LOCAL ATTENTIONAL BIAS INCREASES APPROACH MOTIVATION: EVIDENCE FROM EVENT-RELATED POTENTIALS AND FREQUENCY ANALYSES

A Dissertation

by

PHILIP ARVIS GABLE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfilment of the requirements of the degree of

DOCTOR OF PHILOSOPHY

May 2010

Major Subject: Psychology

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ABSTRACT

Local Attentional Bias Increases Approach Motivation:
Evidence from Event-Related Potentials and Frequency Analyses. (May 2010)
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Chair of Advisory Committee: Dr. Eddie Harmon-Jones

Over twenty years of research have examined the cognitive consequences of positive affect states, and suggested that positive affect leads to a broadening of cognition. However, this research has primarily examined positive affect that is low in approach motivational intensity (e.g. contentment). In my program of research, I have systematically examined positive affect that varies in approach motivational intensity, and found that positive affect high in approach motivation (e.g. desire) narrows cognition, whereas positive affect low in approach motivation broadens cognition. In this dissertation, I will review past models and present a motivational dimension model of affect that expands understanding of how affective states influence attentional and cognitive breadth. I then review a body of research that has varied the motivational intensity of positive and negative affect and found that affect of low motivational intensity broadens cognitive processes, whereas affect of high motivational intensity narrows cognitive processes. Furthermore, a bi-directional link exists between attentional narrowing and approach motivation, such that a narrowed attentional focus causes greater approach motivation toward appetitive stimuli, as compared to a broadened attentional focus.

TABLE OF CONTENTS

Page

ABSTRACT iii

TABLE OF CONTENTS iv

CHAPTER

I INTRODUCTION: MOTIVATION-COGNITION INTERACTION 1

Theories of Affect-Cognition Interaction 3
The Motivational Dimension Model of Affect 6

II APPROACH-MOTIVATED POSITIVE AFFECT REDUCES BREADTH OF ATTENTION 10

Study 1 12
Study 2 14
Study 3 16
Study 4 18
General Discussion 20

III RELATIVE LEFT FRONTAL ACTIVATION TO APPETITIVE STIMULI: CONSIDERING THE ROLE OF INDIVIDUAL DIFFERENCES 23

Method 24
Results 26
Discussion 29

IV NEURAL ACTIVITY UNDERLYING THE EFFECT OF APPROACH-MOTIVATED POSITIVE AFFECT ON NARROWED ATTENTION 31

Method 32
Results and Discussion 34

CHAPTER Page

V LATE POSITIVE POTENTIAL TO APPETITIVE STIMULI AND LOCAL ATTENTIONAL BIAS: INTEGRATING ATTENTION AND MOTIVATION 37

- Method 41
- Results 43
- Discussion 46

VI POSTAURICULAR REFLEX RESPONSES TO PICTURES VARYING IN VALENCE AND AROUSAL 49

- Method 51
- Results 53
- Discussion 55

VII THE EFFECT OF LOW VERSUS HIGH APPROACH-MOTIVATED POSITIVE AFFECT ON MEMORY FOR PERIPHERALLY VERSUS CENTRALLY PRESENTED INFORMATION 57

- Experiment 1 60
- Experiment 2 65
- General Discussion 66

VIII THE BLUES BROADEN, BUT THE NASTY NARROWS: ATTENTIONAL CONSEQUENCES OF NEGATIVE AFFECTS LOW AND HIGH IN AROUSAL 69

- Experiment 1 72
- Experiment 2 74
- General Discussion 76

IX EFFECTS OF LOCAL-GLOBAL ATTENTION ON NEUROPHYSIOLOGICAL MEASURES OF APPROACH MOTIVATION 78

- Method 84
- Results 86
- Discussion 88

X SUMMARY AND DISCUSSION 92

Page

REFERENCES 97

VITA 112

CHAPTER I

INTRODUCTION: MOTIVATION-COGNITION INTERACTION

Affective states influence cognition. Most previous conceptual approaches to the study of affect-cognition effects have been predicated on models that emphasize major differences between positive and negative affect (Fredrickson & Cohn, 2008). Recent conceptual models that emphasize the approach vs. withdrawal dimensions underlying affect, however, suggest similarities between specific positive and negative affects, as well as dissimilarities between specific positive (or negative) affects (Harmon-Jones, 2003b, 2004; Harmon-Jones & Gable, 2008). These (dis)similarities may suggest an increased understanding of affect-cognition interactions.

In this article, we first review previous models of affect-cognition interactions, particularly those models that make predictions for how affect influences attentional and cognitive breadth. Then, we present a conceptual model concerning the relationship between motivational intensity and cognitive breadth. Next, we review recent research investigating positive affect that differs in approach motivational intensity. Finally, we present evidence obtained with negative affect that further support the model.

Before beginning, we will clarify what we mean by different terms used throughout this

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This dissertation follows the style of *Psychological Science.*

article. An emotion or affect is not a "thing" but is a multi-component process made up of basic processes such as feelings of pleasure or displeasure, facial/body expression components, particular appraisals, and particular action plans and activation states (Frijda, 1993). Moreover, these components are not perfectly correlated with each other (Lang, 1995).

Previous research on positivity and cognition has used the term affect (Isen, 2002), mood (Gasper & Clore, 2002), or emotion (Fredrickson, 2001) to describe the positive state manipulated. Although moods may be different than emotions, past research has found that both positive moods and positive emotions typically yield identical outcomes on cognitive processes. Because of this and because it is difficult to empirically separate moods from emotions at the measurement level, we use the broader term "affect" to describe the state manipulated in experiments.

Approach and withdrawal motivation are often implicated in emotional processes. Some theorists have linked positive affect directly with approach motivation and negative affect with withdrawal motivation (Watson, 2000). Other research and theory, however, suggests that motivational direction and affective valence are not linked in this manner. In particular, anger is a negative affective state associated with approach motivation (Carver & Harmon-Jones, 2009; Harmon-Jones, 2003a). Thus, motivational direction and affective valence can be independent.

Theories differ regarding whether approach and withdrawal are viewed as bipolar or unipolar dimensions. We believe that this debate need not be settled here. Regardless of whether a bipolar or unipolar model is preferred, we posit that approach and withdrawal motivation vary in intensity. Motivational direction is the drive to approach or avoid an object or goal. Motivational intensity refers to the strength of the motivation, and it can range from low to high.

That is, within a given motivational direction (e.g. approach), the motivation can range from low to high in intensity.

An important clarification should be mentioned here. The concept of arousal is often related to the concept of motivational intensity. Motivational intensity or the impetus to act is related directly to arousal, but unlike arousal, motivation always has action implications (even if they are vague). In Bradley and Lang's (2007) theory of emotion, "judgments of arousal index (again, roughly) the degree of activation in each motivation system" (p. 585). More motivationally intense states are also associated with greater sympathetic nervous system activation (for review see Bradley & Lang, 2007). Although these concepts are similar, there are instances in which arousal is divorced from motivational intensity. For instance, amusement can be thought of as an arousing, positive state or a "higher activation state" (Fredrickson & Brannigan, 2005, p.326). However, this state is unlikely to urge one to approach something in the environment.

Theories of Affect-Cognition Interaction

Several theories have made predictions regarding the influence of affective states on cognitive breadth. In an early model on affect-cognition interactions, Schwarz and Clore (1983) proposed that affect provides information for cognitive processing. This affect-as-information model proposed that individuals in a positive mood rely on general knowledge structures, whereas individuals in negative moods focus on specific details and rely on outside information (Bless, Schwarz, Clore, Golisano, & Rabe, 1996). Positive affect is proposed to signal a safe situation, resulting in more global, heuristic cognitive processing. In contrast, negative affect signals a problematic situation, resulting in a more local, analytic processing. In sum, the affect-as-information model could be viewed as an unconscious affective appraisal which in turn leads to a cognitive script (Schwarz & Clore, 2003).

Along similar lines, Fredrickson (2001) proposed that positive affect increases cognitive breadth. This model was based largely on evidence that positive affect increases cognitive flexibility (see Isen, 2002, for a review). In this model, positive affect broadens momentary though-action repertoires, whereas negative affect narrows thought-action repertoires. Positive affect is posited to suggest a stable and comfortable environment and encourage an organism to be more attentionally and cognitively broad (Fredrickson, 2001). In this theory, the affect itself is believed to cause the broadening.

Research supporting this model has found that positive affect creates a broadening of cognitive processing in categorization (Isen & Daubman 1984), unusualness of word association (Isen, Johnson, Mertz, & Robinson,1985), social categorization (Isen, Niedenthal, & Cantor, 1992), and the recall of memory details (Talarico, Berntsen, Rubin, 2008). In these studies, positive affect was manipulated by having participants receive a gift (Isen, Daubman, & Nowicki, 1987), watch a funny film (Isen & Daubman, 1984), recall a pleasant memory (Schwarz & Clore, 1983; Murray, Sujan, Hirt, & Sujan, 1990), or remember a positive life event (Talarico, Berntsen, Rubin, 2008).

Working within the affect-as-information model, Gasper and Clore (2002) tested whether a positive, as opposed to negative, affect manipulation would cause a more global and heuristic bias. In both studies, participants were assigned to recall a positive or negative memory. Then, they were asked to reproduce a novel drawing (Study 1) or perform the Kimchi and Palmer (1982) global-local attention task (Study 2). The concept of global-local attentional scope is similar to the idea of seeing the forest (global) or the trees (local). To measure this attentional scope, Kimchi and Palmer (1982) developed a task where individuals make similarity judgments. In this task, three global figures (large triangles or squares) each comprised of local elements (small triangles or squares) are presented. The standard figure is positioned on top and the two comparison figures are positioned below. One of the comparison figures has local elements that match the standard, whereas the other comparison figure has global elements that match the standard. Individuals can make similarity judgments based on either the global or local elements of the standard figure. Similarity judgments based on global elements indicate a global attentional focus, whereas judgments based on local elements indicate a local attentional focus.

Results of the Gasper and Clore (2002) studies suggested that positive, relative to negative, mood states produced a dependency on heuristics or gist and also a global bias. However, in Study 2, where a neutral memory condition was included, no differences occurred between positive and neutral mood states. Nonetheless, they concluded that “positive affective cues, whether resting or manipulated positive affect, foster global processing” (p. 39, Gasper & Clore, 2002).

In 2005, Fredrickson and Branigan used the same measure of attention to investigate the attentional broadening effects of discrete positive states of amusement and contentment. Using film clips to evoke these discrete positive states, the authors found that relative to neutral affect states, amusement and contentment broadened attentional focus. More recently, Rowe, Hirsh, and Anderson (2007) found positive moods, as opposed to neutral moods, elicited by music resulted in broadened visual-spatial processing.

The idea that positive affect creates attentional and cognitive broadening is widely accepted and supported by many investigations (Fredrickson & Branigan, 2005; Gasper & Clore, 2002; Rowe, Hirsh, and Anderson, 2007). However, recent evidence indicates these theories to be incomplete in their consideration of all positive (and negative) affect. Below, we present evidence that supports a new model of affect-cognition interactions. It incorporates previous work on the influence of positive affect on attentional and cognitive broadening and extends it by showing how motivational intensity rather than affective valence is the primary cause of attentional and cognitive narrowing/broadening.

The Motivational Dimension Model of Affect

In most previous work on the attentional and cognitive consequences of affect, research has focused on the valence dimension, that is, whether the affect was positive or negative. Another important and relatively neglected dimension of affect is motivational direction: whether the affect is associated with a motivation to approach or avoid a stimulus. All past research on the broadening effects of positive affect could be said to have used positive affect that evoked low intensity approach motivation. That is, positivity was created by giving participants gifts (Isen & Daubman, 1984), having them watch a funny film (Isen et al., 1987), listen to pleasant music (Rowe, Hirsh, and Anderson, 2007), or recall pleasant memories (Murray, Sujan, Hirt, & Sujan, 1990; Gasper & Clore, 2002). These manipulations likely evoked low approach motivation; they involve affect that is post-goal or not goal-relevant.

Positive affect, however, varies in the degree with which it is associated with approach motivation. Some positive affective states are relatively low in approach motivation (e.g., joy after watching a funny film), whereas others are relatively high in approach motivation (e.g., enthusiasm while approaching a desirable object). Positive affect that varies in motivational intensity could have different effects on attention, cognition, and behavior.

Given the importance of approach-motivated positive affective states to biologically important outcomes such as reproduction, social attachment, and the ingestion of food and water, it seems unlikely that such states would be associated with increased attentional and cognitive broadening. Rather, they should be associated with reduced broadening or more narrowing, as organisms shut out irrelevant stimuli, perceptions, and cognitions as they approach and attempt to acquire the desired objects. As such, positive affect high in approach motivation may encourage tenacious goal pursuit. During goal pursuit, broadening of attention might prove maladaptive as it may lead one away from the current goal pursuit. Easterbrook's (1959) model that emotional arousal causes a reduction in the "range of cue utilization" is consistent with these ideas. However, Easterbrook's model referred to drive. He defined drive as "a dimension of emotional arousal or general covert excitement, the innate response to a state of biological deprivation or noxious stimulation… The emotional arousal is greater in neurotic than in normal subjects…" (p. 184). Easterbrook clearly viewed this arousal state as negative. More recent models of emotion consider arousal to be positive or negative and to reflect motivational activation.

The distinction between low vs. high approach positive affect bears similarity to other concepts. For instance, Panksepp (1998) discussed a PLAY emotive system that "may help animals project their behavioral potentials joyously to the very perimeter of their knowledge and social realities…" (p. 283). He also discussed a second system, the SEEKING emotive system "that leads organisms to eagerly pursue the fruits of their environment…" (p. 145). The PLAY system seems linked to broadening, whereas the SEEKING system seems linked to narrowing/focusing. Others have discussed appetitive or pre-goal positive states as being different from consummatory or post-goal positive states (Knutson & Wimmer, 2007), or "wanting" as different from "liking" (Berridge, 2007). SEEKING, pre-goal, approach-motivated positive affect may have emerged to assist in promoting reward acquisition. Also, intrinsically motivated interest in a given task may arouse approach-oriented positive affect that attentionally narrows one’s focus rather than broadens it. The narrowing of attention and cognition as one is engaged in goal pursuit is likely to assist in the goal-directed action and increase the chances of success. Such a process has been noted in research on action orientation (vs. state orientation) and implemental mindsets. Implemental mindsets increase approach-motivated positive affect and increase the likelihood of goal accomplishment (Brandstätter, Lengfelder, & Gollwitzer, 2001).

These pre-goal and post-goal positive affective states are associated with different patterns of neural activation in areas of the prefrontal cortex, nucleus accumbens, anterior cingulate cortex, and hippocampus (Berridge, 2007; Davidson & Irwin, 1999; Harmon-Jones, 2006; Knutson & Wimmer, 2007; Panksepp, 1998). In addition, asymmetrical frontal cortical activity has been found to relate to motivational direction and intensity, with greater relative left frontal activity relating to more approach motivation and greater relative right frontal activity relating to more withdrawal motivation (Harmon-Jones, 2003b). Indeed, manipulations of positive affect high in approach motivation increase relative left frontal cortical activity, whereas manipulations of positive affect low in approach motivation do not (Harmon-Jones, Harmon-Jones, Fearn, Sigelman, & Johnson, 2008). In addition, individuals with stronger approach-motivational tendencies show greater relative left frontal activation to appetitive stimuli (Gable & Harmon-Jones, 2008b; Peterson, Gable, & Harmon-Jones, 2008).

In contrast, positive affective states low in approach motivation may increase attentional broadening and enhance memory for peripherally presented information because such states suggest that things are going better than necessary, coasting can occur, and attention and efforts are open to unforeseen opportunities (Carver, 2003). This conception of low approach-motivated positive affect is broadly consistent with the previously reviewed models of positive affect, which posit that positive affect suggests a stable and comfortable environment and encourages broadened cognitive processing. The motivational model, however, suggests that only positive affect *low* in approach motivational intensity should broaden cognitive processing. In contrast, positive affect *high* in approach motivational intensity should narrow cognitive processing.

CHAPTER II

APPROACH-MOTIVATED POSITIVE AFFECT REDUCES BREADTH OF ATTENTION

Much research over the past 20 years has found that positive affect broadens cognition and attention (e.g., Rowe, Hirsh, & Anderson, 2006; for reviews, see Fredrickson, 2001; Isen, 2000). Indeed, this result is considered "one of the most robust and widely confirmed findings in the affect literature" (Isen, 2002, p.57).

Previous research on positivity and broadening has used the term affect (Isen, 2002), mood (Gasper & Clore, 2002), or emotion (Fredrickson, 2001) to describe the positive state manipulated. Emotions are often viewed as moderately correlated multi-component phenomena that involve feelings of pleasure or displeasure, overt or covert motor behaviors, action readiness, physiological changes, and cognitive appraisals (Frijda, 1993; Lang, 1995). Moods are similar to emotions, except that moods are said to lack objects (Frijda, 1994). Although moods may be different than emotions, past research on positive states and broadening has found that both positive moods and positive emotions yield identical outcomes on broadening.

Much work on emotions has emphasized a number of underlying dimensions. Two dimensions that have received much consideration are affective valence and motivational direction. Affective valence refers to the felt pleasure or displeasure. Motivational direction refers to action tendency associated with particular emotional states -- approach or withdrawal. Approach motivation refers to an urge/action tendency to go toward an object, whereas withdrawal motivation refers to an urge/action tendency to move away from an object. Because the word emotion is often used to specify discrete emotion words like joy and because we focus on the dimensions underlying specific emotions, we use the term positive affect in this article.

In past studies on positivity and broadening, positivity was created by gifts, funny films, or recall of pleasant memories. These manipulations likely evoked low approach motivation; they involve emotions that are post-goal or not goal-relevant. Positive affects, however, vary in the degree to which they are associated with approach motivation. Some positive affects states are low in approach motivation (e.g., joy after watching a funny film), whereas others are higher in approach motivation (e.g., enthusiasm or desire while approaching an attractive object).

Given the importance of approach-motivated positive affects states to biologically important outcomes such as reproduction, social attachment, and the ingestion of food and water, it seems likely that such states would not be associated with increased attentional and cognitive broadening. Rather, we would expect them to be associated with reduced broadening, as organisms shut out irrelevant stimuli, perceptions, and cognitions as they approach and attempt to acquire the desired objects.

The distinction between low vs. high approach positive affect bears similarity to other concepts. For instance, Panksepp (1998) discussed a play emotive system that “may help animals project their behavioral potentials joyously to the very perimeter of their knowledge and social realities…” (p. 283). He also discussed a second system, the seeking emotive system “that leads organisms to eagerly pursue the fruits of their environment…” (p. 145). The play system seems linked to broadening, whereas the seeking system seems linked to focusing. Others have discussed appetitive or pre-goal positive states as being different from consummatory or post-goal positive states (Knutson & Wimmer, 2007), or wanting as different from liking (Berridge, 2007). These pre-goal and post-goal positive affective states are associated with different neural structures and neurochemicals (Berridge, 2007; Harmon-Jones, 2006; Knutson & Wimmer, 2007; Panksepp, 1998). Seeking, pre-goal, approach-motivated positive affects may have emerged to assist in promoting reward acquisition.

