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REVIEW

Timing in cognition and EEG brain dynamics: discreteness versus continuity

Andrew A. Fingelkurts · Alexander A. Fingelkurts

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Abstract This article provides an overview of recent developments in solving the timing problem (discreteness vs. continuity) in cognitive neuroscience. Both theoretical and empirical studies have been considered, with an emphasis on the framework of operational architectonics (OA) of brain functioning (Fingelkurts and Fingelkurts in Brain Mind 2:291–29, 2001; Neurosci Biobehav Rev 28:827–836, 2005). This framework explores the temporal structure of information flow and interarea interactions within the network of functional neuronal populations by examining topographic sharp transition processes in the scalp EEG, on the millisecond scale. We conclude, based on the OA framework, that brain functioning is best conceptualized in terms of continuity–discreteness unity which is also the characteristic property of cognition. At the end we emphasize where one might productively proceed for the future research.

Keywords Temporal structure · Consciousness · Cognition · Perception · EEG · Discreteness · Continuity · Operational architectonics · Brain operations · Large-scale networks · Metastability · Synchronization · Binding problem · Brain and mind

A. A. Fingelkurts (✉) · A. A. Fingelkurts
BM-SIENCE Brain and Mind Technologies
Research Centre, PO Box 77,
02601 Espoo, Finland
e-mail: andrew.fingelkurts@bm-science.com
URL: http://www.bm-science.com/team/fingelkurts.html

Introduction

There has been an accumulation of phenomenological and experimental evidence that the *temporal structure* of cognition and of activity of its neural substrate is the key intrinsic attribute of perceiving and processing information (Dennett and Kinsbourne 1995; Pöppel 1997; Glicksohn 2001). Nevertheless, without a clear understanding of the nature of such temporal structure, it is hard to determine the temporal relations among various cognitive processes. One important question concerning the possible nature of the temporal structure of information processing is the following: Does each cognitive process produce a discrete packet of information, or is the flow of information continuous? Indeed, at any given moment, an individual has many distinct phenomenological experiences, which seem to be *continuously* unified and evolving (Bayne and Chalmers 2002); in the normal and awake mind the objects of thought are continuously being represented (Damasio 2000). At the same time, the individual has a stream of *discrete* conscious units—thoughts or images (James 1890; see also Mangan 1993a, b; Chafe 1994; Galin 1994, 2000). Given such conflicting everyday observations, it is difficult to reach a firm conclusion about the temporal structure of information processing. This apparent dual nature of information processing requires an explanation in a complete scientific account of consciousness and brain processing.

The temporal properties of individual neurons and of neuronal assemblies/populations have been postulated to underlie key visual (Bair 1999), motor (Baker et al. 2001), sensoriomotor (Crone et al. 1998), audio (Galambos et al. 1981) and audiovisual (Fingelkurts