Incorporating motivational intensity and direction into the study of emotions: implications for brain mechanisms of emotion and cognition-emotion interactions

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Contemporary dimensional models of emotion regard the positive to negative valence dimension as an important organising principle. This principle has been used to organise empirical observations of the relationship between left vs. right (asymmetrical) frontal cortical activations and positive vs. negative emotional experience and expression. This affective valence organising principle has also been used in research concerned with how emotions affect cognition, and much research has suggested that positive affects have different effects on cognition than negative affects. In this paper, we review recent research that questions the utility of the affective valence dimension in understanding the functions of asymmetrical frontal cortical activity and in understanding the effects of emotions on cognition. We will show that the incorporation of motivational direction as a separate dimension from affective valence will benefit understanding of brain mechanisms involved in emotions as well as emotion-cognition interactions. (*Netherlands Journal of Psychology*, 64, 132-142.)

Keywords: affective valence; cognition; emotion; frontal cortex; lateralisation; motivation

Contemporary dimensional models of emotion regard the positive to negative valence dimension as an important organising principle (Lang, 1995; Watson, 2000). Over the last three decades, this principle has been used to organise empirical observations of the relationship between left vs. right (asymmetrical) frontal cortical activations and emotional experience and expression. In this body of research, positive affect has been found to relate to relatively greater left than right frontal cortical activity, whereas negative affect has been found to relate to relatively greater right than left frontal cortical activity. This affective valence organising principle has also been used in research concerned with how emotions affect cognition, and much research has suggested that positive affects have different effects on cognition than negative affects. In this paper, we will review research that questions the utility of the affective valence dimension in understanding the functions of asymmetrical frontal cortical activity and in understanding the effects of emotions on cognition. We will show that the incorporation of motivational direction

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as a separate dimension from affective valence will benefit understanding of brain mechanisms involved in emotions as well as emotion-cognition interactions.

Affective valence, motivational direction, and asymmetrical frontal cortical activity

The interest in the relationship between asymmetrical frontal brain activity and emotional valence was sparked in part by systematic observations that damage to the left frontal cortex caused depression, whereas damage to the right frontal cortex caused mania (see review by Robinson & Downhill, 1995). Following closely after these observations, research demonstrated that both trait and state positive affect was associated with increased left frontal cortical activity, whereas trait and state negative affect was associated with increased right frontal cortical activity (see review by Silberman & Weingartner, 1986). Conceptually similar results have been obtained using a wide variety of neuroscience methods, including lesion studies (Robinson & Downhill, 1995), repetitive transcranial magnetic stimulation (rTMS; van Honk, Schutter, d'Alfonso, Kessels, & de Haan, 2002), positron emission tomography (PET; Thut et al., 1997), functional magnetic resonance imaging (fMRI; Canli, Desmond, Zhao, Glover, & Gabrieli, 1998), event-related brain potentials (ERPs; Cunningham, Espinet, DeYoung, & Zelazo, 2005), and electroencephalographic activity (EEG; Coan & Allen, 2003). Moreover, these effects have been observed in nonhuman and human animals (Berridge, España, & Stalnaker, 2003).

Until the late 1990s, all studies examining the relationship between asymmetrical frontal cortical activity and emotion confounded affective valence (positive vs. negative affect) with motivational direction. That is, all positive affective states/traits (e.g., joy, interest) that had been empirically examined were approach motivating, whereas all negative affective states/traits (e.g., fear, disgust) were withdrawal motivating. To understand whether these asymmetrical frontal cortical activations were due to affective valence or motivational direction (approach vs. withdrawal), we needed to examine an emotive state that avoided this confound of valence and motivational direction. To do so, we began investigating the relationship of anger with asymmetrical frontal cortical activity, because past social psychological and animal behaviour research suggested that anger is a negative emotion that evokes approach motivational action tendencies. If asymmetrical frontal cortical activity relates to motivational direction, then *anger should relate to greater left than right frontal activity*, because anger is associated with *approach motivational direction*. On the other hand, if asymmetrical frontal cortical activity relates to affective valence, then *anger should relate to greater right than left frontal activity*, because anger is associated with *negative valence*.

