

Conceptual, Methodological, and Empirical Ambiguities in the Linkage Between Anger and Approach: Comment on Carver and Harmon-Jones (2009)

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C. S. Carver and E. Harmon-Jones (2009) have made an important contribution to the understanding of anger, its linkage to higher order dimensions of emotion, and potential neurobiological substrates. The authors believe, however, that their model and future research conducted to test it would be improved by a more precise explication and parsing of the primary constructs, a clearer articulation of the relation between anger and approach, and the use of methods for assessing brain activation that are more precise than the electroencephalogram. Neuroimaging studies reviewed generally fail to corroborate several features of their model.

Keywords: anger, emotion, approach, anterior asymmetry, affective neuroscience

Carver and Harmon-Jones (2009) have made an important contribution to the understanding of a fundamental discrete emotion (anger), its linkage to higher order dimensions of motivation, and the neurobiological substrates that might account for this linkage. Their argument has particularly important implications for understanding the relation between cerebral asymmetry and emotion and motivation. As they correctly noted, although most previous studies on anterior asymmetry have confounded approach versus withdrawal (or avoidance) and positive versus negative affect, the emotion of anger might well provide a critical test of the approach–withdrawal model because it is a negative emotion that appears linked to approach. Harmon-Jones and his collaborators have conducted a systematic and creative series of studies testing this hypothesis. In turn, Carver and Harmon-Jones’s article represents an important review and theoretical synthesis of this and several additional sources of evidence that link anger to approach motivation.

Although this article has a number of positive features, we believe that there are several conceptual and empirical ambiguities that weaken the overall strength of the argument that the authors are trying to make. In particular, we believe that the primary constructs require greater specificity and elaboration and that more precise methods are needed to provide a more rigorous test of hypotheses. These points apply to many articles within the area of affective neuroscience, and, in addition, Carver and Harmon-Jones (2009) have acknowledged some of these limitations. As such, our

goal is less to highlight flaws than to map out directions for future work.

The Need to Parse Approach and Withdrawal/Avoidance

Carver and Harmon-Jones (2009) have brought to bear various sources of evidence in support of the notion that anger is associated with enhanced approach motivation. Arguably, the most critical support comes from two sets of findings concerning the correlates of asymmetrical activation in the anterior regions of the brain: (1) studies indicating a linkage between relative left anterior activation and both state and trait measures of anger, and (b) the broader body of literature indicating that anterior asymmetry maps onto a dimension of approach versus withdrawal. The authors argued that, when considered together, these two sets of findings imply a linkage between anger and approach motivation.

We address the degree to which extant findings actually support this conclusion below. A logically prior issue is the authors’ treatment of the primary constructs (e.g., approach motivation, anger) that are the focus of the article. In our view, these are very broad constructs that first need to be parsed before they can be effectively linked to each other and underlying neural substrates. Consider the approach construct that has been central to thinking about anterior brain asymmetry and the neurobiology of motivation (e.g., Stellar & Stellar, 1985). In our view, there are several respects in which the authors’ treatment of this construct is too vague.

As used among psychologists, the term *approach motivation* typically denotes some feature of the organism’s perceptual, cognitive, or motor response to rewarding or pleasurable stimuli or, in a broader sense, a motivational set that places greater priority on the attainment of favorable outcomes than the avoidance or prevention of aversive outcomes (e.g., Carver & White, 1994; Davidson, 1998; Higgins, 1997; Tomarken & Keener, 1998). In addition, evidence that stimulation of brain regions that mediate responses to reward also elicits behavioral approach (e.g., Stellar, Brooks, &

