



Reply to comment

# Instruments, conductors, dancers, and intendants

## Reply to comments on “The quartet theory of human emotions: An integrative and neurofunctional model”

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I am happy about each commentator’s contribution [1–27], about the wealth of the kind and generally positive comments, and the many interesting and enriching remarks, observations, and extensions. In the following, I will summarize some major points of the comments, and relate them to the Quartet Theory (henceforth QT) proposed in the target article [28].

### The roles of language in emotions

Several authors emphasized that language is not only important for the verbalization and regulation of emotions, but also that “words at least in spoken language are capable of eliciting strong emotional feelings” [4]. A particular question across several comments was *when* exactly emotional meaning of language is processed [4,6,12,25]. Does

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a word have to be processed “psycholinguistically” in the language-network in order to elicit emotional responses, or can words – similar to conditioned stimuli – be recognized by an affect system even *prior* to the processing in the (neo-cortical) language network? The Quartet Theory would predict that (both written and spoken) *words can gain symbolic quality (especially in the course of contextual learning) by which they can elicit affective activity in the orbitofrontal cortex (OFC), even without – or prior to – “psycholinguistic” processing in the neo-cortical language system.* In this regard, the QT would explain what Braun [4] puts nicely as “the striking fact that the emotion-eliciting function of words can be of a pre-verbal nature.”

Consistent with this notion, several comments cite evidence of surprisingly speedy emotional responses to words [12,4,6]. Kuiken and Douglas [15], moreover, provide nice examples of OFC-based judgements and “emergence of a ‘felt sense’ of a perceptual object that precedes articulation of the ‘nameable’ category to which it belongs”. The mechanisms of emotion–evocation by symbolic verbal stimuli are probably even more powerful in the case of words spoken with a significant voice (such as the voice of mother or father, or the affective colour of their voices), i.e. when we hear words spoken by persons with prominent roles in our personal contextual learning history. In this regard, investigations with bilingual individuals can help elucidate this issue (see also [29] and comment by Conrad [6]). While I presume that the OFC is an important structure for associations between symbols and emotions, it would be interesting to investigate to which extent the other affect systems are also capable of recognizing and learning symbolic content of words and vocalizations (see also comment by Hofmann and Kuchinke who remark that some hippocampal neurons code the coincidence of different contextually learned representations, including words [13]).

Conrad [6] even raises the question as to whether, “besides serving as a vehicle for communication of emotion, language also influences emotion percepts.” When investigating this question, it would be important to differentiate the symbolic (“conditioned”) quality of words and vocalizations, which might act indirectly on the emotion percept via affect-eliciting processes in the affect systems, from the neo-cortical “psycholinguistic” language processes, which might act on the emotion percept via conscious appraisal processes (as suggested in the QT).

Note that pre-verbal processing of words might also occur independently of the emotional content of words (i.e., not only with regard to emotional information). As mentioned above, Kuiken and Douglas [15] describe that categorical learning might take place “even before the basis for categorization can be stated”. This might, in part, also be due to objects evoking sensorimotor codes (including the basal ganglia) before these objects can be verbally categorized. Interestingly, this raises the question as to whether the *perception* of an emotion of another individual can evoke representations of meaningful concepts *before* this emotion is mimicked, or mirrored. Kuiken and Douglas [15] also ask the question: “how do ‘action tendencies’ become manifest as aspects of subjective feeling? Are the processes mediated by the basal ganglia and orbitofrontal cortex separable from ‘conceptual-semantic language functions’?” The QT conceptualizes “motor drives” or “motor impulses” as components that contribute to the emotion percept. Language, on the other hand, can also initiate motor impulses [30,31] (although the conceptual-semantic language system appears to be neuroanatomically different from the neural substrate of the emotion percept, as also nicely illustrated by Kuiken and Douglas).

Herbert [12] presents highly interesting evidence extending “emotional word processing to the domains of social cognition and emotion regulation” [12]. Intriguingly, she found that emotions decoded from words elicit activity in the ventromedial prefrontal cortex when these refer to an individual’s own feelings [12]. This appears to be related to self-referential processing and the appraisal of stimuli in terms of their personal significance. Future work could further investigate the role that the orbitofrontal-centred affect system plays in evaluative processes when stimuli with emotional significance are related to an individual’s self (and, thus, also the role of the evaluative function of the OFC in “default mode network” activity).

Finally, Engelen [8] makes the important remark that “language and cultural practices may reconfigure the neurological material and therefore build up neural correlates for the thereby arising long-term emotions.” Engelen also argues that emotional expression by one individual is a means of verifying (or falsifying) the correct use of an emotion word by another individual (thus enabling a teacher to teach emotion words for basic emotions to a child). This, however, is problematic, because some discrete emotions have very similar expression (e.g. anxiety and fear, or fun and happiness). A teacher cannot look into the head of the pupil, and therefore cannot guarantee that his or her use of an emotion word is ‘correct’. I would also like to note that, for “basic” as well as more “complex” emotions, the QT conceptualizes expression *and* emotion percept as parts of the emotion. Thus, the QT does not oppose “basic emotions” and “emotion percepts” (neither does it prefer one over the other).

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