The role of the amygdala in the appraising brain

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Abstract: Lindquist et al. convincingly argue that the brain implements psychological operations that are constitutive of emotion rather than modules subserving discrete emotions. However, the *nature* of such psychological operations is open to debate. I argue that considering appraisal theories may provide alternative interpretations of the neuroimaging data with respect to the psychological operations involved.

Affective neuroscience has considerably extended our knowledge of the emotional brain during the last two decades. Most of the work in this domain has consisted of searching for discrete dedicated brain systems underlying each basic emotion, using as evidence either neuropsychological dissociations (see Calder et al. 2001) or brain imaging results (see Vytal & Hamann 2010). Although this approach has extended our knowledge of the emotional brain, it has been strongly challenged by both empirical results and conceptual analyses (for details, see Sander, in press). Given that research on the brain basis of emotion has only rarely been explicitly considered in relation to psychological theories of emotion, the general aim of the current target article by Lindquist et al. is very beneficial to emotion research.

Lindquist et al. convincingly argue that we need to consider how the brain implements psychological operations that are constitutive of emotion rather than modules subserving discrete emotions. However, the nature of such psychological operations is open to debate. The authors only oppose their psychological constructionist view to the locationist view. Here, I argue that appraisal theories provide alternative interpretations to those offered by both the basic emotions perspective and by the authors. Lindquist et al. do not consider what can be seen as the third major research tradition in addition to "basic emotion" models and "core affect" models: namely, appraisal models. As a justification, the authors argue that: "Relatively little work from an appraisal perspective has investigated the brain basis of emotion (although see Sander et al. 2003; 2007). Therefore, we do not discuss appraisal models further in this article" (sect. 2, para. 2). I feel that, although an affective neuroscience approach to appraisal mechanisms is relatively recent (see Sander et al. 2005), many appraisal mechanisms (e.g., novelty detection, intrinsic pleasantness, or goal-relevance) have in fact been the focus of intense empirical research in cognitive and affective neuroscience, but typically without links being made directly to emotion elicitation (see Sander, in press). In addition, some studies have explicitly tested appraisal-driven hypotheses (e.g., Grandjean & Scherer 2008). As described below, conceptual analyses and empirical research have also pointed to a role of particular brain structures (e.g., the amygdala) in specific appraisal mechanisms (e.g., relevance detection).

Where Lindquist et al. do consider alternative interpretations of their results (sect. 6.1), they consider alternative methodological interpretations of the *absence* of findings supporting basic emotions theories, but they do not consider alternative conceptual interpretations of the *presence* of their meta-analytical findings. Consider the authors' conclusion concerning the brain region that has most clearly been associated with emotion in the literature: the amygdala. The authors write that their meta-analytical finding "is consistent with our hypothesis that the amygdala responds preferentially to salient exteroceptive (vs. interoceptive) sensations" (sect. 5.1, para. 6). Attributing a key role to the amygdala in processing saliency of exteroceptive stimuli indeed characterizes this brain structure with respect to a specific psychological operation, rather than to a basic emotion. Historically, the amygdala was typically associated with one emotion: fear. Associating a basic emotion to a specific brain system was consistent with basic emotion models (see Ekman 1999, p. 50). A common view has been that the amygdala is central to a "fear system," or even a "fear module" (Öhman & Mineka 2001). However, the lack of empirical evidence to conclude that the amygdala is specific to fear led scholars such as Kringelbach and Berridge (2009) to consider that equating the amygdala with fear is one of those "overly simple equations between neurobiology and psychology that merge into myth" (p. 481).

In the framework of appraisal theories of emotion, Sander and colleagues have argued that the computational profile of the amygdala is best characterized as default detection of stimuli appraised as relevant, given the individual's current concerns, such as goals, needs, and values (Sander et al. 2003; see also, Sander, in press). The idea that the amygdala is critical for relevance detection is grounded in appraisal models of emotion (see Frijda 1986, p. 390; Sander et al. 2005). Therefore, an alternative interpretation of the function of the amygdala that does not advocate a specific role of the amygdala for *fear* can be offered from an appraisal perspective. I believe that there is an interesting distinction between our analysis of the function of the amygdala and the authors' suggestion that the amygdala is associated with the psychological operation of "core affect" (see Figure 2 of the target article). Indeed, Lindquist et al. define "core affect" as the mental representation of bodily sensations that can be experienced as feelings of hedonic pleasure and displeasure with some degree of arousal. However, the very notion that a bodily sensation is mentally represented implies that a bodily response has been elicited *before* interoception could possibly lead to experienced feelings. In our account, relevance detection is supposed to be primary to the mental representation of bodily sensations because it is supposed to be involved in the *elicitation* of the emotional response, including the generation of bodily sensations. When considering conceptualization/categorization, Lindquist et al. "hypothesize that this psychological operation makes a prediction about what caused core affective changes within one's own body or what caused the affective cues (e.g., facial actions, body postures, or vocal acoustics) in another person" (sect. 3, para. 6). By contrast, appraisal theories are not typically concerned with how an individual *predicts* the cause of an affective change, but rather, with how a relevant event actually *causes* an affective change (see Moors 2009; Scherer & Ellsworth 2009). When the authors attribute a saliency processing function to the amygdala, it makes a critical theoretical difference whether they consider the role of saliency in (1) categorizing an external event as being a potential cause of an *already present* core affect, or rather in (2) the context-sensitive evaluation of an event as a function of the current concerns of the individual, which *causes* a change in the affective response, the latter being very much in line with appraisal theories of emotion.

Functional specialization does not require a one-to-one mapping between brain regions and emotions

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Abstract: Lindquist et al. have assumed that functional specialization requires a one-to-one mapping between brain regions and discrete emotions. This assumption is in tension with the fact that regions can