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THE MODULATION OF COVERT ATTENTION BY EMOTION: AUTOMATIC PROCESSING OF EMOTIONAL VERSUS NEUTRAL VALENCED CUES IN A COVERT ATTENTION PARADIGM

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by

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Selective attention has been studied extensively and it is shown, for example, that individuals with conditions such as anxiety show attention bias to threat-related stimuli. It has been proposed that humans are predisposed or that it is naturally adaptive to selectively attend to emotional stimuli (Lang, 2000). Similarly, LeDoux (1996) and others have proposed limbic brain networks allowing for quick and automatic, but sometimes inaccurate, processing of emotion which bypasses primary cortical areas. Along these lines, automatic attention bias to subliminal image cues in an adapted Posner Covert Attention Task was examined in the current study. A sample of 64 participants was used in each of three separate experiments to examine how individuals were cued subliminally by negative or positive emotional vs. neutral images and the modulation of covert attention by emotion. Due to automatic or motivated attention to emotionally salient stimuli, participants were expected to be facilitated in task performance by negative and positive emotional image cues, relative to neutral cues. Further, state anxiety and depression were expected to impact performance on emotional cueing as well.

As expected in Experiment 1, subliminal images produced significant covert attentional cueing and only negative image cues compared to neutral ones produced response time (RT) reduction by valid cueing across both cue-target delay conditions. Further, cueing differences between neutral and negative images were seen only at short delays, supporting differential subliminal processing of emotional cues in attentional paradigms and supporting previous evidence of unconscious fear processing and specialized automatic fear networks. Moreover, in Experiment 2, when delays following subliminal cues were extended further, emotional cues did not differentially modulate covert attention, suggesting that subliminal emotional cueing seems to occur more immediately. Positive subliminal imagery in Experiment 3 was largely unsuccessful in differentially modulating covert attention compared to neutral cues, suggesting that positive information is either not effective in modulating covert attention or occurs over similar immediate time durations as negative cues in Experiment 1. Finally, the presence of self-reported state anxiety and depression affected task performance, especially in Experiment 1 negative for subliminal discrimination of negative vs. neutral image cues. Overall, the current study adds to the research literature which demonstrates that emotional information, especially negative imagery processed at short intervals, can be processed below awareness to modulate attention in a different manner than less salient neutral stimuli and this modulation is further influenced by state anxiety or depressive symptomatology. Implications of these findings and future directions for research are discussed.

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CHAPTER 1

INTRODUCTION

An important aspect of everyday life is the ability to make quick, automatic decisions, sometimes based on limited available information. Many examples of rapid cognition were discussed in a popular book, such as psychologists accurately predicting marital satisfaction from brief interpersonal observations, students showing useful teacher effectiveness ratings from observing a 2-second video clip, and art experts knowing from a 2-second glance that an alleged ancient sculpture was a forgery (Gladwell, 2004). Such rapid cognition can be important in a variety of areas, from firefighters or police officers making split-second decisions affecting others' lives, to military commanders reacting to the actions of opposing forces, to even athletes performing actions quickly in the heat of competition. The focus of this dissertation is on how certain quick and automatic decisions can be made based on emotional information and how such rapid processing is modulated by emotional cues.

A variety of cues are utilized in automatic cognitive processing, with innately prepared or emotion-related cues especially helpful at times in aiding cognitive processes such as attention, decision-making, or memory. Danger signals, for example, are important in making quick decisions and acting automatically to keep oneself safe (LeDoux, 1996). During a hike in the woods, if one is about to step on a snake, it is very important to be able to quickly and automatically recognize and act to avoid the snake by stepping out of the way, without having to stop and contemplate about a proper decision. Likewise, most individuals can recall an instance in which they flinched or ducked when an object was thrown at them rapidly, before they fully realized what was occurring. Only afterwards does one usually notice that physiological responses such as increased heart rate has occurred. Reactions driven by emotions, especially fear, can occur automatically, and help regulate defensive reactions, food or sex seeking, and other behaviors (LeDoux, 1996). Stimuli that can be processed rapidly, with little or no training, are sometimes referred to as biologically prepared or “hardwired” into one’s brain by LeDoux and others. Certain stimuli including spiders, snakes, or blood are thus assumed to be innately feared due to this tendency being passed down from ancestors, because the fear allowed avoidance of harm, aided survival, and was proven to be adaptive (Cummins & Cummins, 1999). Negative emotional cues, especially fear cues, may fall into this category. Quick, automatic emotional reactions are the main focus of the current project, with the primary goals being to examine ways in which emotional reactions interact with attentional processes and to determine whether attentional cueing by salient emotional cues promotes faster attentional processing.

Attention and emotion are broad constructs that have been researched and theorized about by a variety of disciplines, yet remain somewhat vague concepts even though nearly everyone has an idea of what emotion and attention are. A number of attention definitions and several types of attentional processes have been described — some of them will be discussed in the first section of this literature review. Likewise, emotion has been defined in various ways by researchers, though presently emotion seems to be described in somewhat unclear terms and to be inadequately understood. Some emotional models are explored later in this literature review, as well as the importance of attention-emotion interactions and novel approaches to studying such interactions.

In order to better understand what elicits attention, and how situations such as one's current emotional state relate to selective attention, different attentional mechanisms need to be understood. Aspects of attentional processing such as covert attention are explained in the upcoming literature review, but first a few concepts are briefly explained. Various types of selective attentional processes have been studied, including early, automatic processes such as covert attention and more executive processes such as sustained attention. Covert attention is a type of visual-spatial processing that can be engaged quickly to spatial locations, using peripheral vision independent of foveal eye movement (Posner & Peterson, 1990). Sustained attention, or the maintenance of attention and concentration over time, can allow one to perform demanding tasks for an extended period. In general, covert visual spatial attention allows detection of the location of stimuli on which to selectively attend and quick assessment of the importance of stimuli at that location. The major focus of the current project is covert spatial attention rather than sustained attention. The ensuing literature review focuses on the interaction among attentional and emotional processes to explain how emotional cues affect covert attention. The primary goal is discovering whether emotional images, compared to neutral cues such as arrows or other symbols, are able to be processed more quickly and utilized at shorter cue-target intervals as attentional cues.

Other terms are sometimes used interchangeably with the term "selective attention", though there are several discrete aspects to selective attention and types of visual attention. Stimuli to which one selectively attends are often referred to as “grabbing” or “catching” one’s attention, while boring tasks requiring one to maintain attention to keep from missing necessary information are also sometimes described as measuring selective attention. Selective attention can be described simply as the cognitive process of selecting certain more relevant stimuli over others, or as attending to some stimuli while ignoring others. It is important to be able to selectively attend to certain stimuli, as one cannot possibly process all available stimuli and information in the environment.

One classical attentional theory, Broadbent’s filter theory (1957), suggested that early selection of stimuli based on a filtering mechanism allows salient stimuli (i.e., one’s name) to pass through while less important ones are blocked from further processing (See Figure 1 below). For example, in dichotic listening tasks, individuals hear information presented to both ears but selectively attend to and repeat only the information at one ear. They are able to describe very little information from the unattended ear, and in fact, often cannot identify words, phrases or even the language of the information presented to the unattended ear (Moray, 1959).

While dichotic listening tasks lent some support to Broadbent’s early selection theory, apparently not all information is selectively filtered and blocked from more thorough processing. Further research failed to fully support predictions of this early selective attentional filter model. For example, in the “cocktail party effect,” a person can selectively hear and attend to their own spoken name amidst numerous noises and other distractions (Moray, 1959) in a crowded setting. Similarly, familiar faces elicit visual selective attention in a crowd filled with other available and interesting visual cues, and seem more likely to draw our attention than strangers. Thus, it is clear that certain environmental stimuli elicit attention more readily than others.

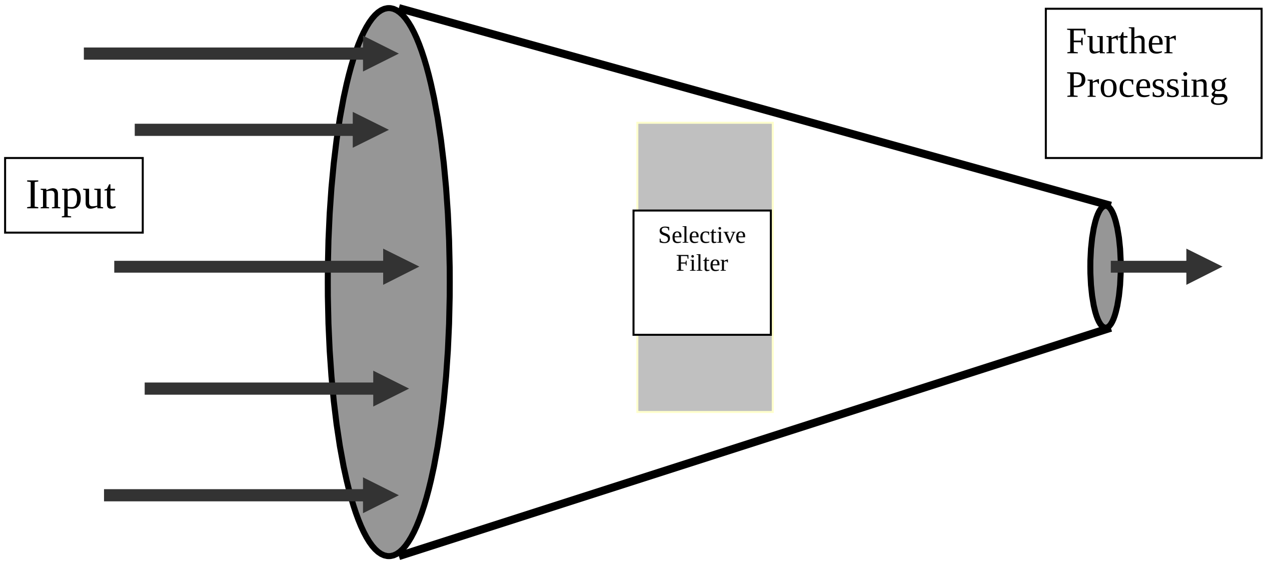


Figure 1. Depiction of bottleneck in Broadbent's limited capacity filter model of attentional processing. Environmental information is temporarily stored, sorted by a filter, and either processed further or decays, thus demonstrating the limited capacity of human attentional processing due to the bottleneck.

Emotionally salient information is a type of environmental stimulus that readily elicits attention, such as emotional imagery, seeming to elicit greater selective attention than other neutral images (Lang, 2000). Certain paradigms within psychology have examined not just how, but why selective attention occurs to such emotional stimuli. In Lang's (2000) concept of motivated attention, also called natural selective attention, attentional allocation is driven by current physiological states including hunger, by states such as avoidance of harm, or by emotional/mood states. Motivated attention hypothesizes that attention is allocated to certain salient environmental stimuli because of evolutionary survival advantages. It may have been adaptive, for example, for animals to notice and attend to potential predators in the environment, or to ignore some stimuli in the environment so that other important stimuli are not overlooked. Allocating attentional resources to insignificant stimuli in the presence of potential predators would not have promoted survival. Perhaps inability to notice and attend to emotional stimuli such as facial expressions for humans would have been detrimental for the human species, while being able to determine emotional expressions or notice dangerous stimuli aided in survival and social development.

Similar to Lang's notions might be that emotional information including affective words can elicit greater attention or be particularly hard to ignore, especially when in an emotional state. What becomes clearer based on the great deal of research and theories about attention and emotion is that humans appear to be predisposed or biologically "hardwired" to attend and respond to certain types of emotional information (LeDoux, 1996). In other words, certain stimuli need less training or conditioning in order to be prepared to respond promptly. As mentioned, just as one would be more likely to selectively attend to food cues when in a hungry state, one may similarly show greater responses and selective attention to emotional cues, especially when they are congruent with current emotional states.

Lang's model may thus help explain the tendency to attend to events related to psychopathology. Individuals with certain psychological disorders, for instance, may be predisposed to attend to stimuli related to their disorder. Those with anxiety disorders tend to focus more readily on perceived environmental threats; those with affective disorders may more easily notice such interpersonal cues as a disparaging tone to a peer's voice. Such attentional bias has been found in a number of studies, with panic-related words for panic disorder patients, threat-related words during high state anxiety, with phobic words in phobia patients in the presence of the feared stimuli, and with negative concern-related words for depressed patients, among other research (Brosschot, de Ruiter, & Kindt, 1999; Lundh, Wikstrom, Westerland, & Ost, 1999; Nunn, Mathews, & Trower, 1997; Wells & Matthews, 1994). Bradley and colleagues found selective attention biases for depression-related words during negative mood induction (Bradley, Mogg, & Lee, 1997) and negative recall bias to negative trait words after negative mood induction (Bradley, Mogg, Galbraith, & Perrett, 1993). In a real world situation, such attention biases may apply to situations such as finding it particularly difficult to ignore a crying baby when in a negative emotional state, or to keep from being distracted by attractive individuals or cheerful music when in a positive emotional state.

While models such as Lang's motivated selective attention strive to explain how and why selective attention occurs for certain environmental stimuli, other neuropsychological models have sought to explain the processing of emotion-related stimuli by the brain. As Lang (2000) discusses, brain systems that are related to approach and avoidance behavior may aid in modulating motivated attention and help determine which environmental stimuli are deemed most salient. Also related to assigning importance to emotional cues, LeDoux's (1996) model of emotional processing in the brain describes a direct pathway to the amygdala from the thalamus that allows quicker, automatic processing of emotion-related stimuli. LeDoux has used his model in an attempt to explain how psychological disorders such as phobias and post-traumatic stress disorder (PTSD) relate to fear responses based on the direct, fast processing of particular emotional information.

LeDoux's model is related to and may be useful for studying relationships between selective attention and emotional processing. Studying selective attention bias and emotion requires the development of specialized methodology, and has led to the use of various cognitive and attentional tasks to examine responses to stimuli such as words and imagery. Such tasks have aided in relating selective attention to emotional states and psychopathology, but may not completely measure ways in which emotion affects attention and information processing. Discovering how individuals attend to emotional stimuli and use emotional information to cue attention may provide useful insights and implications, including the nature of psychopathology, or ways in which to conduct clinical interventions and assessments.

Related to quick, automatic processing, cognitive models have described how information can be processed without conscious awareness, or subliminally. This has been found in various studies, including Winkielman and Berridge's (2004) findings that suggest that processing of emotional information below the conscious threshold can affect subsequent behavior and choices even without conscious feelings. In addition, Bradley, Mogg, and Williams' work with subliminal priming in relation to mood and affect shows that automatic attentional processes in response to subliminal emotional cues may be biased or disrupted in individuals with high negative affect (Bradley, Mogg, & Williams, 1994; Mogg, Bradley, and Williams, 1995).

In order to extend research in areas of attention, emotional processing, and subliminal priming, the current study is designed to examine covert attention and cognitive processing related to emotional cues in order to better understand the relation of attention and emotion. LeDoux's (1996) model of emotional processing is discussed as a basis for how emotional information might be processed more quickly than other types of information. Interactions between emotional processing and covert attention are examined using a modification of an existing attentional task, Posner's covert attention paradigm (Posner, Snyder, & Davidson, 1980). The primary goal of the current project is to examine behavioral responses to cognitive versus emotional cues to investigate whether faster emotional processing and greater attentional priming by salient emotional cues occurs. Many current models of attentional processing and tasks designed to measure aspects of selective attention (i.e., Lang, 2000) do not incorporate the quick, automatic nature of emotional effects on selective attention. Before reviewing the interaction of emotion and attention as well as specifics of emotional information processing, it is first necessary to describe the broad construct of attention and explore some basic definitions.

LITERATURE REVIEW

In focusing on attention, emotion, and interactions among attentional and emotional processes in the current literature review, several primary areas are first addressed. The review briefly addresses prior descriptions and models of attention, as well as methods that have been used to investigate selective attentional biases. Since it refers to several methods of studying the association between emotional and attentional processes, it is useful to briefly discuss such methods. Among the different types of attention that have been researched, the current project focused on covert attention to emotional versus neutral image cues. Moreover, this review describes attentional and emotional processing models, including a model explaining why emotional cues should be processed more quickly, and thus impact covert attention at shorter cue-target intervals. First, however, the focus is on models of attention.

Descriptions of Attentional Processing

"Focus your attention; pay attention now." Such phrases are frequently used, whether it is a parent speaking to a small child while teaching basic skills, or a college professor addressing a class while preparing for an upcoming test. For the purpose of the current literature review, it is necessary to define the concept of attention and basic attentional processes. However, it can be a challenge to define a broad construct such as attention and describe it in practical terms. Though attention may be a complex process to describe and research, numerous experts have tried to create suitable working definitions. In this review, a few classical and more contemporary conceptualizations of attention are explained before moving on to models of attentional processes.

Wells and Matthews (1994) describe attention within an information-processing model as a selection or prioritization of certain types of information for further processing, which does not necessarily differentiate between attention as a more controlled or conscious process and as containing automatic aspects. Utal (2000) concludes that attention, which is an observable component of information processing, is not a separate element of cognition but a measure of it, and, he considers attention an observable component of information processing. Some authors, then, consider attention to be dependent upon or a measure of information processing, suggesting that stimuli are processed at some level before or during selection and attentional allocation. Such notions of attentional processing will be further discussed in an upcoming section. As will be pointed out, while some early attentional models do propose that information is processed at some level before selective attention, not all theorists were in agreement.

Attention has also been described within a motivational context, as the notion of attention as a somewhat rational or voluntary process may overlook the idea of attentional modulation by states such as hunger or need for protection from harm (Lang, Bradley, & Cuthbert, 1997). This aspect of attention has been referred to as natural selective attention or motivated attention, and refers to assigning attentional priority to the most important stimuli to which organisms are naturally more motivated to respond. This view of attention will be described thoroughly in upcoming sections.

Though “paying attention” or “focusing attention” seems to imply an active or conscious role, voluntary selection of stimuli is not always necessary for attentional allocation to occur (Cowan, 1997). For example, a loud explosion nearby would likely draw one’s attention for some amount of time, regardless of what one is doing. Wells and

Matthews (1994) note that several processes, both controlled and automatic, contribute to attentional processing. Hence, a potentially useful way to describe attention is to identify distinct steps or basic processes in attentional allocation. Such distinct aspects to attention, including the ability to select a specific stimulus on which to concentrate, shifting attention from one stimulus to another or among stimuli, or maintaining attention, could occur at more than one point in the selective attention process (Zubin, 1975). Mirsky, Pascualvaca, Duncan, and French (1991) relied on factor analysis of over 600 individual neuropsychological assessments in discovering several discrete attentional components. By including many individuals with attentional deficits and using selected assessment batteries believed to be most sensitive to attentional impairments, Mirsky et al. found such distinct components as encoding (i.e., information processing), focusing (i.e., fixating attention), executing, sustaining (i.e., concentrating), and shifting of attention to a new location or stimulus.

From above-mentioned research, it becomes clear that attention is a process that can occur in steps. Covert attention also occurs in distinct steps similar to Zubin's (1975) above descriptions. Covert attention is described briefly as allocation of visual attention to a spatial location without eye movement, using peripheral vision to attend to visual stimuli. One step in covert attention is disengagement from its current focus; the next step is the shift of attentional focus to a new location. Finally re-engagement of covert attention to the new location occurs (Posner & Peterson, 1990). Another way of referring to covert attention is in terms of a spotlight (Goolkasian & Tarantino, 1999). If attention is focused on some central point, then any stimulus that falls within in the range of the visual "spotlight" can be processed, even when not looking at the stimulus directly.

Support for this view comes from covert attention studies showing the benefit of peripheral attentional cues to targets and a number of other studies (Posner, Snyder, & Davidson, 1980).

All in all, despite difficulty in characterizing the broad concept attentional processing, it seems apparent that several discrete and identifiable aspects of attention exist. Further examples of attentional mechanisms and models of attention are described in more detail in upcoming sections. Possible explanations for selective attention to certain types of stimuli are also identified and discussed in upcoming sections before attentional processes are related to emotional processes. Next, early attentional models are briefly described. Classic attentional models are important to mention since they provided a basis for further conceptualizations of and research on attention.

Classical Models of Attention

In the 1950s, psychological researchers (e.g., Broadbent, 1957; Moray, 1959) provided models for examining attentional functioning, and covert attention appears similar to what cognitive theorists described in early-processing attentional models. Broadbent's original conceptualization of attention is probably most relevant to early attentional processes. In Broadbent's (1957) model of limited capacity attentional processing (see Figure 1), incoming information is temporarily stored, and a "filter" selects which information is to be further processed. Information can be sorted based on physical characteristics or sorted based on "channels," such as attending to auditory information from one versus the other ear. Information that is filtered out is not processed further and decays quickly, while information that passes through the attentional filter enters into short-term memory and is further processed. Thus, based on Broadbent's early attentional processing, human attention has a limited capacity and seems to have trouble processing simultaneous arriving signals, which can create an attentional “bottleneck.” Despite the filter, physical attributes such as pitch or loudness of voices or the darkness of printed words can be processed (Broadbent, 1957). Certain problems do exist with this model, such as the aforementioned “cocktail party effect” in which one can attend to a current conversation at a large, noisy party while tuning out other conversations as background noise. However, if someone close by mentions one’s name or a salient word such as “sex,” then this stimulus might be hypothesized to break through the attentional filter and be processed for meaning.

Moray (1959) studied the cocktail party phenomenon by asking participants to listen to a message presented to one ear while ignoring another message presented to the opposite ear. This paradigm is called dichotic listening, and classical attention models were based in large part on dichotic listening tasks using shadowing techniques. In dichotic listening, participants are required to listen to and “shadow” one message played to one ear through headphones while attempting to ignore the message to the other ear (Reisberg, 2001). In shadowing, participants listen to the attended message and are able to repeat the speech word for word after some practice, though usually unable to process or report information of substance about the unattended message (Cherry, 1953; Treisman, 1964).

The important point from Moray’s research is that despite attempts to ignore a message at the unattended ear, and hearing very little of this message, certain words would “leak” through and catch one’s attention. In fact, about a third of participants could hear their own name embedded within the unattended message. Hence, Broadbent’s model of early filtering and limited capacity seems to be somewhat lacking, as certain information which was actively ignored and supposedly filtered out was still processed for meaning at some level. However, Broadbent did conceptualize early attentional processes such as those involved in covert attention.

What seems to emerge from considering Moray's dichotic listening data and from the "cocktail party effect" is this: individuals apparently understand at least some meaningful information from unattended or ignored stimuli. In fact, that attention can be captured at all by such meaningful stimuli as one's name implies that the meaning has been analyzed or processed at least some of the time by certain individuals. Therefore, early selection attentional theories such as Broadbent's do not seem to be satisfactory. However, individuals appear to gain more meaningful information from actively attended stimuli and thus late selection models may also be inadequate to thoroughly describe selective attention.

An alternative model was clearly needed, and Treisman (1964) sought to integrate early and late selection models to provide a more thorough description of attentional processing. In Treisman's study, individuals fully fluent in two languages were able to perceive identical messages presented in one language to one ear and in the other language to the unattended ear. Though processing appeared much better for attended messages, some processing still occurred for unattended messages, leading Treisman (1964) to propose an attenuation model of attentional processing. The attenuation model asserts that a selective filter attenuates, rather than completely blocks, information to the attended channel so that one can still ignore unattended stimuli. When salient information such as one's own name reaches an unattended channel, "breakthrough" can occur so that unattended information is processed. Stimuli can be filtered based on physical properties, while messages can be selected for attention and further processing based on content. Salient stimuli such as one's name have lower thresholds for awareness, non-attended information could pass through in a weaker form, and this system would allow nearly simultaneous processing of several inputs. It seems likely that other salient information, such as emotional cues, would also would pass through the filter threshold for awareness.

Thus, Treisman's (1964) attenuation model explained existing attentional data and achieved a more thorough explanation of selective attention. Though some questions, such as how a stimulus could be partially processed, were left unanswered, classical models helped provide a foundation for subsequent research and are still relevant. Most important for the current project would be the way emotional stimuli would be recognized as salient and be selected for further processing. Also, early filtering relates to rapid, automatic aspects of covert attention and whether emotional stimuli such as affective images would be selected as salient. Early versus late processing and Treisman's attenuation model can be related to current overall research goals of examining whether emotional stimuli as those discussed by Lang or LeDoux lead to faster selective attentional responses. Therefore, it is useful and necessary to mention such classic attention models in the current literature review.

Since these classical models were proposed, based in large part on such tasks as dichotic listening, other selective attention measurement tasks have been developed and tested. Next, basic methodology that has been utilized to measure attentional processes is reviewed before more specific aims of this project are mentioned.

Selective Attention Measurement

In the preceding section, classical models describing early versus late attentional selection were briefly described in terms of how they set a foundation for later models, including how emotional stimuli are more likely to draw attention (Lang, 2000) or be processed more quickly (LeDoux, 1996). Original attentional models were based in large part from dichotic listening data using shadowing techniques, during which little unattended auditory information is processed, though salient stimuli such as one's name leak through (Moray, 1959). Other methods of attentional measurement have been developed and frequently used in order to further develop attentional models and study interactions among emotion and attention. Such methods have allowed researchers to study which types of stimuli catch one's attention over others and are the basis for selective attention research. Stimuli that readily draw attention may provide insight into more controlled versus automatic attentional mechanisms, and how emotional stimuli might draw covert attention more quickly.

Selective attention is often measured by instructing participants to attend to certain stimuli, often "oddballs," which might be shapes, images, written words, or sounds, while ignoring others (Lang, 2000). Negative threat words or comments during tasks are often more attended to or are more distracting to certain individuals, for example (Wells & Matthews, 1994). Responses under such conditions help to characterize selective attention in terms of stimulus salience, since all environmental cues cannot be processed at once (Colby, 1991). The important need to be aware of potentially salient environmental stimuli such as novel visual cues or emotional information can be studied (Lang, 2000), as can how quickly such stimuli are processed.

