

RESEARCH ARTICLE

Musical training induces functional and structural auditory-motor network plasticity in young adults

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Funding information

National Natural Science Foundation of China, Grant/Award Numbers: 81171403, 81471731; National Natural Science Foundation of China Excellent Youth Fund, Grant/Award Number: 81622025

Abstract

Playing music requires a strong coupling of perception and action mediated by multimodal integration of brain regions, which can be described as network connections measured by anatomical and functional correlations between regions. However, the structural and functional connectivities within and between the auditory and sensorimotor networks after long-term musical training remain largely uninvestigated. Here, we compared the structural connectivity (SC) and resting-state functional connectivity (rs-FC) within and between the two networks in 29 novice healthy young adults before and after musical training (piano) with those of another 27 novice participants who were evaluated longitudinally but with no intervention. In addition, a correlation analysis was performed between the changes in FC or SC with practice time in the training group. As expected, participants in the training group showed increased FC within the sensorimotor network and increased FC and SC of the auditory-motor network after musical training. Interestingly, we further found that the changes in FC within the sensorimotor network and SC of the auditory-motor network were positively correlated with practice time. Our results indicate that musical training could induce enhanced local interaction and global integration between musical performance-related regions, which provides insights into the mechanism of brain plasticity in young adults.

KEYWORDS

auditory-motor network, brain plasticity, functional connectivity, musical training, structural connectivity

1 | INTRODUCTION

Musical performance is complex requiring a strong coupling of perception and action (Schlaug, 2015) which intensive training can induce structural and functional changes in the brain (Boyke, Driemeyer, Gaser, Büchel, & May, 2008; Herdener et al., 2010; Klein, Liem, Hänggi, Elmer, & Jäncke, 2016), even in a short-term training (Song, Skoe, Banai, & Kraus, 2012). Musical training is an excellent model to study training-related plasticity in auditory and motor areas. Previous studies have reported that acquiring musical performance skills is associated with functional and structural changes in the auditory and motor cortices (Elmer, Hänggi, Meyer, & Jäncke, 2013; Putkinen, Tervaniemi, Saarikivi, de Vent, & Huotilainen, 2014). Morphological changes (such as grey matter volume and cortical thickness) in different parts of the auditory and motor cortices due to musical training have been reported in the whole-

brain analysis in cross-sectional (Bermudez, Lerch, Evans, & Zatorre, 2009; Gaser & Schlaug, 2003) and longitudinal (Hyde et al., 2009) studies. In addition to morphological alterations, musical training has also been associated with functional and structural connectivity between cortices.

The human brain is organized in a form of network architecture in which local interactions (short-range connections) are integrated by long-range connections to support diverse brain high-order cognitive function (Park & Friston, 2013). String players, when playing their musical instruments, require information integration between different brain regions supporting auditory, somatosensory, motor, and cognitive function. Resting-state functional MRI usually measures the spontaneous low frequency fluctuations (<0.1 Hz) in the blood oxygen level-dependent (BOLD) signals which reflects patterns of brain activity in the absence of an external task. The functional connectivity measured by rs-fMRI is generally inferred by the correlations of BOLD signals

Research Article

Topological Properties of Large-Scale Cortical Networks Based on Multiple Morphological Features in Amnestic Mild Cognitive Impairment

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Received 26 July 2015; Revised 20 December 2015; Accepted 30 December 2015

Academic Editor: Stuart C. Mangel

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Previous studies have demonstrated that amnestic mild cognitive impairment (aMCI) has disrupted properties of large-scale cortical networks based on cortical thickness and gray matter volume. However, it is largely unknown whether the topological properties of cortical networks based on geometric measures (i.e., sulcal depth, curvature, and metric distortion) change in aMCI patients compared with normal controls because these geometric features of cerebral cortex may be related to its intrinsic connectivity. Here, we compare properties in cortical networks constructed by six different morphological features in 36 aMCI participants and 36 normal controls. Six cortical features (3 volumetric and 3 geometric features) were extracted for each participant, and brain abnormalities in aMCI were identified by cortical network based on graph theory method. All the cortical networks showed small-world properties. Regions showing significant differences mainly located in the medial temporal lobe and supramarginal and right inferior parietal lobe. In addition, we also found that the cortical networks constructed by cortical thickness and sulcal depth showed significant differences between the two groups. Our results indicated that geometric measure (i.e., sulcal depth) can be used to construct network to discriminate individuals with aMCI from controls besides volumetric measures.

1. Introduction

Mild cognitive impairment (MCI) is considered to be a transitional period between normal aging and Alzheimer's disease (AD), which is a progressive, neurodegenerative disease characterized by cognitive decline greater than expected for one's age and educational level yet not fulfilling the criteria of AD [1]. Amnestic MCI (aMCI), as the most common subtype of MCI, is characterized by primary memory impairments with single or multiple cognitive domains impaired and likely progresses to AD [2–4]. Current studies of aMCI have shown disrupted functional integration [5] and abnormal structural

connections between regions [6]. Morphological features have been widely used to characterize brain structures [7, 8] and also served as structural measures to investigate topological properties in large-scale cortical networks [9–11]. Previous studies on large-scale cortical network in MCI mostly used cortical thickness and gray matter volume as descriptors to construct structural network of the human cortex [12, 13].

However, different morphological features reveal different intrinsic properties of cerebral cortex. For example, volumetric measures (i.e., cortical thickness, gray matter volume) reflect the size, density, and arrangement of cells