To expand understanding of the effects of positive affect on attentional processes, we designed four studies to examine the consequences of approach-motivated positive affect states on attention. Whereas previous studies found that playful, low approach positive affect (e.g., amusement) broadens attention, we predicted that seeking, high approach positive affect (e.g., desire) would reduce broadening.

Study 1

42 introductory psychology students participated in exchange for course credit. After receiving instructions for the local-global task, participants viewed a neutral film, which showed the outside of houses and was designed to make participants feel neutral. Next, participants were randomly assigned to view one of two films. Low-approach positive affect was manipulated with a film that depicted cats in humorous situations. High-approach positive affect was manipulated with a film that showed delicious desserts. All film clips lasted 1 min, 39 sec.

After the film, participants completed Kimchi and Palmer's (1982) 24 item global-local visual processing task to assess breadth of attention (Fredrickson & Brannigan, 2005; Gasper & Clore, 2002). In the task, three figures each comprised of 3-9 local elements (triangles or squares) were presented. The standard figure was positioned on top and the two comparison figures were positioned below. One of the comparison figures had local elements that matched the standard, whereas the other comparison figure had global elements that matched the standard. Thus, similarity judgments could be based on either the global or local elements of the standard figure. Participants were to choose which of the two comparison figures in each triad best matched the standard figure by pressing a key. Participants were asked to give their "first and most immediate impression."

Scores for the task were the number of times participants chose comparison figures matching the global elements of the standard figure. Responses for global choices were summed, such that higher scores indicated a more global focus. Because the scores were skewed, they were log transformed to produce a more normal distribution.

Next, participants rated how they felt during each film. Feelings were: amusement, anger, anxiety, contentment, desire, disgust, engagement, fear, happiness, interest, sadness, and serenity (0 = No emotion, 8 = Strongest feeling; Ekman, Friesen, & Ancoli, 1980).

For the global attention measure, the cats film caused more global attentional focus (M = 2.04, SD = 0.93) than the desserts film (M = 1.54, SD = 0.74; t = 1.95, p_{rep} = .87, d = .31).

We predicted that the positive films would differentially affect amusement and desire. All other positive affect items were averaged together to form a measure of general positive affect; the same occurred for negative affect items. The cats film evoked more amusement (M = 6.05, SD = 2.24) and general positive affect (M = 3.56, SD = 1.93) than the houses film (M = 0.70, SD = 1.13; M = 1.28, SD = 1.44), ts > 5.00, p_{rep}s = .99, ds > .80. The desserts film evoked more desire (M = 5.14, SD = 2.85) and general positive affect (M = 2.91, SD = 1.80) than the houses film (M = 2.57, SD = 2.42; M = 1.88, SD = 1.81), ts > 3.60, p_{rep}s = .98, ds > .56.

Comparison of the two positive films revealed that the cats film evoked more amusement (M = 6.05, SD = 2.24) than the desserts film (M = 2.67, SD = 2.58; t = 4.48, p_{rep} = .99). In contrast, the desserts film evoked more desire (M = 5.14, SD = 2.85) than the cats film (M = 1.00, SD = 1.65; t = 5.65, p_{rep} = .99, d = .87). As expected, general positive affect and negative affect did not differ between the two positive films (ts < 1.11, p_{rep}s < .66).

Results from Study 1 found that approach-motivated positive affect (desire) decreased attentional broadening as compared to low-approach positive affect (amusement). However, this study did not include a neutral comparison condition, making it difficult to know whether approach-motivated positive affect would decrease attentional broadening as compared to a neutral condition. That is, approach-motivated positive affect may reduce broadening to the same level as neutral affect. Study 2 tested whether high-approach positive affect reduced attentional breadth relative to a neutral condition.

Study 2

32 (13 female) introductory psychology students participated for course credit. On individual monitors, participants viewed 6 neutral practice trials and then 64 pairs of pictures. After a fixation cross (500 ms), a picture of a dessert or neutral (rocks) object picture appeared (6 s). Pictures were matched for color, brightness, and object size. After that picture and another fixation cross (500ms), a letters picture was displayed until the participant responded. If a response did not occur within 5 s, the next trial began. Inter-trial interval was 18-20 s.

Navon's (1977) letters task was used to assess attentional breadth. In the task, each of the letters pictures was a large letter composed of smaller letters. The large letters were made up of five closely spaced local letters on each vertical or horizontal line (e.g., an *H* of *F*s). Participants were asked to respond "as quickly as possible" if the picture contained the letter *T* by pressing the left shift key or the letter *H* by pressing the right shift key. Global targets were those in which a *T* or an *H* was composed of smaller letter *L*s or *F*s. Local targets were those where a large *L* or *F* was composed of smaller *T*s or *H*s. Faster responses to the large letters indicate a global (broad) focus, whereas faster responses to the small letters indicate a local (narrow) focus. 32 local and 32 global trials were randomly presented. Response times were logarithmically transformed. Incorrect responses (4% of the sample) and those more than 3 standard deviations from the mean (0.08% of the sample) for each stimulus were removed (Fazio, 1990).

Following picture pairs, participants viewed food and neutral pictures (3 sec each), and indicated their pleasure (1 = very pleasing; 9 = very unpleasing) and arousal (1 = exciting; 9 = calm) on the Self-Assessment Manikin (Bradley & Lang, 1994). Desire for each picture was measured (1 = really desired; 9 = did not desire).

A 2 (food or neutral picture) X 2(local or global target) within-subjects ANOVA revealed a significant interaction, $F\ (1, 32) = 35.61$, $p_{\text{rep}} = .99$, $\eta_p^2 = .53$. Reaction times (RTs) to global targets were slower after dessert pictures than after rock pictures, $p_{\text{rep}} = .92$. In contrast, RTs to local targets were faster after dessert pictures than after rock pictures, $p_{\text{rep}} = .99$. After rock pictures, participants responded faster to global targets than local targets, $p_{\text{rep}} = .99$. This finding is consistent with Navon (1981); participants generally show a global bias on this task. After dessert pictures, participants responded similarly to global and local targets, $p_{\text{rep}} = .70$.

For picture ratings, a 3 (valence, arousal, or motivation rating) X 2 (dessert or rock picture) within-subjects ANOVA revealed a significant interaction, $F\ (2, 66) = 16.99$, $p_{\text{rep}} = .99$, $\eta_p^2 = .34$. Food pictures were more pleasing ($M = 3.38$, $SE = .17$), arousing ($M = 5.08$, $SE = .34$), and desirable ($M = 4.12$, $SE = .26$) than neutral pictures ($M = 5.05$, $SE = .21$; $M = 7.43$, $SE = .23$; $M = 7.15$, $SE = .28$), $p_{\text{rep}}\text{s} = .99$.

Studies 1 and 2 revealed that high-approach positive affect reduced broadening of attention. The self-reported responses to the pictures suggested that the positive stimuli evoked approach motivation.

To provide further evidence the approach motivation was responsible for the effects of our positive affect manipulations on reduced attentional broadening, in Study 3, we measured individual differences in approach motivation and related them to attentional responses. We predicted that individuals higher in trait approach motivation would respond with less broad attention following approach-motivating stimuli.

Study 3

239 (110 female) introductory psychology students participated in exchange for course credit. The methods in Study 3 were identical to ones in Study 2, except for two changes. First, trait approach motivation was measured using Carver and White's (1994) behavioral inhibition/behavioral activation sensitivity (BIS/BAS) questionnaire. The BIS portion measures reactions to the expectation of punishment; the BAS portion measures persistent pursuit of desired goals, positive responses to the occurrence or anticipation of reward, and a desire for new rewards and a willingness to approach rewarding events.

Second, two sub-studies were run. The first sub-study used the same food pictures as Study 2. The second sub-study used baby animal pictures designed to evoke approach motivation. For both sub-studies, different neutral pictures were shown; they were matched to the affective pictures as in Study 2.

In the first sub-study, the interaction of dessert/neutral pictures and local/global attentional bias was significant, F (1, 135) = 30.13, p_{rep} = .99, η_p^2 = .18. In the second sub-study, the interaction of baby animal/neutral pictures and local/global bias was significant, F (1, 112) = 24.77, p_{rep} = .99, η_p^2 = .18. Because these studies produced identical results, they were combined. Decomposition of the interaction revealed after neutral pictures, participants responded faster to global targets than local targets, p_{rep} = .99. In contrast, after approach motivating pictures, participants responded faster to local targets than global targets, p_{rep} = .99. Also, RTs to global targets were slower after approach motivating pictures than after neutral pictures, $p_{\text{rep}} = .99$. RTs to local targets did not differ between approach motivating and neutral pictures, $p_{\text{rep}} = .18$.

To examine whether BAS related to attentional responses, regressions were conducted in which RTs to targets following approach pictures were predicted by BAS and RTs to targets following neutral pictures. For approach-global RTs, BAS predicted slower responses, $\beta = .06$, partial $r = .17$, $t\ (235) = 2.63$, $p_{\text{rep}} = .96$. For approach-local RTs, BAS was a non-significant predictor. BIS was not a significant predictor of RTs when analyzed as above.

Study 3 provided evidence supportive of the hypothesis that the reduced attentional broadening caused by appetitive stimuli is due to approach motivation, as individuals high in BAS showed greater reductions in attentional broadening following appetitive stimuli.

To further test whether approach motivation is responsible for the reduction in attentional broadening following appetitive stimuli, we manipulated the intensity of approach motivation by experimentally varying the expectancy to act, as past research has suggested that the expectancy to act increases motivational intensity (for review, see Brehm & Self, 1989).

Specifically, we manipulated the expectancy to consume desserts, as previous studies have found that such manipulations cause greater approach motivation (Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006). In this past work, the expectation to act upon one’s anger increased relative left frontal cortical activation, a brain region involved in approach motivation. Moreover, this increased cortical activation related to behavioral measures of approach motivation (Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). However, the expectancy of action did not affect self-reports of anger; that is, both the low-expectation and the high-expectation-to-act produced increased self-reported anger relative to no-anger conditions.

For Study 4, we predicted that participants who viewed dessert pictures and expected to consume them would be the least attentionally broad, followed by participants who simply viewed the food pictures, and finally participants who viewed neutral pictures.

Study 4

49 female introductory psychology students participated in exchange for course credit. Participants first indicated how they felt at the moment (1 = not at all; 7 = extremely) on these words: afraid, angry, content, discouraged, disgusted, distressed, down, eager, enthusiastic, excited, frustrated, glad, gloomy, good mood, happy, interested, irritated, mad, nervous, pleasant, sad, satisfied, serene, and tranquil.

After viewing six neutral practice pictures, participants were randomly assigned to condition: two-thirds of participants viewed 36 dessert pictures, and one-third viewed 36 neutral pictures (e.g., paper plates). Half the participants who viewed dessert pictures were given the expectancy to consume the items, to increase approach motivation; the other half were not given the expectancy to consume the items. All participants who viewed the neutral pictures were given the expectancy to take the items they viewed. Because the neutral items are not desirable, they should not evoke approach motivation. Expectancy to obtain the items was manipulated by informing participants, “At the end of the experiment, you will be presented with a large tray that contains most of the items you will see in the pictures. You will be able to take as many as you want."

Each picture was displayed for 12 s and preceded by a fixation cross (2 s). Inter-trial interval varied between 6 and 8 s. After viewing pictures, participants completed another emotion questionnaire. Then, they completed the Navon letters task, consisting of 48 (24 local, 24 global) pictures randomly presented, with the first twelve trials being practice. Response times were logarithmically transformed. Incorrect responses (3.2%) and outlying responses (0.17%) were removed. Finally, participants were allowed to take any desserts they wanted.

Results from Studies 2-3 suggested that a contrast-coded local minus global difference score captures the outcome variable of interest. Based on our prediction, conditions were contrast-coded from least to most approach motivated positive affect. Therefore, the neutral condition was weighted -3, the dessert condition was +1, and the dessert condition with expectation to consume was +2. The latter two conditions were psychologically closer to each other and thus were closely weighted. As predicted, the contrast was significant, F (1, 46) = 5.53, p_{rep} = .92, η_p^2 = .11; it indicated that the dessert picture/expectancy to consume condition showed the least broad attention, followed by the dessert picture only condition, and then the neutral condition.

The first emotion questionnaire was used as a covariate to control for baseline affect. For the high-approach positive affect variables excited and enthusiastic, the contrast-coded ANCOVA revealed significant effects, F (1, 45) = 5.82, p_{rep} = .93, η_p^2 = 0.12; F (1, 45) = 6.33, p_{rep} = .93, η_p^2 = 0. 12. Excitement and enthusiasm increased from the neutral condition (*M* = 1.88, *SE* = .44; *M* = 2.11, *SE* = .42) to the dessert condition (*M* = 2.87, *SE* = .44; *M* = 3.43, *SE* = .42) to the approach-dessert condition (*M* = 3.36, *SE* = .43; *M* = 3.45, *SE* = .42).

Because all other affect variables were not expected to follow the contrast-coded prediction, one-way ANCOVAs were conducted for general positive affect and general negative affect. Results revealed a significant condition difference for general positive affect (F [2, 45] = 5.27, p_{rep} = .95, η_p^2 = 0. 19; neutral *M* = 3.22, *SE* = .28; dessert *M* = 3.87, *SE* = .29; approach-dessert *M* = 4.51, *SE* = .28). A marginal effect for negative affect also occurred between conditions (F [2, 45] = 2.88, p_{rep} = .86, η_p^2 = 0. 11; neutral *M* = 1.75, *SE* = .18; dessert *M* = 1.24, *SE* = .18; approach-dessert *M* = 1.23, *SE* = .17). Follow-up simple effects tests revealed that both positive and negative affect differed between the neutral condition and the approach-dessert condition (F [1, 45] = 10.55, p_{rep} = .98, η_p^2 = 0.19; F [1, 45] = 4.58, p_{rep} = .90, η_p^2 = 0.09).

Study 4 conceptually replicated and extended Studies 1-3 by showing that reduced attentional breadth occurred in a design in which approach motivation was further manipulated. The approach-motivation manipulation did not strongly influence affective ratings, consistent with past work showing that emotions that vary in approach motivational intensity have different physiological and behavioral characteristics but not necessarily subjective characteristics (e.g., Berridge, 2007; Harmon-Jones et al., 2003, 2006).

General Discussion

Results from Study 1 found approach-motivated positive affect decreased global attentional focus relative to low approach-motivated positive affect. Study 2 found approach-motivated positive affect reduced global attentional focus relative to neutral stimuli. Study 3 found that individuals high in trait approach motivation showed even more reductions in attentional broadening following appetitive stimuli. Study 4 revealed similar effects in a between-subjects design, using an additional manipulation of approach motivation on top of picture type. This study, which experimentally manipulated the proposed mediator (approach motivation), strongly supports our hypothesis that approach-motivated positive affect reduces broadening. These results are directly opposite to the increase in broadening found with positive affects lower in approach motivation.

Positive affects, particularly those low in approach motivation, suggest a comfortable, stable environment and allow for a broadening of attention and cognition, which may serve adaptive functions (Carver, 2003; Fredrickson, 2001). However, broadening does not occur for positive affects high in approach motivation. These positive affects often encourage specific action tendencies, such as tenacious goal pursuit, and an associated reduction in attentional breadth. This reduced broadening of attention may prove adaptive as it assists in obtaining goals.

Together with past research, the present research supports the idea that low vs. high approach-motivated positive affect produces opposite effects on attentional broadening. It is possible that withdrawal-motivational intensity exerts similar attentional effects; that is, low withdrawal-motivated negative affect may cause more broadening, whereas high withdrawal-motivated negative affect may cause less broadening. Indeed, such an interpretation would fit with past research. For example, individuals with depression, a low intensity motivation, are more creative (Andreasen, 1987) and show broadening of attention and memory (von Hecker & Meiser, 2005). With low-motivated negative affects such as sadness and depression, "a more open, unfocused, unselective, low-effort mode of attention would prove not deficient but, on the contrary, beneficial" (von Hecker & Meiser, 2005, p. 456), as one disengages from a terminally blocked goal and becomes open to new possibilities (Klinger, 1975). On the other hand, the past research that found negative affect caused decreased broadening may have evoked negative affective states that were high in withdrawal motivation (fear; Gasper & Clore, 2002). This chapter was based in part on Gable and Harmon-Jones (2008a).

In conclusion, the present research provides further evidence suggesting that emotions of the same valence can have very different consequences for attention, cognition, and behavior (Bodenhausen, Sheppard, & Kramer, 1994). Moreover, it adds to a growing literature focused on the examination of motivational intensity and direction within emotions (Harmon-Jones, 2003). A more complete understanding of positive emotions and their relationships with attentional and cognitive processes will assist not only in better understanding positive emotions and emotion-cognition interactions, but may have important applications for performance. As Izard (1991) noted, positive emotions high in approach motivation are extremely important in the development of skills, competencies, and intelligence.

CHAPTER III

RELATIVE LEFT FRONTAL ACTIVATION TO APPETITIVE STIMULI: CONSIDERING THE ROLE OF INDIVIDUAL DIFFERENCES

The prefrontal cortex is asymmetrically involved in emotive processing, with greater relative left frontal activity involved in approach (or positive) emotive processes and greater relative right frontal activity involved in withdrawal (or negative) emotive processes (for reviews, see Davidson, 1992; Harmon-Jones, 2003, 2006; Peterson, Shackman, & Harmon-Jones, in press; van Honk & Schutter, 2006).

Although much research has found asymmetrical frontal cortical activations in response to manipulations of emotion, some past research has failed to produce predicted results (see reviews by Murphy, Nimmo-Smith, & Lawrence, 2003; Pizzagalli, Shackman, & Davidson, 2003). One area in which failures to find predicted effects has been especially prevalent is in studies using affective pictures (Elgavish, Halpern, Dikman, & Allen, 2003; Hagemann, Ewald, Becker, Maier, & Bartussek, 1998). Affective pictures may not evoke sufficient emotional or motivational intensity to engage asymmetrical frontal cortical activations. In support of this idea, experiments revealed that when approach motivation in response to anger-inducing pictures was increased by an expectancy of action manipulation, the expected relative left frontal activation occurred in response to the anger-inducing pictures (Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006). These experiments suggest that increased approach motivation causes greater relative left frontal activity to anger-inducing pictures.

To extend these findings, we conducted the current study to examine whether individual differences in emotive tendencies influence relative left frontal activation to positive affective stimuli. Because approach motivation and positive affect are often confounded when examining reactions to positive affective stimuli, the present study was not designed to test whether approach motivation or positive affect provided a more accurate explanation of the psychological functions of relative left frontal activation. Observing a relationship between emotive individual differences (approach motivation or positive affect) and relative left frontal activation to positive stimuli would be consistent with both affective valence and motivational direction interpretations.