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Mills, 1979) supports a linkage between the behavioral and motivational senses of this term. That being said, there are a variety of incentive-related component processes that could conceivably be nested under the broad rubric of approach motivation. For example, it might conceivably involve heightened attention or reactivity to signals of reward, the maintenance of a motivational set for reward, preparatory adjustments in anticipation of obtaining rewards, the willingness to work for reward, consummatory responses triggered by the rewards themselves, the inhibition of responding to short-term rewards in favor of longer term rewards of greater magnitude, the development of long-term plans to attain desired outcomes, or any combination thereof. Unfortunately, it is unclear which of these components of approach Carver and Harmon-Jones believe are related to anger. Consistent with their global characterization of an approach system as one that “organizes behavior involved in approaching desired incentives (rewards, goals)” (Carver & Harmon-Jones, 2009, pp. 184–185), we suspect that Carver and Harmon-Jones would argue for a higher order system that organizes multiple components of incentive motivation. However, in our view, the existence of such a broad, integrative system has to be empirically demonstrated rather than assumed, and the only way to begin is by parsing the construct of approach motivation into its constituent parts. There is a particular need for precise explication and parsing when, as in the present context, one’s primary goals are to link such constructs to (a) specific brain regions or neural systems, and (b) other broad constructs, such as anger.

Concerning linkages to the brain, the authors leave unclear the precise components of approach versus withdrawal that are mediated by, and asymmetrically represented in, the prefrontal cortex. This is salient given the evidence that other brain regions (e.g., the lateral and ventromedial hypothalamus) can also mediate approach and withdrawal (e.g., Stellar et al., 1979; Stellar & Stellar, 1985). It is also relevant to note the wealth of evidence from infrahuman and human studies indicating the presence of dissociable systems that mediate different components of reward motivation (e.g., Berridge & Robinson, 1998; Knutson, Adams, Fong, & Hommer, 2001; Knutson, Fong, Adams, Varner, & Hommer, 2001). We address this evidence in greater detail below. At this juncture, the key point is that *any* theoretical attempt to link a given brain region or system to a broad construct, such as approach motivation, needs to “get specific” by first parsing the construct and then establishing lower level linkages between specific components and specific neural structures or functions. As sympathetic as we are to integrative constructs, such as approach motivation, at some point one has to grapple with the remarkable specificity of the human brain.

Unfortunately, Carver and Harmon-Jones (2009) have not addressed these questions in any detail, if at all. Indeed, anterior asymmetry is essentially treated as a nondescript biological marker of approach versus withdrawal motivation, with almost no attention given to the question of what components of approach or withdrawal are mediated by the prefrontal cortex. Left unanswered is the question of what approach-related processes researchers are tapping into when recording from frontal electrode sites. What exactly are the frontal lobes *doing*? In our view, the most reasonable starting point for addressing this question is to link approach and withdrawal to the extensive body of evidence concerning known functions of the prefrontal cortex (e.g., Herrington et al., 2005; Tomarken & Keener, 1998).

Ambiguity Concerning the Linkage Between Anger and Approach

We readily acknowledge that the critique offered above could easily be leveled at the great majority of published articles that refer to anterior asymmetry. There are, however, some problems with construct and theory explication that are more specific to Carver and Harmon-Jones (2009). We were unclear about the precise nature of the linkage between anger and approach motivation. Several distinct possibilities are suggested at different points in the article. The position most frequently endorsed by the authors characterizes anger as a response to a disruption of approach motivation. For example, at various points in the article, anger is characterized as a response to goal blockage and the disruption of approach, and, in the concluding sections, anger is described as an internal indicator that progress toward a goal or reward is not going well. This conceptualization suggests that heightened approach motivation is more of a precursor or necessary condition for anger, or, in the case of individual differences in approach tendencies, a predisposition toward anger that interacts with situational factors that block attainment of goals.

There are, however, other possible conceptions of the relation between anger and approach. For example, the authors noted that the link between anger and approach might originate in the fact that the behavioral component of anger is typically approach toward the target of anger, as when one is preparing to strike or confront the target of one’s response. At other points, the authors observed that anger may not simply be a response to blocked approach motivation but a reassertion of approach motivation in response to blockage. Although this latter perspective implies that approach is a more central component of anger, the authors described this association as more secondary. Adding to the confusion here is the fact that some of the experimental results reviewed do not clearly reflect a linkage between anger and approach (e.g., Harmon-Jones & Sigelman, 2001), whereas others appear primarily to reflect the type of association viewed by the authors as secondary (e.g., Harmon-Jones, Sigelman, Bohlig, & Harmon-Jones, 2003). Although the authors acknowledge the lack of clarity concerning the precise linkage between anger and approach, this issue will need to be addressed in future work.

