Selective Control of Attention to Emotionally Salient Stimuli

by

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The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled “Selective Control of Attention to Emotionally Salient Stimuli” by Amanda Hudson in partial fulfilment of the requirements for the degree of Master of Science.

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ABSTRACT

Selective attention may be an effective strategy for regulating emotions. The current study measured selective attention to emotional pictures in healthy adults using a novel computerized task. Participants saw pictorial cues on the right or left of the screen, followed by target words on the same or opposite side. Participants were divided into two groups. The suppress group had to avoid looking at pictures (cues), whereas the attend group had to look at them. Both groups categorized targets as indoor or outdoor words. Subsequent cue/target recognition tests were administered. Performance on both tasks was assessed by picture valence, revealing reduced inhibitory control to negative picture and difficulties reorienting to negatively cued locations. These findings contribute to our understanding of affective-attentional interactions in healthy adults. Moreover, the apparent inability to avoid looking at negative items may highlight a need to explore other emotion regulation techniques.

LIST OF ABBREVIATIONS USED

PFC	Prefrontal Cortex
ERP	Event-Related Potential
RSVP	Rapid Serial Visual Presentation
ADHD	Attention Deficit Hyperactivity Disorder
PNS	Parasympathetic Nervous System
HPA	Hypothalamic-Pituitary-Adrenal
LPP	Late Positive Potential
DSM	Diagnostic and Statistical Manual of Mental Disorders
IAPS	International Affective Picture System
SOA	Stimulus Onset Asynchrony
IOR	Inhibition of Return
SS	Same Side
OS	Opposite Side
ISI	Interstimulus Interval
SAM	Self-Assessment Manikan
ANOVA	Analysis of Variance
LSD	Least Square Difference
COMT	Catechol-O-methyltransferase

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CHAPTER 1: INTRODUCTION

Emotion

Emotions are complex phenomena, consisting of a multitude of components. At a biological level, emotions involve hormonal fluctuations in the endocrine system, electrophysiological changes in the brain, as well as peripheral alterations in the autonomic nervous system (Gross, 1999). Emotions are inherently subjective, influencing intrapersonal experience, but are also strongly linked to behaviour, leading to interpersonal communication and expression (Gross, 2002). Thus, affect can be viewed as socially beneficial, promoting social cohesion through emotional displays that provide a basis for bonding, intimacy, and alliance (Gross, 2002). Another adaptive feature of emotional experience is its ability to facilitate decision making. For example, Bechara (2004) proposed a framework for decision making that relies heavily on emotion-induced changes in homeostasis and feeling-related somatic signals. Furthermore, emotional processes are intimately and bi-directionally linked to attention (Most, Chun, Widders, & Zald, 2005), cognition (Simpson, Ongur, Akbudak, Conturo, Ollinger, Snyder, Gusnard, & Raichle, 2000), and memory (Cahill, Babinsky, Markowitsch, & McGaugh, 1995), influencing how people perceive, understand, and remember the world around them.

Emotional experience holds both functional significance and adaptive value, as it provides useful information to an organism about its environment, priming it to respond in particular ways (Gross, 2002). Evolutionarily, emotionally primed responses were advantageous in that encountering threatening environmental elements, such as predators, triggered rapid negative responses, preparing the organism for fight or flight reactions. In contrast, positive emotions elicited by appetitive stimuli, such as food and mates, ensured appropriate approach behaviours (Bradley, Maurizio, Cuthbert, & Lang, 2001). This evolutionary approach helps to elucidate the rapid and often intense nature of modern day emotion, proposing that organisms are biologically prepared to respond emotionally to stimuli that hold survival value. Recent technologies (guns, weapons) are also emotionally relevant, although they would have been meaningless to past generations. Hence, whereas attentional biases to evolutionarily meaningful items may be biologically pre-wired, current technologies come to hold emotional significance through learning and conditioning. Once reward and punishment contingencies are established, emotional reactions and response biases can be generated to previously neutral stimuli.

Emotion Processing

Emotion processing (of visual origin) involves retinotectal efferents to the thalamus. The thalamus then sends direct projections to the amygdala, which initiates a preliminary response (Le Doux, 1996). Thalamic inputs also reach sensory/association cortices, in turn activating dorsomedial regions of the prefrontal cortex (PFC) that are important for reflective emotion processing. Orbitofrontal cortices receive direct input from the amygdala, permitting additional reprocessing of preliminary emotional and motivational information (Zelazo & Cunningham, 2007). Moreover, the orbitofrontal cortex may be implicated in reward and evaluative processes both directly and indirectly, through connections with the ventral striatum (Le Doux, 1996; Toates, 2001). This mesocortico reward circuit contains dopaminergic neurons that respond both to familiar appetitive items and novel stimuli that resemble previously encountered rewards. Dopaminergic responses to novel emotionally salient stimuli may promote exploratory behaviours that are likely to be rewarded (Schultz, Tremblay, & Hollerman, 2003). Other amygdala projections innervate the anterior cingulate cortex, which acts to monitor emotions and process ambivalent emotional information. The anterior cingulate is activated upon exposure to emotional situations as well as during retrieval of emotion laden memories. This overlap in activity might reflect association formation with past emotional experience upon exposure to novel, but similar, situations (Bush, Luu, & Posner, 2000).

Various sources of evidence endorse the view that emotion processing is highly automatic and rapid in its onset. The rapid, preconscious registration of emotional information has been attributed to the anatomical and functional properties of the amygdala. Positioned to receive bottom-up sensory input and to distribute output to motor and autonomic centres, the amygdala is the ideal candidate for rapid emotion processing. Emotionally salient stimuli have been shown to trigger psychophysiological responses without entering into conscious awareness (Ohman & Soares, 1993). For example, Kemp-Wheeler and Hill (1992) illustrated that negative and positive primes could influence subsequent judgements, even when these primes were consciously inaccessible. Further evidence for un-innervated, low-level processing comes from cases of emotional blindsight, in which individuals who cannot consciously see are able to respond to visual stimulation. More specifically, they are able to discriminate between emotional valences through priming and forced-choice paradigms in the absence of cortical activity, supporting the presence of a direct pathway from extrageniculostriate regions to the amygdala. Rapid discrimination between negative and positive items has also been demonstrated in the form of event-related potentials (ERPs), which illustrate valence differentiation within 100 ms of stimulus presentation (Smith, Cacioppo, Larsen, & Chartrand, 2003). Finally, subliminal versions of response-based tasks have yielded evidence for preconscious valence effects. For instance, findings from dot probe paradigms indicate a very rapid propensity to attend to emotional stimuli (Bradley, Mogg, & Lee, 1997) and modified Stroop tasks show an impairing effect of preconscious emotional items on colour naming (Bradley, Mogg, Millar, & White, 1995). Together these findings hint at an initial mode of emotion processing that is highly automatic.

Emotional influences also appear in later stages of processing, particularly in terms of enhanced memory for emotional events. There are two main memory systems which interact to produce emotional memories. The central components of each of these systems are found in the temporal lobe, and include the amygdala and the hippocampal complex. While emotional information is processed in the hippocampus as long-term memory representations, the amygdala manipulates its encoding and storage. The hippocampal complex can also have a moderating effect on the amygdala. Emotional memories that are stored in the hippocampus can be retrieved upon exposure to emotional stimuli, modifying the corresponding amygdala response. The amygdala has been a central focus for theorists examining the phenomenon of increased memory for emotional events. Support for the amygdala's status in emotional memory comes from clinical studies of patients who have confined brain damage to the amygdaloid region. Such patients fail to show the enhanced memory intensity and vividness of emotional representations that control participants typically demonstrate, despite having comparable memory for unemotional events and reporting equal levels of affective reactivity (Phelps, 2006). Thus, the amygdala seems to have a distinct role in forming emotional memories and recalling emotional events.

Emotional Biases

A number of tasks have been employed to examine emotion-based attention and response biases, elucidating a range of affective influences over resource availability, orientation propensities, disengagement effects, and mood-processing relations. Support for affective biases in later stages of processing, such as memory consolidation and memory retrieval, has also been demonstrated.

Emotion and Memory Biases

A great deal of interest has been generated by apparent interactions between emotion and memory. Heuer and Reisberg (1990) demonstrated enhanced long-term memory for emotionally salient items. Cahill and McGaugh

(1998) replicated this finding, observing improved retention of pictorial content for emotionally arousing scenes relative to neutral ones. In addition to a general replication of Heuer and Reisberg's experiment, they expanded their study to include a second experiment in which pictorial scenes remained the same, but the corresponding narration differed to describe either an emotional or neutral event. This manipulation served the purpose of controlling for variables other than emotional valence that could influence retention. Again, enhanced memory for story slides that were assigned an emotional caption was demonstrated, lending further weight to the notion of increased memory for emotional content. Valence-specific memory effects have also been reported by Ellenbogen, Schwartzman, Stewart, and Walker (2002), with negative words evoking the greatest recognition, followed by positive, and lastly by neutral words.

Emotion and Attention Biases

Affect-based emotion processing effects have also been studied in terms of attentional biases. One response-based procedure used to measure attentional allocation to emotionally evocative stimuli is the startle reflex paradigm. The general design for startle reflex experiments involves presenting participants with a sudden, startling stimulus (often in the auditory modality), and recording subsequent startle response magnitudes using electromyography of the orbicularis oculi muscles. Reasoning that increased attention to the startling stimulus produces heightened startle responses, Anthony and Graham (1985) examined attentional effects of various stimuli by presenting them in the pre-startle stimulus time frame. Emotionally evocative scenes presented before the startle stimulus decrease the size of the startle reflex, suggesting prolonged capture of attention by emotional pictures and reduced responsiveness to the startle pulse (Anthony & Graham, 1985; Lang, Bradley, & Cuthbert, 1990).

Many emotion-based attention tasks have taken the form of Rapid Serial Visual Presentation (RSVP) paradigms in which a rapid stream of items is presented and participants must identify a target item embedded within the visual series. Target identification performance is generally quite high in single target tasks; however, when an emotional distractor precedes the target, performance declines significantly, reflecting a depletion of attentional resources. For example, Most, Smith, Cooter, Levy, and Zald (2007) examined the effect of emotion on attention by assessing the distracting nature of positive, arousing stimuli on subsequent visual perception. When RSVP targets were presented after erotic images, performance was significantly impaired relative to target identification following neutral stimuli. This effect was termed "emotion-induced blindness" to describe deficits in visual discrimination that occur following exposure to emotionally arousing scenes.

Similar studies have also reported instances in which aversive emotional stimuli encourage allocation and hold attention more strongly than neutral ones. For example, Most et al. (2005) found that negative pictorial distractors cause greater target processing impairments than neutral pictures when distractors and targets are presented in close temporal proximity in an RSVP task. This effect persists even when distractors are not inherently aversive, but are manipulated to be so through conditioning (Smith, Most, Newsome, & Zald, 2006). Thus, whether negative stimuli have biological relevance or only come to be evaluated as negative through learning and socialization, humans seemingly allocate greater attentional reserves to these items, depleting available resources for processing other information. However, Arnell, Killman, and Fijavz (2007) found that only sexually arousing stimuli drew attention at the expense of target identification; negative stimuli did not. The reason for the discrepancy between this study and other RSVP experiments is unclear.

Other response-based measures have been helpful for examining emotion-based attentional biases. For instance, dot probe paradigms, which simultaneously present neutral and threatening stimuli, generally find faster reaction times for subsequent targets occurring in the threatening stimulus location (Koster, Crombez, Verschuere, & De Houwer, 2004; MacLeod, Mathews, & Tata, 1986). This has been taken by some as evidence that attention is advantageously allocated to threatening emotional stimuli (Williams, Watts, MacLeod, & Mathews, 1988). Others have argued that aversive stimuli influence attentional dwell time, and that response time results reflect reduced attentional disengagement rather than facilitated allocation (Fox, Russo, Bowles, & Dutton, 2001; Koster et al., 2004). Typical probe detection tasks employ stimulus durations of 500 ms (or more), permitting time for multiple attention shifts. Thus, response time data may not truly reflect initial orientation biases, but may provide a measure of attentional maintenance preferences. However, Mogg, Millar, and Bradley (2000) assessed dot probe responses in combination with eye movement data and observed an orientation bias to threat, indicating that vigilance preferences are indeed present.

Along with the debate regarding orientation and disengagement explanations, dot probe tasks have contributed to opposing theories of trait and state (mood) influences on emotion processing. A great deal of evidence has suggested that dot probe response biases obey mood/state-congruency principles. In general, participants demonstrate faster reaction times to items appearing in “threat locations” (Koster et al., 2004; Macleod et al., 1986). However, Bradley, Mogg, and Millar (2000) found that individuals low in state anxiety showed longer response times to threat cued targets than individuals high in state anxiety. This increased latency to respond to stimuli cued by threatening faces was also seen for stimuli preceded by sad faces, whereas happy faces triggered faster reaction times in low anxiety individuals relative to high anxiety individuals. Likewise, Mogg et al. (2000) used eye movement tracking in a similar dot probe task and reported a slight attentional bias away from negative information and toward positive stimuli in a healthy control group, whereas anxious individuals showed the opposite effect. Mogg, Bradley, Hyare, and Lee (1998) provided evidence that these mood-congruent dispositions extend to include natural drive states by showing that hunger can induce attentional biases for food-related stimuli.

Exogenous cueing paradigms, like dot probe tasks, involve presenting cues and measuring manual reaction times to respond to subsequent targets. They are different, however, in that cues appear one at a time, to the right or left of a central fixation point. Orienting is speeded to targets appearing in validly cued locations, an effect that can be further enhanced by using emotionally salient cues. Conversely, latencies to respond to invalidly cued targets are prolonged compared to validly cued targets in conventional cueing tasks, although responding on invalid trials can also vary as a function of cue valence. By examining responses to emotionally cued targets on both valid and invalid trials, inferences can be made regarding the impact of emotion on orienting and disengagement speeds, respectively (Fox et al., 2001).

Although dot probe findings tend to support state-congruent processing biases, studies using exogenous cueing have found that stress and negative affect can cause avoidance of threatening or unpleasant information. Ellenbogen et al. (2002) found faster shifts away from negative/stressful stimuli than from positive or neutral stimuli by negative stressor group participants. Furthermore, the ability to shift away from negative stimuli was significantly correlated with stress-induced negative affect. Other cueing procedures have exposed increases in difficulty disengaging from affective stimuli (particularly those that are threat-related), as demonstrated by increased latencies to detect targets on emotionally cued invalid trials relative to neutrally cued invalid trials. For instance, Fox et al. (2001) found reduced disengagement from threat in high trait anxious individuals compared to low trait anxious individuals, supporting a mood-congruent processing bias. Perhaps differences in the nature of participant anxiety (trait vs. state) could explain discrepancies between the Ellenbogen et al. and Fox et al. reports.

Like other attentional measures, visual search tasks have been employed to study the effects of emotion on attention. Ohman, Flykt, and Esteves (2001) had participants perform a visual search for various objects within a matrix grid, and found an automatic bias for threatening stimuli, as indicated by faster detection of these stimuli relative to non-threatening stimuli. This effect was exaggerated in those who reported having specific fears for those negative items. Gilboa-Schechtman, Foa, and Amir (1999) also conducted affective visual search experiments, employing a “face in the crowd” approach to studying emotional influences on attention capture. Consistent with the mood congruent findings of Ohman et al., participants with generalized social phobia displayed faster detection of angry faces than happy faces presented in a neutral crowd. However, others have reported a disparity between mood/state and search biases, with words related to current individual health concerns eliciting avoidance rather than detection (Constans, Mathews, Brantley, & James, 1999).

Although attention research has yielded some disagreement regarding emotion-based attentional biases, the most robust reports are in favour of enhanced attentional allocation to, and reduced disengagement from, emotional stimuli relative to neutral stimuli. Those findings in conflict with this notion have typically been tied to specific mood conditions and may not represent general interactions between emotion and attention.

Emotion Regulation

The process by which individuals selectively control the timing and nature of emotional experience and expression is referred to as emotion regulation

(Gross, 1999). Being able to adjust feelings flexibly to meet environmental, interpersonal, and intrapersonal demands is crucial for successful functioning in many aspects of daily life.

Perhaps the most important feature of emotion regulation is its influence on personal health. Long-term practice of successful regulation has been reported to promote mental and physical health (Ochsner, Bunge, Gross, & Gabrieli, 2002). Furthermore, dysregulation has been associated with a number of forms of psychopathology. Failure to adopt and implement appropriate regulation techniques may be one of the main etiological factors of mood disorders, such as anxiety and depression (Jackson, Malmstadt, Larson, & Davidson, 2000), and emotion dysregulation is among the core symptoms of many psychiatric conditions. For instance, patients with schizophrenia display a collection of affective problems, including anhedonia and avolition, which refer to lack of pleasure and absence of motivation, respectively (Firestone & Dozois, 2007). Together, these symptoms hint at an underlying inability to regulate emotions effectively – a notion which has been explored and supported by neural and behavioural studies (Radulescu & Mujica-Parodi, 2008).

A number of disorders with general impairments in inhibitory control, such as Tourette's Syndrome, Obsessive Compulsive Disorder, and Attention Deficit Hyperactivity Disorder (ADHD), are also characterized by emotional disturbances (Coffey & Park, 1997; Leckman, Grice, Boardman, Zhang, Vitale, Bondi et al., 1997; Maedgen & Carlson, 2000). For example, struggles in regulating affect are consistently reported among children with certain subtypes of ADHD, specifically those with combined type ADHD. Dysregulation (inappropriate regulation) and under-regulation (lacking control) seem to be characteristics of this disorder, manifesting in the form of highly intense feelings and elevated aggression (Maedgen & Carlson, 2000). This difficulty in emotion control seen in general inhibitory disorders may reflect an overlap in neural mechanisms that underlie affective self-control and those responsible for more general self-regulatory behaviours.

Command over one's feelings is also central to interpersonal relationships. By effectively matching the moods of others, individuals are deemed to be empathetic and compassionate, and are ultimately more popular among peers (Calkins, 1994). Disruption of normal affective self-control processes can result in social awkwardness and eventually isolation. Furthermore, reduced control of affect has been linked to socially unapproved conduct such as impulsivity, violence, and criminal tendencies (Davidson, Putnam, & Larson, 2000).

Finally, effective self-control over emotions can be facilitative in pursuing personal goals, such as academic or professional excellence. Gumora and Arsenio (2002) found that emotion regulation is predictive of school performance in middle-school children. Affective regulatory abilities are not only associated with school-related affect and general temperamental dispositions, but are also uniquely related to student grade point average. A possible explanation for this connection could be that skilled emotion regulators are superior at sustaining focus on academic tasks (Eisenberg, Fabes, Shepard, Murphy, Guthrie, Jones et al., 1997) such as homework, and ignoring hedonistic impulses to procrastinate.

The ability to modify affect flexibly has also been linked to job success in positions in which there are strict rules regarding appropriate deportment, as exemplified in medical and military professions (Bandura, 1977; Smith & Kleinman, 1989).

Regulatory Strategies

As biological beings, humans are predisposed to respond to emotionally salient stimuli, but such emotional responses are amenable to the deliberate use of control strategies. Researchers have strived to identify and label the various regulatory processes that are employed when controlling emotion. Certain researchers have chosen to describe each strategy individually as a unique mode of control, whereas others have grouped processes into inclusive categories based on general similarities. The former of these perspectives has aimed to pinpoint specific behavioural attempts to alter emotions. Such studies have identified over 200 regulatory examples. This behavioural directory lists a number of mood-control practices, ranging from exercise to social interaction (Parkinson, Totterdell, Briner, & Reynolds, 1996).

Other categorization attempts have relied on a more general examination of strategies. Walden and Smith (1997) clustered mood-control efforts into groups based on the target emotional component, be it expressive, physiological, or experiential. Though this approach may be superior to Parkinson et al.'s (1996) detailed behavioural account in terms of organization and practicality, it is not without fault. For instance, very different strategies may result in the same type of outcome, without warranting a similar classification (Gross, 1998).

Alternatively, Gross (1998) viewed emotion regulation as being either preventive or modulatory. In other words, strategies are viewed as antecedent or response-focused, respectively. Building on this two-way model, Gross expanded this classification scheme to include five main regulatory approaches that deal with the heterogeneous and multi-componential nature of emotion. This scheme categorizes strategies based on their temporal location in the emotion generative process. Situation selection strategies are antecedent-focused, representing the earliest point of emotion-regulation implementation. They involve making choices about interactions, activities, and events based on the expected emotional outcomes (Gross, 1998; Gross, 2002). This form of regulation can actually be self-detrimental depending on whether selections are based on short- or long-term implications (Tice & Bratslavsky, 2000). Consider, for example, the dieter who indulges to feel the immediate pleasure of forbidden food, but in the long run feels guilty and unsuccessful for diverting from the long-term goal. The second group of strategies is termed situation modification and, as the name implies, occurs post-situation selection. These techniques involve reshaping current scenarios to comply with emotion-regulatory goals (Gross, 1998; Gross, 2002). Both of these emotion-preceding control techniques (situation selection and situation modification) have been described by others, being classified not so much for their temporal placement in emotion generation but rather for their reliance on environmental features (Tice & Bratslavsky, 2000).