Characterizing how and when emotional states or emotional information influences selective attention and subsequent processing and studying the relationship between attention and emotion have been a goal of a great deal of research. For now, procedures and tasks that have been developed and used to measure selective attention are described.

Perhaps the most widely used and most well-known task used in studying selective attention has been the Stroop task. This task requires naming the color of various words printed in different colors of ink, while the words also name colors. For example, the word “blue” may be written in yellow ink or the word “red” written in green ink (Stroop, 1935). Naming the color of such words, when measured over a number of trials, is substantially slower than naming the color of neutral words such as “hair” or “clock.” The tendency to automatically process the word meaning interferes with the naming of the color of the word, and the failure to ignore this tendency is known as the Stroop Effect (Posner & Snyder, 1975).

The Stroop task is useful in that it requires participants to ignore information in order to perform the task, and one’s ability to inhibit the automatic urge to read or think about the words can be assessed (Wells & Matthews, 1994). Ability to actively inhibit processing of certain environmental stimuli may have important implications such improving quality of everyday functioning, as maintaining attention in the face of potential distraction is difficult and can be affected by many factors including current emotional state. Although the Stroop task has been an important cognitive task, it does not measure the more automatic aspects of covert peripheral attention. Aspects such as the location of visual attention are also not measured, which can be important. Visual spatial attention paradigms are discussed next and subsequently covert attention.

Visual Spatial Attention

Visual spatial attention, or where in the visual environment selective attention occurs, is controlled in a different manner psychologically and neurobiologically than attention to stimuli in the Stroop task (Rafal, 1996). It incorporates more bottom-up, primitive processes than the Stroop paradigm, and likely aided survival in that it is important to ascertain where in the environment attention should be allocated. The neurological difference between the Stroop and visual spatial paradigms is also very important, as the covert attention task investigates earlier, more automatic attentional responses to both emotional and neutral cues. One visual spatial task, the dot probe paradigm, is discussed next before covering covert attention in greater depth.

Dot probe paradigm. As noted, the allocation of attention typically implies the focus of one's gaze upon a particular visual location. Certain types of stimuli are deemed more salient (i.e., emotionally or motivationally important) and elicit greater attention, and often dot probe tasks are used to discover stimuli on which individuals are focusing. The dot probe paradigm is relevant because it measures how attention can be affected by emotional stimuli such as words or imagery (MacLeod, Matthews, & Tata, 1986).

The basic premise is that two stimuli are presented simultaneously, either on the left or right side of, or at the top or bottom of, a central point on a screen. When the stimuli disappear from the screen, a small, difficult to see target (sometimes a small dot or pair of targets such as vertically oriented dots or arrows) occurs in the same position as one of the preceding words or images. Participants are required to press a button as rapidly as possible when the target probe appears (e.g., to press one of two buttons corresponding to the vertical versus horizontal orientation of the arrow or the dot pair). Instead of using covert attention, participants must look directly at the probe target because the probe is very small and requires a directed foveal gaze to resolve the orientation. This task also gives participants a choice of which preceding stimuli on which to focus. Direct eye gaze is thus measured as an index of selective attention, and assumedly target locations on which participants fixate are responded to most quickly and stimuli drawing one's gaze are deemed most salient.

Discovering stimuli that are apparently deemed the most salient for visual attention is important for concepts such as LeDoux's conceptualization of emotional stimuli as leading to quicker processing. In the dot probe task, threatening words have been used to study stimuli that draw attention in depressed or anxious individuals, as threat words produce quicker responses to targets at those locations (MacLeod, Matthews, & Tata, 1986). Similarly, attentional processes have been examined using depression and anxiety-related words paired with neutral words (Mogg, Bradley, & Williams, 1995). Mogg et al. found the dot probe task useful for examining how attentional processes both above and below conscious awareness related to psychological disorders, implicating influence of emotion on attentional processes.

Covert Attention Paradigm

Usually, visual attention allocation implies selecting a stimulus on which to focus with the eyes, such as focusing on an attractive person in public. According to an established body of research (i.e., Posner et al., 1980), however, focus of attention can occur separately from eye movement. Visual attention without eye movement is referred to as covert visual attention. Examples include drivers catching a glimpse of an animal peripherally while driving a car and avoiding an accident, or basketball players seeing a teammate out of the corner of their eye and passing the ball without directly looking. In tasks developed by Posner (Figure 2), visual attention is cued to peripheral targets with the use of central arrows or peripheral lighted boxes (Posner et al., 1980).

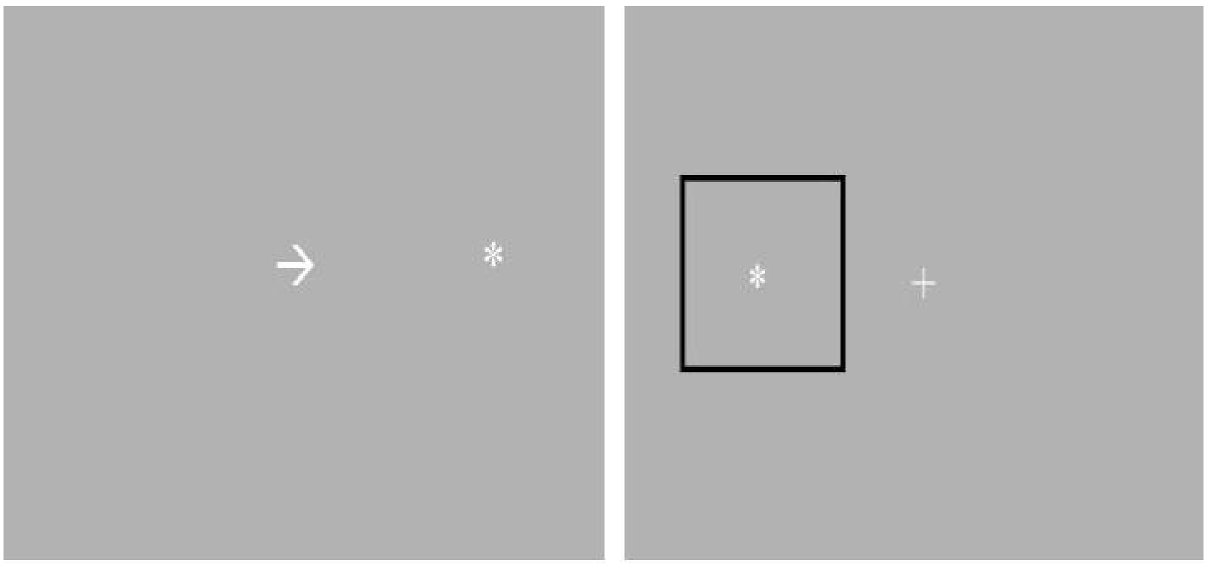


Figure 2. Central arrow cues (left) and peripheral cues (right) to a lateralized target in a covert attention task. Attention is validly cued to the right visual field with the central arrow, or focused on a central fixation cross and validly cued to the left with an illuminated box. Individuals must detect a peripheral asterisk using covert attention.

In the arrow task version, participants focus on a central fixation point such as a cross on a computer screen and are told not to move their eyes from this point. Then, an arrow appears pointing to the left or to the right and cues attention in that direction. Attention remains in the center of the screen while participants detect and respond to the presentation of a target, usually an asterisk. In the peripheral cue condition, illuminated boxes or other stimuli appear on one side of the screen to cue attention peripherally. However, the peripheral version is not the focus of this project.

In the covert attention tasks, participants are able to detect targets without moving their eyes, and performance is facilitated by the arrow or lighted box cues that precede targets and usually give correct hints to the target location. Two types of lateral cues to subsequent target stimuli are presented: valid cues, cueing attention to the correct side as a target, and invalid cues, cueing attention away from targets. The participant must respond as soon as he or she detects this target, and allocation of visual spatial attention peripherally is able to occur without eye movement. Typically in normal adults stimuli at validly cued locations are responded to more rapidly, and the difference in reaction time between the validly and invalidly cued target sequences is known as the validity effect (Posner et al., 1980). A disruption of the validity effect can often signal attentional problems related to a variety of disorders.

An important application of the covert attention task for this proposal is examining how quickly emotional versus neutral cues can be processed and benefit covert attention. In one relevant study, the alerting or arousing effects of auditory tones on covert attentional shifts were examined (Whitehead, 1991). In this study, in which auditory tones preceded lateral targets, alerting tones produced speeded reaction times and increases in maintenance of attention. Enhancement in task performance and attentional maintenance based on arousal was produced for up to 12 seconds at specific visual locations. This suggests that enhanced attention occurs in states in which individuals are more alert and can be produced by auditory stimuli. Since attention is greater to emotional cues according to Lang, and emotional stimuli are more quickly and automatically processed according to LeDoux (1996), emotional imagery may also be potent in producing arousal and attentional enhancement. The covert attention task may provide a basis for studying attentional effects of such stimuli as visual imagery.

In sum, the main premise behind the covert attention task is the automatic shift of attention produced by spatial cues such as arrows, and covert attention shifts are measured by reaction times to lateralized targets. Lateralized brain mechanisms involved in covert attentional processing and their importance in examining emotional and attentional associations are described next.

Assessing brain mechanisms for covert attention. Although covert attention, like emotional processing, is complex, specific lateralized regions believed to play a role in foveal movements allowing for covert attention can be described. The fovea processes visual stimuli without actual head or eye movement in covert attention, with the right parietal lobe appearing to exert the greatest effect on such visual orienting and the left parietal lobe playing a more minor role (Posner, 1996). Since normal subjects' performance differs greatly from those with brain deficits, covert attention discrepancies can be easily detected based on hemispheric asymmetry (Swanson, Posner, Potkin, Bonforte, Youpa, et al., 1991). Studies show individuals with parietal lesions lack ability to disengage attention from targets on the same side as the lesion in order to respond to targets opposite the lesion (Rafal, 1996). Posner and Peterson (1990) also suggest posterior parietal involvement in disengagement, movement, and re-engagement attentional aspects. Posterior systems involved in these early attentional aspects occurring around 100 ms do not appear affected in ADHD (Swanson et al., 1991). Related attentional deficits such as inattention, defective response inhibition, and lack of persistence are often seen in patients with right hemisphere dysfunction and suggest involvement of right hemisphere structures such as the striatal system including the putamen and caudate (Heilman, Voeller, & Nadeau, 1991).

Moreover, neurotransmitter systems involved in covert attentional processes have been studied. Men with dopamine depletion occurring in the disorder phenylketonuria show impaired responses to invalidly cued right visual field targets, suggesting left hemisphere dopamine effects on covert attention (Craft, Gourovitch, Dowton, Swanson, & Bonforte, 1992). Dopamine distribution in the brain may differ with gender and play a role in attentional problems in ADHD or schizophrenia, perhaps explaining in part why more males are diagnosed with these disorders. Neurotransmitter influence on covert attention is also seen from the fact that covert attention is disrupted when brainstem cholinergic projections are damaged (Witte, Davidson, & Marrocco, 1997). Increases in cholinergic activity from drugs likely due to increased acetylcholine in the left hemisphere also relate to quicker attentional disengagement from invalidly cued target locations, which indicates two possibilities (Witte et al., 1997). Stimulating cholinergic forebrain projections may enhance left parietal transmission, or forebrain projections to the parietal cortex may presynaptically act on glutamate receptors to disengage attention.

Other researchers have proposed dysfunctional frontal and striatal catecholamine systems, such as dopamine and norepinephrine imbalances, in which an excess of these neurotransmitters affects both hemispheres and may explain some attentional deficits (Malone, Kershner, & Swanson, 1994). This model includes a hypoactive left-anterior-ventral dopamine system and an overactive right-posterior-dorsal noradrenaline system, which can be corrected with stimulant medication in moderate doses. Neurotransmitter deficits found in disorders such as Parkinson's disease (PD) has been studied in order to understand dopaminergic influence on covert attention, with PD patients showing slower responses and much smaller validity effects especially with cue-target delays (Yamaguchi & Kobayashi, 1998). These covert attentional deficits at longer delays indicate that difficulty with later, voluntary attentional shifts are related to dopamine depletion especially in basal ganglia and frontal lobes, while earlier attentional aspects are not impaired. Brown and Marsden (1990) also propose executive attentional dysfunction as related to dopamine deficits in PD.

Clearly, as described above, hemispheric asymmetry, such as a greater role of the right hemisphere in attentional disorders, is involved in attentional processes including covert attention. Also of importance is the understanding of how patterns of attentional deficits can provide insight into their relation to emotional processing, symptoms of emotional disorders, and the nature of emotional and attentional associations. In order to study emotional and attentional interactions, much literature is based on indirect measures to make inferences about the nature of emotional attention biases, such as recall methodology briefly reviewed next.

Indirect Recall Bias Measures of Selective Attention

How current states including emotions can affect other processes such as attention or memory is an important concept, and a great deal of research has been conducted on state-dependent learning and situational memory recall such as divers learning information underwater performing better when tested underwater (Godden & Baddeley, 1975). What seems to be most important is the psychological context in which learning and memory retrievals occur (Reisberg, 2001). An important psychological context is one's current mood state, which seems to impact memory retrieval in a similar fashion, such as when individuals are happy they tend to be more likely to think about and recall happy memories, but when depressed they tend to think of and recall sad memories. Memory retrieval is best when mood state at recall matches mood state at the time of learning (Bower, 1981). Mood state-dependent learning and recall has important implications for examining attention as well as emotional processing, and can shed light on how attention and emotional processes are associated.

Mood induction is often used in order to examine recall bias related to emotional state. Better memory recall can suggest greater attentional allocation, and can be used to indirectly assess attentional processes. The recall of negative words compared to other words has been examined, indicating that depressed individuals recall negative information more readily or that positive information recall is somewhat suppressed (Bellew & Hill, 1990). Recall bias of negative words has also been found in subjects with high neuroticism levels, but only following mood induction (Bradley, Mogg, Galbrath, & Perrett, 1993).

Negative recall appears to be mood-congruent, that is, more accurate for affective material matching one's current mood at the time of encoding or retrieving memories. Further, recall bias in depression may be produced by less recall of positive material, rather than greater recall of negative material (Wells & Matthews, 1994). In fact, current depressed mood and anxiety have also related to poor recall of positive words describing personality factors (Bradley & Mogg, 1994). Nonetheless, current context including one's mood and affect can influence memory processes and can have implications for attentional processing. What is important is that emotional effects on attention can be directly measured. Much of the aforementioned research examining selective attention has utilized cognitive measures with computer tasks or memory data. Physiological data used in order to highlight important components of attentional mechanisms, event-related potentials, is briefly reviewed next. Then how computerized tasks and physiological measurement are used to examine associations between attention and emotion is discussed.

Event-Related Potentials and Attention

As mentioned, many indirect cognitive measures of selective attention have been utilized in attentional research. Event-related potentials (ERPs) provide a useful measure of attention-related brain activity (Andreassi, 1995). Event-related potentials are time-locked averages of brain wave activity that have been used more than raw EEG measures in the study of attention. Event-related potentials are essentially a series of positive and negative voltage variations usually occurring in response to novel stimuli (Andreassi, 1995). ERP amplitudes in response to attended versus unattended stimuli are commonly used as attentional indices, identifying parts of the brain that are activated during attentional processing.

ERP analysis has become common in the study of selective attention, since it can be concluded that attentional allocation or disruptions in attentional processes also affect ERP components. Two ERP components, the P300 and N200, are commonly used to assess selective attention (Mirsky, 1987). Though exact brain regions and structures involved in the origin of ERPs are not yet fully understood, some evidence suggests hippocampal origin of the P300 depending on the task used (Munte, Heinze, Scholz, Bartusch, & Dietrich, 1989).

Analysis of ERPs has been used in attention research in a number of ways. Impaired attentional processes have been found for certain disorders such as clinical depression, for example, based on decreased ERP amplitudes or entirely absent ERP components in response to auditory stimuli (Massioui & Lesevre, 1988). Early or automatic attentional dysfunction is implicated in depression, showing the usefulness of examining attentional functioning and its relation to emotion via ERP analysis.

All in all, event-related potentials (ERPs) appear to be a useful physiological measure to study attentional processes, as ERP research may indicate important attentional mechanisms within the brain. ERP research indicates important attentional mechanisms, and analyzing amplitudes of ERP components give insight into selective attention (Mirsky, 1987) and how emotional stimuli affect attentional processing. Much research examining attentional and emotional associations utilizes ERP measurement. The present discussion does not aim to thoroughly discuss all pertinent studies, but simply reference ERP measurement as a tool in researching selective attention.

Summary of Selective Attention Measurement

In summary, the tasks and methods described in above sections have been used to study selective attentional processes in normal adults and adults with attentional dysfunction. Particular stimuli clearly elicit greater selective attention, which is the basis for research on attention bias. Stimuli such as our own name seem to catch our attention above all else, which helped to provide a basis for attentional models and to further examine selective attention mechanisms. Research described in preceding sections also describes how attention to specific stimuli such as emotional imagery or words can be measured. An important implication of the research described is learning how selective attention relates to emotional states and may play a role in mood and anxiety disorders. One way to explore this important issue, examining the association of attentional and emotional processing, is explained in subsequent sections.

The basic tasks and procedures mentioned, including Posner's covert attention paradigm, the Stroop task paradigm, dot probe tasks, memory recall procedures, and EEG/ERP analysis are referred to in discussing ways they relate to relationships between attentional and emotional processes. Hence, it was important to describe basic methodology that is important for the upcoming discussion.

Relationships Between Selective Attention and Emotion

Using a covert attention paradigm is a somewhat novel approach to examining how quickly emotional cues can benefit attentional processing. Typically, however, aforementioned methods have been utilized in examining emotional and attentional interactions. The Stroop task, for example, has been used in numerous studies to relate attentional processing to emotional state or to specific emotional disorders. The colored word naming interference effect in the Stroop task, leading to slower reaction times, is also seen for words related to specific emotions or emotional disorders. Clinical patients seem to have a greater tendency to automatically process words that are related to their specific disorder (Wells & Matthews, 1994). Individuals with panic disorder and agoraphobia have displayed more interference by panic-related words presented both above and below the threshold for conscious identification (Lundh, Wikstrom, Westerland, & Ost, 1999). In addition, high levels of state anxiety have been associated with greater intereference when reading physical threat, social threat, and positive social words compared to words unrelated to anxiety (Brosschot, de Ruiter, & Kindt, 1999).

The benefits of integrating emotional and cognitive processes are described by Jeremy Gray (2004) in terms of cognitive control dilemmas such as balancing risk versus reward, short-term versus long-term results, or personal versus group advantages. Gray further describes benefits of emotion such as using anger to be more assertive or confrontational, and states that if emotional effects on cognition are useful at times but detrimental at others it would imply integration.

Studies examining Stroop interference effects in phobics have helped shed further light on the association of attentional bias and emotional state. Mathews and Sebastian (1993) had snake phobics perform the color naming using snake-related words, both in the presence of and away from an actual snake. Stroop color-naming interference was found for snake-related words compared to neutral words only in the absence of the actual snake, which raises three possibilities according to Matthews and Sebastian. First, the actual snake may have had a general distracting effect overall, in which attention to any word meaning may have been reduced. The second explanation is that increased arousal from the presence of a snake led to more focused attention to the color naming task in an attempt to ignore the actual snake. Finally, the real fear-producing snake may have taken priority and caused less thorough processing of word meanings, suggesting that attentional mechanisms assigned priority to the most important stimuli. Emotional cues, especially the most salient ones such as real fear-inducing stimuli, clearly modulate selective attention, whether distraction or increased attention depending on situational effects. But can emotional image cues be processed more quickly according to LeDoux's emotional model, and thus produce cueing at shorter intervals compared to more cognitive-based cues in a covert attentional model? This is why the current project is necessary, as this question was investigated.

The final explanation by Mathews and Sebastian (1993), that real snakes were salient and assigned attentional priority, is similar to the Lang et al. (1997) concept of motivated attention. In this view, mood or emotional state at the time of the task as well as the predisposition to attend to fear-related words similar to LeDoux's notions can affect allocation of attention. If an individual feels threatened by stimuli such as snakes, then it would be feasible and safer to pay the most attention to the perceived threat. Wells and Matthews (1994) point out that the ability of participants to ignore information, such as threatening words, is assessed with the Stroop task, and the ability to ignore certain environmental stimuli can lead to higher quality of functioning. Individuals with anxiety disorders who may tend to focus on any potential threat over other important environmental features may also miss important cues, such as worrying about having a wreck while driving and then missing important events such as brake lights.

Thus, ignoring certain information in the environment can have advantages, and the aforementioned research shows the importance of studying attentional biases due to emotional states. Overgeneralization of perceived threats and greater attentional allocation, for example, may help lead to or maintain psychological disorders (e.g., Wells & Matthews, 1995). Previously mentioned studies investigated attentional biases using the Stroop paradigm, which is rather different from the covert attention paradigm. However, studying emotional cueing effects on covert attentional processes may lead to implications for cognitive and attentional biases in emotional disorders and how the disorders are maintained.

Depressed patients also show Stroop interference, especially showing biased attention toward negative concern words (Nunn, Mathews, & Trower, 1997). Nunn and colleagues suggest that color-naming interference occurs when more thorough processing negative word meaning occurs, regardless of whether the words match current depressive symptoms. Depressives seem to process any negative word and relate it to themselves, showing that both emotional interference of attention and interpretative biases may occur in depression.

In examining color naming of disorder-related words in individuals with psychological disorders, Stroop interference is not always found. In individuals with blood/injection/injury phobias, Stroop interference was not found in one study for blood or disgust-related words (Sawchuk, Lohr, Lee, & Tomlin, 1999), while performance improved for implicit memory related to medical and disgust words. Likewise, no Stroop interference was found for pain-related words in chronic pain patients in a similar study (Pincus, Fraser, & Pearse, 1998). More direct effects of emotional state on attentional processing can be studied by inducing mood or studying depressed patients. Inducing positive or negative mood using video clips, Brand, Verspui, and Oving (1997) found that both positive and negative induced mood led to faster Stroop task performance. The depressive mood induction group did have significantly longer reaction time on trials in which they made errors, although they made fewer errors than the positive induction group. However, this is a self-paced task and the effort required may not be enough to reveal subtle differences between mood-induced groups. No trouble in processing information irrelevant to the task was seen in the depressive group as expected, suggesting no effects of induced mood on Stroop accuracy.

In summary of using the Stroop paradigm to investigate how emotional states affect attentional processing, tasks employing color naming are somewhat useful in the study of certain aspects of attention bias related to specific disorders. Individuals with anxiety disorders, such as certain phobias, show attention bias to words related to the disorders in terms of slower reaction times when words are read aloud. Though the Stroop task measures attentional aspects such as ability to focus attention and inhibit distraction, other important attentional aspects and their relation to emotional processing are not assessed. Salient emotional images, their relationship to covert attentional mechanisms, and how quickly such stimuli can be processed are not utilized in the Stroop paradigm. The use of images may a more powerful tool in the study of attentional mechanisms (Lang, 2000).

Dichotic listening data has been used in prior studies to examine attention bias related to emotional states. Nielsen and Sarason (1981) presented salient auditory taboo words, finding that scores on the Multiple Affect Adjective Checklist predicted how subjects responded to these words. Higher scores on anxiety, hostility, and depression scales predicted whether participants became aware of taboo words presented in an ignored channel.

The impact of emotional disorders on attentional biases was investigated by Mogg, Bradley, and Williams (1995) by using a dot probe task to study conscious and unconscious presentation of emotional words. Anxious and depressed participants, in relation to controls, showed attentional bias toward negative words presented above the threshold for consciousness, while the depressed groups showed the greatest bias toward anxiety-related words. The anxious group showed greater bias toward subliminal preconscious negative words, suggesting early disruption of attentional processes. This could have important implications because if this early preconscious attention causes greater attention toward unpleasant stimuli in the environment, then it is uncertain whether therapy fully eliminates early attentional disruption.

Bradley, Mogg, and Lee (1997) also examined attentional biases in induced negative mood and natural dysphoria using the dot probe task. Depressed mood induction related to faster reaction times for targets following depression-related words at word durations of both 500 and 1000 milliseconds. In naturally dysphoric subjects, depressed mood showed a positive association with reaction time for words of 1000 ms duration, while no effects were found for the 500-ms condition. Negative attentional bias seems to occur in both natural and induced depressive mood for longer word duration, though not for subliminal word durations of 14 ms followed a mask with either natural or induced dysphoria participants. Bradley et al. suggest that negative attention bias in depressed mood is only seen for certain aspects of selection attention, such as disengagement from previously attended areas and greater attentional maintenance to negative information. No evidence of negative attention bias in early, automatic attentional processes was seen for depression based on the subliminally cued dot probe task, though anxiety may be related to earlier aspects of attention.

Other evidence of the association of emotional and attentional processes can be seen in the manner that individuals exhibiting attentional deficits process emotional information. Becker, Doane, and Wexler (1993) studied auditory perceptual asymmetry in individuals with ADHD, normal controls, and psychiatric inpatients in response to emotional cues. The ADHD group showed less perception to positive words presented to the right ear compared to other words, while controls and other patients showed the opposite in greater right ear perception. More specifically, in ADHD patients, the presence of positive emotional words decreased left hemisphere activity, which is opposite from normal individuals. This is suggestive of an overactive left hemisphere in ADHD during emotional stimulation, which would compete with the processing of other information, or as deficits in the right hemisphere. More anatomical evidence for how emotional and attentional brain processes are related is discussed later.