In addition, we think the authors need to give more weight to the evidence that there are multiple triggers that can provoke anger. These range from perceived threat or injury to oneself or one’s possessions to the sort of goal blockages emphasized by Carver and Harmon-Jones (2009). Ideally, an argument that anger is globally related to approach requires a demonstration that the varied contexts and triggers in which anger occurs consistently can be characterized in terms of approach. A parallel argument can be made in terms of aggressive behavior, which researchers often divide into a hostile–irritable–retaliatory aggression (which is largely linked to negative affect), and a more goal-oriented, instrumental aggression. This later type of aggression has clear approach characteristics, in that animals are willing to work to gain the opportunity to aggress—a process that is dependent on nucleus accumbens dopamine (Couppis & Kennedy, 2008). To date, the more hostile, retaliatory types of aggression have not been demonstrated to specifically depend on accumbens dopamine. Although Carver and Harmon-Jones acknowledged that some types of aggression are more linked to approach than others, they leave

unaddressed whether all anger is similarly linked to approach. If not, a more specific terminology is called for.

Limitations of Electroencephalogram (EEG) Studies

Throughout the article, a primary, though not exclusive, source of evidence supporting linkages among anterior asymmetry, approach motivation, and anger is the result of EEG studies on the correlates of anterior brain asymmetry. In particular, the authors have presented evidence that EEG studies conducted by Harmon-Jones and his collaborators indicate that anger is associated with the same pattern of relative left anterior activation as shown in previous EEG studies assessing positive affect and other potential indicators of approach motivation. Given the centrality of this evidence to the authors' argument, it is important to critically examine the methodological, conceptual, and other issues raised by the now-extensive body of data on the correlates of anterior EEG asymmetry.

Although there are many points that could be made regarding the literature on anterior EEG asymmetry, we focus on just one: the limitations of using EEG to assess whether two psychological processes recruit the same brain regions or circuits. Any rigorous test of the notion that, say, the experience of anger and the anticipation of reward recruit the same neural "approach circuitry" requires a measure of brain activity that has good spatial resolution and the ability to localize precisely sources of brain activation. Otherwise, genuine differences in neural substrates and circuitry might be masked by imprecise measures that serve to aggregate and "smear" signals from neural generators that are actually quite distinct. It is generally conceded that EEG recorded by the more traditional methods used in the great majority of the studies reviewed by Carver and Harmon-Jones (2009) has relatively poor spatial resolution and source localization capabilities (e.g., Nunez, 1981). A key issue here is the well-known *inverse problem*: a given pattern of electrical activity recorded at the scalp may have an indefinite number of different scalp generators. In application to the present context, then, the fact that anger and more classic indices of approach motivation (e.g., the anticipation of reward) both are linked to anterior EEG asymmetry constitutes relatively weak evidence that they have the same neural generators.

Let us put this problem in perspective to communicate its gravity. In terms of spatial resolution, EEG generally suffers relative to other methods for assessing human brain activity, such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET). Yet, questions have been raised concerning whether even fMRI as conventionally recorded and quantified has sufficient resolution to accurately capture specialized functions and patterns of brain activity (e.g., Kanwisher, 2006). Indeed, recent evidence indicates that methodological and analytic enhancements to fMRI are necessary to reveal cortical "hot spots" indicating highly specialized processing (e.g., Tsao, Freiwald, Tootell, & Livingstone, 2006) and to reveal differences among ongoing perceptual and attentional states (e.g., Kamitani & Tong, 2005) that are otherwise missed by conventional methods. This evidence highlights the fact that conventional EEG methods probably do not provide a sufficiently rigorous test of a neural-concordance hypothesis. Indeed, the very terms "anterior asymmetry" and "frontal asymmetry" imply that the precise localization of the brain activity observed in EEG studies is rather imprecise.