Testing competing hypotheses: motivational direction vs. emotional valence

In 1997, two studies observed that trait approach motivation was related to greater left than right frontal activity at resting baseline, as measured by electroencephalographic (EEG) alpha power activity (Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997). Trait approach motivation was assessed using Carver and White's (1994) behavioural activation and behavioural inhibition scale. Sample items from the BIS scale include: 'I worry about making mistakes' and 'I have very few fears compared to my friends (reverse scored).' Sample items from the BAS include: 'It would excite me to win a contest', 'I go out of my way to get things I want'; 'I crave excitement and new sensations'. The scale was based on Gray's (1987) theory of motivation, which posits that a behavioural activation system (BAS) and behavioural inhibition system (BIS) motivate and guide behaviour. BAS is posited to be a motivational system sensitive to signals of conditioned reward, nonpunishment, and escape from punishment. Its activation causes movement toward goals. BIS is hypothesised to be sensitive to signals of conditioned punishment, nonreward, novelty, and innate fear stimuli. It inhibits behaviour, increases arousal, prepares for vigorous action, and increases attention toward aversive stimuli.

These studies suggested that asymmetrical frontal cortical activity could be associated with motivational direction instead of affective valence, even though BIS and BAS were also mostly associated with negative and positive affect, respectively (Carver & White, 1994). That is, past research had essentially confounded emotional valence (positive, negative affect) with motivational direction (approach, withdrawal motivation), and researchers were claiming that relatively greater left than right frontal cortical activity reflected greater approach motivation and positive affect, whereas relatively greater right than left frontal cortical activity reflected greater withdrawal motivation and negative affect. These claims fit well into dominant emotion theories that associated positive affect with approach motivation and negative affect with withdrawal motivation (Lang, 1995; Watson, 2000).

However, other, older theories suggested that approach motivation and positive affect are not always associated with one another. Anger, for example, is a negatively valenced emotion that evokes behavioural tendencies of approach (e.g., Darwin, 1872; Ekman & Friesen, 1975; Plutchik, 1980; Young, 1943). For instance, anger is associated with attack, particularly offensive aggression (e.g., Berkowitz, 1993; Blanchard & Blanchard, 1984; Lagerspetz, 1969). Offensive aggression, associated with anger, can be distinguished from defensive aggression, associated with fear. Offensive aggression leads to attack without attempts to escape, whereas defensive or fear-based aggression leads to attack only if escape is not possible.

Other research also suggested that anger was associated with approach motivation (e.g., Izard, 1991; Lewis, Alessandri, & Sullivan, 1990; Lewis, Sullivan, Ramsay, & Alessandri, 1992). More recent studies examined whether trait behavioural approach or BAS related to anger-related responses. In two studies, trait BAS, as assessed by Carver and White's (1994) scale, was positively related to trait anger at the simple correlation level, as assessed by the Buss and Perry (1992) aggression questionnaire (Harmon-Jones, 2003; see also, Smits & Kuppens, 2005). Carver (2004) also found that trait BAS predicts state anger in response to situational anger manipulations. BAS sensitivity has been found to predict aggressive inclinations even more strongly when approach motivation was first primed (Harmon-Jones & Peterson, 2008). Other research found that BAS predicted vigilance to angry faces presented out of awareness, consistent with the idea that attention toward angry faces is the first step in an approach-based dominance confrontation (Putman, Hermans, & van Honk, 2004).

Because of the large body of evidence suggesting that anger is often associated with approach motivation (see Carver & Harmon-Jones, in press, for a review), my colleagues and I examined the relationship between anger and relative left frontal activation to test whether the frontal asymmetry is due to emotional valence, motivational direction, or a combination of emotional valence and motivational direction.