A number of studies have found negative recall bias in tasks such as the Stroop task with emotional words or dichotic listening (Burgess, Jones, Robertson, Radcliffe, & Emerson, 1981). Bradley, Mogg, Galbrath, and Perrett (1993) similarly found negative recall bias of negative trait words in subjects scoring high in Neuroticism, but only after negative mood induction. Without mood induction, those high in Neuroticism showed less recall of negative trait words, suggesting that recall bias can be suppressed in the absence of negative current mood. Bradley and Mogg (1994) also studied recall of positive and negative recall information in different levels of mood and the association with personality variables. High neuroticism scores were related to greater recall of negative information but this association depended on current negative mood state. Neuroticism scores were able to predict greater recall of negative information, but only in a group showing high negative mood. Current depressed mood and anxiety also related to poor recall of positive words describing personality factors. Negative recall, suggesting greater attention, appears to depend on both personality traits related to negative emotions and current mood, with neuroticism and current dysphoria interacting to produce greater negative recall bias.

Mood or personality adjectives that can be related to one's self appear more sensitive to negative recall bias. Research has found greater negative recall bias when personally relevant information was used in the study (Teasdale & Russell, 1983). In their own series of experiments, Bellew and Hill (1990) found that subclinically depressed individuals did exhibit negative recall bias when self-esteem threatening words were used compared to positive words. Self-esteem threatening words may be sensitive to negative recall bias and may indicate underlying beliefs of vulnerability in depression.

Personality factors related to emotional functioning have also been studied to examine ways in which emotion and attention are related. Some cognitive personality approaches consider processes such as appraisals, attributions, or attentional processing (Derryberry & Reed, 1997). Other approaches, such as Cloninger's (1998) consideration of personality as the organization of psychobiological systems that adapt to the environment, emphasize both cognitive processes and neurobiology. Cloninger's approach can be valuable to understanding how emotion and personality are related, as well as how related attentional processes are affected by emotion. Matthews (1997) suggests behavioral responses as a starting point to understanding how cognitive processes such as attention relate to personality factors, and several studies have examined the relation of personality and attention.

Using a covert attention task with emotional word cues and measuring ERPs, De Pascalis and Speranza (2000) studied emotion/attention interactions related to various personality factors. All participants showed greater attention to pleasant and unpleasant words compared to neutral cues based on increased P300 peaks, and extraverts compared to introverts showed greater P300 peaks in frontal-parietal areas for left visual field

(LVF) targets. The study demonstrates interaction of personality traits with responses to emotional stimuli, which affects covert attention, and further suggests asymmetrical processing and attention to positive emotional stimuli by extraverts. Cloninger (1998) also describes evidence implying that harm avoidance tendencies are associated with less benefit from valid cues, suggesting behavioral inhibition in avoidant individuals as measured by covert attentional performance. Derryberry and Reed (1994) describe similar evidence that attention is affected by emotionally salient stimuli depending on personality factors, based on a task cueing attention to locations where points are either awarded or removed. Those high in extraversion showed covert attention bias for award locations, while those high in introversion were biased toward punishment locations when attention had to be disengaged and shifted away from those locations. In other words, introverts, or individuals susceptible to negative emotions, are slower to disengage attention from negatively valenced locations, which might suggest that personality plays a part in emotion/attention interactions.

Assessing memory of emotional words is a way to infer increased attention to emotional stimuli and how personality and mood interact to affect emotion-congruent cognitive processes. Extraversion and positive affectivity are related to improved positive memory retrieval and judging words more positively, while neuroticism and negative affectivity relate to improved negative memory retrieval and judging words more negatively (Rusting, 1999). Moreover, individuals high in positive emotional personality traits show greater positive memory congruency during mood induction, while those higher in negative emotional traits show greater negative mood congruency. These results show interactive effects of mood and personality on memories to which individuals are attending. Overall, personality factors related to emotional processing or inclination for certain emotions appear to affect attentional processes, which may also relate to other factors such as motivation (Derryberry & Reed, 1994).

Associations between attention and emotion can also be studied neuroanatomically. Further evidence explaining how neuroanatomical research aids in showing associations of emotional and attentional processes is described next.

Neuroanatomical Evidence of Relationships Between Emotion and Attention

Discussed above were cognitive measures investigating the interaction of attentional and emotional processing. That emotional cues can affect attentional cueing depends on neuroanatomical mechanisms, which are briefly reviewed here.

LeDoux (2002) discusses the interaction of emotional and cognitive processing in terms of how processing by the amygdala relates to processing by areas such as the hippocampus during fear contextualization. In attending to and processing environmental cues during fearful events, the context of the fearful event becomes significant. This occurs during very salient memories such as one's location and activities when first hearing of Kennedy's assassination or the events of 9/11/2001. This type of conditioning is thought to be mediated by the amygdala as well as the hippocampus, as this is a kind of memory created by integrating environmental information and emotional content.

Examining brain anatomy controlling both emotion and attentional processes may be useful, then, to studying the association between emotion and attention. The anterior cingulate cortex (ACC), which is part of the limbic system, controls a form of attention regulating cognitive and emotional processing (Bush, Luu, & Posner, 2000). According to Bush et al., the ACC processes emotional and cognitive information separately, with the dorsal region being the cognitive division and the ventral region having affective control. The cognitive ACC division is a section of an attentional network including the prefrontal cortex, parietal cortex, and motor areas, and may play a role in modulating attentional functions such as influence on response selection, motivation, error detection, working memory, and anticipation of tasks. On the other hand, the affective division connects to areas such as the amygdala, hypothalamus, nucleus accumbens, and hippocampus, and may aid evaluation of emotional importance.

Other interesting features of the ACC further suggest the association of attention and emotion. First, the cognitive division is not only activated by cognitively demanding tasks such as Stroop tasks, but its activity is reduced during intense emotion. Further, the affective division can be activated during emotional processing and with symptoms of psychological disturbance, but is also suppressed during tasks requiring cognitive processing (Bush et. al, 2000). Thus, emotion clearly affects cognitive processes including attentional mechanisms, and vice versa, as seen within the anterior cingulate cortex structure which seems to help regulate emotional/cognitive interrelationships. The present study aims to provide further evidence for the association between emotion and covert attention in terms of how quickly subliminal emotional cueing can occur.

ERP analysis has been often used in relation to the study of attentional deficits related to emotional disturbance. In one such study, Massioui and Lesevre (1988) studied ERPs and attentional processes in depressed patients in response to auditory stimuli. Among their findings were significantly decreased or entirely absent early ERP components to target and non-target auditory stimuli. The authors conclude that early selection processes are impaired in depression, and that these patients have trouble using automatic attentional processes. Decreased reaction time, wide variation, and more errors in performance data probably suggest difficulty in maintaining attention for these depressed individuals. Posterior attentional deficits suggested by P300 analysis are also seen in attentional disturbance related to a variety of disorders. Anhedonia, common in psychological disorders such as major depression and schizophrenia, involves lack of pleasure as well as attentional dysfunction. Dubal, Pierson, and Jouvent (2000) collected ERPs and found lower P300 amplitudes in anhedonics than in controls during a focused attention task, especially at posterior sites. Clearly, therefore, anatomical evidence suggests the relationship between emotional deficits and attentional processing.

Summary of Association Between Emotion and Attention

Selective attention and emotion are closely related in that individuals appear to be more predisposed to allocate attentional resources to emotional stimuli. The described procedures have made progress in understanding selective attention processes as they relate to emotional stimuli, though they don’t necessarily tap LeDoux’s concept of quicker, more prepared emotional processing and the benefit to covert attention. Dot probe tasks using emotional pictures show the effects of emotion on spatial selective attention, especially related to certain psychological disorders, while Stroop tasks can measure the effects of semantic emotional information on focused attention. Clearly, further research examining why emotional information more readily elicits attention and investigating specific ways in which emotional cueing occurs is needed.

Another model that explains the attentional benefit of emotional information, called motivated attention is presented by Lang and colleagues (Lang, 2000; Lang et al., 1997). Greater attention to emotionally salient stimuli has an adaptive benefit according to Lang et al. (1997) and is related to and influenced by factors such as hunger in animals or emotional state in humans. Lang's model helped establish emotional factors involved in attention, which may lead to clinical implications as well. Since motivated attention is highly relevant to the current project, this model is reviewed below.

Emotional Influence on Motivated Attention

The complex nature of selective attention, such as attention as a process occurring in several steps and the influence of emotion on attention and vice versa, has been reviewed. Obviously, there is much more to learn and understand regarding attentional processes, such as the importance of selective attention, that is, why attention is allocated to important stimuli such as emotional cues rather than others. Beneficial effects of emotional cues compared to more cognitive ones, as well as quicker processing and subsequent covert attentional cueing of emotional cues, are expected. The process of motivated attention helps explain attentional allocation to the most salient emotional stimuli and why attending to such stimuli would be useful.

Phylogenetic arguments and evolutionary theories would suggest that the most important stimuli should elicit selective attention over less salient or unimportant stimuli. But what types of stimuli are deemed most important by our attentional systems? This is assessed using the tasks that were discussed and related to emotional processing in terms of stimuli that elicit greater attentional responses, such as personally relevant negative information in those with emotional disorders. Being predisposed to attend to arousing, emotion-producing stimuli over others is the basis of natural selective attention, or motivated attention.

Motivation has been referred to as brain processes that guide one toward goals, desires, or outcomes that one wishes to avoid, and for which one will exert effort (LeDoux, 2002). Motivation to attend to certain stimuli based on drive states such as hunger, protection from harm for survival, or current emotional states, can aid attentional systems in assigning priority to intrinsically salient environmental cues (Lang et al., 1997). Knowing which environmental stimuli are priorities for attention and which ones to neglect has likely been important for survival and adaptation, according to motivated attention theory. Emotional stimuli are a type of stimuli that appear to be prioritized for attention.

The intrinsic prioritization of emotional stimuli driving attention and varying with preexisting state relates to motivational brain systems: the appetitive and defensive systems (Lang, 2000). The appetitive system aids modulation of approach behavior and attention to stimuli associated with pleasant affect, while the defensive system seems to modulate withdrawal behavior and attentional allocation based on protection from danger or avoidance of unpleasant stimuli. According to Lang, motivated attention can also be described in terms of animals in natural settings. A hungry lion notices a herd of zebras and will likely allocate attention to and stalk this herd before attacking, while a satiated lion is less likely to allocate attention to possible food. On the other hand, a zebra noticing the lion probably fears danger and thus allocates and maintains attention to the lion, with less priority and attention assigned to a bird or other harmless stimulus. The appetitive brain system in the lion’s case leads to greater attentional allocation, while for the zebra, the activated defensive system assigns greater attentional priority for protection from harm.

Most importantly, the brain's appetitive and defensive systems' association with responses to emotional imagery can be measured physiologically in humans. Brain activation of areas associated with defensive and appetitive systems in response to emotional imagery occurs and relates to naturally motivated attention to environmental cues (Lang et al., 1997). One area likely involved in motivated attentional brain systems described by Lang et al. is the anterior cingulate cortex, a structure suggested to be involved in priming the visual cortex to promote attention to motivationally salient stimuli (Posner & Raichle, 1995) and which was mentioned as regulating both emotional and attentional processes (Bush et al., 2000). Brain activation from emotional imagery, then, can be quite useful to study responses to motivationally important stimuli and how such attentional processes interact with emotional processing.

To sum up motivated attention, Lang's model takes into account the predisposition to attend to emotionally salient stimuli and explains not just how but why attentional allocation occurs. Brain activation to emotional imagery is quite useful in studying motivationally important stimuli and how emotional processing interacts with attention. Ways in which emotional information and emotional states affect attentional processing were discussed, and the motivated attentional model further relates attention and emotion. This model is important for the present study. Motivated attention as well as LeDoux's (1996) model of emotional processing help explain that emotional stimuli should be deemed important, processed quickly, and thus immediately impact covert attention. LeDoux's model is further described and related to covert attentional mechanisms in upcoming sections, and how attentional and emotional processes can be related is further explained by recent literature.

Summary of Further Evidence for Attention/Emotion Interaction

To sum up, selective attention and emotion are closely related in that individuals appear to be more predisposed to allocate attentional resources to emotional stimuli, and greater attention to emotionally salient stimuli has an adaptive benefit according to Lang et al. (1997). Hence, the relation of motivated attention and its role in explaining affective influence on attention has been described. The concept of motivated attention is related to other conditions as well, in that attention is influenced by factors such as hunger in animals or emotional state in humans. If research can establish the emotionally motivating factors involved in attention, this may have clinical implications as well.

Several tasks have been designed to study selective attention processes as they relate to emotional stimuli; however, these tasks don't necessarily tap the adaptive concept of emotionally motivated attention or the quicker processing of emotional cues. Dot probe tasks using emotional pictures measure the effects of emotion on spatial selective attention. Stroop tasks can measure different aspects of selective attention, such as the effects of semantic emotional information on sustained attention. Arousing effects of emotion relating to approach or avoidance behavior have also been observed in terms of lateralized brain activity, with the left hemisphere most involved in positive emotion and the right hemisphere most involved in negative emotional responses. The next section turns to the study of emotion and ways in which emotional information is processed, to better understand how this information may be processed more quickly and how it may impact attention.

Emotional Processing

Previous sections described ways in which selective attention is allocated to the most relevant and salient stimuli, especially emotional cues, and how attentional and emotional processes are related. In order to better understand factors involved in quicker processing of emotional versus neutral cue types, potential benefits of quick emotional processing, and brain networks involved quick emotional processing, first must be asked: what is meant by emotional processing?

Emotion has been described as “the process by which the brain determines or computes the value of a stimulus” (LeDoux, 2002). Emotional reactions, including thoughts, feelings, or behaviors, occur following determination of the emotional value of a stimulus. Emotion-related processes help regulate defensive reactions, food-seeking behaviors, or sexual behavior, and can take place rapidly, and automatically even below consciousness. One example is that most people can recall jumping aside or ducking to avoid an object such as a rapidly thrown object (LeDoux, 1996). Only after the behavioral avoidance occurs do individuals realize that they feel fear and that physiological arousal, such as increased heart rate, has occurred.

But how is emotional information processed and how is an emotional reaction determined? Early emotional models examined emotional reactions such as anxiety and sought to understand why such psychological disorders as clinical phobias develop, providing a starting point for better understanding emotional reactions and mechanisms underlying emotional disorders. Freud’s psychodynamic views of anxiety, and behavioral theories of fear, helped achieve better understanding of emotion. Contemporary research, expanding on earlier models, has examined brain mechanisms and structures involved in emotion, how emotion can influence attentional processes, or vice versa. In subsequent sections, such issues as how the brain processes different emotions, modern formulations of emotional processing including LeDoux's (1996) model, and how his model might predict covert attentional benefits of emotional stimuli are explored.

Among the first explanations for emotional responses were psychodynamic models of emotion. Freud referred to anxiety and responses to deal with anxiety as neuroses, viewing clinical anxiety as the result of early traumatic experiences such as the 5-year-old "Little Hans" displacing fear of castration to fearing horses (Freud, 1909). Freud's model of anxiety may relate to areas such as unconscious aspects of emotion and also should be mentioned to recognize Freud's theoretical contributions to theories of emotion.

Alternatively, behavioral approaches explained anxiety through an extension of Pavlovian classical conditioning (Pavlov, 1927). From this behavioral perspective, maladaptive aspects of behavior (e.g., phobic reactions) were conceptualized from learning through conditioned responses to stimuli. For example, Watson's classic example of Little Albert demonstrated this type of learning (see Watson & Rayner, 1920). Therefore, in the classical conditioning paradigm individuals develop emotional responses (e.g., fear) to particular stimuli (e.g., loud noises) as well as to other stimuli that were present in the environment (e.g., food aversion after being paired with nausea). This type of conditioning paradigm also explains how formerly neutral stimuli can elicit emotional arousal when those stimuli were only present in the environment and not directly paired with any given response.

On the other hand, such behaviorists as Mowrer (1939) and Miller (1948) used instrumental conditioning to explain how behavior aimed to reduce fear became reinforced when it helped avoid fearful stimuli and resulting unpleasant emotion. Wolpe and Rachman (1960) described “Little Hans” as exhibiting fear or anxiety conditioned to an otherwise neutral occurrence. They explained anxiety disorders such as phobias as conditioned responses that have persisted, rather than Freud’s notions of displaced anxiety, though such behavioral views of phobias as resulting from traumatic prior experiences are somewhat similar to Freud. LeDoux also (1996) points out that similar brain mechanisms likely contribute to dysfunctional anxiety in humans and conditioned fear in animals.

Early behavioral theories provide a good foundation on which to study and better understand emotion related to phobias, but may not explain more complex anxiety disorders. LeDoux has made significant progress in attempting to fill in some of these conceptual gaps to further understanding the development of fear responses. Before transitioning into an explanation of LeDoux’s theory it is necessary to introduce brain anatomy and processes involved in emotional responses.

Emotion and Brain Anatomy

Since emotional processing has entailed a wide variety of definitions and descriptions, various brain regions and structures, as one might expect, have been implicated in emotional processing. Models regarding the neurobiology of emotions have often involved description of the limbic system and its structures, and LeDoux’s model of emotional processing which guides the current proposal also involves limbic structures. Originally, neuroscientists such as MacLean (1970) described the limbic system as a center for emotions in mammals and more primitive animals. Evidence including cortical specialization in mammals for higher-level processing and the lack thereof in primitive animals led to the notion that the more primitive limbic system was involved in less complex aspects of processing such as emotion. Limbic structures thought to play important roles in emotion are outlined momentarily.

An important concept in emotional processing is lateral modulation, as particular lateral brain regions are believed to modulate positive or negative emotional states. Physiological activation of these regions during presentation of emotional stimuli suggests involvement in emotion. Research has found, for example, that normal humans show greater activation in right anterior regions during negative emotion and greater left anterior activation during positive emotions (Ahern & Schwartz, 1985). EEG asymmetry in frontal regions has also been found to predict affective responses to emotional film clips (Tomarken, Davidson, & Henriques, 1990). Sad and happy versus neutral emotional facial rating tasks produce greater right parietal activation compared to an age rating task, while happy versus neutral discrimination produces greater left frontal activation than the sad facial task (Gur, Skolnick, & Gur, 1994), further showing lateralized emotional processing.

Lateralized emotional processing is also seen with right posterior activation by autonomic emotional arousal and the fact that it is dysfunctional in depression, perhaps decreasing ability to process emotional facial expressions (Heller & Nitschke, 1998). In fact, ERPs in response to positive emotional faces do show reduced N200 peaks in right posterior regions, especially in depressed individuals (Deldin, Keller, Gergen, & Miller, 2000). The right hemisphere even seems to be involved in processing positive images presented briefly with neutral images, even when presented quickly enough so that the images could not be verbally described afterwards (Zaidel, Hugdahl, & Johnsen, 1995).

Further, Benson (1984) explains lateral neuroanatomical specialization of affect and mood, with the right hemisphere playing a more major role in non-verbal affective expression such as gestures or tones, while the left hemisphere is more involved in verbal affect.

Finally, visual cortex activity during emotional imagery viewing shows greater activation when processing both unpleasant and pleasant pictures in comparison to neutral patterns (Lang, Bradley, Fitzsimmons, Cuthbert, Scott, Moulder, & Nangia, 1998). Females had significantly greater activity during unpleasant images while males showed the opposite trend. Processing emotional images activated specific brain regions including left and right occipital gyrus, right fusiform gyrus, and right parietal regions, though only pleasant pictures activated the left fusiform gyrus. Emotional stimuli, then, produce greater activity in brain areas thought to be involved in early perceptual processing, although this could also have been an effect of picture complexity.

Lateralized brain activation in response to emotional stimuli can also be discussed in terms of approach or avoidance behavior. Research suggests the anterior region of the left hemisphere is involved in approach-related behavior while the right anterior region is involved in withdrawal behavior (Davidson, 1995). Evidence is seen from the study of patients with brain lesions and from assessing brain activity in normal subjects during approach- or avoidance- related emotional arousal. Luria (1966) explains that the left frontal region is involved in processes such as self-regulation and planning, which relate to approach behavior.

Further evidence of lateral modulation of approach and avoidance behavior is seen in that right frontal and temporal regions are activated during induced emotion from viewing frightening or disgusting images, which usually relates to withdrawal behavior (Davidson, 1995). Brain activity in response to positive or negative emotional film clips intended to induce approach or avoidance behavior has been studied as well, with disgust associated with right frontal brain activation and happiness associated with left temporal activation (Davidson, Ekman, Saron, Senulis, & Frieson, 1990). In a similar study, Sobotka, Davidson, and Senulis (1992) studied brain activity related to approach and withdrawal behavior by manipulating reward and punishment for task performance. Brain activity was greater in right frontal areas during the punishment condition compared to the reward condition, while emotion related approach behavior seem to activate left frontal areas, which is consistent right hemispheric involvement in negative and left hemispheric modulation of positive affect.

Other evidence is taken from positron emission tomography studies of panic disorder patients who exhibit severe anxiety, an emotional state related to avoidance behavior (Davidson, 1995). Resting subcortical brain activation in a right hemisphere site that projects to the amygdala suggests anterior cortical and subcortical involvement in negative affect. The amygdala and limbic networks proposed in quicker, more automatic emotional processing are central to LeDoux’s model (1996). As noted, it has been thought that cognition is mostly mediated by the cortex and emotional information processed by the limbic system, even though the limbic system concept has sometimes included midbrain or even cortical areas. Even though there are no definitive criteria for the limbic system and logic defending the limbic system notion is somewhat circular, emotions may be more primitive and basic processes (LeDoux, 2002).

The amygdala is a forebrain limbic structure, named due to its almond shape, closely involved in the interaction of incoming sensory stimuli and responses to those incoming stimuli. Out of many divisions within the amygdala, the lateral nucleus and central nucleus seem to be the most involved in emotional processing. The lateral nucleus receives information about the environment, and then activates the central nucleus, which initiates responses to emotional or dangerous stimuli (LeDoux, 2002). Moreover, the central nucleus also appears to be involved in a number of processes related to fear conditioning, including freezing responses, autonomic responses such as blood pressure increase, pain suppression, stress hormones, and reflexive behavior (LeDoux, 1996). The amygdala project to and receives input from many cortical regions (Leonard, Rolls, Wilson, & Baylis, 1985) and might be involved in processing cross-modal input, such as combining voices and faces, for situations related to positive emotions (Nahm, Tranel, Damasio, & Damasio, 1993). However, the amygdala's role in such cross-modal processing is probably rather small based on research using modern surgical techniques, though (Aggleton & Young, 2000). In patients with bilateral amygdala damage, one of the most reliable observations has been the failure to identify fearful faces or detect fear and anger-related auditory sounds, and this and other research implies that the amygdala's main function is related to perceiving and reacting to negative emotional stimuli (Scott, Young, Calder, Hellawell, Aggleton, & Johnson, 1997).

LeDoux (1996) refers to the amygdala as a "hub" in a wheel responsible for fear processing, allowing the structure to process emotional properties of single stimuli or more complex situations involving many stimuli. Adolphs and Tranel (2004) studied individuals with amygdala damage and found that not only does the amygdala play an important role in processing fearful facial expressions, but also seems to be important in processing other emotional expressions such as sadness. Though individuals with unilateral amygdala damage did not show significant emotional rating deficits, those with bilateral damage showed large impairment versus controls in rating sad faces. Aggleton and Young (2000) also mention that although the amygdala is especially important for processing negative and fearful stimuli, it seems to be involved in a wide variety of processes and more research is needed regarding the amygdala's role in such functions as social behavior and positive emotional processing or stimulus-reward decisions.

The hippocampus is another important brain structure for the present discussion, as it has been implicated in memory processes as well as in the role of emotional processing. Jacobs (2004) discusses new hippocampal neuron production in the role of the development and recovery from depression, hypothesizing that factors such as accumulated stress suppress neurogenesis and leads to or maintains depressive episodes. He takes evidence from such factors as neuroplasticity in response to subtle trauma and that in the fact that the number of neurons is not constant, and the findings that parts of the hippocampus seem to depend on serotonin to continue to produce new neurons. Drugs such as fluoxetine (Prozac) when given over a few weeks can increase the production of new neurons, and chronic stress may act to reduce neurogenesis by reducing neurotransmitter transmission. This theory not only implicates the role of the hippocampus in depressive episodes but also presents a specific mechanism for the maintenance or reduction of depression. Jacobs, Van Praag, and Gage (2000) suggest further evidence of hippocampal involvement in depression, such as the finding that depressed individuals tend to have smaller hippocampi and that loss of hippocampal cells due to epilepsy is often related to development of depression.

To sum up, research has established that in general the left hemisphere processes more positive emotional information, while the right hemisphere including parietal and frontal regions primarily processes more negative emotions. Further, the right hemisphere is impaired in depression and appears to be involved in facial expression and other nonverbal features of emotion, while specific brain areas such as the hippocampus appear to be involved not only in memory processes but also in aspects of depression. Responses to emotional stimuli relate to tendency to approach positive stimuli and avoid negative stimuli, which is also modulated by particular lateralized structures. Evidence of brain areas involved in approach/avoidance behavior can be important for research and development related to paradigms mentioned earlier. For example, related to motivated attention (Lang et al., 1997), can reaction times to targets be facilitated or hindered by emotional image cues compared to less emotionally prepared neutral cues, such as arrows or symbols, in a covert attentional task? This would provide important evidence for greater or quicker selective attention due to emotional processing, and may provide important implications for psychopathology.

Emotional states certainly seem to affect attentional processing, and examining associations between emotional processing and selective attention may provide insight into potential factors leading to and maintaining psychopathology. Next is Joseph LeDoux's model of emotional processing by the brain, in which fast emotional processing is proposed to be useful in some ways but problematic when over-generalized.