In the present study, we measured individual differences in emotive tendencies toward positive stimuli, and then assessed regional brain activation (using EEG) during the viewing of the positive stimuli. We predicted that individuals with stronger emotive tendencies toward positive stimuli would show greater relative left frontal activation to those stimuli but not neutral stimuli, because these individuals may have stronger approach motivation or positive emotional responses to the stimuli. Based on past research, we also predicted that pictures alone would not cause significant shifts in asymmetrical frontal cortical activity.

In addition, we examined whether these predicted asymmetrical frontal cortical activations would occur as early as one sec into picture viewing. Previous work has only investigated asymmetrical frontal differences over the first three seconds of picture viewing (Harmon-Jones et al., 2006).

Method

Twenty-six right-handed female introductory psychology students volunteered in exchange for course credit. Only females were included because more were in the participant pool, and we sought to avoid a gender-imbalanced sample.

Participants completed measures of liking of dessert and time since eaten. Responses were made along with other unrelated attitude questions on 1 (*strongly dislike*) to 4 (*strongly like*) scales. Time since eaten was measured using the question, “How long has it been since you last ate?”, answered in “hours” and “minutes”, which were rescored in min. Responses for liking for dessert ranged from 2 to 4, $M = 3.54$, $SD = 0.58$; time since eaten ranged from 5 to 780min, $M = 174.42$, $SD = 227.23$.

Participants viewed six neutral pictures and were then randomly assigned to view either 36 dessert pictures or 36 additional neutral pictures. The neutral pictures were of objects that would not evoke motivation (e.g., plastic fork, paper plate). Each picture was displayed 12 s and preceded by a fixation cross for 2 s. ITI varied between 6 and 8 s.

Following picture viewing, participants reported affective reactions. The questionnaire asked participants to indicate how they felt “right now” (1 = *not at all*; 7 = *extremely*) for the following words: afraid, angry, content, down, discouraged, disgusted, distressed, eager, enthusiastic, excited, frustrated, glad, gloomy, good mood, happy, interested, irritated, mad, nervous, pleasant, sad, satisfied, serene, and tranquil. Participants also rated how much they wanted, liked, and desired the objects and how appetizing they found them (1 = *not at all*; 5 = *very*).

To record EEG, 64 Ag/AgCl-sintered electrodes mounted in a stretch-lycra Quik-Cap (Neuroscan, El Paso, TX) were used. A ground electrode was mounted midway between FZ and CZ. An online reference was acquired from an electrode mounted between CZ and CPZ. Vertical eye movements were recorded from the supra- and suborbit of the left eye to facilitate artifact scoring of the EEG. Electrode impedances were under 5000 Ω and homologous sites were within 1000 Ω of each other. Quik Gel (El Paso, TX) was the conducting medium. Signals were amplified with Neuroscan SynAmps2 amplifier unit (El Paso, TX), bandpass filtered (0.1-100Hz; 60-Hz filter enabled), and digitized at 500 Hz. Processing used Scan 4.3.

First, data containing artifacts were removed by hand (Cohen's Kappa for inter-rater agreement over subsample = .95). A regression-based eye movement correction was applied (Semlitsch, Anderer, Schuster, & Presslich, 1986). Then, all epochs 1.02 s in duration were extracted through a Hamming window (50% taper of distal ends) and re-referenced using a common average reference. Consecutive epochs were overlapped by 50%, to minimize data loss due to windowing. A fast Fourier transform calculated power spectra. Power values within the alpha band (8-13 Hz) were averaged across epochs for all 12 sec, the first sec, and 2-12 sec of picture viewing. Asymmetry indexes (log right minus log left) were computed for all homologous sites. Asymmetry scores greater than 3 SD were removed (2 participants). An average frontal asymmetry index (AF3/4, F3/4, F5/6, and F7/8) was created, based on past research with fewer electrodes that focused on F3/4 and F7/8. Because alpha power is inversely related to cortical activity (Lindsley & Wicke, 1974), higher scores indicate greater left hemisphere activity. Predictions for asymmetrical frontal activity and self-reports of motivation were directional, derived from theory, and specified in advance; they were evaluated using a one-tailed criterion of significance (Rosenthal, Rosnow, & Rubin, 2000).

Results

Dessert pictures were rated as more liked ($M = 4.16$, $SD = 1.40$), wanted ($M = 3.67$, $SD = 1.56$), desired ($M = 3.75$, $SD = 1.54$), and appetizing ($M = 4.25$, $SD = 1.22$) than neutral pictures ($M = 2.23$, $SD = 0.93$; $M = 1.54$, $SD = 0.78$; $M = 1.31$, $SD = 0.48$; $M = 1.39$, $SD = 0.65$), ts > 4.10, ps < .001, ds > 0.80.

After picture viewing, participants indicated how they felt at that moment. Because this affect assessment was not in response to feelings created by the pictures and was given following the picture presentation, it is likely to be less sensitive than ratings of the pictures. Thus, we sought to explore whether condition affected any of the affect items. Participants reported feeling more enthusiasm after viewing dessert pictures ($M = 3.75$, $SD = 1.81$) than after viewing neutral pictures ($M = 2.21$, $SD = 1.58$), $t\ (1, 24) = 2.31$, $p < .05$, $d = 0.43$. Also, participants reported feeling more pleasant and good mood after viewing dessert pictures ($M = 4.75$, $SD = 1.35$; $M = 4.92$, $SD = 1.44$) than after viewing neutral pictures ($M = 3.46$, $SD = 1.66$; $M = 3.50$, $SD = 1.65$), ts > 2.11, ps < .05, ds > 0.39. In contrast, participants reported being significantly less mad after viewing the dessert pictures ($M = 1.00$, $SD = 0.00$) than after viewing neutral pictures ($M = 2.14$, $SD = 1.66$), $t\ (1, 24) = 2.38$, $p < .05$, $d = 0.44$. No other items differed between conditions.

Comparison of picture conditions on asymmetrical frontal cortical activation revealed no significant results within the 12 sec of picture viewing, sec 1, or sec 2-12, ps > .26. It was expected that this comparison would not be significant based on past findings that picture stimuli alone do not evoke asymmetrical frontal cortical activity (Harmon-Jones et al., 2006).

To test the prediction that individuals with stronger approach motivation would respond to dessert pictures with greater relative left frontal activation, we conducted a regression analysis in which the emotive individual difference variables (liking for dessert and time since eaten) and condition were used to interactively predict asymmetrical frontal cortical activity. We first examined responses over the 12sec of picture viewing and then examined responses during the first sec and during 2-12 sec separately.

For the entire picture viewing, a significant interaction of condition and liking for dessert emerged, $F\ (1, 22) = 6.40$, $p < .05$, $\eta_p^2 = 0.23$. In addition, a significant interaction of condition and time since eaten emerged, *F* (1, 22) = 4.66, $p < .05$, $\eta_p^2 = 0.18$. These interactions indicated that more time since eaten (dessert liking) related to greater relative left frontal activation in the dessert pictures condition: liking for dessert, $r = .49$, $p = .05$, and time since eaten, $r = .51$, $p < .05$. For the neutral pictures condition, greater left frontal activation was not related to liking for dessert, $r = -.45$, $p = .11$, and time since eaten, $r = -.29$, $p = .31$.

Next, we tested left frontal activation during the first sec of picture viewing and 2-12 sec of picture viewing. For the first sec, a significant interaction of condition and time since eaten emerged, *F* (1, 22) = 9.15, $p < .01$, $\eta_p^2 = 0.29$. Furthermore, the interaction of condition and liking for dessert approached significance, *F* (1, 22) = 3.58, $p = .07$, $\eta_p^2 = 0.14$. For 2-12 sec of picture viewing, a significant interaction of condition and liking for dessert emerged, *F* (1, 22) = 6.28, $p < .05$, $\eta_p^2 = 0.22$. In addition, the interaction of condition and time since eaten approached significance, *F* (1, 22) = 3.75, $p = .06$, $\eta_p^2 = 0.15$. These results indicated that more time since eaten and dessert liking related to greater relative left frontal activation in the dessert pictures condition for the first second (time since eaten, $r = .53$, $p < .05$; liking for dessert, $r = .43$, $p = .08$) and 2-12 sec (time since eaten, $r = .49$, $p = .05$; liking for dessert, $r = .49$, $p = .05$). In the neutral pictures condition, left frontal activation was not related or was inversely related to liking for dessert ($r = -.31$, $p = .27$; $r = -.45$, $p = .11$) and time since eaten ($r = -.55$, $p < .05$; $r = -.22$, $p = .44$) during both viewing windows.

Analyses then tested whether self-reported ratings of the pictures or self-reported affective states following pictures interacted with picture condition to predict relative left frontal activation. They did not (*p*s > .24).

For self-reported motivation, regression analyses revealed an interaction of liking for dessert and condition in predicting reported desire and want, *F* (1, 21) = 4.69, $p < .05$, $\eta_p^2 = 0.18$;

F (1, 21) = 4.86, $p < .05$, $\eta_p^2 = 0.19$. Liking dessert related to more desire and want in the dessert pictures condition: desire, $r = .60$, $p < .05$; want, $r = .64$, $p < .05$. For the neutral pictures condition, more liking for dessert was not related to desire or want, *p*s > .26.

For self-reported affect, regression analyses revealed an interaction between picture condition and time since eaten in predicting reported serenity, *F* (1, 22) = 4.48, $p < .05$, $\eta_p^2 = 0.17$ (within dessert condition, $r = .56$, $p = .06$; within neutral condition, $r = -.22$, $p = .45$). All other interactions between condition and individual differences of liking dessert or time since eaten on self-reports were not significant (*p*s > .09).

All non-frontal asymmetries were not significantly predicted by the interaction of the approach motivated individual difference variables and condition (Bonferroni correction [$p = .001$] was used because of the large number of non-predicted effects). Also, an index of four parietal asymmetries was not significantly predicted by liking for dessert or time since eaten, *p*’s > .56.

Discussion

Emotive tendencies, as measured by liking for desserts or greater time since eaten, related to greater relative left frontal activation to dessert pictures but not to neutral pictures. These effects emerged as early as one sec into picture viewing and continued throughout the full 12 sec of picture viewing. Dessert pictures were evaluated as more appetitive than neutral pictures. In addition, individual differences in emotive tendencies predicted self-reported appetitive motivation toward the dessert pictures.

Participants also felt more enthusiastic, pleasant, and good but less mad after viewing dessert pictures than after viewing neutral pictures. These results suggest that our sample did not show ambivalent or negative feelings about desserts because of health or weight concerns.

Furthermore, these self-reported affects were unrelated to emotive individual difference variables or left frontal activation.

As noted earlier, the current results are consistent with both the motivational direction and affective valence model of asymmetrical frontal cortical activity. However, the literature at large has shown that asymmetrical frontal cortical activity is more sensitive to motivational direction than affective valence (Harmon-Jones, 2003). That is, at least 12 studies have shown a relationship between relative left frontal activity and anger, which is negative but approach motivating (for review, see Peterson et al., in press). Moreover, research has shown that whereas high approach-motivated positive affect causes an increase in left frontal activation, low approach-motivated positive affect does not (Harmon-Jones, Harmon-Jones, Fearn, Sigelman, & Johnson, in press).

Our results suggest that past failures to find differences in asymmetrical frontal activity to affective stimuli may have used person-situation complexes that did not evoke strong emotive tendencies. The present study extends other research by showing that asymmetrical frontal activations are potentiated by emotive differences that individuals bring to the laboratory as well as by manipulation of motivational variables within the laboratory (Harmon-Jones et al., 2006). This chapter was based in part on Gable and Harmon-Jones (2008b).

CHAPTER IV

NEURAL ACTIVITY UNDERLYING THE EFFECT OF APPROACH-MOTIVATED POSITIVE AFFECT ON NARROWED ATTENTION

Directly in front of you lies a delicious piece of chocolate cake. You experience a positive feeling of desire. Will you notice the pattern of the china plate upon which the cake sits? Decades of research on positive affect would suggest you would notice the china pattern, because positive affects broaden attention (Fredrickson, 2001; Rowe, Hirsh, & Anderson, 2007). However, recent research suggests you would completely miss the pattern (Gable & Harmon-Jones, 2008a). Your attentional breadth will be influenced by whether the positive affect is low or high in approach motivation – the urge to move toward something in the environment. If you are in a positive affective state high in approach motivation, your attention will be narrowed. On the other hand, if you are in a positive state low in approach motivation, your attention will be broadened (Gable & Harmon-Jones, 2008a). Approach-motivated positive affective states are essential in the process of acquiring biologically important outcomes related to reproduction, social attachment, and the ingestion of food and water. They may also be involved in addiction processes. Such states should be associated with attentional narrowing, as organisms shut out irrelevant stimuli, perceptions, and cognitions as they approach and attempt to acquire the desired objects.

The present research examines three novel questions: (1) Do neural activations involved in approach motivation also underlie the effect of approach-motivated positive affect on narrowed attention? (2) Do individual differences in approach motivation relate to this attentional narrowing? (3) Do the neural activations associated with approach motivation mediate the effect of individual differences in approach on attentional narrowing? Both approach motivation and narrowed attention have been found to involve left hemispheric activity (Davidson, 1995; Volberg & Hübner, 2004), though these two diverse literatures have never been integrated.

The frontal cortex is asymmetrically involved in approach vs. withdrawal motivation, with greater relative left frontal activity associated with approach motivation and greater relative right frontal activity associated with withdrawal motivation (Davidson, 1995; Harmon-Jones, 2003). Thus, relatively greater left frontal activation should be associated with the narrowing of attention, particularly following the activation of approach motivated positive affect by exposure to appetitive stimuli. Importantly, much cognitive research has suggested that left hemispheric processing is involved in the narrowing of attention (Volberg & Hübner, 2004).

The increased left frontal activity toward the appetitive stimuli should be particularly evident in individuals with greater approach motivation, as in Gable and Harmon-Jones (2008b). Thus, we predicted: (1) that individual differences in approach motivation (time since eaten) would relate to local attentional bias following appetitive (dessert) stimuli; (2) that relative left frontal activation would relate to this local attentional bias; and (3) that relative left frontal activation would mediate the relationship of individual differences in approach motivation and local bias.

Method

43 right-handed introductory psychology women participated for course credit. After providing informed consent, they indicated how long it had been since they had last eaten (in minutes). EEG electrodes were applied.

Participants viewed 32 dessert pictures and 32 neutral pictures in random order. Pictures were used in past studies (Gable & Harmon-Jones, 2008a; Gable & Harmon-Jones, 2008b) and dessert pictures were found to significantly increase approach motivated positive affect relative to neutral pictures. Each trial involved a fixation cross (500 ms), a picture prime (6000 ms), another fixation cross (500 ms), and a Navon (1977) letter, which was displayed until there was a response. Inter-trial interval was 3000 ms. Participants were instructed to respond to the Navon letter as quickly as possible by pressing one button upon detection of letter T and another button upon detection of letter H. The stimuli in this letters task were larger letters composed of smaller letters; each line of a large letter was made of five closely spaced local letters in Times New Roman font. Global targets (32) consisted of a large T or H composed of smaller L's or F's. Local targets (32) consisted of a large L or F composed of smaller T's or H's. Large letters had a visual angle of 3.34 (height) by 1.91 (width) degrees; small letters had a visual angle of 0.48 by 0.32 degrees.

EEG, recorded with 64 tin electrodes in a stretch-lycra electrode cap, was referenced to left earlobe. Eye movements were recorded from the supra- and suborbit of left eye. Electrode impedances were under 5000 Ω; homologous sites were within 1000 Ω of each other. Signals were amplified with Neuroscan SynAmps2, bandpass filtered (0.1-100Hz; 60-Hz filter enabled), and digitized at 500 Hz.

Artifacts were removed by hand. A regression-based eye movement correction was applied (Semlitsch, Anderer, Schuster, & Presslich, 1986). All epochs 1.02 s in duration were extracted through a Hamming window and re-referenced to averaged ears. Consecutive epochs were overlapped by 50%. A fast Fourier transform calculated power spectra. Power values within low alpha band (8-10.25 Hz) were averaged across epochs of picture viewing. Asymmetry indexes (log right minus log left) were computed for frontal (F3 - F8), frontal-central (FC3 - FC6), central (C3 - C6), and parietal regions (P3 - P8). Of these, the frontal and frontal-central regions were expected to be sensitive to approach motivation, as past research has revealed such (Harmon-Jones, 2003; Urry et al., 2004). Because alpha power is inversely related to cortical activity, higher scores indicate greater left hemisphere activity. Predictions were directional, derived from theory, and specified aprioi; they were evaluated using a one-tailed criterion of significance (Rosenthal, Rosnow, & Rubin, 2000).

Results and Discussion

Appetitive pictures caused a local bias, as revealed in a 2 (dessert or neutral picture) X 2 (local or global target) within-subjects ANOVA of log transformed RTs, F (1, 42) = 9.14, *p-rep* = .97. After neutral pictures, participants responded faster to global targets than local targets (M = 6.66, SD = .19; M = 6.71, SD = .18), *p-rep* = .98. After dessert pictures, participants responded faster to local than global targets (M = 6.69, SD = .17; M = 6.72, SD = .18), *p-rep* = .89. Also, more time since eaten predicted greater relative left frontal-central activity to dessert pictures, r = .33, *p-rep* = .91 (and marginally predicted relative left frontal activity, r = .27, *p-rep* = .84), even though picture type did not affect asymmetry. No other asymmetries were related to time since eaten (*r's* < .02). These results replicate past findings (Gable & Harmon-Jones, 2008a, 2008b), thus permitting tests of the hypotheses. Because effects were stronger in frontal-central than frontal regions, we focused on the frontal-central region (see also Urry et al., 2004).

Greater left frontal-central activation during dessert pictures predicted faster local target RT after dessert pictures, *partial* r = -.31, *p-rep* = .93, controlling for RT to local targets after neutral pictures. More time since eaten predicted faster RT to local targets after dessert pictures, *partial* r = -.31, *p-rep* = .93, controlling for RT to local targets after neutral pictures.

Other analyses were performed to test the specificity of the above effects. In contrast to the above, greater left frontal-central activation during neutral pictures did not significantly predict local target RT after neutral pictures, *partial r* = .25, *p-rep* = .81, controlling for RT to local targets after dessert pictures. For global targets, greater left frontal-central activation during dessert pictures or neutral pictures did not predict faster RT to global targets after dessert pictures (*p-reps* < .33, controlling for global RT after the other type of picture). Also, controlling for RT to global targets (dessert minus neutral global) did not reduce the relationship between relative left-frontal central activation to desserts and local bias, *partial r* = -.37, *p-rep* = .97.

