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Comment

The hippocampus is an integral part of the temporal limbic system during emotional processing
Comment on "The quartet theory of human emotions: An integrative and neurofunctional model" by S. Koelsch et al.

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The proposed quartet theory of human emotions by Koelsch and colleagues [1] identifies four different affect systems to be involved in the processing of particular types of emotions. Moreover, the theory integrates both basic emotions and more complex emotion concepts, which include also aesthetic emotions such as musical emotions. The authors identify a particular brain system for each kind of emotion type, also by contrasting them to brain structures that are generally involved in emotion processing irrespective of the type of emotion. A brain system that has been less regarded in emotion theories, but which represents one of the four systems of the quartet to induce attachment related emotions, is the hippocampus.

The hippocampus, primarily known to play a key role in memory processing, learning and spatial orientation, has only recently been acknowledged to be involved also in emotion processing. Koelsch and colleagues argue that the hippocampus plays a role for social emotions that do not, or satiate only in very long-term, such as the bond of affection for a child or love. The hippocampus is also sensitive to emotional stressors, as it has been reported for example that the hippocampal volume is reduced in persons with post-traumatic stress disorder [2]. Moreover, the hippocampus has been associated with attachment anxiety and insecurity [3]. However, the hippocampus is also involved in processing aesthetic emotions induced by music, notably emotions of low arousal such as tenderness, peacefulness and nostalgia [4].

Given this large involvement of the hippocampus in emotional processing, we recently have summarized the literature reporting implications of the more general temporal limbic system in the processing of affective stimuli, especially of affective sounds [5]. The temporal limbic system includes both the amygdala and the hippocampus. A review on

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the literature on emotions that are recognized in voices or evoked by music showed that very often both the amygdala and the hippocampus are involved. Regarding the structural and functional connectivity between the two structures and their relationship to the auditory system we have pointed out that for processing emotions in human voices, which represent more direct way of emotional signalling, rather fast and direct (especially subcortical) pathways from the auditory system to the amygdala play a critical role. While the amygdala seems to play a major role during the processing of vocal emotions, connectivity of the amygdala to the hippocampus might support the storage of emotional experiences based on these encountered vocalizations. Processing of emotions in music, which is a more culturally imprinted and subjectively appreciated stimulus, involve also more indirect pathways that connect the auditory cortex both with the hippocampus and the amygdala. We therefore argued that more complex emotional stimuli that might include personal preferences, memory associations, and aesthetic evaluations elicit activity in the hippocampus and the amygdala when processing auditory emotions.

Another critical point concerns the habituation of activity in the hippocampus and the amygdala. Whereas amygdala activity shows very fast habituation, the hippocampus is less affected by habituation. This also points to the notion that the hippocampus seems to be involved in more long-lasting affects whereas the amygdala is involved in rather short emotional responses. Given that the hippocampus is implicated in social synchronization processes [6], which are known to promote prosocial behaviour and feelings [7], the role of the hippocampus might also include some socio-emotional functions.

Taken together, based on the anatomical closeness, the close connectivity, and the functional collaboration of the hippocampus and the amygdala during emotional processing, their interactions should not be neglected, as it has been highlighted here for the example of affective sound processing. Given that the hippocampus is strongly influenced by the activity in the different nuclei of the amygdala, it seems rather unlikely that the hippocampus would represent an affect system that stands on its own. We thus suggest an integrated amygdala–hippocampus complex for emotional processing.

References

[1] Koelsch S, Jacobs A, Menninghaus W, Liebal K, Klann-Delius G, von Scheve C, et al. The quartet theory of human emotions: an integrative and neurofunctional model. Phys Life Rev 2015;13:1–27 [in this issue].

[2] Smith ME. Bilateral hippocampal volume reduction in adults with post-traumatic stress disorder: a meta-analysis of structural MRI studies. Hippocampus 2005;15(6):798–807. PubMed PMID: 15988763.

[3] Quirin M, Gillath O, Pruessner JC, Eggert LD. Adult attachment insecurity and hippocampal cell density. Soc Cogn Affect Neurosci 2010;5(1):39–47. PubMed PMID: 20007241. Pubmed Central PMCID: 2840841.

[4] Trost W, Ethofer T, Zentner M, Vuilleumier P. Mapping aesthetic musical emotions in the brain. Cereb Cortex 2012;22(12):2769–83. PubMed PMID: 22178712. Pubmed Central PMCID: 3491764.

[5] Fruhholz S, Trost W, Grandjean D. The role of the medial temporal limbic system in processing emotions in voice and music. Prog Neurobiol 2014;123C:1–17. PubMed PMID: 25291405.

[6] Fairhurst MT, Janata P, Keller PE. Being and feeling in sync with an adaptive virtual partner: brain mechanisms underlying dynamic cooperativity. Cereb Cortex 2012;23(11):2592–600. PubMed PMID: 22892422.

[7] Launay J, Dean RT, Bailes F. Synchronization can influence trust following virtual interaction. Exp Psychol 2013;60(1):53–63. PubMed PMID: 22935329.