LeDoux's Model of Emotional Processing

In the present discussion, LeDoux's (1996) conceptualization of the brain's fear system and how it relates to emotional processing, and possibly psychological disorders, is explained. According to LeDoux's model, the way that the amygdala processes and forms reactions to incoming fear or emotion-related stimuli has been an important evolutionary tactic to help not only humans but also more primitive creatures such as reptiles and birds survive danger. For instance, in distinguishing a slender shape such as a garden hose from a potentially dangerous snake, by the time the slower cortical pathway has figured out the difference, the amygdala has already started a defense reaction allowing a potentially dangerous snake.

Essentially, the way the brains of rats and humans react to danger appear to be similar, even though what produces the fear can be vastly different. The main premise of LeDoux's (1996) model is that a shorter and quicker neural pathway exists in which incoming sensory stimuli are processed via connections from the thalamus directly to the amygdala (see Figure 3). Thus, the amygdala is able to form fast, automatic albeit more mistake-prone reactions to possible danger signals. A separate, slower but more rational neural pathway also exists in which connections from the thalamus to the cortex then influence the amygdala, allowing consideration of a potentially dangerous situation and reducing or halting a fear response if necessary.

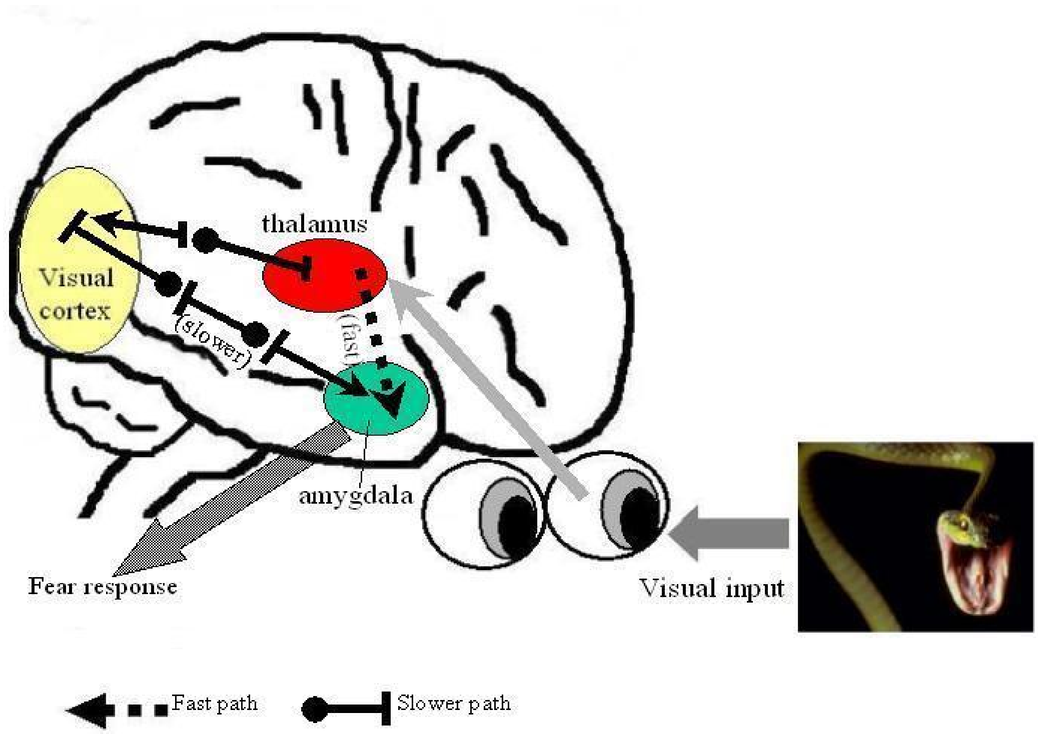


Figure 3. Depiction of LeDoux's proposed emotional processing brain, with a quicker pathway directly from the thalamus to the amygdala with less distance and fewer synaptic connections, which processes fear stimuli such as this snake image and allows more rapid fear responses, though it is a less accurate and refined brain system.

Typically incoming sensory stimuli reach the thalamus, which projects to the visual cortex for processing, which then projects to the amygdala to categorize input for a proper response. This pathway is slower due to greater distance and more synaptic connections within the brain.

The advantage of the shorter, faster direct thalamic-amygdala pathway is that one can react to stimuli much more quickly, even though the amygdala may not know exactly what it is reacting to. As mentioned earlier, once the cortex comprehends, via the slower thalamic-visual cortex route, what the stimulus is, the amygdala is ready to respond.

Other implications also arise from neural networks described by LeDoux (1996). Ideally, the thalamic-amygdala and the cortical-amygdala pathways interact for optimal emotional processing and fewer false alarms, but a discovery described by LeDoux is that connections between the amygdala and the cortex are asymmetrical. Connections between the amygdala and the cortex are much stronger than those between the cortex and amygdala. Hence, once the amygdala reacts to potential danger and emotional arousal occurs, it is difficult to reduce or shut down through rational cortical processes. This probably explains why it is easy for emotions to surpass rational thought at times, whereas when one is emotionally aroused it is not possible to override emotions using rationality. Moreover, it shows why certain disorders, especially anxiety disorders such as phobias, PTSD, or panic attacks, can be difficult for individuals to manage and tend to be long-lasting with symptoms seeming to suddenly or automatically occur. If the quicker and mistake-prone direct thalamic-amygdala pathway is “overactive” in some individuals, they may tend to respond automatically to many less harmful stimuli and may imply that these individuals are more prone to anxiety disorders. As mentioned, the amygdala is involved in processing incoming stimuli and producing danger responses including fear, and in rats it even appears to respond to species-salient danger stimuli such as cats. Amygdala functioning may actually be facilitated by stress, causing automatic reaction to danger signals, fear responses to become stronger, and the threshold for anxiety lowered. This likely has implications for how anxiety disorders develop or are worsened by stress (LeDoux, 1996).

Cognitive approaches to understanding emotion have suggested attentional bias to negative or threat stimuli as involved in certain emotional or anxiety disorders (Matthews & Macleod, 1994; Williams, Watts, MacLeod, & Matthews, 1998). Anxiety or fear can be normal reactions as in response to danger signals, and in and of itself does not necessarily suggest pathology. In fact, in situations such as if walking alone at night along a dark street or in a dangerous neighborhood, it might be abnormal to *not* experience some anxiety. Diagnostic criteria for anxiety disorders such as clinical phobias, though, include specifications that the fear-based reactions be persistent, disruptive, and out of proportion to the actual danger that is posed (American Psychiatric Association, 1996). When such emotional responses to environmental stimuli are persistent and disruptive, then a disorder may be present.

Emotional processing can occur outside of conscious awareness, either with subliminal stimulus presentation or when stimulus properties and implications are noticed later. Preferences, for example, can be created with mere exposure to stimuli even without conscious recognition of the stimuli (Zajonc, 1980). Subliminal exposure to faces have led to subliminally viewed faces being rated more positively and even led to subjects siding with the person to whose face they had subliminally perceived. In fact, the exposure effect is even stronger when stimuli are perceived subliminally versus consciously (Bornstein, 1992). As LeDoux (1996) notes, emotional cues are implicitly used in advertising frequently to persuade the public. Subliminal emotional priming procedures have also been employed, in which an emotional stimulus is presented subliminally, subsequently followed by a masking image which erases the priming image from consciousness. After a delay, a target is presented, and it is found that subjects' like or dislike of a target image relates to whether it was primed by a smile or frown (Murphy & Zajonc, 1993). Winkielman and Berridge (2004) argue that emotion can be completely unconscious and that that brain systems that regulate affective reactions evolved prior to brain systems which lead to consciousness. These authors describe evidence pointing to affect without any described subjective feelings as well as subliminal emotional processing even affecting subsequent behavior such as beverage consumption. That emotional reactions do not depend on conscious awareness from cortical structures was also seen in studies of anencephalic infants who were born only with a brain stem, yet were able to show positive facial expressions from sweet tastes and disgust expressions from bitter tastes (Steiner, 1973).

Bradley et al. (1994) also used subliminal presentation in a task requiring participants to rate whether a letter string preceded by 28-ms subliminal words was an actual word, and found that subliminal depressive words versus other word types led to greater priming in a group with high negative affect. Subliminal negative priming related more to depression than anxiety, suggesting automatic processing bias in depression, while nearly significant subliminal priming effects for positive words may also suggest overall automatic emotional processing bias. Clearly then, emotional processing *can* occur quickly and automatically and even affect subsequent processing, seen by the fact that subliminal processing of emotional cues occurs, which also suggests the existence of a brain pathway responsible for such automatic emotional processing.

In LeDoux's model of emotional processing (1996), anxiety and emotional disorders are described in terms of brain systems and based upon the brain's fear system. According to LeDoux, fear responses and anxiety are related in that they represent reactions to potentially harmful or dangerous stimuli. Fear and anxiety can be normal, healthy responses to dangerous situations, though when fear or anxiety responses are in excess of what would be considered reasonable, then psychopathology or a clinical condition may be present (Ohman, 1992). LeDoux (2002) describes the occurrence of emotional reactions in terms of neurology – sensory information is received and circuits in the brain that mediate emotional processing are activated in order to evaluate the information for emotional content and trigger the appropriate response. Hence, LeDoux’s theory is what he refers to as a processing approach to understanding emotional processing, because he is interested in the way in which brain circuits process emotional information. His approach varies from cognitive theories about emotions since emotion-related cognitions are conscious appraisals about emotional information and do not necessarily describe the basic brain processes responsible for the emotional processing (LeDoux, 1996). LeDoux’s processing approach to understanding emotions can allow emotional functioning to be studied in the same way in humans as in animals as well as allowing emotion to be integrated with cognition. Basically, similar brain mechanisms contribute to pathological anxiety and conditioned fear responses in animals in LeDoux’s view.

Studying fear conditioning can be useful to studying brain systems and processes involved in emotions, as studying fear-related responses merely involves making a neutral stimulus into a fearful one if pairing it with something aversive (LeDoux 2002). In addition, many kinds of stimuli can be used to condition fear automatically, and can be used similarly in both humans and animals, allowing for comparisons among human and animal brain systems. The fact that the brain is wired to automatically respond to fearful stimuli allows fear-processing brain circuits to be mapped by examining the interaction of sensory systems receiving input with the system that controls fear responses. The brain area that seems to be the center of this interaction is the amygdala, involved in sorting stimuli to respond to emotional or dangerous stimuli.

One key to LeDoux's concept of faster emotional processing is the theory of preparedness, originally proposed by Seligman (1971) who suggested that certain types of stimuli are prepared evolutionally to learn about and react to fearfully. In fact, in conditioning little Albert, Seligman mentions that choosing a furry animal may have shown the potency of prepared stimuli. Preparedness may be more complex than originally suggested, as monkeys raised in a lab do not seem afraid upon first seeing a snake; however, infant monkeys do appear to act fearfully after seeing their mother show fear of snakes (Mineka, Davidson, Cook, & Keir, 1984). Hence, prepared, fear-inducing stimuli such as snakes seem to produce fast and strong learning via observation.

Other evidence of preparedness was offered by Ohman (1992), who suggests that humans are prepared to easily acquire fear of stimuli that threatened the survival of prior ancestors, and through genetic variation, some humans are more prepared than others to develop phobias. Support for preparedness is found with such results as conditioned fear being more resistant to extinction using prepared stimuli while modern stimuli such as guns do not show resistance, and prepared conditioning can even occur outside of conscious awareness using subliminally presented stimuli. This shows that phobias may not be completely conscious and may suggest some reasoning for the seemingly irrational occurrence of phobias or the difficulty in reducing fear in anxiety disorders (LeDoux, 1996). Posttraumatic stress disorder (PTSD) may also be based in part on unconscious fear responses, in which individuals may not have good memory of a trauma but still develop strong emotional memories outside awareness through the amygdala fear system preparing to react to danger, according to Ledoux's model (1996). Preparedness allows strong rapid learning to occur and be retained regarding dangerous stimuli, and likely served the survival needs of previous ancestors, though it can lead to problems when someone overreacts to non-dangerous stimuli. Basically, the differences in the way individuals with disorders and normal individuals process emotional cues probably suggests differences in the functioning of the brain's fear system. Thus, prepared learning as described by LeDoux suggests one possible mechanism for formation or maintenance of anxiety or other emotional disorders. Further explanation of LeDoux's model and resulting implications is needed before describing current hypotheses.

LeDoux's (1996) model may also help explain why psychotherapy alone is often difficult, since the automatic and quick processing by the amygdala tends to be stronger than rational control over fear responses by the cortex. Most important to the current proposal, if this thalamic-amygdala process is quicker, more automatic, and stronger and subsequent amygdala-cortical connections are weaker, methods to assess the resulting fear and emotional responses to incoming stimuli are necessary. Cognitive approaches to understanding emotion have suggested attentional bias to negative or threat stimuli as involved in certain emotional or anxiety disorders (Matthews & Macleod, 1994; Williams, Watts, MacLeod, & Matthews, 1998). Therefore, computerized covert attention task procedures, with emotional versus neutral cueing in covert attention, are used in order to assess how quickly such cues impact covert attentional processes. More specific hypotheses and the methodology to test these hypotheses are described below, but first implications of emotional processing models are described.

Implications of Emotional Processing and Possible Applications

Ways in which individuals process emotional stimuli can have a number of implications affecting everyday life. For example, individuals who tend to quickly make negative evaluations in computer word rating tasks report more negative affect, more somatic complaints, and less overall life satisfaction (Robinson, Vargas, Tamir, & Solberg, 2004). Moreover, quick negative emotional processing can not only be maladaptive, but also can become akin to a personality style in that as one habitually makes quick negative evaluations it becomes easier, and this tendency is actually independent from the number of actual negative life events occurring and is not affected by mood induction. Thus, examining speed of emotional processing of cues may be a useful perspective on individuals' functioning, well-being, or personality style, as people may vary widely in what they consider to be a negative situation and many events are experienced each day which could be considered either negative or neutral. Mogg et al. (1995) also mention implications for quick emotional processing and their findings of pre-conscious negative biases and early attentional disruption in anxiety. This is important because if preconscious processes cause greater attention toward unpleasant environment stimuli, then it is uncertain whether therapy fully eliminates this early attentional disruption.

Wells and Matthews (1994) suggest that attention biases toward negative, threatening stimuli implies ways in which clients may view the world and may impact aspects of therapy. If one tends to attend to threatening stimuli over more neutral stimuli, or has trouble disengaging attention from negative stimuli, it may reflect that person's view of the world as a depressing, threatening, or harmful place. Beck's cognitive therapy (Beck, 1995) is based on changing dysfunctional thinking and teaching clients to recognize negative automatic thoughts related to negative views of the self, the world, and the future. However, it may be a difficult task to change clients' distorted or overly negative cognitions as proposed if they frequently selectively focus on negative environmental events. Wells and Matthews (1995) also discuss the challenge of teaching clients to mistrust emotional reactions to stimuli if they are predisposed to notice and attend to negative stimuli. It may take major therapeutic effort to teach clients to focus on more positive environmental aspects or see a positive spin to negative occurrences, but if some emotional disorders are related to attentional disruption such as inability to attend to positive cues, then training clients to attend more to positive stimuli may be possible.

It is possible that attentional disruption in emotional disorders, or personality features related to emotion/attention interactions, can predict individual differences in response to psychotherapy, and more individualized therapy may be designed based on specific attention biases. MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) also propose using experimental procedures based on an emotional dot-probe task varying probability of probe appearance to modify attention and cognitions and reduce emotional vulnerability as a therapeutic approach. Thus, reducing negative attentional biases in psychopathology may impact the way individuals function in their daily environment.

Bradley and Lang (1994) suggest further useful clinical applications of emotional processing in using the Self-Assessment Manikin (SAM), an assessment procedure used to rate affective responses such as pleasure and arousal while processing affective imagery. Pleasure and arousal can be plotted separately into a 2-dimensional “affective space” and an arousing image or one producing positive emotions is not necessarily experienced as pleasurable. Using affective space ratings can indicate anxiety or brain damage and can be used quickly, inexpensively, and with diverse client populations to measure wide-ranging clinical problems and to examine therapeutic changes over time or other factors that may affect emotional reactions. Incorporating emotional imagery into assessment procedures or treatment validation could be a new and interesting application.

Some authors have also proposed how personality factors that relate to negative emotions may affect cognition or attentional processing. Matthews (1997) proposes that introversion may be constructive in environments low in stimulation by allowing introverted individuals to reflect or ponder, while extraversion which relates to less negative emotionality may help optimal performance in environments with many cues to possibly draw attention and lead to cognitive overload by improving stress tolerance. Moreover, as Cloninger (1998) mentions, personality factors relating to emotionality can predict differential responses to treatments such as antidepressant medication of psychotherapy, which very practical and useful for clinicians, and that more individualized therapy may be designed based on specific cognitive or attentional deficits. For example, an individual who is prone to attend more to negative cues, or is less able to disengage attention from negative cues, may benefit more from cognitive therapy designed to recognize and change such tendencies. Similarly, if a person is prone to misinterpret ambiguous social cues, he or she may benefit from social skills training or interpersonal therapy based upon learning to read facial expressions or respond to ambiguous cues.

Therefore, a number of issues related to emotional processing are crucial not only to better understanding how automatic emotional processing impact covert attention, but also exactly how the interaction between emotional processing and attention occurs. Some of the implications of emotional processing described above touch on the importance of examining such issues, as it could help to better understand benefits or detriments related to emotional responses and effects of emotion on attention. Examining emotional responses and interactions between emotion and attention might also suggest therapeutic approaches which could improve disruptions in these processes. Next, some limitations of existing research literature are briefly described and ways upon which the current project could improve upon previous research are suggested. Then, hypotheses are proposed.

Limitations of Existing Literature and Importance of Current Project

A few limitations of previous research deserve to be mentioned briefly, to address ways in which the current research improves upon them. First, some studies examining selective attention to emotionally relevant stimuli involve the presentation of words or less potent and less emotionally prepared images, which may not be as salient as visual imagery and may produce weaker emotional responses. The current study used mostly animate emotional imagery and recognizable facial features as well as some complex image scenes that have been previously rated and normed in well-designed studies as emotion-inducing stimuli. Complex stimuli may be important to include because as Rusting (1999) notes, real life situations often involve dealing with complex or ambiguous situations that may involve interpreting emotional content, such as interpersonal situations in which reading a smile versus a smirk or judging helpful suggestions versus nagging might be important to avoid conflicts.

In addition, often emotion and cognitive or attentional processing are examined separately, as in how individuals with mood disorders or in an induced mood state perform attentional tasks, which may lead to inconsistent results. Some approaches, such as mediation models proposing that personality factors predisposing individuals to mood states which then affect cognitive processing, show promise (Rusting, 1998). Rusting also mentions that existing studies have examined negative emotional processing such as depression or anxiety, but often neglect other negative emotional states such as anger as well as positive emotions. The current project utilized a variety of both positive and negative emotional images, including positively rated happy images of cute babies or animals, positive facial expressions, and negative threat-related, disgust images, and sad facial expressions.

Moreover, current tasks do not seem to tap exactly how, and perhaps more importantly, why emotional information is attended to more readily. The question of how emotional information is attended was addressed in examining early, covert attentional processes and how such processes are affected by brief emotional cue presentations. The issue of why such information is attended to more readily and perhaps more quickly was based on LeDoux's (1996) model. LeDoux's emotional processing model is based in large part on anatomical brain research in animals, and few if any human cognitive or attentional paradigms exist to study the ideas put forth in his model. Existing cognitive or attentional tasks that have been developed to examine emotion/attention interactions do not directly measure the automatic, direct thalamic-amygdala brain pathway proposed to be responsible by LeDoux for quick processing of danger and other emotional stimuli.

Tasks have been developed which have made progress in tapping the way in which emotional and other motivated stimuli affect aspects of selective attention. A recent study found that centrally presented emotional and smoking-related images improved target detection accuracy and response speed versus a no distractor condition in a rapid visual information processing task (RVIP, Gilbert, Izetelny, Radtke, Hammersley, Rabinovich, Jameson, & Huggenvik, 2005). However, negative emotional images and smoking images produced significantly slower reaction times (RT) compared to neutral and positive images embedded in the RVIP task. This interference (RT increase) suggests that neutral and positive images cued attention in the information processing task, whereas negative and smoking images had distracting and cueing effects. Images used in the current dissertation studies were designed to be used purely as attentional cues indicating the location of subsequent targets, rather than as distractors, and emotional images were predicted to be processed more quickly than emotionally neutral images, thereby producing decreased reaction times in a covert-attention task.

Therefore, the current project behaviorally measures emotional effects on covert attention, which are predicted based on LeDoux's model. More specifically, effects of emotional covert attention cues at shorter intervals are expected overall, compared to neutral emotional cues, which are described in upcoming hypotheses. Prior to presenting specific hypotheses, pilot study results are presented below in order to provide further rationale for the current project and some basis for proposed hypotheses.

Pilot Studies

Pilot studies conducted in preparation for the dissertation experiments described below provided additional evidence of more rapid processing of emotional than neutral cues during spatial attention tasks and supported the feasibility and sensitivity of using the techniques used in the subsequent studies. One pilot study compared subliminal emotional (25 ms duration positive or negative images followed by a mask) versus cognitive (25 ms duration right or left arrow) covert attention cues at three different masking durations of 50, 100, and 200 ms. In this task, positive images were always cues to expect the target on the right side and negative images always cues to expect the target on the left side of the screen; left arrows cued covert attention to the left and right arrows always cued attention to the right side. Eight subjects participated in this pilot phase of the study, which was intended to test a version the experimental task to be used in the series of experiments. Factors were mask duration, cue type, cue validity, and cue direction.

A 3 (Mask Duration: 50, 100, 200 ms) × 2 (Validity: valid or invalid cue) × 2 (Cue type: emotional vs. cognitive) × 2 (Cue direction: left vs. right cueing) ANOVA was run. Significant main effects on RT were found for Mask Duration, $F(2, 14) = 5.1$, $p < .05$ and Validity $F(1,7) = 7.7$, $p < .05$; and significant Mask Duration × Validity × Cue Direction, $F(2, 14) = 12.4$, $p=.001$ and Cue × Type × Cue Type interactions $F(1, 7) = 15.3$, $p =.006$ were also observed. Moreover, a significant Mask Duration × Validity × Cue Type interaction showed a trend toward significance ($p=.09$). Follow-up pairwise comparisons for the Mask Duration × Validity × Cue Direction suggest that, as expected, validity effects were greatest for emotional cues at the shortest interval, while at longer intervals validity effects were greater for cognitive arrow cues (see Table 1).

Within the Left Cue Direction condition, cognitive arrow cues (left arrows) produced significantly slower responses to valid (left visual field [LVF]) targets relative to LVF targets cued by negative emotional image cues (see Table 2). Therefore, this initial pilot study provided evidence that emotionally negative subliminal image cues in a covert attention task can reduce RTs to targets to a greater extent than emotionally neutral cues (arrows).

Table 1

Validity Differences within Each Cue Type and Mask Delay

Delay	Cue Type	Validity 1	Validity 2	Mean Difference (Valid – Invalid Cues)	Standard Error
50ms	Cognitive	Valid	Invalid	-17.86	19.6
	Emotional	Valid	Invalid	-39.21(*)	14.7
100ms	Cognitive	Valid	Invalid	-17.71(*)	6.5
	Emotional	Valid	Invalid	6.04	8.9
200ms	Cognitive	Valid	Invalid	-24.24(*)	9.6
	Emotional	Valid	Invalid	-12.570	5.5

* $p < .05$

Table 2

Cue Type × Cue Direction Pairwise Comparison

Cue Direction	Cue Type 1	Cue Type 2	Mean Difference (Cognitive – Emotional)
Left	Cognitive	Emotional	22.4**
Right	Cognitive	Emotional	-14.3

** $p < .01$

Note. Left-directional cognitive cues (arrows) have significantly slower response times compared to emotional cues.

The present dissertation studies were designed to enhance understanding of how covert attention might be especially sensitive to emotional stimuli. A number of patterns were expected to emerge in the data that are not the main goals of the current project, but nonetheless would be important findings. A validity effect, regardless of cue type, would be an important observation if found because it means the subliminal cues are being processed and utilized as covert attentional cues. It would hence be a promising paradigm in which to examine early, automatic attentional processes that might be impaired in certain emotional or neurological disorders. In addition, at longer mask durations following subliminal images, faster subsequent responses due to delay in which to prepare to respond would demonstrate the cognitive mechanism of response expectation. This process could be disrupted in certain emotional disorders and could be important to examine in future research projects.

CHAPTER 2

METHODS

Participants

Participants were undergraduate psychology students who received class credit in exchange for research participation. A sample size of 64 subjects in each of three experiments was obtained, in order to have sufficient power to measure within-subjects effects and to test proposed hypotheses. In Experiments 2 and 3, several participants (approximately 8) participated in both experiments.

Each participant signed an informed consent document before beginning research procedures and was run in a small group of one to five persons at a time at individual, sectioned computer stations, allowing semi-privacy. Only individuals without vision or dexterity problems that would prevent them from performing the computerized tasks were used in this experiment. A brief vision test, using a Snellen chart, was performed to ensure that participants have no vision problems that would interfere with viewing the monitor from a distance of one meter. In order to assure anonymity and confidentiality, a numerical coding system was used on data sheets and computer data records. Participants were informed that they could withdraw from the experiment at any time without consequence, though no discomfort or withdrawals from experimental procedures is expected. No participants chose to withdraw from the study.

Equipment

Participants in each of three experiments completed two computerized attentional tasks at a distance of one meter from a 17-inch computer monitor, and experimental stimuli were presented using SuperLab® 4.0 computer software (San Pedro, CA). A

SuperLab® response pad RB series model 610 containing six separate keys was used to record responses to target stimuli, on which participants were instructed to press only the far left and far right buttons marked “L” and “R.” Reaction times (RTs) were measured in milliseconds (ms) by Superlab 4.0® software (San Pedro, CA) for all attentional tasks, and mean reaction times for each participant under each condition were computed using Microsoft Excel 2000.