The third class of regulatory attempts involves attentional deployment and is the focus of the current study (Gross, 1998; Gross, 2002). These attention control strategies have been described by Thompson (1994), and further elaborated by Ochsner and Gross (2005) as a primary form of cognitive emotion control. Most often, attentional deployment involves ignoring certain aspects of the environment to avoid eliciting negative emotions. Inhibition of attention to negative stimuli has intuitive appeal, but at times it may also be necessary to ignore positive stimuli. For instance, when interacting with a grieving peer or distressed friend, it would be appropriate to ignore positive distractors to avoid incompatible feelings and behaviours. Moreover, attention inhibition can be helpful in avoiding distraction and temptation. Consider the importance of ignoring the television while studying for an exam. In addition, attention control can entail attentional allocation to selective aspects of the environment to generate a desired emotion state, such as looking at a friendly face while giving an oral presentation. Although attention deployment has most often been used in reference to external stimuli, internal controlled attention of emotional mental representations has also been described as a crucial component of emotion control (Johnson, 2008).

The fourth category of strategies in Gross' model is reappraisal, or cognitive change, and involves reinterpreting the situation to modulate event-related emotional responses. The meaning one attributes to an event is crucial in predicting the elicited emotional experience, and has been shown to alter physiological, behavioural, and expressive aspects of emotion (Gross, 2002). Finally, the fifth class of regulatory processes is practiced at the stage of the response itself. It does not necessarily alter the individual's immediate experience, but is focused on the expressive component of the response (Gross, 1998; Gross 2002). This tailoring of behavioural expression is often called response modulation (Thompson, 1994), but has also been referred to as suppression. Emotional suppression has been described in the affective literature as causing potential harm to the individual. For instance, John and Gross (2004) reported disrupted mental functioning during times of emotional suppression and Gross (2002) found a suppression-induced increase in cardiovascular activity. Suppression of emotional expression is also accompanied by increases in electrodermal skin conductance, increases in blood pressure, decreases in finger pulse amplitude, and decreased temperature of extremities. Increased activation of the cardiovascular system and other peripheral changes could, with chronic behavioural suppression, increase susceptibility to certain illnesses (Gross, 2002). In fact, Petrie, Booth, and Pennebaker (1998) compared white blood cell levels in individuals who suppressed emotional behaviour and in individuals who displayed expressions freely, and found weakened immune system function in individuals who inhibited communicatory behaviours. It is important to note that these reports are in reference to suppression of expressive behaviours and not of attentional allocation, highlighting the need for a clear distinction between these two processes. Few disadvantages have been observed in the attention-suppression research, although research is needed to explore potential physiological consequences of this and other forms of emotion regulation to understand the implications of each.

Development of Emotion Regulation and Changes across the Lifespan

Some features of emotion regulation are observable in early infancy, with the development of orienting abilities enabling infants to direct attention toward or away from emotionally arousing stimuli (Posner & Rothbart, 2000). For example, Mangelsdorf, Shapiro, and Marzolf (1995) reported gaze aversion to negative stimuli among 6-month-olds, revealing the earliest cognitively generated form of emotional inhibition. Although endogenous orienting originates at this time, it is highly sensitive to distraction, and only becomes fully functional in mid-adolescence (Harman & Rothbart, 1997; Kuhn, 2000). Other coping strategies also appear in early infancy, such as self-stroking, rocking, and hand clasping in response to distress (Mangelsdorf et al., 1995). By the first year of life infants are skilled at eliciting attention from caregivers as a form of emotion regulation, and by the second year of life they are adept in instrumental behaviours such as leaving an unhappy scene (Diener, Mangelsdorf, McHale, & Frosch, 2002). Many other aspects of self-regulation also emerge during the second year of life due to enhanced motor control and cognitive functioning that occur during this time (Calkins, 1994). For instance, it is at this age that children begin to experience self-directed affect such as pride and guilt, and are able to understand emotion in the context of specific situations and behaviours (Barrett, Zahn-Waxler, & Cole, 1993). Subsequent language development is also useful in shaping and enhancing regulatory abilities, particularly those that rely on communicative skills, verbal reappraisal, and self-talk (Bloom, 1993). Between the ages of 2 and 5, rapid regulatory growth occurs to the extent that most children are able to make new friendships and obey class rules (Kopp, 1989). While cognitive and executive functions continue to grow, children's regulatory abilities also mature, owing to the increased availability and efficiency of resources that enable effective execution of multiple strategies (Zelazo & Cunningham, 2007).

Standard developmental markers of emotion regulation can be assessed at a physiological level, by looking at parasympathetic nervous system (PNS) and hypothalamic-pituitary-adrenal (HPA) system function. The key PNS indicator of regulatory maturation is cardiac vagal tone – a measure of heart rate regulation in response to environmental demands, which reflects attention deployment skills and related abilities to monitor distress (Kovacs, Joormann, & Gotlib, 2008; Porges, 1996). Vagal tone maturation occurs between seven weeks of age and the second year of life (Bornstein & Suess, 2000) and abnormal maturation predicts psychological problems linked to poor affect control in preschool (Calkins, Graziano, & Keane, 2007). The human stress response, which is also an indicator of temperament and emotion control, is coordinated through HPA connections. HPA function has been noted to fluctuate across development, rising during adolescence, and stabilizing in adulthood (Gunnar & Vazquez, 2006).

Early behavioural and physiological developments are accompanied by corresponding neural maturation. Longitudinal imaging studies have found that regions of PFC that are highly influential in emotion control show a developmental trajectory beginning in late infancy and continuing through adolescence (Crone, Donohue, Honomichl, Wendelken, & Bunge, 2006). In fact, brain maturation generally progresses from back to front, from systems involved in general motor and sensory processes to temporal and parietal regions used in language and spatial tasks, and finally to the PFC, which mediates higher order cognitive functions (Casey, Tottenham, Liston, & Durston, 2005). During early infancy, the brain is able to support basic somatosensory regulatory responses. In early childhood, maturing brain processes permit additional forms of rudimentary attention control. For instance, neural networks involved in selective visual attention (thalamus-superior parietal lobule-mid frontal gyrus) are highly developed in childhood, whereas frontal-striatal regions, which may be necessary for attention inhibition, are still immature (Booth, Burman, Meyer, Lei, Trommer, Davenport et al., 2003). In relating attention inhibition to emotional stimuli, these medial prefrontal delays may cause reduced inhibition of amygdala activity, explaining early limitations in emotion control (Booth et al., 2003). The more demanding strategies, which draw upon cognitive PFC resources, develop throughout adolescence, becoming more efficient with age. This increased efficiency can be linked to fine-tuning of the neural connections involved in emotion regulation, moving from diffuse to focal activation of brain regions required for goal pursuit (Casey et al., 2005).

Although developmental landmarks are fairly consistent, differences in biological-support systems do exist (Kopp, 1989). On the one hand, children may differ in their abilities to regulate emotion due to aberrant neuroendocrine, cardiovascular, or central nervous system function. Variability in adaptive and maladaptive regulatory functions may also result from differences in behavioural traits, such as attentiveness, adaptability, and sociability. Cognitive sources of regulatory variation may also be present, including awareness of social demands, abilities to form and apply strategies, and internal beliefs and expectations. On the other hand, observable regulatory skills are partially attributable to environmental influences, such as caregiver styles and training/experience (Calkins, 1994). Thus, the individual's capacity to regulate successfully is a congregate of both organismal qualities and acquired learning. By studying the underlying mechanisms that give rise to differences in children's regulatory skills and understanding the course of acquiring such regulatory styles, maladaptive regulation and its causes can be identified. Furthermore, appropriate steps can be taken to correct dysfunctional regulation and to promote adaptive regulation. For this reason, developmental studies and clinical emotion regulation research are intimately connected, with each influencing the other.

Childhood-affective studies are of obvious relevance not only for their ability to identify early adaptive and maladaptive behaviours, but also for revealing the development of adult pathologies and plausible treatments for these affective problems. As a result, developmental studies of emotion regulation have been conducted primarily with child and adolescent participants. Nonetheless, some scientific effort has been directed to assess changes in emotion regulation during healthy aging. A positivity effect has been described by Charles, Mather, and Carstensen (2003) in which older adults generally report greater well-being than young and middle-aged individuals. Until recently it remained unclear whether this effect was due to an increase in processing of positive information or a decrease in processing of negative material (Kisley, Wood, & Burrows, 2007). Through event related potential (ERP) analyses, Kisley et al. (2007) demonstrated that the late positive potential (LPP) waveform response to positive stimuli was stable from early to late adulthood, but that negative induced LPP waveforms were significantly reduced in older adults. In the past, LPP waveform amplitudes have been shown to reflect involuntary responses to emotionally salient stimuli. More recently, deliberate regulatory manipulations have been found to modulate LPP amplitudes. Thus, it is unknown whether the observed decrease in responsiveness to negative stimuli is due to bottom-up processes, top-down processes, or a combination of both. Some researchers have favoured a top-down explanation, suggesting that motivational factors prompt older individuals to inhibit negative material and attend to positive emotional content (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Williams, Brown, Palmer, Liddell, Kemp, Olivieri et al., 2006). Alternatively, older adults may show reduced efficiency at orienting or attending to negative stimuli.

Emotion Regulation – Adult Research

Research has shown that all aspects of emotion are subject to deliberate modification. As mentioned, initial identification of emotional stimuli is rapid, yet subsequent emotional reactions can be modified by top-down strategic processes. Furthermore, the initial appraisal of stimulus valence precedes the generation of affective states and behavioural responses (Phillips, Drevets, Rauch, & Lane, 2003). Therefore, if regulatory strategies are implemented immediately after encountering an emotional situation, emotional responses can be altered in their early stages or prevented altogether.

Functional Neuroanatomy

A number of studies have examined the neural correlates of various forms of emotion regulation. For example, Beauregard, Levesque, and Bourgouin (2001) observed differences in neural activity in participants who were requested to respond naturally to a sexually arousing film and those who were asked to inhibit arousal to the same film. To fulfill the inhibition instructions, participants were asked to garner psychological distance from the arousing stimuli by becoming detached observers. The authors found significant differences in activation, with the natural arousal condition showing increased activity in the limbic and paralimbic structures and the inhibition group demonstrating higher overall levels of activity in the right superior frontal gyrus and right anterior cingulate gyrus. These functional magnetic resonance imaging (fMRI) data were supported by corresponding subjective measures in that scenes viewed in the absence of a control strategy increased subjective arousal, whereas those viewed under suppression conditions induced weaker arousal. Ochsner et al. (2002) also investigated the neural correlates of emotion control, focusing on the cognitive strategy of reappraisal. Participants were presented with scenes of highly negative scenarios, and were requested to either (a) naturally experience the evoked emotions or (b) attribute unemotional meanings to the presented scenes. Functional magnetic resonance imaging showed increased activation of the lateral and medial prefrontal regions (involved in self-control) and decreased activation of the amygdala and medial orbitofrontal cortex (associated with emotion processing) in the unemotional condition. Along with altering neurophysiological responses, reappraisal reduced negative affect experienced by participants. Together these results support the view that emotion regulation circuitry consists of regions within the PFC and subcortical limbic system. These findings also support the hypothesis that activity in emotion-processing centers can be modulated by top-down control processes.

Whereas different strategies surely give rise to slight variations in circuit activity, all forms of affective self-control share some general features that rely on similar functional anatomy. For instance, strategy selection and implementation is essential regardless of the specific regulatory approach, and has been suggested to involve lateral and medial frontal cortices (Ochsner et al., 2002). The dorsomedial PFC reprocesses affective information and relays this material to lateral PFC areas implicated in managing emotions in the context of other goals (Zelazo & Cunningham, 2007). The lateral PFC is involved in generating self-talk during certain coping strategies through its bidirectional connections with Broca's region (Ochsner et al., 2002). The cingulate cortex has received notable attention both as a monitoring device that tracks competition between top-down regulation and bottom-up affective influences and as a key relay to the lateral PFC. Other cortical regions, such as the right anterior temporal region and the medial PFC contribute to affect regulation through their roles in emotional memory retrieval. A unique function has been ascribed to the ventromedial region on the basis of localized lesion effects, which include deficits in emotional experience and difficulties in the use of emotion to guide decision making (Corbetta, Miezin, Dobmeyer, Shulman, & Petersen, 1990). Ventral-lateral PFC designations can thus be established in which affect-based comparative processes rely on ventral PFC function and higher order cognitive processes draw upon more lateral regions (Le Doux, 1996; McClure, Botvinick, Yeung, Greene, & Cohen, 2007).

Along with regional specializations that have been linked to emotion regulation, more general hemispheric asymmetries also exist. For instance, the right PFC seems to have a greater involvement in emotion-based executive function than the left. This may be due to increased somatic processing in the right hemisphere, which could aid in understanding emotion states through bodily signals (Anderson & Phelps, 2000). The right hemisphere may also demonstrate a negativity bias, thus showing more activation in typical avoidance-type paradigms (Wager, Phan, Liberzon, & Taylor, 2003). Still, laboratory measures that draw upon specific types of emotion regulation (such as reappraisal) may preferentially activate the left PFC due to the linguistic basis of these tasks (Corina, Vaid, & Bellugi, 1992).

The described neural basis for emotion regulation resembles that of other inhibitory functions in many respects. Support for an integrative self-control system comes from the large overlap in the circuitry responsible for emotion regulation (Damasio, 1998), autonomic regulation (Benarroch, 1997), and attentional regulation (Devinsky, Morrell, & Vogt, 1995). Duncan and Owen (2000) reported that diverse higher order cognitive demands consistently draw upon similar regions of frontal cortex, including the lateral PFC and the anterior cingulate. Thus, a similar neural unit seems to underlie a variety of goal-directed tasks.

Though many similarities in underlying functional anatomy exist among different self-regulatory processes, certain distinctions can also be made regarding emotion-control mechanisms. Orbitofrontal and medial prefrontal activity has been specifically linked to inhibition of affect, especially for appetitive and reward-associated responses, whereas the lateral PFC has been shown to encode higher order regulatory goals (Roberts & Wallis, 2000). Dias, Robbins, and Roberts (1997) also advocated for dissociable forms of inhibitory control and corresponding prefrontal localizations, proposing a role for orbital regions in affective flexibility and lateral regions in selective attention. In summary, emotion control taxes general goal-directed, self-control functions of the PFC, but also draws uniquely upon affective processing and analysis to achieve desired emotional end points.

Experiential Reports

Studies examining experiential changes in emotion have found that affective ratings and descriptions are related to the particular control strategy of choice. Gross and John (2003) administered emotion regulation questionnaires to participants to assess affective coping styles (suppression vs. reappraisal). Suppression was used to refer to behavioural suppression of emotion, whether positive or negative (rather than attentional suppression to emotional stimuli or thoughts). They found that suppression was associated with reduced positive affect and slight increases in negativity. Reappraisal, on the other hand, was related to strengthened feelings of pleasure and happiness and decreases in negative emotional experience. As noted, Ochsner et al. (2002) also focused on the strategy of reappraisal, asking participants to re-evaluate negative scenes in non-emotional terms. Relative to controls, participants who reappraised described less negative affect after scene viewing. Further support for a contingency between deliberate regulation and corresponding subjective experience comes from Beauregard et al. (2001). As described earlier, Beauregard et al. found that both brain activity and participant reports varied as a function of strategic self control.

Other experimenters have addressed the experiential effects of attentional strategies, showing that attending to or ignoring emotional aspects of pictorial stimuli can produce significant differences in subjective levels of emotionality (Lane, Fink, Chua, & Dolan, 1997). Derryberry and Rothbart (1988) also investigated affect-attention control relations and found an inverse correlation between self-reported negative affect and self-reported attention-shifting ability. Although results from these studies are consistent with neurophysiological findings, subjective reports have the inherent issue of participant bias. It is possible that those who were instructed to regulate feelings were hesitant to report arousal due to perceived experimenter expectations. Thus such methods may not provide reliable assessments of regulatory interventions.

Observational Reports

Behavioural correlates of emotion regulation and dysregulation have been most commonly discussed in the clinical literature. As mentioned previously, regulatory failure has been associated with a number of clinical conditions, ranging from mood disorders to psychiatric illness. In fact, virtually all Axis 1 disorders of the Diagnostic and Statistical Manual of Mental Disorders (DSM) include some form of affective symptoms, as do the majority of the Axis 2 personality disorders (Gross & Levenson, 1997; Thoits, 1985). Because DSM classification relies heavily on behaviourally observable symptoms, many of the typical clinical problems in affect control are described as visible manifestations of maladjusted behaviour.

Developmental studies have also touched upon this connection between emotion regulation and behavioural tendencies, or as conventionally termed in the developmental literature – temperament. Research in this field suggests that balanced temperament patterns (i.e., not overly expressive or inhibitive) are superior, facilitating social adjustment and predicting increased immunity to psychopathology. Children who tend to inhibit emotional expression may be at increased risk for internalizing conditions, such as anxiety, later in life. In contrast, children who are overly expressive in their affective displays may be vulnerable to externalizing conditions, including impulsivity-related disorders (Rothbart, 2007). Recently, connections between temperament control and attentional abilities have suggested that children who perform superiorly in attentional control are adept regulators of behaviour. For example, children who score at the highest level on executive attention tests are consistently judged by parents and teachers to be skilled in behaviour control (Rothbart, 2007). This may be indicative of a general, inclusive construct of emotional intelligence in which control in one stage of emotion generation predicts regulatory success in other stages. Alternatively, it may be that attention-control skills ensure emotional stability early in the emotion generative process, leading to suitable behavioural displays.

Overcoming Emotional Biases – Attention Control

Selective attention is a well recognized form of emotion regulation (Gross, 2002). Selective attention, or the ability to deliberately ignore certain aspects of the environment while attending to others, is a major aspect of self-regulation. Attending to important and meaningful aspects of the environment and ignoring irrelevant components is necessary for cohesive thought, optimal cognitive functioning, and protection against sensory overload (Rothbart, 2007). According to affective researchers, attention control is also an essential tool in mood maintenance and repair (Gross, 2002). Moreover, this strategy lends itself well to objective, response-based assessments, permitting a valid evaluation of its effectiveness.

Some evidence for the practicality of attention deployment in controlling affect comes from general attentional research. Adult performance on non-affective attention orienting and attention switching tasks has been linked to emotional positivity/stability (Compton, 2000). Still, the majority of these studies have not addressed attention to emotional elements specifically, but have focused on performance on general attention control tasks. Although attention control is related to emotion regulation capacity, emotional versions of selective-attention tasks should prove to be even stronger predictors. Attention control may be particularly challenging when the distracting information is of affective value, given that emotional information may more readily attract attentional resources. The promises and challenges of emotion-laden attention control have been assessed from a variety of neural and behavioural standpoints.

Neural Studies

Neural studies have found that emotion processing is highly responsive to attentional manipulations. For instance, Pessoa, McKenna, Gutierrez, and Ungerleider (2002) used fMRI to observe brain activation related to processing of both emotional and neutral faces, under full attention and limited attention conditions. Results illustrated differential activation depending on whether faces were neutral or emotional and whether attention was available or limited, with increased limbic system activity seen only on fully attended emotional trials and not on limited attention or neutral trials. Another successful attention control attempt was demonstrated in an ERP study of spatial attention to expressive faces, neutral faces, and neutral non-face stimuli (Holmes, Vuilleumier, & Eimer, 2003). Increased frontal activity was observed in response to fearful faces approximately 100 ms after stimulus onset when attention was allocated to the stimulus. When attention was spatially withheld from stimuli, the frontal activation evoked by emotional faces was not observed (Holmes et al., 2003).

Similarly, Lane et al. (1997) had participants view emotional picture sets, either attending to emotional content or ignoring emotional content by focusing on neutral/spatial aspects of the photos. Participants who attended to the emotional content showed increased neural activity in the rostral anterior cingulate. Those who attended to spatial elements displayed greater activation in the parieto-occipital cortex. Along with divergences in brain activity, significant differences in subjective emotionality were seen as a function of attentional allocation. This study served a dual purpose of supporting attention deployment as a valid means of altering emotion processing, as well as elucidating the possible neural underpinnings of emotional experience and inhibition.

A follow-up study by Lane, Chua, and Dolan (1999) also found altered brain activity following attentional manipulations. In this study, participants viewed emotional picture sets while taking part in a distraction task, which varied in attentional demands across groups. Three valences of pictures were viewed (positive, neutral, negative), with two arousal ratings (low vs. high), and two attention conditions (low vs. high distraction). Positron emission tomography and ^{15}O-water were used to observe brain activity associated with the various combinations of variables. Regions of the extrastriate visual cortex and anterior temporal cortex were activated differentially depending on all three factors (valence, arousal, and attention). This example illustrates that both emotion and attention can modulate processing of visual stimuli.

Response-based Tasks

Rapid Serial Visual Presentation.