Also, even when left frontal-central activation to neutral pictures was statistically controlled, greater left frontal-central activation to dessert pictures still predicted greater local bias following dessert pictures, *partial r* = -.28, *p-rep* = .89. This effect of dessert left frontal-central activation on dessert local bias also remained significant when controlling for relative left central, central parietal, parietal, and parietal occipital activations to dessert pictures, *partial r* = -.33, *p-rep* = .93. None of the other cortical indexes were significant predictors, *p-reps* < .84.

To test whether relative left frontal-central activity mediated the effect of time since eaten on local bias after dessert pictures, a relative left frontal-central index was first created by taking the difference between relative left frontal-central activity and all posterior indexes. Then, a local bias index was created by subtracting local RT after neutral pictures from local RT after dessert pictures, to control for individual differences in RT. Time since eaten predicted local bias (β = -.35, *p-rep* = .95). Time since eaten also predicted relative left frontal central activity to dessert pictures (β = .29, *p-rep* = .91). The first two conditions for mediation were met (Kenny, Kashy, & Bolger, 1998). The third condition was supported in a regression in which local bias was predicted by relative left frontal central activity to dessert pictures (β = -.31, *p-rep* = .93) when controlling for time since eaten. The Sobel (1982) test was not significant ($z = 1.35$, *p-rep* = .83). Thus, relative left frontal central activation to desserts partially (but not fully) mediated the effect of time since eaten on dessert local bias.

The present results demonstrated that greater narrowed attention induced by appetitive stimuli is driven by approach motivational processes. Individual differences in time since eaten and relative left frontal-central activation to dessert stimuli both related to greater narrowed attention following dessert stimuli. Also, relative left frontal-central activation partially mediated the relationship of time since eaten and narrowed attention following appetitive stimuli. Did hungry individuals show increased left frontal-central mediation because of frustration? No, according to our research: dessert pictures, compared to neutral pictures, decrease frustration and increase positive affect even in hungry individuals (Gable & Harmon-Jones, 2008b). The present study integrates research on motivation, attentional focus, and their associated neural processes. Approach motivation engages the same neural circuitry that drives local attention in general, and the approach-motivated activation of this circuitry biases local attention even more. This chapter was based in part on Harmon-Jones and Gable (2009).

CHAPTER V

LATE POSITIVE POTENTIAL TO APPETITIVE STIMULI AND LOCAL ATTENTIONAL BIAS: INTEGRATING ATTENTION AND MOTIVATION

Decades of research has suggested that positive emotions “broaden the scopes of attention, cognition, and action, widening the array of percepts, thoughts, and actions presently in mind” (Frederickson & Branigan, 2005, p. 315). In support, research found that positive affect increases flexible and inclusive categorization, unusualness of word association, breadth of social categorization, creativity, and openness to information (see review by Isen, 2004). More recently, investigations have shown that positive affect causes a broadening of the scope of attention (Frederickson & Branigan, 2005; Gasper & Clore, 2002; Rowe, Hirsh, & Anderson, 2007). This research used gift, film clip, and memory manipulations to induce positive affect, and the positive affect induced is likely one low in approach motivational intensity. That is, the positive affects were irrelevant to goals or occurred after goal accomplishment.

Positive affects, however, vary in the degree to which they are associated with approach motivation, and positive affects of different motivational intensities have distinct effects on attention and cognition. Low approach-motivated positive affects cause broadening of cognition and attention (Fredrickson & Brannigan, 2005; Gable & Harmon-Jones, 2008a; Gasper & Clore, 2002; Rowe et al., 2007), presumably because these positive affects suggest a stable and comfortable environment (Fredrickson, 2001). In contrast, high approach-motivated positive affects cause narrowing of cognition and attention (Gable & Harmon-Jones, 2008a; Harmon-Jones & Gable, 2009), presumably because narrowed processes assist in the shutting out of irrelevant stimuli and cognitions as organisms approach and attempt to acquire desired objects (Harmon-Jones & Gable, 2008).

Past experiments on positive affect and attentional scope used local-global bias tasks to assess attentional scope. One prominent measure of attentional scope is the Navon (1977) letters task (for review, see Kimchi, 1992). In this task, pictures of a large letter composed of smaller letters are presented. The large letters are made up of closely spaced local letters, and the participant's task is to identify one of the letters. Hundreds of studies using this task have revealed that individuals respond more quickly to global than local letters under neutral conditions (Kimchi, 1992). Our past research has found approach-motivated positive affect to slow global reactions or both slow global and speed local reactions (Gable, & Harmon-Jones, 2008a; Harmon-Jones & Gable, 2009). Similar effects emerged in research on arousing negative affect (Wachtel, 1968). These results suggest that it is the difference in attentional scope between affective and neutral states that is of importance; becoming less broad (or globally biased) and/or becoming more narrow (or locally biased) should confer similar advantages in adaptively responding to affective stimuli.

The present experiment was designed to investigate a possible neurophysiological underpinning of the effect of approach-motivated positive affect on the narrowing of attention. The late positive potential (LPP), a component of the event-related potential (ERP) occurring between 300 and 1200ms after stimulus onset, is larger in amplitude to affective than neutral stimuli, especially arousing affective stimuli (for reviews, see Keil et al., 2001; Olofsson, Nordin, Sequeria, & Polich, 2008). This LPP effect has been interpreted as reflecting motivated attention, or the reflexive engagement of attentional resources (Lang, Bradley, & Cuthbert, 1997). The LPP is likely driven by several structures, including the lateral occipital, inferior temporal, and medial parietal cortex (Sabatinelli, Lang, Keil, & Bradley, 2007) and the temporal parietal junction and lateral prefrontal cortex (Nieuwenhuis, Aston-Jones, & Cohen, 2005).

Some studies have found that the LPP is hemispherically lateralized over the frontal cortex to affective stimuli. For instance, Cunningham, Espinet, DeYoung, and Zelazo (2005) found that that “good” words evoked a greater left frontal LPP, whereas “bad” words evoked a greater right frontal LPP. Van de Laar, Licht, Franken, and Hendriks (2004) found that pictures of drug stimuli evoked greater LPPs over the left frontal cortex in recovering drug addicts than in controls. Graham and Cabeza (2001) found that correctly recognized happy faces evoked greater LPPs over the left than right frontal cortex. Lateralization of the LPP over the frontal cortex is consistent with other research using multiple methods that has demonstrated that the frontal cortex is asymmetrically involved in emotive processing (for reviews, see Harmon-Jones, 2003; Pizzagalli, Shackman, & Davidson, 2003). Specifically, the left prefrontal cortex is involved in approach motivational processing, which is often associated with positive emotions like desire (Gable & Harmon-Jones, 2008b) and negative emotions such as anger (Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006; van Honk & Schutter, 2006). In contrast, the right prefrontal cortex is involved in withdrawal motivational processing, which is often associated with emotions such as fear (Buss et al., 2003).

Whereas many studies have found LPP amplitude to differ between neutral and affective stimuli, only a few of these studies have found a hemispheric lateralization of LPP over frontal regions. Experiments that have found frontal hemispheric lateralizations have used stimuli that were uniform and evoked strong appetitive reactions (van de Laar et al., 2004) or they have used idiographically-defined stimuli (Cunningham et al., 2005). The use of only one type of appetitive stimuli (or using idiographic methods) may have kept participants’ approach motivation relatively high to all stimuli. Mixing different types of appetitive stimuli may weaken the approach motivational impact of the stimuli, as individuals may not find all types of appetitive stimuli approach motivating. Because of these past findings, we use only one type of appetitive stimuli in the current experiment.

In addition to previous work associating the LPP with motivated attention, other work has found that local attentional processes are more lateralized to the left than right hemisphere (Hübner & Volberg, 2005). Asymmetrical attentional processing could be facilitated by other asymmetrically related processes, specifically approach motivational processes. That is, appetitive processing, which is associated with the left prefrontal cortex and lateralized frontal LPPs, may also facilitate the relative narrowing of attention. This prediction is consistent with findings that approach emotional states related to left frontal cortical activation facilitate cognitive processes engaged by the same region (Gray, 2001; Gray, Braver, & Raichle, 2002).

Based on the above, several hypotheses were generated. First, based on the idea that LPP amplitude indexes motivated attention, we predicted that appetitive stimuli would cause greater LPP amplitudes (over several regions) than neutral stimuli. Second, because motivated attention may underlie the effect of appetitive stimuli on narrowed attention, we predicted that LPP amplitude would relate to greater narrowing of attention following appetitive picture primes. Third, based on past research suggesting the frontal cortex to be asymmetrically involved in approach motivational processes, we predicted LPPs to appetitive pictures would be larger in the left than right frontal cortex, and the left LPP should be larger to appetitive pictures than to neutral pictures. Finally, because the left hemisphere is more involved in both approach motivation and local attention, we predicted that the left as compared to right frontal LPP should predict more local attentional focus following appetitive primes.

Method

30 (11 female) unselected right-handed introductory psychology students participated for course credit (gender exerted no significant effects). After providing informed consent, EEG electrodes were applied. Due to equipment malfunction, cite F3 on one participant was not included in analyses.

Participants viewed 64 pairs of pictures preceded by 6 neutral practice trials. Each trial consisted of a fixation cross (500 ms) followed by an appetitive (desserts) or neutral (rocks) picture (6 s) used in previous research (Gable & Harmon-Jones, 2008a, 2008b; Harmon-Jones & Gable, 2009). Pictures were matched for color, brightness, and object size. After the picture and another fixation cross (500ms), a letters picture was displayed until the participant responded. If the participant did not respond within 5 s, the next trial began. Inter-trial interval varied between 18 and 20 s in order to allow participants time to recover between the RT task and affective stimuli.

Letters pictures were based on the Navon letters task (1977), and were used to assess local vs. global attentional focus. Each picture was a large letter composed of smaller letters. The large letters were made up of five closely spaced local letters on each vertical or horizontal line (e.g., an *H* of *F*s). Participants were asked to quickly identify if the picture contained the letter *T* or the letter *H* by pressing corresponding buttons. Global targets were those in which a *T* or an *H* was composed of smaller letter *L*s or *F*s. Local targets were those where a large *L* or *F* was composed of smaller *T*s or *H*s. Faster responses to the large letters indicate a global bias, whereas faster responses to the small letters indicate a local bias. 32 local and 32 global trials were randomly presented.

Following picture pairs, participants viewed the appetitive or neutral pictures again (3 s each), and indicated their pleasure (1 = very pleasing; 9 = very unpleasing) and arousal (1 = exciting; 9 = calm) on the Self-Assessment Manikin (Bradley & Lang, 1994). Desire for each picture was also measured (1 = really desired; 9 = did not desire). Consistent with ratings from previous studies (Gable & Harmon-Jones, 2008a; Gable & Harmon-Jones, 2008b), participants rated the appetitive pictures more pleasing (*M* = 3.49, *SE* = .18), arousing (*M* = 5.15, *SE* = .35), and desirable (*M* = 4.15, *SE* = .28) than neutral pictures (*M* = 5.10, *SE* = .23; *M* = 7.45, *SE* = .26; *M* = 7.07, *SE* = .31), *p*'s < .0001.

EEG was recorded with 22 tin electrodes in a stretch-lycra electrode cap. We focused our data acquisition on the frontal sites because of our interest in frontal asymmetry. All sites were referenced online to the left earlobe; offline, data were re-referenced to linked ears. Electrode impedances were under 5000 Ω; homologous sites were within 1000 Ω of each other. Signals were amplified with Neuroscan SynAmps2, bandpass filtered (0.05-500 Hz), notch filtered (60 Hz), and digitized at 2500 Hz. Artifacts (e.g., horizontal eye movements, muscle) were first removed by hand. Then, a regression-based eye movement correction was applied (Semlitsch, Anderer, Schuster, & Presslich, 1986).

The data were epoched for 100ms before picture (appetitive or neutral) onset until 1200 ms after picture onset, and filtered with a lowpass of 35Hz. Aggregated waveforms for each picture type were created and baseline corrected using the pre-stimulus activity. LPP amplitude was measured as the mean EEG activity within a window of 500-1000 ms, based on visual inspection and consistent with previous research investigating frontal lateralized LPPs (van de Laar, Licht, Franken, & Hendriks, 2004; Graham & Cabeza, 2001).

To limit the number of statistical tests, our results focused on testing a priori predictions. Consequently, no controls for type-1 error were used (Keppel & Zedeck, 1989). Reaction times (RT) to local and global targets were logarithmically transformed. Incorrect responses (6% of the sample) and those more than 3 standard deviations from the mean (0.6% of the sample) for each stimulus were removed.

Results

The RT results revealed that appetitive stimuli, relative to neutral stimuli, sped detection of local stimuli and slowed detection of global stimuli, replicating previous experiments (Gable & Harmon-Jones, 2008a; Harmon-Jones & Gable, 2009). These effects were revealed in a significant 2 (appetitive or neutral picture) X 2 (local or global target) within-subjects ANOVA, $F\,(1, 28) = 32.39$, $p < .0001$, $\eta_p^2 = .54$. Follow-up tests revealed that RTs to local targets were faster after appetitive pictures ($M = 6.62$, $SE = 0.04$) than after neutral pictures ($M = 6.69$, $SE = 0.04$), $t(29) = 4.66$, $p < .0001$, $d = 0.62$. In contrast, RTs to global targets were slower after appetitive pictures ($M = 6.63$, $SE = 0.04$) than after neutral pictures ($M = 6.58$, $SE = 0.04$), $t(29) = 2.36$, $p = .03$, $d = 0.31$. After neutral pictures, participants responded faster to global targets than local targets, $t(29) = 4.94$, $p < .0001$, $d = 0.65$. This finding is consistent with previous studies (Gable & Harmon-Jones, 2008a; Harmon-Jones & Gable, 2009; Kimchi, 1992); participants generally show a global bias on this task. After appetitive pictures, RTs did not differ between global and local targets, $t(29) = 0.49$, $p = .62$, $d = 0.07$.

Replicating past work, LPP amplitudes were greater after appetitive pictures than after neutral pictures at mid-line frontal, central, and parietal sites, all t's > 3.81, p's < .001, d's > 0.50. Also consistent with past research, appetitive pictures produced larger LPP amplitudes at lateral central and parietal sites (C3, C4, P3, P4), all t's > 3.40, p's < .01, d's > 0.44.

For left lateral frontal sites (F3, F5, F7), LPP amplitudes were greater after appetitive pictures than after neutral pictures, all *t's* > 3.47, *p's* < .001, *d* > 0.45. In contrast, at right lateral frontal sites, no consistent differences between appetitive and neutral pictures were found. For instance, at one right frontal site, F4, LPP amplitude was greater after appetitive than neutral pictures, *t*(29) = 3.19, *p* = .003, *d* = 0.42. But at another right frontal site, F8, LPP amplitude was greater after neutral pictures than after appetitive pictures, *t*(29) = 2.23, *p* = .03, *d* = 0.29. And finally, at the other right lateral frontal site, F6, no picture type differences were found, *t*(29) = 0.75, *p* = .46, *d* = 0.10.

Next, we compared LPPs to appetitive pictures between the two hemispheres. LPPs to appetitive pictures were greater in the left hemisphere than the right hemisphere for all lateral-frontal sites, all *t's* > 2.19, *p's* < .05, *d's* > 0.29. In other regions, no hemispheric differences were observed. These results are conceptually consistent with the results of van de Laar (2004) and Cunningham et al. (2005).

Because of our interest in the effects of appetitive motivation on attentional bias, we examined the correlations between LPP amplitudes to appetitive pictures and RTs to local (and then global) targets after appetitive pictures, controlling for RTs to local (global) targets after neutral pictures. These controls were implemented to control for individual differences in RT to stimuli, to test whether the predicted correlations were significant after eliminating variance due to RTs to neutral stimuli.

At midline sites, LPPs to appetitive pictures significantly predicted faster RTs to local targets after appetitive pictures, controlling for RTs to local targets after neutral pictures, *partial r's* > -.49, *p's* < .01. Similar results also occurred at the frontal sites, particularly left frontal sites.

Regarding global bias, LPP amplitudes at midline and frontal sites did not relate to global target RTs after appetitive pictures, *partial r*'s < -.34, *p*'s > .07.

We next examined correlations between LPP amplitudes to appetitive pictures and RTs to local (and then global) targets after appetitive pictures, controlling for LPPs to neutral pictures. These controls were implemented to test whether the appetitive LPP still predicted appetitive local bias after eliminating variance due to LPPs to neutral stimuli. Based on the previous results, we created a single criterion variable to capture local attentional bias induced by appetitive pictures (local targets after appetitive pictures minus local targets after neutral pictures).

At midline sites FZ and CZ, LPPs to appetitive pictures predicted faster RTs to local targets after appetitive pictures, controlling for LPPs to neutral pictures, *partial r's* > -.38, *p's* < .05. At PZ, the partial correlation was nonsignificant, *partial r* = -.32, *p* = .12.

At left frontal sites and one right frontal site, LPPs to appetitive pictures predicted faster RTs to local targets after appetitive pictures, controlling for LPPs to neutral pictures, *partial r's* > -.37, *p's* < .05. Other lateral right frontal sites produced nonsignificant effects, *partial r's* < -.20, *p's* > .31. Regarding global bias, LPP amplitudes at midline and frontal sites did not relate to global target RTs after appetitive pictures, *partial r*'s < -.24, *p*'s > .22.

The above results suggest that the LPP at midline and frontal sites correlated with greater local bias following appetitive pictures. Next, we wanted to test whether left frontal LPP amplitudes predicted more of this local attentional bias than right frontal LPPs. Local attentional bias induced by appetitive pictures was captured with a difference score of local targets after appetitive pictures minus local targets after neutral pictures.

Greater left LPP amplitudes to appetitive pictures predicted faster RTs to local targets after appetitive pictures (difference score), controlling for right LPP amplitudes to appetitive pictures, all *partial r's* < -.40, *p's* < .05. In these regressions, right LPP amplitudes to appetitive pictures did not relate to RTs to local targets after appetitive pictures, *partial r's* < -.20, *p's* > .32.

Left appetitive LPP amplitudes predicted faster RTs to local targets following appetitive pictures, when controlling for left LPP amplitudes to neutral pictures, all *partial r's* < -.37, *p's* < .05.

These results are consistent with the prediction that the local bias induced by appetitive stimuli is more strongly associated with the left frontal LPP (compared to the right lateral LPP) to appetitive pictures (compared to neutral pictures).

Discussion

Replicating past research, appetitive stimuli, as compared to neutral stimuli, evoked greater LPPs (over several regions) and more narrowed attention. Also, LPP amplitudes were consistently greater for appetitive pictures than for neutral pictures in the left but not right frontal sites, and LPP amplitudes to appetitive pictures were greater at left frontal sites than at right frontal sites.

