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Is Human vmPFC Involved in Coding Emotional Significance of Complex Scenes?

— Yes. According to a recent study by Kawasaki et al. [?] several regions of human ventral and medial PFC participate in encoding emotional responses to complex visual scenes. In turn, I will outline the experimental setup employed in their study, researchers' motivation, the results obtained and how these were interpreted. Finally, I will remark on restrictions and extensions.

What was done?

In their study, Kawasaki et al. used single unit recordings from chronically implanted clinical depth electrodes in four epileptic patients. 267 neurons in four subregions of vmPFC—right subgenual cingulate cortex (sgCC), left and right medial orbitofrontal cortices (mOFC), and left gyrus rectus (GR)—have been recorded. Patient #1 (male, 48) had two recording sites in each right OFC and right sgCC; #2 (female, 30) two recording sites in left mOFC. Patient #3 (male, 39) had two recording sites in left GR, #4 (male, 18) two recording sites in each left GR and right mOFC. Electrode locations were verified using pre- and postimplantational MRI, appeared structurally normal and were distant from seizure foci.

All subjects performed normal on standardized tests for basic cognitive and frontal lobe functions. Stimuli were rated normally for arousal and valence by #1, #2 and #3.

During recording, patients were presented 150 (#4: 256) complex visual scenes of three emotional categories (neutral, pleasant, aversive) in a free viewing task where categories were assigned as a function of valence and arousal. Images did not differ significantly in low-level features and were of known emotional valence and arousal. Each session consisted of 60-256 stimuli presented in randomized order (1 s; #1: 4 s) with varying intertrial intervals (5-8 s; #4: 800-1200 ms).

Recordings were statistically analyzed for deviations in post- from pre-stimulus firing rate and selectivity for specific emotions.

Why was it done?

The procedure just sketched was intended to fill the gap between neurophysiological studies in non-human primates and lesion studies in humans indicating PFC's involvement in emotional processing and possible specialization of subsectors to specific emotions (left hemisphere for positive, right for negative stimuli). More specifically, Kawasaki et al. posed three questions: (1) Do neurons in human PFC respond selectively to aversive, pleasant and neutral stimuli? (2) If so, are responding neurons distributed topographically? (3) Are there neural representations along continuous stimulus dimensions (arousal & valence)?

What did they find?

The authors report significant responses to emotional stimuli in 56 neurons, 16 of which were selective (cf. [?], figure 3) to only one class of emotional stimuli (9 aversive, 6 neutral, and 1 pleasant). No significant differences in latencies or between hemispheres could be found.

What does it mean?

With respect to their three questions, Kawasaki et al. conclude that (1) several regions of left and right vmPFC participate in encoding emotional significance of complex visual images; single neurons selectively respond to one out of the three emotional categories. (2) No distributed topography could be identified. (3) Selectivity could not be explained in terms of valence or arousal dimensions. Hence, human vmPFC is involved in sparse and widely distributed processing of emotional value; it shows predominant responses to aversive stimuli.

What's wrong? What's left?

Now that we have seen how Kawasaki et al. reach their conclusions, let me give a few remarks. The perhaps most salient aspect concerns the tools employed. Single unit recording in humans is rare and restricted to clinical cases. Nevertheless, one should be aware that the authors are drawing general conclusions from very few recording locations, sparse sampling, and considerably different subjects.

Data are averaged over four patients, where recording sites varied. Subjects were of different educational statuses, sex and age. Note that hemispheric asymmetry is hypothesized to vary with sex and functional organization is likely to change with age. Furthermore, all patients were epileptic. It is far from unlikely that—although no seizures were visible—functional organization and cortical connectivity have been affected. Such changes might yield crucial differences to healthy humans and across subjects. Moreover, the impact of medication (e.g. on emotional and attentional state) remains to be considered.

Another issue are differing experimental conditions. #4 was shown 256 images, all others only a subset of 150. Intertrial intervals varied accordingly which might have caused stronger interference of stimuli in #4. Presentation duration was prolonged in #1 which might yield more conscious consideration about the scene and therefore, e.g., involvement of memories. Since different screens were used to display images, it should be considered that varying contrast and color settings have an impact on scene recognition.

Finally, eye-tracking could be used as a simple but effective improvement for the present study. The current setup does not allow to judge whether subjects really attended to stimuli and, if so, whether they perceived the key aspects (e.g. blood or a smile) eliciting emotional responses. Scanpath analysis could reveal if patients look at emotionally significant components of a scene.

References

- [1] Kawasaki, H. et al. (2005). Analysis of single-unit responses to emotional scenes in human ventromedial prefrontal cortex. *Journal of Cognitive Neuroscience*, 17(10), 1509-1518.