires more advanced processing than that which can occur at the arousal level in the subcortex (Davidson, 2003).

Electroencephalography (EEG) is a frequent method for examining emotion processing at the cortex. Davidson (2003; see also Wheeler et al., 1993)

describes an investigation in his laboratory that tested whether cortical activation is a valid means to test an individual's sensitivity to emotion elicitation using film clips. In order to detect lateral asymmetries in hemispheric activation, a baseline EEG response was collected as a dependent measure of activation before positive and negative film clips were used to induce a transient valenced mood state. In addition to the EEG measure, participants were asked to rate their emotional experience during the films.

Baseline responses were averaged using a within-subjects analysis in order to compare the level of mood change and, as predicted, the results showed a positive correlation between a lateral activation bias and the degree of valence response given. Participants with more LH activation at baseline rated their experience during the positive films as more affectively positive, while those with stronger RH activation at baseline demonstrated that they experienced negative films as more negative than participants with greater baseline LH activation. Davidson (2003) reported that physiological data collected before the experimental trial indicated a personality bias and effectively predicted participant's reaction to emotional stimuli. Davidson and colleagues focus on individual difference biases in emotion processing localized in the PFC and they investigate what hemispheric specificity can tell us about personality. Davidson (1994) and Davidson, Jackson, and Kalin (2000) suggest that emotional experience can change frontal EEG patterns of activity.

Personality is relevant to the current research as personality traits in the form of negative attentional biases can indicate symptoms of dysphoria. Our

investigation will induce a transient negative mood state in order to investigate what aspects of sentence processing are trait-specific compared to aspects of emotional cognition related to current mood state. The focus on mood-state specific processing has been influenced by research that has looked at aspects of how depressed individuals process emotional words (reviewed by Gotlib & Neubauer, 2000). When considering theoretical models of cognitive bias in depression, researchers must make a distinction between the state-dependent aspects of current mood and those better accounted the enduring trait-specific characteristics of cognition influenced by affective experience (see discussion by (Matthews & MacLeod, 1994).

A discussion of how emotion is organized at the cortical level suggests that appraising an emotional stimulus is more complex than the automatic responses initiated by subcortical structures. In order to discuss trait-specific differences in personality versus more fluctuating state-specific phenomenon, we will consider models of emotion that consider how mood state is modified at the cortical level and how life experience and mood state interact.

#### Factors that Modify Emotion Processing

By state-specific processing, the current research refers to the idea that mood can influence how we process emotional content, as in the case of how we remember emotional content while in a negative mood (Kenealy, 1997; Chepenick et al., 2007). Our definition of trait-specific processing refers to the influence of stable cognitive traits that occur over a prolonged time period and result in cognitive biases that are persistent irrespective to mood. For example, an

individual diagnosed with clinical depression is likely to have distinct personality traits developed throughout his or her experience with affect that influence lexical organization (Atchley, Ilardi, & Enloe, 2003).

In making the distinction between trait-like versus state-like systems, Wendy Heller (1990; 1993) proposes that the modification of emotional experience is localized in the PFC. She presents a definition of emotional state as a function of this system combined with the RH, which has a more long-lasting role in personality and on-going attentional biases. Heller's model of emotional state utilizes the Circumplex model of affect (Lang et al., 1985; Russell, 1980), a multidimensional continuum illustrated by 2 overlapping axes: valence and arousal. According to the model, all possible emotional states fall somewhere in the four quadrants that range from high to low (arousal) and pleasant to unpleasant (valence). The current study has adopted this theoretical approach as the emotional stimuli range from pleasant to unpleasant, though only items rated low in arousal will be used in the current design.

The connectivity model is a theoretical construct in the depression literature that considers this trait-specific approach. In this theory, the absence of executive control causes allows for compensation initiated by subcortical structures that inappropriately employ emotional resources in generating a physiological response (see discussion by Levin et al., 2007; for executive function and the role of PFC, see Miller & Cohen, 2001). Without higher-order control over cognitive resources, brain structures in the limbic system that are strategically positioned along pathways oriented for stimulation and the initiation

of behavior may respond improperly to the environment and, in the case of depression, show a negative bias in attention (Gotlib, Ranganathand, & Rosenfeld, 1998; Davidson, 1993).

The amygdala plays a significant role in emotion processing and hyperactivity in this structure has been found in some cases of depression (Beck, 2008; Davidson, 2003). This structure being hyperactive can lead to depressive symptoms as it is primarily involved in the evaluation of aversive stimuli (Beck, 2008; Davidson, 2003). This structure has great significance in the development of the central nervous system as it processes information critical for survival. The amygdala has significance for depression particularly as it activates during the processing of stressful life events (Levin et al., 2007). According to Levin et al. (2007), regular exposure to stressful events, activating the amygdala and other structures involved in stress response networks, could contribute to a general tendency to respond aversively and develop response patterns resembling those found in depression.

With stressful experiences recurring early in life, physiological systems affected by emotional cues from the environment have the potential to adapt and depression symptoms could develop (Levin et al., 2007). This adaptation to the environment can influence the cortical and subcortical regions already discussed in the current review related to emotion. This includes the lateralization of brain activation and the release of regulatory hormones and neurotransmitters in response to persistent signals in an individual's surroundings (Teicher et al., 2003; McEwen, 2007; Gunnar & Quevedo, 2007). In mood disorders such as

depression, different biological patterns can develop across an individual's lifespan in response to stress and anxiety, emphasizing the connection between depression, environmental stimulation, and the biological substrates that modulate emotional reactivity (Klaasen et al., 2002).

Impairment in the hippocampus can lead to hyperactivity in the amygdala resulting in symptoms of depression (Levin et al., 2007). Those with recurrent exposure to stress might experience ambiguous circumstances as stressful and have an inclination to respond aversively to stimuli they encounter in their environment. How hormonal mechanisms in the brain are activated in early experience, particularly due to stress, and the impaired ability to regulate emotional experiences can be an important factor in whether an individual will develop a mood disorder. Activation of hormonal mechanisms related to stress can alter emotional structures in the brain or lead these structures to function inappropriately. In the current study, we are interested in the biases in emotion-related language processing that can occur as a result of affective experience. There is evidence to suggest that emotional language processing is a trait-like phenomenon as similar biases occur in depression and remission from depression (Atchley, Ilardi, & Enloe, 2003). Similar biases in attending to emotional information are suggested to exist in mood-state specific cases of dysphoria (Siegle, Ingram, & Matt, 2002). However, other evidence is available to suggest that attention to emotional information is a state-like phenomenon (Ilardi et al., 2007; Ilardi & Craighead, 1999).

Research in depression has contributed to our knowledge of hemispheric specificity and how we process language (Borod, Bloom, & Haywood, 1998; Atchley, Ilardi, & Enloe, 2003). For example Richard Davidson has assigned the role of the RH to process negative stimuli and processing deficiencies here could suggest negative attentional biases (Davidson, 2003). According to Davidson's theory of emotion, depression is indicated by specific patterns of activity and the development of problems in the PFC can result in cognitive deficits, further indicating the potential role of the PFC in emotion processing (Kim & Hamann, 2007; Davidson, 1995).

The authors discussed thus far have suggested that there are consistencies in emotional experience and consistent patterns in the evidence presented related to individual differences. Research by Levin, et al. (2007) indicates the potential for changes in the environment and life events to contribute to biological abnormalities that may result in a deficiency when these individuals encounter specific kinds of information having emotional significance.

Given that emotion-related experience and anxiety directly influence how future emotion-related stimuli will be attended to and categorized, our discussion will take into account the research on mood state specific processing more specifically. Mood elicitation and the issue of how affective content is processed while experiencing valenced mood states has been addressed extensively (Zevon & Tellegen, 1982; Watson & Tellegen, 1985; Kenealy, 1997; Tucker et al., 1999; Davidson, 2003; Chepenick et al., 2007; Coan & Allen, 2007) and there is a range of evidence to suggest that mood is related to subcortical, limbic, and cortical

structure activation, particularly localized to such as the amygdala, hippocampus, hypothalamus, and specific areas of the PFC (Heller, 1990; Heller; 1993; Davidson, 1990; Tucker 1981; Derryberry and Tucker; 1992).

Studies utilizing state-dependent processes implementing mood elicitation with normal populations as well as trait-dependent processes with depressed patients have been shown to reliably estimate how individuals can uniquely process information that they encounter in their environment (Gotlib & Neubauer, 2000). The external factors considered to influence affective experience are exemplified language, as in lexical access (Atchley, Ilardi, & Enloe, 2003), and picture processing (Bradley et al., 2001; Schupp et al., 2004). Resting baseline activation in response to emotional stimuli is also susceptible to environmental change related to affective experience (Davidson, 1994; Davidson et al., 2000).

