

## Comment

# Human emotion in the brain and the body: Why language matters

## Comment on “The quartet theory of human emotions: An integrative and neurofunctional model” by S. Koelsch et al.

Cornelia Herbert <sup>a,b,c,d,\*</sup><sup>a</sup> *Institute of Psychology and Education, University of Ulm, Germany*<sup>b</sup> *Department of Psychiatry and Psychotherapy, University of Tübingen, Germany*<sup>c</sup> *Department of Biomedical Magnetic Resonance Imaging, University of Tübingen/Max Planck Institute for Biological Cybernetics Tübingen, Germany*<sup>d</sup> *Department of Psychology, University of Würzburg, Germany*

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What is an Emotion? This question has fascinated scientific research since William James. Despite the fact that a consensus has been reached about the biological origin of emotions, uniquely human aspects of emotions are still poorly understood. One of these blind spots concerns the relationship between emotion and human language. Historically, many theories imply a duality between emotions on the one hand and cognitive functions such as language on the other hand. Especially for symbolic forms of written language and word processing, it has been assumed that semantic information would bear no relation to bodily, affective, or sensorimotor processing (for an overview see Ref. [1]). The Quartet Theory proposed by Koelsch and colleagues [2] could provide a solution to this problem. It offers a novel, integrative neurofunctional model of human emotions which considers language and emotion as closely related. Crucially, language – be it spoken or written – is assumed to “regulate, modulate, and partly initiate” activity in core affective brain systems in accord with physical needs and individual concerns [cf. page 34, line 995]. In this regard, the Quartet Theory combines assumptions from earlier bioinformational theories of emotions [3], contemporary theories of embodied cognition [4], and appraisal theories such as the Component Process Model [5] into one framework, thereby providing a holistic model for the neuroscientific investigation of human emotion processing at the interface of emotion and cognition, mind and body.

Empirically, neuroscientific research on emotional word processing has accumulated evidence that lends support to the Quartet Theory. Systematic investigation of the neurophysiological mechanisms of emotional word processing by means of electroencephalography (EEG), functional imaging (fMRI), and biopsychological methods reveal that activity in the ventral visual processing stream increases within the first 200 ms after emotional word presentation [6,7], an observation that has since been reported exclusively for concrete emotional stimuli such as pictures or faces.

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\* Correspondence to: Institute of Psychology and Education, University of Ulm, Germany/Department of Psychiatry and Psychotherapy, University of Tübingen, Germany.

E-mail addresses: [cornelia.herbert@uni-ulm.de](mailto:cornelia.herbert@uni-ulm.de), [cornelia.herbert@med.uni-tuebingen.de](mailto:cornelia.herbert@med.uni-tuebingen.de).

During functional imaging, visual processing of emotional words is accompanied by activity in phylogenetically old emotion brain structures such as the amygdala [8,9] or insula [10]. Crucially, it has been shown that effects triggered by emotional words are not restricted to affective processing per se. In a series of studies, emotional word processing produced facial emotional expressions [11] and involuntary modulation of the startle eye blink response [12–14] suggesting that words, like pictures, can lead to motivational priming of action tendencies of approach and avoidance. Although the exact anatomical pathways have not been examined in these studies, the results offer support for Koelsch and colleagues' proposal that activity of the core affective systems, including activity controlled by brain-stem nuclei, can be shaped by symbolic sensory input. Further, for words some of these processes can appear pre-lexically [15], probably at that stage of information processing at which – as proposed by Koelsch and colleagues – sensory information from within and outside the body is synthesized into an emotion percept.

One of the most compelling experimental demonstration of how closely related human language and emotions can be and how this can affect activity in some of the core affective systems proposed by Koelsch and colleagues comes from very recent research. This body of literature extends emotional word processing to the domains of social cognition and emotion regulation and investigates how emotions are decoded from words when these refer to the subject's own feelings (e.g., my fear, my pleasure) [16]. Functional imaging has revealed activation of a large scale network comprising the right and left amygdala and insula and the medial parts of the orbitofrontal-centered affect system involved in low- and high-level appraisal, as described by Koelsch and colleagues. Notably, when related to the self, positive and negative emotion words selectively enhanced activity in the ventromedial prefrontal cortex (VMPFC), including the anterior cingulate cortex [16]. As a cortical midline structure and part of the default mode network [17], the VMPFC is critically involved in self-referential processing and the appraisal of stimuli in terms of their personal significance. More specifically, it has been suggested that VMPFC integrates and evaluates information from the amygdala and the insula in order to generate an internal feeling state [17,18]. Thus, during processing of self-related emotion words, VMPFC activation likely indicates the appraisal by which information is transformed into an awareness, sensation, or feeling of emotional ownership. As outlined by Koelsch and colleagues, none of the aforementioned brain regions (belonging to the orbitofrontal-centered affect system) constitutes a typical language processing region nor was a direct connectivity with typical language regions observed empirically in these studies. This supports the idea put forward by the Quartet Theory that, despite a close relationship between emotion and language, subjective feelings may not be readily transformed into language code even if the feeling states arise from verbal input. This, however, does not mean that putting feelings into words would be ineffective in shaping emotion perception. In contrast, as predicted by the Quartet Theory, there is growing evidence that labeling one's feeling verbally (i.e. “the reconfiguration of emotion percepts into language”) leads to adaptive emotion processing and emotion regulation, including down-regulation of amygdala activation and peripheral physiologic responses as well as of self-reported negative distress [19]. Importantly, reframing emotion percepts verbally, for instance, by mere exposure to certain cue words during face processing, can induce emotion regulatory effects akin to intentional forms of cognitive emotion regulation such as cognitive reappraisal [20–22], whereas loss of semantic word meaning can lead to loss of discrete emotion perception [23].

To conclude, the research outlined above supports the Quartet Theory in arguing against a purely cognitive-based foundation of language. Emotion and language are mutually interacting. They construct each other at the level of the brain and the body as well as with respect to personal experiences, sensations, and behavior.

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