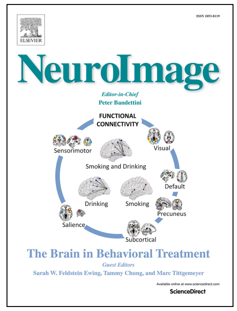

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Cortical cores in network dynamics

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Abstract

Spontaneous brain activity at rest is spatially and temporally organized in networks of cortical and subcortical regions specialized for different functional domains. Even though brain networks were first studied individually through functional Magnetic Resonance Imaging, more recent studies focused on their dynamic 'integration'. Integration depends on two fundamental properties: the structural topology of brain networks and the dynamics of functional connectivity. In this scenario, cortical hub regions, that are central regions highly connected with other areas of the brain, play a fundamental role in serving as way stations for network traffic. In this review, we focus on the functional organization of a set of hub areas that we define as the 'dynamic core'. In the resting state, these regions dynamically interact with other regions of the brain linking multiple networks. First, we introduce and compare the statistical measures used for detecting hubs. Second, we discuss their identification based on different methods (functional Magnetic Resonance Imaging, Diffusion Weighted Imaging, Electro/Magneto Encephalography). Third, we show that the degree of interaction between these core regions and the rest of the brain varies over time, indicating that their centrality is not stationary. Moreover, alternating periods of strong and weak centrality of the core relate to periods of strong and weak global efficiency in the brain. These results indicate that information processing in the brain is not stable, but fluctuates and its temporal and spectral properties are discussed. In particular, the hypothesis of '*pulsed'* information processing, discovered in the slow temporal scale, is explored for signals at higher temporal resolution.

1. Introduction

Two complementary principles underlie cognition in the brain: functional specialization and dynamic integration (Fox and Friston, 2012; Tononi et al., 1994). Over the past two decades it has been shown that spontaneous brain activity (i.e. at rest in the absence of any task) is organized in functionally specialized large-scale networks (or resting state networks – RSNs) (Attwell and Laughlin, 2001; Biswal et al., 1995; Fox et al., 1988; Snyder and Raichle, 2012). Several RSNs have been observed: attentional, visual, somato-motor, auditory, language, executive control, and default systems that roughly correspond to different functional domains (Doucet et al., 2011; Glasser et al., 2016; Hacker et al., 2013; Yeo et al., 2011). These networks were originally studied assuming temporal stationarity, but recent methodological developments indicate that these networks are dynamic (i.e. they evolve over time). For recent reviews, see (Hutchison et al., 2013; Preti et al., 2016), although see the critique on the influence on the fMRI dynamics of head motion, sampling variability and fluctuating sleep state reported in (Laumann et al., 2016). We posit that efficient processing of information necessarily must involve dynamic (i.e. time varying) integration among