Experimental Tasks

Overview. The present study was broken into three separate experiments, with 64 participants in each experiment. Experiments 1 and 2 were identical, in terms of experimental tasks, with the exception of different presentation times for certain stimuli. Both Experiment 1 and Experiment 2 used the Animate-Inanimate Cued Attention Task (AICAT) and the Negative Emotional Cued Attention Task (NECAT). Two different versions of each task were used, with half of participants being trained to use animate cues (AICAT) or negative images (NECAT) as left cues, and the other half trained to use these images as right cues. Experiment 3, which was more exploratory in nature, differed from the first two experiments in that a Positive Emotion Cued Attention Task (PECAT), in addition to the Animate-Inanimate Cued Attention Task, (AICAT) was used. The Positive Attentional Cued Attention Task (PECAT) identical to the Experiment 2 NECAT with the exception of positive versus neutral imagery rather than negative versus neutral. In Experiments 2 and 3, the same basic AICAT version was used. In each Experiment, each emotional cued attentional task (NECAT or PECAT) had entirely different neutral imagery than those used in the AICAT.

Masking stimulus presentation times for the PECAT were the same as the NECAT in Experiment 2 (160 vs. 320 ms.) The three factors within each task were the duration of presentation for the masking imagery (Mask Duration), the validity of image cues (Validity), and emotional or animate nature of image cues (Valence). Mask duration is described first. All trials in each NECAT, AICAT, and PECAT were completely randomized and counter-balanced. The Superlab® software was set up to completely randomize every trial during each unique presentation of the experimental tasks.

For each cued trial, time in milliseconds from presentation of the target to the button push response was recorded, and this response time is the primary dependent variable examined in this project. Accuracy was calculated to ensure adequate performance, since 90% accuracy or greater was expected for all conditions because of the simple task of detecting and responding to either left or right peripheral visual targets. Compliance with and understanding of task directions and proper task performance were verified by checking that responses to targets were no faster than 100 ms and no slower than 1000 ms. Previous attentional research has shown that responses faster than 100ms or slower than 1000 ms are probably not reliable. Further, only correct responses to targets were measured and analyzed. Fixation crosses and asterisk targets were white stimuli presented on a black background. Using the participants' distance of one meter from the screen and the distance between the central fixation cross, the visual angle between the fixation cross and the asterisk can be calculated. Asterisk targets were presented five degrees to the left or right of the central fixation cross.

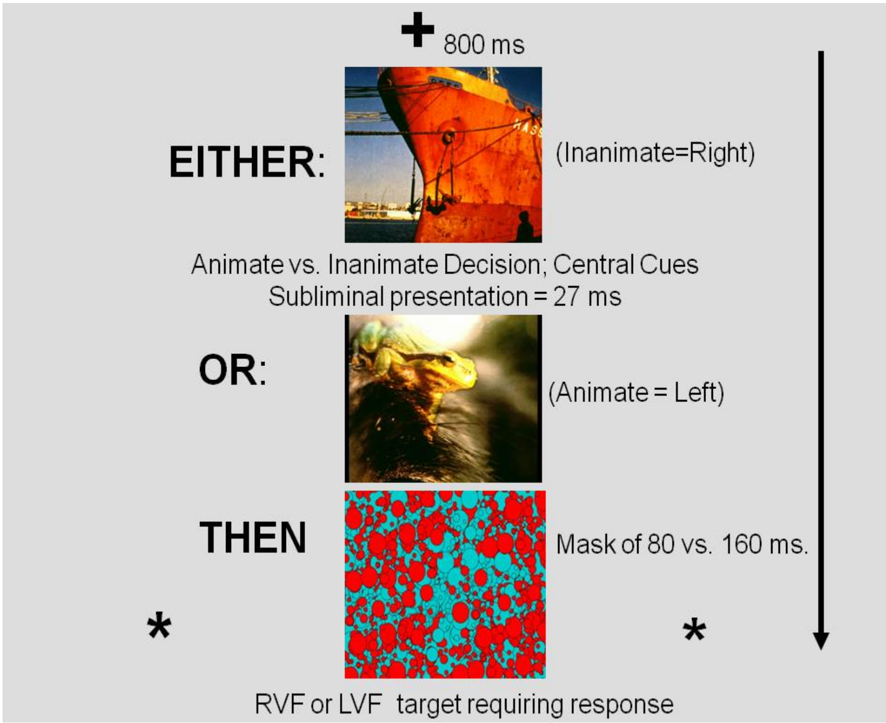
Mask Duration. Each of the three separate tasks (AICAT, NECAT, PECAT) has neutral pattern images to mask the attentional cueing images, which were presented at two different durations. Overall, in Experiment 1, one-half of the trials of each task included a masking image duration of 80 ms, and one-half of the trials included mask durations of 160 ms, for 90 trials of each mask duration. In Experiments 2 and 3, one-half of the trials of each task included a masking image duration of 160 ms (90 trials), and one-half of the trials included mask durations of 320 ms (90 trials). These varying masking durations in between the image presentation and target allowed comparisons to be made among different image types in terms of how quickly the images can be processed and subsequently used as covert attentional cues. The masking images act to make the emotional or images subliminally presented, essentially erasing the priming image cues from consciousness. Based on the work of Bradley et al. (1994) a 27 ms prime duration was used.

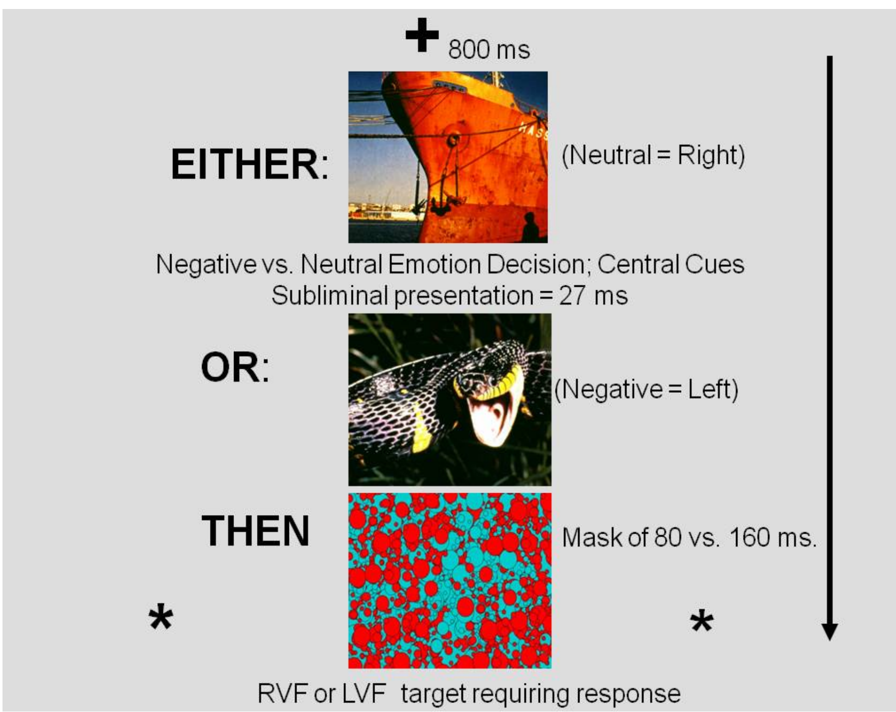
Validity. Across the three experiments, two different types of cued trials were used in each cued attention task: validly cued target trials and invalidly cued target trials (see Tables 3 through 5). Out of the 90 trials in each of the two masking duration conditions, 80% (72) were validly cued trials in which the cue direction correctly predicts the target location; 20% or 18 of the 90 trials each mask condition were invalidly cued targets, in which the cue direction is opposite to the actual target location. Prior research using covert attention tasks typically uses the 80/20 ratio of valid to invalid cues, which ensures that participants learn to expect targets in the direction of the valid cues (Posner, 1996). Within each of the two validity conditions of the AICAT, half of image cues were animate and half were inanimate images, with 36 valid animate and 36 valid inanimate image cues and 9 each of invalid animate and inanimate image cues. Within each validity condition of the NECAT, half of cues were negative and half neutral images, with 36 valid negative and 36 valid neutral image cues and 9 each of invalid negative and neutral cues. Likewise, each validity condition of the PECAT contained half positive and half neutral image cues, with 36 valid positive and 36 valid neutral image cues and 9 each of invalid positive and neutral cues. All images were presented on a black background.

Experiments. With the study design, the Animate-Inanimate Cued Attention Tasks (AICATs) in Experiments 1, 2 and 3 were designed to establish whether a validity effect with all neutral images can be obtained. The Negative Emotion Cued Attention Task (NECAT) in Experiments 1 and 2 compared negative emotional versus neutral imagery to ascertain whether validity effects are obtained at shorter intervals with negative emotional images compared to neutral images, and thus whether they are more effective covert attention cues. The validity effect measured in the NECAT in Experiment 1 and Experiment 2 could then be compared to the validity effect obtained in the AICAT. Experiment 2 was identical to Experiment 1 with the exception that stimuli presented at different time durations in order to determine whether validity effects are obtained more quickly with negative emotional images compared to neutral images in a task with longer cue-target delays (160 vs. 320 ms) than in Experiment 1 (80 vs. 160 ms). Also, NECAT validity effects measured in Experiment 2 are again compared to validity effects obtained in the AICAT, therefore demonstrating whether negative vs. neutral emotional cues impact covert attention.

In the Animate-Inanimate Cued Attention Task (AICAT), two different versions were used: one in which participants were trained to use animate images as left cues and inanimate images as right cues; and a 2nd version of the AICAT in which the other half of participants in Experiment 1 use animate images as right cues and inanimate images as left cues. Likewise, for the Negative Emotion Cued Attention Task (NECAT), two different versions were used: one in which participants were trained to use negative images as left cues and neutral images as right cues, and a 2nd NECAT version in which half of participants in use negative images as right cues and neutral images as left cues. In each image cue type condition (animate versus inanimate in AICAT, neutral versus negative in NECAT), half of the trials were left cues and half of the trials were right cues. Task order was also counterbalanced, in that half of participants performed the AICAT first and half of participants performed the NECAT first. In Experiment 3, half of participants also performed the PECAT first and half performed the AICAT first. As mentioned, both Experiment 1 tasks differed from Experiment 2 tasks only in that mask durations were longer in Experiment 2 (160 vs. 320 ms).

Each cued trial of both the AICAT and NECAT consisted of the following sequence of events: a central fixation cross presented for 1200 ms; a central image acting as a covert attention cue presented briefly for 27 ms (neutral animate versus neutral inanimate images in the AICAT; neutral versus negative emotional images in the NECAT); a neutral pattern image designed to mask the covert attentional cue, presented for durations of either 80 versus 160 ms, (or 160 vs. 320 ms in Experiment 2); an asterisk target presented left or right of the central fixation location for 1000 ms; a button press response corresponding to the visual field of the asterisk; and a blank screen intertrial interval of 500 ms, allowing participants to recuperate briefly preceding the subsequent trial. Once the button was pressed during an asterisk, the screen moved to the next event; however, the asterisk was the only stimulus for which this was the case. In Experiment 3, the AICAT parameters were exactly the same as in Experiment 2. See Figure 4 for a graphic depiction of the AICAT.





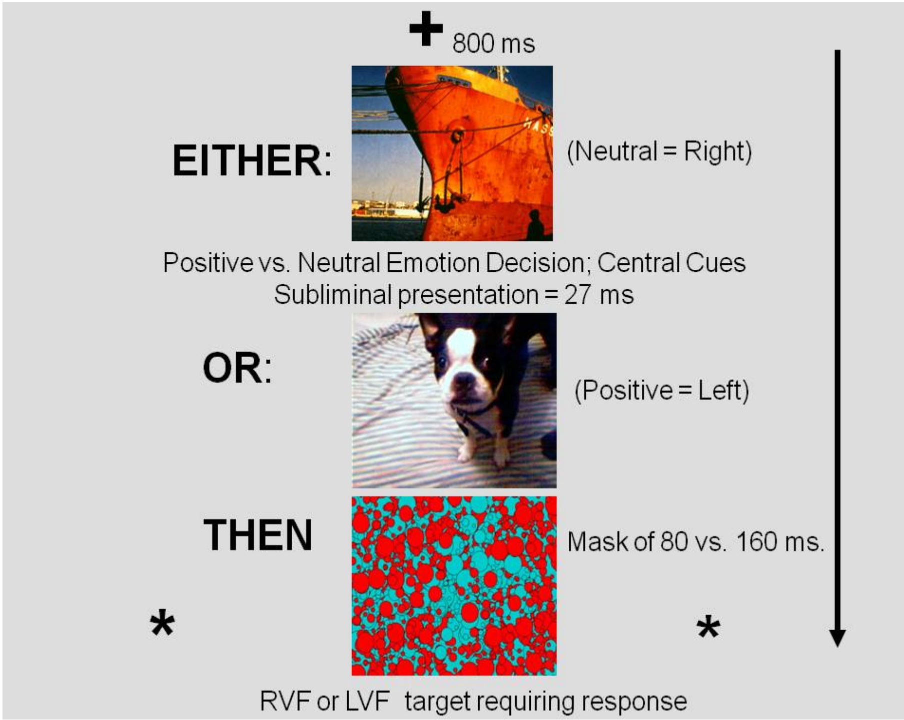


Figure 4. Series of events presented in cued covert attention trials. The Animate-Inanimate Cued Attention Task is demonstrated in the first image; the Negative Emotion Cued Attention Task in the second image; and the Positive Emotion Cued Attention Task in the third image. Covert attention is cued centrally by a fixation cross, then directed laterally by a subliminal image presented centrally based on the Animate vs. Inanimate, Negative Emotional vs. Neutral, or Positive Emotional vs. Neutral decision. Samples are shown of each task used in the present study with examples of the types of images that might be used, but that are not actual stimuli in the study. Image cues are then masked by a neutral pattern of durations of either 80 vs. 160 ms to allow investigation of emotional cueing at shorter intervals. Finally, an asterisk target appears for 1000 ms and requires a response from participants corresponding to whether the target appears in the right visual field (RVF) or left visual field (LVF).

The NECAT and the AICAT each contained 180 total cued trials, with each task lasting approximately 12 minutes. In pilot studies, this task length with a short break midway through seemed to be nearly the limit for participants to endure in a task without sacrificing performance accuracy. In Experiment 1, the Animate-Inanimate Cued

Attention Task contains all neutral images, with half of the neutral images animate and half inanimate in this task. The attentional cue in the AICAT is whether the image presented is animate versus inanimate. In the Negative Emotion Cued Attention Task, half of the images were neutral and half of the images were negative. The attentional cueing decision is whether the image presented is neutral versus negative emotionally valenced. See Tables 3 and 4 below for a complete classification of the number of trials in each condition of each of these tasks.

Before beginning the tasks, participants were given detailed written and verbal instructions and were shown the SuperLab® response pad. Participants completed a 10-minute practice session prior to performing the cued attention tasks, in which they performed sample trials at slower speeds and then increasingly faster speeds, in order to ensure that they completely understood how to do each task. Every task was divided into two sections of 90 trials each, with a short break in the middle of the task to allow for a brief rest.

For the Animate-Inanimate Cued Attention Task, half of participants were explicitly told to use animate images (meaning any image containing a living person or animal) as a cue that a target requiring a response usually occured on the left side and to use inanimate images (meaning any image containing nonliving objects) as a cue that targets usually occurred on the right. For the other half of participants, animate images were right cues and inanimate images were left cues. For the Negative Emotion Cued Attention Task, half of participants were told explicitly to use negative images, meaning any image which elicits a negative emotional response in the majority of people, as a cue that a target requiring a response usually occured on the left side and to use neutral images, meaning any image eliciting no emotional response in most people, as a cue that targets usually occurred on the right. For the other half of participants, negative images were right cues and neutral cues were left cues.

Table 3

Classification of number of trials in each condition of the Animate-Inanimate Cued Attention Task in Experiment 1

Mask Duration	Cue Validity	Image Cue Type	Cue Direction	Target Visual Field
80 ms (90)	Valid (72)	Animate (36)	L	L
		Inanimate (36)	R	R
	Invalid (18)	Animate (9)	L	R
		Inanimate (9)	R	L
160 ms (90)	Valid (72)	Animate (36)	L	L
		Inanimate (36)	R	R
	Invalid (18)	Animate (9)	L	R
		Inanimate (9)	R	L

Note. Number of trials in each condition are listed in parentheses after trial name description. Half of the participants in each experiment performed the task in the reverse order (Animate images are right cues and inanimate images are left cues).

Participants were instructed to maintain eye gaze fixation on the center of the screen (on the fixation cross hair) and respond as rapidly as possible without sacrificing accuracy. They were told to press either the left key with the thumb of the left hand or the right key with the thumb of the right hand using a response box, indicating their detection of the corresponding left versus right location of the asterisk target.

The Animate-Inanimate Cued Attention task in Experiments 1 through 3 contains all neutral images; half of the neutral images are animate and half were inanimate. There were 45 animate and 45 inanimate images in each of the two different mask delay conditions. In the Negative Emotion Cued Attention task, half of the images were neutral and half of the images were negative. In this task, there were 45 negative and 45 neutral images in each of the two different mask delay conditions (See Table 4).

Table 4

Classification of number of trials in each condition of the Negative Emotion Cued Attention Task in Experiment 2

Mask Duration	Cue Validity	Image Cue Type	Cue Direction	Target Visual Field
160 ms (90)	Valid (72)	Negative (36)	L	L
		Neutral(36)	R	R
	Invalid (18)	Negative (9)	L	R
		Neutral(9)	R	L
320 ms (90)	Valid (72)	Negative (36)	L	L
		Neutral(36)	R	R
	Invalid (18)	Negative (9)	L	R
		Neutral(9)	R	L

Note. Number of trials in each condition are listed in parentheses after trial name description. Half of the participants in each experiment performed the task in the reverse order (Negative images are right cues and neutral images are left cues).

In the Positive Emotion Cued Attention Task as well, two versions, one in which participants were trained to use positive images as left cues and neutral images as right cues and one in which positive images are right cues and neutral images left cues, were used. Half of participants were instructed that in the Positive Emotion Cued Attention Task (PECAT) to use positive images, meaning any image eliciting a positive emotional response in most people, as a cue that a target requiring a response will usually occur on the left side and to use neutral images, meaning any image eliciting no emotional response in most people, as a cue that targets will usually occur on the right. For the other half of participants, positive images were right cues and neutral cues were left cues.

Each cued trial of the PECAT in Experiment 3 consists of the following sequence of events: a central fixation cross presented for 1200 ms; a central image acting as a covert attention cue presented briefly for 26.67 ms (neutral versus positive emotional images in the PECAT); a neutral pattern image designed to mask the covert attentional cue, presented for durations of either 160 ms (159.96 ms) ms versus 320 ms (319.92 ms); an asterisk target presented left or right of the central fixation location for 1000 ms; a button press response corresponding to the visual field of the asterisk; and a blank screen intertrial interval of 500 ms, allowing participants to recuperate briefly preceding the subsequent trial. The PECAT contained 180 total cued trials, with each task lasting approximately 12 minutes. In the PECAT, half of the images were neutral and half of the images were positive while attentional cueing is whether the image presented is neutral versus positive emotionally valenced. Participants were given the same instructions as in Experiments 1 and 2: maintain eye gaze on the center fixation cross hair, respond as rapidly as possible without sacrificing accuracy, and press either the left key with the thumb of the left hand or the right key with the thumb of the right hand using a response box indicating detection of the left or right star. As in Experiments 1 and 2, fixation crosses and asterisk targets were white stimuli presented on a black background, and asterisk targets were presented five degrees to the left or right of the central fixation cross.

Table 5

Classification of number of trials in each condition of the Positive Emotion Cued Attention Task in Experiment 3

Mask Duration	Cue Validity	Cue Type	Cue Direction	Target Visual Field
160 ms (90)	Valid (72)	Positive (36)	L	L
		Neutral (36)	R	R
	Invalid (18)	Positive (9)	L	R
		Neutral (9)	R	L
320 ms (90)	Valid (72)	Positive (36)	L	L
		Neutral (36)	R	R
	Invalid (18)	Positive (9)	L	R
		Neutral (9)	R	L

Note. Number of trials in each condition are listed in parentheses after trial name description. Half of the participants in each experiment did the task in the reverse order (Positive cues are right cues and neutral cues are left cues).

Image Set

Mean image rating norms from the International Affective Picture System, (Lang, Bradley, & Cutbert, 2001) were used to choose the image set for the current study. In the

International Affective Picture System (IAPS), images are rated on several dimensions which include affective valence and arousal. On the IAPS valence ratings scale, low numbers signify negatively rated images while high numbers signify positively rated images. The IAPS ratings are done on a scale of 1 to 9, with 1 being the most negative image possible, 9 being the most positive image possible, and 5 being an exactly neutral image. Negative-valenced IAPS images chosen for the current study have mean valence of approximately 1.9 on a scale of 9, with a standard deviation of approximately 0.3 and ranging in valence from 1.3 to 2.3. Positive images that were used range in valence from approximately 7.4 to 8.3, with a mean IAPS rating of approximately 7.8 and approximate standard deviation of 0.24. Neutral images have a mean of approximately 4.9 with a SD of approximately 0.22. An attempt was made when choosing negative and positive images to include as many animate images as possible, and negative and positive images balanced as much as possible based on such features as facial expressions, scenery, interesting visual features, and complexity. In the task that compares Animate and Inanimate image cues, the chosen Animate images had a mean valence of 5.0 and standard deviation of 0.39, ranging from 4.4 to 5.8, while chosen Inanimate images also had a mean of 5.0 with a standard deviation of 0.2 and ranged from 4.6 to 5.3.

In addition, arousal was standardized as much as possible across positive and negative pictures. Negative and positive IAPS images are rated on arousal level on a scale of 1 to 9, with 9 being the most emotionally arousing images and 1 being the least arousing. Overall valence ratings across gender were used. Negative IAPS images used in the current study have a mean arousal rating of approximately 6.2, ranging from 4.0 to 7.3, with a standard deviation of 0.27. Positive IAPS images used have a mean arousal rating of approximately 5.1 with a standard deviation of 0.23 and a range of 3.1 to 7.3. Since negative emotional images are more disgusting and show some gruesome scenes, they are typically rated somewhat more arousing. Positive images that were chosen were also somewhat less arousing, as the more highly rated images in terms of arousal were often of nudity or pornographic scenes, and were avoided to reduce differences between males and females. For images used in the Animate-Inanimate tasks, animate images had mean arousal ratings of 3.7 and standard deviation of 0.9, while inanimate images had mean arousal ratings of 3.1 and standard deviation of 0.9.

Mood Questionnaires

Level of depression was measured using the Beck Depression Inventory – II (BDI-II, Beck, Steer, & Brown 1996). The BDI-II is a self-report questionnaire that contains 21 questions pertaining to depressive symptoms, including affective, cognititive, and phsyical symptoms. Beck et al. (1996) have suggested that scores below 13 indicate minimal depressive symptoms, while scores from 14 to 19 show mild to moderate depression levels. However, these guidelines are suggested for patients with a prior diagnosis of major depression, and cutoff scores for screening depression in normal populations are less clear. Anxiety levels were assessed using the Beck Anxiety Inventory (Beck & Steer, 1990), which is also a self-report questionnaire containing 21 items measuring anxiety symptoms. In the BAI manual, Beck and Steer (1990) suggest that total scores from 0 to 7 indicate minimal anxiety while scores of 8 to 15 reflect mild anxiety levels.

Based on previous research (e.g., Lasa, Ayuso-Mateos, Vazquez-Barquero, Diez-Manrique, & Dowrick, 1996), a cutoff score of 12 to 13 has been shown to be effective in differentiating depressed from non-depressed individuals in screening large community groups. In both the BDI-II and BAI, each item is scored from 0 to 3 points and has a maximum total score of 63. After completing the Informed Consent document, participants filled out the questionnaires before beginning computerized attention tasks.

Procedure

Participants were instructed to meet at the appointed time in Room 5 in the basement of Life Science II, SIU-C. Participants signed the informed consent document and then were informed that they were completing some forms such as a demographic survey and mood questionnaires, and performing a computerized attentional task. Participants attended a single experimental session lasting approximately one hour to one and a half hours, completed the questionnaires, and performed computer tasks. Participants performed computer tasks at individualized computer stations in separate cubicles. After completing the experiment they were thanked for their time, given a debriefing form describing the experiment they participated in, and were told they are free to leave at this time.

Hypotheses

Hypotheses in the current proposal were based on the LeDoux's emotional processing model and on previous bodies of research (i.e., Lang et al., 1997) that propose adaptive benefit of attending to and/or quickly processing emotional stimuli. The body of research described in the literature review above also describes the close relation of selective attention and emotion and how individuals are predisposed to allocate attention to certain emotional stimuli. Briefly, the specific hypotheses tested the general hypothesis that subliminal emotional stimuli are processed and thus utilized more quickly in covert attention tasks.

If emotional information can indeed be processed more quickly, then, relative to neutral cues, emotional cues should benefit covert attention, especially in the valid cue condition. Such a benefit would demonstrate quicker processing of emotional stimuli and suggest evidence for LeDoux's direct thalamic-amygdala pathway. Since negative emotional images such as disgust or threat cues are most relevant to LeDoux's (1996) model based on neural fear pathways and reactions to potential danger, differences in emotional cue types would be expected. Negative emotional cues would be expected to shorten RTs more than positive emotional cues and be expected to result in larger validity effects when utilized as valid cues. However, since both emotional cue types (positive and negative valenced images) are not included in the same task or within the same experiment; this possibility cannot be explicitly examined in the current experiment. This important finding would lend further support to LeDoux's notions of faster processing by the brain for emotional stimuli, and could be an important area of future study that could be investigated in clinical psychology in relation to emotional disorders. Based on expected benefits of processing emotional information and the above-noted pilot work, the hypotheses in the present studies were as follows.

