Training-dependent changes of cortical network dynamics in musicians

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Introduction

Background: Creativity across several domains is associated with altered brain network dynamics, including heightened interactions between the executive control network (ECN) and default mode network (DMN) (1). One domain of creativity in real time comes from musical improvisation, in which individuals spontaneously create novel auditory-motor sequences that are aesthetically and emotionally rewarding (2). Recent work has shown that resting state network dynamics differed between improvisational and non-improvisational (hereafter referred to as classical) musicians, including increased connectivity between ECN and DMN among improvisational musicians (3). Here, we present a longitudinal follow-up to this work, with a particular focus on the developing connectivity patterns of these networks of interest. As previous work has also identified the salience networks as potentially relevant to creative cognition (1), we also include the salience network within our analysis.

Hypothesis: We expect that connectivity between ECN and DMN will be higher in improvisational musicians than in classical musicians, and that this difference will increase throughout the course of training.
Given previous findings (3), we also expect classical musicians to have higher connectivity between regions belonging to the same network.

Methods

Subjects: 23 participants with two MRI scanning sessions were included in the study. They included students from Wesleyan University, Hartt School of Music, and Northeastern University, as well as Middletown and Boston area community members. Participants were classified as either Classical Musicians (N=12, 6 female) or Improvisational Musicians (N=11, 0 female). The second MRI session followed after at least one semester of continued musical study after session 1.

Behavioral Measures: After informed consent, participants completed the baseline tasks for the experiment, including a pitch discrimination threshold-finding test (4), the Shipley Institute of Living Scale (5), and a digit span task for short term memory (6). Subjects then completed a questionnaire on their musical background.

Magnetic Resonance Imaging acquisition and preprocessing: MRI (DTI and rsfMRI) data were acquired in a 3T Siemens scanner. T1 Structural data had a voxel resolution was $2 \times 2 \times 2$ mm[3]. rsfMRI data: 947 EPI volumes (TR = 475 ms; voxel size= $3 \times 3 \times 3$ mm[3]). MRI data were analyzed using the Conn Toolbox (7). T1 and rest data underwent standard preprocessing and denoising steps, including a band pass filter for resting state data from 0.008 to 0.09 Hz.

Participants

|	Improvisational (N = 11)	Classical (N = 12)
Pitch Discrimination (Hz)	4.1085 (2.055)	7.65 (7.79)
Digit Span (digits)	8.13 (1.464)	7.51 (2.033)
Shipley (raw score)	17.3 (1.947)	17.167 (2.29)
Age of onset of music training (years)	8.3 (2.751)	6.58 (2.267)
Duration of classical music training (years)	8.4 (3.565)	11.08 (2.61)
Duration of improvised music training (years)	5.75 (3.553)	1.208 (1.64)
Time between scans (days)	152.27 (123.43)	243.83 (85.77)

LECN Seed-Based Connectivity

Seed-based connectivity was analyzed using ROIs from the Stanford FIND lab atlas (8). Using the left executive control network as a seed, connectivity to traditional ECN regions can be observed in both groups. Improvisational musicians also show increased connectivity to medial PFC across both sessions.