The novel contribution of the present research was that LPPs to appetitive stimuli related to local attentional bias. That is, greater LPPs to appetitive stimuli at several sites predicted more local attention following appetitive primes. In addition, left frontal LPP amplitudes to appetitive pictures predicted more local attention after appetitive pictures. In contrast, right frontal LPPs to appetitive pictures did not consistently predict such. These left frontal LPP and appetitive local bias relationships remained significant when controlling for right frontal LPPs and when controlling for left frontal LPPs to neutral pictures. Future work should test whether frontally lateralized LPPs are involved in similar or different psychological processes than LPPs at other sites. Also, future work with larger electrode arrays should perform source analyses to uncover precise neural generators of the LPPs over the frontal cortex.

The present results are consistent with previous work on the LPP that has suggested it is related to motivated attention and with other work that suggests local attentional processes are lateralized to the left hemisphere (Hübner & Volberg, 2005). The current results extend past work by finding that asymmetrical attentional processing is facilitated by other asymmetrically related processes, specifically approach motivational processes (Gray, 2001; Gray et al., 2002). Appetitive processing, which is associated with the left prefrontal cortex, also increased locally biased attention.

We sought to examine positive approach motivational processes, because of the long-standing interest in positive affect and attentional breadth. Future studies should examine similar processes involved in negative affect and attentional breadth. Negative stimuli high in motivational intensity should evoke a relative narrowing of attention (Easterbrook, 1959; Mathews & Mackintosh, 2004), whereas negative stimuli low in motivational intensity (e.g., sad pictures) should evoke a relative broadening of attention (Gable & Harmon-Jones, in press).

In this article, we have explained our conceptual variables in terms of motivational intensity instead of arousal. Motivational intensity overlaps considerably with arousal. Self-reported arousal and sympathetic nervous system activation are both associated with motivational intensity (Bradley & Lang, 2007). However, motivation is not isomorphic with arousal; arousal can be increased without increasing motivation. We recently completed an experiment in which arousal was manipulated through bicycling. Although the arousal manipulation increased subjective arousal and heart rate, it did not enhance attentional narrowing (Harmon-Jones, Gable, & Hobbs, 2009). In contrast, manipulating positive approach motivation by giving participants the expectancy to consume desirable desserts does enhance attentional narrowing (Gable & Harmon-Jones, 2008a).

The current experiment extends past research by incorporating models of motivation, the LPP, and local-global attentional bias. Our results provide the first evidence that LPPs are associated with the local attentional bias induced by appetitive motivation, and thus they suggest a new understanding of the relationships between properties of emotions and cognitive processes. This chapter was based in part on Gable and Harmon-Jones (in press-b).

CHAPTER VI

POSTAURICULAR REFLEX RESPONSES TO PICTURES VARYING IN VALENCE AND AROUSAL

Reflexes are modulated by the emotional state of the organism. Much research has revealed that the startle reflexive eyeblink response is modulated by emotion (e.g., Amodio, Harmon-Jones, & Devine, 2003; Hawk & Kowmas, 2003; Vrana, Spence, & Lang, 1988). During the midst of processing of stimuli (2-5 sec after stimulus onset), unpleasant emotional images increase the startle eyeblink response, whereas pleasant emotional stimuli decrease this reflexive response, compared to neutral emotional stimuli. These results have been interpreted in terms of a response-matching hypothesis that suggests that the defensive startle reflex is enhanced during unpleasant emotional visual and auditory cues because the motivational state induced by the stimuli is defensive (Lang, Bradley, & Cuthbert, 1990). In contrast, the startle eyeblink reflex is reduced during pleasant emotional visual and auditory cues because the defensive motivational state induced by the startle noise is inconsistent with the appetitive state evoked by the pleasant cues. In support of a motivational interpretation of these results, experiments have revealed that it is primarily high arousal pleasant images that cause attenuation of startle eyeblink responses and high arousal unpleasant images that cause potentiation of startle eyeblink responses (Cuthbert, Bradley, & Lang, 1996).

In an innovative experiment, Benning, Patrick, and Lang (2004) extended research on emotion-reflex interactions by examining the postauricular reflex, a vestigial muscle response in humans that acts to pull the ear backward. During the presentation of the pictures, startling noises were occasionally presented, and postauricular reflex was recorded. Results revealed a significant effect of picture valence on the postauricular reflex. Follow-up tests showed that the postauricular reflex was larger during pleasant pictures than during unpleasant pictures. However, the postauricular reflex was only marginally larger during pleasant as compared to neutral pictures. When the arousing nature of the valenced pictures was taken into account, the postauricular reflex was larger during high arousal pleasant pictures than high arousal unpleasant pictures. The postauricular reflex did not differ between high arousal pleasant pictures and the low arousal pleasant and unpleasant pictures.

In another experiment, Hess, Sabourin, and Kleck (2007) found that during the viewing of female faces, the postauricular reflex was increased during happy expressions and decreased during angry expressions, as compared to neutral expressions. During the viewing of male faces, the postauricular reflex was attenuated during anger expressions compared to both neutral expressions and happy expressions, which did not differ. Hess et al. (2007) also found that the postauricular reflex was potentiated during the viewing of pleasant scenes compared to inter-trial intervals and unpleasant scenes, which did not differ. The latter results involving affective scenes partially replicated the results of Benning et al. (2004) but lacked the neutral picture control condition used in most previous startle eyeblink experiments.

Taken together, these results suggest that postauricular reflex is larger during pleasant pictures compared to unpleasant pictures. However, in Benning et al. (2004), the postauricular reflex was only marginally larger during pleasant as compared to neutral pictures. In Hess et al. (2007), a neutral affective picture condition was not included, so comparisons with this critical condition could not be made. Other experiments using similar methods have found no effects of affective picture type on postauricular reflex (Bradley, Drobes, & Lang, 1996; see Benning et al., 2004). For the relationship between postauricular reflex and emotion to be clearly interpretable, the postauricular reflex should differ significantly between neutral pictures and at least one type of affective picture. The present experiment was designed to examine whether such would occur with a different experimental paradigm.

In previous postauricular reflex and emotion experiments, pleasant, unpleasant, and neutral affective pictures were inter-mixed. In such designs, an unpleasant picture stimulus can occur at any time, and the affective tone of the pictures differs drastically from one presentation to the next. This degree of uncertainty may increase tonic negative affect throughout the entire picture viewing session, as (at least some) individuals are vigilant for unpleasant pictures. The tonic elevation of negative affect may attenuate positive affective responses (Neumann, Seibt, & Strack, 2001). Similarly, affective responses may be less intense in this mixed picture viewing session because of difficulties involved in switching from one valenced affect to an opposite valenced affect. To eliminate these design features that may work against observing emotional valence affecting the postauricular reflex and to give the postauricular reflex a stronger likelihood of differing between pleasant and neutral pictures, we had participants view the pictures in a block-type design, where affective pictures of one type were only pitted against neutral pictures. We also included high and low arousal pleasant and unpleasant pictures to assess whether the arousal level of the pictures would affect postauricular reflex activation to startle probes.

Method

48 undergraduates (10 women and 38 men) participated in exchange for course credit. To ensure participants were pleasantly aroused and not upset by the erotic pictures, the sample was pre-screened to include only those who were willing to view pictures of partially nude couples.

Participants viewed 128 color photographs, selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005). Half were affective and half were neutral. Neutral pictures were matched with valenced pictures for color, brightness, object size, and human presence.

Pictures were displayed for 6 sec and preceded by a fixation cross for 3s. Intertrial interval varied between 8 and 12 sec. At either 3.5 or 4.5s after picture onset, a 50ms 102dB (near-instantaneous rise time) startle probe of white noise was delivered through over-ear stereo head phones. During 25% of the trials, startle probes were delivered during the intertrial interval to increase the unpredictability of startle noise stimulus. Probes were presented either during the picture or during the ITI, not both. Six neutral pictures with startle probes were presented before picture viewing to habituate participants.

Pictures were presented in a semi-blocked fashion. Each block consisted of 32 pictures: 16 pictures from one affective picture category type (high arousal pleasant, low arousal pleasant, high arousal unpleasant, or low arousal unpleasant) and 16 matching neutral pictures. Thus, four blocks of pictures occurred. Neutral pictures and affective pictures (e.g., high arousal pleasant pictures) were randomly presented within a particular block. Block order was randomized between participants.

Placement and measurement of the postauricular reflex followed Benning et al. (2004). Electrode sites were prepared with an abrasive gel and an alcohol pad. Two tin electrodes were used to measure postauricular muscle activity. One electrode was placed in line with the postauricular muscle tendon on the pinnea of the ear. The other was placed on the scalp over the postauricular muscle. A ground electrode was placed on the forehead. Electrode impedance was below 5 kΩ. Data were recorded amplified with Neuroscan Synamps (El Paso, TX), and filtered online using a bandpass filter of 0.05-1000Hz (sampling rate = 5000 Hz).

Data were hand artifact rejected; 5.3% of trials were excluded. Then, data were epoched for 50ms before probe onset until 125ms after probe onset, filtered off-line with a bandpass of 8-1000Hz. Peak amplitude activity was measured as the maximum EMG activity within a window of 5-35ms. The window for peak measurement was based on visual inspection. Individual trials were standardized across individuals, then averaged by picture block.

After providing informed consent, participants were instructed they would be viewing a variety of pictures. They were told to watch each picture the entire time it was displayed, and to ignore intermittent noises presented over the headphones. Following picture viewing, participants rated pictures on valence and arousal in the same randomly sorted semi-blocked design. Our arousal ratings were lower than normative arousal ratings. This result is most likely due to our sample rather than the semi-blocked design, because we have observed similar results in other mixed presentation designs in similar samples.

Results

Because pictures were presented in a blocked fashion, comparisons were made between neutral pictures and their matched affective pictures from within each block. Postauricular reflex activation was greater during high arousal pleasant pictures (M = 0.21; SD = 0.49) than matched neutral pictures (M = 0.05; SD = 0.49), $t(47) = 2.79$, $p = .007$. It was also greater during low arousal pleasant pictures (M = 0.07 SD = 0.43) than matched neutral pictures (M = -0.05 SD = 0.43), $t(47) = 1.99$, $p = .05$. Neither unpleasant picture set differed significantly from matched neutral pictures, t's < .14, p's > .73.

Next, difference scores were created between affective and neutral pictures within each block. Postauricular reflex activation to neutral pictures was subtracted from activation to affective pictures, such that greater scores indicate more activation to affective than neutral pictures. A 2 (pleasant vs unpleasant) X 2 (low vs high arousal) ANOVA revealed a significant main effect of picture valence, $F(1, 45) = 7.52$, $p = .009$, η_p^2 (partial eta squared) = .14. This main effect indicated that postauricular reflex activation was significantly greater during pleasant pictures ($M = 0.15$, $SE = 0.05$) than unpleasant pictures ($M = -0.02$, $SE = 0.04$). The main effect of arousal and the valence by arousal interaction were not significant, *p's* > .39. A 2 (valence) X 2 (arousal) ANOVA for matched neutral pictures produced no significant effects, *p*'s > .39. To further test for possible effects of arousal within pleasant pictures only, we conducted a 2(arousal) X 2(pleasant vs. neutral) ANOVA. There was a significant main effect for pleasant vs. neutral pictures, $F(1, 45) = 10.48$, $p = .002$, $\eta_p^2 = .19$. However, there was no main effect for arousal, and the interaction was not significant, *p's* > .27.

To examine whether order of block presentation affected postauricular reflex, we tested whether first block presented (pleasant vs. unpleasant) affected PAR; it did not, $p = .33$. Furthermore, neither sex of participant nor ear produced significant effects, *p's* > .35.

Startle eyeblinks were also collected. Data replicated past results, 2(valence) X 2(arousal) ANOVA, $F(1, 45) = 20.07$, $p < .0001$, $\eta_p^2 = .31$. High arousal unpleasant pictures evoked greater eyeblinks ($M = 0.15$ $SD = 0.51$) than matched neutral pictures ($M = -0.13$ $SD = 0.44$), $t(48) = 4.66$, $p < .0001$. Also, high arousal pleasant pictures evoked smaller eyeblinks ($M = -0.22$ $SD = 0.46$) than matched neutral pictures ($M = -0.06$ $SD = 0.54$), $t(47) = 3.10$, $p = .003$. No other picture types differed from matched neutral pictures, *t*'s < .51, *p*'s > .61.

Discussion

The present experiment demonstrated that pleasant scenes caused significant potentiation of the postauricular reflex relative to neutral scenes and unpleasant scenes. Finally, the arousal level of the scenes did not affect the postauricular reflex activation. This is the first demonstration of a significant difference between pleasant and neutral scenes on postauricular reflex potentiation. These results are in accord with previous expectations that the postauricular reflex is potentiated by pleasant stimuli (Benning et al., 2004; Hess et al., 2007).

In the current experiment, the postauricular reflex was not modulated by unpleasant scenes. These results are consistent with the previous results of Benning et al. (2004) and Hess et al. (2007), which used IAPS to manipulate unpleasantness. However, Hess et al. (2007) found postauricular reflex inhibition to angry facial expressions emitted by men and women. Considering the results of these two experiments with the present results, it appears that the postauricular reflex is more responsive to pleasant stimuli than unpleasant stimuli. Further research is required to understand the special effect angry facial expressions have on postauricular reflex responses.

The present experiment used a semi-blocked design in which valenced scenes of one type were presented against neutral scenes. No inter-mixing of pleasant and unpleasant scenes occurred within one block of presentations. This separation of affective types appears to have potentiated the effects of positive affect on the postauricular and eyeblink reflex. That is, we observed a significant difference between pleasant and neutral scenes on postauricular and eyeblink responses. Past experiments using mixed designs have not produced this significant difference for postauricular reflex. Moreover, this difference is occasionally not significant for eyeblink responses (Larson, Nitschke, & Davidson, 2007). Unpleasant scenes in an event-related design may dampen the physiological responses associated with positive affect. However, self-reports, particularly when obtained during a second viewing, may not be sufficiently sensitive to detect differences between mixed and blocked designs. By including matched neutral pictures within blocks and randomly ordering block presentations, concerns regarding habituation can be eliminated. Consequently, future reflex studies should consider using semi-blocked designs.

Unlike the startle eyeblink reflex, the postauricular reflex was not affected by the arousal level of the scenes. This result suggests that the postauricular reflex may directly tap pleasantness independent of arousal, and thus may not be a reflex modulated by motivation but one only modulated by affective valence. To our knowledge, the postauricular reflex is the only reflex that shows greater activation to pleasant than neutral stimuli. Consequently, it can be used fruitfully in investigations of positive affect. Moreover, interrogation of the neural underpinnings of positive affect's modulatory influence on the postauricular reflex may enlighten the understanding of basic emotion-reflex linkages. This chapter was based in part on Gable and Harmon-Jones (2009).

CHAPTER VII

THE EFFECT OF LOW VERSUS HIGH APPROACH-MOTIVATED POSITIVE AFFECT ON MEMORY FOR PERIPHERALLY VERSUS CENTRALLY PRESENTED INFORMATION

Emotions influence attention and processes involved in the formation, retrieval, and distortion of memories (Brown & Kulik, 1977; Cahill & McGaugh, 1995; Kensinger, 2009a). Although some research has suggested that positive affect categorically influences these processes differently than neutral affect (Kensinger, 2009a), recent research suggests that motivational intensity of positive affective states may influences these processes. For example, positive affects low in approach motivational intensity broaden attentional scope (Fredrickson & Branigan, 2005; Gable & Harmon-Jones, 2008a), whereas positive affects high in approach motivational intensity narrow attentional scope (Gable & Harmon-Jones, 2008a; Harmon-Jones & Gable, 2009). These results suggest that positive affects of differing motivational intensity levels may have different influences on memory, an idea that has been recently proposed but not yet directly tested (Kensinger, 2009b; Larson & Steuer, 2009; Levine & Edelstein, in press). The present research provides an initial test of this idea by extending research on positive affect and attention to memory.

Positive affects vary in motivational intensity. Some positive affective states are low in approach motivation (e.g., feeling serene), whereas others are higher in approach motivation (e.g., feeling desire). Positive affects high in approach motivation often occur in the pursuit of a goal (pre-goal). In contrast, positive affects low in approach motivation occur after a goal has been achieved (post-goal) or when there is no goal (goal irrelevant).

The distinction between low-to-high approach motivated positive affect and pre-goal vs. post-goal positive affect is similar, if not identical, to the distinction between appetitive and consummatory components of reward processing. While seeking out and obtaining a reward, high approach pregoal positive affect occurs, whereas consummatory responses after obtaining a reward are associated with low approach positive affects such as satisfaction (Knutson & Wimmer, 2007). Neurobiological differences exist between pre-goal and post-goal attainment positive affect in the prefrontal cortex, nucleus accumbens and other structures (Davidson & Irwin, 1999; Harmon-Jones, Harmon-Jones, Fearn, Sigelman, & Johnson, 2008; Knutson & Peterson, 2005; Knutson & Wimmer, 2007).

Approach-motivated positive affective states may be associated with narrowed attention and memories, as organisms shut out irrelevant perceptions and cognitions while they approach and attempt to acquire the desired objects (Gable & Harmon-Jones, 2008a; Harmon-Jones & Gable, 2008). Broad attention and memory for peripheral information might cause distraction and hinder acquisition of desired goals, but such cognitive states may be adaptive following goal acquisition. That is, positive affective states low in approach motivation increase attentional broadening and enhance memory for peripherally presented information because such states suggest that things are going better than necessary, coasting can occur, and the mind is open to unforeseen opportunities (Carver, 2003).

Broadening vs. narrowing of attention as a function of differing positive affective states has been examined in several experiments using global-local visual bias tasks. In these tasks, individuals are presented with visual stimuli that could be viewed in a local (narrow) manner or a global (broad) manner. Low approach positive affect causes broadened attention (Fredrickson & Branigan, 2005; Gable & Harmon-Jones, 2008a; Gasper & Clore, 2002), whereas high approach positive affect causes narrowed attention (Gable & Harmon-Jones, 2008a, in press-a; Harmon-Jones & Gable, 2009). For example, low approach positive affect (amusement) broadens attentional focus relative to high approach positive affect (desire; Gable & Harmon-Jones, 2008a, Study 1). Also, high approach positive affective stimuli that cause attentional narrowing also evoke significantly more approach motivation relative to neutral stimuli (Gable & Harmon-Jones, 2008a, Studies 2-3). In addition, trait behavioral approach sensitivity, as measured by the BAS scale (Carver & White, 1994), and experimental manipulations of approach motivation have been found to relate to attentional narrowing after appetitive stimuli (Gable & Harmon-Jones, 2008a, Studies 3-4). Specifically, individuals high in behavioral approach sensitivity (BAS; Carver & White, 1994) respond with more narrowed attention following positive approach-motivating stimuli, and manipulations that increase the intensity of approach motivation cause greater attentional narrowing following appetitive stimuli (Gable & Harmon-Jones, 2008a, Studies 3-4). Neural activations involved in approach motivation – relative left frontal cortical activity – are associated with more narrowed attention following appetitive stimuli (Gable & Harmon-Jones, in press-a; Harmon-Jones & Gable, 2009).