Asymmetrical frontal cortical activity and anger

Because much past research from a variety of empirical approaches suggests that anger is associated with approach motivational tendencies, we proposed that by assessing the relationship of anger and asymmetrical frontal cortical activity, we would be better able to determine whether asymmetrical frontal cortical activity related to motivational direction or affective valence. If asymmetrical frontal cortical activity relates to motivational direction, then anger should relate to greater left than right frontal activity, because anger is associated with approach motivational direction. In contrast, if asymmetrical frontal cortical activity relates to affective valence, then anger should relate to greater right than left frontal activity, because anger is associated with negative valence.

Trait anger

In one of the first studies testing these competing predictions, Harmon-Jones and Allen (1998) assessed trait anger using the Buss and Perry (1992) questionnaire and assessed asymmetrical frontal activity by examining baseline, resting regional EEG activity (alpha power) in a four-minute period. In this study of adolescents, trait anger related to increased left frontal activity and decreased right frontal activity. In addition, a subset of this sample was comprised of adolescents in a psychiatric inpatient unit for impulsive aggression. Even among these individuals, trait anger related positively with greater left than right frontal activity (see also, Rybak, Crayton, Young, Herba, & Konopka, 2006). Asymmetrical activity in other regions did not relate with anger. The specificity of anger to frontal asymmetries and not other region asymmetries has been observed in all of our studies. Thus, we focus our review on asymmetrical frontal activity.

Other research addressed an alternative explanation for the observation that relative left frontal activity related to anger (Harmon-Jones, 2004). The alternative explanation suggested that persons with high levels of trait anger might experience anger as a positive emotion, and this positive feeling or attitude toward anger could be responsible for anger being associated with relative left frontal activity. After developing a valid and reliable assessment of attitude toward anger, a study was conducted to assess whether resting baseline asymmetrical activity related to trait anger and attitude toward anger. Results indicated that anger related to relative left frontal activity and not attitude toward anger. Moreover, further analyses revealed that the relationship between trait anger and left frontal activity was not due to anger being associated with a positive attitude toward anger.

State anger

To address the limitations inherent in correlational studies, we conducted experiments in which we manipulated anger and measured its effects on regional brain activity. In Harmon-Jones and Sigelman (2001), participants were randomly assigned to a condition in which another person insulted them or to a condition in which another person treated them in a neutral manner. Immediately following the treatment, EEG was collected. As predicted, individuals who were insulted evidenced greater relative left frontal activity than individuals who were not insulted. Additional analyses revealed that within the insult condition, reported anger and aggression were positively correlated with relative left frontal activity. Neither of these correlations were significant in the no-insult condition. These results suggest that relative left-frontal activation was associated with more anger and aggression in the condition in which anger was evoked.

More recent experimental evidence has replicated these results and also revealed that state anger evokes both increased left and decreased right frontal activity. In addition, when participants were first induced to feel sympathy for a person who insulted them, this reduced the effects of insult on left and right frontal activity (Harmon-Jones, Vaughn-Scott, Mohr, Sigelman, & Harmon-Jones, 2004). This suggests that the reason experiencing sympathy for another individual reduces aggression toward that individual (e.g., see review by Miller & Eisenberg, 1988) may be because sympathy reduces the relative left frontal activity associated with approach-oriented anger.

Independent manipulation of approach motivation within anger

In the experiments just described, the designs were tailored in such a way as to evoke anger that was approach oriented. Although most instances of anger involve approach inclinations, it is possible that not all forms of anger are associated with approach motivation. To manipulate approach motivation independently of anger, Harmon-Jones, Sigelman, Bohlig, and Harmon-Jones (2003) performed an experiment in which the ability to cope with the anger-producing event was manipulated. Based on past research that has revealed that coping potential affects motivational intensity (Brehm & Self, 1989) it was predicted and found that the expectation of being able to take action to resolve the anger-producing event would increase approach motivational intensity relative to expecting to be unable to take action. That is, angered participants who expected to engage in approach-related action evidenced greater left frontal activity than angered participants who expected to be unable to engage in approach-related action. Moreover, only within the action-possible condition did greater left frontal activity in response to the angering event correlate directly with greater self-reported anger and more approach-related behaviour.