The current study will look specifically at what aspects of cognitive processing are dependent upon mood state. More specifically, we will investigate how processing sentences containing emotional context changes after an induced negative mood. Our sample will use non-depressed participants in order to assess the potential for differences in mood to show distinct patterns of performance on a plausibility task for self-referent sentences. We are interested in how mood changes semantic access for emotional words in a sentence and also how a negative mood changes the perception of self-referent content.

We will investigate cortical involvement in emotion by engaging the cognitive processes involved in linguistic processing and aspects of higher order cognition considered in the domains of language and memory. In order to provide

a thorough description of the goals of the current study, it is necessary to look at the literature on emotion and language. The following section discusses how emotion has been considered an important factor in the study of language comprehension.

## Influence of Emotion on Higher Order Cognition

### Emotion and Language

Although there is considerable evidence presented in this review to suggest that emotion influences subcortical structures and the nervous system, much remains to be established in the domains of language and emotion and what these domains can tell us about the contribution of the cerebral cortex to emotional language comprehension. Our study is critical as there is limited evidence for how we process emotion words at the sentential level (Havas, Glenberg, & Rinck, 2007; Hale, 2003; see review by Shanahan, 2008). As part of the background to the current research, we will discuss the findings on emotional language processing more generally.

In a review by Daniel Shanahan (2008), language is considered a vehicle for emotional symbolism. He cites Robert Haskell's (1987) view that language conveys meaning and serves to evoke the unconscious schemas that influence our thoughts and behavior through the construction of meaning. The models put forth by Aaron Beck (2002) give incredible insight into how these schemas might influence cognition as a function of life experience. He considers self-schemas consistent with a negative self-evaluation relevant to the cognitive aspects of depression. The current study will apply Beck's model by investigating what

aspects of mood change how participants judge the plausibility of sentences that are consistent with a positive self-schema and those consistent with a negative self-schema. Other work considering emotion and language has explored the localization of the mechanisms behind emotion processing in order to better understand how language influences cognition.

Carl Broca's work indicated the LH as the seat of language, but it is now widely accepted through lateralized brain damage patient evidence that the RH possibly plays a larger role in the comprehension and expression of emotional language (see review by Beeman & Chiarello, 1998), especially in the case of depression (Borod et al., 1998; Atchley, Ilardi, & Enloe, 2003). For example, interpreting prosody in speech is regarded as superior in the RH. Prosody that is congruent with the content of a sentence has been shown to generate faster responses (Nygaard & Queen, 2008). Other examples include the ability of the RH to comprehend the narrative of a story and to interpret metaphors due to more globally organized semantic access. Many researchers have presented work that discusses emotion as being conveyed through the context of language (Barrett, Lindquist, & Gendron, 2007; see review Shanahan, 2008) and we now turn to a consideration of how emotion influences semantics.

Atchley, Ilardi, and Enloe (2003) investigated laterality and semantic memory access for emotional words using population samples that varied by affective experience. These samples consisted of 23 depressed, 28 remitted-depressed, and 23 never-depressed controls recruited in an introductory psychology course. Behavioral data were collected to investigate hemispheric

differences using a priming task with primes presented centrally and targets presented using a divided visual half-field paradigm. For their dependent variable, participants were asked to make a valence judgment between two words, while these researchers recorded reaction time to the valence judgment. Each pair of words was evaluated by participants as either related in valence (STUPID-DIRTY) or unrelated (BRAVE-LAZY). As independent variables, these researchers used diagnostic group, valence of the target word, whether the word pairs shared the same valence and whether the target word was presented to the left or right visual field.

The results showed that all 3 population samples demonstrated a processing advantage for related pairs presented to the RH (i.e. in the left visual field) and this processing advantage was positively correlated with affective experience. In the RH, currently depressed and remitted-depressed participants showed higher accuracy and faster responses for related pairs of negative valence. A RH advantage was also observed among the never-depressed control population and this sample showed better accuracy and faster responses for positive items. This study provides evidence that semantic networks in the RH are organized according to affective experience and, as remitted depressed showed the same pattern as the currently depressed. These results using emotional words provide evidence that semantic networks are organized in a trait-specific manner.

Investigating laterality in response to emotional stimuli presented using the divided visual half-field paradigm, Atchley, Ilardi, and Enloe (2003) found that language and emotion have a distinct function in each cerebral hemisphere.

This paradigm allows for information to be exposed to either the left or right hemisphere exclusively by presenting the stimulus to either the left or right visual half-field of each eye while participants focus on the center of a computer display. The stimulus is presented briefly so that participants are unable to move their eyes, as to prohibit both hemispheres from gaining access to the information presented. Consistent with evidence that the RH has an advantage for processing emotional language as in the case of speech and the facial communication of emotional speech (Borod, Bloom, & Haywood, 1998), these researchers found improved accuracy and faster responses occurred for stimuli presented in the left visual field, supporting the role of the RH in emotion processing.

The results of Atchley, Ilardi, and Enloe (2003) are incompatible with evidence that has been found showing a LH advantage for positive emotions (Davidson et al., 1990) and an overall LH advantage for word processing proposed by Carl Broca. This discrepancy is most likely due to the complicated nature of cortical processing and linguistic functions being attributed to the LH, which activates simultaneously upon the presentation of an emotionally latent language stimulus. Results for dominance in the RH for processing emotional language are complicated by this overlap in hemispheric processing and it is therefore necessary to utilize the visual half-field paradigm to uncover RH processes. Research using this paradigm as well as evidence from patient populations and lesion patients generally suggest a RH mechanism that specializes in emotion processing (Chiarello & Beeman, 1998; Borod, Bloom, & Haywood, 1998).

Inconsistent results have been found using normal populations, but patients with right hemisphere damage more reliably indicate the function of the RH. The research of Borod, Bloom, and Haywood (1998) showed that RH lesion patients demonstrated impaired abilities to recognize emotional words and to use intense emotional language to express feelings. Speculations on why the RH possesses an emotionally specific role in cognition are similar to conclusions made by other researchers related to the evolutionary significance of emotion processing and functionally distributed processing networks that attribute emotional biases hemispherically (Davidson, 1990; Derryberry & Tucker, 1992).

Of more relevance to the current study, emotional language has been shown affect judgment (Johnson & Tversky, 1985) and evidence from Havas, Glenberg, and Rinck (2007) suggests that factors outside of emotion can influence the judgment of plausibility. Havas, Glenberg, and Rinck (2007) found that judging plausibility is faster when the valence of a sentence matches the emotional posture of the face. They postulated that facial posture is simulating emotion by partially activating the systems responsible for generating the complete emotional response (i.e. smiling with joy). The current research will attempt to assimilate previous findings using a mismatch paradigm with the induction of a negative mood. We hypothesize that an induced negative mood will activate the emotional systems involved in naturally occurring mood, generating attention biases in reading comprehension and the judgment of semantic plausibility.

Havas, Glenberg, and Rinck (2007) concluded that emotion simulation only occurs at the sentential level, as they did not show the same mismatch effect using a lexical decision task (i.e. without context). However, these researchers do acknowledge that emotion influences word processing when the word directly names an emotional state. Their research suggests that emotion is measurable at the sentential level and the current design will further these assumptions of Havas, Glenberg, and Rinck (2007) by investigating how mood influences sentence comprehension.

This background on the field of language and emotion gives support for models of emotion that are considered trait-specific processing. The work of Atchley, Ilardi, and Enloe (2003) and the work reviewed by Borod, Bloom, & Haywood (1998) accounts for emotion processing that appears to be less plastic, as semantic networks organized by affective experience provide evidence of trait-specific processing. While the research presented here on processing emotional language contributes to trait-specific theories of emotion processing, research in the domain of emotional memory has focused more on the aspects of emotion processing that are dependent on current mood state.

### Emotional Memory

The current study aims to contribute to the issue of how emotion influences memory and how memory is changed by affective experience. The literature on emotion and memory has been particularly influential in the domain of mood-specific processing. This review of emotion might suggest that emotional information affects attention more than neutral information, making

emotional items more available for recall. However, the effects of mood on memory performance are more elusive and have been the subject of much debate. One of the most prominent dichotomies in the mood and memory literature appears to be a focus on mood-dependent effects versus mood-congruent emotion processing (for reviews, see: Blaney, 1986; Buchanan, 2007).

Mood-dependent effects occur regardless of the stimulus valence and refers to the enhanced memory while experiencing a valenced mood, such as sadness (Chepenik, Cornew, & Farah, 2007). According to this theory, enhanced retrieval will more likely occur while experiencing the same affective state that was experienced during exposure to the stimulus (i.e. mood-congruence between learning and retrieval). Mood induction has been a common method of testing this phenomenon, though the effectiveness of mood induction has been somewhat problematic. For example, cognitive priming effects, demand characteristics, and a limited amount of time afforded during an experiment are considered obstacles encountered when eliciting mood (Blaney, 1986; Buchanan, 2007).