Based on the above findings, we predicted that positive affects of varying levels of approach motivational intensity would differentially affect memory for centrally vs. peripherally presented information. Specifically, high approach-motivated positive affect, as compared to a neutral state or low approach-motivated positive state, should cause better memory for centrally presented information. In contrast, low approach-motivated positive affect, as compared to a neutral state or high approach-motivated positive state, should cause better memory for peripherally presented information. In this initial examination of the effects of different positive affects on memory, the physical location of stimuli was varied to be either centrally or peripherally presented. Across all affective states, centrally presented information may be better remembered than peripherally presented information; our predictions are focused on testing the differences between affective states on peripherally (or centrally) presented information.

Experiment 1

Low and high approach-motivated positive affects were manipulated using the monetary incentive delay paradigm, which has been used in other experiments to create low vs. high approach-motivated positive affect or pre- vs. post-goal positive affective states (Knutson & Wimmer, 2007; Knutson, Westdorp, Kaiser, & Hommer, 2000). In this paradigm, cues indicating the possibility of gaining money for subsequent task performance are used to evoke pre-goal (high approach) positive affect. Different cues indicating the outcome of the task performance (i.e., whether a reward was obtained) are used to evoke post-goal (low approach) positive affect. Experiments using this task have found that pre-goal positive cues indicating the possibility of gaining money activate anticipatory reward circuitry such as the nucleus accumbens. In contrast, post-goal positive cues indicating monetary gain do not activate this anticipatory reward circuitry (Kuntson, Fong, Bennett, Adams, & Hommer, 2003). Furthermore, participants report greater positivity and arousal during pre-goal anticipated monetary gain than after post-goal obtained monetary gain (Nielsen, Knutson, & Carstensen, 2008).

Predicated on research that has found that positive affects high in approach motivation cause a narrowing of attention, whereas positive affects low in approach motivation cause a broadening of attention, we predicted high approach (pre-goal) positive affect would cause better memory for centrally presented information, whereas low approach (post-goal) positive affect would cause better memory for peripherally presented information.

Twenty-seven introductory psychology students participated for course credit. Participants were informed that they had the chance to win a monetary prize of $10. Twelve practice trials were included at the beginning of the game.

Each trial (n = 120) began with a white circle or square presented in the center of the computer monitor. Half of the participants were told that the circles were reward cues indicating they could gain money on the trial based on their reaction times and the squares were neutral cues indicating the could not gain money on the trial based on their reaction times; the meaning of cues was reversed for the other half of the participants. Half the trials were reward trials and half the trials were neutral trials.

Following 40 pre-goal cues, a word was presented in a central or peripheral location on the monitor. Central words (n = 20) were presented in the center of the screen; peripheral words (n = 20) were presented in the center of one of four quadrants of the computer screen. Participants were told they would see words displayed, but that they were unrelated to the game. All words were neutral words from the Affective Norms of English Words (ANEW; Bradley & Lang, 1999).

Next, participants performed the goal-related task, which was a flankers task (Eriksen & Eriksen, 1974). Participants were instructed to indicate the direction of the center arrow by pressing buttons marked left or right as quickly and accurately as possible. Participants were told that if they correctly responded to the arrow faster than the average college student, they would gain money on the trial, if the trial was a reward one.

Following the flankers, participants received post-goal feedback. A white circle or square appeared with a monetary value displayed in the circle/square indicating the amount of money gained ($0.15 or $0.00). In order to give participants the expectancy that they could beat the average reaction time and gain money, gain and non-gain post-goal feedback was manipulated. Two thirds of the trials with the expectancy of monetary gain resulted in gaining money. In contrast, on the non-reward trials, two-thirds of the trials resulted in no-gain. Following 40 post-goal gain feedback cues and 40 post-goal no-gain feedback cues, another neutral word was presented centrally or peripherally. A total of 120 neutral words (40 pre-goal and 80 post-goal) were presented in the study.

One-third of the reward expectancy trials resulted in no-gain. This was done to give participants the impression their efforts were resulting in achieving the reward as opposed to the game being fixed. Also, one-third of the non-reward expectancy trials resulted in monetary gain, so we could examine whether such affected memory. Participants were instructed at the beginning of the game that gains on these trials were unrelated to their reaction time.

After all trials were presented, memory was measured. The old words (10 words in each of the 12 conditions; e.g., post-goal gain reward-expectancy centrally presented words) and 80 new neutral foil words were presented one at a time until participants responded whether or not they remembered seeing the word. Finally, participants were paid $10 and debriefed.

A 2 (reward expectancy vs. non-reward expectancy) X 2 (word presentation: central vs. peripheral) X 3 (pre-goal cue vs. post-goal gain feedback vs. post-goal no-gain feedback) ANOVA revealed a significant three-way interaction, $F(2, 50) = 5.09$, $p = .01$, $\eta_p^2 = .17$. This three-way interaction was unpacked by examining the 2 (reward expectancy) X 2 (word presentation) within the pre-goal cue, post-goal feedback, and post-goal no-gain feedback conditions.

In response to the pre-goal cue, an interaction occurred, $F(1, 25) = 5.45$, $p = .03$, $\eta_p^2 = .18$. Centrally presented words after reward expectancy were recognized significantly more than centrally presented words after non-reward expectancy ($p = .0007$). Peripherally presented words after reward expectancy did not differ from peripherally presented words after non-reward expectancy ($p = .57$). Centrally presented words were recognized more than peripherally presented words for both trial types (p's < .0001).

In response to the post-goal gain feedback, an interaction occurred, $F(1, 25) = 3.81$, $p = .06$, $\eta_p^2 = .13$. Peripherally presented words after reward gain were recognized significantly more than peripherally presented words after non-reward ($p = .01$). Centrally presented words after reward expectancy did not differ from centrally presented words after non-reward expectancy ($p = .93$). Centrally presented words were recognized more than peripherally presented words for both trial types (p's < .004).

As expected, within the post-goal no-gain feedback condition, the 2 (reward expectancy) X 2 (word presentation) interaction was not significant, $F(1, 25) = 0.59$, $p = .45$, $\eta_p^2 = .02$.

As compared to a neutral state, a high approach-motivated (pre-goal) positive state caused better memory for centrally presented stimuli. A low approach-motivated (post-goal) positive state, however, caused better memory for peripherally presented stimuli, as compared to a neutral state. This improved memory for peripheral information occurred only after participants were in a pre-goal positive state; it did not occur to monetary gain when there was no expectancy for the gain.

The no-gain conditions produced no differences in central or peripheral memory. Failing to receive an expected reward has been shown to produce anger for some individuals but sadness for others (Crossman, Sullivan, Hitchcock, & Lewis, 2009). Anger, a high-approach negative affect, likely produces a narrowing of attention and cognition, whereas sadness, a low-approach negative affect, likely produces a broadening of attention and cognition (Gable & Harmon-Jones, in press-b). These diverse emotional outcomes may have led to the lack of differences in the no-gain conditions.

Some of our results – post-goal positive affect causing better memory for peripheral information -- are conceptually consistent with other findings (Berntsen, 2002; Storbeck & Clore, 2005; Talarico, Berntsen, & Rubin, 2008), if we assume that the past studies evoked positive affects that were low in approach motivation. This may be the case. Storbeck and Clore (2005) used pleasant music, and Berntsen (2002) and Talarico et al. (2008) had participants recall pleasant memories. The affective states created by these manipulations are not associated with specific goal-directed action tendencies and unlikely to be associated with strong approach motivation.

The results of Experiment 1 illuminate the diverse effects that pre-goal and post-goal positive affect states can have on basic cognitive processes such as central or peripheral memory. Despite fitting with predictions based on previous research on the attentional effects of pre-goal and post-goal positive affect, the findings in Experiment 1 are novel. In addition, the affective manipulation used in Experiment 1 is novel in its application to studying basic cognitive processes associated with positive affect.

To more fully explore these memory differences in positive affective states, we wanted to replicate the novel finding that pre-goal positive affect causes better memory for centrally presented stimuli. However, we sought to conceptually replicate this effect using a different manipulation of approach-motivated positive affect. Specifically, we designed Experiment 2 to manipulate affect using affective picture stimuli (e.g. dessert pictures).

Experiment 2

In Experiment 2, we used pictorial stimuli that have been found to reliably evoke approach-motivated positive affect (Gable & Harmon-Jones, 2008a; Gable & Harmon-Jones, 2008b; Harmon-Jones & Gable, 2009). We hypothesized that appetitive pictures would cause better memory for centrally presented stimuli than neutral pictures.

Eighty-eight introductory psychology students participated. Four practice trials occurred at the beginning of the game. Each trial ($n = 120$) began with an appetitive (dessert, $n = 60$) or neutral (rock, $n = 60$) picture presented full-screen on a 17-in computer monitor (2 s), followed by an ISI of 400-800 ms. Following 20 of the appetitive and 20 of the neutral pictures, a neutral word was displayed for 250ms in the center or periphery, as in Experiment 1. Next, the flankers task of Experiment 1 occurred. ITI varied between 3-5s. Finally, memory for the words was measured, as in Experiment 1. Forty old words (10 in each of the 4 conditions) and 40 new neutral foil words were presented.

A 2 (picture type: appetitive vs. neutral) X 2 (word presentation: central vs. peripheral) ANOVA produced a significant interaction, $F(1, 87) = 24.17$, $p < .0001$, $\eta_p^2 = .22$. Centrally presented words after appetitive pictures ($M = 5.62$, $SD = 2.74$) were recognized significantly more than centrally presented words after neutral pictures ($M = 4.89$, $SD = 2.53$, $p < .0001$). In contrast, peripherally presented words after neutral cues ($M = 2.50$, $SD = 2.15$) were recognized significantly more than peripherally presented words after appetitive pictures ($M = 2.00$, $SD = 2.02$, $p = .006$). Centrally presented words were recognized more than peripherally presented words for both picture types, p's $< .0001$.

Results of Experiment 2 conceptually replicated the results of Experiment 1 with stimuli used that have been found to consistently evoke approach-motivated positive affect and narrowed attention. Appetitive, as compared to neutral, pictures caused better recognition of centrally presented words.

General Discussion

The current results indicate that approach-motivated positive affect enhances memory for centrally presented stimuli. In Experiment 1, approach-motivated positive affect was manipulated using an expectancy to win rewards, as in other research (Knutson & Wimmer, 2007; Knutson, Westdorp, Kaiser, & Hommer, 2000). In Experiment 2, approach-motivated positive affect was manipulated using appetitive pictures, as in other research (Gable & Harmon-Jones, 2008a, 2008b). Although different methods were used in the two experiments, both found improved memory for centrally presented information. These results agree conceptually with experiments showing that approach-motivated positive affect narrows attention (Gable & Harmon-Jones, 2008a; Harmon-Jones & Gable, 2009).

In contrast, post-goal, low approach-motivated positive affect enhanced memory for peripherally presented stimuli (in Experiment 1). This affective state was created through accomplishing the goal of winning rewards, as in other research (Knutson & Wimmer, 2007). This manipulation of low approach-motivated positive affect produced results conceptually consistent with past research that demonstrated that positive affect causes a broadening of memory (Berntsen, 2002; Storbeck & Clore, 2005; Talarico, Berntsen, & Rubin, 2008).

Of note is that the affective states in the current experiments affected memory for stimuli unrelated to the affective state. These results indicate that the memory consequences of high and low approach-motivated positive affects are general and not specifically tied to memory for the affective stimuli.

Is approach motivational intensity the best explanation for the current results? Might emotional intensity or arousal account for the effects? Although it is impossible to answer these questions because the experiments did not include measures of affect, we would suggest that approach motivational intensity provides a better explanation than emotional intensity or arousal. Regarding emotional intensity, past experiments on the attentional consequences of low vs. high approach positive affect found that low and high approach positive affect evoked similar levels of self-reported general positivity but differed on amusement (low approach) and desire (high approach; Gable & Harmon-Jones, 2008a). These results suggest that emotional intensity, as measured by self-reported emotional experience, can not account for the attentional differences produced, which parallel the memory effects found here.

Regarding arousal, consistent with other theories of emotion, we view motivational intensity as being closely related to the arousal level of affective states (Bradley & Lang, 2007). Thus, high intensity motivation stimuli evoke strong levels of arousal. However, arousal and motivation are not identical. In a recent experiment, the effect of general arousal on attentional narrowing was tested by having participants respond to an attentional bias task after appetitive and neutral pictures while undergoing stationary physical exercise. Although physical exercise heightened arousal as measured by heart rate, the increased arousal level did not cause narrowing of attention (Harmon-Jones, Gable, & Hobbs, 2009). In addition, some affective states, such as amusement, are thought to be high in arousal or a “higher activation state” (Fredrickson & Branigan, 2005, p.326), and these states cause attentional and memory broadening (Gable & Harmon-Jones, 2008a; Fredrickson & Branigan, 2005; Talarico et al., 2008). We would posit that these states are low in approach motivation, because they were not associated with strong urges to act, and past work has revealed these states to differ in relative left frontal cortical activation, which is associated with approach motivational intensity (Harmon-Jones et al., 2008). Finally, our conceptual model explains both the narrowing associated with high approach motivation and the broadening associated with low approach motivation. We are aware of no theories based on emotional intensity and arousal that would predict both narrowing and broadening.

The current research highlights the importance of incorporating motivation into studies on affect, an idea that has been called for in research on central and peripheral memory (Larson & Steuer, 2009; Levine & Edelstein, 2009). A more complete examination of affects and their relationships with memory and cognitive processes will assist not only in better understanding affect-cognition interactions, but may have important applications for performance. This chapter was based in part on Gable and Harmon-Jones (in press-a).

CHAPTER VIII

THE BLUES BROADEN, BUT THE NASTY NARROWS: ATTENTIONAL CONSEQUENCES OF NEGATIVE AFFECTS LOW AND HIGH IN AROUSAL

A loaded gun is pointed in your face. A coiled and hissing rattlesnake startles you. If you have experienced these situations, you probably recall how your attention became intensely focused on the source of the negative emotion you felt. More than that, these negative affective experiences would narrow your attentional focus generally and affect your processing of other stimuli, as over 50 years of research have revealed (Chajut & Algom, 2003; Easterbrook, 1959; Wells & Matthews, 1994). But is that the whole story? Do all negative affective states cause a narrowing of attention?

Along similar lines, over 20 years of research suggested that all positive affective states cause the opposite effect on attention – positive affect broadens attention (Fredrickson & Branigan, 2005; Hicks & King, 2007). However, recent research suggested a consideration of the approach motivational intensity of positive affect alters the effect of positive affect on attentional broadening vs. narrowing (Harmon-Jones & Gable, 2008). Whereas positive affects low in approach motivational intensity broaden attentional scope (Fredrickson & Branigan, 2005; Gable & Harmon-Jones, 2008), positive affects high in approach motivational intensity narrow attentional scope (Gable & Harmon-Jones, 2008; Harmon-Jones & Gable, 2009). Does a consideration of the motivational intensity of negative affective states also play a role in how negative affect influences attentional scope?

Negative affects vary in motivational intensity, with some being higher in motivational intensity (e.g., disgust, fear) and others being lower in motivational intensity (e.g., sadness). Motivational intensity or the impetus to act is related directly to arousal, but unlike arousal, motivation always has action implications (even if they are vague). In Bradley and Lang's (2007) biphasic view of emotion, "judgments of arousal index (again, roughly) the degree of activation in each motivation system" (p. 585). The more motivationally intense a negative affective state, the greater the sympathetic nervous system activation (for review, Bradley & Lang, 2007).

Negative affects high in motivational intensity are associated with a narrowing of attention, and these states have been the primary negative states examined in research on emotion and attentional scope. Early work on emotion and attention found that high withdrawal-motivated negative affect narrowed attentional focus (Easterbrook, 1959). Easterbrook referred to drive, which he viewed as "a dimension of emotional arousal or general covert excitement, the innate response to a state of biological deprivation or noxious stimulation… in subjects under stress or threat …" (p. 184). Other studies have found attentional narrowing occurs to high withdrawal-motivated affects evoked by social stress (Sanders, Baron, & Moore, 1978), electric shock (Wachtel, 1968), scary novel situations (Weltman & Egstrom, 1966), faces expressing negative emotion (Fenske & Eastwood, 2003), difficult ego threatening tasks, and noise stimuli (Chajut & Algom, 2003).

Research investigating the effect of negative affects low in motivation on attentional scope is less abundant, less direct, and primarily correlational. For example, persons with depression tend to be more creative (Andreasen, 1987; Ludwig, 1994) and show broadening of memory (von Hecker & Meiser, 2005). These results suggest that negative affects low in motivational intensity may broaden attention much like positive affects low in motivational intensity. However, no direct tests of this hypothesis have been performed.

Negative affects low in motivational intensity (e.g., sadness) may promote broadened attention because they assist with disengagement from terminally blocked goals and cause the organism to become open to new and previously irrelevant possibilities (Klinger, 1975). In such negative affect situations, “a more open, unfocused, unselective, low-effort mode of attention would prove not deficient but, on the contrary, beneficial” (von Hecker & Meiser, 2005, p. 456).

Based on the above reasoning, we predicted that negative affects low in motivational intensity would increase attentional breadth, whereas negative affect high in motivational intensity would decrease attentional breadth. Experiment 1 focused on sadness because no past research has experimentally tested its hypothesized attentional broadening effect. In Experiment 2, participants viewed high withdrawal-motivated pictures (disgust) and neutral pictures. Experiment 2 used the same design as Experiment 1, to show the attentional effects were caused by motivational intensity and not due to our particular methods of manipulating affect or assessing attentional scope. Instead of combining both types of negative affect within the same experiment, separate experiments for low and high motivated negative affects were conducted because we were concerned that the affective state created by one negative affect might spill over into the other negative affect and lead to a mixed sad-disgust state (Gable & Harmon-Jones, 2009). In all experiments, breadth of attention was measured using the Navon (1977) global-local letter task, a widely used, objective measure of attentional breadth used in several past experiments (Yovel, Revelle, & Mineka, 2005; for a review, see Kimchi, 1992). We expected sadness to cause a relatively broader attentional scope and disgust to cause a relatively narrower attentional scope as revealed by the relative difference between local and global reaction times.

This prediction is based on past positive affect research using local-global stimuli that has found approach-motivated positive affect to slow global reactions (Gable & Harmon-Jones, 2008 Experiment 3; Gable & Harmon-Jones, 2009; Harmon-Jones & Gable, 2009), or both slow global and speed local reactions (Gable, & Harmon-Jones, 2008 Experiment 2). Similar effects have also emerged in some past research on arousing negative affect (e.g., Wachtel, 1968; Weltman & Egstrom, 1966).

Experiment 1

Participants were 35 (14 female) introductory psychology students participating for course credit. Participants viewed 32 color photographs, selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005). Half were unpleasant, low in arousal, and selected because they were likely to evoke sadness. The other half were neutral, and matched with unpleasant pictures for color, brightness, object size, and human presence.