As seen in traditional RSVP paradigms, emotion processing seems to induce attentional blinks, transiently impairing identification of subsequent visual stimuli. Most et al. (2005) used a standard RSVP task with negative distractors, and described the usual deficit in target performance. Interestingly, participants were able to minimize performance deficits through strategic manipulations that reduced attention to distractors. The ability to avoid distraction was highly related to personality type, with participants low in harm-avoidance showing success in ignoring emotional stimuli, whereas those high in harm-avoidance tendencies were much less able to do so (Most et al., 2005). Thus for some individuals, attention suppression appears to be a practical and effective means of preventing emotional distraction. A follow-up study by Most et al. (2007) determined whether attention could be withheld from erotic distractors to preserve normal levels of target accuracy. Most et al. found that participants were unable to suppress attention to erotic distractors, as compared to the non-erotic distractors, even when given the opportunity to gain monetary incentives for correct target responses. The discrepancies between erotic distractor (2007) and negative distractor (2005) studies suggest that positive arousing stimuli may be less susceptible to attentional control than unpleasant items or events, perhaps due to a natural preference of healthy individuals to attend to positive information and avoid negativity.

Modified Stroop Tasks.

Tasks other than RSVP experiments have also been employed to examine inhibitory control over emotional stimulation. A study by Pratto and John (1991) used a Stroop-type task in which participants had to ignore the semantic meaning of emotion-evoking words and name the colours in which they were displayed. Emotional versions of this task produce prolonged latencies to complete, with aversive words eliciting greater attentional capture and dwell (longer response times) than positive words (see also Fox, Bowles, & Dutton, 2001; Williams, Mathews, & MacLeod, 1996). However, Stroop performance is better on similar tasks in which the colour and the word appear simultaneously, but separately (Fox, Henderson, Marshall, Nichols, & Ghera, 2005; White, 1996). Thus the demands on inhibitory control may be lessened when emotional distractors and target stimuli are spatially segregated.

Stroop tasks also provide insight on the influence of mood on attention inhibition to emotional stimuli. For example, Mogg, Mathews, Bird, and Macgregor-Morris (1990) and Chen (1996) found mood-congruent attentional biases in the form of increased distraction and prolonged colour naming for mood-related words relative to words unrelated to current mood state. These mood-based findings are compatible with those obtained by Bradley et al. (1997) and Mogg et al. (2000) using affective dot probe tasks, Fox et al. (2001) using modified cueing paradigms, and Ohman et al. (2001) and Gilboa-Schechtman et al. (1999) using facial and pictorial visual search tests.

Existing Study Limitations

Emotion regulation research has provided a comprehensive description of various regulatory approaches and their influences on heterogeneous components of emotion. These findings are encouraging, suggesting that people can willingly implement control strategies and that these strategies can in turn modulate various aspects of emotional responding. In terms of attention-based emotion regulatory strategies, neural studies have illustrated that attention control can modify emotional responding (Chawla, Rees, & Friston, 1999;

Corbetta, Kincade, Ollinger, McAvoy, & Shulman, 2000; Holmes et al., 2003; Lane et al., 1997; Lane et al., 1999; Pessoa et al., 2002; Pessoa, Rossi, Japee, Desimone, & Ungerleider, 2009). Subjective reports of affective attention control reflect similar regulatory success (Lane et al., 1997). Still, certain problems arise from conventional methodologies. For instance, experiential and observational measures of emotion regulation often rely on subjective forms of analysis, whether through participant reports or behavioural observation. These techniques may be problematic in terms of accuracy and reliability, given that subjective reports can reflect perceived expectations or personal biases. Issues also exist in using biological methods to assess regulatory effects, as it is difficult to interpret the behavioural significance of these findings. For instance, neuroscientists who study affective processing often take increased PFC activity accompanied by reduced amygdala activation to indicate successful emotion regulation. However, these neural changes could reflect a number of experiential processes other than deliberate emotion suppression, such as guilt over not following instructions. Thus, there is a need to supplement the current body of emotion regulation studies with more objective response-based measures.

As described, attention control lends itself well to objective, response-based assessment and a number of researchers have pursued emotion-based attentional tasks using RSVP, dot probe, cueing, search, and Stroop paradigms. Unfortunately the applicability of these tasks is often restricted (to be discussed below).

Stimulus properties

Along with methodological limitations, other study drawbacks lie in the nature of task stimuli. The majority of attentional research has not been conducted in the context of emotion regulation, taking instead a more general focus. Consequently, such studies have used a limited range of emotional stimuli and do not permit conclusive interpretations to be made regarding the effectiveness of attentional strategies in managing diverse human emotions.

A number of attentional studies, especially those using psychophysiological measures, have used facial stimuli (Bradley et al., 1997; Bradley et al., 2000; Holmes et al., 2003; Mogg et al., 2000; Pessoa et al., 2002). There are certain issues inherent in limiting the stimulus range to emotional faces. Although facial expressions can communicate a range of feelings, they cannot account for the complete spectrum of human emotions and may be less effective at provoking certain emotions than pictorial scenes. Furthermore, facial processing may differ from other forms of affective processing given that the emotional valence of a face is conveyed by simple, invariant features, such as the position of the mouth and eyebrows (Lundqvist, Esteves, & Ohman ,1999). A final concern with using facial expressions as emotional stimuli lies in the observation that facial expressions and affective pictures activate divergent neural networks, though some structural overlap exists (Britton, Taylor, Sudheimer, & Liberzon, 2006). These processing differences might limit the applicability of studies using facial stimuli in addressing questions regarding emotional processes.

A number of response-based attentional studies have employed words as emotional stimuli (Anderson, 2005; Arnell et al., 2007; Bradley et al., 1995; Chen, 1996; Constans et al., 1999; Ellenbogen et al. 2002; Fox et al., 2001; Macleod et al., 1986; Mogg et al., 1990; Murphy, Sahakian, Rubinsztein, Michael, Rogers, Robbins, & Paykel, 1999; Pratto and John, 1991; White, 1996; Williams et al., 1996). The use of such stimuli could also be problematic in that verbal stimuli draw upon higher-level semantic processes, and are therefore incapable of triggering rapid, bottom-up reactions that emotional scenes can evoke (Compton, 2003). Thus, words may serve as indirect symbols of emotion, whereas pictorial scenes may act as more direct affective prompts.

Other studies have used highly arousing stimuli, such as gruesome scenes of violence, threatening stimuli, or graphic eroticism (Fox et al., 2001; Koster et al., 2004; Macleod et al., 1986; Most et al., 2005; Most et al., 2007). Again, these do not permit a realistic evaluation of attentional strategies as a form of emotion regulation considering that stimuli encountered in day to day life are rarely that extreme. Furthermore, when stimulus profiles do not include normative data (Most et al., 2005), it is difficult to establish the degree and nature of valence and arousal.

Some researchers have taken a more encompassing approach, including stimuli of various valence and arousal levels. For instance, Lane et al. (1997; 1999) and Smith et al. (2003) used both negative and positive slides taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1995) – a comprehensive and normative database of emotion-inducing pictures.

Still, these studies were concerned with the neural representations of emotion and selective attention, and were not response-based studies. Thus, response-based assessments of attentional control to well-defined emotional stimuli are still lacking.

Nature of Task

Particular tasks may be better suited for measuring attention to emotional stimuli than others. For example, it is difficult to distinguish between orientation and maintenance biases in the Stroop task, as both functions would lead to longer colour-naming times. Modified dot probe studies (Bradley et al., 1997; Bradley et al., 2000; Koster et al., 2004; Macleod et al., 1986; Mogg et al., 1998; Mogg et al., 2000) hold similar limitations in that it is impossible to distinguish between orienting and disengagement effects when relying solely on conventional reaction time data. An inability to detect distinct attention and response stage effects may also characterize certain tasks. For instance, it is unclear whether emotions interfere with the input/colour recognition or output/colour naming phase of the Stroop task (MacLeod, 1991).

Fixation versus Saccades

Dot probe tasks are further confounded by the fact that stimuli appear within foveal vision. Although foveal vision and spatial attention are not synonymous, there is general agreement that items occurring within 1 degree of fixation cannot be effectively ignored (Fox et al., 2001). Thus, attention may be divided between the two dot probe task cues, masking actual attentional preferences that would appear under different experimental contexts. This is also true for the standard Stroop task in that the to-be-ignored information and task relevant material are elements of a single compound. Items in affective RSVP paradigms appear in the same fixated location (Anderson, 2005; Arnell et al., 2007; Most et al., 2005; Most et al., 2007; Smith et al., 2006), which may also counteract attempts to suppress attention to distractors.

In the real world, visuospatial attention is the primary means of attention control (Johnson, 2008), and thus tasks requiring saccadic eye movements provide a more representative assessment of attention deployment. Attention and eye movements tend to work in synchrony in natural settings, permitting investigation of visual scenes and selection of items for further processing (Kowler, 1995). As a result, tasks that tap into saccadic selection and inhibition, such as segregated Stroop and exogenous cueing paradigms, are of primary interest to researchers interested in external attention deployment as a means of emotion regulation. The importance of enabling eye movements by incorporating adequate stimulus separation is highlighted in comparisons between standard affective Stroop tasks and separated stimuli versions. As mentioned previously, emotional interference is reduced, or eliminated altogether, when the colour and word are presented as two simultaneous but separate items (White, 1996).

Emotional Effects on Learning and Judgement

The use of cognitive skills to modulate emotion is the foundation of emotion regulation, and has been described in previous sections. However, just as cognition can shape emotional experience, emotion has been shown to strongly influence cognitive functioning. In addition to the described affect-attention and affect-memory interactions, emotional influences on judgement and learning may exist. The power of emotions to influence analytical and decision-making skills may contribute to valence effects reported in the literature. In fact, emotional effects on reasoning could potentially confound interpretations made from response-based attentional and memory tasks.

A common view is that emotion and cognition are in direct opposition of one another. Such a perspective predicts competition between affective and cognitive processing, suggesting an overall impairing effect of emotion on cognition (Metcalfe & Mischel, 1999). Others have proposed a more flexible relation between emotion and cognition, recognizing that the influence of emotion on cognitive functioning is situation specific. Gray (2004) has discussed a possible adaptive function for this flexible modulation of cognitive skills, proposing that emotion states may prioritize certain abilities over others, preparing the individual for optimal, situation-congruent responses.

Indeed, support can be found for both impairment and flexible modulation of cognitive abilities as a result of exposure to emotional stimuli. On the one hand, spatial assessment of surface features in pictorial scenes is faster for neutral pictorial stimuli than for negative scenes (Simpson et al., 2000). Hartikainen, Ogawa, and Knight (2000) observed similar affective influences on spatial discrimination skills. Hartikainen et al. presented participants with trials consisting of an emotional cue in either the right or left visual field, followed by a brief interstimulus interval (ISI) and spatial target. Target discrimination was found to be hindered by emotional pictorial distractors, with greater impairments occurring for targets that were preceded by negative cues than by positive cues. Thus categorization decisions appear to be influenced by the emotional nature of the preceding material. Other studies have included positive stimuli in their exploration of affective influences on cognition. One adult study of interest is that of Isen, Niedenthal, and Cantor (1992) in which positive mood induction was related to altered categorization abilities and vague analytical tendencies. Bless, Mackie, and Schwartz (1992) found that participants in positive emotion conditions were more susceptible to manipulation, illustrating less critical thinking and poorer judgment. These results have been attributed to reduced resource availability caused by affect-induced resurgence of positive memories (Mackie & Worth, 1989). This explanation could extend to cover negative judgement effects, given that negative affect should also prime individuals for valence-congruent thoughts and memories. On the other hand, emotion has also been linked to improvements in certain cognitive functions. For instance, Qu and Zelazo (2007) found that positive stimuli have a facilitative effect on children's cognitive flexibility, and Dreisbach and Goschke (2004) described similar effects of positive emotions on adult cognition.

Current Study

Objectives

The current study strived to assess attention control to emotional stimuli as a form of emotion regulation, while minimizing the aforementioned limitations of existing studies. A response-based task – the emotional orienting task - was devised to limit the potential limitations present in other forms of assessment (e.g. neural, observational, subjective methods). A pictorial cue (neutral, negative, positive) drawn from the IAPS appeared on the right or left of the screen, followed by a target word. Participants were given instructions to either avoid looking at the pictorial cue (suppress) or to deliberately look at the pictorial cue when it appeared (attend). Along with the emotional orienting task, a recognition test for pictures (cues) and targets (words) was conducted as an additional measure of inhibitory control to strengthen the findings obtained in the study's primary task. A mood check was also administered following the emotional orienting task, with the expectation that cue-induced mood would be reported by participants who attended to pictorial cues, but not by those who successfully inhibited attending to cues. Furthermore, the selected stimuli consisted of pictures from a well-accepted and normed affective stimulus database (IAPS; Lang et al., 1995), providing a representative range of positive and negative pictures of moderate intensities. Additionally, as discussed shortly, the current task's timing and high target predictability enabled discrimination between orienting and disengagement effects. Moreover, because eye movements were not restrained and both overt and covert orienting was permitted, the task modeled natural visuospatial attention control processes. Finally, the task design permitted a preliminary assessment of emotional valence effects on categorical decision-making, independent of attentional processes.

Orienting Responses and Cueing Effects

To understand the attentional processes at play in the emotional orienting task, a general understanding of orienting responses and cueing effects is required. According to Posner (1980), orienting is the alignment of attention with a source of sensory input. Orienting responses can be driven automatically by external stimulation, that is to say exogenously, or can occur as a result of internal, goal-directed processes, in which case orienting is said to be endogenous. These two types of orienting differ in terms of orienting speed, automaticity, and neural mechanisms. Exogenous orienting is more rapid, is difficult to inhibit, and implicates ventral attention systems in the brain. Endogenous orienting, on the other hand, is slower, deliberate, and draws upon dorsal neural systems (Corbetta & Shulman, 2002; Danziger & Kingstone, 1999; Jonides, 1981; Posner & Cohen, 1984). Orienting responses can also be categorized based on the involvement or lack of eye movements, which are termed overt and covert orienting, respectively (Posner, 1980). As reported by Posner and Cohen (1984), both overt and covert visual orienting can be controlled exogenously or endogenously.

The most commonly reported cueing effects for non-informative, peripheral cues involve biphasic patterns in which early responding at cued locations is facilitated and later responding at cued locations is inhibited. This delayed responding at cued locations with longer stimulus onset asynchronies (SOAs) is referred to as inhibition of return (IOR) and is thought to reflect a bias against returning attention to previously attended locations (Posner & Cohen, 1984) or a bias against responding to targets at previously cued or "old" locations (Klein & Taylor, 1994; Danziger, Kingstone, & Ward, 2001; Chica, Lupianez, & Bartolomeo, 2006).

Different cueing effects occur when the cue is predictive of the upcoming target (i.e. when targets are expected in either the cued location or in some location with a specific spatial relation to the cue). By measuring performance differences for targets at expected versus unexpected and cued versus non-cued locations, it is possible to assess attentional orienting effects on target detection, identification, and discrimination. Posner, Cohen, and Rafal (1982) placed exogenous and endogenous attention in direct competition by employing cues that predicted opposite side targets 80% of time. Target detection was faster at cued, unexpected locations at an SOA of 200 ms, whereas target detection was faster at uncued, expected locations at longer SOAs. This was taken to indicate that exogenous attention prevailed initially and endogenous processes were engaged later to orient attention to the appropriate location. Alternatively, IOR may have developed at the cued location at longer SOAs (Danziger & Kingstone, 1999). An experiment by Danziger and Kingstone (1999) tested these hypotheses by examining cueing effects when targets were predicted to occur in the cued location (cued condition) or at a location clockwise to the cue (clockwise condition). When targets were expected in the cued location, and thus exogenous and endogenous orienting occurred to that location, detection was faster at both short (50 ms) and long (950ms) SOAs – a typical finding for predictive cues. When targets were predicted to appear at a location clockwise to the cue, response times were fastest to predicted, uncued locations, moderate to non-predicted, uncued locations, and slowest to the cued location at both SOAs. The authors suggested that discrepancies between the two conditions (cued vs.

clockwise) arose due to masking of IOR by endogenous attentional orienting in the cued condition and unmasking of IOR in the ``clockwise`` condition. To strengthen this interpretation, a follow-up experiment was conducted in which participants had to identify targets, rather than simply report their presence. As will be discussed, IOR is minimal or non-apparent in these types of more difficult tasks. Participants were quicker to identify targets in the cued (non-predicted) location than the predicted, clockwise location at all SOAs. This influence of task mode (detection vs. identification) on cueing effects indicates that the original inhibition to cued targets in the ``clockwise`` condition of the simple detection task reflects an unmasking of IOR rather than competition between endogenous and exogenous orienting (since endogenous and exogenous orienting occur regardless of task difficulty).

Thus, cueing effects vary with task difficulty. In particular, cueing effects (including IOR) are strongest for simple target detection tasks, and are minimized or unobservable for more difficult discrimination tasks (Danziger & Kingstone, 1999; Klein & Taylor, 1994; Posner, 1980). Posner has suggested that this effect may occur because attention is redirected from visual input to internal representations that are needed to complete the task. Others have found that IOR does occur in discrimination tasks, but is only apparent at long SOAs. For instance, Chica, Lupianez, and Bartolomeo (2006) reported an IOR effect at cued, expected locations at an SOA of 700 ms in discrimination tasks and 400 ms in detection tasks. In order to detect target onset, cues and targets must be dissociated as distinct perceptual events. Therefore IOR in detection tasks may reflect disrupted detection of items at cued locations due to cue-target integration and a corresponding advantage for detecting targets at uncued locations. On the other hand, presenting targets at the cued location in discrimination tasks may help select spatial positions for feature processing, which could in turn speed target analysis. This may explain why IOR at cued locations appears earlier and more consistently in detection tasks than discrimination tasks (Chica, Lupianez, & Bartolomeo, 2006).

Current Study Description

In the current study, participants were administered three tasks; the emotional orienting task, a mood induction check, and a recognition test. The orienting task was the present study's primary focus and the other tasks were conducted to verify results obtained in the orienting task. The present study presented participants with a cue to either the right or left of a central fixation cross, followed by a target occurring in either the same or opposite position as the cue, depending on the participant's assigned condition. Cues used in the present study were detailed pictorial stimuli drawn from the IAPS, which predicted target locations 80% of the time. By using imperfect cue-target contingencies, a purer measure of attentional orienting effects could be provided. In addition to target predictability, group instructions had the potential to influence orienting responses to targets given that spatial attention was allocated differentially in relation to upcoming targets depending on whether cues were attended or ignored.

Participants were assigned to one of two groups: attend or suppress. The suppress group was requested to avoid looking at the picture (cue) when it was presented, but to use the position of the cue to predict the upcoming target location. In other words, suppress group participants were required to inhibit exogenously driven overt responses (saccades) to the cue, but to detect the cue through covert attentional processes in order to determine subsequent target positions. Peripheral cue processing seems to occur automatically, given that such cues can be processed accurately and rapidly even under substantial cognitive load and are resistant to suppression (i.e., they capture attention to a certain degree even when they are to be ignored; Jonides, 1981). Nonetheless, evidence suggests that participants can exert some control over attending to peripheral cues (Jonides, 1980). Thus, whereas there is an automatic component to peripheral cue processing, there is also a non-automatic component. More importantly, this voluntary component may change with cue features, such as emotional salience. Participants in the attend group were instructed to purposefully look at the content of the cue, and thus endogenous and exogenous attentional processes worked together in this group. Both groups were required to classify the target word as quickly and accurately as possible. The inclusion of these two groups permitted a stronger assessment of participants' ability to suppress because there was a full attention baseline group to which the suppress group could be compared.

Attend and suppress groups were further divided into two conditions: opposite side (OS) and same side (SS). In the OS condition, cues and targets appeared on opposite sides of the screen 80% of the time (predicted targets), whereas in the SS condition cues and targets were presented on the same side of the screen on 80% of trials (predicted targets). Therefore, there were four study groups: attend OS, attend SS, suppress OS, and suppress SS.

The suppress OS group was required to suppress saccades to cues and divert attention to targets presented primarily on the opposite side of the screen. In terms of attentional processes, the suppress OS group had to inhibit exogenously generated overt responses to cues, but covertly detect cues in order to orient endogenously to the predicted opposite side target locations. Successful suppression of saccades (overt responses) to cues was expected to promote target identification of predicted opposite side targets and limit performance for non-predicted same side targets. In other words, a large difference in target accuracy between predicted and non-predicted targets was anticipated (**Table 1**).

The attend SS group instructions required saccades to cues presented primarily on the same side of the screen as upcoming targets (Johnson, 1995). Because attend instructions involved saccading to cues, both endogenous and exogenous attentional processes worked together. The attend SS group was then required to sustain attention at the cued location to process the predicted same side target. Because exogenous and endogenous attention were simultaneously directed to the cued location, performance was expected to be better for predicted (cued) targets than non-predicted (uncued) targets in the attend SS group. Therefore, like the suppress OS group, a large contrast between predicted and non-predicted target accuracy was expected to appear for the attend SS group (**Table 1**).

The suppress SS group differed in that participants were instructed to avoid saccades to the cue (i.e., suppress exogenously-driven overt orienting) even though targets were presented primarily in the cued location. Thus suppress instructions had the potential to disrupt same side target detection and reduce accuracy differences between predicted and non-predicted trial targets (**Table 1**).

In the attend OS group, a saccade to the cue was required despite the fact that targets appeared on the opposite side of the screen. Stated otherwise, exogenous and endogenous processes worked together to direct attention to the cued location. Rapid disengagement and attention shifting from the cued location to the opposite side of the screen was then required to process predicted targets. These attend OS group demands were expected to hinder opposite side target identification and limit variability between predicted and non-predicted target accuracy (**Table 1**).