Experiment 1

Design. Tasks that were used were The Negative Emotional Cued Attention Task (NECAT) and Animate-Inanimate Cued Attention Task (AICAT). In Experiment 1, factors included Mask Duration (80 vs. 160 ms), Validity (Valid vs. Invalid cued trials), and Valence (Negative vs. Neutral images in NECAT; Animate vs. Inanimate images in

AIDAT) in order to characterize the potential effects of negative emotional cues on covert attention.

Hypothesis 1.1. A validity effect (Validly Cued minus Invalidly Cued Responses) was expected in both the Negative Emotional Cued Attention Task (NECAT) and Animate-Inanimate Cued Attention Task (AICAT). This would be an important observation if found because it means the subliminal cues can be effective covert attentional cues. The validity effect compares RTs of valid versus invalid targets. Thus, the more beneficial the valid versus invalid cues are, the larger the difference scores (benefit of valid cues).

Hypothesis 1.2. The primary hypothesis in Experiment 1 involves the pairwise comparison of neutrally versus negatively cued trials within each mask duration, only for the Valid target condition. Thus, it was hypothesized that within the Validity × Mask delay (80 ms vs. 160 ms) × Valence interaction in the NECAT, a significant difference between negative and neutral images would be observed for validly cued RTs. That is, negative emotional image cues were expected to show more impact on covert attention compared to neutral cues, especially in the valid-cue condition. Hence, valid negative image cues were expected to produce significantly shorter RTs in both mask delay conditions than neutral ones.

Hypothesis 1.3. Participants were expected show greater attention to negative emotional versus neutral image cues. Thus, shorter RTs were expected overall (across Mask delays and Validity) when validly cued by subliminally presented emotional images compared to subliminally presented neutral images within the NECAT.

Hypothesis 1.4. Greater validity effects were expected for subliminal negative emotional versus subliminal neutral images overall and greater emotionally cued validity effects were expected at shorter mask durations within the NECAT. The two different mask delay conditions (80 ms versus 160 ms) were designed to allow comparisons between neutral and emotional cueing at two different durations between attentional cues and targets.

Experiment 2

Design. In Experiment 2, masking image stimuli were presented at longer time durations (160 vs. 320 ms) than in Experiment 1 (80 vs. 160 ms) in order to characterize the time period over which the benefits negative emotional cues affect covert attention. This experiment was identical to Experiment 1, with the exception that delays between cue and target stimuli were presented at longer time durations in both of the tasks that were used: The Negative Emotional Cued Attention Task (NECAT) and Animate-Inanimate Cued Attention Task (AICAT).

Hypothesis 2.1. A validity effect was expected overall in both the NECAT and AICAT, which was important in Experiment 2 in order to further characterize the time range in which the effects of emotional cueing could be observed. A significant validity effect would mean that subliminal cues were utilized as covert attentional cues even with longer time durations (160 and 320 ms versus the 80 ms and 160 ms in Experiment 1) preceding targets.

Hypothesis 2.2. The primary hypothesis in Experiment 2, as in Experiment 1, involved the pairwise comparison of neutrally versus negatively cued trials within each mask duration only for the validly cued targets. In the Validity × Mask delay × Valence interaction in the NECAT, negative emotional image cues were expected to be more effective to covert attention compared to neutral cues, especially when targets were validly cued by negative emotional images. Hence, valid negative image cues were expected to produce significantly shorter RTs in both the 160 ms and 320 ms mask delay conditions. Although results could not be compared across experiments, as these experiments are separate, in different participant pools, and have different stimuli timing, more salient differences between neutral and negative cues were expected in this NECAT version than in the first experiment.

Hypothesis 2.3. Participants were expected show greater attention to negative emotional versus neutral image cues in this NECAT version, as in Experiment 1. Thus, shorter RTs were again expected overall when validly cued by subliminally presented emotional images compared to neutral images within the NECAT in Experiment 2.

Hypothesis 2.4. Greater validity effects were expected for negative emotional compared to neutral images and greater emotionally cued validity effects were expected at shorter mask durations within this NECAT version. The validity effect was expected to be especially strong for negative image cues at the shorter mask duration in this experiment due to the differing timing from Experiment 1. That is, since timing was changed from Experiment 1 for masking duration based on preliminary results, and 160 ms is the short duration in this experiment, a strong validity effect at this shorter duration would demonstrate quicker negative emotional cueing.

Experiment 3

Design. In Experiment 3, The Positive Emotional Cued Attention Task (PECAT) and Animate-Inanimate Cued Attention Task (AICAT) were used, with mask images presented at the same time durations (160 vs. 320 ms) as the tasks in Experiment 3. Although cueing properties of positive emotional stimuli have been less frequently studied and are thus less understood, these masking durations were expected to be optimal time durations to measure emotional cueing in covert attention. Experiment 3 was needed to examine whether positive emotional cueing could occur in a covert attention task, and to characterize the time durations at which positive emotional cueing occurs.

Hypothesis 3.1. A validity effect was expected overall in both the PECAT and AICAT, which would be an important observation if found because it would mean that not only neutral subliminal cues but also positive subliminal image cues were used as covert attentional cues.

Hypothesis 3.2. The primary hypothesis in Experiment 3.2 again involves the pairwise comparison of neutrally versus positively cued trials within each mask duration only for the validly cued targets. In the Validity × Mask delay × Valence interaction in the PECAT, positive emotional image cues were expected to be more effective to covert attention compared to neutral cues, especially when targets were validly cued by positive emotional images. Hence, valid positive image cues were expected to produce significantly shorter RTs in both the 160 ms and 320 ms mask delay conditions compared to neutral images cues during each of those mask delays due to the expected benefits of valid emotional image cues. Although results cannot be compared across experiments, the most salient differences between neutral and positive cues were expected in this PECAT version.

Hypothesis 3.3. More rapid reaction times were expected overall when validly cued by subliminally presented emotional images compared to neutral images within the Positive Emotion Cued Attention Task (PECAT). Hence, participants were expected to show greater attention to positive emotional versus neutral image cues, though proposed hypotheses were more tentative in Experiment 3 because of less evidence for attentional cueing by and rapid processing of positive emotion

Hypothesis 3.4. Greater validity effects were expected for positive emotional versus neutral images overall (across both mask durations), and greater positive emotionally vs. neutrally cued validity effects were expected at shorter mask durations within the PECAT. The validity effect compares valid versus invalid targets and thus the more effective the valid versus invalid cues, the larger the change scores in terms of milliseconds of benefit. This would demonstrate that not only negative emotional cues but also positive emotional cues differentially impact visual attention.

CHAPTER 3

RESULTS

Statistical Procedures

Only RTs between 100 ms and 1000 ms were included in data analyses because based on previous research using computerized attentional tasks, it is unlikely that responses shorter than 100 ms are responses to the actual target and that RTs this short are in fact anticipated responses to the target stimulus or premature button presses. RTs longer than 1000 ms are more likely to have been the result of inattention to the computer screen and are also considered outliers. Thus, only data from correct responses above 100 ms and below 100ms were included.

After obtaining median RT values for within-subjects performance factor for each participant, data was exported into SPSS statistical software for subsequent analyses and RTs in each of the conditions for each participant were checked extensively for potential outliers.

Based on these procedures, in Experiment 1, 4.4 % of trials were discarded due to incorrect responses or missed targets, and analysis was performed on 95.6 % of the total trials. A total of 5 participants were excluded from Experiment 1 due to faulty performance, aberrant data, or computer malfunction. In Experiment 2, 4.9 % of trials were discarded due to incorrect responses or missed targets, analysis was performed on 95.1 % of the total trials, and 4 participants were excluded from the performance results. In Experiment 3, 4.7 % of trials were discarded due to incorrect responses or missed targets, analysis was performed on 95.3 % of the total trials, and again 4 participants were excluded from the performance results.

Specific, a priori hypotheses were tested using pairwise comparisons within SPSS. Pairwise comparisons were calculated to test the specific, predicted hypotheses, rather than ANOVAs, because of the specific nature of the predicted hypotheses and to avoid the large number of complex results and interactions not of relevance to experimental hypotheses. The overall pattern of results and secondary hypotheses were tested using General Linear Model repeated measures ANOVAs. The goal of analyses within GLM is to best explain the total variance in the dependent variable (Murphy & Myors, 1998). For some specific hypotheses, SPSS Pair-wise comparisons were used to calculate mean differences between specific categories; in this case, reverse logarithms of mean differences (between overall median RTs) are reported.

Repeated-measures factors tested in Experiments 1 through 3 were Mask Duration (80 ms versus 160 ms in Experiment 1; 160 vs. 320 ms in Experiments 2 and 3); Cue Type (animate vs. inanimate images in the AICAT; negative vs. neutral images in the NECAT; positive vs. neutral images in the PECAT); and Cue Validity (valid versus invalid cues). The overall statistical procedure for each design was thus a 2 × 2 × 2 Repeated Measures ANOVA. Validity effects (the response time difference of validly versus invalidly cued targets) were computed for each task, and compared across tasks within each experiment in a separate ANOVA that included the between subject variable Task Version. Alpha levels of .05 were used for ANOVAs and follow-up analyses. A total of 64 participants were planned for each of the 3 experiments, although several additional participants showed up for experiment one on the last day of data collection and were used. Power analyses showed a total of 48 participants to be sufficient in the current experimental design, assuming a medium effect size. Considering novel features included in the present experiments, such as subliminal image cues and the study of positive emotional cueing, the sample size was increased to a total of 64 participants in each of the three Experiments.

Distribution Normality

Normality of distributions for reaction time data was measured in SPSS using Skewness Analyses. Skewness is the measure of the asymmetry of data distribution, or the amount that the distribution varies from normal, with a perfectly normal distribution having a Skewness value of 0. According to statistical guidelines, skewness values that are more than twice the value of the standard error for that factor indicate significant asymmetry. Overall, the response time data in Experiments 1 through 3 were positively skewed, showing that the response time data were distributed with a significantly longer than normal right tail. Therefore, logarithms were calculated for each response time value in order to make data more normally distributed.

All statistical analyses were conducted using the logarithm values in order to deal with skewed RT distributions, but reverse logarithms of response times are displayed in the text and discussed for ease of reporting and explaining results.

Demographics

The demographics of the participants in the present experiments were as follows. In Experiment 1, ages ranged from a minimum of 18 years to a maximum of 60 years of age, with a mean of 20.5 years of age. Out of the 66 total participants, self-reported ethnicity included 24 African-American, 3 Asian, 1 biracial, and 38 Caucasian participants. Out of 59 total participants who completed Experiment 2, self-reported ethnicity included 21 African-American, 1 Asian, 1 Hispanic, 1 individual wishing not to report ethnicity, and 35 Caucasian participants. In Experiment 2, ages ranged from a minimum of 18 years to a maximum of 23 years of age, with a mean of 18.9 years of age. Finally, Experiment 3 included 24 African-American, 1 Asian, 1 Hispanic, and 36 Caucasian participants. Mean age in Experiment 3 was 19.1 years of age, with a range of 18 to 23.

Testing of Proposed Hypotheses

Experiment 1. Experiment 1 was designed to establish a validity effect with all neutral images in the Animate-Inanimate Cued Attention Task (AICAT) and then examine whether validity effects are obtained at shorter intervals with negative versus neutral images in the Negative Emotion Cued Attention Task (NECAT). In Experiment 1, two participants were eliminated from the data set for analysis due to inappropriate responses and highly aberrant response time values.

Hypothesis 1.1 predicted an overall validity effect in both Experiment 1 tasks, a finding that would demonstrate that neutrally and negatively valenced subliminal stimuli can function as covert attentional cues. As predicted, significant validity effects for RTs were found in the NECAT, $F(1, 64) = 25.31$, $p < .001$, as well as in the AICAT, $F(1, 65) = 19.83$, $p < .001$. Further, in the NECAT, validity had an overall effect size (eta squared) of 0.39, while in the AICAT the effect size (eta squared) was 0.23.

Hypothesis 1.2 predicted that in the NECAT, negative emotional cues would be more effective than neutral cues for validly cued targets at both 80ms and 160ms mask conditions, and thus negative cues were expected to lead to more rapid responses compared to neutral pictures within the valid condition. Pairwise comparisons of RTs within the Validity × Mask delay × Valence interaction were calculated to test the hypothesis directly, because of the specific nature of the predicted hypotheses and to avoid interpreting a potentially large number of complex results and interactions. Contrary to prediction, in the NECAT, there were no significant differences between neutral and negative validly cued targets at either the 80 ms (p = 0.08) or 160 ms (p = 0.12) mask duration, though there was a trend toward reduced response times for negative vs. neutral cues. See Table 6 below.

Table 6

Hypothesis 1.2 Validity × Mask Duration × Valence Pairwise Comparisons

Validity	Mask Delay	Valence Level	Valence Level	Mean Difference in Ms (Neutral – Negative)	Standard Error
Valid	80 ms	Negative	Neutral	-5.30	3.44
	160 ms	Negative	Neutral	-6.06	3.95

Note. In Experiment 1, no significant differences were observed between neutral and negative images for validly cued targets in either the 80 ms or 160 ms mask delay conditions. The mean neutral-negative difference reported above represent mean differences between reverse logarithms of RT medians. Neutral minus negative RTs were calculated within each of the above mask delay and validity categories.

However, further follow-up analyses for Hypothesis 1.2 showed that in both the 80ms and 160ms mask conditions, negative but not neutral images cues produced a significant validity effect. This result is consistent with Hypothesis 1.2 that proposed that only negative imagery would be processed quickly enough to show benefits in terms of greater validity effect (see table 7 below).

Table 7

Mask Duration × Validity × Valence Pairwise Comparisons

Mask Delay	Valence	Cue Validity	Cue Validity	Mean Difference in Ms (Valid – Invalid)	Standard Error
80 ms	Negative	Valid	Invalid	-15.78**	4.23
	Neutral	Valid	Invalid	-4.04	4.02
160 ms	Negative	Valid	Invalid	-16.58*	4.89
	Neutral	Valid	Invalid	-7.84	4.34

* p <.01, ** p <.001
Note. In both the 80ms and 160ms mask conditions, negative image cues but not neutral cues produced a significant validity effect. The mean valid-invalid difference reported above represent reverse logarithms of mean differences between RT medians. Valid minus invalid RTs were calculated within each of the above mask delay and valence categories.

Hypothesis 1.3 predicted shorter RTs when validly cued by emotional compared to neutral NECAT images. Contrary to prediction, there was no overall main effect of Valence on RTs, p > .05, and the effect size (eta squared) of valence was 0.01. However, this main effect is not an accurate assessment of negative versus neutral images if collapsed across validity conditions, as negative cues may actually slow responses to invalid targets if negative images are attention-grabbing and then attentional fixation is required to shift to the opposite visual field for target response. Neutral versus negative RTs for validly cued targets, collapsed across both 80ms and 160ms mask delays, did not differ significantly, p = 0.10, though the trend was in the direction of reduced response times for valid negative vs. neutral cues (Table 8).

Table 8

Validity × Valence Pairwise Comparison

Validity	Valence Level	Valence Level	Mean Difference in Ms (Negative - Neutral)	Standard Error
Valid	Negative	Neutral	-5.68	3.41
Invalid	Negative	Neutral	4.56	4.51

Note. There was a trend toward reduced response times (signified by a negative difference) for negative versus neutral responses for validly cued targets, collapsed across mask durations. The mean neutral-negative difference reported above represent reverse logarithms of mean differences between
RT medians.

Finally, Hypothesis 1.4 predicted greater negative emotionally cued validity effects than for neutral images overall within the NECAT. As expected, when the Validity × Valence interaction was broken down to compare valid and invalidly cued targets within the negative image category and collapsed across mask durations, the valid-invalid difference was significant, mean difference = 16.18 ms, $p < .001$. Lending more support to Hypothesis 1.4, the valid-invalid difference (Validity Effect) was not significant for neutral images (see Table 9). While lending support for greater validity effects for negative emotional versus neutral images, this comparison does not fully test the proposed hypothesis.

To directly test Hypothesis 1.4, first difference scores were calculated for validity effects, in order to interpret more complex interactions and examine this difference at levels of each other variable. Thus, the three main within-subjects variables, in effect, are reduced to two variables, and the validity effect becomes a separate dependent variable.

Table 9

Hypothesis 1.4 Validity × Valence Pairwise Comparison

Valence	Cue Validity	Cue Validity	Mean Difference in Ms (Valid – Invalid)	Standard Error
Negative	Valid	Invalid	-16.18**	3.90
Neutral	Valid	Invalid	-5.94	3.39

** p <.001
Note. Greater validity effects were found for negative emotional versus neutral images, as calculated by pairwise comparisons based on reverse logarithms differences of median RT values.

Table 10

Mask Delay × Valence Pairwise Comparison for Validity Change Scores

Mask Delay	Valence Level	Valence Level	Mean Difference in Ms (Negative – Neutral)	Standard Error
80 ms	Negative	Neutral	-12.06*	6.39
160 ms	Negative	Neutral	-6.90	6.99

* p <.05
Note. Differences between negative and neutrally cued targets is significant on validity effect at 80 ms masks, but not 160 ms masks. A negative difference denotes shorter response times for negative valence.

As seen in Table 10, the validity effect comparison between negative and neutrally cued targets is significant at the 80 ms mask duration for negative cued targets, Mean Difference = 12.06 ms, p = .045, and not significant at the 160 ms mask duration for negative vs. neutral cues, p = 0.11. Hypothesis 4 was partially supported based on these results.

Experiment 2. In Experiment 2, masking stimuli were presented at longer time durations (160 vs. 320 ms) than in Experiment 1 (80 vs. 160 ms) in order to determine whether negative emotional cues differentially affect covert attention. This experiment was identical to Experiment 1, with the exception that stimuli presented at different time durations in order to determine whether validity effects are obtained more quickly with negative emotional images compared to neutral images in a task with longer cue-target delays than in Experiment 1. In Experiment 2, mask durations were extended to 160 ms versus 320 ms in both of the tasks that were used, the Negative Emotional Cued Attention Task (NECAT) and Animate-Inanimate Cued Attention Task (AICAT), in order to better characterize time periods over which negative emotionally cued attention occurs.

Hypothesis 2.1 predicted an overall validity effect in both tasks that would demonstrate that neutrally and negatively valenced subliminal stimuli can function as covert attentional cues. Contrary to expectation, the validity main effect was not significant in the Experiment 2 NECAT, $F(1, 58) = 2.4$, $p = 0.12$ with an overall effect size (eta squared) of 0.05. However, in the AICAT, a significant validity effect was found, $F(1, 60) = 10.1$, $p = .002$, with an overall effect size (eta squared) of 0.12. Thus, Hypothesis 1 was partially supported. Specifically, subliminal image cues significantly speeded RTs for animate-inanimate discrimination with neutral imagery in the AICAT but not for neutral-negative discrimination in the NECAT. Unlike Experiment 1, which found significant validity effects across both tasks using shorter mask durations (80 vs. 160 ms), in Experiment 2 significant validity effects were found only in the AICAT but not in the NECAT with the longer mask durations used (160 vs. 320 ms).

Hypothesis 2.2 predicted that in the NECAT, negative emotional cues would improve covert attention overall, especially for validly cued targets. Valid negative cues were expected to lead to more rapid responses at both 160 ms and 320 ms mask durations compared to neutral cues. The increase in the mask duration, creating longer delays between image cues and targets in this Experiment 2 NECAT version, was expected to be useful in more fully characterizing differences between neutral and negative cues observed in Experiment 1. Pairwise comparisons within the Validity × Mask delay × Valence interaction were calculated to test the predicted hypothesis. Contrary to prediction, in the NECAT, there were no significant differences between neutral or negative validly cued targets, within either the 160 ms or 320 ms mask duration, *p*s > .05 (see Table 11 below). Moreover, unlike in Experiment 1 in which negative image cues but not neutral cues produced significant validity effects at both mask durations, in Experiment 2 there were no significant validity effects for either neutral or negative cues in either mask duration. Thus, Hypothesis 2.2 was completely unsupported: at longer mask durations than in Experiment 1, the negative-neutral discrimination appeared to be unable to produce validity effects at masking durations of 160 or 320 ms.

Table 11

Hypothesis 2.2: Validity × Mask Duration × Valence Pairwise Comparisons

Validity	Mask Delay	Valence Level	Valence Level	Mean Difference in Ms (Neutral – Negative)	Standard Error
Valid	160 ms	Negative	Neutral	-1.64	4.39
	320 ms	Negative	Neutral	-1.12	4.52

* *p* <.05

In Hypothesis 2.3, participants were expected show greater overall attention to negative than to neutral cues in the Experiment 2 NECAT version, as evidenced by shorter (more rapid) RTs with validly cued emotional images compared to neutral images. When neutral versus negative cued targets were compared for validly cued targets (within the Validity × Valence interaction), collapsed across both 160ms and 320 ms mask delays, the mean difference (-1.37 ms) did not approach significance, $p = 0.45$. Thus, when the time between the negative or neutral cue is extended from 80ms and 160 ms in Experiment 1, to 160 ms and 320 ms in the present experiment, participants did not benefit from making emotional discrimination between negative and neutral cues.

In Hypothesis 2.4, greater emotionally cued validity effects for negative emotional versus neutral images were expected at the shorter 160 ms mask durations within this NECAT. Contrary to expectation, when the Validity × Valence interaction was compared for valid vs. invalid cues (Validity Effect) within the negative image category, collapsed across mask durations, the valid-invalid cue difference (-7.72 ms) was not significant, $p = 0.13$. The valid-invalid difference was also not significant for neutral images.

To directly test Hypothesis 2.4 further, difference scores were calculated for validity effects in order to further examine valid-invalid cue differences at levels of each other variable. Analyzing validity effect as a separate dependent variable, the differences between negative and neutrally cued targets were clearly not significant at the 160 ms mask duration, (-1.73 ms, $p = 0.22$) or at the 320 ms mask duration for (3.77 ms, $p = 0.92$). See Table 12. Hence, Hypothesis 2.4 was not supported and the premise of extending cue-target delays from 80 ms and 160 ms to 160 ms and 320 ms was not supported. It remains possible that mask durations were shorter than optimal to best measure emotional cueing in Experiment 1, but somewhat too long in Experiment 2.

Table 12

Hypothesis 2.4 Valence Differences within Each Mask Duration for Validity Effects

Mask Duration	Valence Level	Valence Level	Mean Difference (Negative – Neutral)	Standard Error
160 ms	Negative	Neutral	-1.73	5.00
320 ms	Negative	Neutral	3.77	5.41

Experiment 3. In Experiment 3, masking stimuli were presented at the time durations (160 vs. 320 ms) as in Experiment 2. The tasks used in Experiment 3 included the Animate-Inanimate Cued Attention Task (AICAT), with exactly the same stimuli and design as in Experiment 2, and the Positive Emotional Cued Attention Task (PECAT) in place of the Negative Emotional Cued Attention Task (NECAT). The main goal of the third experiment in this project was to begin to characterize time durations at which positive-emotionally cued attention can occur with subliminal stimuli. Again, in Experiment 3, main hypotheses were first tested with specific analyses.

As hypothesis 3.1 predicted, a significant overall validity effect on RT was observed for both the PECAT, $F(1, 62) = 5.5$, $p < .05$, and the AICAT, $F(1, 60) = 8.28$, $p < .01$. In the PECAT, validity had an overall effect size (eta squared) of 0.08, while in the AICAT the effect size (eta squared) was 0.11.

However, Hypothesis 3.2 was not supported. Primary analysis involved the pairwise comparison within the Validity × Mask delay × Valence interaction in the PECAT, with valid positive image cues, relative to neutral ones, expected to differentially affect covert attention. There were no significant differences in the PECAT between neutral or positive validly cued targets within either the 160 ms or 320 ms mask duration (5.2 and 1.5 ms difference, respectively), all *p*s > .05. Thus, neither neutral nor positive cues in either mask duration showed significant differential effects on covert attention in Experiment 3, and Hypothesis 3.2 was completely unsupported.

In Hypothesis 3.3, participants were expected show greater overall RT benefit from positive emotional versus neutral image cues. Thus, shorter RTs were expected overall when validly cued by subliminal positive vs. neutral images within the Positive Emotion Cued Attention Task (PECAT). Since invalid positive cues may actually increase RTs targets when a target is expected in one visual field and occurs in the other, only validly cued trials should be considered. As expected, there was no main effect of image valence, $F(1, 62) = 2.33$, $p = 0.13$. Effect size (eta squared) for valence was 0.04.

Comparing neutral versus positive cues within the valid condition (Validity × Valence pairwise comparisons), across both masking durations, the mean difference between image valences was not significant, $p = 0.44$, Mean Difference = - 3.33 ms (See Table 13). Thus, in Experiment 3, participants did not benefit from making emotional discrimination between positive and neutral cues, though responses to valid positive versus valid neutral cues were slightly shorter (faster) but non-significant.

Table 13

Hypothesis 3.3 Valence Differences within Each Validity Condition

Validity	Valence Level	Valence Level	Mean Difference in Ms (Neutral – Positive)	Standard Error
Valid	Positive	Neutral	-3.33	3.27
Invalid	Positive	Neutral	-4.51	4.73

Hypothesis 3.4 predicted greater validity effects for positive emotional versus neutral images overall and greater emotionally cued validity effects within the PECAT. As in Experiment 2, Valid vs. Invalid trials (the validity effect) were compared only within the positive image category collapsed across both mask durations (See Table 14). Contrary to the prediction, the valid-invalid response time difference was not significant for positive cues, $p = 0.31$, Mean Difference = -6.02 ms, and the there were also no validity differences for neutral images either when collapsed across mask durations, $p = 0.08$, Mean Difference = 7.19 ms, though there was a trend for a significant validity effect.