Chepenik, Cornew, and Farah (2007) intended to investigate cognitive performance using a sustained mood induction technique. These researchers found effects for emotion-related cognitive processes, including a recognition bias for negative words, but no effects were found for cognition more generally. More conclusive findings have been found when investigating the mood-congruence theory of memory, to which we next turn.

Mood-congruence is indicated by enhanced processing that occurs for affective content when the corresponding affective mood is also present. In this

case, there is no need for valence and mood to match at the time of retrieval, though affective state is likely to cue retrieval. Contrary to mood-dependence, results supporting mood-congruent memory have been much easier to replicate. Also contrary to mood-dependent theories, research on mood-congruence is more often tested using individual differences, where mood induction is not required. Research has found increased memory for information congruent with the valence of the negative mood as in the case of improved memory for negative information congruent with negative mood (Knight, Maines, & Robinson, 2002). This domain is also important for research that considers depressed populations and trait-specific processing models of emotion. For example, mood-congruence studies have shown that depressed populations show enhanced processing for failure scenarios, while non-depressed populations show enhanced recall for content related to success (Johnson, Petzel, Hartney, & Morgan, 1983).

Other studies have suggested that the mood-congruence effect is only found when using self-referent material, especially in non-depressed individuals (Ingram, 1983; Clark & Teasdale, 1985). Furthermore, actual life experience and personal descriptors have also been shown to enhance the effects of mood-congruent memory (Clark & Teasdale, 1985). Several studies have attempted to apply these theories of emotion-related memory, but more research is necessary to more accurately establish the differences between these two dominant theories as well as important findings for emotion and memory.

Levine and Burgess (1997) showed evidence for a nonspecific memory advantage while in a negative mood state using a study that asked students to

recall a short narrative heard during an introductory psychology class. As a dependent variable, amount of recall and recall for specific information was recorded. Before participating in the recall task, each student was randomly assigned a grade that was an “A, B, C, or D” on a previous test and this served as the independent variable. Each student’s grade provided the elicitation of emotional affect that was later collected on a survey in which each student assessed his or her own mood among possible selections of happy, angry, sad, fearful, surprised, and other. Each discrete emotional category included a 5-point rating scale that ranged from “not at all” to “very much.”

Greater recall for the entire narrative was shown for participants that selected happy as their emotional state and had received a passing grade. Participants that marked angry or sad also showed enhanced memory for certain events within the narrative. For example, angry participants showed enhanced recall for goal-oriented information and sad participants had better recall for information about event outcomes. The authors concluded that a positive mood state can show enhanced recall due to leaving cognitive resources available for an incoming stimulus. The categories of anger and sadness require further investigation, as there was little evidence provided by Levine and Burgess (1997) that distinguished between these distinct categories of negative mood.

Overall, Levine and Burgess (1997) supports the theory that mood can have a specialized influence how memory is encoded. More specifically and consistent with the emotion theories in this review, negative emotions were attributed to a general attention bias that was congruent with the respective mood

state. Also worth noting, this study controlled for demand characteristics as the participants were asked to recall a narrative and not to recall emotion-related material. Levine and Burgess found that a negative mood state can enhance recall and their data support mood-dependent memory. The following study found enhanced recall for negatively valenced items and also considered the influence of emotional arousal.

Kensinger and Corkin (2003) measured recall for negative words and neutral words. In a series of 6 experiments, these researchers provided 18-20 never-depressed male undergraduates with lists of words and then asked them to recognize words seen previously after a 15-minute delay. The dependent variable in all experiments was recognition accuracy, based on whether they had seen a word presented on the previous list. The unique objective of experiments 3 and 4 was to look at the difference between high and low negative words. Experiment 5 controlled for a possible recall advantage due to a semantic integration memory strategy and implemented neutral words that were all semantically related. Experiment 6 controlled for an enhanced memory effect due to high frequency words.

Kensinger and Corkin (2003) found enhanced memory for negative words compared to neutral words, with the greatest recall for highly arousing negative words. This effect was present in all 6 experiments. Enhanced recall for negative words was also found in experiment 2, indicating greater recall for the color of negative words compared to neutral words. In experiments 3 and 4, enhanced memory was found for negatively valent items that were rated high and low in

arousal when compared to neutral items. No advantage was found for semantically related neutral words in experiment 5 and this suggests that semantic integration was not a sufficient memory strategy for these participants.

Experiment 6 did not find an advantage for high frequency words. The authors proposed item distinctiveness as a possible reason for enhanced recall on negative items as negative items are more semantically salient when compared to neutral items. Another conclusion posited by the authors was an attention bias for negative words over neutral words.

Although the Kensinger and Corkin (2003) study addressed processing of negative words in considerable detail, their study did not assess recall for positive words. The current study will also present positive words, which we believe is an important component to include in attempting to establish a more comprehensive report of the effects of emotional content on memory processing.

Deficits in memory processing have contributed to our understanding of emotional memory, particularly in the case of memory performance in depression. The literature on memory in depression is relevant to the current investigation as we are interested in contributing evidence to the research problem of whether the symptoms of depression are dependent on mood state or related to trait-specific factors. Evidence for deficits in memory processing will be considered next.

Depressed individuals may generate a bias for remembering negative material and a general fixation on negative material. A negative bias has been considered a deficit in the management of attention as an inability to efficiently encode stimuli in the environment might result in perseverative attention (Levin et

al., 2007). The inability to disengage attentional focus from particular stimuli does not allow attention to fulfill its evolutionary role to completion and this could result in attentional bias. For example, Joorman and Gotlib (2008) compared control participants who received a sad mood induction to depressed individuals and found negative memory intrusion effects among only the depressed population. Joorman and Gotlib (2008) supports mood-state specific memory. The results of Chepenick, Cornew, and Farah (2007) found a negative memory bias and difficulty recognizing faces after a sad mood induction. Although this study did not show a bias in other cognitive tasks, these researchers concluded that cognitive biases in depression may not only be due to sad mood.

Many cases of depression indicate a problem in the PFC with the initiation of effective cognitive strategies when faced with specific emotional stimuli (Levin et al., 2007). Deficits in the LH may lead to overcompensation in the RH, which predominantly processes negative material. A general decrease in PFC activity has also been observed in depressed individuals combined with this negative bias in attention (Levin et al., 2007). The role of the RH in inhibition and avoidance processing has been well-established and deficits in this region account for an inability to initiate avoidance strategies. As suggested by Levin et al. (2007), memory deficits in depression may implicate the hippocampus, which plays a large role in relating important environmental cues to different brain regions and making associations with new information in the environment. Activation in the PFC has been shown to be influenced by emotional cues in the environment that

require further processing to play a large role in working memory (Davidson 1999, Schupp et al. 2004).

Higher cognitive functions such as attention and memory are affected by the emotional significance of an object or situation. Memories that have emotionally significant information are more likely to be given priority and be readily available for feedback in appraising a stimulus. For example, information that is crucial for survival would be assigned this priority and, in the event that relevant information is available, processed immediately (Schupp et al. 2004). Under this theory of emotion processing, specific structures activate according to whether priority is assigned and appropriate objects or situations are given the advantage of being processed in a more expedient manner. Whether emotionally laden stimuli and this processing advantage apply to memory has received less attention in past research.

A stimulus that has emotional significance is processed similarly to all stimuli in the environment and can activate any appropriate resource in the brain necessary to make sense of that stimulus. Therefore, emotional information is processed on both cortical and subcortical levels of brain activity, but there are particular structures that are most important for emotion processing. Labeling the affective significance of incoming information for further processing is done by the amygdala and processing aversive information has been shown to be a specific objective of the amygdala (Davidson, 2003). This structure becomes active with the presentation of emotional stimuli and is important for responding to the affective significance of sensory information.

The limbic system lies between cortical and subcortical structures and processes sensory information, including that which is emotionally significant, before it sends the information to the frontal cortex for higher cognitive processing. The amygdala and other limbic structures have also been linked to working memory and the storage of permanent memories. In order to make sense of complex emotional stimuli, the frontal cortex appraises material that has been designated as emotionally significant by these subcortical structures.

Research conducted by Kensinger and Corkin (2003) shows an advantage for remembering emotionally valent words over neutral words with a greater advantage for recalling words with more arousal. Schupp et al. (2004) have proposed the same enhanced effect for negative pictures due to motivated attention and these researchers suggest evolutionary significance as the reason for priority being given to negative emotional material. Emotional memory researchers have also found that a negative mood state aids the availability of negative memories (Kern et al. 2002) and other research presented by Anderson and Shimamura (2005) suggests that this negative mood state decreases memory for the context of events. Similar findings have been found by Davidson (2003) suggesting poor memory performance while in a negative mood state. Research presented by Kern et al. (2002) is inconsistent with poor memory performance while in a negative mood and instead indicates that memory performance is more likely enhanced by negative mood, particularly when rated high in emotional arousal.

