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Comment

The problem with emotion
Comment on "The quartet theory of human emotions: An integrative and neurofunctional model" by S. Koelsch et al.

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In everyday use, emotion typically refers to conscious feelings. It *feels like something* to be happy or sad, afraid or angry. These emotions have qualia. That qualia are so central to what we mean by emotion makes emotion research both exciting and frustrating. Exciting because understanding how the brain gives rise to qualia is a fundamental goal of neuroscience, and frustrating because despite centuries of inquiry, qualia continue to defy a mechanistic explanation. But this obstacle has not completely blocked progress because there are other aspects of emotion – behavioral and physiological – that are more accessible to research, and the study of these has produced considerable advances in our understanding of how emotions work [13].

The focus on experimentally accessible aspects of emotion has not, however, stopped researchers from theorizing about emotional qualia. Over the years, many different brain areas have been proposed as key players, sometimes as the seat of qualia in general, and sometimes as the origin of specific qualia, e.g., fear or disgust. The list of structures is long. Recently popular candidates include the periaqueductal gray [11], insula [2,3], temporoparietal junction [7], and somatosensory cortices [8].

Drawing on ideas about the importance of neural maps of the body [4,5], Koelsch et al. [9] propose that emotional qualia arise specifically in secondary somatosensory cortex (SII),[1] which is situated between the insula and primary somatosensory cortex (SI). Although consistent with current thinking, two points should be emphasized regarding this hypothesis. First, the researcher most responsible for moving the field towards the consideration of body maps in understanding emotional qualia, has himself expressed skepticism about SII as the critical player, citing evidence that "behaviors clearly indicative of feeling states" persist in both humans and macaques with bilateral lesions that "encompass both SI and SII, albeit not in their entirety" [5]. Second, although the idea that emotional qualia arise from brain areas that respond to the internal and external status of the body is very attractive, a mechanistic account of how neural events produce qualia remains out of reach.

The aim of Quartet theory, however, is not to explain qualia. Koelsch et al. seek to simplify and organize how we think about emotion by delineating four key regions of the brain and assigning each with a different set of affective

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[1] First described by Adrian [1], who reported a secondary representation of a cat's feet in a region located lateral to the "primary" representation in SI [14].

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functions. Progress in neuroscience often begins with associations between specific brain areas and psychological phenomena, but it depends critically on clear definitions of the phenomena in question. Problems for Quartet theory arise with the term "affect", which, despite occurring many times in the main text is never clearly defined. Although initially careful to establish that affect does not refer to "the conscious subjective aspect of emotion" (Section 1.1), this negative definition proves too difficult to stick with, as terms like "tender positive feelings", "courage", and "joy" are regularly used to describe what Quartet members do.[2] This example illustrates how hard it is to theorize about the neural bases of emotion without relying on emotional qualia – a key problem in emotion research.

Definitional issues also arise in the aspects of Quartet theory that aim to integrate emotion and language, another key area of neuroscientific research. In reference to the intriguing hypothesis that the orbitofrontal cortex (OFC) internalizes social norms during development, the authors argue that "because the OFC is not a language area (and because the OFC does not consist of neocortex), such internalized contents cannot be directly verbalized... and are thus non-conscious" (Section 2.4.5). This presumes that the neurobiology of language (and its association with consciousness) is sufficiently defined that we may draw conclusions about verbalization based on the locus of neural activation. A simple analogy demonstrates that this is not the case: neocortical areas primarily involved in visual processing are not traditionally considered "language areas" and yet visual percepts can be verbally described with ease.

A final comment concerns the general approach of defining distinct emotional subsystems. The advantages in doing so include simplification and organization. But we must acknowledge that the complexity of the underlying substrates may be too great to permit simple divisions that accurately describe how the system works. Two examples from Quartet theory highlight this problem. First, Koelsch et al. attribute arousal to the reticular formation in the "brainstem-centered" affect system (Section 2.1). While this makes good sense, there are other neural substrates outside the brainstem that are also critically important in stimulating cortical arousal, e.g., dopaminergic neurons in the midbrain and cholinergic neurons in the basal forebrain.[3] A second example concerns the attribution of pain and pleasure to the "diencephalon-centered" affect system (see Section 2.2). While there is evidence in support of this association, there is also evidence that areas outside the diencephalon, such as the periaqueductal gray, nucleus accumbens, and anterior cingulate cortex, are also critically involved in pain and pleasure [12]. These examples are not intended as explicit criticisms of Quartet theory per se. Theoretical work in science often requires some amount of over-simplification. Rather, they highlight an inherent problem with our tradition of ascribing specific functions to bounded regions of the brain. A shift towards circuit-based approaches that emphasize the richly interconnected and distributed nature of nervous systems seems inevitable. This shift is somewhat apparent in Koelsch et al.'s emphasis on interaction between quartet members and other systems.

In conclusion, Quartet theory represents an important synthesis of emotion research that both simplifies and organizes current thinking. Koelsch et al.'s formulation of a clear four-part framework has considerable advantages and will undoubtedly stimulate further thinking and debate. The author's deserve credit for taking on a formidable task and their work inspires us to think about central challenges in emotion research and neuroscience in general. Using the methods and explanatory frameworks available now, we will surely continue to make progress in our understanding of emotional behavior and its physiological basis. But explaining emotional qualia will likely require something else, and until that something is identified and understood, theories of emotion will always come up short in this regard.

Acknowledgement

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[2] Craig AD. How do you feel – now? The anterior insula and human awareness. Nat Rev Neurosci 2009;10:60–70.

[2] A positive definition of affect is offered later – "in our terminology, 'affect' refers only to activity in affect systems" (Section 6) – but this definition is circular.

[3] Disorders of these systems are associated with motor deficits in Parkinson's disease [10] and cognitive decline in Alzheimer's disease [6].

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