IOR was not considered in making study predictions because, as noted, discrimination tasks tend not to produce observable IOR effects or reveal IOR only at long SOAs (700 ms). Because our study employed an SOA of 440 ms (i.e., cue duration was 260 ms and ISI was 180 ms) and required complex decisions about target words, IOR was likely indiscernible. However, as discussed, exogenous and endogenous control of overt and covert orienting responses varied by group and was expected to contribute to performance disparities across groups. To recapitulate, it was anticipated that participants in the attend group would perform well on same side trials, but would struggle on opposite side trials. That is, saccades made to the cue were expected to impede opposite side target identification, but to promote same side target identification (Johnson, 1995). In contrast, participants in the suppress group were predicted to do well on opposite side trials and to have difficulty on same side trials.

Whereas group predictions were centered on past research and attentional orienting principles, potential valence effects could only be described by considering the literature on emotional biases. Based on the evidence for preferential attentional allocation to emotionally salient items (see Arnell et al., 2007; Fox et al., 2001; Macleod et al., 1986; Most et al., 2005; Most et al., 2007; Ohman et al., 2001), it was expected that inhibiting attention to emotional cues would be more difficult than to neutral cues, leading to impaired predicted target performance on emotional trials in the suppress OS group. This, in turn, would manifest as a smaller difference between predicted and non-predicted target accuracy on emotional trials relative to neutral trials (**Table 2**). An inability to ignore emotional cues was anticipated to have the opposite effect on target discrimination in the suppress SS group, potentially manifesting as more rapid/ accurate identification of emotionally cued, same side targets than neutrally cued, same side targets. In terms of predicted versus non-predicted trial comparisons, improved performance on predicted SS trials would produce greater accuracy difference scores (predicted-non-predicted trial accuracy; **Table 2**).

The attend group was also expected to show differential performance as a function of pictorial valence. Again, emotional stimuli have been found to capture and hold attention more strongly than neutral stimuli, thus the attend OS group's performance was expected to suffer on predicted emotional trials relative to predicted neutral trials (**Table 2**). Because the attend SS group's attention was pre-directed to the appropriate target location for the majority of trials, predictions about valence effects could not be based on reported attentional biases. Thus, any differences in the attend SS group's predicted target performance were hypothesized to appear due to emotional influences on categorization abilities (**Table 2**). As described, emotion processing has been found to have a variety of effects (some facilitative, some impairing) on a vast array of cognitive skills, thus word categorization for this group was projected to vary according to the valence of the preceding cue only if valence effects extended beyond attentional abilities to other cognitive processing skills.

The current study's results may provide important information regarding the attentional mechanisms involved in affect regulation. For instance, if valence effects are seen in suppress group analyses, the distracting nature of emotional stimuli described in other affective studies will be further supported. Furthermore, cross-valence comparisons may be helpful in resolving the question of whether attentional effects occur across a range of valence qualities. Because this study will contain a more representative sample of stimuli than standard emotion-attention paradigms, broader conclusions regarding emotion-attention interactions can be made.

By assessing memory for cues and targets from the emotional orienting task, participants' ability to follow attend/suppress instructions could be verified (**Table 3**). Though the relation between attention and memory may not be perfect, there is evidence for a strong connection between the two. Arnell et al. (2007) assessed target identification performance following a variety of emotionally salient words in a rapid stream of visual stimuli. Subsequent memory testing revealed that memory was greatest for arousing, attention-grabbing distractors that had impairing effects on target performance. Thus, cue and target memory performance should be suggestive of whether cues were attended to or ignored and whether targets were identified or missed. Lastly, by comparing target categorization in the emotional orienting task with target recognition in the word recognition task, it was possible to determine if affective stimuli disrupted only target categorization or target processing/ encoding more generally.

Cue-induced mood reports collected in the post-emotional orienting task mood check were also indicative of whether pictures were attended or not. Cue valence was expected to affect mood if cues were attended (**Table 4**).

Together, the emotional orienting and recognition task results permitted an examination of the relative challenges in inhibiting attention to different qualities of emotional information. In turn, the feasibility of attention control as a form of emotion regulation could be assessed.

CHAPTER 2: METHODS

Participants

Participants were Dalhousie University undergraduate psychology students, who gave informed consent and were awarded credit toward an eligible psychology course for their participation. Eighty-two women and fourteen men took part in the study, ranging between the ages of 18 and 48. All participants were void of mood and psychiatric disorders and had normal or corrected-to-normal vision. Participants were randomly assigned to groups. Data from five participants were excluded due to technical complications (i.e., computer freezing, n = 3) or misunderstanding of instructions (i.e., asked to categorize words, but instead responded to pictures, n = 2).

Apparatus

Tasks were programmed and run using Super Lab Pro 2.0.4, and were presented to participants on a general PC desktop computer equipped with a 17-inch black Samsung Magic Touch Sync Master 753 DF monitor with a resolution of 1024 X 768 pixels and a refresh rate of 85 Hz. Participants sat approximately 40 cm from the computer screen and were centered to face the monitor. Task stimuli were presented to participants at a visual angle of approximately 10 degrees from fixation.

Stimuli

The pictorial cues were drawn from the IAPS developed by Lang, Bradley, and Cuthbert (1995). Normative data for the valence, arousal, and dominance of each picture were collected by Lang et al. and are accessible to researchers through the IAP system. Valence ratings range from 1 to 9, with 1 representing unpleasant stimuli, and 9 representing pleasant stimuli. The arousal ratings are also based on a 9-point scale, with a rating of 1 indicating low arousal and 9 indicating high arousal levels. The dominance ratings correspond to figure size. A picture rating of 1 indicates low dominance (small subject size), whereas a picture with a rating of 9 is high in dominance (large subject size). Although valence and arousal ratings are commonly reported in the affective literature, the dominance scale is rarely used by researchers in their stimuli selection, nor was it considered in the current study. Because arousal ratings tend to increase within the low range of the valence scale (Greenwald, Cook, & Lang, 1989), arousal ratings were not balanced across valences, though they were recorded.

The average valence of the eighty pictures that were employed in the emotional orienting task as negative cues was 2.95 (where values in proximity of 4.5 are considered neutral), and the negative block mean arousal rating was 5.66 (where 4.5 is neutral). An example of a typical negative picture that closely matches these mean values depicts an armed terrorist. The negative picture with the lowest valence rating in the current study was a photo of a starving child, which was attributed a mean valence score of 1.67. Corresponding values and examples for the positive and neutral study pictures are presented in Table 5. Cue valences throughout the three blocks of testing ranged from 1.67 (most unpleasant) to 8.32 (most pleasant). Although the IAPS stimuli have been repeatedly shown to evoke emotional reactions in individuals, it is noteworthy that the pictorial content is no more intense or graphic than material commonly encountered in media sources such as newspapers and television programs. Pictorial cues depicting indoor and outdoor scenes were paired evenly with indoor and outdoor targets to control for potential semantic influences. Moreover, pictures selected for the recognition task were balanced for valence and arousal ratings, so that new and old picture variables were similar (see Table 6).

Target words were chosen from the University of Western Australia, Department of Psychology Psycholinguistics Database. All words referred semantically to either indoor or outdoor items. Word length and Kucera-Francis written frequency were recorded for each of the selected words. All word lists that were used in the experiment were controlled for word frequency and length to ensure that performance differences were not attributable to differences in the target words. As an extra precaution, three lists were formed, which were balanced across groups and block valences. All mean word lengths and written frequencies for indoor and outdoor words for each list are presented in Table 7. Word length and frequency were also controlled in the recognition portion of the study so that new and old word traits were statistically equivalent (see Table 8).

Study Design

Emotional Orienting Task

A fixation cross was presented in the center of the screen, followed by a pictorial cue to either the left or right of the fixation point, which in turn was followed by a target word (**Figure 1**). The initial fixation cross was displayed for 5 s, at which point a pictorial cue was shown for a duration of 260 ms. This cue duration was suitable to permit a goal-directed saccade to the picture (100 ms;

Fischer & Ramsperger, 1984) for participants who were instructed to do so, and to allow processing of pictorial features (150 - 250 ms; Luck & Hillyard, 1994), while enabling emotional valence differentiation (100 ms; Holmes et al., 2003, Smith et al., 2003). Upon cue offset, a brief ISI (180 ms) was provided prior to target onset. The target word was then presented for a period of 180 ms, at which time a response was required, representing the final trial event. Word presentations of 180 ms were appropriate given that ERP peaks associated with semantic categorization of word targets have been shown to begin 130 ms following target onset (Boddy & Weinberg, 1981). Once a response was made, the task advanced to the next trial which repeated this sequence of cue, ISI, target, and response.

Participants were randomly assigned to two groups: attend and suppress, which were further divided into two conditions, same side (SS) and opposite side (OS). In the suppress group, participants were asked to focus on the fixation cross and to avoid looking at the picture (cue) when it was presented. They were, however, required to detect the location of the cue in order to predict the location of the upcoming target word. Thus, if instructions were followed, suppress group participants would have covertly (endogenous and exogenous) attended to the cue to predict upcoming target locations, but endogenously inhibited overt attention to the cue. Participants in the attend condition were also instructed to fixate on the cross in the center of the screen. In contrast to the suppress group, they were requested to purposefully look at the picture (cue) when it was presented to either side of the cross. Consequently, both covert and overt attention should have been endogenously (as well as exogenously) drawn to the cue in the attend group. Within each group, half of the participants were randomly assigned to the SS condition, in which the target appeared in the same location as the cue on 80% of trials, and half were assigned to the OS condition, in which targets occurred on the opposite side of the fixation cross on 80% of trials. Thus in all there were four groups: attend OS, attend SS, suppress OS, and suppress SS. All groups were required to categorize the target word as indoor or outdoor by key press, as quickly and accurately as possible. (Key presses were counterbalanced, with M representing indoor and Z symbolizing outdoor for half of the participants, and Z corresponding to indoor and M to outdoor for the other half.) Because the goal of the task was to accurately and quickly categorize targets, attention should have been directed endogenously to predicted targets across groups (opposite to the cue for OS groups; in the cued location for SS groups). However, the speed and ease with which attention could be allocated to predicted targets would have varied according to group instructions (attend vs. suppress) and spatial relations between targets and cues (same side vs. opposite side).

Trials were grouped into three blocks of testing based on cue valence, with each block consisting of 80 trials. That is, all negatively cued trials were presented in one block, all positively cued trials were presented in a separate block, and all neutrally cued trials occurred in another block. Each valence-specific block was separated by a short rest period. The rationale for blocking trials by valence was to prevent valence-related carry over effects that could occur from one trial to the next if picture valences had been mixed. Blocked testing was counterbalanced across participants to control for any effects that could result from testing order or pattern, (i.e., Participants were pseudo-randomly appointed to a given block order in a manner that permitted equal exposure to the various block orders within each experimental condition.)

Mood Check

Following the last block of testing of the emotional orienting task, a mood-induction check was administered using Likert-scale ratings, similar to those of the Self-Assessment Manikan (SAM; Lang, 1980). Participants were asked to report their mood following the final block of trials by selecting a value from 1 to 9, with 1 representing negative mood, 4 to 5 representing neutral mood, and 9 indicating positive mood. Mood-induction ratings were only obtained after the third block to avoid interfering with participants' performance on the emotional orienting task. However, because the blocks were counterbalanced, a representative assessment of mood induction was obtained for each of the valences. No mood checks were collected prior to beginning the experiment. However, because participants were randomly assigned to groups and task orders, mean initial moods were assumed to be comparable across groups and conditions.

Recognition Task

Following the emotional orienting task and mood check, participants were asked to complete a memory recognition test. This test assessed recognition for pictures and words that were viewed during the three blocks of the emotional orienting task. The recognition test consisted of one block of pictures and one block of words, each of which contained an equal mixture of unfamiliar stimuli (new) and stimuli which had been presented during the emotional orienting exercise (old). The recognition test was not blocked by valence because valence carry over effects were not anticipated for this task. To elaborate, in the recognition test participants were presented with one stimulus at a time that remained on the screen until a response was made, which differs from the rapid stimulus presentations and instructions to respond quickly given in the emotional orienting task. Thus, the slower pace of the recognition task should have reduced trial to trial valence effects. The new and old pictures were similar in valence and arousal ratings (**Table 6**). Likewise, the new and old words were balanced in length and written frequency (**Table 7**). The order of recognition testing (word vs. picture) was counterbalanced among participants.

The pictorial recognition portion consisted of ten pictures from each of the emotional orienting blocks, and ten new pictures of each valence type. Although the IAPS contains a broad selection of emotional pictures, those remaining after the 240 pictures used in the emotional orienting task were removed were somewhat limited (i.e., many were gruesome or erotic). Because it was desirable to have new pictures that resembled the old pictures in terms of valence and arousal levels, only ten new pictures of each valence were selected. Thus, there were 20 neutral, 20 positive, and 20 negative pictures presented to participants. Stimuli were presented one at a time in one random order. Participants were asked to report, by key press, if the picture had been presented during the previous task. Key presses were counterbalanced so that half of the participants pressed M for new items and Z for old items, whereas the other half pressed Z for new items and M for old items.

The word recognition portion followed a similar format. Ten words from each of the emotional orienting blocks were presented, along with 30 additional new words. For each group of old words, there were five from the indoor category and five that were outdoor words. Similarly, half of the new words were indoor words and half were outdoor words. Due to the limited availability of indoor and outdoor words in the University of Western Australia Psycholinguistics Database, the selection of novel words for the recognition test was somewhat restricted. Accordingly, only 30 new words appeared in the recognition test, mixed amongst 30 old words from the orienting task.

Positive Mood Induction Procedure

Following the last block of memory testing, a final series of positive pictures were viewed by all participants. This served to induce positive moods (or alleviate potential negative moods) before participants left the laboratory. A final mood check similar to the first one was administered following the positive picture series to assess its effectiveness. Upon completion of the test phase, participants were debriefed through a more detailed explanation of attention deployment and emotion regulation.

CHAPTER 3: RESULTS

Emotional Orienting Task

Preliminary analyses confirmed that key press (M vs. Z for indoor and outdoor words) and block order (positive, negative, neutral; positive, neutral, negative; etc.) had no significant effects on task performance. Thus, to simplify the data analyses, data were collapsed over these theoretically uninteresting variables. A series of analyses of variance (ANOVAs) were then conducted to examine group effects on neutral/baseline emotional orienting task performance, as well as across valences.

Neutral Block – Baseline Analyses

Neutral block data were analyzed on their own initially to verify that participants could learn cue-target contingencies in the absence of emotional influences and to establish baseline group differences in task performance. As expected, an analysis of variance (ANOVA) with repeated measures on trial predictability showed a significant effect of trial predictability on target accuracy, $F(1, 92) = 124.99$, $MSE = 0.01$, $p = .001$, partial $\eta^2 = .58$, indicating better performance on predicted (80%) trials (M =.82, SD = .13) than non-predicted (20%) trials (M =.63, SD = .13). To determine whether neutral block word categorization performance differed across groups (attend OS, attend SS, suppress OS, suppress SS), an ANOVA with group as a fixed factor was conducted on the difference in mean target accuracy between predicted (80%) and non-predicted (20%) trials. Group was found to have a significant main effect on target accuracy difference scores (predicted target accuracy - non-predicted target accuracy), *F*(3, 92) = 3.12, *MSE* = 0.03, *p* = .03, partial η^2 =.09 (**Figure 2**). Post hoc analyses using Fisher's Least Square Difference (LSD) test revealed that the difference in target accuracy between predicted and non-predicted trials was significantly greater in the attend SS group (*M* = .27, *SD* = .21) than in the attend OS group (*M* = .13, *SD* = .13, *p* = .003). LSD tests also illustrated that difference scores comparing target accuracy on predicted and non-predicted trials varied across SS groups, with larger difference scores corresponding to the attend SS group (*M* = .27, *SD* = .21) than the suppress SS group (*M* = .17, *SD* = .17, *p* = .048). A large difference between predicted and non-predicted trials in attend SS participants was anticipated, as this group (who was required to make a saccade to the cue) should have performed well on predicted trials but experienced difficulty directing attention to the non-predicted words occurring opposite to the cue. The mean difference score for the suppress OS group (*M* = .19, *SD* = .13) was not significantly different from those of the other groups. ANOVAs were then conducted for predicted target accuracy and non-predicted target accuracy separately to pinpoint the source of group effects on accuracy difference scores (**Figure 3**). Comparable target accuracy performance was revealed across groups on the predicted trials, *F*(3, 92) = .38, *MSE* = .02, *p* = .771, partial η^2 = .01, whereas word accuracy on non-predicted trials differed across groups, *F*(3, 92) = 6.75, *MSE* = 0.02, *p* = .001, partial η^2 = .18. (Mean predicted target accuracy and standard deviations were .81 (.10), .81 (.21), .84 (.07), and .81 (.11) for attend OS, attend SS, suppress OS, and suppress SS groups). Post hoc analyses using Fisher's Least Square Difference (LSD) test revealed that non-predicted target performance was worse for participants in the attend SS condition (*M* = .54, *SD* = .12) than the attend OS condition (*M* = .69, *SD* = .11, *p* = .001), the suppress SS condition (*M* = .63, *SD* = .14, *p* = .007), and the suppress OS condition (*M* = .65, *SD* = .12, *p* = .002). No significant differences appeared between the other three conditions (attend OS, suppress OS, and suppress SS). Poorer performance by attend SS participants on non-predicted trials was not surprising, as this group had to disengage from the cued (predicted) location and shift attention to the opposite side of the screen when non-predicted targets appeared.

Analyses were also conducted on response times. For this and all other response time analyses, outlier response time values were replaced with a time that was three standard deviations from the mean (4768.41 ms), as per the Winsorising technique. In total, 0.6% of the response time values were replaced. Neutral block target response times were examined as a function of trial predictability using an ANOVA with repeated measures on predictability. Trial predictability was found to have a significant effect on response time, $F(1, 92) = 13.63$, $MSE = 47011.27$, $p = .001$, partial $\eta^2 = .13$, illustrating more rapid responding for predicted (80%) words (*M* =1080.67 , *SD* = 368.72) relative to the non-predicted (20%) words (*M* = 1196.20, *SD* = 453.90). Response times for neutral block word categorization were also compared across groups by conducting a univariate ANOVA with response time difference scores (predicted – non-predicted mean response times) as the dependent variable and group as the fixed factor. No significant effects were observed, $F(3, 92) = 1.17$, *MSE* =

94022.54, p = .32, partial η^2 = .04 (**Table 9**). A similar analysis was carried out to examine response time difference scores across groups using only *correct* response trials. Again, no significant group differences were observed, $F(3, 92)$ = 1.20, *MSE* = 88189.54, p = .31, partial η^2 = .04 (**Table 9**).

Valence Effects

Previous research has revealed emotional effects on general cognitive function (including categorization skills), as well as emotional effects on attention. Thus, in response-based tasks, valence effects could be attributable to affective influences on general cognitive abilities rather than attentional processes. To examine whether the emotional valence of the cue had an impact on participants' ability to categorize the target word, an ANOVA with repeated measures on valence was conducted solely for the 80% predicted trials of the attend SS condition. Data from this study group was used to look for valence-specific categorization effects because attention should have been allocated in advance to the majority of predicted trial targets. Results revealed no cross-valence variability, $F(2, 46)$ = .81, *MSE* = .003, p = .45, partial η^2 = .03, suggesting that in the context of the attend SS group's instructions, categorization skills were unaffected by emotional cues. (Mean target accuracy and standard deviations for the predicted trials of the neutral, negative, and positive blocks were .8053 (.21), .7936 (.18), and .7871 (.19), respectively). Thus, valence-related effects were unlikely to appear due to categorization differences and could more readily be attributed to attentional processes. In other words, having found no valence-related effects on participants' ability to categorize words in the attend SS condition, the data could be analyzed and interpreted in terms of attentional effects.

To examine valence effects on word categorization accuracy as a function of group, a 3 (valence) x 4 (group) ANOVA with repeated measures on valence was conducted on target accuracy difference scores (predicted – non-predicted mean accuracy). Valence had a significant effect on target accuracy difference scores, $F(2, 184) = 3.96$, $MSE = 0.02$, $p = .02$, partial $\eta^2 = .04$. The greatest difference between predicted and non-predicted target accuracy was observed for the negative valence block ($M = .23$, $SD = .15$) and smaller difference scores were revealed for the neutral ($M = .19$, $SD = .17$) and positive blocks ($M = .18$, $SD = .15$), which did not differ ($p = .01$ for the negative-positive comparison and $p = .04$ for the negative-neutral comparison using LSD tests). A significant two-way interaction was found between valence and group, $F(6, 184) = 3.88$, $MSE = 0.02$, $p =.001$, partial $\eta^2 =.11$ (**Figure 4**).