The current research intends to provide further evidence of the influence of valenced emotional states on memory performance. We will look specifically at how information is processed that is self-schema driven (Beck, 2002; Haskell, 1987) and how we remember emotion-related content more generally. How the theories presented in the current review have been applied in the current study to non-depressed individuals and their judgment of valenced self-statements while in a negative mood state will be discussed in the following section. Competing evidence requires the replication of findings in the domain of emotional language and memory processing has led to the current empirical goals, and we now turn to the experimental design.

#### Current Empirical Goals and Predictions

In order to provide an adequate discussion of the current empirical goals and predictions, we begin with a brief summary of our research design. Our investigation will assess reading comprehension for sentences and recall for the sentence final word. To provide evidence of how mood influences semantic processing, the current study will use mood induction technique specifically designed to elicit sadness. Data for reading performance and memory performance will be gathered on two separate tasks that will be administered while in a neutral mood and while in a negative mood state.

#### Reading Performance

For the reading task, participants will read sentences word-by-word before making a decision based on whether they endorse each sentence as semantically plausible or implausible. Each sentence will end with either a positive, negative,

or neutral target word. Our targets were selected from multiple papers that reported valence norms (Gotlib et al., 1988; Myers, 1980; Siegle, 1995; and the Affective Norms for English Words [ANEW], Bradley & Lang, 1999). As we are currently interested in how participants process the semantic aspects of language, our target words were chosen because they are rated low in level of arousal. Our three dependent variables for this reading task are reading time (READ) for the sentence final word target, reaction time (RT) for making the semantic plausibility judgment based on the entire sentence, and response choice (RESP) for the plausibility judgment based on whether participants choose to endorse each sentence as plausible or implausible.

Reading time refers to the amount of time that the target word is present on the screen before the participant advances to the following plausibility judgment screen. Reaction time measures the amount of time participants take to make their plausibility judgment and will be recorded directly after the participant advances past the target word. Response choice measures whether the participant endorses each sentence as plausible or implausible and this measure will be recorded as responding “yes” (plausible) or “no” (implausible). Accuracy could be a logical alternative description for RESP, though a description of semantic plausibility being accurate misrepresents the nature of the data collected in Conditions 1 and 2 (eg. I am essentially a failure/I’d call myself a leader).

There will be two independent variables manipulated during the reading task. Current mood contains 2 levels and will refer to whether participants are in a neutral mood state or a negative mood state. The second independent variable for

the reading task is sentence condition and this manipulation contains 6 levels. Each sentence will vary upon whether the sentence final word is negative, positive, or neutral and whether each sentence is a self-referent or other-referent. Within the 6 sentence levels, there will be there is also a manipulation of plausibility, where each sentence final word will indicate whether the entire sentence is semantically plausible or implausible. Six sentence levels will be presented to our participants, but conditions 5 and 6 served as other-referent distracters or “filler” sentences and they will not be reported in the reading task results section. Four critical sentence levels considered in our analysis and they are listed as sentence conditions 1-4. Table 1 shows examples of all of the 6 sentence conditions [below].

Table 1  
Stimulus Examples

Stimulus Condition	Example Stimulus
Negative Self-Statements (1)	People consider me to be worthless.
Positive Self-Statements (2)	My family thinks that I am interesting.
Neutral, Implausible Self-Statements (3)	Others see me as a desk.
Neutral, Plausible Other-Statements (4)	Maids often clean the kitchen.
Filler Implausible Other-Statements (5)	The weather was cool and printed.
Filler Plausible Other-Statements (6)	Terrorists are often thought of as evil.

Table 1. Examples of the 4 main sentence conditions (1-4) and filler sentence examples (5-6).

Condition 1 contains self-referent statements that end with a semantically plausible negative target word, thus, endorsing this condition is not consistent with a positive self-evaluation. Condition 2 contains plausible self-referent statements that end with a positive target. Conditions 3 and 4 will serve as the

neutral control conditions, with condition 3 containing implausible self-referent statements that end in a neutral target and condition 4 containing plausible other-referent statements that end in a neutral target. Due to the difficult nature of designing a neutral plausible sentence condition, condition 3 will contain implausible sentence final words and condition 4 will serve as a plausible control condition that contains the same neutral targets as used in Condition 3. The reason for including condition 3 is due to the difficulty in designing neutral self-statements that are unambiguously neutral. Also, we considered that the unambiguously neutral self-statements would not be plausible for every participant. Consider the sentence, “Others consider me to be bearded.” This sentence is unambiguously neutral in valence according to our prior norming results, but not everyone is bearded, rendering this condition plausible for some and implausible for others. The other two conditions present in the current experimental design serve as filler sentences and they vary according to the valence of the target word as they contain negative, positive, and neutral targets. Condition 5 contains implausible other-referent statements and condition 6 contains plausible other-referent statements.

Sentence condition will be entered into the ANOVA as an analysis of the 4 critical sentence conditions using planned comparisons to assess differences in sentence processing between these 4 different types of sentences. Conditions 1 and 2 are the critical sentence levels as they contain negative and positive targets, respectively. These critical sentences are the primary concern of the current research design as they were created to allow for the investigation of reading

valenced words in a self referent context. Conditions 5 and 6 will not be included in the reading performance analysis, though they will be included in the analysis for the memory task.

As influenced by previous findings, our a priori predictions for the reading task are that the data will show that emotional stimuli improve cognitive performance (Schupp et. al, 2004; Landis, 2006; Kissler et al., 2007; Herbert, Junghofer, & Kissler; 2008; Silvert et al., 2004). This will be shown through an overall difference in how participants read sentences that end in emotion-valent targets compared to sentences that end with a neutral target. More specifically, our a priori predictions for the dependent variables in the reading task are that participants will read negative and positive targets faster when compared to the neutral targets. We predict that participants will show faster reaction time for making the plausibility judgment for conditions containing emotion-related targets compared to neutral targets. Regarding the primary sentence conditions 1 and 2, we predict sentences containing positive words will be read faster overall. We also predict a sentence condition by mood interaction will occur for these two categories of valenced sentence final words. While in the negative mood, we predict an overall decrease in the reading time and reaction time measures as compared to the reading time for negative words in a neutral mood. We expect that participants will consider negative targets longer because the negative words, though less plausible for this never-depressed population, will be consistent with their negative mood state.

For response choice, we predict that participants will show a trait-specific bias to endorse positive self-statements of Condition 2 and that this response will be similar to response choice on the plausible other-referent statements with neutral targets of Condition 4. We predict that our never-depressed, non-dysphoric participants will endorse the critical sentence conditions consistent with a positive self-evaluation. In contrast, we expect that participants will judge the Condition 1 sentences (with negative final words) as implausible even though these sentences are syntactically and semantically possible. A difference between conditions 1 and 2 will provide evidence for aspects of trait-specific processing found previously (Atchley, Enloe, & Ilardi, 2003; Ilardi et al. 2007).

We also predict a significant interaction between mood and sentence condition. While in the negative mood, we predict participants be less likely to endorse as plausible the positive self-statements Condition 2. Regarding the negative sentences of Condition 2, we expect to see a mood-congruent effect on reading performance as evidenced by the more likely endorsement of the negative self-statements of Condition 1 while in the negative mood. Practice effects are inherent in the current design as our procedure did not counterbalance mood. All participants were tested in the neutral mood, followed by the negative mood. Therefore, the interaction of mood by sentence condition is crucial as it provides evidence for mood-state specific effects in reading sentences and for the judgment of plausibility. Research regarding the influence of negative mood on reading performance is limited (Hettena & Ballif, 1981; Watkins, Teasdale, & Williams,

2003; Jacoby, Brewin, & Watkins, 2008;) and the current study intends to provide evidence of how mood-state influences language processing.

### Memory Performance

The dependent variable to be collected for the memory task is recall accuracy. For this task, participants will be asked to recall the target word for 24 previously viewed sentence stems. Participants will be presented with examples of all 6 sentence conditions presented during the reading task and recall accuracy will serve as the dependent variable. This dependent variable will be calculated as a percentage correct out of the total possible correct in each sentence condition (eg. 1.0 = 100% correct, .20 = 20% correct).

For the memory task, our independent variable of mood will be the same as in the reading task. The memory data will include all 6 sentence conditions and include target word valence and self-referent context as independent variables. Encoding conditions 5 and 6 for the memory data analysis allows for a more comprehensive consideration of how participants remember sentence final word targets according to valence and whether there is an advantage for a self-referent context.

Our a priori predictions for memory performance regarding emotion targets are similar to those in the reading task. We predict the data will show improved cognitive performance for emotionally-relevant stimuli compared to neutral stimuli (Bradley et al., 2001; Schupp et. al, 2004). For example, this prediction is consistent with Schupp et al. (2004), who found emotional material

requires more mental resources using a startle probe paradigm. This prediction will be supported by a significant main effect of target word valence.

