According to a survey conducted in 2007, 35-40% of adult U.S population chronically restricts their sleep on less than 7 hours on weekday nights, compared with 8-9 hours to maintain brain normal function during the day. Studies have demonstrated that sleep deprivation reduces the capabilities and efficiency of performance by impairing perception, increasing effort to keep concentrate, as well as introducing vision disturbance. In this way, sleep deprivation has been identified as a vital factor in many accidents in transportation and industrial settings. It has been usually recognized that performance decrements after sleep loss are mainly due to attentional deficits. Given the adverse effects of sleep deprivation, researchers have paid increasing attention to investigate the brain activity during attention tasks after insufficient sleep. However, the mechanism of how sleep deprivation impacts human attention has not been fully understood.

The aim of this study was to investigate the effects of chronic sleep deprivation on human brain from perspective of dynamic functional connectivity. In present study, modified spatial cueing paradigm go/no-go task was used to assess human sustained attention in both rested wakefulness and chronic sleep deprivation conditions. With performance analysis, we observed the speed accuracy trade off mechanism that sleep deprived subjects intended to maintain response speed through sacrificing accuracy. To further investigate the neural basics of such mechanism, we firstly applied partial least squares approach with sliding-window technique to distinguish and estimate dynamic functional connectivity between rested wakefulness and sleep deprivation. Dynamic property of functional connectivity was observed with fluctuating estimated correlations while changing between conditions. After that, we performed graph theoretical analysis with network measures, clustering coefficient and characteristic path length, to compare the property of dynamic functional networks in two conditions. In chronic sleep deprivation, a compensatory mechanism was illustrated between highly clustered organization and ineffectiveness adaptability of functional networks, with larger variance of clustering coefficient but smaller variance of characteristic path length compared with those in rested wakefulness. Furthermore, in rested wakefulness condition, functional networks showed dominant of an optimal network structure, small-world network, with higher clustered coefficient and similar characteristic path length compared with those of corresponding random networks. However, the dominant structure was disrupted in sleep deprivation conditions and networks were more randomized in most of sliding-windows, with higher clustering coefficient and longer characteristic path length compared with corresponding random networks.

In conclusion, this study is the first attempted to investigate the effects of chronic sleep deprivation on human brain from perspective of dynamic brain functional connectivity. First, we illustrated that human brain showed a compensatory mechanism between highly clustered organization and ineffective adaptability to maintain sustained attention in sleep deprivation condition. Furthermore, we presented the evidence that brain functional networks showed dominant of small-world property in rested wakefulness, which has been approved as an optimal network with well-balancing between local and global information processing. However, such dominant of optimal network structure was disrupted after chronic sleep deprivation, resulted in more randomized network of human brain.

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