Roughly 50% of the cerebral cortex can be considered anterior, and, depending on one's precise demarcation, the prefrontal region constitutes roughly 30%–40% of the cortex.

Have Neuroimaging Studies Yielded Consistent Results?

The fact that, even though limited in their own right, other neuroimaging techniques typically have better spatial resolution than EEG raises an important question: Are the results of PET and fMRI studies consistent with the authors' conclusions concerning linkages among anger, approach, and anterior asymmetry? Before examining the neuroimaging data, we note three issues that must be considered in evaluating whether there is a convergence of anger- and approach-induced activations in the frontal lobe.

The first issue reflects what is classified as approach versus withdrawal. Similar to the confound identified by Carver and Harmon-Jones (2009) with primary reference to EEG findings, neuroimaging researchers have at times operationalized approach and withdrawal as identical to positive and negative valence. Second, very few neuroimaging studies have been analyzed to specifically examine asymmetry (i.e., left hemisphere activity greater than right activity or vice versa; Davidson, 1998; Herrington et al., 2005). Rather, the primary analytic approach has been to simply assess which brain regions activate relative to a baseline or control condition. Thus, assessments of asymmetry are typically rather coarse and imprecise because they are based on the relative frequency or magnitude of activations in homologous structures in the left and right hemispheres rather than the sorts of within-study lateralization indices that characterize the EEG frontal asymmetry literature. In reviewing the neuroimaging literature, we focus on relative frequency because this measure is more amenable to analysis across studies and has been used in existing meta-analyses of emotional processing. We acknowledge that this can introduce inaccuracies in conclusions, in the same way that box-score summaries of significant results are inferior to measures of effect size.

The third issue is localization. The EEG sites that have produced the most consistent effects for anterior asymmetry (F3/F4 and, secondarily, F7/F8) would appear to be those most heavily influenced by the dorsolateral prefrontal cortex, as broadly defined (F3 and F4 overlie Brodmann's Area 46, and F7 and F8 overly Areas 45 and 46; Homan, Herman, & Purdy, 1987). Thus, in imaging studies, one would most expect to see evidence of asymmetry in more dorsolateral prefrontal regions (e.g., Herrington et al., 2005). It is certainly possible that asymmetries in other frontal areas could produce data in the frontal leads utilized in EEG studies of frontal asymmetries, but to date explicit source localization models of frontal asymmetry are rare (for an exception, see Pizzagalli, Sherwood, Henriques, & Davidson, 2005). Nevertheless, the co-localization argument could be tenable if both anger and approach inductions were found to consistently engage a common frontal region. Because Carver and Harmon-Jones (2009) did not specify the source for the EEG asymmetries, we also consider whether there is a convergence of approach- and anger-related activations in parts of the left prefrontal cortex other than the dorsolateral region. To be explicit, the issue of co-localization in the current context involves four related questions: (1) Is approach associated with left frontal activation (and conversely withdrawal with right frontal activations)?; (2) Is anger associated with left frontal acti-

vation?; (3) Assuming answers to 1 and 2 are positive, do anger and approach both recruit the dorsolateral prefrontal cortex?; and (4) If convergence does not occur in the left dorsolateral prefrontal cortex, does it occur elsewhere in the frontal lobe?

One of the best known meta-analyses of the affective neuroimaging literature was performed by Wager, Phan, Liberzon, and Taylor (2003), who culled the available PET and fMRI literature and reported what initially appears to be partial support for a frontal asymmetry model. In their analysis, the authors contrasted a valence categorization (in which anger and aggression were categorized with negative emotions) and an approach-withdrawal categorization (in which anger and aggression were categorized with positive emotions). The authors found a significant trend toward more frequent left than right lateral (both dorsal and ventral) frontal activation to approach emotions (approach emotions activated the left frontal cortex 26 times vs. 14 times for the right frontal cortex). A relatively similar ratio (18:9) of left versus right activations in the left lateral frontal cortex arose when anger was excluded from the analysis (although it did not approach significance because of the smaller sample size). There was no evidence for greater right than left lateral frontal activation for either negative valence or withdrawal categorizations. Although failing to find evidence of lateralization for withdrawal, the trend toward greater activation of left lateral frontal regions to approach emotions appears consistent with a left frontal bias for approach emotions.