Based on evidence presented in arousal models of improved memory (Levine & Burgess, 1997; Kensinger & Corkin, 2003), our prediction is that a negative mood will increase overall recall accuracy with improved memory for all sentence targets in the negative mood. The investigation of this prediction will be supported by a significant main effect of mood.

As we are including only never-depressed we predict enhanced emotional recall will occur for positive target words. Considering the mood-congruent memory evidence in the current review, we that recall for negative targets will increase while in a negative mood state. Our mood-congruence prediction will be supported by a significant interaction effect of mood by valence with a planned comparison showing that negative targets are more memorable in the negative mood.

Atchley, Ilardi, Enloe (2003) suggests that positive information is processed faster and more accurately in populations that have never experienced depression. As our participants are all currently non-depressed, this population will show positive bias in the neutral mood that will decrease in the negative mood. Atchley, Ilardi, Enloe (2003) found this positive bias in a word valence judgment task and we predict that this bias in language comprehension will have a similar effect in the domain of memory performance. We predict that if the primary influence on memory performance is current mood (i.e. a state-dependent effect), then mood should change memory performance for the positive words. If

recall memory for the positive targets does not change between the neutral and negative moods, the results will be consistent with trait-specific models of emotion processing.

We will also investigate the influence of self-reference in a 3-way interaction of mood by self-reference by valence. This analysis allows for the examination of all three independent variables in order to consider how remembering negative, positive, and neutral words is affected by reading self-referent information in a negative mood. Our initial prediction for this analysis is that participants will show improved recall for targets that are present in self-statements. There is evidence for a bias to attend to self-referent information (Ingram, 1983) and we predict that the self-statements will be overall remembered better than the other-referent sentences presented. We also predict a negative memory bias for self-statements while in the negative mood as compatible with evidence using depressed populations has suggested a bias to focus on self-reference while in a negative mood state (Ingram, 1990).

## Methodology

### *Subjects and Measures*

Eighty-five (49 males and 36 females, 18-21 years of age) strongly right-handed Kansas University students were recruited for this study from an introductory psychology course in exchange for course credit. Only participants with native level proficiency in English and normal or corrected to normal vision were accepted. In order to be included in this study, participants must have scored between 2 and 9 on the Beck Depression Inventory, which indicates that

participants are not currently depressed (Beck et al., 1988). As an additional measure that served as part of our inclusion standard, scoring lower than 25 on the Inventory to Diagnose Depression-Lifetime edition suggested that participants were not currently in a depressed mood state and that they had no history of depression (Zimmerman and Coryell, 1987).

### *Stimuli and Apparatus*

Stimuli were displayed on a Dell XPS laptop computer that recorded reading time (READ), response choice (RESP), and reaction time (RT) while the participants performed the reading task. These stimuli were presented using E-prime software. Sentences were presented in the center of the screen, one word at a time, and participants were allowed to read at their own pace by advancing using the spacebar. Two counterbalanced experimental blocks were presented, the neutral mood block followed subsequently by the negative mood block. Each experimental block contained one reading task and one memory task. Each reading task contained 48 randomized sentences, including 24 of our critical conditions and each containing 18 self-referent statements. All sentence final word targets were chosen according to its negative, positive, or neutral valence according to norms reported in previous research (Gotlib et al., 1988; Myers, 1980; Siegle, 1995; and the Affective Norms for English Words [ANEW], Bradley & Lang, 1999). Example sentences are presented in Table 2 [p. 60].

For each experimental block, a memory task was administered and recorded using pencil and paper. The stimuli on each memory task included 24 sentence stems that were presented in the previous reading task and participants

were asked to fill in each sentence final word. Each memory task included 12 self-statements and 12 other-referent statements and all sentence conditions were divided equally by valence so that there were 8 negative, 8 positive, and 8 neutral sentence targets. Subjects were allowed to work on the memory task at their own pace, though they were encouraged to work more quickly after about 10 minutes.

Table 2  
Sentence Condition Codes

Sentence Condition	Target Valence	Self-Referent	Plausible
1	Negative	Yes	No*
2	Positive	Yes	Yes**
3	Neutral	Yes	No
4	Neutral	No	Yes
5	Negative/Positive/Neutral	No	Yes
6	Negative/Positive/Neutral	No	No

Table 2. Condition codes for all sentence conditions. \*Sentences in Condition 1 are considered grammatically plausible, but we have considered them implausible as consistent with a positive self-evaluation. \*\*Condition 2 is considered plausible as consistent with a positive self-evaluation.

The independent variable of sentence condition consists of 6 conditions. Condition 1 consists of plausible self-statements that end with negative target words. Items in condition 1 are considered grammatically plausible, though for the purposes of this study, they have been coded as implausible as they are inconsistent with a subjective positive self-evaluation. Condition 2 contains plausible self-statements ending in positive target words. Condition 3 contains semantically implausible self-statements ending with neutral targets. Condition 4 contains plausible other-referent statements that end with a neutral target word. Condition 5 contains plausible other-referent filler sentences that end with

alternating negative, positive, and neutral targets. Condition 6 contains implausible other-referent filler sentences that end with alternating negative, positive, and neutral targets. See table 3 for examples of all sentence conditions [below].

Table 3  
Stimulus Examples

Stimulus Condition	Example Stimulus
Negative Self-Statements	People consider me to be worthless.
Positive Self-Statements	My family thinks that I am interesting.
Neutral, Implausible Self-Statements	Others see me as a desk.
Neutral, Plausible Other-Statements	Maids often clean the kitchen.
Plausible Other-Statements	Tornadoes are a type of natural disaster.
Implausible Other-Statements	Albert Einstein was a hamster.

Table 3. Examples of all sentence condition.

### *Procedure*

Upon arriving, subjects were seated and asked to read a description of the experiment and sign the research consent form. After signing the consent form, we administered each participant the Beck Depression Inventory, the Inventory to Diagnose Depression, and the Visual Analog Scale (VAS). The VAS offers a subjective measure of current mood according to how sad participants indicate that they feel at the moment. Each participant was given the VAS upon arrival to the study and again after the mood induction in order to assess a subjective level of mood.

Following filling out these forms, participants were given an introduction to the sentence reading task, with the directions for the task displayed on the screen as

the experimenter read the instructions aloud. As sentences words appeared, participants were asked to use their right hand to advance to the next word by pressing the spacebar. Oral instructions were given aloud to use the left hand to make their judgment of semantic plausibility for each statement by pressing 1, for “yes” this is a plausible statement, or 2, for “no” this statement is implausible or doesn’t make sense. Further explanation by the experimenter indicated that a period will reveal the sentence final word, followed by a prompt the participant to make their plausibility judgment (signaled by “?”).

Following the first experimental block of the reading task, the first memory task was administered and the participant was left to complete the task alone. Then, participants listened to instructions given by the experimenter about the mood induction procedure. The experimenter mentioned that the experiment is completely confidential and that the participant was free to leave at any time with full participation credit. Following these oral instructions for the mood induction, further instruction were given by a narrator on a recording and an 8 minute musical score was played to the participant via headphones. During the mood induction portion of the experiment, the participant was left in the room alone to encourage a more intimate setting. Once the recording ended, the experimenter asked participants to write a brief description (1 or 2 sentences maximum) of the sad moment they were thinking about while listening to the musical score. This was followed by the administration of two questionnaires assessing current mood state, the second VAS and the Multiple Affect Adjective Checklist Depression Scale (MAACL-D) (Zukerman & Lubin, 1965), which provided an additional

self-report measure of current mood as participants mark items on a list of adjectives that refer to possible mood states. The MAACL-D was only administered while in the negative mood.

For the second half of the experiment, a second practice block was given before the participant performed the second experimental block of the reading task with a new set of sentences followed the second corresponding memory task. After the memory task, the experimenter debriefed the participant and he or she was allowed to leave. On average, the entire experiment took about 50 minutes to complete.

The two experimental blocks of the reading task were separated by the mood induction procedure delivered via headphones using Windows Media Player software. For the induction of negative mood, participants were asked to consider a sad moment in their life while listening to the musical score, entitled Prokofiev's "Russia under the Mongolian yoke." This form of mood induction have been found to successfully elicit a transient negative mood as assessed using self-report measures such as the VAS (Teasdale & Taylor, 1981; Clark & Teasdale, 1985; Gemar et al., 2001; Richell & Anderson, 2004). Therefore, the second within-subjects independent variable was current mood state, of which the two levels were neutral (before the mood induction) and negative (after the mood induction). Current mood state was rated using measures of self-report that included VAS (before and after the mood induction) and Multiple Affect Adjective Check List Depression Scale (after the mood induction).