The research by Harmon-Jones, Sigelman et al. (2003) suggests that the left frontal region is most accurately described as a region sensitive to approach motivational intensity. That is, participants only evidenced the increased relative left frontal activation when anger was associated with an opportunity to behave in a manner to resolve the anger-producing event. The effect of approach motivation and anger on left frontal activity has recently been produced using pictorial stimuli that evoke anger (Harmon-Jones, Lueck, Fearn, & Harmon-Jones, 2006). In this experiment, participants low in racial prejudice were shown neutral, positive, and fear/disgust pictures from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2005). Mixed among those pictures were pictures depicting instances of racism and hatred (e.g., neo-Nazis, Ku Klux Klan). Prior to viewing the pictures, half of the participants were informed that they would write an essay on why racism is immoral, unjust and unfair at the end of the experiment. This manipulation served to increase their anger-related approach motivation. Results revealed that participants showed greater relative left frontal activity to anger pictures than other picture types only when they expected to engage in approach-related behaviour. A second study revealed that individuals who scored lower in racial prejudice evidenced even greater relative left frontal activation to the anger-evoking racist pictures in the approach motivation condition.

The above findings may suggest that relatively greater left frontal activity will occur in response to an angering situation only when there is an explicit approach motivational opportunity. However, it is possible that an explicit approach motivational opportunity is not necessary for increased left frontal activity to anger to occur, but that it only intensifies left frontal activity. In other words, other features of the situation or person may make it likely that an angering situation will increase approach motivational tendencies and activity in the left frontal cortical region. For example, individuals who are chronically high in anger may evidence increased left frontal activity (and approach motivational tendencies) in response to angering situations that would not necessarily cause such responses in individuals who are not as chronically angry. This prediction is based on the idea that angry individuals have more extensive angry associative networks than less angry individuals, and that anger-evoking stimuli should therefore activate parts of the network more readily in these angry individuals (Berkowitz, 1993).

In the study, participants were exposed to anger-inducing pictures (and other pictures) and given no explicit manipulations of action expectancy. Across all participants, a null effect of relative left frontal asymmetry occurred. However, individual differences in trait anger related to relative left frontal activity to the anger-inducing pictures, such that individuals high in trait anger showed greater left frontal activity to anger-producing pictures (controlling for activity to neutral pictures; Harmon-Jones, 2007). These results suggest that the explicit manipulation or opportunity for approach motivated action may potentiate the effects of approach motivation on relative left frontal activity, but may not always be necessary.

Manipulation of frontal cortical activity and anger processing

Other research is consistent with the hypothesis that anger is associated with left frontal activity. For example, d'Alfonso, van Honk, Hermans, Postma, & de Haan (2000) used slow repetitive transcranial magnetic stimulation (rTMS) to inhibit the left or right prefrontal cortex. Slow rTMS produces inhibition of cortical excitability, so that rTMS applied to the right prefrontal cortex decreases its activation and causes the left prefrontal cortex to become more active, while rTMS applied to the left prefrontal cortex causes activation of the right prefrontal cortex. They found that rTMS applied to the right prefrontal cortex caused selective attention towards angry faces whereas rTMS applied to the left prefrontal cortex caused selective attention away from angry faces. Thus, an increase in left prefrontal activity led participants to attentionally approach angry faces, as in an aggressive confrontation. In contrast, an increase in right prefrontal activity led participants to attentionally avoid angry faces, as in a fear-based avoidance. Conceptually similar results have been found by van Honk and Schutter (2006). The interpretation of these results concurs with other research demonstrating that attention toward angry faces is associated with high levels of self-reported anger and that attention away from angry faces is associated with high levels of cortisol (van Honk, Tuiten, de Haan, van den Hout, & Stam, 2001; van Honk, Tuiten, van den Hout, Koppeschaar, Thijssen, & de Haan, 1998; van Honk, Tuiten, Verbaten, van den Hout, Koppeschaar, Thijssen, & de Haan, 1999), which is associated with fear.