However, when considered with the caveats raised above, some concerns quickly arise. First, given the ability to localize activations to specific gyri, or cytoarchitectural areas, is an analysis at the level of the entire lateral prefrontal surface compelling evidence of co-localization? A review of activation peaks included in Wager et al.'s (2003) analysis reveals a distributed pattern of foci, rather than a common co-localization to a single specific portion of the lateral prefrontal cortex. A similar conclusion is elegantly illustrated in a meta-analysis by Murphy, Nimmo-Smith, and Lawrence (2003). Thus, to the extent that positive or approach emotions preferentially engage the left lateral prefrontal cortex, it is at a relatively broad level. Although these findings are intriguing, they are problematic for a co-localization hypothesis in that they do not provide a specific cytoarchitectural, or functional, region to focus on. It also causes a reverse inference problem. In a focal area, if we can show that an area is always activated during a given type of function, we can feel confident that when that area is activated, a specific function or operation is being performed. However, within a region as broad as the lateral prefrontal cortex, where there are so many different causes of activations, it is doubtful that we will ever be able to confidently infer that a specific process (such as a process related to approach) is being engaged, on the basis of the presence of an activation within that broad region. Even in the domain of working memory, which is tightly linked to lateral prefrontal functioning, this type of reverse inference has proven untenable (D'Esposito, Ballard, Aguirre, & Zarahn, 1998).

Second, examination of the paradigms analyzed by Wager et al. (2003)—and Murphy et al. (2003)—reveals that a large number of the stimulation paradigms simply involve exposure to emotional facial expressions. Although a happy face may be viewed as positive and may even evoke a happy subjective experience (through a process of emotional contagion), it is unclear how

motivationally significant the faces are. Notably absent from Wager et al.'s analysis are studies that actually engage the participants with motivationally significant stimuli, such as food (when participants are hungry), or that involve the expenditure of effort to obtain a reward.

If we focus on the motivational aspects of approach, the very studies that Wager et al. (2003) excluded need to be analyzed. The most critical dimension of approach that can be used to constrain the analysis may well be what Davidson (1998) has called pre-goal attainment affect elicited as an organism moves toward a goal. He has argued that anterior asymmetry is more strongly linked to pre-goal attainment affect than post-goal attainment affect. This division between pre-goal and post-goal attainment affect is similar to Berridge and Robinson's (1998) distinction between wanting and liking. Examination of neuroimaging studies that focus on wanting/pre-goal attainment do not provide substantial support for the asymmetry model. For example, studies in which hungry participants are exposed to pictures of food, or participants are exposed to pictures of foods that they crave (which can be viewed as prototypical approach stimuli), have most consistently been shown to engage ventromedial frontal cortex (subgenual cingulate or medial orbitofrontal cortex [OFC]), with bilateral activations occurring in many of the studies (Fuhrer, Zysset, & Stumvoll, 2008; Holsen et al., 2005; Killgore et al., 2003; Rolls & McCabe, 2007; Simmons, Martin, & Barsalou, 2005). Although examples of right and left dorsolateral activations exist in this literature (e.g., Killgore et al., 2003; Rolls & McCabe, 2007), the region is notably absent in most studies (Fuhrer et al., 2008; Holsen et al., 2005; LaBar et al., 2001; Pelchat, Johnson, Chan, Valdez, & Ragland, 2004; Simmons et al., 2005).

