Time-frequency dynamics of resting-state functional connectivity measured using fMRI based on Hilbert-Huang Transform

Tong Wu¹, Xia Wu¹,*
¹College of Information Science and Technology, Beijing Normal University, 100875, Beijing, China
*wuxia@bnu.edu.cn

Background: The functional connectivity (FC) has emerged as an effective measurement of the functional interactions between the different brain regions (Van et al. 2010), particularly in the resting state functional magnetic resonance imaging (fMRI) studies. The time-domain FC analysis can only examine the time-point-to-time-point relationship between fMRI signals. Recent studies have shown that the dependency between the fMRI signals on frequency domain may convey more information regarding the interaction between the brain regions (Wei et al. 2012; Wen et al. 2012). So far, common frequency-domain approaches always assume that the fMRI signals are temporally stationary and FC was fixed from time to time. However, previous studies suggest that FC may changes in seconds or minutes, reflecting the important dynamic nature of the real neural systems (Chang et al. 2010; Kiviniemi et al. 2011;), which is still elucidate in many aspects. For analyzing the time-frequency dynamic nature of FC, Hilbert-Huang Transform (HHT) which was a novel time-frequency method providing more accurate instantaneous frequency (Huang et al. 2005; Huang et al. 2008; Donnelly et al. 2006; Peng et al. 2005) was applied. The aim of this study was to reveal the time-frequency dynamics of the resting-state FC using HHT.

Methods: The resting-state fMRI data recorded from 16 healthy subjects were analyzed. First, the time series from the 90 regions of interest (ROIs) defined by the Automated Anatomical Labeling template were extracted. Second, each time series was decomposed into five intrinsic mode functions (IMFs) and the corresponding instantaneous frequency was calculated using HHT. Finally, the FC based on instantaneous frequency for each subject was calculated, we then created the group average map of instantaneous frequency for all brain regions.

Results: The time series of each brain region can be self-adaption separated into 5 IMFs with distinct frequencies (shown in Fig. 1A). Furthermore, Fig. 1B displayed the map of instantaneous frequency dynamics for all brain regions. And then, the FC of instantaneous frequency for each IMF was also calculated (shown in Fig. 1C).

Conclusions: In this study, HHT was introduced to reveal the time-frequency dynamics of the resting-state FC. The results demonstrated that dynamic frequency-based FC may convey more information regarding the interaction between the brain regions. Our finding may help to the understanding of the cognitive and neural mechanisms from the view of time-frequency domain.