We recently extended the work of van Honk, Schutter, and colleagues by examining whether a manipulation of asymmetrical frontal cortical activity would affect behavioural aggression. Based on past research showing that contraction of the left hand increases right frontal cortical activity and that contraction of the right hand increases left frontal cortical activity (Harmon-Jones, 2006) we manipulated asymmetrical frontal cortical activity by having participants contract their right or left hand. Participants then received insulting feedback ostensibly from another participant. They then played a reaction time game on the computer against the other ostensible participant. Participants were told they could give the other participant a blast of 60 to 100 dB of white noise for up to 10 seconds if they were fastest to press the shift key when an image appeared on the screen. Results indicated that participants who squeezed with their right hand gave significantly louder and longer noise blasts to the other ostensible participant than those who squeezed with their left hand (Peterson, Shackman, & Harmon-Jones, 2008).

Incorporating motivation into the study of positive affect

The consideration of motivational direction as independent from affective valence assisted in elucidating the psychological and behavioural functions of asymmetrical frontal cortical activity. Given this independence of motivational direction and affective valence, we began to consider how incorporating the motivational dimension into positive affect might add to the relatively new interest in positive affect. For much of psychology's history, the study of positive affect had been neglected relative to the study of negative affect. However, with the spawning of the positive psychology movement, scientists have become more interested in the study of positive affect.

In the midst of this explosion of interest in positive affect, Fredrickson (2001) postulated that all positive affects expand attentional and cognitive resources. This expansion or broadening of cognition and attention is predicated on the idea that all positive affects suggest a stable and comfortable environment, and thus cause individuals to be more creative, categorically more inclusive, and increase attentional breadth.

Indeed, much research has found that positive affect creates a broadening of cognitive processing in categorisation (Isen & Daubman, 1984), unusualness of word association (Isen, Johnson, Mertz, & Robinson, 1985), social categorisation (Isen, Niedenthal, & Cantor, 1992), and recalling memory details (Talarico, Berntsen, & Rubin, 2008). In these studies, positive affect was manipulated by having participants receive a gift (Isen & Daubman, 1984; Isen et al., 1992), watch a funny film (Isen et al., 1985; Isen, Daubman, & Nowicki, 1987), recall a pleasant memory (Schwartz & Clore, 1983; Murray, Sujan, Hirt, & Sujan, 1990), or remember a positive life event (Gasper & Clore, 2002; Talarico et al., 2008).

Positive affect and broadening of attention

More recently, the concept of cognitive broadening within positive affect has been investigated using measures of global (broad) and local (narrow) attention. Global as compared with local attentional processing can be likened to seeing the forest (global) vs. the trees (local). 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 features. Participants are asked to identify or compare features of the figure. For example, Kimchi and Palmer (1982) developed a task where individuals make similarity judgements. In the task, three global figures (large triangles or squares) each composed 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 a global configuration that matches the standard. Individuals can make similarity judgements based on either the global configuration or local elements of the standard figure. Similarity judgements based on global configurations indicate a global attentional focus, while judgements based on local elements indicate a local attentional focus.

Another prominent measure 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 focus, whereas faster responses to the small letters indicate a local focus.

In one experiment examining the effect of positive affect on attentional focus, Gasper and Clore (2002) compared a positive with a negative affect manipulation on global-local bias. Individuals were assigned to recall a pleasant, neutral, or negative memory. Then, they completed the Kimchi and Palmer (1982) global-local attention measure. Results indicated that positive as compared with negative affect produced a more global bias. However, no differences occurred between positive and neutral affects.

