From spatio-temporal brain-mind dynamics to Spatiotemporal Neuroscience

Comment on “Is temporo-spatial dynamics the “common currency” of brain and mind? In Quest of “Spatiotemporal Neuroscience” by Georg Northoff, Soren Wainio-Theberge, Kathinka Evers

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Keywords:

spatio-temporal brain dynamics; Spatiotemporal Neuroscience; common currency; cinematic cognitive dynamics; EEG; metastability; synergetics; thermodynamics; Operational Architectonics; brain-mind relation; nested architecture; operation; one-to-one correspondence; brain fields.

The target paper of Northoff, Wainio-Theberge, and Evers [1] is an excellent and comprehensive review of diverse evidences on spatio-temporal brain dynamics that urges to bridge the “epistemic gap” between brain and mental realities through so called “common currency” which is the dynamics of the brain’s time and space. Analyzing the dynamics of time and space, as they understood in contemporary physics (in contrast to a classical physics) and observing the recent empirical evidence from different experimental models of consciousness, self, and psychiatric disorders, the authors of the target paper presented a convincing argument that the dynamics of the brain’s own “inner time and space” is the “common currency” of neuronal and mental features. They further proposed to establish a new brunch of Neuroscience – “Spatiotemporal Neuroscience” that conceives the brain and mind in terms of their spatio-temporal dynamics rather than in terms of specific functions like cognitive, affective, social, cultural, etc. [1]. Importantly, the ‘function-based view’ is here replaced by what can be described as ‘dynamic-based view’ of the brain [2-4]. And in its own turn, the dynamic-based view of the brain shifts the focus away from the stimulus-induced or task-evoked activity to its own spontaneous activity, the so-called resting state activity [5,6].

The main strength of the target article is that it provides an upper- (meta-) level conceptualization of the work that has been in focus of a number of researchers (including the authors of the target article [1]) for many years. In this respect it is important to mention the lifetime work of Walter Freeman, which was focused on mass action in the brain in the form of nested, dynamic neuronal
assemblies [7-9] (for a review see [10,11]). Based on his work, Freeman has proposed a
cinematographic (or cinematic) model of cognitive dynamics [12]. This model states that the brain
cortical code that supports cognition and mind, in general, consists of repetitive spatial frames of
metastable amplitude modulation (AM) patterns in brain’s electromagnetic filed [2,8,12-16] that are
analogous to the movie frames. In a set of experiments Freeman proved that AM patterns (frames)
embody the meaning of the stimuli rather than be their representations [17]. The major significance of
this cinematic model is that it led to a new understanding that all brain-mind processes share the
same coding in the form of cinematic sampling [11]. The cinematic synchronization of activity
observed in multiple experiments in diverse cortex locations allows Freeman to propose that the rapid
transition that initiates every AM spatio-temporal pattern does so by creating a field of nonsynaptic
communication in the neuropil shared by all synchronized neuronal assemblies in a simultaneous
coordination rather than by serial synaptic transmission [18]. Such emergent neural fields of self-
organized activity framed within the AM patterns, incorporated Haken’s synergetics [19] and
Prigogine’s ‘dissipative structures’ [20] that feed on energy, and leaded to self-organizing, far-from-
equilibrium brain thermodynamics [2]. While Freeman never spoke about the “common currency” of
brain and mind, he nevertheless systematically stressed that it is the spatio-temporal brain dynamics
that is the best available candidate that neuroscientists have for connecting neural (physical) activity
to mental (subjective) activity [21].

As a result of our own research work that has lasted already about 30 years and has been
constantly inspired by Freeman studies, we have proposed a theoretical conceptualization formulated
within the brain-mind Operational Architectonics (OA) framework as an attempt to reduce the
“epistemic gap” between a subjective experience (mind) and its neurophysiologic counterpart (brain).
This OA theory is centered around the common feature (“currency” in terms of authors of the target
article [1]) for both the physics/matter/brain and the mind/subjectivity/cognition – operation [22-27].
Approaching the notion of operation as a process lasting in time, present in both brain and mind, and
considering its combinatorial nature (increasing nested complexity) it is evident that operation is
especially well suited for understanding and studying the mechanisms of how a conscious mind
emerges from the physical brain [25,26]. Furthermore, such definition provides a basis for analyzing
the relative complexity and compositionality of operations, where there is a more complex
operation/operational act that subsumes the simpler ones [25,26]. In other words, every operation of
this nested hierarchy of operations is not monolithic, it has its own inherent structure, whereas every
simpler operation exists within every other more complex one.

According to the OA framework, the simplest mental operations (presenting qualia or simple
computations) are expressed in the brain in the form of local 3D fields generated by transient
functional neuronal assemblies, while complex operations (presenting complex objects, images or thoughts) are brought into existence by joint simple operations (temporal coupling of local 3D fields by means of operational synchrony, OS) in the form of so-called operational modules (OM) of varied complexity [25,26]. In this context, brain OA is presented as a highly structured and dynamic extracellular electric field nested in *spatial* and *temporal* domains and over a range of frequencies, thus forming a particular *operational space–time* (OST) [25,26]. This OST exists within brain *internal physical space–time* (IPST) and is best captured by the electroencephalogram (EEG) measurement [28]. The advantage of the OST level is that it intervenes between IPST level (where it literally resides) and the *phenomenal* (*experiential/subjective*) *space-time* (PST) level to which it is isomorphic. Therefore, phenomenal (PST) level supervenes on the operational (OST) level with one-to-one correspondence and is ontologically inseparable from it (though it is separable from the brain neuroanatomical processes) [25,26,27]. Such description of the brain-mind OA has a number of striking resemblances with quantum processes as we have recently discussed in [27].

The briefly outlined in the present comment research, together with the research of the authors of the target article [1], mark the beginning of developing a comprehensive theory of spatio-temporal dynamics of brain-mind. It is hoped that in the future, with increased experimental research programs more knowledge of the spatio-temporal brain-mind dynamics will be accumulated and this would lead to establishment of a complete brunch of Spatiotemporal Neuroscience.

References


