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Cognitive Neuroscience Needs Affective Neuroscience (and Vice Versa)

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We are continuously being bombarded by a myriad of diverse sensory stimuli. Recollections from our past and reflections upon our future add to this cacophony and we need to select among the vast array of stimuli to which we are exposed and approach what is useful to meet our appetitive needs and withdraw from what is harmful so we avoid situations of threat or danger. The successful negotiation of these life challenges requires an intact cognitive and affective system. The purpose of this brief essay is to underscore the importance of affect to various components of cognition and hint at some of the major advances that have been made in its neuroscientific study.

In its beginning, the cognitive revolution did not include feelings within its scientific purview. There was a clear sense among the leading scientists of this era that the major problems of cognition would yield to an experimental and/or computational analysis that did not require emotion. The most striking evidence of this is simply the absence of very many references to emotion in the classic works of cognitive science and cognitive neuroscience that helped to define the field (e.g., Neisser, 1967). This feelingless stance, however, is now yielding to a more balanced analysis and a renewed appreciation for the role that affect might play in the basic mechanisms of cognition. And one of the most powerful sources of this new evidence is derived from affective neuroscience (Davidson & Irwin, 1999; Davidson & Sutton, 1995). One reason for the inescapable conclusion regarding the necessity of considering both cognition and emotion in our efforts to understand the brain bases of complex mental processes is that the circuitry of emotion and the circuitry of cognition at least partially overlap. These anatomical facts begin to provide the mechanistic substrates by which two-way interactions between affect and cognition are likely to occur.

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Some Functional Anatomical Considerations

Of primary significance is the fact that the brain circuitry of cognition and emotion is not segregated. The idea that the ''limbic system'' was the seat of emotion while cognition resided in the cortex has yielded to the experimental fact that subcortical structures assumed to be part of the limbic system are critical for certain cognitive processes (e.g., the hippocampus for memory) while cortical regions once thought to be the exclusive province of complex thought are now known to be intimately involved in emotion as well (e.g., the prefrontal cortex).

The prefrontal cortex (PFC) is likely to be an essential convergence zone (Nauta, 1971; Damasio, 1989) for cognitive and affective information. Studies using a diverse range of methods including the analysis of patients with discrete prefrontal lesions, electrophysiological studies in normal subjects and patients with mood and anxiety disorders, and neuroimaging studies using positron emission tomograpy (PET) and functional magnetic resonance imaging (fMRI) in both normals and patients have consistently identified various sectors of the PFC as playing a crucial role in emotion (see Davidson & Irwin, 1999; Davidson, et al., 1999 for reviews). Some of these are the same sectors of the PFC that we know to be activated during specific types of cognitive operations. Such findings help us to identify the common role that this territory might be playing in both cognition and affect. For example, the dorsolateral sector of the PFC has long been considered an important part of the circuit underlying working memory and the representation of mental activity for stimuli and events not physically present (Goldman-Rakic, 1987). This form of mental activity is particularly critical for operations that require the anticipation of possible future outcomes (e.g., planning). Some types of human emotion arise specifically as the organism anticipates future outcomes. Fear is an emotion that often arises when we anticipate an uncertain contingency that might be potentially deleterious. There is a form of happiness (which I have referred to as pregoal attainment positive affect; see Davidson, 1994, 1998) that arises as an individual anticipates a future positive outcome. Both of these future-oriented emotions are likely to require the involvement of PFC. A growing corpus of data suggests that asymmetry in the PFC may be essential in the computation of affective value, thus resulting in asymmetric PFC representations of fear and happiness (Davidson & Irwin, 1999).

The amygdala is a limbic brain region that has been convincingly demonstrated to play a major role in fear (e.g., LeDoux, 1996) and possibly other emotions associated with novelty and ambiguity (e.g., Whalen, 1999). Though it is often considered a region ''dedicated'' to emotion, anatomical studies illustrate widespread back projections from the amygdala to early stages of sensory and perceptual processing (Amaral et al., 1992). These connections provide the means by which the amygdala can bias sensory and

perceptual function (Morris et al., 1998) and likely play an important role in the selective aspect of attention.

There are many other examples that could be provided of the dual role played by particular components of cortical and subcortical circuitry in both cognition and affect. The interested reader can refer to several recent reviews that consider these issues in considerably more detail (e.g., Cahill & McGaugh, 1998; Davidson & Irwin, 1999).

Conclusion

This brief essay has argued, not just for the importance, but actually for the necessity of including a serious account of emotion in any systematic analysis of cognition. Emotion has evolved to facilitate the organism's adaptation to complex challenges that it has faced during its evolutionary past (Tooby & Cosmides, 1990). Cognition would be rudderless without the accompaniment of emotion, just as emotion would be primitive without the participation of cognition. This conclusion has been forced upon us by many sources of evidence, but perhaps most compelling are the data that indicate there are no parts of the brain dedicated exclusively to cognition and others to emotion. It is ironic that the duality between reason and emotion that has been perpetuated through the ages is a distinction that is not honored by the architecture of the brain. We have an enormous opportunity and obligation in the biobehavioral sciences today to finally integrate into a meaningful whole the cognitive and affective processing systems. Neuroscience and neuropsychology will play crucial roles in this process, as will the new technologies of brain imaging that are enabling us to rigorously examine underlying circuitry. The chilling wind of cold cognition is giving way to the warmer breeze of a cognitive neuroscience that recognizes the crucial functions of emotion and to an affective neuroscience that appreciates its inextricable intertwining with cognition.

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