An ANOVA with repeated measures on valence was used to examine predicted versus non-predicted differences in target accuracy across valences for the attend OS group. Accuracy difference scores were significantly affected by valence, $F(2, 46) = 7.90$, $MSE = 0.01$, $p = .001$, partial $\eta^2 =.26$. LSD tests revealed a greater difference between predicted and non-predicted target accuracy for the negative block ($M = .25$, $SD = .17$) compared to the neutral block, ($M = .13$, $SD = .13$), $p = .001$, and positive block ($M = .15$, $SD = .16$), $p = .016$. The attend OS group's neutral and positive block accuracy difference scores were not significantly different (**Panel A**). As with the attend OS group, analyses revealed significant group variability in the suppress OS group's accuracy difference scores, $F(2, 46) = 4.03$, $MSE = 0.02$, $p = .024$, partial $\eta^2 =.15$. There was a greater difference between predicted and non-predicted target accuracy for the negative block (*M* = .26, *SD* = .14) than the positive block (*M* = .16, *SD* = .13), $p = .014$, of the emotional orienting task (**Panel B**). Positive and neutral block (*M* = .19, *SD* = .13) accuracy difference scores did not differ, nor did negative and neutral block scores. Similar analyses were conducted for both the attend SS and suppress SS groups independently, but accuracy difference scores were unaffected by valence (**Panels C and D**).

To investigate what was contributing to group differences in valence effects on accuracy difference scores, a 2 (valence) x 2 (predictability) x 4 (group) ANOVA with repeated measures on valence and trial predictability was conducted (**Figure 5**). The attend OS group's predicted trial accuracy was similar across neutral (*M* = .80, *SD* = .11), negative (*M* = .80, *SD* = .11), and positive (*M* = .82, *SD* = .08) block valences, $F(2, 46) = 1.07$, $MSE = 0.003$, $p = .35$, partial $\eta^2 =.04$. However, non-predicted trial accuracy was affected by valence, $F(2, 46) = 6.76$, $MSE = 0.01$, $p = .003$, partial $\eta^2 =.23$. LSD tests revealed that non-predicted target accuracy was significantly greater in the positive block (*M* = .68, *SD* = .12) than the negative block (*M* = .58, *SD* = .13), $p = .01$. Similarly, non-predicted trial accuracy was significantly higher for the neutral block (*M* = .69, *SD* = .11) than the negative block, $p = .006$ (**Panel A**). Like the attend OS group, the suppress OS group's predicted trial accuracy did not vary across neutral (*M* = .84, *SD* = .07), negative (*M* = .82, *SD* = .07), or positive (*M* = .82, *SD* = .06) valences, $F(2, 46) = 1.02$, $MSE = 0.003$, $p = .37$, partial $\eta^2 = .04$. There was, however, an effect of valence on non-predicted trial accuracy, $F(2, 46) = 6.61$, $MSE = 0.01$, $p = .003$, partial $\eta^2 = .22$, in which higher accuracy was observed in the positive block ($M = .67$, $SD = .12$) than the negative block ($M = .56$, $SD = .13$), $p = .005$. Superior non-predicted target accuracy was also seen in the neutral block ($M = .65$, $SD = .12$) relative to the negative block, $p = .013$, whereas neutral and positive blocks did not differ (**Panel B**). As with the other groups, predicted trial performance remained stable across valences in the attend SS, $F(2, 46) = .81$, $MSE = 0.003$, $p = .45$, partial $\eta^2 = .03$, and suppress SS groups, $F(2, 46) = 1.07$, $MSE = 0.003$, $p = .35$, partial $\eta^2 = .04$. Mean predicted target accuracy for the attend SS group was .81 (.21) for the neutral block of the orienting task, .79 (.18) for the negative block, and .79 (.19) for the positive block. The suppress SS group's neutral, negative, and positive block predicted target accuracy was .81 (.11), .80 (.11), and .82 (.08), correspondingly. In contrast to the attend OS and suppress OS groups, non-predicted trial accuracy was unaffected by valence in the attend SS group, $F(2, 46) = 2.49$, $MSE = 0.01$, $p = .094$, partial $\eta^2 = .10$, and suppress SS group, $F(2, 46) = 0.59$, $MSE = 0.01$, $p = .56$, partial $\eta^2 = .03$ (**Panels C and D**). Mean non-predicted target accuracy was .54 (.12) for the neutral block, .60 (.13) for the negative block, and .59 (.14) for the positive block in the attend SS group, and .63 (.14), .60 (.12), and .60 (.13) for the neutral, negative, and positive blocks in the suppress SS group.

Similar ANOVAs using emotional valence as a repeated measure and group as a between-subject variable were performed for response time and correct response time difference scores (predicted - non-predicted trials). No significant effects were observed in the response time analyses, $F(2, 184) = 2.02$, $MSE = 114225.59$, $p = .14$, partial $\eta^2 = .02$, or the correct response time analyses, $F(2, 184) = 1.570$, $MSE = 191472.00$, $p = .21$, partial $\eta^2 = .02$ (**Table 10**).

Recognition Task

Neutral (baseline) Analyses

Memory for neutral pictures was assessed by examining recognition accuracy for old pictures (from the emotional orienting task) and new pictures (not seen in the emotional orienting task) across groups. The purpose of the recognition task was to evaluate whether instructions to attend and suppress were followed in the neutral block of the emotional orienting task. To do so, memory scores were calculated by subtracting the proportion of 'false alarms' or 'old responses' for new pictures from the proportion of 'hits' or 'old responses' for old pictures from the neutral block of the emotional orienting task. An ANOVA with group as the fixed factor was then conducted on the memory scores, exposing a lack of significant group differences, $F(3, 92) = 0.65$, $MSE = 0.04$, $p = .59$, partial $\eta^2 = .02$.

Memory for words from the neutral block of the emotional orienting task was also examined using a univariate ANOVA with memory scores (proportion 'hits' – proportion 'false alarms') as the dependent measure and group as the fixed factor. Once again, no group differences were observed, $F(3, 92) = 0.71$, $MSE = 0.06$, $p = .55$, partial $\eta^2 = .02$.

Valence Effects

Potential valence effects on picture recognition were appraised across groups using an ANOVA with repeated measures on valence. A main effect of picture valence was observed, $F(2, 184) = 15.47$, $MSE = 0.04$, $p = .001$, partial $\eta^2 = .14$. Memory scores (proportion 'hits'- proportion 'false alarms') were highest for negative pictures ($M = .23$, $SD = .22$), followed by positive pictures ($M = .15$, $SD = .21$), and lastly by neutral pictures ($M = .07$, $SD = .21$). (Using LSD tests, $p = .001$ for the negative-neutral comparison, $p = .005$ for the negative-positive comparison, and $p = .006$ for the neutral-positive comparison; **Figure 6**). No significant group effects on pictorial cue memory scores were found, $F(3, 92) = 1.99$, $MSE = 0.14$, $p = .12$, partial $\eta^2 = .06$ (**Table 11**).

Pictures recognition data was then analyzed across valences (neutral, negative, positive) using paired samples t-tests to determine whether the proportion of hits for old pictures was significantly greater than the proportion of false alarms for new pictures for each of the three picture valences. The proportion of hits and false alarms were significantly different for neutral recognition task pictures, $t(95) = 3.12$, $p = .002$, for negative recognition task pictures, $t(95) = 10.46$, $p = .001$, and for positive recognition task pictures, $t(95) = 7.01$, $p = .001$. The proportion of old pictures that were recognized accurately (hits) was significantly greater than the proportion of new pictures that were recognized falsely (false alarms) for neutral *(*$M = .24$, $SD = .23$; $M = .17$, $SD = .18$), negative *(*$M = .59$, $SD = .20$; $M = .35$, $SD = .25$), and positive *(*$M = .40$, $SD = .21$; $M = .25$, $SD = .17$) recognition task pictures (**Figure 7**).

Recognition task analyses were also conducted for word memory scores (proportion ‘hits’- proportion ‘false alarms’), revealing a main effect of valence, $F(2, 184) = 5.96$, $MSE = 0.04$, $p = .003$, partial $\eta^2 = .06$. Memory scores were higher for negatively cued words ($M = .46$, $SD = .22$) and positively cued words ($M = .43$, $SD = .25$) than neutrally cued words ($M = .36$, $SD = .24$). (Using LSD tests, $p = .001$ for the negative-neutral comparison and $p = .02$ for the positive-neutral comparison; **Figure 8).** No significant group differences were exposed, $F(3, 96) = 1.09$, $MSE = 0.29$, $p = .36$, partial $\eta^2 = .03$ (**Table 12**).

As with the picture recognition data, word recognition results were examined using paired samples t-tests to compare the proportion of ‘hits’ for old words from neutral, negative, and positive blocks of the emotional orienting task with the proportion of ‘false alarms’ to new words. The proportion of hits for words from the emotional orienting task was significantly greater than the proportion of false alarms to new words. This difference was significant for comparisons between neutrally cued, negatively cued, and positively cued old words and their new length- and frequency-matched counterparts, ($t(95) = 14.70$, $p = 0.001$; $t(95) = 19.98$, $p = .001$; $t(95) = 17.06$, $p = .001$, respectively). More specifically, the proportion of old words that were recognized accurately (hits) was significantly greater than the proportion of new words that were recognized falsely (false alarms) for neutrally cued ($M = .72$, $SD = .18$; $M = .36$, $SD = .19$), negatively cued ($M = .73$, $SD = .18$; $M = .27$, $SD = .17$), and positively cued ($M = .74$, $SD = .18$; $M = .31$, $SD = .18$) words (**Figure 9**).

Mood Effects

A univariate analysis was conducted on mood scores that were collected after the emotional orienting task to determine whether mood was influenced by picture valence and/or group. The picture valence of the last block of the emotional orienting task had a significant impact on post-task mood ratings, $F(2, 84) = 6.21$, $MSE = 2.03$, $p = .003$, partial $\eta^2 = .13$. Participants who were presented with the negative block as the last emotional orienting block were in less, albeit still positive moods ($M = 5.28$, $SD = 1.35$) than those who last received the neutral block ($M = 6.00$, $SD = 1.30$), $p = .05$, or positive block ($M = 6.53$, $SD = 1.71$), $p = .001$, regardless of group, $F(6, 84) = 0.91$, $MSE = 1.84$, $p = .49$, partial $\eta^2 = .06$ (**Table 13**).

A final series of positive pictures was shown after the recognition test to induce positive moods in participants prior to their departure from the laboratory. An ANOVA with repeated measures on mood check (post-emotional orienting task check vs. final mood check) revealed a significant main effect of mood check on participant mood ratings, $F(1, 84) = 80.95$, $MSE = 0.51$, $p = .001$, partial $\eta^2 = .49$, in that mood ratings were higher following the positive picture series ($M = 6.86$, $SD = 1.34$) than after the emotional orienting task ($M = 5.93$, $SD = 1.53$). The valence of the last emotional orienting block that participants were presented with also had a significant effect on final mood ratings, $F(2, 93) = 7.13$, $MSE = 1.60$, $p = .001$, partial $\eta^2 = .13$, paralleling the pattern seen in the first mood check. The mean final mood rating (following the positive picture series) for participants who last received the negative block was slightly positive at 6.19

(1.20), whereas those who last received the neutral block had a mean rating of 7.09 (1.00), and those who last received the positive block of emotional orienting testing reported a mean mood rating of 7.31 (1.53). Thus initial valence-induced mood effects persisted throughout the course of testing, and remained following exposure to the positive picture series (**Figure 10**). A two-way interaction was also revealed between mood check (first or final check) and group, $F(1, 92) = 3.89$, $MSE = 0.49$, $p = .01$, partial $\eta^2 = .11$. Separate analyses were conducted across mood checks for each group, revealing that the difference between the first and final mood ratings was significant for the attend SS group, $F(1, 23) = 25.09$, $MSE = 0.48$, $p = .001$, partial $\eta^2 = .52$ the suppress OS group, $F(1, 23) = 34.5$, $MSE = 0.35$, $p = .001$, partial $\eta^2 = .60$, and the suppress SS group, $F(1, 23) = 31.32$, $MSE = 0.68$, $p = .001$, partial $\eta^2 = .58$, whereas first and final mood ratings for the attend OS group were not significantly different (**Figure 11**). The valence of the last block of emotional orienting testing had no effect on mood change from the first mood check to the final mood check.

CHAPTER 4: DISCUSSION

Objectives

The current study's primary objective was to measure inhibitory control of attention to emotional stimuli. More specifically, we wanted to assess the practicality of attention control as a form of emotion regulation by examining attention control to a normative and representative range of emotional pictures. A number of secondary objectives were also pursued. Namely, we strived to gauge valence effects on categorical decisions, to evaluate memory for emotional items as a function of attention control, and to measure valence and attentional effects on mood.

To address these questions, a short series of tasks was administered to participants. The emotional orienting task was the primary focus of the study, and involved presenting participants with a cue to either side of a central fixation cross, followed by a target. There were two main study groups: the attend group, which was asked to look at cues, and the suppress group, which was asked to avoid looking at the cues, but to detect their location to predict the most likely location for target onset. Within each study group, half of the participants were assigned to the SS condition and half were assigned to the OS condition. For participants in the SS condition, cues and targets occurred on the same side of the screen 80% of the time (predicted trials), whereas in the OS condition they appeared on opposite sides of the screen on 80% of trials. Thus in all there were four different study groups: attend OS, attend SS, suppress OS, and suppress SS. Once the target appeared, all participants, irrespective of group, were asked to categorize the target word as representing an indoor or outdoor item as quickly and accurately as possible. By assessing target categorization performance, interpretations regarding participants' ability or inability to ignore cues could be made. To elaborate, the rapid task timing was such that target identification in non-attended locations was expected to suffer and identification of targets in attended positions was expected to excel. Thus, by analyzing target categorization accuracy across groups, interpretations regarding attention control could be made. Participants in the attend SS group were predicted to categorize predicted targets with high accuracy, individuals assigned to the suppress OS group were expected to do well on predicted trials granted they could follow instructions, and those in the attend OS and suppress SS groups were expected to struggle with predicted target categorization in comparison to the other groups. Moreover, overall performance was expected to vary with target predictability (predicted vs. non-predicted) due to statistical learning of cue-target contingencies. Taking the above group predictions into consideration, target accuracy for predicted targets was expected to exceed that of non-predicted targets by a large degree for the attend SS and suppress OS groups, and to a lesser extent for the attend OS and suppress SS groups.

Emotional orienting Task

Neutral Block

Target categorization performance for the neutral block was analyzed as a baseline measure to determine whether participants followed instructions to look at (attend groups) or avoid looking at (suppress groups) non-affective cues, and to evaluate whether participants learned the 80% cue-target contingencies. Participants responded more accurately and more quickly to targets in the 80% predicted location, illustrating that they learned the task and directed attention more quickly to the most probable target position. Neutral block analyses also revealed some expected group effects, in that the attend SS group had a greater target accuracy difference score (predicted – non-predicted) than the attend OS and suppress SS groups. A large disparity between predicted and non-predicted target accuracy was expected to appear for attend SS participants given that they were instructed to saccade to predicted (cued) target locations and would have had to redirect attention to non-predicted targets once they appeared. Relatively smaller differences between predicted and non-predicted target accuracy in attend OS and suppress SS groups are also in line with predicted outcomes, considering that group instructions would have fostered non-predicted target categorization and made predicted target identification more challenging. The only group that did not respond as expected was the suppress OS group, whose mean accuracy difference score did not vary significantly from other groups. This group was expected to show larger target accuracy difference scores than attend OS and suppress SS groups because instructions to suppress should have eased categorization of predicted, opposite side targets and hindered categorization of non-predicted, same side targets.

Cross group comparisons for both predicted target accuracy and non-predicted target accuracy were also carried out to identify the source of group differences in accuracy difference scores. Non-predicted targets were categorized most poorly by the attend SS group, whereas the other groups did not differ significantly from one another. Once more, the attend SS group was expected to perform poorly on non-predicted, opposite side trials. Hence, this group's low non-predicted target accuracy and high target accuracy difference scores correspond well with our predictions. Unlike non-predicted target accuracy, target accuracy for predicted trials was comparable across groups. Yet, based on the task design and attentional instructions, predicted trial target processing deficits were anticipated for the suppress SS group and the attend OS group. Strong cue-target contingency learning could have enabled rapid saccades to targets, even if instructions to attend or avoid cues were followed. If this is the case, future work should aim to increase task difficulty by reducing stimulus durations or minimizing interstimulus intervals. Increasing the angular distance between stimuli and central fixation might also make the task more challenging. Alternatively, participants may have disregarded or struggled with attentional instructions, leading to comparable between-group target accuracy on predicted trials. By analyzing cue recognition performance across groups, these possibilities could be explored. Indeed, recognition task results revealed a lack of group variability in cue recognition, indicating that attend and suppress group instructions were not reliably fulfilled by participants. More precisely, all groups scored poorly in the neutral picture recognition test, which may imply that attend group participants struggled with instructions to attend to cues and performed the task similarly to suppress group participants. However, despite the lack of significant group effects on predicted trial accuracy, the described between-group differences in accuracy difference scores (predicted - non-predicted) suggest that some attempts to attend and suppress were made.

Valence Effects

Once baseline performance results were established, valence effects were evaluated by comparing performance measures across the different valences of emotional orienting blocks. Because emotional effects on both attention and cognition (including categorization skills) have been reported in the literature, emotional effects in response-based studies can appear due to affective influences on cognitive abilities and/or attentional processes. To examine whether the emotional valence of the cue had an impact on participants' ability to categorize the target word, independent of attentional effects, the attend SS group's predicted trial target accuracy was examined for valence effects. This group was considered because, based on group instructions, attention should have been allocated in advance to the majority of predicted trial targets. Non-attention based impacts of valence on word discrimination were expected to be detected in the attend group's same side target identification if they existed. Precise predictions were not made due to the range of emotional influences on cognitive performance that have been reported in past studies (Bless et al., 1992; Hartikainen et al., 2000; Isen et al., 1992; Qu & Zelazo, 2007; Simpson et al., 2000). Results revealed no valence effects, suggesting that in the context of the attend SS group's instructions, categorization skills were unaffected by emotional cues. Thus, subsequent findings were interpreted in terms of attention control effects.

A cross-valence analysis served to assess the influence of emotion on attention control. Emotional stimuli have been reported to influence performance on a variety of attentional tasks. These effects have generally been described in terms of attentional biases and depleted resource availability. For instance, when negative distractors precede targets in RSVP paradigms, deficits in visual discrimination result, reflecting a depletion of attentional reserves (Most et al., 2005; Most et al., 2007). Evidence for affective attentional biases also comes from dot probe studies, which find faster reaction times for targets occurring in emotion cued locations (Koster et al., 2004; Macleod et al., 1986). These results have been taken to signify attentional vigilance and capture preferences for emotional stimuli (Mogg et al., 2000; Williams et al., 1988). Visual search procedures have revealed similar attentional biases for emotional items, with threatening stimuli triggering speeded search responses (Ohman et al., 2001), whereas exogenous cueing tasks tend to expose prolonged attentional dwell and reduced disengagement from negative stimuli (Fox et al., 2001). Other indices of emotional effects on attention can be taken from modified Stroop tasks in that aversively salient words elicit delayed color naming (Fox et al., 2001; Pratto & John, 1991; Williams et al., 1996), suggesting a presence of valence-specific inhibitory deficits and attentional biases. Based on these affective attentional studies, saccadic inhibition (or inhibition of overt orienting) to emotional items was anticipated to be more challenging than to neutral stimuli in the current study's emotional orienting task. This disposition to attend to emotional items was expected to manifest itself as improved predicted target performance on emotional blocks relative to neutral blocks for the suppress SS group. As a result, a larger difference between predicted and non-predicted target accuracy would occur in emotional blocks compared to the neutral block for the suppress SS group. Reduced inhibition to emotional pictures should have had the opposite effect on suppress OS performance, resulting in poorer predicted target identification and better non-predicted target accuracy in emotional blocks relative to the baseline neutral block. In turn, smaller accuracy difference scores (predicted-non-predicted trial accuracy) should have been observed in the emotional blocks for the suppress OS group. Attend group performance was also hypothesized to succumb to emotional influences in that predicted target categorization for the attend OS group was expected to deteriorate due to increased attentional capture and reduced disengagement from emotional items (Fox et al., 2001; Mogg et al., 2000; Williams et al., 1988). In regard to target accuracy differences, lower predicted target accuracy and enhanced processing of non-predicted same side targets on emotional trials compared to neutral trials would reduce variability between predicted and non-predicted target accuracy in the attend OS group.

Having performed initial analyses solely on the attend SS group's predicted trial data, the remainder of the analyses considered all four groups (attend OS, attend SS, suppress OS, suppress SS). An effect of negative pictorial cues on target accuracy difference scores was observed, in which accuracy difference scores (predicted – non-predicted) for words displayed after negative pictures was significantly larger than for words that followed positive or neutral pictures. These general valence effects seem to be carried by group-specific valence effects on target accuracy difference scores. That is, a greater difference between predicted and non-predicted target accuracy was revealed in the negative block of the emotional orienting task than the neutral or positive blocks for the attend OS group, and the negative block accuracy difference score was larger than that of the positive block and equal to that of the neutral block for the suppress OS group. In contrast, accuracy difference scores were unaffected by valence for the attend SS and suppress SS groups. As illustrated in the results, the large disparity between predicted and non-predicted target accuracy in the attend OS group’s negative block data reflects poor categorization of non-predicted, same side words. More precisely, non-predicted target accuracy in the negative block was significantly lower than in the other blocks for both OS groups. Thus, the enhanced accuracy difference scores in the attend OS group suggest that participants had difficulty redirecting their gaze to negatively cued locations once a saccade had been initiated to the opposite side of the screen. Hence, negative valence seems to disrupt reorienting of attention to negatively cued locations. Large accuracy difference scores in the suppress OS group (brought on by disrupted non-predicted target categorization) could also hint at negative valence-induced reorienting delays. The lack of group differences observed in the predicted target analyses might be indicative of a reluctance or inability to fulfill study instructions, thus suppress OS participants may have in fact looked at the cues and, like the attend OS group, had difficulty returning gaze to negatively cued locations to categorize non-predicted targets. Indeed, high memory scores for negative pictures were observed across all groups in the recognition test, suggesting that suppress group participants looked at the negative pictures.