In 2005, Fredrickson and Branigan used the same measure of attention to investigate the attentional broadening effects of discrete positive emotions of amusement and contentment. Using film clips to evoke these discrete positive emotions, the authors found that relative to neutral emotion states, positive emotional states of 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 view that positive affect broadens attention has been the dominant view of the positive affect literature for over 20 years. Current research continues to operate under the theoretical assumption that all positive emotions are the same and that all positive emotions expand attentional breadth. The view that positive affect creates attentional and cognitive broadening, while negative affect creates narrowing, is widely accepted.

Positive affects vary in approach motivational intensity

This previous work on the attentional and cognitive consequences of affect focused on the valence dimension, that is, whether the emotion, mood, or affect was positive or negative. Another important and relatively neglected dimension of emotion is motivational direction: whether the emotion motivates the organism to approach or avoid a stimulus. All past research on the broadening effects of positive affect could be said to have used positive affects that evoked low intensity approach motivation. Positive affects, however, vary in the degree to which they are associated with approach motivation. Some positive affective states are low in approach motivation (e.g., feeling content, serene, or tranquil), whereas others are relatively high in approach motivation (e.g., feeling enthusiastic, excited, or desirous). The studies to be described have sought to examine the varied consequences of positive affective states that differ in the intensity of motivation.

Our work is predicated on conceptual models of emotion that emphasise emotions' motivational functions (Frijda, 1986) and that consider emotion to involve subjective, expressive, and physiological components. For example, Lang, Bradley, and Cuthbert (1990) proposed a dimensional model of emotion, with two orthogonal dimensions, valence and arousal. According to this conceptual view and its large empirical base, strong approach motivation is associated with stimuli that are positive and arousing, whereas strong avoidance motivation is associated with stimuli that are negative and arousing. Stimuli that reliably elicit approach are photos of erotica and food, whereas photos of mutilations and threat reliably elicit avoidance (Lang, 1995).

Positive affects vary in motivational intensity, and may have different effects on attention and cognition. Indeed, Lang and colleagues' programme of research has revealed that the processing of pleasant stimuli varies in approach motivation, and this processing affects autonomic, reflexive, and electro-cortical responses (Lang, 1995). Given the importance of approach-motivated positive affective states to biologically important outcomes such as reproduction and the ingestion of food and water, it seems likely that such states would not be associated with increased attentional and cognitive broadening. Broadening of attention and cognition might cause distraction and hinder acquisition of basic biological necessities. In contrast, approach-motivated positive affective states should be associated with attentional narrowing, as organisms shut out irrelevant perceptions and cognitions while they approach and attempt to acquire the desired objects.

Research has suggested that appetitive and consummatory components of reward processes relate to different types of positive affect. 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 pregoal and postgoal attainment positive affect in the prefrontal cortex, nucleus accumbens and other structures (Davidson & Irwin, 1999; Knutson & Peterson, 2005; Knutson & Wimmer, 2007).

Also, intrinsically motivated interest in a given task may arouse approach-oriented positive affects that attentionally narrow one's focus rather than broaden 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) as well as increase left frontal cortical activity (Harmon-Jones, Harmon-Jones, Fearn, Sigelman, & Johnson, 2008).

Research examining attentional consequences of approach-motivated positive affect

Past work on the cognitive consequences of positive affects has studied only low intensity approach-motivated positive affect, leaving the area of approach-motivated positive affect unexplored. Consequently, we have begun a programme of research aimed at examining the consequences of approach-motivated positive affect on attention and the neurophysiological underpinnings associated with these states.

Comparing the attentional effects of low vs. high approach-motivated positive affect

Our first experiment compared the attentional effects of high approach positive affect to low approach positive affect (Gable & Harmon-Jones, 2008a), using methods similar to those used in previous studies. Participants first viewed a neutral film. Then, they viewed either a low approach positive affect film (cats in humorous situations) or a high approach positive affect film (delicious desserts). After this film, participants completed Kimchi and Palmer's (1982) global-local visual processing task to assess breadth of attention (Fredrickson & Brannigan, 2005; Gasper & Clore, 2002). Then, participants rated how they felt during the film.