X = -5   Y = 20   Z = 40

Improvisational

Classical
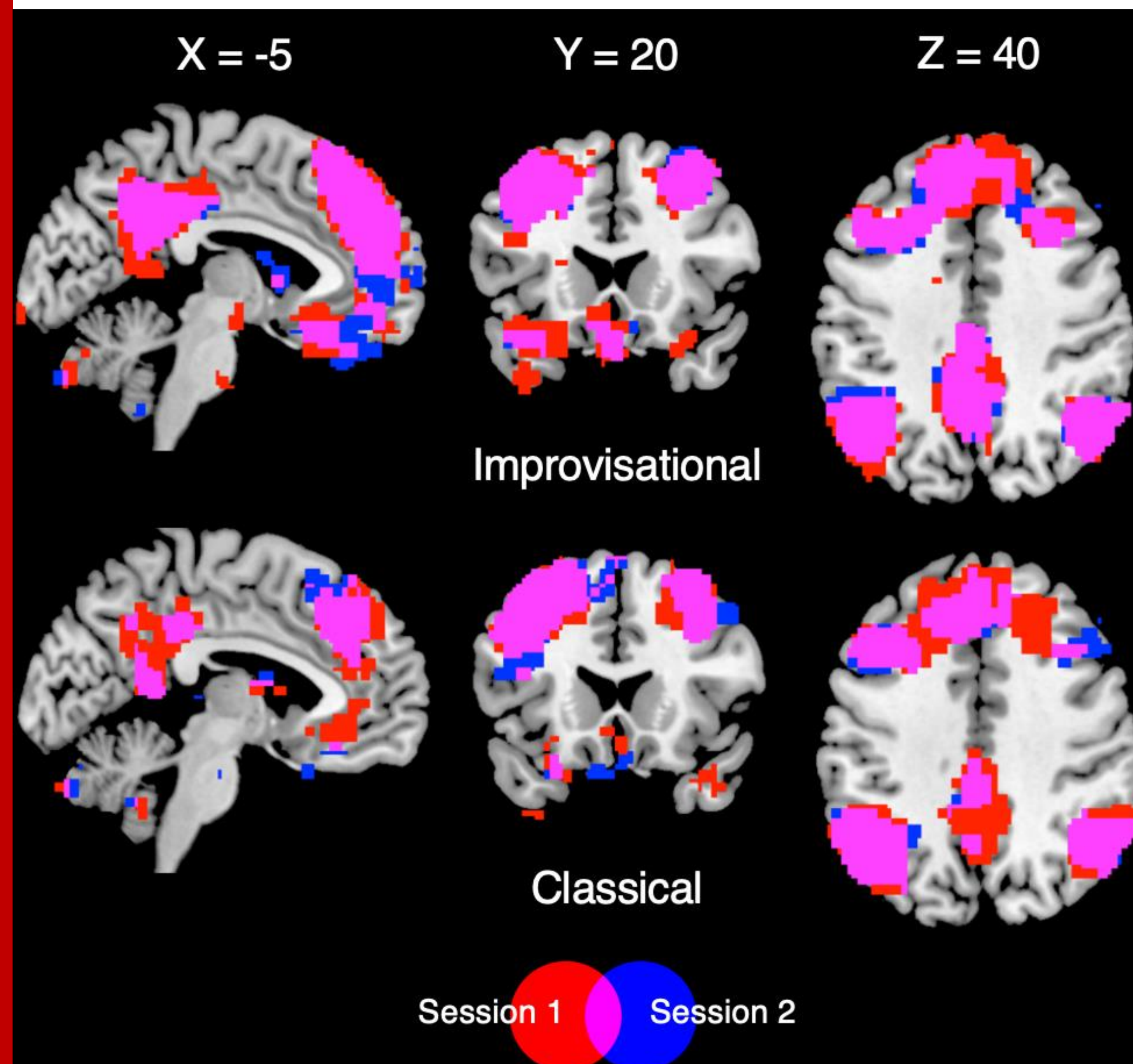
Session 1   Session 2

RECN Seed-Based Connectivity

Right ECN seeded connectivity also demonstrated classic ECN connectivity patterns, with a preference towards classical musicians in session 1. While Classical musicians showed greater connectivity to mPFC in session 1, this pattern reversed in favor of Improvisational musicians in session 2.