Although negative valence effects on reorienting have not been described in the affect-attention literature, certain negative valence effects on vigilance and disengagement have been reported that can potentially be reinterpreted in terms of delayed reorientation. For instance, Bradley et al. (2000) found prolonged response times to targets appearing in threat and sadness cued positions, suggesting that low-anxiety individuals are less vigilant in detecting negative stimuli than neutral or positive stimuli. However, because typical probe detection tasks employ stimulus durations that are long enough to allow multiple attention shifts, response time data may not truly reflect initial orientation or vigilance biases. Indeed, some researchers have acknowledged that dot probe response times may reflect attentional maintenance and disengagement effects rather than orientation tendencies (Fox et al., 2001; Koster et al., 2004). Yet, the possibility that reorienting effects might alter response times to emotion-cued targets has not been addressed. Whereas the findings in Bradley et al. (2000) were taken to indicate initial detection preferences for neutral or happy stimuli relative to sad or threatening stimuli, they could also reflect reorienting effects similar to those seen in the current study. For instance, based on task timing that permits attention shifting, slowed responding to negatively cued targets could actually reflect initial allocation to negative stimuli and subsequent reluctance to reorient to those stimuli once attention had been shifted away.

Exogenous cueing experiments have also revealed negative valence effects on attention that could potentially reflect difficulty in returning gaze to negative stimuli. Exogenous cueing paradigms involve presenting cues one at a time, to the right or left of a central fixation point, and displaying subsequent targets in cued (valid) or uncued (invalid) locations. Spatial attention is accelerated to targets in validly cued locations and decelerated for invalidly cued targets. Ellenbogen et al. (2002) found speeded shifting of attention away from negative stimuli in a negative stressor group, as indicated by more rapid responding to negatively cued invalid trial targets than neutrally or positively cued invalid targets. Although these results may indeed indicate speeded disengagement from negative cues, an aversion to reorient to negative cues could also be a contributing factor. Resistance to return attention to negatively cued locations combined with a lack of such resistance to positively and neutrally cued locations could promote stronger disengagement on negative trials, leading to speeded responses to invalid targets. Thus, disrupted reorienting to and speeded disengagement from negative cues are not necessarily competing explanations, but may actually be cooperating factors that achieve the same end result (impeded reorientation and promoted attention shifting).

The disrupted reorientation to negative cues seen in the current study is also consistent with attentional search task findings, although such findings have not directly been interpreted in this context. Constans et al. (1999) demonstrated that individuals who worry about future health problems show avoidance rather than vigilance for words associated with those health concerns. However, it is possible that this avoidance occurs after initial (and perhaps subconscious) processing of negative health words, and thus more specifically reflects an aversion to reengage with health-related words rather than an avoidance of initial engagement with those words.

It is evident that a number of tasks have produced findings that can be reinterpreted in terms of valence effects on reorientation/reengagement. However, the majority of these tasks make it difficult to distinguish between potential reorienting effects versus initial orienting and/or disengagement effects. Although this distinction could potentially be made by the aid of eye movement tracking devices, many response-based tasks cannot do so on their own. The emotional orienting task is valuable in this respect given that performance on non-predicted (same side) trials for OS groups provides a measure of reorienting that can be examined across valences.

Recognition Test

Neutral

The recognition test served as an additional manipulation check to verify whether participants could follow the attend and suppress instructions of the emotional orienting task. If saccades to cues were successfully inhibited by the suppress groups, then picture memory scores (proportion ‘hits’ for old pictures – proportion ‘false alarms’ for new pictures) should have been near zero values, whereas if cues were attended, greater picture memory scores should have been observed. If cues were attended in OS groups, word memory scores should have suffered, whereas superior word memory scores were expected if cues were ignored in the OS groups. The reverse is true for SS groups in that attending to cues should have resulted in better word processing and recognition (i.e. higher memory scores) and avoiding cues should have impaired word processing and recognition (lower memory scores). Thus, if instructions were successfully followed, the attend OS group should have displayed high memory scores for pictures but low memory scores for words, the attend SS group should have shown high memory scores for both pictures and words, the suppress OS group should have demonstrated low cue recognition (poor picture memory scores), but high target recognition (high word memory scores), and the suppress SS group should have displayed poor recognition of both cues and targets (low memory scores for pictures and words). Again, the rationale behind all of these predictions lies in the notion that memory improves for attended items (Arnell et al., 2007; Chen, Ehlers, Clark, & Mansell, 2002; Kandel, Schwartz, & Jessell, 2000).

The recognition test for neutral pictures was delivered as a manipulation check to determine whether instructions to attend and suppress were followed in the neutral emotional orienting block. Analyses revealed a lack of group differences in picture memory scores, which implies that attend and suppress groups performed the emotional orienting task similarly in terms of attentional allocation to cues. The proportion of hits for neutral emotional orienting task pictures was significantly greater than the proportion of false alarms to new neutral pictures, suggesting that attention was at least occasionally/ partially distributed to emotional orienting task cues across groups. However, as we will see, memory scores (proportion ‘hits’ – proportion ‘false alarms’) for neutral pictures were significantly lower than for positive or negative pictures. Thus, in comparison to other cue valences, it would seem that all groups directed minimal attention to the neutral baseline cues.

Memory for words from the neutral emotional orienting block was also assessed to determine whether the task timing and group instructions produced the hypothesized results on target processing (and hence memory). As with the neutral picture recognition test, no group differences were apparent in the neutral word recognition analyses. Considering that word recognition results were expected to parallel emotional orienting task findings, group similarities in word memory scores mesh nicely with the similarities observed in predicted target accuracy in the emotional orienting task. Although there were group effects on accuracy difference scores in the emotional orienting task, these group effects were carried by differences in non-predicted target performance. Because recognition task stimuli were selected randomly from the emotional orienting task and the trial predictability (80% vs. 20%) of the selected stimuli was not controlled, most recognition task items were from the 80% predicted side trials. Thus, it makes sense that word memory scores matched the predicted target accuracy results in the emotional orienting task. Follow-up studies should include a set number of non-predicted targets in the recognition test so that memory score analyses can be conducted for predicted and non-predicted trial words. In turn, group variability in non-predicted word memory scores might be revealed.

The lack of group variability in picture and word memory scores suggests that participants did not follow instructions to attend and suppress. The idea that participants either chose not to or were unable to strictly/consistently follow group instructions was also made earlier in interpreting the lack of group variability in target accuracy on predicted trials of the emotional orienting task. Another explanation was also proposed in discussing the emotional orienting group similarities – that the nature of the task permitted group instructions to be fulfilled without influencing target performance. If this were the case, word memory scores would be expected to remain stable across groups (similar to the pattern of target categorization in the emotional orienting task), but picture memory scores would be expected to vary according to group (attend vs. suppress). Considering that the attend and suppress groups did not differ in terms of picture recognition, this alternative explanation is unlikely. Thus, it would seem that group instructions were not reliably fulfilled by participants. In particular, attend group participants seemed to resist study instructions in the neutral block of the emotional orienting task given that neutral picture memory scores were significantly lower than those of other valences (to be discussed). Nonetheless, the finding that hits for neutral emotional orienting task pictures outweighed false alarms to new neutral pictures indicates that a certain degree of attention was allocated to neutral cues in the emotional orienting task. Additionally, the described group effects on accuracy difference scores (predicted – non-predicted) in the neutral block of the emotional orienting task signify that some attempts to follow group instructions were made. Yet, the cumulative findings of group similarities in predicted target accuracy in the emotional orienting task and in picture and word memory scores, along with relatively low neutral picture memory scores, suggest that overall adherence to instructions was minimal, especially for the attend group.

Valence Effects

While neutral recognition testing established baseline between-group differences, a cross-valence analysis assessed emotional influences on memory. By assessing between-group differences in cue and target memory scores across valences, valence effects on instructional adherence (to attend or suppress) could be examined. Like the emotional orienting task, significant main effects of cue valence were seen in the recognition task analyses. Overall, picture recognition was enhanced for negative pictures, whereas picture memory scores for positive pictures were significantly lower than for negative pictures, and neutral picture memory scores were poorer still. Like the neutral cue recognition analyses, a cross-valence comparison failed to show any significant group effects on picture recognition. Thus, it would seem that there were no clear differences in how the various groups performed the emotional orienting task, at least in terms of pictorial cue retention. High negative picture memory scores across groups suggest that the negative emotional orienting block was treated differently than the positive and neutral blocks, eliciting attention to cues regardless of group status. Previous research has shown that memory improves for emotional items (Cahill & McGaugh, 1998; Heuer & Reisberg, 1990; Ellenbogen et al., 2002). However, it is unlikely that affective quality alone can account for valence effects on picture recognition given the large difference between positive and negative picture memory scores. Instead, valence effects on recognition performance are most likely a result of divergent attentional processes employed during different emotional orienting blocks. To summarize, participants seemed to perform the task differently depending on block valence, largely ignoring the content of positive and neutral pictures and attending to negative pictures.

Word recognition task accuracy was also examined for potential group and valence effects, but no significant effects were observed. The lack of valence effects on word recognition outcomes is somewhat surprising. As mentioned, word recognition analyses were expected to parallel findings from the emotional orienting task. However, whereas word memory scores were stable across valences, affective influences appeared in the emotional orienting task results. As noted, valence had a significant effect on target accuracy difference scores (predicted – non-predicted) in the emotional orienting task, with negative cues eliciting the largest accuracy difference scores. Larger accuracy difference scores (attributable to poor non-predicted target categorization) were observed in the negative block of the task for the attend and suppress OS groups. One explanation for these discrepancies between the orienting task and recognition task results is that negative contexts are unique in that they permit stimulus processing and encoding, but hinder categorical decisions. Indeed, Hartikainen et al. (2000) found that negative distractors obstructed target categorization, whereas Qu and Zelazo (2007) reported category sorting deficits for negative stimuli in preschool-aged children. Yet, no valence effects were revealed in the emotional orienting task attend SS group analyses, which served to check for emotional influences on target categorization. Perhaps negative valence impedes categorization, but only under contexts in which cognitive/attentional load is more intense than that elicited by attend SS instructions. Future work could address this question by requiring negatively cued categorization decisions under various cognitive/attentional demands (distraction, mental math, list rehearsal, etc.). It is also important to note that the negative valence effects that occurred in the emotional orienting task are ascribable to target categorization on non-predicted trials. Again, recognition task stimuli were randomly selected and no effort was made to include a representative number of non-predicted trial items, thus strong interpretations regarding valence effects on categorical decisions cannot be made at this time. (i.e., It could be that negative valence effects on non-predicted target accuracy in the emotional orienting task were not detected in the recognition task because non-predicted targets were underrepresented in the recognition stimulus set.) Follow-up work will need to examine whether valence effects on non-predicted target accuracy are mirrored in the recognition test when non-predicted targets are systematically included. If this work still reveals a presence of valence effects in the orienting task and an absence of such effects on word memory scores, then the above argument on negative cues and disrupted categorical reasoning will apply.

Mood Effects

The effectiveness of various picture types to induce congruent mood states was determined by looking at participant mood scores after the last block of the emotional orienting task. Based on the reported efficacy of IAPS pictures to induce corresponding emotional states (Lane et al., 1997; Lang et al., 1995), it was expected that positive pictures would elicit higher (more positive) mood ratings, whereas negative pictures would trigger lower mood ratings, and neutral pictures would lead to neutral mood scores. If instructions to attend and suppress had been fulfilled, this pattern of picture-induced mood scores should have held true for the attend group, whereas the suppress group should have displayed much weaker cue-evoked mood induction. In combination with other analyses, mood induction checks were suggestive of whether instructions to attend and suppress were fulfilled.

In fact, mood checks conducted after the emotional orienting task revealed that participants' moods were affected by the valence of the last block of testing they received, irrespective of group. Results confirmed the predicted pattern of valence effects, illustrating superior mood reports after positively cued task blocks, followed by neutral blocks, and lastly by negative blocks. However, closer inspection revealed that mean mood scores were positive, regardless of which block of testing was administered last (although those recorded after the negative block of the emotional orienting task were significantly less positive than those reported following neutral or positive blocks). Because negative moods are typically reported following exposure to negative IAPS photos (Lane et al., 1997), the reduction of this effect in the current study suggests that cue-induced emotion processing was interrupted by target identification attempts, consequently disrupting mood induction. Another explanation for the lack of negative mood involves an unwillingness of participants to permit negative mood induction. A desire to protect against negative mood might also underlie the reorienting delays to negative cues displayed in the emotional orienting task.

There were no group differences in post-task mood ratings, thus whether participants were instructed to look at pictures or avoid saccading to pictures, no influence on post-task mood was observed. Previous work has provided evidence that attentional manipulations can alter affective states. For instance, Lane et al. (1997) found significant differences in reported emotionality based on whether participants attended or ignored emotional features of pictorial stimuli. Similar attention-based variability in emotional responding has been revealed in neural studies in which attentional availability to emotional items has been linked to greater activity in limbic system centers (Holmes et al., 2003; Lane et al., 1997; Lane et al., 1999; Pessoa et al., 2002). Thus if attend and suppress instructions had fully been implemented by participants in the current study, group effects on mood should have been observed. Together with the emotional orienting task and recognition task results, the similarities in group mood scores suggest that the attend groups failed to fully/consistently look at pictures and/or the suppress groups did not inhibit saccades to cues. Once more, based on recognition test results, it appears that attend group instructions may have been neglected in the positive and neutral blocks and that suppress group instructions were disregarded in the negative block.

A final series of positive pictures was shown before participants left the laboratory in an attempt to induce positive moods (and to alleviate potential residual negativity from exposure to negative pictures). The mean mood rating following the final set of positive pictures was 6.86, indicating that in general, the picture series functioned to elicit more positive mood states. Moreover, comparisons between emotional orienting task-induced mood (first mood check) and positive picture series-induced mood (final mood check) revealed that, overall, mood reports were more positive following the final picture series than following the emotional orienting task, regardless of which block valence was viewed last. A between-group examination of the change in mood from first to final mood check illustrated that final mood checks were significantly more positive than first mood checks for the attend SS, suppress SS, and suppress OS groups, whereas first and final mood checks for the attend OS group were not significantly different. The reason for this group effect is unclear.

Implications

Attention Control

Attention deployment has been deemed one of the main strategies for emotion regulation, yet objective-based research examining the practicality of this regulatory technique has been limited. Although many emotionally oriented attention studies have been conducted, most have used stimulus sets and task designs that are unsuitable for assessing attention control as a means of emotion regulation. By incorporating a broader selection of emotional stimuli, the current study's results can be discussed in terms of the feasibility of attention-based emotion control.

If our findings had illustrated fulfillment of group instructions across valences, this would have supported attention deployment as a means of affect control. Although between-group differences in target accuracy difference scores in the neutral emotional orienting block would suggest that instructions to suppress were attempted, predicted trial target categorization showed limited group variability, reflecting either participants' inability to follow attentional instructions or a failure of the task design to expose attentional manipulations through target categorization. The former of these two explanations seems to be the case given the absence of group differences in picture and word memory scores and post-emotional orienting task mood ratings. More specifically, based on the relatively low memory scores for neutral pictures, overall participants seemingly adopted a strategy of ignoring neutral cues. Similarly, comparatively low memory scores for positive pictures could imply that participants failed to consistently attend to positive pictures (even when instructed to do so). However, 'hits' for emotional orienting task pictures of both neutral and positive valences were greater than 'false alarms' for new pictures of those valences, which suggests that a certain degree of neutral and positive cue processing occurred in the emotional orienting task. Negative picture memory scores, on the other hand, were high across groups, hinting at an inclination to attend to negative cues, regardless of group status. Thus, considering the current study's results, attention control does not appear to be an easily implemented form of emotion regulation.

Effective emotion control strategies enable individuals to deal with life's every day ordeals and function competently in spite of emotional disturbances. Control strategies also hold clinical relevance in designing therapeutic interventions for treating mood disorders and other psychiatric conditions characterized by affective symptoms. The difficulties in attention control witnessed in the current study may highlight a need to explore other mood regulation techniques to supplement or substitute this form of affect control.

Valence-Specific Effects

Nonetheless, the current study's results are theoretically meaningful, providing insight regarding valence-specific influences on attentional processes. Based on the congregate of emotional orienting and recognition task results (negative valence effects on target categorization, but not on target recognition), negative contexts may permit intact information processing/encoding, but hinder categorical judgments, at least under certain conditions. It must be recognized, however, that negative valence effects in the emotional orienting task reflect disrupted non-predicted target accuracy. Once more, recognition task stimuli were selected at random, and as a result most of the chosen emotional orienting words were from predicted trials. Therefore, the lack of negative valence effects on word memory scores could be attributable to an underrepresentation of non-predicted targets in the recognition task. Future studies will need to establish whether valence effects on word memory scores are still absent when a sufficient portion of non-predicted targets are included.

Valence effects also appeared in the form of reorienting difficulties to negative material, as illustrated by inaccurate categorization of negatively cued non-predicted, same side targets in the emotional orienting task. This effect may reflect an evolutionary response in which impeded reengagement with negative or threatening stimuli would have promoted initiation of appropriate survival behaviours. Reduced reorienting to negative information may also represent an adaptive coping mechanism for preventing rumination and protecting against mood deterioration. Because individuals who participated in the current experiment represented a healthy, non-clinical sample, negativity-induced reengagement delays might have been especially prominent. If a clinical group had been included in the study, divergent results may have been obtained. Alternatively, negative items may be processed more quickly than neutral or positive stimuli, and so the need to reorient to negative stimuli may be weaker than for other types of information. Indeed, the high memory scores for negative pictures in the recognition test suggest that negative cues were processed superiorly (and conceivably more quickly) than neutral or positive cues.

Future Directions

Task Adaptations

Future use of the current study's emotional orienting task would benefit from certain modifications. As mentioned, a lack of group variability in predicted target categorization, post-task mood induction scores, and cue and target recognition accuracy would suggest that attention to cues was not allocated/withheld differently across groups. The inability to follow task instructions implied by these between-group similarities could reflect a basic difficulty in saccadic control to pictorial stimuli, or might be attributable to inappropriate emotional orienting task timing. If the timing was adjusted, instructional adherence might be encouraged, in turn exposing expected between-group differences. More specifically, this could be accomplished by using different stimulus durations or SOAs. Alternatively, altering the angular distance of stimuli from fixation could potentially serve to enhance group variability. The persistence of this inability or unwillingness to follow group instructions could also be examined across motivational states. A follow-up study that provided participants with incentive motivation to follow instructions might enable a more valid assessment of attentional effects on target accuracy, memory scores, and mood induction. Such a study could also help determine whether selective attention to emotional stimuli is more feasible in highly motivated states, or whether the control deficits seen here are largely insurmountable.

Another worthy amendment involves addressing cue-target predictive contingencies in the recognition task. Old recognition task stimuli were selected randomly from emotional orienting task picture and word sets. Although selected stimuli were balanced across valences, word categories (indoor/outdoor), and stimulus properties (picture valence ratings, word frequencies, etc.), the trial predictability (80% vs. 20%) of the selected emotional orienting stimuli was not controlled. Stimuli were selected randomly, so most recognition items were from predicted trials, but more accurate interpretations could be made if recognition data were analyzed separately for predicted and non-predicted trials.

Extending the current experiment's tasks (or improved versions thereof) for use with clinical groups would also be a worthwhile endeavour. Affective dysregulation is among the core symptoms of a number of psychological and psychiatric disorders (Beauregard et al., 2001; Radulescu & Mujica-Parodi, 2008). Emotional disturbances have specifically been attributed to attentional problems for some of these conditions. A disability to consciously screen out affective information can be seen in a number of illnesses, both psychological and somatic, including depression, alexithmia (the inability to express emotion with words), panic disorder, generalized anxiety disorder, hostile personality, hypertension, and coronary heart disease (Thayer & Lane, 2000). Attentional biases to threat have been emphasized as potential etiological/maintenance factors for anxiety disorders, and biases for negativity have also been reported in people with depression, though less robustly (Fox et al., 2001). Indeed, Murphy et al. (1999) found enhanced vigilance for unpleasant items in individuals with depression, as well as greater detection of happy images in manic patients. Thus, the current study's tasks should be sensitive to the defining affective features of a variety of clinical conditions. More precisely, clinical sample results would be expected to reflect reduced inhibition, speeded reorientation, and delayed disengagement for trait-congruent stimuli.