According to the VAS, the mood induction was considered successful by the participants,  $F(1, 47) = 46.37, p < .001$ . Scores for the VAS in the neutral mood ( $M = 12.18, SD = 13.08$ ) were significantly smaller than the VAS scores in the negative mood ( $M = 26.38, SD = 17.13$ ), reflecting increased negative affect while in the negative mood state. However, mean scores for the Multiple Affect Adjective Check List Depression Scale were not consistent with the VAS. According to this self-report measure, participants rated their mood as moderately positive ( $M = 3.66, SD = 18.33$ ). These two self-report measures suggest that participants felt more sadness after the mood induction procedure when compared to scores recorded before the mood induction (VAS), but that participants still considered themselves in a positive mood (MAACL-D).

### Results – Reading Task

#### *Reaction Time (RT)*

A main effect of mood did not reach statistical significance,  $F(1, 78) = .406, p = .53$ . While in a neutral mood, participants responded to the plausibility probe ( $M = 656.51\text{ms}, SD = 531.33$ ) as quickly as participants in the negative mood ( $M = 685.73\text{ms}, SD = 425.41$ ). There was a significant main effect of sentence type,  $F(3, 78) = 7.16, p < .001$ . The results for RT in the four critical sentence types are presented in Table 4 [pg. 65].

Table 4  
Reaction Time: Sentence Type

	Neutral Mood	Negative Mood	Across Mood
Condition	MEAN (ms)	MEAN (ms)	MEAN (ms)
Negative	585.87 (269.28)	700.17 (485.80)	643.02 (377.54)
Positive	699.14 (794.30)	722.63 (484.18)	710.89 (639.24)
Neutral Implaus	574.89 (290.90)	598.37 (334.18)	586.63 (312.54)
Neutral Plaus	766.13 (770.83)	721.75 (397.47)	743.94 (584.15)

Table 4. Estimated marginal means presented in milliseconds (ms), with standard deviations in parentheses, for sentence type in the neutral mood, the negative mood, and the average across mood for sentence type.

Across sentence type, post-hoc comparisons with Bonferroni adjustments indicated that the critical valenced sentences of conditions 1 and 2 were not significantly different ( $p = .17$ ). Participants reacted significantly faster to the neutral implausible self-statements of condition 3 than to conditions 2 and 4 ( $p < .05$ ) and condition 3 was not statistically different than the negative self-statements of condition 1 ( $p < .09$ ). The negative sentences of condition 1 were marginally different from the neutral plausible sentences of condition 4 ( $p = .06$ ). The reactions to positive sentence of condition 1 did not react differently from the neutral plausible sentences of condition 4 ( $p = 1$ ). Participant reaction was significantly slower to the neutral plausible statements of condition 4 than to condition 3 ( $p < .05$ ).

The interaction effect of mood by sentence type did not reach statistical significance,  $F(3, 78) = 1.15$ ,  $p = .22$ . Though the interaction of mood by sentence type did not reach significance, we performed planned comparisons with least significant difference adjustments based on our a priori predictions regarding the

influence of mood on sentence processing according to target valence. Planned comparisons revealed that participants responded more slowly to the plausibility probe in condition 1 while in the negative mood ( $p < .05$ ). While in the negative mood, participants were slower to reject the self-statements with negative targets ( $M = 700.17$ ,  $SD = 485.80$ ) as compared to the neutral mood state ( $M = 585.87$ ,  $SD = 269.28$ ). A change in mood did not affect reaction time for any other sentence condition. For the results of the mood by sentence type interaction, see Figure 1 [below].

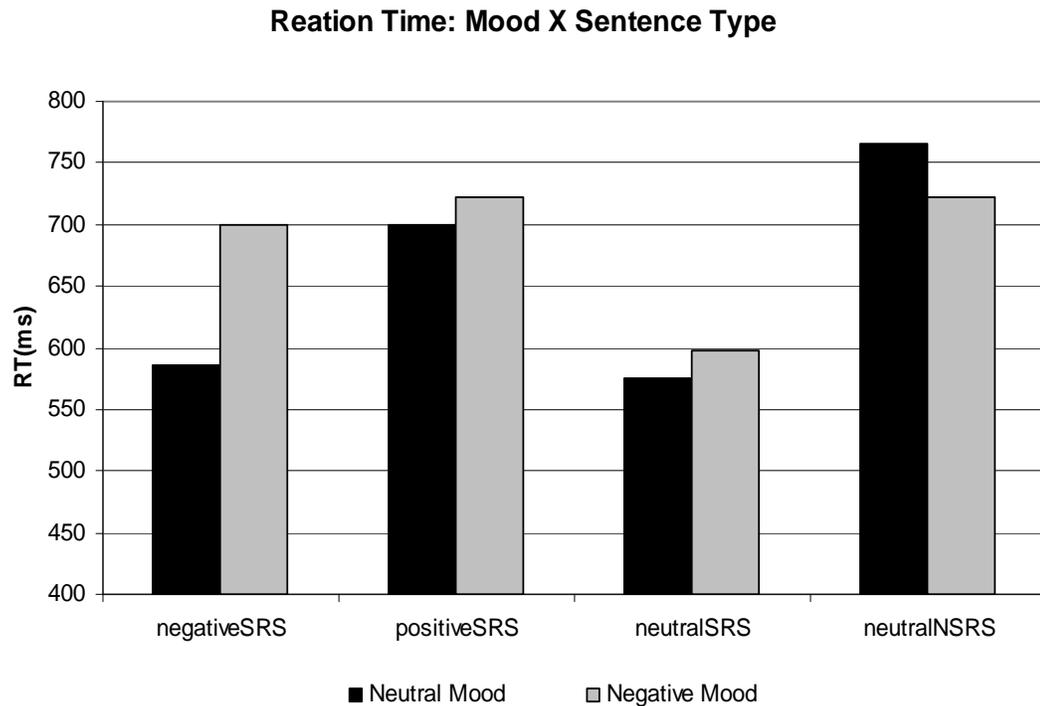


Figure 1. Reaction time results: The effect of mood by sentence type.

### *Reading Time (READ)*

There was a statistically significant main effect of mood,  $F(1, 78) = 10.70$ ,  $p < .001$ . The estimated marginal means for this main effect indicate that all

participants read the sentence final word faster while in a negative mood ( $M = 880.97$ ,  $SD = 423.28$ ) as compared to reading time during the neutral mood state ( $M = 1001.37$ ,  $SD = 491.21$ )(\*see Table 5). An effect of sentence type did not reach significance,  $F(3, 78) = 1.65$ ,  $p = .18$ . The reading time results for sentence type are presented in Table 5 [below].

Table 5  
Reading Time: Sentence Type

	Neutral Mood	Negative Mood	Across Mood
Condition	MEAN (ms)	MEAN (ms)	MEAN (ms)
Negative	1014.66 (400.56)	939.35 (448.71)	977.01 (424.64)
Positive	1005.94 (455.74)	901.27 (481.80)	953.61 (468.77)
Neutral Implaus	969.98 (352.59)	896.16 (341.91)	933.07 (347.25)
Neutral Plaus	1014.89 (755.96)	787.09 (421.10)	901.00 (588.53)
*Across Condition	1001.37 (491.21)	880.97 (423.28)	

Table 5. Estimated marginal means presented in milliseconds (ms), with standard deviations in parentheses, for sentence type in the neutral mood, the negative mood, the average across mood for a main effect of sentence type, and the average across sentence type for a main effect of mood.

The interaction of mood by sentence condition did not reach statistical significance,  $F(3, 78) = 2.338$ ,  $p = .074$ . Though the interaction of mood by sentence condition did not show significance, planned comparisons with least significance difference adjustments indicated that sentence target conditions 2 and 4 were read differently than the targets in conditions 2 and 3. While in the negative mood, the positive targets of condition 2 ( $p < .05$ ) and the neutral plausible targets of condition 4 ( $p < .05$ ) were read faster. Reading time for the negative targets of condition 2 and the neutral implausible targets of condition 3

reached marginal significance ( $p < .06$ ). Reading words faster in all sentence conditions while in a negative mood possibly indicates that these results were influenced by practice effects. The results for the mood by sentence type interaction are displayed in Figure 2 [below].

