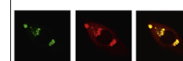


Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/brainres

Brain Research



Research Report

Functional organization of intrinsic connectivity networks in Chinese-chess experts



Xujun Duan^{a,1}, Zhiliang Long^{a,1}, Huaifu Chen^{a,*}, Dongmei Liang^{b,c},
Lihua Qiu^d, Xiaoqi Huang^d, Timon Cheng-Yi Liu^{b,*}, Qiyong Gong^d

^aKey Laboratory for NeuroInformation of Ministry of Education, School of Life Science and Technology, University of Electronic Science and Technology of China, Chengdu 610054, PR China

^bSchool of Physical Education & Sports Exercise, South China Normal University, University Town, Guangzhou 510006, PR China

^cCenter for Studies of Psychological Application, School of Psychology, South China Normal University, Guangzhou 510631, PR China

^dHuaxi MR Research Center, Department of Radiology, West China Hospital of Sichuan University, 610041, PR China

ARTICLE INFO

Article history:

Accepted 17 February 2014

Available online 22 February 2014

Keywords:

Chess expert

Resting-state fMRI

Functional connectivity network

Graph theoretical analysis

Small-world topology

ABSTRACT

The functional architecture of the human brain has been extensively described in terms of functional connectivity networks, detected from the low-frequency coherent neuronal fluctuations during a resting state condition. Accumulating evidence suggests that the overall organization of functional connectivity networks is associated with individual differences in cognitive performance and prior experience. Such an association raises the question of how cognitive expertise exerts an influence on the topological properties of large-scale functional networks. To address this question, we examined the overall organization of brain functional networks in 20 grandmaster and master level Chinese-chess players (GM/M) and twenty novice players, by means of resting-state functional connectivity and graph theoretical analyses. We found that, relative to novices, functional connectivity was increased in GM/Ms between basal ganglia, thalamus, hippocampus, and several parietal and temporal areas, suggesting the influence of cognitive expertise on intrinsic connectivity networks associated with learning and memory. Furthermore, we observed economical small-world topology in the whole-brain functional connectivity networks in both groups, but GM/Ms exhibited significantly increased values of normalized clustering coefficient which resulted in increased small-world topology. These findings suggest an association between the functional organization of brain networks and individual differences in cognitive expertise, which might provide further evidence of the mechanisms underlying expert behavior.

© 2014 Elsevier B.V. All rights reserved.

*Corresponding authors.

E-mail addresses: chenhf@uestc.edu.cn (H. Chen), liutcy@scnu.edu.cn (T.-Y. Liu).

¹Xujun Duan and Zhiliang Long contributed equally to this work.

1. Introduction

Task-free spontaneous neural activity has been proposed to play an important part in maintaining ongoing representations of conscious activity in the resting brain, and it demonstrates temporal coherence between brain regions that are anatomically connected or functionally related (Biswal et al., 1995; Raichle, 2010; Zhang and Raichle, 2010). Recently, assessments of brain intrinsic functional connectivity were conducted in order to investigate the level of integration of brain systems at a resting state when no task is being performed (Greicius et al., 2003). Along with intrinsic functional connectivity analyses, graph theoretical approaches have also emerged as powerful tools to explore brain organization on the level of large-scale functional networks (Bullmore and Sporns, 2009; He and Evans, 2010). It is well accepted that functional connections of brain networks are organized in a highly efficient small-world manner, characterized by a high level of neighborhood clustering and a short average distance of nodes within the overall network (Achard et al., 2006; Sporns et al., 2004).