Dividing study groups based on nonclinical criteria might also prove to be informative. According to Most et al. (2005), the ability to prevent distraction by emotional stimuli is strongly linked to personality traits with individuals high in harm avoidance displaying weaker attention control relative to those low in this trait. Future efforts to decompose subject pools by personality type might reveal similar variability in the current study's tasks. Such a finding might suggest that strategic attention-based emotion control is attainable for individuals with specific personality traits, whereas others should pursue alternative forms of emotion control.

Multidisciplinary Collaborations/Extensions

Affective research is exciting in that it integrates findings from a number of fields to provide a detailed and multifaceted account of human emotion and its regulation. Though individual disciplines can be informative in understanding particular aspects of emotion, each holds its own drawbacks and limitations. By uniting multidisciplinary methods, affective studies can overcome these boundaries. For example, by combining subjective and biological forms of assessment with more objective tasks, methodological biases and uncertainties can be addressed. Moreover, by pursuing interdisciplinary collaborations a more comprehensive description of emotion and its constituents can be achieved.

By combining the current study's task with other measures of emotion control, a range of research questions could be addressed. One exciting possibility involves merging hormone analysis techniques with emotional orienting testing given that hormone levels have been found to fluctuate as a function of emotion regulatory abilities. A study by Urry, van Reekum, Johnstone, Kalin, Thurow, Schaefer et al. (2006) categorized participants as successful or unsuccessful emotion regulators based on neural responses during reappraisal of negative scenes. Those who showed greater prefrontal activation and lower amygdala activity (successful regulators) were found to have more stable cortisol levels throughout the day, whereas those who were unable to attenuate amygdala reactivity (unsuccessful regulators) showed steep increases in cortisol from morning to night. A similar trend is described in the developmental literature in which children who are at-risk for developing depression show higher and more variable cortisol levels (Halligan, Herbert, Goodyer, & Murray, 2004). Kovacs et al. (2008) postulated that high childhood cortisol levels may affect the function and maturation of key regulatory networks. Thus, attentional forms of emotion regulation should deteriorate with higher daily cortisol concentrations, and a revised version of the emotional orienting task would be expected to reflect this relation. Furthermore, based on the available literature, this pattern should be apparent across age groups. Recognition task accuracy would also be interesting to analyze across hormone levels, given that heightened adrenaline and noradrenaline concentrations have been linked to memory enhancement for emotional events (Cahill et al., 1995).

Another potential biological-cognitive collaboration could draw upon molecular analyses and emotional orienting testing. Differences in emotion control have been linked to specific allelic variants. Most candidate genes thought to underlie affective regulation are involved in dopamine and serotonin transmission. For instance, Bishop, Cohen, Fossella, Casey, and Farah (2006) found evidence for an association between emotion regulatory abilities and certain variants of the catechol-O-methyltransferase (COMT) gene, which codes for an enzyme that degrades dopamine. When a particular site of this gene is occupied by the valine codon, enzymatic dopamine degradation increases, and lower dopamine concentrations are found in the prefrontal cortex. Alternatively, if methionine occupies this site, dopamine levels increase and attentional control and executive functions improve accordingly (Bishop et al., 2006). Genes responsible for serotonin function have also been linked to emotion regulation through their influence over corticolimbic circuit activity and consequent emotional behaviours. Hariri and Holmes (2006) reported that genetic variants of the serotonin transporter, which removes serotonin from the synaptic cleft, affect the development and strength of neural pathways involved in emotion regulation. Individuals with one or two copies of short variants of the serotonin transporter polymorphism display reduced extracellular transport of serotonin, which shifts the amygdala toward hyper-excitability through a complex series of events. By assessing specific types of regulatory skills as a function of genotype, the affective control deficits triggered by these genetic variants can be pinpointed. Thus, assessing emotion-based attention control across individuals with variable COMT and synaptic transporter gene alleles could determine whether some of the phenotypic variability in emotion control is attributable to attentional problems.

Another quantifiable physical trait that seems to reflect emotion control is heart rate variability. Limbic system and regulatory pathway activity is known to modify heart rate through the stellate ganglia and vagus nerve, and dysfunction of these networks can result in reduced heart rate variability. This CNS-cardiovascular link lends insight to a number of affect-health related questions. Some work has suggested a link between heart rate variability and affective pathologies (Friedman & Thayer, 1998). For example, reduced heart rate variability has been observed in those with poor emotion regulatory abilities, panic and anxiety disorders, and depression (Friedman & Thayer, 1998; Thayer et al., 2000). Thus, heart rate variability seems to represent an objective, quantifiable means of assessing regulatory abilities. The use of heart rate variability as a signal of affective disruption or competence could be strengthened by additional objective measures. For instance, if future studies using a modified emotional orienting task were to reveal a correspondence between selective attention to affective items and heart rate variability, the relation between emotion regulation and cardiovascular function would be further supported.

Other research avenues could draw upon neuroimaging techniques to examine the brain basis of affective-attention control. By having individuals complete the current study's tasks while undergoing modern imaging techniques, the neural correlates of specific cognitive-affective processes could be explored. Although a number of studies have investigated the brain basis of emotion regulation (Beauregard et al., 2001; Holmes et al., 2003; Lane et al., 1997; Lane et al., 1999; Ochsner et al., 2002; Pessoa et al., 2002), those that have focused on attention-based regulatory approaches (Holmes et al., 2003; Lane et al., 1997; Lane et al., 1999; Pessoa et al., 2002) have not considered saccadic control to emotional stimuli. In the real world, selective attention and eye movements tend to work in synchrony (Kowler, 1995). As a result, tasks that tap into overt orienting and saccadic inhibition are ideal for studying attention control as a means of emotion regulation. Thus, combining fMRI with paradigms such as the emotional orienting task, which requires control over overt orienting (saccades), might provide a more realistic evaluation of the neural processes involved in attentional emotion control.

Certain questions that could be addressed by pairing fMRI with a revised emotional orienting task deal with the regional and hemispheric localizations of cognitive-affective interactions. For instance, an imaging study of this nature could compare which limbic structures and prefrontal regions are engaged during attentional allocation versus inhibition. Moreover, the ratio of prefrontal to limbic activity could be examined across task demands (attend OS and SS; suppress OS and SS) and stimulus valences (neutral, negative, or positive) to evaluate the relative degree of emotion processing and inhibitory control elicited by diverse variable combinations. It might also be interesting to consider between-group and cross-valence differences within the PFC. For example, distinct patterns of lateral and ventral prefrontal activation could occur across conditions and valences, given that the lateral PFC has conventionally been associated with non-affective executive functions and the ventral PFC has been linked to affective processing

(Le Doux, 1996; McClure et al., 2007). Divergent orbitofrontal responses would also be predicted to appear across cue valences, seeing as how orbitofrontal activity is thought to be involved in reward processing. In addition to regional observations, hemispheric functions could be delineated in future emotional orienting extensions. According to Wager et al. (2003), positive valences may preferentially activate the left hemisphere whereas negative valences may prompt enhanced right prefrontal activation. Differential hemispheric activity would also be expected to appear during target processing, given that targets are word stimuli and language processing is typically supported by the left hemisphere (Corina et al., 1992). It would be exciting to see if hemispheric differences related to cue processing would influence subsequent target induced activity (either through competitive or additive interactions). Finally, the degree of limbic and prefrontal activity recorded in a study of this sort could be weighed against previous emotion control task findings to establish the relative efficiencies at which various strategies attenuate amygdala responding without exhausting prefrontal resources.

If future studies find that emotional orienting results comply with the endocrine, molecular, and cardiovascular measures mentioned above, the current paradigm (or a modified version thereof) may eventually hold clinical relevance as a marker task or diagnostic aid. Additionally, training with attentional tasks such as this may prove useful in strengthening affect control strategies and improving therapeutic outcomes. Finally, imaging studies with the emotional orienting task might contribute to our knowledge of limbic and prefrontal function and could help describe how these systems interact under a range of affective conditions.

Developmental Extensions

Use of the emotional orienting task in developmental experiments may also prove to be a valuable study extension. Investigations of childhood emotion regulation are needed for a number of reasons. First, childhood affective studies can examine patterns of adaptive and maladaptive regulation across development, potentially revealing etiological factors of adult affective conditions. Second, emotional decision making and emotion control undergo rapid development during the preschool years, emphasizing the importance of studies of this nature (Crone & Van der Molen, 2004; Kopp, 1989; Zelazo & Cunningham, 2007). Third, children's aptitude to regulate emotions has been linked to a number of social and intellectual traits, such as popularity among peers (Calkins, 1994) and academic commitment and achievement (Gumora & Arsenio, 2002). Thus, by administering valid measures of emotion control, success and difficulty in other areas of development (social, intellectual, academic) may be elucidated and appropriate childhood interventions can be provided.

Previous research has examined emotion regulation in early life, focusing mainly on temperament control and use of attentional skills. In fact, attentional abilities have been tied directly to overall capacity for emotion control (Eisenberg & Guthrie, 2000). Yet, such studies have used general executive attention tasks as an index of emotion control and have neglected to consider attentional abilities in emotional contexts. Though basic attention control appears to be associated with emotion regulation, performance on affective attentional tasks should provide an even stronger predictor. By extending the current task for use in children, existing gaps in the affective developmental literature can be addressed.

However, use of the emotional orienting task may only be suitable for children of age six and older. It is generally agreed that children under the age of six do not understand tasks that require control over eye movements. Moreover, inhibition of saccades is still quite poor from seven to ten years of age, though the ability to suppress saccades improves progressively during this time (Fukushima, Hatta, & Fukushima, 2000). Thus, the emotional orienting task may not be fit for use with children under the age of six. Other inhibitory control paradigms may be needed to study affect-based attention control in pre-school aged children. Nonetheless, the emotional orienting task may be useful for studying selective attention to emotional stimuli in school-aged children and adolescents.

Conclusions

Though the current task is not without limitations (e.g. non-ideal task timing, problems with stimulus selection in the recognition task), it does hold potential to address a number of practical research questions and give rise to a variety of future study endeavours. As mentioned, future versions of the emotional orienting task may be helpful in studying affective biases in certain clinical populations. It may also be useful as a complement to other measures of affect control, including biological methods such as hormone analysis, allele sequencing, and heart rate assessment. In addition, the current study's emotional orienting task might be a helpful supplement to other affective attention tasks in that it holds the methodological advantage of providing an isolated measure of reorienting responses. Moreover, the current study's findings are theoretically meaningful, revealing potential affective influences on categorical decisions and attentional processes. Together, the negative emotional orienting and recognition task findings indicate that negative cues may permit information processing/encoding, but impede categorical decisions under certain contexts. Follow-up studies with revisions to the recognition task are needed to examine this possibility. Additionally, negative valence effects appeared in the form of delayed reorienting to negative cues. This effect may reflect an evolutionary adaptation in which delayed reorienting to negatively salient items would have promoted initiation of survival responses. Reduced reorienting to negative stimuli may also be a strategy used by healthy individuals to protect against mood deterioration. Alternatively, valence specific reorienting effects might reflect speeded processing of negative information and a corresponding indifference for reorienting to locations where negative material appeared. Finally, the current study's results suggest that selective control of attention is impractical as a regulatory strategy and that different challenges arise with different emotional valences; problems may exist in allocating attention to task irrelevant neutral and positive material, whereas negative information appears to be difficult to ignore.

These findings contribute new information to our understanding of affective-cognitive and affective-attentional interactions in healthy young adults.

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APPENDIX A: TABLES

Table 1. Group predictions for the neutral block of the emotional orienting task.

	Predicted Target Accuracy	Non-predicted Target Accuracy	Accuracy Difference Score (predicted-non-predicted)
Suppress OS	⇧	⇩	⇧
Attend SS	⇧	⇩	⇧
Suppress SS	⇩	⇧	⇩
Attend OS	⇩	⇧	⇩

Table 2. Group predictions for the neutral and emotional blocks of the emotional orienting task.

	Neutral Predicted Target Accuracy	Neutral Non-predicted Target Accuracy	Neutral Accuracy Difference Score	Emotional Predicted Target Accuracy	Emotional Non-predicted Target Accuracy	Emotional Accuracy Difference Score
Suppress OS	⇧	⇩	⇧	⇩	⇧	⇩
Attend SS	⇧	⇩	⇧	?	⇩	?
Suppress SS	⇩	⇧	⇩	⇧	⇩	⇧
Attend OS	⇩	⇧	⇩	⇩	?	⇩

Table 3. Group predictions for the cue and target recognition tests.

	Pictorial Cue Recognition	Target Word Recognition
Suppress OS	⇩	⇧
Attend SS	⇧	⇧
Suppress SS	⇩	⇩
Attend OS	⇧	⇩

Table 4. Group predictions for the mood induction check following neutral, negative, and positive blocks of the emotional orienting task.

	Neutral	Negative	Positive
Suppress OS	No mood effects	No mood effects	No mood effects
Attend SS	Neutral mood	Negative mood	Positive mood
Suppress SS	No mood effects	No mood effects	No mood effects
Attend OS	Neutral mood	Negative mood	Positive mood

Table 5. Mean valence ratings and standard deviations (SD), mean arousal ratings and standard deviations (SD), and extreme valence ratings for negative, neutral, and positive emotional orienting task cues. Examples of pictures with the listed ratings are provided below.

	Mean Valence Rating (SD)	Mean Arousal Rating (SD)	Extreme Valence Ratings
Negative	2.95 (0.80)	5.66 (0.78)	1.67
	Terrorist		Starving child
Neutral	5.00 (0.37)	3.20 (0.78)	-
	Neutral man		
Positive	7.2 (0.57)	4.84 (0.72)	8.32
	Smiling children		Puppies

Table 6. Mean valence and arousal ratings for new and old recognition task pictures of negative, neutral, and positive valences.

	New		Old	
	Mean Valence	Mean Arousal	Mean Valence	Mean Arousal
Negative	2.58	5.92	2.78	5.44
Neutral	4.93	2.96	5.14	3.29
Positive	7.16	4.86	7.34	4.78

Table 7. Mean word lengths and written frequencies for indoor and outdoor words from the three emotional orienting task words lists.

	Indoor Words			Outdoor Words		
	List A	List B	List C	List A	List B	List C
Length	6.10	5.55	5.33	5.38	5.40	5.28
Frequency	30.73	34.98	34.53	31.78	27.68	28.78

Table 8. Mean word lengths and written frequencies for new and old indoor and outdoor words used in the recognition task.

	New		Old	
	Length	Frequency	Length	Frequency
Indoor	5.80	53.27	5.53	51.67
Outdoor	5.33	27.87	5.27	22.80

Table 9. Mean response times and standard deviations (SD) and mean correct response times and standard deviations (SD) for targets in the neutral block of the emotional orienting task.

	Mean Response Time Difference Score (SD)	Mean Correct Response Time Difference Score (SD)
Attend OS	74.89 (274.54)	45.79 (213.45)
Attend SS	182.89 (267.14)	107.66 (270.80)
Suppress OS	162.34 (257.84)	183.39 (369.26)
Suppress SS	42.02 (403.58)	41.67 (312.27)

Table 10. Mean response times and standard deviations (SD) and mean correct response times and standard deviations (SD) for targets in the neutral, negative, and positive blocks of the emotional orienting task.

	Mean Response Time Difference Score (SD)	Mean Correct Response Time Difference Score (SD)
Neutral	115.53 (307.47)	94.63 (297.91)
Negative	95.66 (429.33)	104.77 (479.88)
Positive	188.82 (327.04)	196.23 (434.14)

Table 11. Neutral, negative, and positive picture memory scores for attend OS, attend SS, suppress OS, and suppress SS groups.

	Neural Picture Memory Score	Negative Picture Memory Score	Positive Picture Memory Score
Attend OS	.10 (.24)	.27 (.20)	.20 (.26)
Attend SS	.08 (.19)	.17 (.21)	.21 (.19)
Suppress OS	.03 (.22)	.23 (.27)	.07 (.19)
Suppress SS	.05 (.19)	.26 (.18)	.10 (.16)

Table 12. Neutrally, negatively, and positively cued target word memory scores for attend OS, attend SS, suppress OS, and suppress SS groups.

	Neutrally Cued Word Memory Score	Negatively Cued Word Memory Score	Positively Cued Word Memory Score
Attend OS	.40 (.20)	.41 (.25)	.47 (.20)
Attend SS	.38 (.27)	.49 (.15)	.38 (.29)
Suppress OS	.30 (.25)	.40 (.28)	.39 (.28)
Suppress SS	.37 (.24)	.52 (.17)	.47 (.19)

Table 13. Mood ratings following the neutral, negative, and positive blocks of the emotional orienting task for attend OS, attend SS, suppress OS, and suppress SS groups.

	Neutral Mood Check	Negative Mood Check	Positive Mood Check
Attend OS	6.25 (1.39)	5.75 (1.28)	7.50 (1.69)
Attend SS	6.00 (0.76)	4.38 (1.51)	5.75 (1.75)
Suppress OS	6.00 (1.60)	5.38 (1.06)	5.88 (1.55)
Suppress SS	5.75 (1.49)	5.63 (1.30)	7.00 (1.41)

APPENDIX B: FIGURES

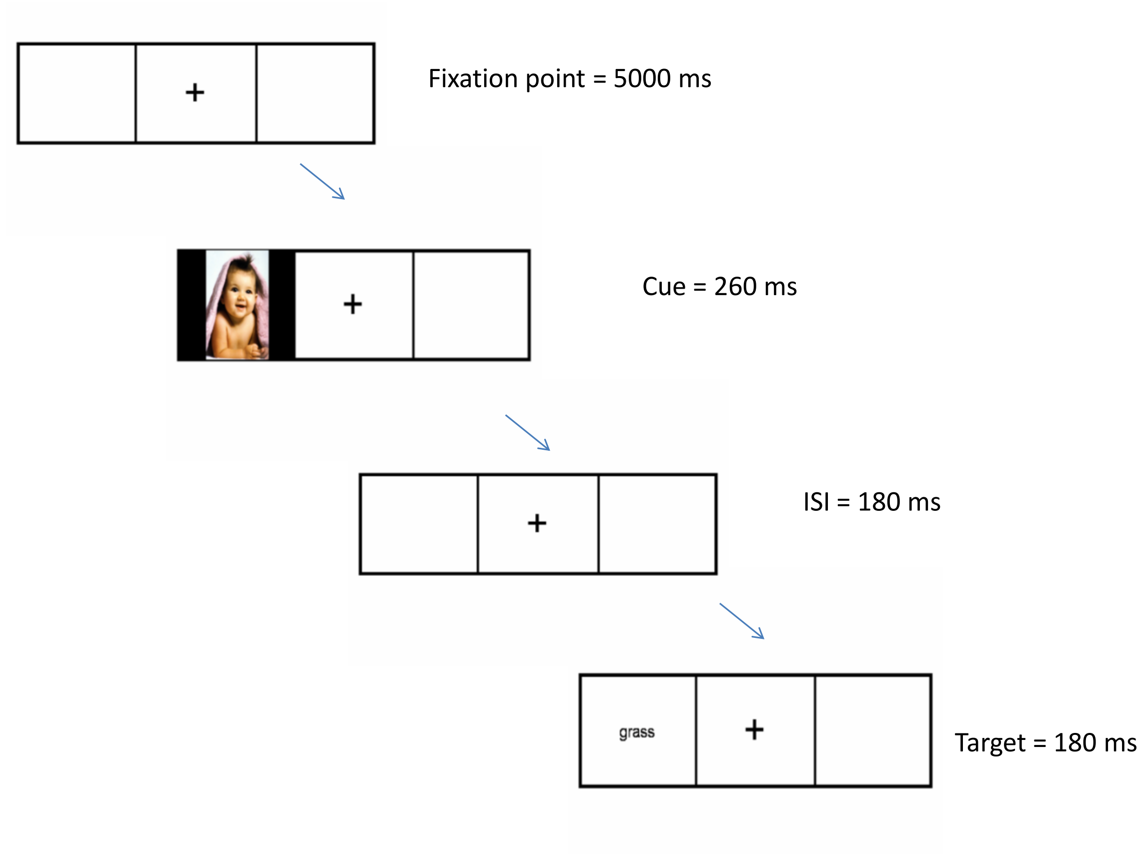


Figure 1. Sequence of trial events in the emotional orienting task.

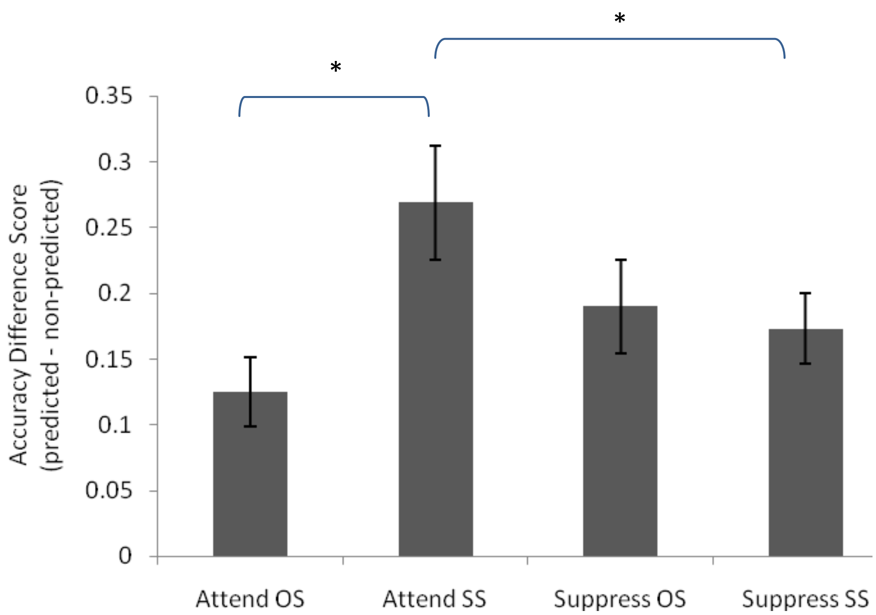


Figure 2. Mean accuracy difference scores for word categorization in the neutral block of the emotional orienting task. The difference between predicted and non-predicted word categorization accuracy was significantly larger for the attend same side group than the attend opposite side group and suppress same side group. The suppress opposite side group was not significantly different from the other groups in terms of predicted versus non-predicted word accuracy scores. Error bars represent standard error.

