in Cacioppo et al. (1996), Levine and Perlovsky (2008; 2010), Perlovsky (2009b; 2010c), and Perlovsky et al. (2010), and emotions related to creativity discussed in Levine and Perlovsky (2010), Lubart and Getz (1997), and Pfenninger and Shubik (2001). "Emotions of the beautiful" are discussed in Biederman and Vessel (2006), Dorfman et al. (2006), Perlovsky (2002; 2006c; 2010b; 2010a), Tooby and Cosmides (2001), and in Silvia (2005). Yet the "beautiful" is mentioned only once in the target article: "A painting is beautiful" (sect. 3, para. 5). Emotions pertaining to the beautiful are not mentioned.

In the Perlovsky studies cited above, I have discussed evidence and other studies relating "emotions of the beautiful," as discussed by Kant, to the need for knowledge; aesthetic emotional mechanisms are essential in every act of perception and cognition; at the level of perception they are autonomous and below the threshold of consciousness, at "higher" levels of cognition they could be experienced as conscious emotions; they are in complicated interaction with cultural discussions of these emotions in language (which usually are more conscious). The origin of aesthetic emotional mechanisms is in the need to adapt mental representations to concrete conditions around us. Contradictions between basic drives and knowledge, as well as within the system of knowledge, cause emotions of cognitive dissonances. A need to resolve these contradictions emotionally is related to the origin of music. (These emotions are usually "continuous" because the number of contradictions, and therefore the number of emotions, is combinatorially large; Spinoza [1677/2005] was the first one to mention that emotions differ depending on the object of reference.)

Lindquist et al. mention in conclusion that emotions and cognition might be a unified process:

> [W]e might not assume that *emotion* and *cognition* battle it out in the brain . . . or that consumer decisions are predicated on competing affective and rational representations . . .. Instead, we might assume that affect and executive attention are merely different sources of attention in the brain . . .. Feeling and seeing might not be as distinct as is typically assumed. (target article, sect. 7, para. 1)

But no discussion was devoted to emotions related to cognition "above" perception of concrete objects. An opportunity to study specifically human "high" cognitive emotions has been lost.

NOTE

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Beyond brain regions: Network perspective of cognition–emotion interactions

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Abstract: Lindquist et al. provide a convincing case against what they call the *locationist* account of emotion. Their quantitative approach elegantly illustrates the shortcomings of this still-entrenched viewpoint. Here, I discuss how a network perspective will advance our understanding of structure-function mappings in general, and the relationship between emotion and cognition in the brain.

The simplest way to conceptualize the mapping between brain area and behavior is to assume a one-to-one mapping between an area and its function (e.g., amygdala <–> fear). It is readily apparent, however, that brain regions are involved in many functions, and that functions are carried out by many regions. More generally, therefore, the mapping between structure and function is both *pluripotent* (one-to-many) and *degenerate* (many-to-one). The combination of the two indicates that there are no "necessary and sufficient" brain regions. Based on these notions, I have argued elsewhere that a network perspective is needed for the understanding of the interactions between emotion, motivation, perception, and cognition (Pessoa 2008; 2009; 2010a; Pessoa & Engelmann 2010). Briefly, networks of brain regions collectively support behaviors (Fig. 1). Hence, the network itself is the unit, not the brain region. Processes *P* that support behavior are not implemented by an individual area, but rather by the interaction of multiple areas, which are dynamically recruited into multi-region assemblies.

I use the term "process" instead of "function" or "computation" because a process emerges from the interactions between regions, as in "emergent property" (Bressler & Menon 2010). Furthermore, a process is viewed as a useful external description of the functioning of the network, and not necessarily as a fixed internal computation implemented by the network (Thompson 2007; Thompson & Varela 2001). In this context, the suggestion by Lindquist et al. of *psychological primitives* is problematic, as the mind should not be viewed as constructed of atomic constituents in the manner that physicists conceive of matter, for instance.

