Tonicity as a marker of sensory awareness across modalities: convergence from computational models and intracranial recordings

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Tonic, sustained responses to tactile stimulation have been demonstrated to be the ideal correlate of somatosensory awareness [1]. The debate on this neural fingerprint is to-date lively, with open points ranging from its origin to a possible generalization as a consciousness underpinning shared by multiple sensory modalities. To settle this open issues, we combined Tonicity Maps (i.e. maps of prevalence of tonic responses) [1] from different sensory modalities (acoustic, visual and somatosensory) with maps of functional [2] and anatomical hierarchy [3]. Stereo-EEG recordings were collected in a cohort of 250 drug-resistant epileptic patients underwent to basic sensory stimulation (somatosensory, acoustic and visual) as part of their pre-surgical evaluation. Measures of information flow (i.e. amount of incoming Gin and outcoming Gout information has been computed by using the public data release from the Human Connectome Project, as detailed in [2]. Myelinization of the brain regions is measured as T1w/T2w ratio and described in [3]. For each peripheral stimulation, Gamma Band Power (GBP) was computed and responsive leads were identified as those having at least three significant time-bins compared to the baseline after z-score normalization ($p<0.001$).GBP time-courses of responsive leads were clustered (correlative k-means). Tonicity Index was computed according to [1] and finally plotted on a continuous map. Correlations with functional measures Gin, Gout, Gtot (i.e. Gin + Gout) and myelinization were obtained according Glasser parcellation.Tonic, long-lasting, sustained responses were exhibited by all the three investigated sensory modalities. A significant linear correlation between the Tonicity Index (T.I.) and Gin ($R=0.64$; $p<0.001$) and Gout ($R=-0.34$; $p=0.013$) was observed. Gtot ($R =-0.02$ $p>0.05$) and myelin content ($R=-0.083$; $p>0.05$), instead, do not exhibit a significant correlation with the Tonicity Index. Tonic, sustained responses are exhibited following different peripheral stimulation, representing a common mechanism of the brain to sustain sensory awareness. Cortical regions exhibiting such neural signature are characterized by a high amount of incoming information Gin and involved in higher-level processing of the sensory input. Tonicity (i.e. recurrency) is, thus, a shared mechanism across different sensory modalities and it reflects a functional property, rather than be a structural, hierarchical, trait of the brain.

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