Pictures were displayed for 6 sec and preceded by a fixation cross for 3s. After the picture and another fixation cross (500ms), a Navon letters picture was displayed until the participant responded. If a response did not occur within 5 s, the next trial began. Intertrial interval varied between 8 and 10 sec. Six neutral practice trials occurred before the recorded trials.

The Navon (1977) letters task was used to assess attentional breadth. In this task, a large letter was composed of smaller letters. The large letters were made up of five closely spaced local letters on each vertical or horizontal line (e.g., an *H* of *F*s). Participants were asked to respond “as quickly as possible” if the picture contained the letter *T* by pressing the left key or the letter *H* by pressing the right key. Global targets were those in which a large *T* or an *H* was composed of smaller letter *L*s or *F*s. Local targets were those where a large *L* or *F* was composed of smaller *T*s or *H*s. Faster responses to the large letters indicate a global (broad) focus, whereas faster responses to the small letters indicate a local (narrow) focus. 16 local and 16 global trials were randomly presented within each block. Response times were logarithmically transformed. Incorrect responses (2.9% of the sample) and those more than 3 standard deviations from the mean (0.86% of the sample) for each stimulus were removed (Fazio, 1990). There were insufficient errors to permit analyses of error rates.

Following all trials, participants viewed all the affective pictures and half the neutral pictures to conserve time (2 sec each), and indicated their pleasure (1 = very pleasing; 9 = very unpleasing) and arousal (1 = excited; 9 = calm) on the Self-Assessment Manikin (Bradley & Lang, 1994). Disgust and sadness for each picture was measured (1 = no emotion; 9 = strongest feeling).

Consistent with predictions, after sad pictures, participants responded faster to global targets than local targets, *p-rep* = .99. After neutral pictures, participants also responded faster to global than local targets, *p-rep* = .91, replicating the often observed global bias (Navon, 1977). Importantly, the difference between global and local targets was larger after sad pictures than after neutral pictures, as revealed by the significant 2 (sad or neutral picture) X 2 (local or global target) ANOVA, $F\ (1, 34) = 4.54$, *p-rep* = 89, $\eta_p^2 = .12$. Reaction times (RTs) to local targets were slower after sad pictures than after neutral pictures, *p-rep* = .91. RTs to global targets were similar across conditions, *p-rep* = .54.

For picture ratings, a 4 (valence, arousal, disgust, and sadness) X 2 (sad or neutral picture) within-subjects ANOVA revealed a significant interaction, $F\ (3, 72) = 38.42$, *p-rep* = .99, $\eta_p^2 = .62$. Sad pictures were more unpleasant ($M = 6.31$, $SD = 4.25$), disgusting ($M = 1.98$, $SD = 1.00$), and sad ($M = 4.05$, $SD = 1.00$) than neutral pictures ($M = 4.53$, $SD = 2.13$; $M = 1.36$, *SD* = 1.00; *M* = 1.47, *SD* = 1.00), *p-rep*'s > .95. Sad pictures (*M* = 7.37, *SD* = 3.63) were similar in arousal to neutral pictures (*M* = 7.38, *SD* = 3.00), *p-rep* = .48. Also, the sad pictures evoked significantly more sadness than disgust, *p-rep* = .99.

In support of the hypothesis and in contrast to much past conceptualizing, these results indicate that sad pictures caused relatively more broadening of attention as compared to neutral pictures. Furthermore, sad pictures were rated as more unpleasant but equivalent in arousal to the neutral pictures, consistent with the idea that the sad pictures were low in arousal and thus motivational intensity.

Experiment 2

Experiment 2 was conducted to assess whether the attentional effects observed in Experiment 1 were caused by motivational intensity and not due to our methods of manipulating affect or assessing attentional scope. Therefore, in Experiment 2, we used picture presentations to evoke negative affect and Navon stimuli to assess breadth of attention, but instead of examining the effect of low motivation, negative affect, we examined the effect of high motivation, negative affect. Based on our conceptual model linking intense emotive states to more narrowed attention, we predicted that high motivation, negative affect would cause more narrowed attention relative to neutral affect. In addition, because most previous experiments showing that high motivation, negative affect narrowed attention used fear or anxiety-producing stimuli, we thought it important to assess whether narrowed attention would result from another motivating, negative affect, disgust. Such would support our conceptual analysis by showing that highly motivating negative affects in general rather than specifically fear/anxiety narrows attention.

Participants were 115 (59 female) introductory psychology students participating for course credit. Participants viewed 64 color photographs collected from the internet. Half were selected because they were likely to evoke disgust; the other half were selected because they appeared neutral. Neutral pictures were matched with unpleasant pictures for color, brightness, object size, and human presence.

Procedures were identical to those in the previous experiment. Response times were logarithmically transformed. Incorrect responses (1.8% of the sample) and those more than 3 standard deviations from the mean (0.73% of the sample) for each stimulus were removed (Fazio, 1990).

Following all trials, participants viewed the affective and neutral pictures (6 sec each), and indicated their pleasure (1 = very pleasing; 9 = very unpleasing) and arousal (1 = excited; 9 = calm) on the Self-Assessment Manikin (Bradley & Lang, 1994). Disgust and sadness for each picture was measured (1 = no emotion; 9 = strongest feeling).

Consistent with predictions, after disgusting pictures, participants responded faster to local targets than global targets, *p-rep* = .91. In contrast, after neutral pictures, participants responded faster to global targets than local targets, *p-rep* = .99, replicating the often observed global bias (Navon, 1977). RTs to global targets were slower after disgust pictures than after neutral pictures, *p-rep* = .99. RTs to local targets were similar across conditions, *p-rep* = .36. The 2 (disgust or neutral picture) X 2(local or global target) interaction was significant, *F* (1, 115) = 48.91, *p-rep* = .99, η_p^2 = .30.

For picture ratings, a 4 (valence, arousal, sadness, and disgust) X 2 (disgust or neutral picture) within-subjects ANOVA revealed a significant interaction, *F* (3, 342) = 469.78, *p-rep* = .99, η_p^2 = .80. Disgust pictures were more unpleasant (*M* = 7.61, *SD* = 1.22), arousing (*M* = 3.94, *SD* = 2.15), sad (*M* = 6.48, *SD* = 2.25), and disgusting (*M* = 7.21, *SD* = 2.02) than neutral pictures (*M* = 3.89, *SD* = 1.22; *M* = 7.39, *SD* = 1.60; *M* = 1.34, *SD* = .56; *M* = 1.19, *SD* = .39), *p-rep*'s > .99. Also, the disgust pictures evoked significantly more disgust than sadness, *p-rep* = .99.

Consistent with predictions, the present results indicated that disgusting pictures caused a relative narrowing of attention as compared to neutral pictures. These results extend previous findings by showing that disgust, in addition to fear and anxiety, reduces the breadth of attention. This important extension reveals that highly motivating negative affects in general cause a relative narrowing of attention.

General Discussion

The present experiments revealed that the relationship between negative affect and attentional precedence is more complex than commonly thought. In line with past theory and evidence, Experiment 2 revealed negative affect caused a narrowing of attention, but this only occurred when negative affect was high in motivational intensity. When negative affect was low in motivation, it caused a broadening of attention, as shown in Experiment 1. These results are consistent with the conceptual idea that the effect of emotion on local/global precedence is not due to negative vs. positive affect but is instead due to motivational intensity. Positive and negative affects of low motivational intensity broaden attention, whereas positive and negative affects of high motivational intensity narrow attention.

Consistent with major theories of emotion, we view motivational intensity as being closely related to the arousal level of affective states (Bradley & Lang, 2007). As expected from this line of reasoning, the sad stimuli used in Experiment 1 evoked low self-reported arousal, equivalent to the arousal reported in response to the neutral stimuli. In contrast, the disgust stimuli used in Experiment 2 evoked high self-reported arousal, significantly higher than the arousal reported in response to the neutral stimuli. But arousal and motivation are not identical. Arousal created through physical exercise does not cause narrowing of attention (Harmon-Jones & Gable, 2009).

Taken together with the results of other recent research on the effect of motivational intensity levels within positive affects on attention (Gable & Harmon-Jones, 2008), the present research suggests that exploring negative affects along the dimension of motivational intensity and their relationships with attentional and cognitive processes will assist in better understanding negative affects and affect-cognition interactions. These results are consistent with a growing trend in research on emotion-cognition interactions to emphasize the importance of the motivation (Larson & Steuer, 2009; Levine & Edelstein, 2009). This chapter was based in part on Gable and Harmon-Jones (in press-c).

CHAPTER IX

EFFECTS OF LOCAL-GLOBAL ATTENTION ON NEUROPHSYSIOLOGICAL MEASURES OF APPROACH MOTIVATION

Positive affects vary in the degree with which they are associated with approach motivation, the drive to approach an object or goal. Some positive affective states are relatively low in approach motivation (e.g., joy after watching a funny film), whereas others are relatively high in approach motivation (e.g., enthusiasm while approaching a desirable object).

The distinction between low vs. high approach positive affect bears similarity to other concepts. For instance, Panksepp (1998) discussed a PLAY emotive system that “may help animals project their behavioral potentials joyously to the very perimeter of their knowledge and social realities…” (p. 283). He also discussed a second system, the SEEKING emotive system “that leads organisms to eagerly pursue the fruits of their environment…” (p. 145). The PLAY system seems linked to low approach-motivated positive affects, whereas the SEEKING system seems linked to high approach-motivated positive affects. Others have discussed appetitive or pre-goal positive states as being different from consummatory or post-goal positive states (Knutson & Wimmer, 2007), or “wanting” as different from “liking” (Berridge, 2007). SEEKING, pre-goal, approach-motivated positive affect may have emerged to assist in promoting reward acquisition. This has been noted in research on action orientation (vs. state orientation) and implemental mindsets. Implemental mindsets increase approach-motivated positive affect and increase the likelihood of goal accomplishment (Brandstätter, Lengfelder, & Gollwitzer, 2001; Harmon-Jones, Harmon-Jones, Fearn, Sigelman, & Johnson, 2008).

Positive affects of different motivational intensities have distinct effects on attention and cognition. Low approach-motivated positive affects cause broadening of cognition and attention (Fredrickson & Brannigan, 2005; Gable & Harmon-Jones, 2008a; Gable & Harmon-Jones, in press-a; Gasper & Clore, 2002; Rowe, Hirsh, & Anderson, 2007), presumably because these positive affects suggest a stable and comfortable environment (Fredrickson, 2001). In contrast, high approach-motivated positive affects cause narrowing of cognition and attention (Gable & Harmon-Jones, 2008a; Gable & Harmon-Jones, in press-a; Harmon-Jones & Gable, 2009), presumably because narrowed processes assist in the shutting out of irrelevant stimuli and cognitions as organisms approach and attempt to acquire desired objects (Harmon-Jones & Gable, 2008). This recent research, showing distinct consequences of positive affect low vs. high in approach motivation, is important because it challenged decades of research that suggested that all positive affective states caused a broadening of attention and cognition.

Studies have revealed that pre-goal positive affect causes better memory for information that was previously presented in the central visual field, whereas post-goal positive affect causes better memory for information that was previously presented in the peripheral visual field (Gable & Harmon-Jones, in press-a). In addition to finding that positive affective states high in approach motivation cause attentional narrowing relative to positive affective states low in approach motivation or a neutral state (Gable & Harmon-Jones, 2008a, Studies 1-3), studies have revealed that trait behavioral approach sensitivity relates to attentional narrowing after appetitive stimuli (Gable & Harmon-Jones, 2008a, Study 3). Specifically, individuals high in behavioral approach sensitivity respond with more narrowed attention following positive approach-motivating stimuli. Moreover, manipulations that increase the intensity of approach motivation cause greater attentional narrowing following appetitive stimuli (Gable & Harmon-Jones, 2008a, Study 4). All of these support the idea that approach motivated positive affect narrows cognition and attention (see Gable & Harmon-Jones, 2010, for review).

Attentional narrowing has been investigated using measures of global (broad) and local (narrow) attention. The concept of global-local attentional breadth can be likened to seeing the forest (global) or the trees (local). To have a more local focus is to focus attention on the smaller parts (trees) comprising the whole (forest). In contrast, to have a global focus is to incorporate the smaller elements to see a larger or whole picture.

Global-local attentional focus has been measured in a variety of ways. The most common measures involve using a figure with both global and local elements. One of the most prominent measures of global or local attention is the Navon (1977) letters task. In the task, pictures of a large letter composed of smaller letters are presented. The large letters are made up of closely spaced local letters (e.g., an *H* made of small *F*s). Individuals are asked to respond to particular individual letters throughout the task (e.g., *T* or *H*). If the response letters were T and H, global targets would be those in which a *T* or an *H* is composed of different smaller letters. Local targets would be those where a large letter is composed of smaller *T*s or *H*s. Faster responses to the large letters indicate a global (broad) focus, whereas faster responses to the small letters indicate a local (narrow) focus.

Past research has established that approach motivation causes more local attentional bias. The current study was designed to extend this work by examining whether the relationship between approach motivation and local attentional bias was bidirectional. That is, would manipulated local attentional focus increase approach motivational processing?

Functionally, narrowed attentional focus may serve as a way to enhance and allocate cognitive resources to attend on a specific object or goal. Zeroing-in on an appetitive object is likely to enhance the focus on the object and may also increase desire for the object as greater cognitive resources are devoted to the object. Along these lines, Liberman and Forster (2009) found that a local as opposed to a global attentional focus (using Navon letters) reduced the estimates of psychological distances of time, space, and social distance. Other research has revealed that highly desired objects are perceived as being physically closer than less desired objects (Balcetis & Dunning, 2010). Balcetis and Dunning (2010) suggest that "perceiving desirable objects as closer can energize actions meant to obtain those objects." (p.151). Thus, both increased desire and narrowed attentional focus tend to bring things psychologically closer, and psychological proximity to a goal enhances motivation (Liberman & Forster, 2008).

Other supportive findings for this bi-directional relationship has been found in neurophysiological investigations. Harmon-Jones and Gable (2009) investigated whether greater left frontal activation associated with high approach-motivated positive affect would relate to attentional narrowing. The study was predicated on previous cognitive research showing left hemispheric activation is associated with attentional narrowing (Volberg & Hübner, 2004; Volberg, Kliegl, Hanslmayr, Greenlee, 2009; Qin & Han, 2007), and other research showing that greater relative left frontal cortical activation was associated with approach motivation (for a review, see Harmon-Jones, Gable, & Peterson, in press). Results of Harmon-Jones and Gable (2009) showed that individual differences in approach motivation (time since eaten) related to local attentional bias following appetitive pictures. Also, relative left frontal-central activation predicted this local attentional bias. Furthermore, relative left frontal-central activation partially mediated the relationship of time since eaten and narrowed attention following appetitive stimuli. Therefore, it seems that both narrowed attentional focus and approach motivation have similar neurophysiological underpinnings and thus suggest a bi-directional relationship between approach motivation and narrowed attention. This hypothesis is based on the idea that motivational and cognitive systems are integrated at some level of processing because they share similar neural substrates, much like previous work that has suggested bidirectional connections between verbal working memory and approach motivation (Gray,2001; Gray, Braver, & Raichle, 2002).

The results of Harmon-Jones and Gable (2009) demonstrated that greater narrowed attention induced by appetitive stimuli is driven by neurophysiological activations associated with approach motivational processes. The present study expanded on this recent research by suggesting that because approach motivation engages the same neural circuitry that drives local attention in general, increasing local attention may increase approach motivation.

Thus, the present experiment tested the hypothesis that manipulating local vs. global bias will influence appetitive motivation, as measured by neurophysiological responses. Specifically, the experiment focused on an event-related brain potential that occurs 100 ms into stimulus processing (the N1 component) and asymmetrical frontal cortical activity. It is predicted that a manipulated increase in local attentional focus (compared to global focus) will increase approach motivation as measured by larger N1s and greater relative left frontal activation to appetitive stimuli.

Evidence suggests that motivational stimuli influence neurophysiological responses as early as 100 ms after the onset of the stimuli (Keil et al., 2001). This evidence has been obtained using event-related potentials (ERPs), in particular the N1 component. The N1 is larger in amplitude to affective pictures as compared to neutral pictures (Foti, Hajcak, & Dien, 2009). This early modulation of the N1 by affective stimuli has been proposed to be associated with the early allocation of attention for affective stimuli, because they are motivationally relevant and thus attract attention (Keil et al., 2001). Other studies have suggested that the N1 is associated with motivational processes (Baldauf & Deubel, 2009, Fichtenholtz et al., 2007, Plihal et al., 2001). Baldauf and Deubel (2009) found that the N1 was greater to a visual probe when it appeared in a goal-relevant position. The authors interpreted these results to mean that the N1 is an indicator of enhanced visual processing for a selected goal-related action. In addition, individuals show greater N1 activation to food-related words when they are in a food-deprived state as compared to a satiated state (Plihal et al., 2001). The N1 is likely driven by several structures, including the amygdale (Olofsson, Nordin, Sequeira, Polich, 2008), anterior cingulate cortex (Esposito, Mulert, & Goebel, 2009), and other areas of the prefrontal cortex (Bar et al., 2006).

In addition to ERP measures of approach motivation, asymmetric activation over the frontal cortex has been linked to approach motivation (for reviews see Coan & Allen, 2004; Harmon-Jones, Gable, & Peterson, in press). Greater left than right frontal activity, referred to as relative left frontal activity, is associated with greater approach motivation. In contrast, greater right than left frontal activity, referred to as relative right frontal activity, is associated with withdrawal motivation (Davidson, 1992; Harmon-Jones, 2003). For instance, studies have revealed that individuals with stronger approach-motivational tendencies towards appetitive pictures show greater relative left frontal activation while viewing appetitive (but not neutral) pictures (Gable & Harmon-Jones, 2008b; Gable & Harmon-Jones, in press-b; Harmon-Jones & Gable, 2009). Gable and Harmon-Jones (2008b) found that individuals who liked desserts or had not eaten for a long time were more likely to show greater relative left frontal activation to dessert pictures (but not neutral pictures).

The aim of the present study was to test the idea that attentional states can modulate components of approach motivation, such that local attentional states enhance approach motivation as compared to global attentional states only when they are relevant to the stimulus or goal state (Gray, 2001). For example, narrowed attentional focus should be more important when viewing appetitive pictures than when viewing neutral pictures. A global attentional manipulation may be nonessential or even deleterious while viewing appetitive as compared to neutral pictures.

Specifically, an increase in local attention (compared to global attention) should increase approach motivation towards appetitive stimuli and thus increase the N1 response to appetitive stimuli. In addition, based on evidence that greater left frontal activation is associated with approach motivation and narrowed attentional focus, we expect that increasing narrow attentional focus will increase approach motivation as measured by greater relative left frontal activation to appetitive stimuli.