Whereas a network perspective is needed for a fuller characterization of the mind-brain, it should not be viewed as a panacea. For one, the challenges posed by the many-to-many mapping between regions and functions is not dissolved by the network perspective. Indeed, one should not anticipate a one-to-one mapping when the network approach is adopted – counter to the recent trend of labeling networks with specific functions; see examples in Bressler and Menon (2010). Additionally, decomposition of brain regions in terms of meaningful clusters, such as the ones generated by community-finding algorithms (Newman 2010), does not by itself reveal "true" sub-networks. Given the heterarchical and multirelational relationship among regions, multiple decompositions will offer different "slices" of the overall connectivity space. In what follows, I briefly discuss some repercussions of a network perspective to the understanding of the relationship between emotion and cognition.

First, given the extensive interactions among brain regions, the emphasis shifts from attempting to understand the brain one region at a time, to understanding how coalitions of regions support the mind-brain. Insofar as brain regions are not the unit of interest, they should not be viewed as "cognitive" or "emotional." Traditionally, however, regions whose function involves homeostatic processes and/or bodily representations have been frequently viewed as "emotional," whereas regions whose function is less aligned with such processes have been viewed as "cognitive."

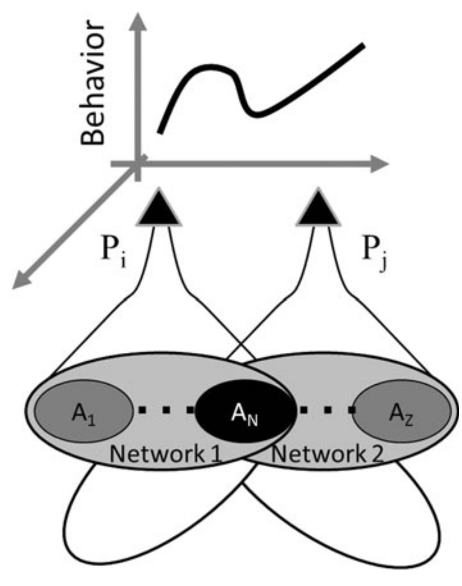

Figure 1 (Pessoa). Structure-function mapping. Networks are dynamically formed when areas (A_1, A_N, A_z) coalesce into temporally stable groupings. Area A_N (in black) is part of multiple networks. P_i, P_j = processes (see text).

Second, the architectural features of the brain are such that they provide *massive* opportunity for cognitive-emotional interactions (Modha & Singh 2010). These interactions are suggested to involve all brain territories. For example, extensive communication between the amygdala and visual cortex exists, and efferent amygdala projections reach nearly all levels of the visual cortex (Amaral et al. 2003). Thus, visual processing takes place within a context that is defined by signals occurring in the amygdala (as well as the orbitofrontal cortex, pulvinar, and other regions), including those linked to affective significance (Pessoa & Adolphs 2010). Therefore, vision is never pure vision, but is *affective vision* – even at the level of primary visual cortex (Damaraju et al. 2009; Padmala & Pessoa 2008). Cognitive-emotional interactions also abound in the prefrontal cortex, which is thought to be involved in abstract computations that are farthest from the sensory periphery. More generally, given inter-region interactivity, and the fact that networks intermingle signals of diverse origin, although a characterization of brain function in terms of networks is needed, the networks themselves are best conceptualized as neither "cognitive" nor "emotional."

Third, regions that are important for affective processing appear to be exceedingly well connected (e.g., Petrovich et al. 2001; Swanson 2000). This suggests that these regions have important "quasi-global" roles and that this is an important feature of this class of region. However, regions traditionally described as "emotional" are not the only ones that are highly connected. Highly connected regions are encountered throughout the brain, including in the occipital, temporal, parietal, and frontal lobes, in addition to the insula, cingulate, thalamus, and regions at the base of the brain (Modha & Singh 2010).

Fourth, emphasizing only interactions between brain regions that are supported by direct, robust structural connections is misleading. For one, the strength of functional connectivity is equally important, and at times will deviate from the strength of the structural connection (Honey et al. 2007). Architectural features guarantee the rapid integration of information even when robust structural connections are not present, and support functional interactions that are strongly context dependent. This is illustrated, for example, by the "one-step" property of amygdala–prefrontal connectivity – amygdala signals reach nearly all prefrontal regions within a single connectivity step (see Averbeck & Seo 2008).