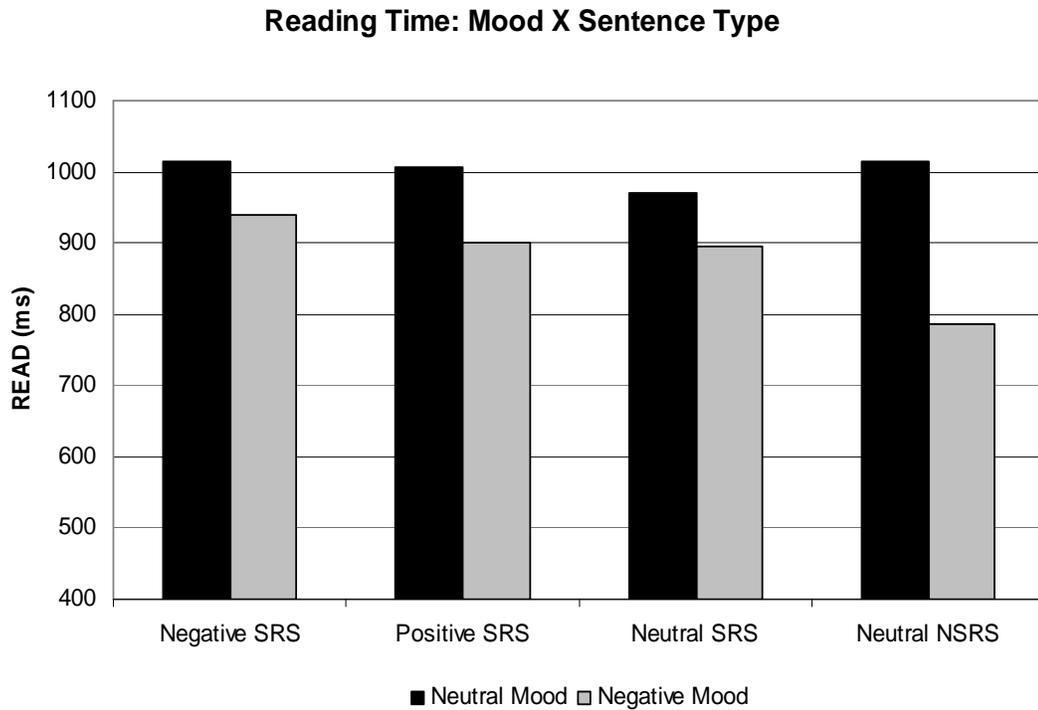


Figure 2. Reading time results: Means for the interaction of mood by sentence type.

### *Response Choice (RESP)*

Regarding the difference in response choice for the negative and positive self-statements, considering the data as a reflection of participants choosing a positive-evaluation implies that there was no difference between how participants endorsed the positive and negative self-statements. However, after converting response choice to the likelihood that participants accept sentences as plausible (i.e. say “yes”), we find this data more meaningful.

A main effect of mood did not reach statistical significance,  $F(3, 78) = .20, p = .66$ . The estimated mean likelihood of how participants endorsed sentence plausibility was similar in a neutral mood ( $M = .90, SD = .01$ ) to how participants chose while in a negative mood ( $M = .89, SD = .01$ ). A main effect of sentence type reached significance,  $F(3, 78) = 17.047, p < .001$ . Regardless of mood, planned comparisons with Bonferroni adjustments indicated that participants were far more likely to endorse the positive self-statements over the negative self-statements. Participants endorsed the negative (condition 1) and positive (condition 2) self-statements consistent with a positive self-evaluation similarly. How participants rejected the negative self-statements of condition 1 was not different from how they accepted the positive self-statements of condition 1 ( $p < .54$ ).

Across sentence type, participants were least likely to endorse as plausible the neutral implausible self-statements of condition 3 (significantly different from conditions 1, 2, and 4,  $p < .001$ ) and most likely to endorse the neutral plausible general-bias statements of condition 4 (significantly different from conditions 1, 2, and 3,  $p < .05$ ). Participants were significantly more likely to endorse the negative self-statements over the neutral implausible self-statements ( $p < .05$ ). Participants were significantly more likely to endorse as plausible the positive self-statements compared to the neutral implausible self-statements ( $p < .001$ ).

The results for the main effect of sentence type are displayed in Table 6 as the percentage likelihood that participants endorsed each condition as plausible. [p. 70].

Table 6  
Response Choice

Response Choice	Negative Condition 1	Positive Condition 2	Neutral SRS Condition 3	Neutral SRS Condition 4
Yes	17% (26%)	85% (16%)	3% (8%)	92%(11%)

Table 6. Percentage of likelihood, with standard deviations in parentheses, for responding “yes” in plausibility judgment task as compared across sentence condition.

The mood by sentence type interaction did not reach statistical significance,  $F(3, 78) = .44, p = .72$ . Planned comparisons with least significance difference adjustments did not reach significance and revealed that response choice did not significantly change with a change in mood.

#### Discussion – Reading Task

For the reading task, our a priori predictions were that participants would show faster reaction time on the plausibility judgment for emotion-related targets. We also predicted faster reading time for emotion-related target words. For response choice, we predicted that normal participants would be more likely to endorse positive self-statements as consistent with previous evidence showing a trait-specific bias in cognitive performance based on life experience (Atchley, Ilardi, & Enloe, 2003). We also predicted that participants would be more likely to endorse negative self-statements while in a negative mood, which would provide evidence for a mood-congruence effect on reading comprehension.

For the independent variables in the reading task, we predicted an interaction of mood by sentence type, providing evidence that reading

comprehension and making plausibility judgments are affected by a negative mood state. The prediction of a mood by sentence type interaction mediated by target valence (Conditions 1 and 2) would provide evidence that emotional-related content affects reading comprehension while in a negative mood. A mood by sentence type interaction mediated by self-reference (Conditions 1, 2, and 3) would suggest that self-referent context affects reading comprehension while in a negative mood.

Regarding the main effect of mood, faster RT for implausible sentences is somewhat surprising in light of previous findings showing that reading implausible sentences is more difficult than plausible sentences (Speer & Clifton, 1998). Making a plausibility judgment may have been easier for the implausible sentences of Condition 3 as we used implausible sentence target words that may have been obvious.

In support of our predictions, the RT data indicated that judging the plausibility of self-statements and other-referent statements is affected by negative mood. Negative mood increased the length of time participants spent making all plausibility judgments. More specifically, negative mood influenced the length of time participants spent making a decision about negative self-statements. Though the RT results for a mood by valence interaction did not show significance, the planned comparison analysis suggests that participants were slower to reject the self-statements with negative targets while in a negative mood.

Regardless of mood state, the RESP analysis indicated that participants were more likely to endorse the positive self-statements over negative self-statements. The direction of this finding supports our prediction based on previous evidence for trait-specific processing of lexical information (Atchley, Ilardi, & Enloe, 2003; Joorman & Gotlib, 2008). These never-depressed participants judged the positive self-statements similarly to the neutral general-bias statements. Conversely, our participants processed the negative sentences of condition 1 similarly to the implausible sentences in condition 3. The response choice results are interesting in light of past research that has shown the opposite effect in depressed populations (Atchley, Ilardi, & Enloe, 2003). This evidence asserts aspects of sentence processing as trait-specific in never-depressed populations.

Reaction time was shown to be a more reliable variable over reading time and response choice as an indicator of mood-congruent language processing. A comparison of the reaction and response choice data suggests that reaction time may be more sensitive than response choice for detecting the influence of current mood state on sentence processing. Furthermore, the delayed reaction time effect for negative self-statements occurs even though participants are spending less time overall reading the sentence final words while in a negative mood, as reflected by reading time being reduced for the critical sentence final words in all conditions after the mood induction.

Further evidence is needed in order to explain why there is a difference between how reaction time and reading time are affected by mood, especially as we are tempted to consider the possibility that reading sentences faster in the

negative mood may be due to practice effects. Reducing the possibility of practice effects during the second experimental block may be necessary for research investigating how cognitive performance is changes after a mood induction procedure.

As we did not find mood-congruent effects for all of our dependent variables, our results for reaction time results may indicate that only specific aspects of language comprehension are affected by mood. In the case of reaction time, participants took longer to make the plausibility judgment in the negative mood. A recent study suggests that mood does not affect all aspects of cognition, but that mood may have specialized effects on the cognitive processing of emotional material, as in the case of memory performance for information that is congruent with the valence of mood state (Chepenick, Cornew, & Farah, 2007).

### Results – Memory Task

#### *Negative Mood (MOOD)*

A main effect of mood state was significant,  $F(1, 82) = 15.17, p < .001$ . Participants had better memory performance while in the neutral mood ( $M = .51, SD = .11$ ) and worse memory while in the negative mood ( $M = .46, SD = .12$ ).

#### *Target Word Valence (VAL)*

A main effect of valence was statistically significant,  $F(2, 86) = 172.08, p < .001$ . Planned comparisons with least significant difference adjustments indicated that the most accurate recall was for positive target words and the comparison between the negative sentences and positive sentences showed

marginal significance ( $p = .06$ ). Negative targets were recalled more accurately than neutral targets ( $p < .001$ ). Participants showed the least accurate recall for neutral targets ( $p < .001$ ). The results for the analysis of valence are presented in Table 8 [below].

Table 8  
Valence

	Neutral	Negative	Across Mood
Target word Valence (VAL)	MEAN	MEAN	MEAN
Negative	.27 (.20)	.22 (.19)	.25 (.20)
Positive	.30 (.23)	.25 (.21)	.28 (.22)
Neutral	.03 (.07)	.02 (.07)	.03 (.07)
Across Valence	.51 (.11)	.46 (.12)	

Table 8. Results for Valence: Estimated marginal means, with standard deviations in parentheses, in the neutral and negative mood and also across mood.