Method

Forty-three (16 women) right-handed introductory psychology students participated for course credit. After informed consent was provided by participants, EEG electrodes were applied. Narrowed vs. broadened attentional focus was manipulated by having half the participants identify the small letter in the pictures (i.e., local elements) and the other half identify the large letter (i.e., global elements) in the picture. Participants were asked to respond orally with either the local or global element. Responses were checked to ensure participants in both conditions correctly identified the local or global letter. All participants responded correctly.

On individual computers, participants first viewed and identified either the small or the larger letter in 12 practice Navon letters pictures presented for 3s. Following these practice

Navon letters pictures, participants viewed 64 picture trials. Each trial consisted of a fixation cross (500 ms) followed by a Navon letter picture (1500 ms), where participants identified either the small or the large letter in the picture. Then, another fixation cross appeared (3000 ms), followed by a dessert or rock picture (9000 ms). Rocks were used as the neutral stimuli because they were a single cognitive set easily matched to dessert stimuli on size, shape, and color. The dessert pictures have been used in a number of previous studies and are significantly more pleasant, arousing, and cause more desire relative to the rock pictures (Gable & Harmon-Jones, 2008a, 2008b; Harmon-Jones & Gable, 2009; Gable & Harmon-Jones, in press-a).

EEG was recorded with 64 tin electrodes in a stretch-lycra electrode cap. All sites were referenced online to the left earlobe; offline, data were re-referenced using the common average reference. Eye movements were recorded from the supra- and suborbit of left eye. Electrode impedances were under 5000 Ω. Signals were amplified with Neuroscan SynAmps2, bandpass filtered (0.1-100Hz; 60-Hz filter enabled), and digitized at 500 Hz. Artifacts were removed by hand. A regression-based eye movement correction was applied (Semlitsch, Anderer, Schuster, & Presslich, 1986).

The data were epoched for 100ms before picture (dessert or rocks) onset until 1200ms after picture onset, and filtered with a lowpass of 35Hz (Picton et al., 2000). Aggregated waveforms for each picture type were created and baseline corrected using the pre-stimulus activity. Based on visual inspection of the pronounced N1, N1 amplitude was measured as the minimum (most negative) amplitude within a window of 60-160ms. There was a sensor failure at site FZ for one participant and ERP data were not collected. Also, one participant’s data was excluded due to equipment failure.

N1 amplitudes at midline sites FZ, FCZ, CZ, and CPZ were investigated. However, prior research investigating the source and function of the N1 have found effects in frontal central areas (Esposito, Mulert, Goebel, 2009; Plihal, et al., 2001; Zhang, Lio, Bia, & Zheng, 2009). Therefore, we focused our results on frontal central sites Fz and Fcz and predicted that N1 amplitude at these sites would show an effect of attention manipulation and picture type on N1 amplitude.

All epochs 1.02 s in duration were extracted through a Hamming window and re-referenced to whole head average. Consecutive epochs were overlapped by 50%. A fast Fourier transform calculated power spectra. Power values within low alpha band (8-10.25 Hz) were averaged in three sec epochs of picture viewing (Oakes et al., 2004; Pizzagalli, Sherwood, Henriques, & Davidson, 2005). That is, epochs were created across three segments of picture viewing: the first three sec, the second three sec, and the third three sec. Asymmetry score indexes (log right minus log left) were computed for frontal (AF3, AF4, F1, F2, F3, F4, F5, F6), frontal-central (FC1, FC2, FC3, FC4, FC5, FC6), central (C1, C2, C3, C4, C5, C6), central-parietal (CP1, CP2, CP3, CP4, CP5, CP6), and parietal (P1, P2, P3, P4, P5, P6, P7, P8) sites. Of these, only the frontal and frontal-central regions were expected to be sensitive to approach motivation (Gable & Harmon-Jones, 2008b; Harmon-Jones & Gable, 2009; Harmon-Jones, 2003; Urry et al., 2004). Because alpha power is inversely related to cortical activity, higher scores indicate greater left hemisphere activity.

Results

Effects of attention manipulation and picture type on N1 amplitude were revealed in a significant 2 (appetitive or neutral picture) X 2 (local or global target) within-subjects ANOVA at site FCZ , F (1, 40) = 10.21, p = .003, η_p^2 = .20, and FZ, F (1, 39) = 5.49, p = .02, η_p^2 = .12.

Follow-up tests at site FCZ revealed that participants in the local attention condition showed larger N1 amplitudes to appetitive pictures (*M* = -3.74, *SE* = 0.53) than to neutral pictures (*M* = -2.67, *SE* = 0.47), *p* = .001. In contrast, participants in the global attention manipulation showed similar N1 amplitudes to appetitive (*M* = -2.27, *SE* = 0.48) and neutral pictures (*M* = -2.53, *SE* = 0.43), *p* = .36. Furthermore, participants in the local attention condition showed greater N1 amplitudes to appetitive pictures than participants in the global attention condition, *p* = .03. Participants in both attention manipulation conditions showed similar N1 responses to neutral pictures, *p* = .85.

At site FZ, participants in the local attention condition showed larger N1 amplitudes to appetitive pictures (*M* = -3.21, *SE* = 0.52) than to neutral pictures (*M* = -2.41, *SE* = 0.50), *p* = .05. In contrast, participants in the global attention condition showed similar N1 amplitudes to appetitive (*M* = -1.89, *SE* = 0.48) and neutral pictures (*M* = -2.38, *SE* = 0.46), *p* = .20. Furthermore, participants in the local attention condition showed greater N1 amplitudes to appetitive pictures than participants in the global attention condition, *p* = .06. Participants in both attention manipulation conditions showed similar N1 responses to neutral pictures, *p* = .96. As predicted, N1 amplitudes at CZ and CPZ did not show a significant interaction with attention manipulation and picture type, *p*’s > 31.

Effects of attention manipulation and picture type on greater left frontal activation were revealed in a significant 2 (appetitive or neutral picture) X 2 (local or global target) within-subjects ANOVA at frontal sites during the second three-sec block picture viewing, *F* (1, 40) = 5.06, *p* = .03, η_p^2 = .11, and frontal-central sites, *F* (1, 40) = 9.62, *p* = .003, η_p^2 = .19. As predicted, effects were specific to the frontal and frontal-central regions. Effects were non-significant at central *F* (1, 40) = 0.57, *p* = .45, η_p^2 = .11, and central-parietal sites, *F* (1, 40) =

2.59, $p = .12$, $\eta_p^2 = .06$. There was also a significant interaction at parietal sites, $F(1, 40) = 3.93$, $p = .05$, $\eta_p^2 = .09$.

Follow-up tests at frontal sites revealed that participants in the local attention condition showed greater left frontal activation to appetitive pictures ($M = -0.03$, $SE = 0.07$) than to neutral pictures ($M = -0.10$, $SE = 0.07$), $p = .03$. Picture means were non-significantly different in the global attention condition, *p*’s > .38. At frontal-central sites, participants in the global attention manipulation showed lesser left frontal activation to appetitive pictures ($M = -0.11$, $SE = 0.05$) than to neutral pictures ($M = -0.02$, $SE = 0.04$), $p = .002$. Picture means were non-significantly different in the local attention condition, *p*’s > .12. There were no effects of picture type and condition on left frontal asymmetry in the first three or the last three seconds of picture onset.

Follow-up tests at parietal sties revealed results opposite to those in the frontal areas. The global condition caused greater right parietal activation to neutral ($M = 0.05$, $SE = 0.09$) as compared to dessert pictures ($M = 0.17$, $SE = 0.09$). In the local condition, effects were similar between neutral ($M = 0.05$, $SE = 0.10$) and dessert ($M = 0.08$, $SE = 0.10$) pictures. All other differences at parietal sites were non significant. The increase in right parietal activation to neutral pictures in the global condition might reflect the typical global bias activation often attributed to the right parietal hemisphere (Volberg, Kliegl, Hanslmayr, Greenlee, 2009).

Discussion

The manipulated increase in narrowed attentional focus enhanced N1 amplitude to appetitive as compared to neutral pictures. In addition, the manipulated increase in local attention caused increased relative left frontal cortical activation for appetitive pictures as compared to neutral pictures. Moreover, these effects observed in the local bias condition differed significantly from similar effects in the global bias condition

These results suggest that local attentional focus increases approach motivation towards appetitive stimuli as measured by neurophysiological measures. Moreover, the manipulated increase in local attentional focus influenced very early attentional processes related to approach motivation, as measured by the N1 at midline central sites. In addition, the present results are also consistent with a further aspect of the theoretical account of attentional bias and approach motivation: modulation on a hemispheric basis. Approach motivational processes were enhanced, as measured by greater left frontal activation, in the local, but not global attention condition.

Interestingly, differences in frontal asymmetry were found by condition and picture type only during the second-three sec of picture viewing. It is possible that the vocal utterances to identify the global or local letters could have caused greater left frontal activation , because verbal processing is associated with the left frontal cortex (Gray, 2001). These activations may have continued into the first three sec of picture viewing, thus eliminating any differences between appetitive and neutral stimuli. Future research is needed to explore this. Also, it seems likely that strong approach motivation, as evidenced by greater left frontal asymmetry, might not last the entire nine seconds of picture viewing. This would help explain the absence of an interaction between picture type and condition on frontal asymmetry during the last three seconds of picture viewing.

Based on previous research, it is possible that one would predict that manipulating a local vs. global attentional focus should itself influence asymmetrical hemispheric activity (Volberg, Kliegl, Hanslmayr, Greenlee, 2009; Qin & Han, 2007). That is, when compared to the global condition, the local condition should produce greater left hemisphere activation. This may be the case and future studies should investigate this idea. In the present study, we were unable to undertake these analyses because of the excessive movement artifact contaminating the EEG due to participants uttering the letter for the attention manipulation task.

Manipulated local vs. global attentional bias was highly selective for approach motivation to appetitive pictures. It is unlikely that these effects can be attributed merely to valence, because low approach-motivated positive affects are associated with global attentional focus (Fredrickson & Brannigan, 2005; Gable & Harmon-Jones, 2008a). It will be important for future research to extend the current neurophysiological findings to behavior by measuring whether the same attentional manipulations influence behavioral measures of approach motivation. In addition, future research should investigate whether more general cognitive manipulations (e.g., conceptual categorization) related to broadening or narrowing also enhance approach motivation.

Functionally, attentional narrowing in high approach or high withdrawal states may prove adaptive. In a high approach positive state, narrowed attentional focus likely assists in helping an organism to zero-in on obtaining the desired object or goal. Shutting-out irrelevant cognitions and focusing on the desired goal would help to promote goal-attainment action. Likewise, in a motivationally intense negative state, a narrowed attentional focus would assist in helping an organism to assess and avoid a frightening or disgusting object or situation (Gable & Harmon-Jones, in press-c). In both examples, incorporating distracting peripheral information could hinder goal acquisition or avoidance, and would prove to be dysfunctional. Narrowed attentional focus may serve as a way to enhance and allocate cognitive resources to attend to a specific object or goal, thereby facilitating acquisition of the object or goal. Narrowing cognitive breadth when viewing an object with motivational relevance likely enhances the cognitive resources devoted to the object, and also increases motivation (approach or avoidance) related to the object.

Based on results of the current study, it could be predicted that a narrowed attentional focus will enhance withdrawal motivational intensity towards aversive stimuli. Specifically, a narrowed attentional focus may enhance motivated attention to aversive stimuli. This should result in greater N1 amplitudes to aversive stimuli as opposed to neutral stimuli, because the N1 is a measure of attentional selection based on motivational importance (Kiel et al., 2001). However, frontal asymmetry is more closely related to behavioral response (i.e., greater right with withdrawal motivation; greater left with approach motivation). Therefore, it is unlikely that a narrowed attentional focus would also cause greater left frontal activation to aversive stimuli despite the common neural substrate, because greater right frontal activity is associated with withdrawal motivation. Future studies should investigate whether a manipulated increase in local bias facilitates withdrawal motivation to aversive stimuli.

Together with previous research, the current study indicates that attentional narrowing and approach motivation have a bidirectional relationship: approach motivation causes attentional narrowing (Gable & Harmon-Jones, 2008a), and attentional narrowing causes approach motivation (the present study). These results indicate that emotion and cognition can be integrated during processing (Gray, 2001). Moreover, the functional specialization of both approach motivation and attentional narrowing is not attenuated, but enhanced by this bidirectional relationship. This idea has distinct implications for models of cognition-emotion integration, such that motivation not only modulates attentional focus, but that attentional focus modulates motivation.

CHAPTER X

SUMMARY AND DISCUSSION

Positive affect varies in motivational intensity; some positive affective states are high in motivational intensity, whereas others are lower in motivational intensity. We have shown that these positive affective states have different effects on attentional breadth. Positive affect high in approach motivation causes a narrowing of attentional focus, whereas positive affect low in approach motivation causes a broadening of attentional focus.

The attentional effects predicted by the motivational dimension model are not limited to positive affect, but also apply to negative affect varying in motivational intensity. Negative affect high in motivational intensity narrows attentional focus, whereas negative affect low in motivational intensity broadens attentional focus. Thus, motivational intensity influences affect-cognition interactions across both positive and negative affect.

In the seven experiments using the Navon measure of attentional scope, we have found approach-motivated positive affect to slow global reactions (Gable & Harmon-Jones, 2008 Experiment 3; Gable & Harmon-Jones, 2009a; Harmon-Jones & Gable, 2009a), or to both slow global and speed local reactions (Gable, & Harmon-Jones, 2008 Experiment 2). Similar effects have also emerged in some past research on motivationally intense negative affect (e.g., Wachtel, 1968; Weltman & Egstrom, 1966).Thus, we suggest that motivational states high in intensity will cause a relatively narrow attentional scope, whereas motivational states low in intensity will cause a relatively broad attentional scope (as revealed by the relative difference between local and global reaction times). In other words, the conceptual idea of narrowing could manifest as faster detection of local information or slower detection of global information. Both manifestations may assist with ultimately mobilizing energy toward or away from the significant environmental stimulus.

In addition, high approach-motivated positive affect improved memory for centrally presented information, whereas low approach-motivated positive affect improved memory for peripherally presented information (Gable & Harmon-Jones, 2009b). Also, high approach-motivated positive affect narrowed cognitive categorization, whereas low approach-motivated positive affect broadened cognitive categorization (Price & Harmon-Jones, 2009). In conjunction with the studies on attention, these findings indicate that positive affect varying in motivational intensity may cause a general narrowing vs. broadening of cognitive processes. This evidence indicates that the motivational dimension model extends beyond attention. Future work should incorporate additional measures of broadening/narrowing.

Some readers/theorists may suggest that positive emotions are different than biological pleasures, and that our experiments using dessert primes show that biological pleasures but not positive emotions cause narrowing of cognition. However, our data do not support this interpretation and instead suggest that different positive states have similar effects on attentional/cognitive breadth. Indeed, several of our experiments manipulated appetitive states using dessert pictures, but others have manipulated appetitive states using reward tasks (Gable & Harmon-Jones, 2009b), pictures of cute baby animals (Gable & Harmon-Jones, 2008, Study 3), and body postures and facial expressions (Price & Harmon-Jones, 2009). All of these experiments, regardless of the type of appetitive manipulation used, revealed that appetitive states evoked narrowing of attention and cognition.

Consistent with major theories of emotion, we view motivational intensity as being closely related to the arousal level of affective states (Bradley & Lang, 2007). As expected from this line of reasoning, the high intensity motivation stimuli we used in the reviewed studies evoked strong levels of arousal. In contrast, when low intensity motivation was evoked, participants also reported low arousal, sometimes equivalent to the arousal reported in response to the neutral stimuli. However, arousal and motivation are not identical. In a recent experiment, the effect of general arousal on attentional narrowing was tested by having participants respond to Navon letters after appetitive and neutral pictures while undergoing stationary physical exercise. Although physical exercise heightened arousal as measured by heart rate relative to a no-exercise state, the increased arousal level did not cause narrowing of attention (Harmon-Jones, Gable, & Hobbs, 2009).

Fredrickson & Branigan (2005) manipulated amusement, a state believed to be high in arousal or a “higher activation state” (p.326), but we would suggest that it is low in motivational intensity. Relative to a neutral state, this higher activation positive affect caused attentional broadening and was similar to attentional broadening caused by contentment, a low-arousal low-motivational state. Later, Talarico et al., (2009) investigated peripheral memory for autobiographical memories associated with discrete positive emotions believed to be high in arousal (e.g., happiness and love) and low in arousal (e.g., calm). There were no differences in peripheral memory recall between high arousal positive emotions (happiness and love) and low arousal positive emotion (calm). In both of these studies, however, arousal was not measured. We would posit that these states are low in approach motivation, because they were not associated with strong urges to act.

Attentional narrowing in high approach or high withdrawal states may prove adaptive. In a high approach positive state, narrowed attentional focus likely assists in helping an organism to zero-in on obtaining the desired object or goal. Shutting-out irrelevant cognitions and focusing on the desired goal would help to promote pre-goal target-directed action. Likewise, in a motivationally intense negative state, a narrowed attentional focus would assist in helping an organism to assess and avoid a frightening or disgusting object or situation. In both examples, incorporating distracting peripheral information could hinder goal acquisition or avoidance and could prove to be dysfunctional.

Attentional broadening in low intensity affective states might serve a less specific function and may not be associated with the acquisition or avoidance of a specific goal or action orientation. In a low approach positive state, a broadened attentional focus incorporating a wider array of environmental cues may facilitate exploratory or playful behaviors that could lead to more creative or alternative approaches (Fredrickson, 2001). Low approach positive affect may also induce an organism to “ease back” (Carver, 2003, p.246) in order to conserve energy and resources following successful pre-goal pursuit. Carver (2003) predicted that, “people who exceed the criterion rate of progress (i.e., who have positive feelings) will reduce the subsequent effort in this domain” (p.246). The affect in such a situation is likely low in motivational intensity and is related to part of the goal (i.e., the criterion rate) having been achieved. That is, although the overall goal might not be achieved, the affect is low in motivational intensity and partially post-goal because the goal has been partially accomplished. Likewise, the increase of attentional breadth occurring with low intensity negative affect may cause an indiscriminate and low-effort focus of attention (von Hecker & Meiser, 2005). This may help one to disengage from a failed goal and encourage creative and novel solutions (Klinger, 1975). Low motivationally intense negative affect may also encourage resource conservation in the face of a terminally blocked goal.

Taken together, the research reviewed herein indicates a consistent pattern among both positive and negative affect along the lines of motivational intensity. Affect high in motivational intensity causes a general narrowing of cognitive processes, whereas affect low in motivational intensity causes a general broadening of cognitive processes. These results are consistent with the conceptual idea that the influence of affect on local/global precedence is not due to negative vs. positive affect, but is instead due to motivational intensity. That is, positive and negative affect of low motivational intensity broadens attention, whereas positive and negative affect of high motivational intensity narrows attention. This evidence and its conceptual framework, the motivational dimension model, integrates previous research and theory, and thus leads to an increased understanding of the influence of affective states on cognitive broadening/narrowing. This chapter was based in part on Gable and Harmon-Jones (in press-d).

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