Olfactory decision-making under high uncertainty levels: an fMRI study

Diliana Rebelo diliana.rebelo@gmail.com[1,2] Isabel Catarina Duarte[1,2] Miguel Castelo-Branco[1,2]
[1]*Institute of Nuclear Sciences Applied to Health (ICNAS), Faculty of Medicine, University of Coimbra, Coimbra, Portugal*
[2]*Laboratory of Biostatistics and Medical Informatics, Institute for Biomedical Imaging and Life Sciences (IBILI) and CiBit, Faculty of Medicine, University of Coimbra, Coimbra, Portugal*

Olfactory decision-making plays an important role in chemical cue detection, signaling potential predators, and/or presence of venoms, which is crucial for survival. However, and regardless the advances concerning perceptual decision making in other sensory modalities, little is known concerning olfactory decision-making in humans, in particular when perceptual uncertainty is high. In this work, we addressed olfactory decision-making under high levels of uncertainty and distinct levels of decision confidence; we aimed to understand the decision-making circuitry based on simple olfactory detection and binary decision using functional magnetic resonance imaging.
Thus, we have used an olfactory paradigm using phenylethyl alcohol, a pure olfactory stimulus, with a block design under fMRI. Different concentrations of phenylethyl alcohol were used and the participants (n=20) were asked to classify each stimulus based on detection and to report their confidence level. Our experimental design allowed to separate levels of odor intensity from levels of detection and confidence.
Behavioral results reveal high level of uncertainty either for detection or for confidence, in spite of participants being above chance level. Concerning functional outcomes, our results identify, as expected, that primary and early olfactory pathways (primary olfactory cortex, putamen and amygdala) are activated by detection (maximum PEA concentration vs minimum PEA concentration, $t>2.17$, $p=0.03$) as well as confidence (maximum confidence versus minimum confidence, $t>2.33$, $p=0.02$) analysis. Importantly, higher confidence levels related to higher recruitment of regions responsible for the evaluation of the reward-value and olfactory hedonic memory such as anterior cingulate cortex, medial frontal gyrus, thalamus, insula and hippocampus. These regions are activated only when confidence is tested.
These results show independent patterns of activation of the olfactory and decision making networks, as determined by differences of concentration or confidence levels. High confidence led to activation of circuits related to hedonic pleasure, irrespective of detection.

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