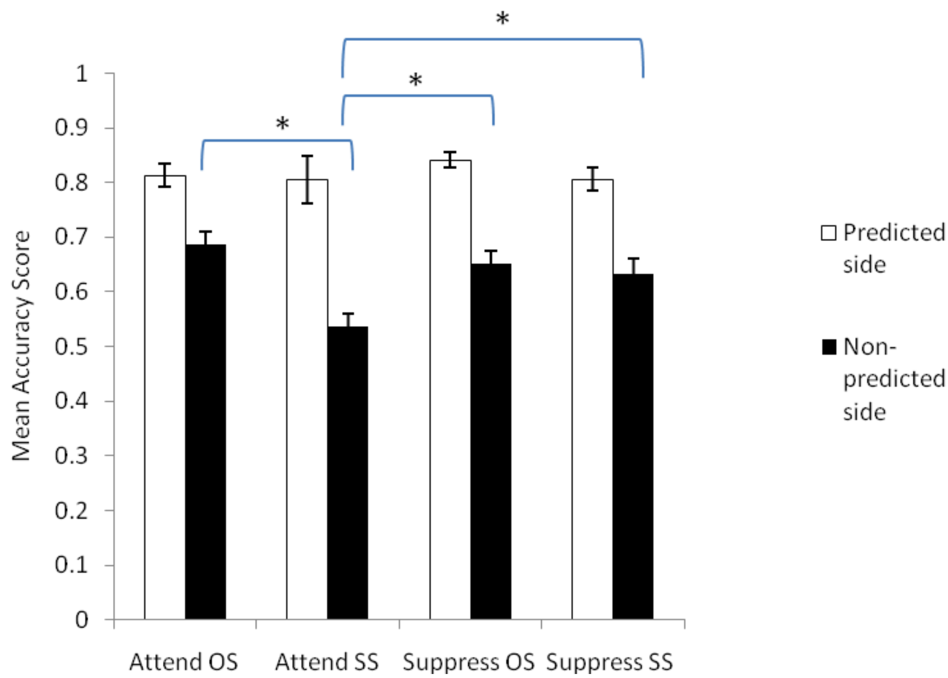


Figure 3. Mean accuracy scores for word categorization in the neutral block of the emotional orienting task. Word categorization performance was comparable across groups for words appearing on the predicted side, but word categorization performance was significantly worse for the attend SS group when words appeared on the non-predicted side. Error bars represent standard error.

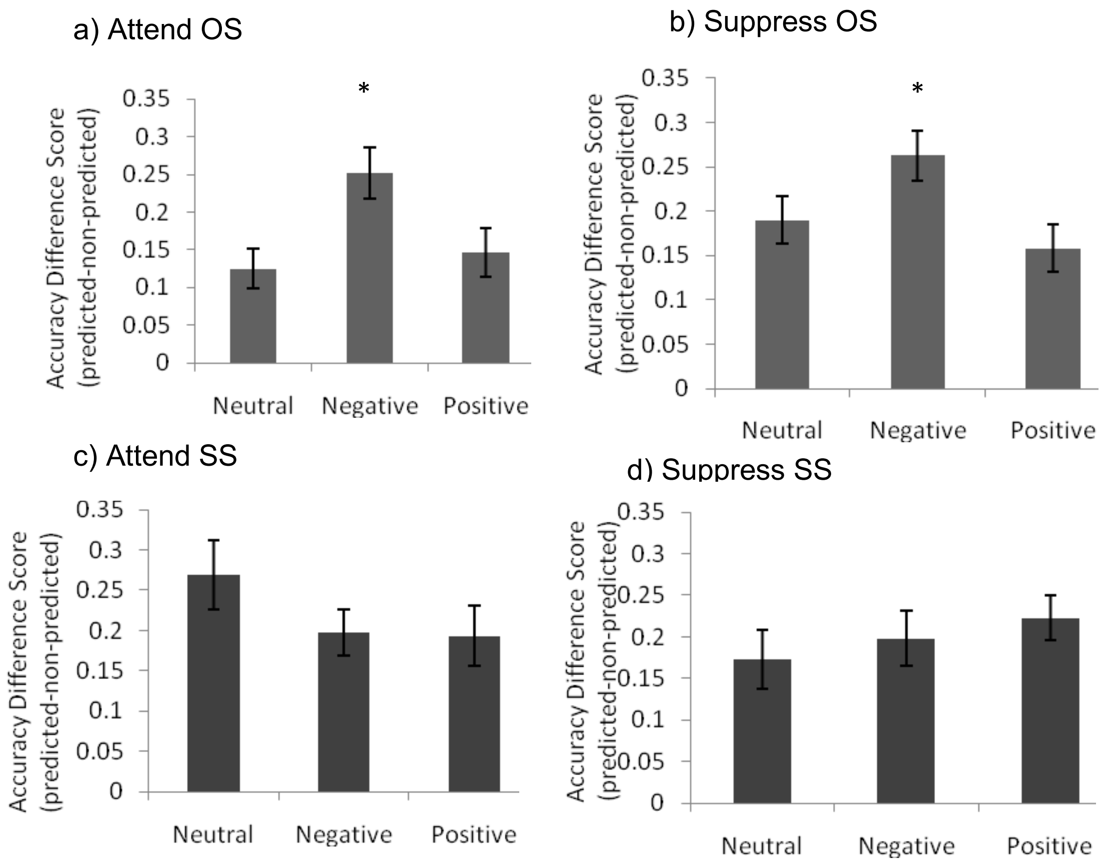
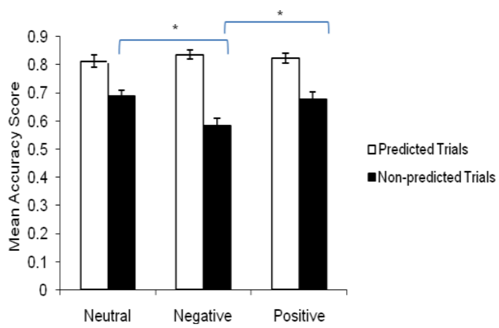
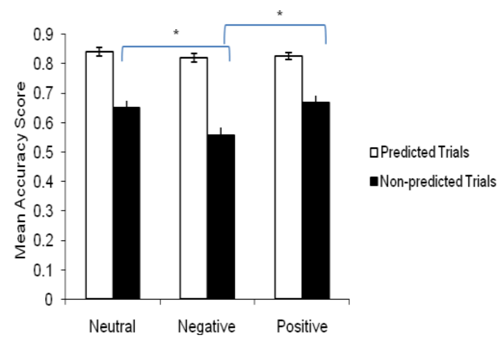


Figure 4. Mean accuracy difference scores (predicted - non-predicted) in the neutral, positive, and negative blocks of the emotional orienting task for the (a) Attend OS, (b) Suppress OS, (c) Attend SS, and (d) Suppress SS groups. Error bars represent standard error.

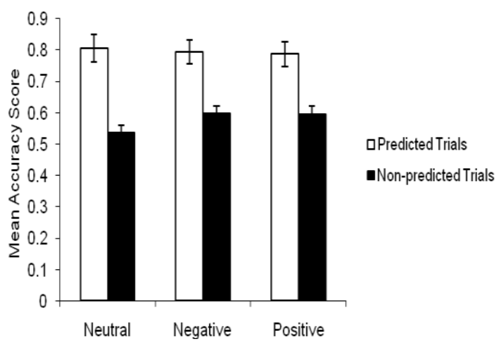
a) Attend OS



b) Suppress OS



c) Attend SS



d) Suppress SS

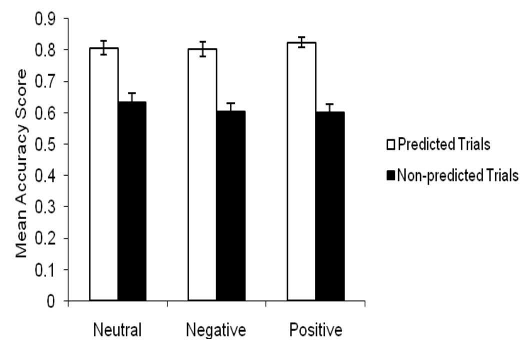


Figure 5. Mean accuracy scores for predicted and non-predicted target word categorization in the neutral, positive, and negative blocks of the emotional orienting task for the (a) Attend OS , (b) Suppress OS, (c) Attend SS, and (d) Suppress SS groups. Error bars represent standard error.

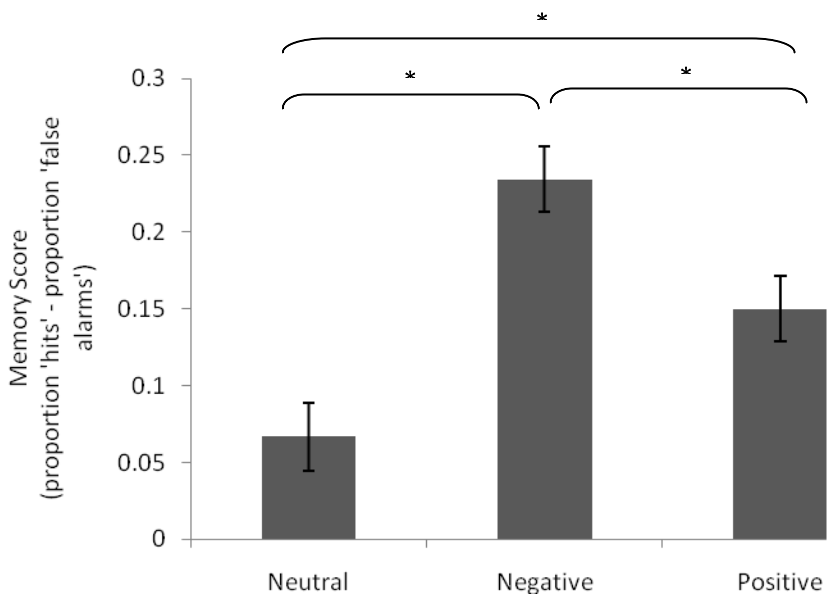


Figure 6. Mean memory scores (proportion ‘hits’ – proportion ‘false alarms’) for recognition task pictures of neutral, negative, and positive valences. Memory scores were highest for negative pictures, followed by positive pictures, and lastly by neutral pictures. Error bars represent standard error.

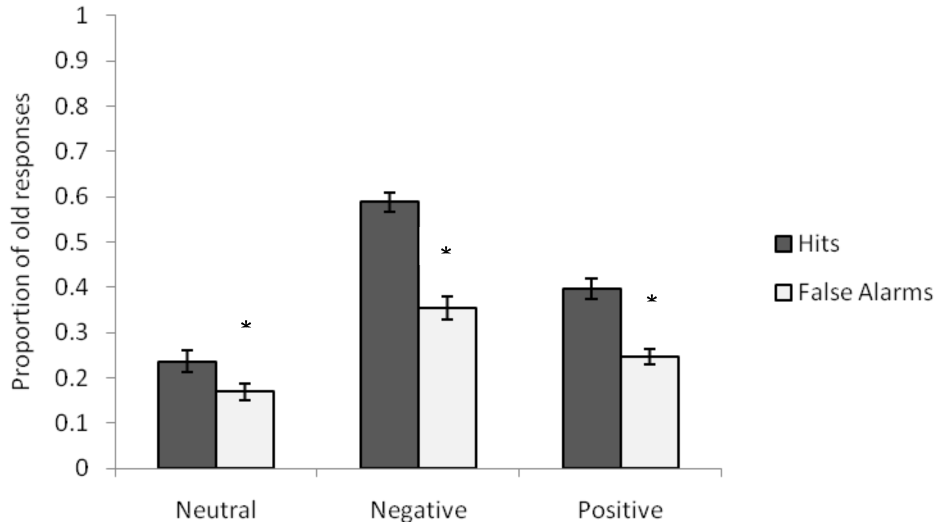


Figure 7. Mean proportion of hits made for old recognition task pictures and false alarms made for new recognition task pictures of neutral, negative, and positive valences. The proportion of hits for old pictures was significantly greater than the proportion of false alarms for new pictures for all three valences. Error bars represent standard error.

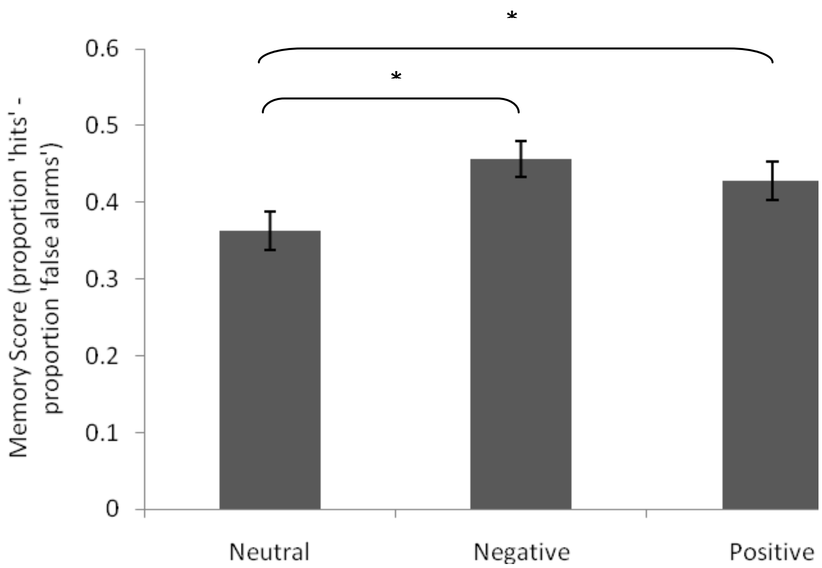


Figure 8. Mean memory scores (proportion ‘hits’ – proportion ‘false alarms’) for recognition task words from the neutral, negative, and positive blocks of the emotional orienting task and new length- and frequency-matched counterparts. Memory scores were significantly higher for negatively and positively cued words than neutrally cued words. Error bars represent standard error.

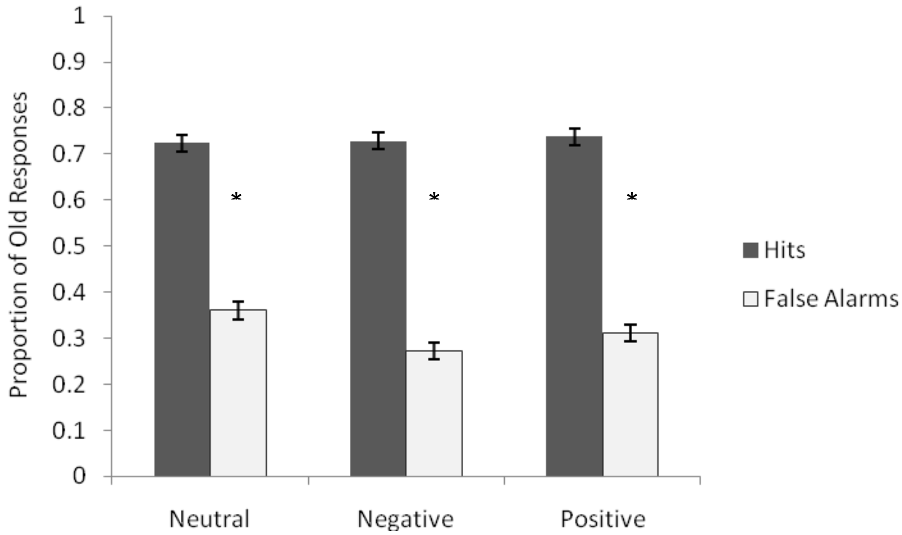


Figure 9. Mean proportion of hits made for old recognition task words from neutral, negative, and positive blocks of the emotional orienting task and false alarms made for new length- and frequency-matched words. The proportion of hits for old neutrally cued, negatively cued, and positively cued words was significantly greater than the proportion of false alarms for new word counterparts. Error bars represent standard error.

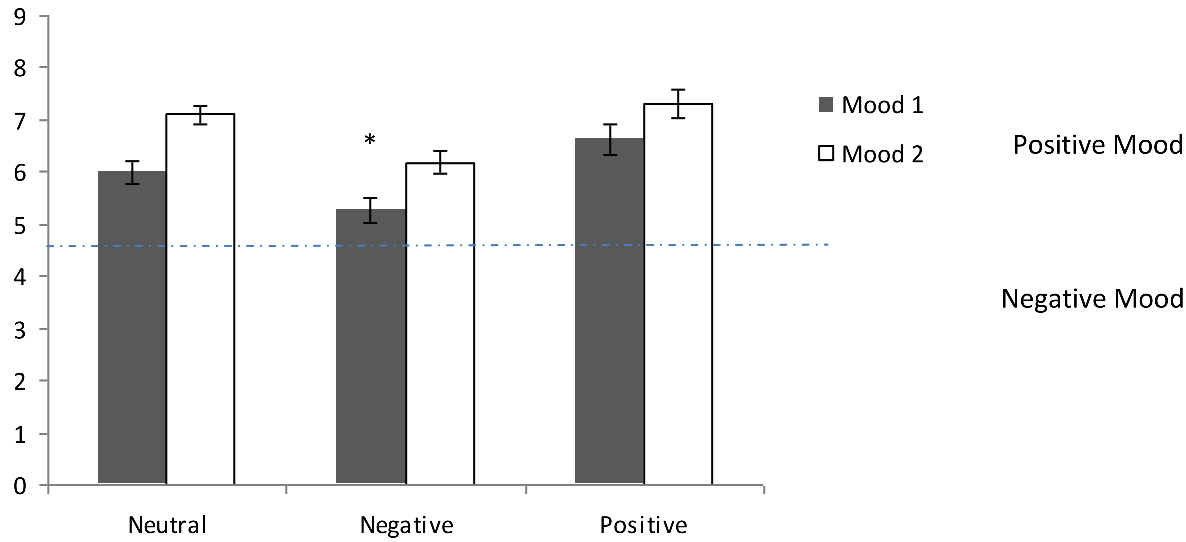


Figure 10. Mood scores recorded following neutral, negative, and positive blocks of the emotional orienting task (Mood 1). Participants who last received the negative block reported the least positive mood ratings. Mood scores recorded following the positive picture series (Mood 2) were significantly higher than those recorded following the emotional orienting task. Error bars represent standard error.

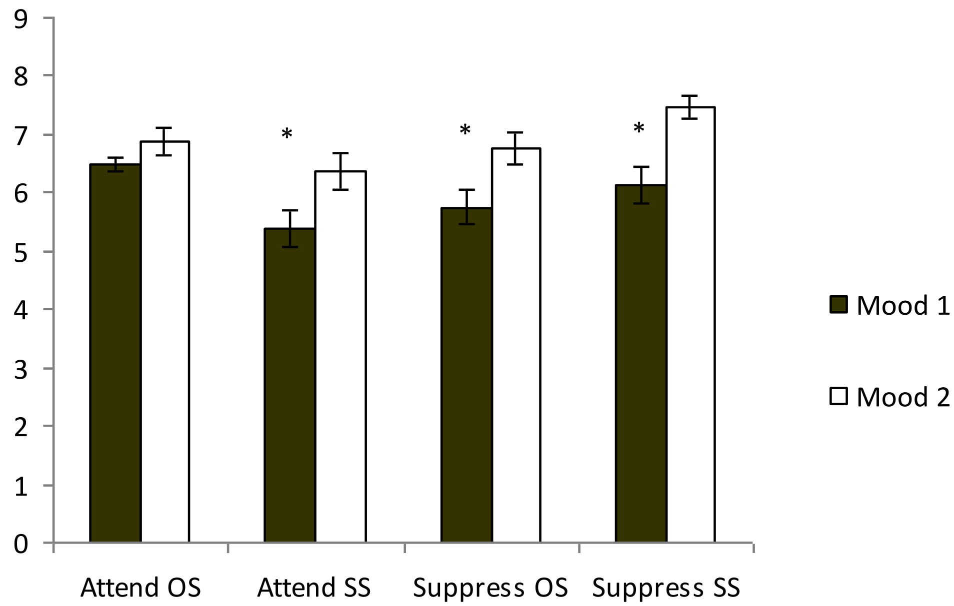


Figure 11. First and final mood ratings for the Attend OS, Attend SS, Suppress OS, and Suppress SS conditions. All groups except the Attend OS group showed a significant positive change in mood from the first to final mood check. Error bars represent standard error.