X = 5   Y = 35   Z = 40

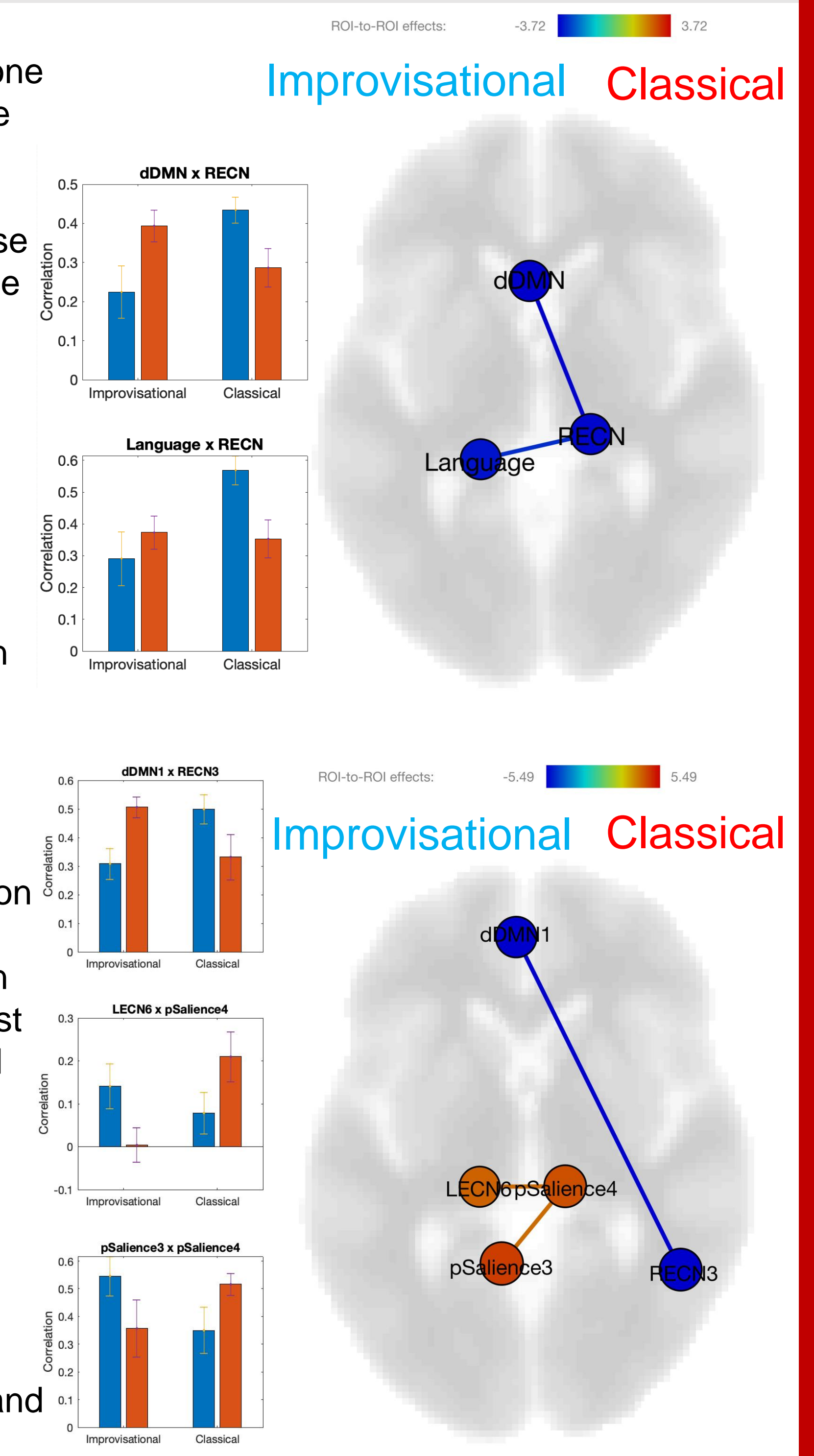Improvisational

Classical
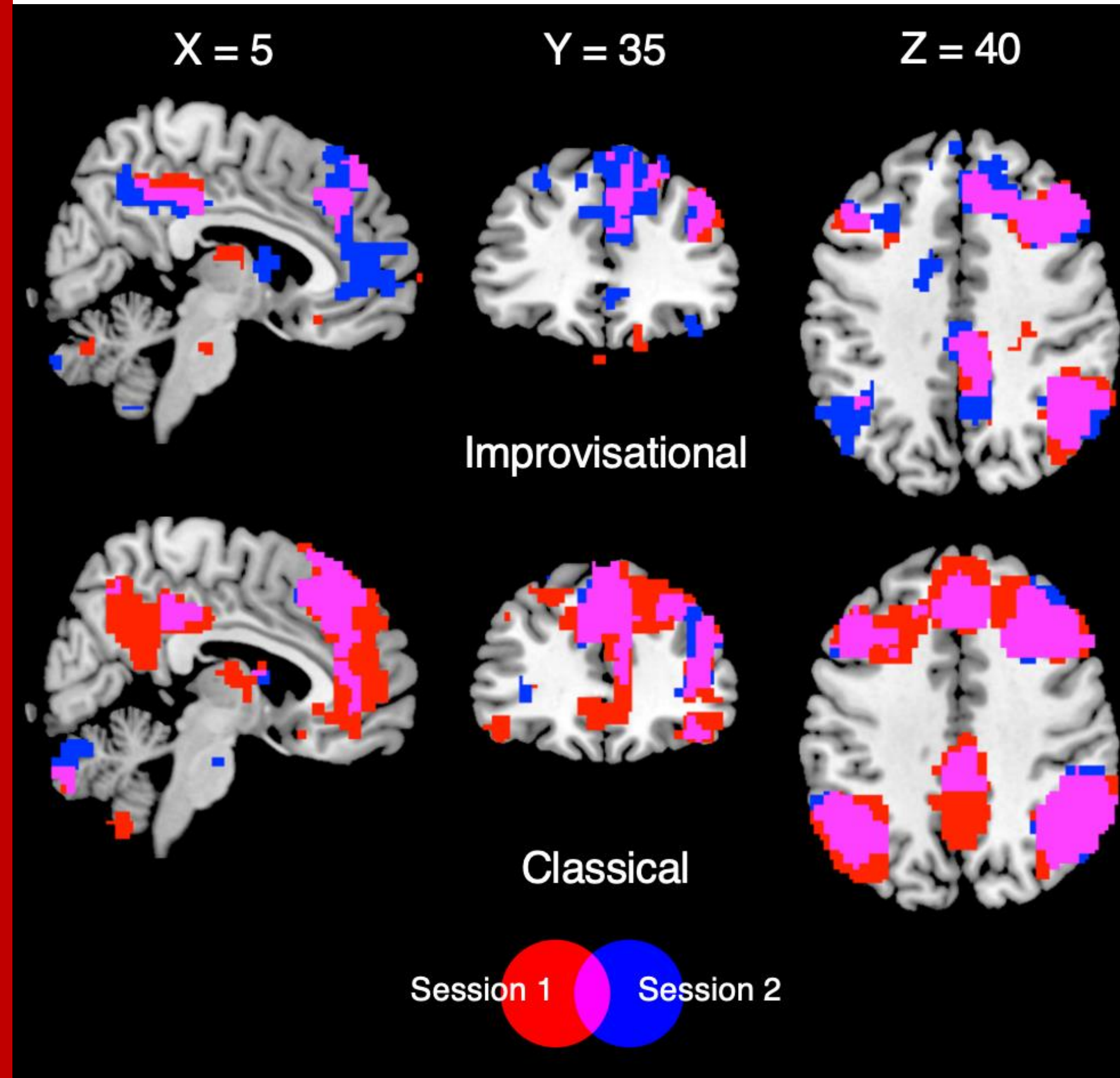
Session 1   Session 2

Group x Session Interactions

Two different ROI-to-ROI analyses were performed, one using the 14 networks of the Stanford atlas (8), and another using the 50 individual ROIs that compose the ECN, DMN, and salience networks. Group x session interaction effects were defined by the contrast of classical > improvisational and session 2 > session 1.

Top: The group x session interaction effect favored improvisational musicians in connectivity between Right ECN and both the dorsal DMN and Language networks.

Bottom: The group x session interaction effect favored improvisational musicians in connectivity between the first node of dDMN and the third node of RECN, but favored Classical musicians in connectivity between the fourth node of the posterior salience network, which covers posterior insular cortices, and both the third node of the same network and the sixth node of the LECN.

Conclusion & Discussion

- As training progresses, Improvisational musicians develop increased resting state connections between ECN and DMN, consistent with previously observed patterns associated with improvisation (2) and general creativity (1)

- Classical musicians lose connections between RECN and mPFC between session 1 and session 2, but gain connections relative to Improvisational musicians between LECN and salience network, as well as intrinsic connectivity between salience regions, suggesting a more specific role of these networks associated with classical musicianship

- Here we provide evidence that different musical training paradigms impact resting state connectivity in different ways, with improvisational training further developing musicians into their characteristic connectivity patterns.

References & Acknowledgment

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