Table 14

Hypothesis 3.4 Validity Effects within each Cue Valence

Valence	Cue Validity	Cue Validity	Mean Difference in Ms (Valid – Invalid)	Standard Error
Neutral	Valid	Invalid	-7.19	4.13
Positive	Valid	Invalid	-6.02	3.66

To more directly test Hypothesis 3.4, valid-invalid difference scores were calculated for validity effects in order to further examine valid-invalid cue differences at levels of each other variable, again in order to reduce the effect of validity to a separate dependent variable. Differences between positive and neutrally cued validity effects (in the Mask Delay × Valence interaction, with Validity Effect as the dependent variable) were not significant at either the 160 ms mask duration, ($p = 0.94$) or at the 320 ms mask duration ($p = 0.10$). See Table 15 below for these analyses. Hence, Hypothesis 3.4 was not supported in Experiment 3, and positive emotional cues do not seem to be successful in increasing validity effects. It remains possible that mask durations were shorter than optimal to best measure emotional cueing in Experiment 1, but somewhat too long in Experiment 2.

Table 15

Hypothesis 3.4 Effects of Positive vs. Neutral Emotion on Validity Effects within each Mask Delay

Mask Delay	Valence Level	Valence Level	Mean Difference (Positive – Neutral)	Standard Error
160 ms	Positive	Neutral	3.73	4.13
320 ms	Positive	Neutral	14.64	3.66

Mood Effects

The overall effects of existing depressive or anxiety symptoms were hypothesized to affect performance on the emotional tasks in the present experiments, due to the emotional discrimination required to perform the Negative Emotion Cued Attention Task (NECAT) and the Positive Emotion Cued Attention Task (PECAT). As described in the literature review, state anxiety and depression can affect selective attention to emotional stimuli, with anxiety possibly predisposing one to pre-conscious negative emotional biases and depression leading to automatically noticing or attending to negative emotional stimuli (Mogg et al., 1995; Wells & Matthews, 1995). The body of literature regarding anxiety and its effects on attention and vigilance might suggest that anxious individuals would be predisposed to respond much more quickly, especially in tasks involving emotional discrimination. Hence, those with high state anxiety were hypothesized to respond more quickly than those with low anxiety, and thus show significantly shorter response times on the NECAT in general.

Another common theme across treatment and research of depressed individuals has been the psychomotor retardation and cognitive slowing as a part of depressive symptomatology (i.e., Beck, 1995). Those high in depressive affect reporting symptoms of depression were therefore expected to perform the NECAT significantly slower due to being distracted and hindered by negative emotional imagery. Depression was measured using Beck Depression Inventory (BDI) scores, while anxiety was measured using Beck Anxiety Inventory (BAI) scores, as described in Methods. Overall mean depression scores on the BDI-II in Experiment 1 were 9.9 with standard deviation of 8.0; Experiment 1 mean anxiety scores on the BAI were 8.3 with standard deviation of 6.0. In Experiment 2, mean depression scores on the BDI-II were 10.3 with standard deviation of 11.3 and mean anxiety scores on the BAI were 11.1 with standard deviation of 12.5. Experiment 3 mean depression scores were 9.7 with standard deviation of 11.3 and mean anxiety scores were 10.2 with standard deviation of 12.2.

Regression Analyses of the Moderating Effects of State Anxiety and Depression

Mixed-effects regression analysis was conducted in SAS to assess within-subjects factors Mask Duration (80 vs. 160 ms in Experiment 1; 160 vs. 320 ms in Experiments 2 and 3), Validity (valid vs. invalid), Valence (neutral vs. negative in NECAT; neutral vs. positive in PECAT), Visual Field (left vs. right), and the between subjects factor Anxiety (Beck Anxiety Inventory total scores) was conducted on the dependent measure of median response time. A separate mixed-effects regression was performed on the same within-subjects factors separately with the between subjects factor of Depression (Beck Depression Inventory total scores). Another mixed regression was performed to analyze the combined effects of Depression and Anxiety on task performance. Due to the original response times, as well as the anxiety and depression scores, being skewed, base-10 logarithms of the raw values were calculated before performing the regression analyses. Again, although base-10 logarithms were used for mixed regressions, mean RTs and RT differences are reported based on raw scores for ease of display and interpretation. BAI and BDI total scores were used separately in a mixed effects analysis to test the hypothesis that anxiety or depressive mood moderated the effects of emotional cueing on covert attention. History of major depressive disorder or anxiety disorder diagnosis was not assessed or selected for based on cutoff scores, because the goal was to assess the potential moderating effects of the continuum of depression and anxiety in a student population using the full range of scores as a predictor. Mixed effects regression was used because regression analysis allows more powerful and appropriate analysis. Specifically, mixed regression analysis allows the full range anxiety and depression scores to be used, and thereby eliminates the loss of power associated that occurs when scores are dichotomized or trichotomized, as required with mixed ANOVAs.

A possible issue, at least in Experiments 2 and 3, was that not all participants in these experiments completed mood questionnaires. One reason was that enough mood questionnaires were not obtained in order to assess all individuals who participated. A few participants also neglected to answer questions, so that their mood data was not able to be assessed, or they chose not to answer questions pertaining to their anxiety or depressive symptoms. This somewhat reduced the power of regression analyses in Experiments 2 and 3.

Experiment 1. Mixed regression analysis (Table 16) was conducted on a total of 65 participants in the first experiment. As expected, there were significant main effects of Mask Duration, F (1, 322) = 32.51, $p < .001$ and Validity, F (1, 322) = 12.54, $p = .001$, with longer Mask Durations and Valid Cues significantly reducing RTs. A significant interaction of Validity with Valence was also observed, F (1, 322) = 6.53, $p = .001$. Regarding mood effects, the presence of depression or anxiety was expected to have significant effects on overall response times in the NECAT. More specifically, anxiety was predicted to reduce overall RTs while depression was predicted to increase RTs, based on the emotional discrimination required to perform the task.

The main effects of Depression and Anxiety on overall NECAT performance RTs were not significant, but there was significant Anxiety × Validity × Valence interaction, F (18, 322) = 2.0, $p < .01$. Consistent with predictions, individuals high in state anxiety experienced greater benefit from emotionally negative cues, relative to neutral cues, than did low anxiety individuals. No interactions with Depression were significant. The combined effect of Depression and Anxiety on task performance was nearly significant, F (18, 6) = 3.6, p = .06.

Table 16

Experiment 1 Mask Duration × Validity × Valence × Anxiety Mixed Regression Output from SAS

Effect	DF	F Value
Mask Duration	1	26.88***
Validity	1	7.63**
Mask Duration × Validity	1	0.36
Mask Duration × Valence	1	0.01
Validity × Valence	1	6.53*
Mask Duration × Validity × Valence	1	0.08
Anxiety	18	0.88
Anxiety × Mask Duration	18	1.14
Anxiety × Validity	18	0.85
Anxiety × Mask Duration × Validity	18	0.77
Anxiety × Valence	18	1.12
Anxiety × Mask Duration × Valence	18	0.36
Anxiety × Validity × Valence	18	2.00**
Anxiety × Mask Duration × Validity × Valence	18	0.27

* p <.05, ** p <.01, ***p < .001

Experiment 2. Mixed regression analysis was conducted with a total of 45 participants in the second experiment, and the presence of depression or anxiety was also expected to significantly impact on overall performance in the NECAT. More specifically, anxiety was again predicted to reduce overall response times while depression was predicted to increase response times. In Experiment 2, there was a significant main effect of Mask Duration, F (1, 161) = 32.97, $p < .001$. There was no significant main effect of Anxiety, though there was a significant interaction of Anxiety with Mask Duration, F (21, 161) = 2.90, $p < .001$ and Anxiety with Validity and Valence, F (21, 161) = 2.46, $p < .01$. The main effect of Depression was also not significant; however, Depression significantly interacted with Mask Duration, F (21, 161) = 1.90, $p < .05$, and Depression showed a trend towards significant interaction with Validity, $p = .06$. Anxiety and depression did not produce combined effects on task performance.

Experiment 3. Mixed regression analysis was conducted on a total of 43 participants in the third experiment. As expected, there were significant main effects of Mask Duration, F (1, 42) = 17.72, $p < .001$ and Validity, F (1, 42) = 4.38, $p < .05$. Regarding effects of depression or anxiety, hypotheses in Experiment 3 were more tentative in nature, but anxiety was expected to reduce overall response times due to hypervigilant responding while depression was predicted to increase response times. There was a significant effect of Depression on PECAT performance, F (20, 23) = 2.18, $p < .05$. However, there was no main effect of Anxiety, but a trend toward a significant interaction of Anxiety with Valence was observed, $p = .055$. Neither Depression nor Anxiety significantly interacted with other PECAT factors. Anxiety and depression did not produce combined effects on task performance.

Table 17

Experiment 2 Mask Duration × Validity × Valence × Anxiety Mixed Regression SAS Output

Effect	DF	F Value
Mask Duration	1	32.97***
Validity	1	0.56
Mask Duration × Validity	1	1.00
Valence	1	0.08
Mask Duration × Valence	1	0.00
Validity × Valence	1	0.03
Mask Duration × Validity × Valence	1	0.19
Anxiety	21	1.28
Anxiety × Mask Duration	21	2.90***
Anxiety × Validity	21	1.25
Anxiety × Mask Duration × Validity	21	0.81
Anxiety × Valence	21	1.32
Anxiety × Mask Duration × Valence	21	1.09
Anxiety × Validity × Valence	21	2.46**
Anxiety × Mask Duration × Validity × Valence	21	1.18

* p <.05, ** p <.01, ***p < .001

Table 18

Experiment 3 Mask Duration × Validity × Valence × Depression Mixed Regression Output from SAS

Effect	DF	F Value
Mask Duration	1	30.39***
Validity	1	2.85
Mask Duration × Validity	1	0.20
Valence	1	0.35
Mask Duration × Valence	1	0.08
Validity × Valence	1	0.11
Mask Duration × Validity × Valence	1	0.01
Depression	21	0.92
Depression × Mask Duration	21	1.90*
Depression × Validity	21	1.57
Depression × Mask Duration × Validity	21	0.64
Depression × Valence	21	1.23
Depression × Mask Duration × Valence	21	1.48
Depression × Validity × Valence	21	2.89***
Depression × Mask Duration × Validity × Valence	21	1.20

* p <.05, ** p <.01, ***p < .001

CHAPTER 4

DISCUSSION

Overview

The findings supported some of the proposed hypotheses, but not others. The discussion is structured in the following way. First, testing of specific, proposed hypotheses is evaluated. Then exploratory supplemental regression analyses evaluating the effects of mood on attentional performance are explained. Finally, implications of hypothesis testing and exploratory analyses and future directions are tied together.

Testing of Specific Hypotheses

Demonstration of subliminal cueing. Consistent with previous research, subliminal images were processed and utilized as attentional cues and subliminal cueing in covert attention paradigms is indeed possible. While not surprising in particular, as subliminal presentation of stimuli has shown to modulate preference of certain faces (i.e., Bornstein, 1992; Zajonc, 1980) or preconscious attentional bias in individuals with certain mood states (Bradley et al., 1994), subliminal processing of subliminal covert attention cues validates the Experiment 1 tasks and proves them useful for cognitive neuroscience research. Using subliminal cueing within covert attention paradigms has several potential applications, which will be discussed.

An important finding in the current project overall was that subliminal image cues led to validity effects in covert attention tasks during which the primary purpose of the task was to differentiate emotional versus neutral imagery. Results were not consistent across all three experiments, though the finding held true for the NECAT in Experiment 1, the AICAT in Experiments 1-3, and the Experiment 3 PECAT. Significant validity effects demonstrate that subliminal images are able to cue covert attention even though presented below conscious awareness. Subliminal discrimination is being made between both animate vs. inanimate negative vs. neutral valences and the tasks seem to be measuring subliminal cueing for which they were designed. Further, since highly significant validity effects were found in both animate-inanimate and negative-neutral discrimination tasks, it was likely not due solely to an arousing or otherwise interesting feature of negative valenced imagery.

Validity effects for negative cues. A further important finding was significant validity effects only for negative image cues, and not for neutral image cues, within each mask duration (80 and 160 ms). In other words, only negative image cues appeared to be processed quickly enough to be utilized as covert attentional cues, by leading to significant validity effects. Examining differential validity effects for each valence is a more appropriate method of testing whether negative versus neutral image cues are beneficial, rather than testing for main valence effects. A main valence effect was not an entirely accurate assessment of negative versus neutral image cueing, as invalid negative images may actually *increase* RTs if negative images grab attention and then attentional fixation is required to disengage and shift. When comparing neutral vs. negative, validly cued trials across both mask durations, this comparison was not significant but a trend toward significance was observed. It is possible that with a larger sample, or data using participants that are motivated to maintain high effort (i.e., with incentives for correct responses), that significant selective effects of negative, valid subliminal cues would be observed. Despite no overall effect of valence, ample evidence was nonetheless seen for selective attentional cueing by negative emotion. Most importantly, partial support was found in Experiment 1 for the hypothesis that negative emotionally cued, rather than neutrally cued, validity effects would be greater when collapsed across both mask durations.

Cue-target delays. The validity effect was highly significant for negative emotionally-cued trials overall, but not significant for neutral images, which would be expected if negative but not neutral cues were being utilized as subliminal covert attention cues. More direct analysis was done by calculating validity effects to use as the dependent variable. With this method, there was a significant difference between negatively and neutrally-cued validity effects, but only at the short (80 ms) mask duration (seen in Table 10). This finding provides the most direct evidence that negative image cues are best utilized at the short delay (80 ms) between cue and target, especially when combined with the finding of no significant differences observed at the longer cue-target delays (160 ms).

Experiment 1 summary. Overall, Experiment 1 hypotheses were largely supported, as validity effect was significant in both the NECAT and the AICAT; only negative images, but not neutral images, produced significant validity effects following both 80 ms and 160 ms mask durations; and valid cues significantly reduced RTs compared to invalid cues overall for negative, but not neutral image cues, as well as showing significant effects of negative vs. neutrally cued validity effects at the short, but not longer, mask duration. Further, a predicted difference between negative vs. neutral, valid cues across mask durations was not found, although a trend approaching significance was observed for this comparison.

Taken together, results from testing specific, predicted hypotheses support the general idea of differential covert attentional cueing by negative emotional imagery in comparison to emotionally neutral imagery. The overall pattern also points to more salient negative emotional cueing at shorter rather than longer delays between cues and targets, perhaps suggesting an automaticity or rapid cueing effect of subliminal negative emotion that is not present as the interval between cues and targets grows longer.

Extended mask durations. Also possible is that differential effects of negative vs. neutral emotional cueing at varying mask durations would best be measured with different masking image times. That is, 80 versus 160 ms durations may not be entirely optimal values, although this timing was successful. It remains possible, nonetheless, that slightly differing mask durations would be optimal, with slightly longer times such as 120 vs. 240 ms or slightly shorter times of 40 vs. 80ms, or other differing values. The point of experiment 2, described next, was to attempt to better characterize such emotional vs. neutral cueing effects at somewhat longer durations.

The second experiment was somewhat successful in characterizing the time intervals for subliminal covert attention cueing by negative emotion, though not for measuring automatic mechanisms for emotional discrimination. It is not clear presently why validity effects were not seen during the Experiment 2 NECAT, when the delays between image cues and targets were extended from 80 vs. 160 ms to 160 vs. 320 ms. It was thought that extending mask durations in Experiment 2 would be more suitable for comparing neutral vs. negative emotional cueing by increasing delays and allowing ample processing time. In fact, based on results across experiments, it seemed as if the brain actually prefers to utilize negative emotional image cues in a rapid, automatic fashion. When measuring validity effects, shorter delays between emotional cues and subsequent targets appears ideal. In other words, when making rapid discrimination decisions, especially in evaluating negative emotional information, current study results support the notion of very little time to process and respond to images as best. A significant validity main effect in the AICAT but not NECAT may suggest detrimental effects less rapid discrimination between negative and neutral emotional images, though the NECAT showed a trend toward a significant validity effect. A possibility is that the effect would be significant with a greater sample size, or with a different or more motivated sample. For instance, it is possible that more motivated students might sign up during a particular semester, or at an earlier point different point in the semester. It is always a possibility that participant behavior differed across the first two experiments in terms of effort, understanding of tasks, or other factors. Data was closely examined to try to exclude aberrant data points, however, and the apparent detrimental effect of extended cue-target delays was not seen within the Experiment 2 AICAT, perhaps simply suggesting a different mechanism for animate-inanimate image discrimination at present task timing.

Inhibition of return. A possibility that was considered for Experiment 2 is that the phenomenon of inhibition of return (IOR) prevented validity effects during the NECAT. An inhibition of return effect might be expected in a task with less emotionally or motivationally salient stimuli, such as in the AICAT, but not with emotionally salient cues as in the NECAT. Essentially, in IOR visuospatial attention appears automatically inhibited from reorienting attention to a location at which nothing significant has happened. In previous research, inhibition of return is typically found for intervals greater than 300 milliseconds between an attentional cues and subsequent targets in the same spatial location (Rafal, Calabresi, Brennan, & Sciolto,1989) and is found with cue-target intervals up to five seconds (Collie, Maruff, Yucel, Danckert, & Currie, 2000). Validly cued targets actually produce slower response times than invalid cues, suggesting an attentional bias in which attention is not returned as quickly to areas that have been previously focused on visually. Implications of IOR include mechanisms for flexible attentional processing, inhibitory control over largely automatic processes, and a way to seek novel environmental stimuli with more methodical scanning and avoiding having to orient attention incessantly to each novel stimulus at a particular location (Rafal, 1996; Rafal et al., 1989). An IOR effect was possible for the 320 ms delays in Experiment 2 and while IOR effects are not typically seen at delays as short as 160 ms, the researcher is unaware of any studies examining IOR with subliminal cueing. However, when examined more closely, no IOR pattern was seen in the Experiment 2 NECAT as valid cues did not produce longer RTs than invalid targets at either the 160 or 320 ms delays.

Negative cueing at longer delays. A further difference based on extending mask durations was no evidence of differential negative vs. neutral cueing for valid targets at either mask duration. Likewise, there was no evidence of differential validity effects for negatively cued trials at either mask duration, as differential negative vs. neutral subliminal cueing did not happen with mask delays of either 160 or 320 ms. It is unclear why differential validity effects for negative emotional cues at the 160 ms mask duration were seen in the first experiment but not Experiment 2. The attempt to better characterize the effects of emotional cueing on spatial attention at longer delays was somewhat successful, as it again appears that subliminal covert attentional cueing by emotion tends to rely on fast, automatic decisions as would be predicted by LeDoux (1998). No benefit was observed at all in the second experiment of negative vs. neutral emotional discrimination. Overall, it appears that extending the mask durations to 160 vs. 320 ms in the second study interfered with or was not ideal for assessing emotional cueing. Although the comparison of negative vs. neutrally cued valid targets, across mask conditions, was not significant in Experiment 1, it at least approached significance whereas it was clearly insignificant in Experiment 2. Whether the comparison would be optimal at delays in between those used in Experiments 1 and 2, or at even shorter delays than in Experiment 1, is not altogether apparent either.

No evidence was found for cueing by either negative or neutral images following 160 ms masks. This finding again differs from Experiment 1, which found highly significant validity effects for negative emotional images at both 80 ms and 160 ms mask durations, but not for neutral images. It is unclear, again, why there would be emotional but not neutral cueing effects at 160 ms in Experiment 1 but not Experiment 2. To more fully characterize the effects of negative vs. neutral cueing, validity effect difference scores were used to test the effects of emotional valence on validity effects, as a separate dependent variable, at each level of mask duration. No significant effects of emotional valence at either mask duration was further evidence that greater and more rapid effects of negative emotional were not present in Experiment 2. Perhaps instead of increasing mask durations to 160 and 320 ms, a more appropriate and feasible alternative would have been to test more incremental increases such as 120 vs. 200, or 160 vs. 240 ms.

Experiment 2 performance and arousal. Additionally, a possible explanation for the lack of significant findings in Experiment 2 is that the NECAT with extended mask durations slowed the overall task down and thus decreased the arousal required to perform the faster-moving Experiment 1 task. As previous research demonstrates (i.e., Tucker & Williamson, 1984), brain mechanisms for affect and arousal can modulate task performance. In fact, auditory arousal, which may be somewhat longer-lasting than visual arousal, can last and impact task performance for as long as 12 seconds subsequent to presentation (Whitehead, 1991). It seems to be a distinct possibility that the quicker-moving, arousing NECAT in Experiment 1 increased and maintained arousal at a constant level, leading to better utilization of negative vs. neutral discrimination for validity cues. It is also possible that Experiment 1 validity effects in the NECAT were due to a synergistic arousal effect due to interaction between negative valence and task speed. Finally, Eysenck has suggested that recovery from arousal, such as due to the negative valenced image cues, might occur after a delay (Eysenck, 1982); it is also possible that lack of validity effects in the second experiment could be due to a brain mechanism allowing individuals to recover from highly arousing negative imagery.

Experiment 2 summary. Taken together, the hypotheses of Experiment 2 were not supported, and extending mask durations out to 320 ms to better measure differential neutral vs. negative emotional cueing did not succeed. In sum, a significant validity main effect was found in the AICAT but not the NECAT; no evidence was seen for differences in negative vs. neutral cueing for valid targets or differential negative vs. neutral validity effects at either mask duration, or collapsed across mask durations; and no evidence was seen for differential validity effects for negative vs. neutral image cues, even when analyzed with validity effect as a separate dependent variable. The general aim of Experiment 2 was to further characterize the time period over which negative emotion cues covert attention by presenting masking stimuli at these longer durations. In that way, the experiment was successful identifying that the more salient negative emotional cueing at shorter delays between cues and targets in Experiment 1, were simply not observed in Experiment 2. Aforementioned results provide some additional evidence implicating automatic or rapid cueing by subliminal negative emotional images, that is present only for short delays around 80 ms between the image and target presentation. Therefore, the results of Experiment 2 did in fact build upon those from Experiment 1 and indeed provided further characterization of time intervals of negative emotional attentional cueing.

Positive emotional cueing. A unique feature of the third experiment was to build upon the first two experiments and begin to characterize time intervals over which subliminal positive vs. neutral emotional cueing can occur. The same 160 vs. 320 ms cue-target intervals were used for both Experiment 3 tasks. Importantly, predicted validity main effects were found in both the PECAT and AICAT, demonstrating that participants were able to use both animate-inanimate and neutral-positive cue discriminations as validity cues in the third experiment. Validity effects were found consistently across all 3 experiments in the AICAT despite timing differences between Experiment 1 and the next two. It appears that at the longer 160-320 ms delays used in this experiment, the neutral-positive emotional discrimination with subliminal images was salient. However, no evidence was seen for positive image cues being more effective as attentional cues overall than neutral ones in the PECAT. Further, no evidence was observed for differential cueing benefits by valid, positive vs. neutral images and the predicted greater validity effects for positive vs. neutral image cues was also not found. In fact, there was no significant validity effect for positive images at all when analyzed independently. No difference between neutrally vs. positively cued validity effects at either 160 or 320 ms mask durations was seen, though a trend toward significance was seen at 320 ms.

Mask delay and positive cues. At the task timing used for image cue-target delays, although there was a main effect of Validity in the PECAT, there were no differential effects of positive vs. neutral valence and positive emotional cueing therefore did not produce greater validity effects. Overall the basic premise of Experiment 3, though more tentative, was not supported and measure of covert attentional cueing differences between positive and neutral imagery at 160 vs. 320 ms delays was mostly unsuccessful. All in all, in Experiment 3, no differences were seen between positive and neutral valence cues, nor did validity effects differ for positive vs. neutrally image cues even analyzing validity effect as a dependent variable. Results do not support the overall notion that positive images show more benefit as covert attention cues than do neutral images, at least at the timing in the present experimental tasks.

Positive emotion and attention. Further research is required to better characterize the experimental parameters at which positive emotion is processed and can be used to cue spatial attention. Myriad research studies have shown the automaticity and rapidity of negative emotional processing, but the attentional benefits of positive emotion are less studied. It is possible that differential benefits of positive versus neutral cueing occurs at either shorter, or longer, mask duration presentation times than used in the present experiment. There are several explanations for potential beneficial effects of positive emotional processing, which have been proposed by Fredrickson (2009). Such benefits might include attracting support and aid from others, although the case could be made that negative emotion might also serve this role. Other benefits of positive emotion might be to act as a buffer against the detriments of negative emotional states, and in fact research has shown that certain positive emotional responses such as amusement or contentment may counteract potentially dangerous cumulative physiological responses to negative emotional stimuli (Fredrickson, Mancuso, Branigan, & Tugade, 2000). While impacts of positive emotional states may indeed be important, such effects are unlikely to be detected in the current experimental procedures and would not be manifested at such short time durations. Furthermore, it remains unclear whether positive emotion, even if adaptive to functioning, is processed rapidly by the brain. Certain attentional benefits have actually been found in regard to positive emotion. Fredrickson & Branigan (2005), for example, found benefits of positive emotion in terms of an attentional or cognitive broadening effect, in which one's cognition is widened to consider a larger range of behavioral options in response to positive emotion. This finding is in contrast to negative emotions, which seem to narrow or restrict one's behaviors, in the classic "fight or flight" scenario. Cognitive and attentional broadening may become even more advantageous over time by increasing one's available coping resources in the face of problematic situations (Fredrickson, 2009).