Fifth, taken together, these considerations suggest that the mind-brain is *not* decomposable in terms of emotion and cognition. In other words, the neural basis of emotion and cognition should be viewed as governed less by properties that are intrinsic to specific sites and more by interactions among multiple brain regions. In this sense, emotion and cognition are *functionally integrated systems*, namely, they more or less continuously impact each other's operations (Bechtel & Richardson 2010). As suggested by Bechtel and Richardson, "The problem is then not one of isolating the localized mechanisms, but of exhibiting the organization and the constituent functions… [A]n explanation in terms of organization supplants direct localization" (p. 151).

The construction of emotional experience requires the integration of implicit and explicit emotional processes

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Abstract: Although we agree that a constructivist approach to emotional experience makes sense, we propose that implicit (visceromotor and somatomotor) emotional processes are dissociable from explicit (attention and reflection) emotional processes, and that the conscious experience of emotion requires an integration of the two. Assessments of implicit emotion and emotional awareness can be helpful in the neuroscientific investigation of emotion.

Lindquist et al. are to be commended for meticulously integrating comprehensive reviews of basic emotion theory with detailed meta-analyses from the neuroimaging of emotion literature. Using the extant neuroimaging literature, they cogently argue that neuroimaging evidence does not support the locationist view that specific brain circuits underlie specific emotional experiences or perceptions. Although this conclusion is not necessarily the final word on the question, as acknowledged by the authors, given the early state of brain imaging technology, the target article makes a convincing case that alternative formulations of the neural basis of emotion and emotional experience are needed.

In general we agree with Lindquist et al. that a constructivist approach to emotional experience makes sense. Indeed, in 1987 one of us described a constructivist model of emotional experience driven by language (Lane & Schwartz 1987). Where we disagree, however, is in the specific content of the constructivist model that is proposed. Throughout their article, Lindquist et al. assume that emotion must, at a minimum, be associated with the conscious experience or mental representation of emotion ("core affect") that is valenced and associated with some degree of arousal. The authors also hold that further differentiation of experience results from linguistically determined categories of specific emotion that do not have any real existence in nature. While we agree that the differentiated experience of emotion is largely language-driven, our primary concern is that the nature of the process of the construction of emotional experience is, in our view, more complex than Lindquist et al. assert.

With the discovery that the vast majority of cognition does not occur consciously, and that each of the steps in the generation and unfolding of an emotional response involves information processing of some kind, one of us has argued that the distinction between implicit and explicit processes, a cornerstone of modern cognitive neuroscience, also applies to emotion (Lane & Nadel 2000). According to this perspective, the visceromotor and somatomotor manifestations of emotion may occur in the absence of emotional experience, and constitute implicit emotional responses.

There is now a considerable literature supporting this view. In a comprehensive review on emotional experience, Lambie and Marcel (2002) concluded that a two-level model of emotional experience is needed that can account for unconscious emotion, that is, emotional responses without conscious experience or awareness (see also Kihlstrom et al. 2000; Lane 2008; LeDoux 1996). Over the past 25 years or so, academic research has been conducted on implicit affect, that is, spontaneous affective reactions associated with changes in peripheral physiology and/or behavior that are not associated with conscious emotional experiences (cf. Quirin et al. 2009a; Winkielman & Berridge 2004; Zajonc 2000). Lindquist et al. do not discuss the potential relevance of this distinction between implicit and explicit emotion processing for the analysis of neural correlates of emotion.

Furthermore, many decades of research preceding the modern era of neuroimaging demonstrated the evocation of visceral and somatomotor expressions of emotion in brainstem stimulation studies of laboratory animals (LeDoux 1996). Although these phenomena cannot be scientifically linked to reportable experiences, they nevertheless are the bodily expression of emotion. We believe that implicit emotion, consisting of the visceromotor and somatomotor expressions of emotion, which may or may not be valenced, constitute the foundation upon which more differentiated emotional experience is built. Moreover,