The interaction of mood by valence did not reach statistical significance,  $F(1, 86) = .56, p < .57$ . Planned comparisons with least significant difference adjustments revealed that there were no significant differences among different valence categories that changed with mood.

#### *Investigation of Self-Reference (SELF)*

The main effect of self-reference was significant,  $F(1, 86) = 960.64, p < .001$ . Planned comparisons with least significant difference adjustments indicated that participants showed better recall for other-referent statements ( $M = .70, SE =$

.01) than for self-statements ( $M = .27$ ,  $SE = .01$ ), ( $p < .001$ ). An interaction effect of mood by self-reference did not reach significance,  $F(1, 86) = .43$ ,  $p = .51$ .

The 3-way interaction of mood by self-reference by valence did not reach statistical significance,  $F(2, 86) = .46$ ,  $p = .633$ . Planned comparisons with least significant difference adjustments did not shown significance. We did find that the interaction of self-reference by valence reached significance,  $F(2, 86) = 55.06$ ,  $p < .001$ . Within the self-referent sentences, post-hoc comparisons with Bonferroni adjustments indicated that both the negative and positive statements were significantly different from the neutral statements ( $p < .001$ ). There was a marginal difference between the negative and positive self-statements ( $p < .07$ ).

#### Discussion – Memory Task

The memory task was successful in showing that mood influenced recall for the critical final word of previously read sentences. We found that a negative mood decreased overall memory performance as we observed a decrease in recall for all sentence targets while in a negative mood. The decrease in recall performance may be due to negative mood; though this finding is not consistent with past research that has suggested that memory performance improves while in a negative mood (Kern, et al., 2005; Levine & Burgess, 1997). Possibly the most parsimonious explanation for the decrease in memory performance is the fan effect (Anderson, 1974; Anderson & Reder, 1999; Moeser, 1979). The fan effect refers to interference among competing associations to a concept held in memory. Due to the limited amount of spreading activation that can occur in memory, more memory associated with one source makes it difficult to access any one

association connected with the memory source (see also Anderson, 2005). For the current findings, the self-statements may be considered high-fan as all associations are connected to one source, the self (i.e. I, me, myself). The fan effect may have reduced recall while in the negative mood due to interference from similar sentence stems that appeared in the memory task performed while in the neutral mood. Furthermore, the fan effect could also explain better memory for the other-referent statements as these concepts would have only received one or two memory associations. For example, “Lawyers can be shifty” and “Lawyers can be pleaded” would have two associates (i.e. shifty, pleaded) connected to one concept (lawyers).

Another possibility contributing to poor memory for the self-statements in the negative mood could be interference produced while in the neutral mood as this may have resulted in a disruption in source monitoring (Johnson, Hashtroudi, & Lindsay, 1993). Source memory refers to our ability to remember details or feature of a memory, more importantly for the current data, when we acquired the information. Cook, Hicks, and Marsh (2007) have asserted that attention to valenced content can reduce source monitoring. Counterbalancing mood by testing two separate groups or testing recall for each mood state on separate days are important steps for future exploration of the current findings.

Another possible explanation for this inconsistency with past research may be due to the sentence final word targets in the current study being rated low in emotional arousal. Though this is not the most parsimonious explanation for a decrease in memory, this is an important difference between the current study and

previous research designs. Regarding decreased memory performance, target words with higher levels of arousal may be necessary for improved memory performance. The low arousal rating of our emotional targets may be why we did not see a significant effect of mood-congruent memory processing. For future research, it will be necessary to include emotional items containing high arousal ratings in order to more precisely identify how level of arousal can affect recall.

The method of mood induction utilized in the current study (i.e. sadness) may be regarded as low in arousal, possibly further explaining inconsistent findings with past research. Negative mood can vary in level of arousal, such that sadness is regarded as low in arousal while anger or frustration may be considered a high arousal, negative mood state. Previous research has proposed sadness and anger as separate mood categories (Lerner & Keltner, 2001; Rusting, 1998)

Our final conclusion based on the finding of decreased memory performance while in a negative mood state is that, given participants showed faster reading time scores while in the negative mood state (for discussion, see pg. 70), participants may not have efficiently encoded these words into short-term memory. Failure to read the sentence final words long enough for sufficient encoding into memory to take place likely contributed to an overall decrease in recall performance while in the negative mood state. This conclusion is further supported by the data suggesting that participants read the implausible sentence final words of Condition 3 as fast as sentences containing plausible sentence final words while in the negative mood state.

Considering the valence of the critical target word, we found an overall memory performance bias to recall positive targets among these non-depressed participants and this happened regardless of mood state. This finding contributes to trait-specific models of emotion processing supported by research showing a cognitive processing advantage for positive items in non-depressed populations (Atchley, Ilardi, & Enloe, 2003).

We found that participants showed greater recall for emotionally-valent targets over neutral targets and this is consistent with the findings of Kensinger & Corkin (2003). However, it was also likely that the nature of our neutral self-referent sentences contributed to this effect. In order to produce neutral self-referent sentences, we chose to use implausible targets due to the difficulty in designing unambiguously neutral self-referent statements that remain neutral across our random sample. It is possible that the implausibility of the neutral self-statements contributed to the reduced memory performance that we are seeing for these stimuli.

The investigation of self-reference and recall indicated that self-statements were processed differently than the other-referent statements. More specifically, self-referent statements showed less recall accuracy than other-referents and this does not support our initial hypothesis based on evidence that dysphoric mood influences the processing of self-referent material by focusing attention on self-referent content (Ingram, 1990; Ingram & Wisnicki, 1999). Again, the fan effect (Anderson, 1974; Anderson & Reder, 1999; Moeser, 1979) has implications for these findings due to the redundant nature of the self-referent sentence stems

being associated with only one concept, the self. Many of these items contained a similar stem and interference may have occurred with a task to remember the sentence final word among several similarly constructed sentence stems.

Possibly contributing to this explanation based on the fan effect, Anderson and Shimamura (2005) suggests that negative mood may result in a decrease in the memory for the context of events and it could be possible that our data indicate a decrease in context-specific memory as participants in this study showed poor recall for items that required memory for the sentence stem in order to more accurately remember the sentence final words.

### Conclusions

To summarize, the goals of this research were to investigate the effect of negative mood on cognitive performance in the domains of language comprehension and memory. Before and after a mood induction, participants made plausibility judgments about sentences containing emotional targets. We measured aspects of reading comprehension and a recall task allowed for the assessment of memory performance when emotional stimuli were present. The mood induction was designed to investigate how performance changes with a negative mood compared a neutral mood state.

Past research has found that words rated high in arousal can generate a valence effect on recall (Kern et al., 2003) and the current study indicates that emotionally-relevant words that were rated low in arousal can also be found to show a significant effect on reading negative words and recall performance. The current design did not compare the effects of high versus low arousal, but the

current findings indicate that the semantic features related to valence alone can influence reading comprehension without drawing heavily on cognitive systems activated by arousal. An independent variable that addresses high versus low arousal would provide more conclusive data relevant to how arousal and valence affect recall.

Considering our predictions for the memory task, a mood congruency effect did not occur. Previous researchers have found enhanced retrieval for information that is consistent with the valence of current mood state (Chepenik, Cornew, & Farah, 2007). However, we found that memory performance goes down generally in a negative mood state regardless of the valence of the material that is to be remembered. Our mood induction technique may not have been sufficient to significantly change mood or may have been too transient to have a lasting effect on cognitive processing. Possible differences in the mood induction procedure are a possible explanation for not replicating previous findings. It will be necessary for future researchers concerned with how reading comprehension is affected by mood to implement a mood induction technique that is high in arousal in order to delineate sadness and anger as distinct categories of negative mood.

In addition to the possible difference of arousal level in the mood induction technique, how we recall information presented at the sentential level is another possible explanation for this inconsistency with previous findings as this format may have increased cognitive load (Hale, 2003; Baddeley, 1988). Recalling information presented at the sentential level increased the amount of information to being held in working memory, leaving less cognitive resources

available to recall the sentence final words. Increasing cognitive load has been shown to impair memory encoding (Fletcher, Shallice, & Dolan, 1998). Further evidence is needed to establish how sentence comprehension is affected by trait-like biases in emotion processing.

The current study contributes to understanding how emotional words influence language comprehension. The majority of the effects found in the current study suggest that how we read emotional sentences and later recall that information is trait-specific. Our data provide an example of how mood state can affect language processing, but more research is needed to establish what specific aspects of language and memory processing are affected by mood state. We found that mood changes performance only in particular aspects of cognitive processing, as in the case of how long it takes to judge plausibility when reading negative information in self-referent statements and our ability to recall critical sentence information.

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