Experiment 3 summary. The present study suggests that subliminal positive-valenced cues are not processed in an entirely different manner from emotionally neutral cues in a covert attention paradigm, and that the benefits of positive emotion on attention might be slower-acting. The positive image-cues are definitely not more effective for covert attention compared to neutral cues when presented below consciousness in this task design. However, the positive images were being processed subliminally and utilized in general, as significant validity effects in the PECAT were observed. Perhaps future research will further explore such issues, and incorporate paradigms that assess more immediate consequences of positive emotional processing, or combine negative and positive emotional cueing in order to measure whether positive emotion does indeed buffer or cancel out the effects of negative emotion.

Supplemental Mood Effects on Task Performance

Overall Negative Emotion Cued Attention Task (NECAT) and Positive Emotion Cued Attention Task (PECAT) performance was specifically hypothesized to be influenced by the presence of anxiety and/or depression symptoms, primarily due to the emotional content of task images and the required emotional discrimination between neutral and either positive or negative image valence for effective task performance.

NECAT and mood. Depression did lead to slower overall responses in task performance, and a trend toward response time speeding by anxiety symptoms was observed. Although a main effect was not found, anxiety symptomatology was found to interact with validity and valence factors, with follow-up mixed model ANOVAs and pairwise comparisons showing that the anxious group showed a large bias to negative-valenced subliminal cues as measured by validity effects. This is in contrast to the non-anxious group, which showed significantly smaller validity effects for negative cues and also showed validity effects for neutral cues while the anxious group did not. It is possible that this effect is evidence for the tendency of anxious individuals to have a pre-existing high threshold for stimulation, or a fine-tuned filter for negative emotional stimuli, so that only subliminal negative cues but not neutral cues are able to be utilized for validity effects. Attention bias has been shown in various research studies, as evidenced for both anxious and depressed individuals.

In experiment 2, there were no main effects of anxiety or depressive symptoms in mixed regression or mixed ANOVA analyses using anxiety and depression as dichotomous variables. Anxiety interacted significantly with mask duration and also interacted with validity × valence. In follow-up analyses, both anxiety groups showed RT benefits from longer cue-target delays but the group high in anxiety showed much less overall benefit compared to those low in anxiety. Although not strong support for attention bias in anxiety, it does demonstrate some evidence that individuals with anxiety do not require long durations for emotional discrimination. However, the large main effect of mask duration seems to have largely driven the significant interactions of mask duration with both anxiety and depression since the effects were seen across all anxiety and depression groups. In addition, depression showed a trend toward significantly interacting with validity and may have been significant with larger sample sizes, as only 44 total participants in Experiment 2 had complete BDI, BAI, and performance data. Another possibility that might have increased effects of anxiety or depression on emotional task performance was to use actual clinical patients in this research rather than subclinical analog samples.

Attention bias and mood. The literature is abundant with examples of research demonstrating various attentional biases to negative emotional information. As reviewed elsewhere in this document, MacLeod and colleagues (1986) have shown bias to threatening words in dot probe tasks, especially for individuals with depression or anxiety. Likewise, Mogg et al. (1995) found individuals with such disorders as anxiety or depression to show bias to words related to one's disorder, in tasks presenting such word stimuli both above and below consciousness. The current study tasks and paradigm seemed ideal to examine mood influences on attentional bias, especially with Mogg et al. (1995) and others showing predisposition of anxious individuals to pre-conscious attentional biases to negative emotional information. Attention bias to negative or anxiety-related information is shown in a variety of anxiety disorders as well, including panic disorder, phobias, and even high state anxiety (Brosschot, de Ruiter, & Kindt, 1999; Lundh, Wikstrom, Westerland, & Ost, 1999; Nunn, Mathews, & Trower, 1997). Likewise, negative attention bias is also found in depressed patients, and for words describing depression and negative traits after negative mood induction (Bradley et al., 1993; Bradley, Mogg, & Lee, 1997).

Therefore, individuals with high levels of anxiety were expected to respond more quickly in the NECAT in Experiments 1 and 2 while effects on the PECAT were exploratory in nature. The influence of anxiety on attentional cueing by subliminal positive emotional stimuli has much less existing literature devoted to its study. Depression, likewise, has been discussed in terms of relation to greater predisposition to noticing and exhibiting attention bias to negative emotional stimuli. Those reporting high levels of depression were expected to perform the NECAT significantly slower due to being distracted and hindered by negative emotional imagery. A few studies have examined differences in attentional processing biases for anxious versus depressed individuals (i.e., Mineka & Gilboa, 1998). From Lang's perspective, a person in an anxious state may be acting in accordance with motivation to protect oneself from dangerous or threatening stimuli. Perhaps individuals with depression are also protecting themselves, from stimuli that could worsen mood, cause rumination, or lead to suicidal ideation for instance, and thus are poor at recognizing and responding quickly to negative emotional cues.

Previous research has shown subliminal negative priming by negative affective words to relate more to depression than anxiety (Bradley et al., 1994) and suggests evidence for negative automatic processing bias and possibly emotional processing bias in general. In a large metaanalysis, it was also concluded that anxious individuals seem to show a bias at multiple levels of attentional processing: automatically assigning information as threatening, using excess cognitive resources to only mild threats or to mild threats perceived as high threats, and inability to consciously counteract such automatic tendencies (Bar-Haim, Lamy, Pergamin, Bakermans-Kraneburg, & van Ijzendoorn, 2007).

PECAT and mood. In Experiment 3, mixed regression showed expected main effects of mask duration and validity and interestingly, a significant main effect of depression on PECAT performance. Depression but not anxiety impacted performance on the positive-neutral subliminal image discrimination, and neither anxiety nor depression interacted with other PECAT factors. Less research literature seems devoted to the effect of depression or anxiety on attention bias to or away from positive emotional information. The experiment PECAT was less than successful measuring differential effects of anxiety or depressive symptoms on emotional modulation of covert attention. Such effects on positive emotional cueing would perhaps would be better measured at differing time durations of task stimuli, but such effects have not been well characterized in previous studies. Research has shown certain mood states or personality factors to affect attention to positive emotional cueing, such as extraverts showing increases in attentional indices including P300 amplitude to positive and negative words used as covert attention cues (Pascalis & Speranza, 2000). Similarly, extraverts tend to show attentional bias in covert attention tasks for locations that are rewarded points, while on the other hand introverts show difficulty disengaging attention from locations which were punished (Derryberry & Reed, 1994) and also tend to benefit less from validly cued targets (Cloninger, 1998).

Mood summary. Hence, research literature suggests mood state and personality impacts covert attentional performance, but few if any studies have attempted to examine and explain how depressive symptoms might impact covert attention. Even less is known about the impact of depression on subliminally cued covert attention performance, but the present experiment is a first step toward characterizing such effects.

General Discussion

There were several findings in the present studies which add to the research literature on automatic emotional processing and its effects on spatial attention. In addition, several findings are consistent with proposed hypotheses and with existing research that found effects of both supraliminal and subliminally-presented emotional stimuli on spatial attention (e.g., Mogg et al., 1995). While the results were not consistent across all 3 experiments, the design of Experiment 1 versus Experiment 2 and 3 differed slightly in terms of task timing, which may partially explain the inconsistency. Also, Experiment 3 studied positive emotional cueing, and therefore hypotheses were somewhat tentative and exploratory. The current experiments attempted to first show that negative emotional imagery, when utilized as covert attentional cues, were more effective than neutral cues, especially at short response times when presented subliminally. Such findings would indicate that negative images are able to be processed much more quickly and automatically in the brain, assumedly as an adaptive response which would increase chances of survival. The examination of covert cueing effects of positive emotional images was more exploratory and less definitive, but the inclusion of an experiment to explore the cueing effects of subliminal positive emotional cues allowed the current study to compare and contrast the neural processing of negative and positive emotional valenced image cues. Implications of the collective results across all three experiments are discussed in the ensuing section.

Validity effects. The first important overall finding was that imagery could be processed rapidly and utilized as spatial attention cues in a covert attention task, even when presented subliminally. The fact that significant validity effects were observed in the first experiment and subliminal covert attention cues produced such effects is important in and of itself, regarding how quickly and automatically emotional information was processed and utilized. Moreover, the finding of significant validity effects in the AICAT shows that the NECAT validity effects are not due merely to the stimulating effects of an emotional decision or the arousing nature of the negative imagery. Clearly, however, positive and negative emotional information is processed in a much different manner, as several results suggested that subliminal negative emotional cues images differentially affect automatic, rapid covert attentional cueing.

Time duration and emotional cueing. An interesting aspect of the findings was that significant validity effects were found in the NECAT in Experiment 1 (with 80 ms versus 160 ms mask durations) but not in Experiment 2 (160 vs. 320 ms mask durations), which may indicate that shorter delays between negative attentional cues and targets may be ideal to measure validity effects. In fact, it seems from the results of the first two experiments that negative emotional cues are best utilized and processed when very little (80 to 160 ms or less) or no delay is presented between attentional cues and targets. However, significant validity effects were found in the PECAT in Experiment 3, with the same stimulus presentations as the NECAT in Experiment 2. Measuring positive attentional cueing may then require longer delays than for negative cueing. A few instances of differential influence of emotional vs. neutral subliminal imagery on covert attentional cueing were in fact demonstrated in the current project.

It is not a new or original discovery that stimuli, emotional or otherwise, presented below the level of conscious awareness can be processed at some level and even influence subsequent actions. Similar phenomena have been examined and are discussed thoroughly elsewhere in this document, but to the author’s knowledge this is the first demonstration of utilization of subliminal emotional imagery as covert attentional cues. Overall results lend some support for attentional mechanisms that allow emotional cues to be processed quickly and automatically, as might be predicted by LeDoux (1998) or others. Other research points to such findings as affective reactions without conscious subjective feeling as evidence for subliminal emotional processing and its regulation by more primitive brain networks (i.e., Winkielman & Berridge, 2004). Various research in addition to the present study also find a modulation of spatial attention by subliminal cues, including fearful faces (Fox, 2002), and other measures such as galvanic skin responses show an effect of subliminal fear cues (Ohman, 2005). Bodies of research have also revealed how motivated stimuli based on drive states, including emotion, are attended to and how emotion can be processed rapidly based on specialized brain pathways (Lang, 2000; Lang et al., 1997; LeDoux, 1996).

A possibility that may be occurring is that when delays are very short, from 80 ms to 160 ms, then emotional cueing is automatic and rapid; however, when delays are stretched longer to 320 ms, then the heightened arousal may also lead to emotional distraction and eliminate any benefits of the emotional cueing, essentially making the effects no different than neutral cues. Whether this can occur with subliminal cueing is debatable, but the fact that validity effects were found in Experiment 1, and in Experiment 3 with positive cues, does point to the fact that the subliminal images are being processed though not perceived.

Another possibility is that extending delays even *longer* than 320 ms would allow recovery from any potential emotional distraction. Although it was not assessed in the current experiments, it is possible that at the longer delays of 320 ms, that the negative emotional cues especially become distracting due to more time to process the visual emotional information. This could potentially explain the lack of validity effects in Experiment 2, which may not occur for positive emotional images and would explain Experiment 3 validity effects in the PECAT. As discussed by Eysenck (1982), among others, one may become susceptible to attentional distraction during emotional arousal and thus not utilize the covert attentional cues as readily. Eysenck also suggests a mechanism to recover from performance deficits due to high arousal, which could lead to re-established validity effects at delays even longer than 320 ms. Previous thesis research (Hammersley, 2002) found similar results, in which attentional recovery was seen for lateralized covert attention image-cues at long delays greater than 500 ms.

Implications. Taking findings of selective attentional processing of emotional cues in this and other studies, it seems possible that both over-focus on or greater tendency to process negative emotional environmental cues in addition to a lack of attention to positive emotional stimuli might be factors in certain psychiatric conditions such as depression or various forms of anxiety disorders. As Fredrickson (2009) suggests, perhaps one needs to learn to better rely on and experience positive emotional states in order to function in a psychologically healthy manner and be well-adjusted, and a first step may be ability to automatically focus on and process positive emotional information. While a plethora of research has shown that negative mood states relate to increase attention to and processing of negative emotional information, less focus has been devoted to attentional mechanisms in relation to positive emotional cues. It could be that overactive quick, automatic processing of negative information is related to anxiety disorders while more slow-acting focus on negative information more relates to depression.

Overall summary. In sum, a number of findings in the current study add to the growing literature demonstrating that emotional cues are processed and modulate attention in a different manner than less salient neutral ones. In the first experiment, overall validity effects in both tasks but only following negative image cues at both mask durations, as well as only valid negative cues but not valid neutral cues reducing RTs, provide support for such a claim. Further, significant differences in negative vs. neutral valid image cues at the shorter but not longer mask delay as well as a trend approaching significance for overall negative vs. neutral cueing differences further suggest differential effects of emotional cues on attention. Indeed, this agrees with research demonstrating that unconscious processing of fear expressions is sufficient to activate the amygdala in fMRI (Whalen, Rauch, Etcoff, McInerney, Lee & Jenike, 1998) and other structures including the amygdala, anterior cingulate cortex, superior colliculus, and locus coeruleus (Liddell, Brown, Kemp, Barton, Das, Peduto, et al., 2005). Liddell and colleagues describe these structures as possibly involved in an automatic fear network in the brain which may also modulate attentional mechanisms. The present study further attempts to characterize such attentional mechanisms that are modulated by negative-valenced cues, and perhaps overall emotion in general. Though emotional cues were not observed as differentially affecting covert attention in Experiment 2, results allow time durations of subliminal emotional cueing to be further characterized and future tasks examining subliminal cueing to be honed. Ideal task timing to measure subliminal cueing by negative emotion is apparently at or close to that used in Experiment 1. Likewise, Experiment 3 was largely unsuccessful in measuring covert attentional cueing by positive imagery, other than overall validity effects in the PECAT; however, again these results may suggest different timing to be used in future tasks incorporating positive emotional image cues.

The association of emotion and cognition has been discussed since the days of Plato, as certain aspects of emotion were seen by Plato as interfering with rational thought, and philosophers have discussed distinguishing between such concepts as cognition and reason, judgment, and emotion or affect (as reviewed by Fox, 2008). Myriad research studies confirm the finding of selective or biased attention to fearful or angry facial expressions (Cooper & Langton, 2006; Fox, 2002; Mogg & Bradley, 2002), even when only viewing just the eyes expressing fear (Fox & Damjanovic, 2006). The effects of such fearful stimuli as snakes, spiders, and needles on visual attention are also well- demonstrated (Beaver, Mogg, & Bradley, 2005; Blanchette, 2006;Ohman, Flykt, & Esteves, 2001).

Moreover, negative and positive emotional imagery have been shown to be processed by and attended to differently depending upon mood state, including individuals with disorders such as depression or anxiety (i.e., Bradley et al., 1994). It may be that individuals with anxiety or depression differ in their ability to not only process emotional image cues rapidly and subliminally, but to differentially benefit from such cues. In fact, some support was seen for this in the present study. The results of Experiment 1 largely agree with this premise, and the timing used in that experiment was clearly best for examining emotion/attention relationships in those reporting anxiety or depressive symptoms. Evidence for depressive symptoms impacting task performance and a trend for impact by anxiety were seen in Experiment 1, as well as evidence for differential negative cue utilization by more anxious individuals. Less support was seen for the impact of anxiety or depressive symptoms on emotional cueing; however, this does suggest that the effects of anxiety and depression, the interactions between symptoms of each, and potential differences between effects of these disorders are perhaps measured at shorter durations between image cues and targets. Such future directions are suggested based on the results of the second two experiments as well.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Methodological Limitations and Future Directions

Nearly as many questions as answers have arisen from the current series of experiments. A number of methodological limitations to be addressed, and directions in which future research could proceed, were suggested. The present area of research in general is planned to be continued, incorporating some of the below areas.

Task Timing. First, the timing within the tasks across three experiments may not have been ideal, as has been noted previously. Upon analyzing preliminary results from Experiment 1, certain measured differences between neutral and negative image cues appeared nearly significant at the longer mask duration (160 ms) but not at the shorter duration (80 ms). The mask presentation times were extended in Experiment 2 to make the shorter duration 160 ms and the longer duration 320 ms. In retrospect, it seems that somewhere in between the mask presentation times of Experiment 1 and Experiment 2 may be more ideal, such as 120 ms versus 240 ms.

Additional basic research should further characterize time periods of both negative and positive emotional cueing in covert attention and other paradigms. Perhaps instead of increasing mask durations to 160 and 320 ms, a more appropriate and feasible alternative would have been to test more incremental increases such as 120 vs. 200, or 160 vs. 240 ms. Varying levels of mask conditions used in the pilot study were not implemented in the experiments in order to increase power. However, now that it is clear that covert attentional cueing by subliminal emotional images can occur, it will be important to better assess the time periods over which this emotional cueing is optimal.

Another study that includes 3 or even 4 different levels of mask durations in one task to assess the optimal presentation times would be helpful. Shortening delays between negative image cues and targets, perhaps to as short as 40 ms, might be feasible in order to study just how rapidly negative emotional cueing is processed and utilized. Similarly, it might be feasible and productive to increase the time durations between positive images and targets even further – perhaps to even as long as 600 or 800 ms.

Subliminal vs. supraliminal cueing. Moreover, the present study focused only on subliminal emotional cueing for covert attention across three experiments, and additional research should focus on not just subliminal but also supraliminal emotional cueing in visual attention tasks. It would be interesting, and informative, to examine how negative and positive emotional information is processed both above and below awareness. Clearly information is processed differently for subliminal as opposed to supraliminal stimuli. In fact, processing differences have been demonstrated neutrally by research showing supraliminally-presented fear information is processed more cortically than subliminal fear stimuli (Ohman, 2005), although both also involve activation of structures such as the amygdala. Another difference seen between subliminal and supraliminal emotional processing is seen in positron emission tomography, as subliminal fear information appears to travel to the right amygdala via a different pathway than supraliminal fear and only unilaterally (Morris, Ohman, & Dolan, 1999).

Moreover, no specific evaluation was done during experimental procedures to check whether the image cues were indeed subliminally presented, although this was tested during the piloting phase of computerized tasks. The possibility remains nonetheless that certain images were able to be perceived supraliminally by some participants and that the processing of such images reached conscious awareness. In future research examining the effects of subliminally-presented image cues on attention, some measures should be instituted in order to ensure processing of such stimuli occurs below awareness. A simple memory task asking which images were seen, or a task in which a random sample of images are presented subliminally and participants are asked how aware they are of the content, could be included. If any images were able to be perceived consciously, this would obviously affect the interpretation of results, based on the differences discussed above between subliminal and supraliminal image processing.

Screening criteria. Another potential limitation to consider is lack of screening and no exclusion criteria for reported or measured recreational or prescription drug use. As commonly found in research largely utilizing undergraduate populations and studies which did screen for such drug use (i.e. Gilbert et al., 2005), recreational marijuana use among other drug use was fairly commonly reported in addition to common psychoactive substances such as nicotine or caffeine. Even use of nicotine and caffeine was not screened for, and these among other common substances with psychotropic effects, if used just prior to the start of an experimental session, could obviously impact attentional performance. Other medications with known psychotropic effects, including some specifically targeting attention (i.e., Ritalin), may well be used by prescription or recreationally by college students regularly.

Indirect behavioral measurement. Further, conclusions of the current study are based on indirect measurements of such principles as attentional cueing or emotional processing by brain pathways. For this reason, eye-tracking data or functional MRI in combination with behavioral measures allow researchers to see precisely what is happening and which neural pathways are activated during image-cue presentation and subsequent responses to targets. Measuring the effects of drugs on attentional cueing and emotional processing through similar paradigms to the current project may be potentially informative as well, since it could provide additional indices by which to measure drug cravings, recovery from mood disorders or anxiety, or improvement in attentional processing by ADHD treatments.

Image exposure. One facet of emotional/attentional interactions not considered in the present study is the effects of continued exposure to emotional cues, such as presenting negative images in large blocks and measuring whether their influence on attention in paradigms such as the PCAT continues to increase or if individuals instead gradually habituate to such images. Previous research has shown that arousal from auditory stimuli can produce an increase of attention that can last for up to 12 seconds (Whitehead, 1991). Therefore, the biased attention seen in the current study to negative and positive stimuli delay may last for an extended time, especially after a block of several emotional images in a row.

Valence categories. Another potential limitation is that different categories within each valence were included, allowing for potential artifacts when interpreting the results of valence. For example, different types of images included human faces, animals, common objects, and scenery, and therefore it is somewhat difficult to know whether the effects of neutral image valence were due to facial processing or the processing of complex or interesting features within the images. Novel stimuli may also increase cortical activation and draw attention (Milner, 1999), which may partially account for some of the effects seen for image cues in the present study. More threat-related stimuli are needed in future studies in order to better evaluate the impact of fear-based, automatic emotional cueing in attentional paradigms. Although the present study used normed emotional images from the IAPS sets, the stimuli were chosen based on their overall negative valence ratings, and thus included a broad range of image subcategories including disgust-related, sad facial expression, and other negative stimuli. In keeping with LeDoux's original fear processing brain network, fear-inducing stimuli that are perceived as threatening or dangerous would be more ideal. The present experiments focused on subliminal processing and automatic attentional cueing, but future studies might use video clips to examine mood induction and its effect on attentional cueing in attention tasks such as the Posner covert attention paradigm. It would also be worthy to examine differences in emotional cueing of attention between various subtypes of negative emotional imagery – i.e., disgust, sadness, threat, and disfiguration categories among others.

Focus on positive emotion. Yet another facet that emerged as a result of the present study is the lack of focus on the potential benefit of positive emotion on cognition, attention, or other processes. Some authors have criticized various areas of psychology due to their lack of focus on positive emotional processing, or an overabundance of the study and discussion of negative emotions. Criticism has been aimed at such well-known psychological theories as Kubler-Ross's (1969) stages one goes through in response to dying as being overly negative-emotion based (Dutton & Zisook, 2005), for example. Textbooks and methods used to teach psychology have sometimes been criticized as well for being overly based on negative emotions and the differences between normal and abnormal functioning (Seligman, 2002). As noted previously, potential benefits of increasing focus on or processing of positive emotion may range from attentional and cognitive broadening effects (Fredrickson & Branigan, 2005) to attracting aid and support from others or buffering against potentially harmful negative emotion (Fredrickson, 2009). Moreover, Seligman, Rashid & Parks (2006) have found benefits of focusing on positive emotions as a component of therapeutic intervention and found exercises targeting an increase in positive emotion to be successful in treating depressive symptoms. It is unclear that increased attention to positive emotion is effective in and of itself in treatment of depression, but the fact that it is a successful component implies a need for further research into focusing attention less on negative emotion-related cues and more onto positive cues.

The present research study incorporated positive emotional cues into Experiment 3 and found no overall differential benefits in positive versus neutral emotional covert attention cues. However, it was designed to measure immediate, automatic attentional cueing when such positive images were presented subliminally and not longer-ranging benefits or buffering of negative emotions. As mentioned earlier, one definite direction needing more research is the development of paradigms that assess immediate, automatic consequences of positive emotional processing, or that utilize a combination negative and positive emotional cueing in order to measure whether positive emotion does indeed buffer or cancel out the effects of negative emotion.

Mood and pathology. Finally, the present study examined how mood state, as measured by anxiety and depression inventories, influences subliminal covert attention cueing by emotional versus neutral images. It would be interesting to examine how the emotional discrimination required to perform the tasks is influenced by personality and individual differences, or by conditions such as Attention Deficit Hyperactivity Disorder (ADHD). It might be that those with symptoms of ADHD could perform tasks requiring emotional discrimination between negative or positive and neutral stimuli, such as in the NECAT or PECAT, but have more trouble performing tasks with all neutral stimuli such as the AICAT. It could be a potential paradigm for evaluating automatic, below-awareness mechanisms that are not readily apparent but could be involved in the maintenance or development of mood and attentional disorders. Other potential implications of automatic attentional cueing might be to examine differences between anxiety and depression, or between specific subtypes of psychiatric disorders such as paranoid versus disorganized schizophrenia. Such research might prove useful in examining predisposition to mental illness or factors in comorbidity of certain mental illnesses. Examining neurocognition and delusional severity in schizophrenia, for example, was able to predict comorbidity of schizophrenia with social anxiety (Lysaker & Hammersley, 2006), and might even have utilization in predicting outcomes and prognosis or identifying preliminary warning signs of mental illness. In fact, a recently growing area in psychiatric medication is aimed towards improving attentional and cognitive functioning in schizophrenia in addition to reducing psychotic symptoms. Future research should certainly examine automatic attentional cueing bias to emotional information in clinical populations, and not just college students based on depression and anxiety screeners. The scores tended to be skewed toward the low end of the symptomatology spectrum, and might explain some of the lack of consistent findings on the effects of anxiety and depression in the present study. Implications of emotional processing and its association with attention might help to better understand and develop therapies to improve emotional and attentional disruptions or factors in the maintenance or development of psychiatric disorders.

Laterality. The current study did not assess participants for handedness, and thus a serious examination of lateralized effects of emotional cueing could not be conducted. Future research should definitely screen individuals for hand dominance in order to make conclusions about whether central or lateral presentation of image cues has differential effects on targets in a particular visual field. Several prior lines of research suggest that covert attentional processing is shown to be lateralized (i.e., Goolkasian & Tarantino, 1999), especially if the stimuli or distracters being presented are peripheral. It is possible that emotional cueing in the present tasks would show lateralized effects or lateralization could be an explanation for certain task findings as well.

Final Conclusions

The present overarching study goal of examining relationships between attentional cueing and emotional imagery processing by the brain, as well as specific study goals investigating emotional discrimination within adapted covert attention paradigms were moderately successful. Timing to be used to measure these effects and to examine influence of current mood states is better characterized and more understood as a result of the present study. Clearly, negative or emotional imagery is processed and affects covert attention differently compared to neutral imagery at least at short delays between subliminal cues and targets. Future research will continue to shed light on these important issues. The current paradigm of using an adapted, image-cue version of Posner’s covert attention task will continue to be utilized.

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