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Actual Physical Potentiality for Consciousness

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Dr. Vukov, analyzing patients with disorders of consciousness, proposed that medical well-regarded policy recommendations cannot be justified by looking solely to patients' actual levels of consciousness (minimally conscious state – MCS *versus* vegetative state – VS), but that they should be justified by looking to patients' *potential for consciousness* (Vukov 2018). This is a novel and previously neglected view that is ethical, morally salient and clinically important. Further, Vukov stressed that such potentiality should be the *actual physical possibility*. To state that something is actually physically possible, is to state that it is consistent with the laws of nature and the actually-obtaining state of affairs (Covey 1991).

One objective way to estimate this potential (*actual physical possibility*) in patients with disorders of consciousness, and beyond such disorders as well, is to adopt a neurophysiologically informed strategy (Fingelkurts et al. 2012a; Bagnato et al. 2013). Ideally, and considering the situations where there is lack of understanding what would constitute the reliable clinical markers of consciousness in the absence of the patient's subjective report, such strategy should utilize objective brain activity markers of consciousness/unconsciousness. To be so, these markers should be based on a theoretical account of what conscious experience is and how it emerges within the brain (Fingelkurts et al. 2014). According to current theoretical understanding consciousness is an emergent phenomenon of coherent but dynamic interaction among operations produced by multiple, relatively large, long-lived and stable, but transient neuronal assemblies in the form of spatio-temporal patterns within a nested, hierarchical brain architecture (Fingelkurts et al. 2012a, 2014). This nested brain architecture, named 'operational', functions as the direct realization base for an emergence of the subjective phenomenal world (conscious mind) (Fingelkurts et al. 2010, 2013).

The Operational Architectonics (OA) framework of brain-mind functioning is an example of such a neurophysiologically informed and theoretically based strategy (Fingelkurts et al. 2010, 2013). The main tenets of the OA theory are the following: The brain generates a non-random, highly structured, and dynamic extracellular electric field in spatial-temporal domains and over a range of multiple frequencies (Basar 2011). This field exists within the brain's internal non-experiential physical space-time (IPST), and the most efficient way to capture it is through an electroencephalogram (EEG) measurement (Freeman 2007). The OA theory explores temporal structure of information flow within a network of dynamic transient and functional neuronal assemblies (whose activity – operations – is 'hidden' in the complex non-stationary structure of the EEG signal; Fingelkurts et al. 2010). Detailed analysis of the EEG complex hierarchical structure reveals the existence of specific operational space-time (OST), which from one side resides within the IPST and from another side is isomorphic to phenomenal/subjective space-time (PST) and, thus, serves as a potential neurophysiological constituent of the phenomenal (consciousness) architecture (Fingelkurts et al. 2010; 2013). According to the OA theory, different qualia or aspects of the whole object/scene/concept are neurophysiologically presented by the operations produced by different individual neuronal assemblies, while the wholeness of the consciously perceived or imagined is brought into existence by joint (synchronized) operations of many functional and transient neuronal assemblies in the brain (for extensive discussion see Fingelkurts et al. 2010; 2013). The recombination of the operations produced by neuronal assemblies in new configurations opens the possibility to present mentally a practically infinite number of different qualities, patterns, objects, scenes, and concepts.

Application of OA strategy to quantitative EEG analysis of patients in VS and MCS revealed that the absence of consciousness in VS is paralleled by impairment of overall EEG operational architecture. Specifically, neuronal assemblies become smaller, their life span shortened, and they became highly unstable and functionally disconnected (desynchronized) (Fingelkurts et al. 2012a). At the same time, fluctuating (minimal) awareness in patients in MCS was paralleled by partial restoration of EEG operational architecture (increased size, life span, and stability of neuronal assemblies, together with an increased number and strength of functional connections among them), approaching the level found in healthy, fully conscious participants (Fingelkurts et al. 2012a). Moreover OA strategy to EEG analysis allowed predicting the emergence of consciousness in VS patients after six months (Fingelkurts et al. 2012b) or even six years (Fingelkurts et al. 2016) following the brain trauma. It has been reported that prognosis for future recovery of consciousness (actual physical potentiality) in persistent VS patients can be determined with high accuracy analyzing a large-scale resting-state EEG structure alone at the time when patients meet all clinical criteria for the persistent VS and when reliable communication with patients could not yet be established. Therefore, the OA methodology could reliably predict which patients may regain consciousness, and thus determine which patients may have the potential (*actual physical possibility*) for consciousness.

If so, the precise measurement of such potentiality for consciousness could allow rehabilitative treatments to be tailored for every given patient. In the future, then, the presence of potentiality and its extent may help to choose the best rehabilitative intervention (or a suitable combination of treatments) for every patient with severe disorders of consciousness by considering the OA markers that are easily quantifiable.

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