Results indicated that the cat film caused more global attentional focus than the dessert film. Also, the dessert film evoked more desire than the cat film, while the cat film evoked more amusement than the dessert film. These results provide initial support that high approach-motivated positive affect (desire) decreases attentional broadening as compared with low approach-motivated positive affect (amusement).

Investigating attentional narrowing of high approach positive affect relative to a neutral state

One caveat of the initial investigation is that it did not include a neutral comparison condition, making it difficult to know whether approach-motivated positive affect decreased attentional broadening as compared with a neutral condition. That is, approach-motivated positive affect may reduce broadening to the same level as neutral affect. Study 2 of Gable and Harmon-Jones (2008a) tested whether high approach positive affect reduced attentional breadth relative to a neutral condition.

Participants viewed either dessert or neutral pictures (rocks). After each affective/neutral picture, a Navon (1977) letter was presented to assess attentional breadth. As predicted, reaction times to global targets were slower after dessert pictures than after rock pictures. In contrast, reaction times to local targets were faster after dessert pictures than after rock pictures. Picture ratings revealed that food pictures were more pleasing and arousing, and caused more desire than neutral pictures. This second study revealed that high approach positive affect reduced broadening of attention.

Relating trait approach motivation to reduced attentional breadth

To provide further evidence that approach motivation was responsible for the effects of positive affect manipulations on reduced attentional broadening, Study 3 investigated whether individual differences in approach motivation would relate to attentional responses following appetitive stimuli. Carver and White's (1994) BIS/BAS questionnaire was used to measure trait approach motivation and the Navon letters task was used to measure attentional breadth following appetitive pictures (desserts and baby animals).

Results indicated individuals higher in trait approach motivation responded with less broad attention following approach-motivating stimuli (controlling for responses to neutral pictures). This study provided further evidence to support 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.

Manipulating approach motivation within high approach positive affect

To test whether approach motivation mediates the reduction in attentional broadening following appetitive stimuli, intensity of approach motivation needed to be experimentally manipulated. Study 4 of Gable and Harmon-Jones (2008a) did this by varying the expectancy to consume desserts viewed in pictures. Past research has suggested that the expectancy to act increases motivational intensity generally (Brehm & Self, 1989) and approach motivation in approach-oriented contexts (Harmon-Jones et al., 2006). Participants were (1) shown dessert pictures and told they could expect to consume them, (2) shown dessert pictures without this expectancy, or (3) shown neutral pictures and told they could expect to take some of the neutral objects. Following the picture viewing, attentional breadth was measured using the Navon letters task.

Participants who viewed dessert pictures and expected to consume desserts were the least attentionally broad, followed by participants who simply viewed the dessert pictures, and finally participants who viewed neutral pictures. Participants reported increasingly more excitement and enthusiasm from the neutral to the dessert and then to the expectancy-dessert condition. It is important to note that in all of our studies on positive affect and attention, we have not observed our positive affect manipulations to cause any negative affect. Results of this study strongly supported the hypothesis that high approach-motivated positive affect causes attentional narrowing.

Linking left frontal activation to high approach positive affect with attentional narrowing

Given previous research showing that approach-motivated positive affect is associated with increased left prefrontal cortical activation (Gable & Harmon-Jones, 2008b), we investigated whether greater left frontal activation associated with high approach-motivated positive affect would relate to attentional narrowing (Harmon-Jones & Gable, in press). The study was predicated on research showing that left frontal activation is associated with approach motivation (Harmon-Jones, 2003), and research showing that left hemispheric activation is associated with attentional narrowing (Volberg & Hübner, 2004).

Specifically, we examined whether neural activations associated with approach motivation would relate to the effect of approach-motivated positive affect on narrowed attention. Also, we examined whether individual differences in approach motivation would relate to attentional narrowing.

