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## **Mind as a nested operational architectonics of the brain**

**Comment on “Neuroontology, neurobiological naturalism, and consciousness: A challenge to scientific reduction and a solution” by Todd E. Feinberg**

Andrew A. Fingelkurts<sup>a,\*</sup>, Alexander A. Fingelkurts<sup>a</sup>

<sup>a</sup>*BM-Science – Brain and Mind Technologies Research Centre, Espoo, Finland*

The target paper of Dr. Feinberg [1] is a testimony to an admirable scholarship and deep thoughtfulness. This paper develops a general theoretical framework of nested hierarchy in the brain that allows production of mind with consciousness. The difference between non-nested and nested hierarchies is the following. In a non-nested hierarchy the entities at higher levels of the hierarchy are physically independent from the entities at lower levels and there is strong constraint of higher upon lower levels. In a nested hierarchy, higher levels are physically composed of lower levels, and there is no central control of the system resulting in weak constraint of higher upon lower levels [1].

Due to space limitations of this commentary we will focus on one important issue. Dr. Feinberg stated in his review paper that “the neural hierarchy displays both nested and non-nested features” and that this unique feature of brain organization allows consciousness to be expressed. The critical point here is that multiple regions within the neural hierarchy that are physically connected within the brain, as objectively observed, are not a physically nested system, in a way as for example a cell is physically nested within an organ. At the same time, consciousness, as subjectively experienced, is expressed as a functionally nested and unified system. From these observations it is not clear what in the brain constitutes the nested part of the hierarchy which could support isomorphic hierarchy of conscious mind. We propose that the brain operational architectonics (OA) centered around the notion of operation [2-4] could be helpful here. Understanding of the operation as a process lasting in time and considering its combinatorial nature (increasing complexity), seems especially well suited for understanding and studying the mechanisms of how conscious mind emerges from the brain [4].

The OA theory claims [4] that local fields of transient functional neuronal assemblies are equivalent to operations which can be conscious (phenomenal). Indeed, it has been shown that distinct neuronal assemblies display preferential processing for certain features (a preference for

color, shape, motion, smell, etc. [5]). Such simple operations responsible for qualia are reflected in the electrical brain field (EEG) in the form of quasi-stationary segments, which can be conceptualized as standing waves within a 3D volume [4]. It has been shown experimentally that these EEG segments are reliably and consistently correlated with changes in the phenomenal (subjective) content during both spontaneous (stimulus independent) and induced (stimulus dependent) experimental conditions (for the review see [6]). Moreover, it has been documented that the local fields of various neuronal assemblies correlate with different conscious percepts [7-9] and if cognitive processing does not take place, such transient neuronal assemblies do not appear [10].

Although phenomenal consciousness is serial in the sense that we subjectively experience the succession of discrete and phenomenal images or thoughts separated by rapid change, each phenomenal object, image or thought per se is unified and quite complex. According to the OA theory, this complexity requires temporally coordinated operations (equivalent of bioelectrical fields) of many neural assemblies, which selectively emerge from the entire brain [4]. Indeed, to have an experience of any phenomenal object, for example an “apple”, several features of that object (shape, color, smell, texture, etc.) should be spatially and temporally integrated. In agreement with the above brief outline of OA theory, different (simple) phenomenal features are presented in the brain by local fields/operations generated by different transient neuronal assemblies. Temporal synchronization of these local fields/operations produces complex brain operations [2]. As a result, metastable brain states emerge that accompany the realization of such complex brain operations, whereas each of them is instantiated by the particular volumetric spatial–temporal pattern in the electromagnetic field [2-4,6]. At this top level of abstractness (reflective consciousness) we already do not have direct access to the brain (physical) processes, and therefore this subjective (conscious) experience seems so strange and mysterious to us [4].

Thus, within the OA, the complex operation or operational act has internal structure where each element in its turn also has its own internal structure and so on until the simplest elemental operations are reached. What we want to argue here is that there is a more complex operation/operational act that subsumes the simplest ones. It is critical that any complex operation/operational act is not just a conjunction of simplest operations (or operational acts) – it is an operation (or operational act) in its own right with emergent properties that are not evident in the subordinate constituents [11]. Such architecture has a clear nested hierarchy and thus could serve as the needed ingredient of brain organization that would allow conscious mind to be expressed and present the features consciousness (referral of neural states, mental unity, qualia, and mental causation), which the target paper discusses [1].

## References

- [1] Feinberg TE. Neuroontology, neurobiological naturalism, and consciousness: A challenge to scientific reduction and a solution. *Physics of Life Reviews* 2012;9(1):xxx–xx, this issue.
- [2] Fingelkurts AnA, Fingelkurts AIA. Operational architectonics of the human brain biopotential field: Towards solving the mind-brain problem. *Brain and Mind* 2001;2:261-96.
- [3] Fingelkurts AnA, Fingelkurts AIA, Neves CFH. Phenomenological architecture of a mind and Operational Architectonics of the brain: the unified metastable continuum. *Journal of New Mathematics and Natural Computation* 2009;5:221-44.
- [4] Fingelkurts AnA, Fingelkurts AIA, Neves CFH. Natural world physical, brain operational, and mind phenomenal space–time. *Physics of Life Reviews* 2010;7:195–249.
- [5] Zeki S. Insights into visual consciousness. In: Frackowiak RSJ, Friston KJ, Frith CD, et al. (eds) *Human brain function*. Academic Press, San Diego; 2004.
- [6] Fingelkurts AnA, Fingelkurts AIA. Brain-mind Operational Architectonics imaging: technical and methodological aspects. *The Open Neuroimaging Journal* 2008;2:73-93.
- [7] van Leeuwen C. What needs to emerge to make you conscious? *Journal of Conscious Studies* 2007;14:115-36.
- [8] Singer W. Consciousness and the binding problem. *Annals of the New York Academy of Sciences* 2001;929:123-46.
- [9] Freeman WJ. Indirect biological measures of consciousness from field studies of brains as dynamical systems. *Neural Network* 2007;20:1021-31.
- [10] Pulvermueller F, Preissl H, Eulitz C, Pantev C, et al. Brain rhythms, cell assemblies and cognition: Evidence from the processing of words and pseudowords. *Psychology* 1994;5:brain-rhythms.1.pulvermueller
- [11] Fingelkurts AnA, Fingelkurts AIA. Operational architectonics of perception and cognition: A principle of self-organized metastable brain states. The VI Parmenides Workshop of Institute of Medical Psychology, University of Munich; VI Parmenides Workshop. Elba/Italy April 5-10; 2003.