Small-world attributes have been found in brain functional networks measured from electroencephalography, magnetoencephalography, functional magnetic resonance imaging (Bassett and Bullmore, 2006; Ferri et al., 2007; Liao et al., 2011a; Smit et al., 2008; Supekar et al., 2009), as well as in brain anatomical networks using structural magnetic resonance imaging and diffusion tensor imaging (Fan et al., 2011; Gong et al., 2009; Hagmann et al., 2007; He et al., 2007). There is increasing evidence that the small-world organization of brain networks can be affected by normal aging (Achard and Bullmore, 2007) and brain diseases, such as schizophrenia (Liu et al., 2008; Wang et al., 2012; Yu et al., 2011), Alzheimer's disease (Sanz-Arigita et al., 2010; Stam et al., 2007), attention-deficit/hyperactivity disorder (Wang et al., 2009b), and epilepsy (Liao et al., 2010; Ponten et al., 2007; Wang et al., 2010). However, it has also been suggested that learning and training can enhance functional organization on the level of large-scale brain networks. For instance, Voss et al. (2010) found that 1-year intervention trial of aerobic training improved the aging brain's resting functional connectivity as well as network efficiency in higher-level cognitive networks, providing important evidence for exercise-induced functional plasticity in large-scale brain systems. A recent study conducted by Albert et al. (2009) showed that motor learning modulated resting state networks in a positive manner, and another study performed by Lewis et al. (2009) demonstrated that visual perceptual learning modified the interaction and organization between functional networks. Moreover, several recent studies also suggested that the level of global communication efficiency of the brain network is positively associated with individual differences in cognitive performance. For instance, van den Heuvel et al. (2009) demonstrated a strong negative relationship between the normalized characteristic path length of the resting-state brain network and intelligence quotient, suggesting a positive association between the global efficiency of functional brain networks and intellectual performance. Another study performed by Li et al. (2009) showed that

people with higher intelligence tend to have greater global efficiency of the brain anatomical network. This evidence suggests an association between large-scale organization of brain networks and individual differences in cognitive performance as well as prior experiences. Such an association raises the question of how cognitive expertise exerts an influence on the topological properties of functional networks.

The board game chess involves many aspects of high level cognition and requires sophisticated problem solving skills (Atherton et al., 2003), thus providing a good opportunity to study the mechanisms underlying cognitive expertise (Wan et al., 2011). In early psychological studies, researchers found that, compared with novices, world-class grandmasters searched much deeper and wider, using more efficient search processes and more complex evaluation functions to assess their decisions when detecting the best moves (Charness, 1981; Reynolds, 1982). Relative to local-club players, grandmasters tended to search at similar depth or width, but generated moves faster, reached a decision faster, and the best next-move was always generated in the very beginning of their search (Connors et al., 2011; De Groot, 1946; Gobet and Charness, 2006; Lassiter, 2000). Several brain imaging techniques have been employed to study chess skills. In general, these studies indicated that frontal and posterior parietal areas, which are known to be involved in top-down orienting of attention, perception and working memory, are engaged in chess playing (Amidzic et al., 2001; Atherton et al., 2003; Bilalic et al., 2010; Campitelli et al., 2005; Gobet and Charness, 2006; Nichelli et al., 1994; Onofrij et al., 1995). There is also some evidence demonstrating different brain activation patterns between experts and amateurs (or novices) while performing tasks related to chess. For instance, Amidzic et al. (2001) found that, compared to amateur players, highly skilled chess grandmasters had more bursts of gamma band activity in the brain regions associated with expert memory retrieval during matches. In more recent research, Wan et al. (2011) studied the neural basis of intuitive best next-move generation in Japanese chess experts, and indicated that the superior capability of board game experts largely depends on quick automatic processing skills which are mediated by the caudate nucleus. In our previous studies we studied the morphological differences of the caudate nucleus between chess experts and novices due to the important role of this region in chess skills. We found that the caudate nuclei of chess experts were significantly smaller relative to those of novice controls but exhibit increased connections with widely distributed brain regions in spontaneous oscillatory activity (Duan et al., 2012a, 2012b). These findings suggest that chess grandmasters may differ from novices in brain functional organization of both local connections and global topologies. However, almost nothing is currently known about the influence of high-level cognitive expertise on large-scale intrinsic functional connectivity, not to mention the global topological properties of the brain networks. In the current study, we hypothesize that superior chess experts might differ with novices on: (1) the functional connectivity of intrinsic brain networks, especially connections associated with learning and memory systems such as basal ganglia and medial temporal lobe, due to the important roles of these

Download English Version:

<https://daneshyari.com/en/article/4324370>

Download Persian Version:

<https://daneshyari.com/article/4324370>

[Daneshyari.com](https://daneshyari.com)