Results showed that individual differences in approach motivation (time since eaten) related to local attentional bias following dessert pictures. Also, relative left frontal-central activation predicted this local attentional bias.

These results demonstrated that greater narrowed attention induced by appetitive stimuli is driven by neurophysiological activations associated with approach-motivational processes. The present study integrated research on approach-motivated positive affect, attentional focus, and their associated neural processes. Thus, it suggests 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.

Conclusion

Approach-related emotions such as anger or desire involve several brain regions, but the reviewed research establishes the importance of the left prefrontal cortex in approach motivation independent of affective valence. Often in discussions on the functions of the prefrontal cortex (PFC), scientists suggest that the PFC is involved in higher level cognitive functions, such as working memory and inhibitory processes. Part of the reason scientists reserve the PFC for higher-level cognitive processes is because it is a region that is much larger in humans than non-human animals. The logic continues that if the PFC were a relatively recent development in evolution, then it must be the source of those psychological processes that separate us from other animals. This logic is likely to be at least partially correct, but not foolproof. For example, recent single-cell research with rats has revealed that the PFC is involved in aggression and most of the cells activated are not inhibitory cells (Halász, Tóth, Kalló, Liposits, & Haller, 2006).

The PFC is a vast territory and is likely involved in a number of psychological processes. Moreover, structures that are involved in certain psychological/behavioural processes in nonhuman animals may be involved in different processes in human animals. For instance, many of the anatomical details of components of emotional response circuits are different in rodents and primates. The organisation, connectivity, and some functions of amygdala nuclei (Amaral, Price, Pitkanen, & Carmichael, 1992), prefrontal cortex (Goldman-Rakic, 1987), and anterior cingulate (Bush, Luu, & Posner, 2000) differ between rodents and primates. In addition, evidence suggests that areas throughout the brain are activated during a variety of mental processes, rather than processes being localised in just one brain area. The size, complexity, and activity of the human PFC suggest that it is integrated in many processes.

The approach and withdrawal processes implemented by left and right frontal cortices have been observed in rhesus monkeys (e.g., Kalin, Shelton, Davidson, & Kelley, 2001) and humans as early as 2-3 days of age (Fox & Davidson, 1986). In addition, damage to these regions of frontal cortex cause depression vs. mania (Robinson & Downhill, 1995), and rTMS manipulations of left vs. right cortical regions affect mood and attentional processing in manners consistent with the idea that asymmetrical frontal cortical activity is involved in motivational direction (d'Alfonso et al., 2000; van Honk & Schutter, 2006). Finally, research with organisms as simple as toads has revealed that approach and withdrawal processes are lateralised in a manner similar to that observed in humans (Vallortigara & Rogers, 2005). However, these lateralisations probably involve more structures than the frontal cortex, as amphibians lack such. It is possible that subcortical structures are lateralised for approach and withdrawal motivational processes in amphibians, reptiles, and birds but that these lateralisations are preserved and elaborated into the frontal cortices of primates. Future research will need to explore connections between subcortical and cortical structures in approach and withdrawal motivation.

Greater left than right frontal cortical activity is associated with approach motivation and not positive affect per se. Research has demonstrated that unlike other negative emotions, anger is often associated with approach-motivational tendencies. Consequently, major dimensional theories of emotion will need to be modified to incorporate the idea that not all negative affects are associated with withdrawal motivation. Also, our recent research on the intensity of approach motivation within positive affect suggests that positive affect high in approach motivation causes a reduction in attentional breadth, a finding that is opposite to that obtained with low approach positive affect. This research provides further evidence suggesting that emotions of the same valence can have very different consequences for attention and cognition. Furthermore, it integrates the areas of motivation, attentional focus, and their associated neural processes. In sum, these findings broaden theorising about the relationship between emotions and motivation. Moreover, they add to a growing literature focused on the examination of motivational intensity and direction within emotions.

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Our main fields of interest are emotion, motivation, and social processes, and the neural processes underlying these psychological constructs.

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