Perhaps the most widely used task for examining motivation for reward versus consummation of reward is Knutson's monetary incentive delay task, in which participants are given a cue that indicates how much money they can earn by making a speeded response. The task has only rarely been observed to produce left lateral frontal activations during the anticipation phase, and indeed in most studies there is no evidence of any prefrontal activation during anticipation of making a response for reward (Bjork et al., 2004; Knutson, Adams, et al., 2001; Knutson, Fong, et al., 2001; Samanez-Larkin et al., 2007; Strohle et al., 2008). This is an important observation given that two prior EEG studies have found greater relative left frontal anticipation in response to cues for reward responding (Miller & Tomarken, 2001; Sobotka, Davidson, & Senulis, 1992). Instead, in Knutson's studies, it is during the receipt phase (when participants are told they won the money) that frontal activations occur, but the activations localize to medial rather than lateral areas of cortex, without consistent evidence of lateralization. Researchers using other paradigms examining reward receipt or consummatory pleasure have also often observed ventromedial engagement (O'Doherty & Dolan, 2006) but again with little evidence of lateralization (Kringelbach & Rolls, 2004). Taken together, these data do not provide a compelling argument for a strict lateralization of either pre- or post-goal attainment approach within the prefrontal cortex.

Turning to the next relevant questions, we ask where in the prefrontal cortex do inductions of anger produce activations, and do these activations overlap with areas engaged by other approach related inductions? We examined the activations reported for five studies utilizing anger inductions in healthy participants (Damasio

et al., 2000; Dougherty et al., 1999, 2004; Kimbrell et al., 1999; Marci, Glick, Loh, & Dougherty, 2007). When contrasts were made between anger and neutral conditions, three of these studies reported selective left ventral frontal cortex activations, one study reported bilateral activations, and one study reported selective right ventral frontal activity. Activations localized to the central or lateral sectors of the OFC, or to a ventromedial sector of the frontal pole. Importantly, however, the left lateral OFC responses were not in areas that are most frequently engaged by appetitive stimuli but rather in sectors of the OFC that have more often been associated with negative emotional experiences (Kringelbach & Rolls, 2004). Perhaps most concerning for the hypothesis of a selective left hemisphere role in anger and approach is the study by Kimbrell et al. (1999), who observed similar left OFC activations for both anger and anxiety. If there is an important distinction of anger from other negative emotions, one might expect a selective engagement of left frontal structures when contrasting anger with a negative emotion, such as anxiety. However, when Kimbrell et al., performed just such a contrast, they observed greater right OFC activation and no left frontal activation. In summary, although there does appear to be a tendency to elicit left ventral frontal activations during anger, it is difficult to conclude that (a) these activations specifically overlap with an approach system and are segregated from areas activated by negatively valenced stimuli, or (b) they reflect the left dorsolateral regions that would be the predicted focus on the basis of the EEG asymmetry. In drawing these conclusions, we do not intend to suggest that anger and approach activations are mutually exclusive, such that there is zero overlap between activations induced by anger and other approach-related paradigms. Rather, when examined as a whole, the neuroimaging literature has yet to provide clear evidence for colocalization, and the degree of lateralization is not robust enough to justify using lateralization as a key framework for the argument that anger is an approach emotion.

Summary and Conclusions

Carver and Harmon-Jones (2009) have made an important contribution to the literature. However, their model would be improved by a more precise explication of the primary constructs and the use of paradigms and techniques that afford greater precision in linking these constructs to the brain regions of interest. To date, neuroimaging evidence does not offer strong support for their model.

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Call for Nominations: *Health Psychology*

Division 38 (Health Psychology) is currently accepting nominations for the editorship of *Health Psychology* for the years 2011–2016. Robert M. Kaplan is the incumbent Editor.

Candidates should be members of Division 38 and of APA, and should be available to start receiving manuscripts in 2010 to prepare issues to be published in 2011. Division 38 encourages participation by members of underrepresented groups and would welcome such nominees. Self-nominations are also encouraged.

Kevin D. McCaul, Ph.D., has been appointed as Chair for this search.

To nominate candidates, prepare a statement of two pages or less in support of each candidate, and provide a current CV. Submit all materials electronically to: apadiv38@verizon.net.

The deadline for receipt of nominations is April 15, 2009.