Effect of comorbid learning and neurodevelopmental disorders on resting-state functional and effective connectivity in adolescents

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Introduction

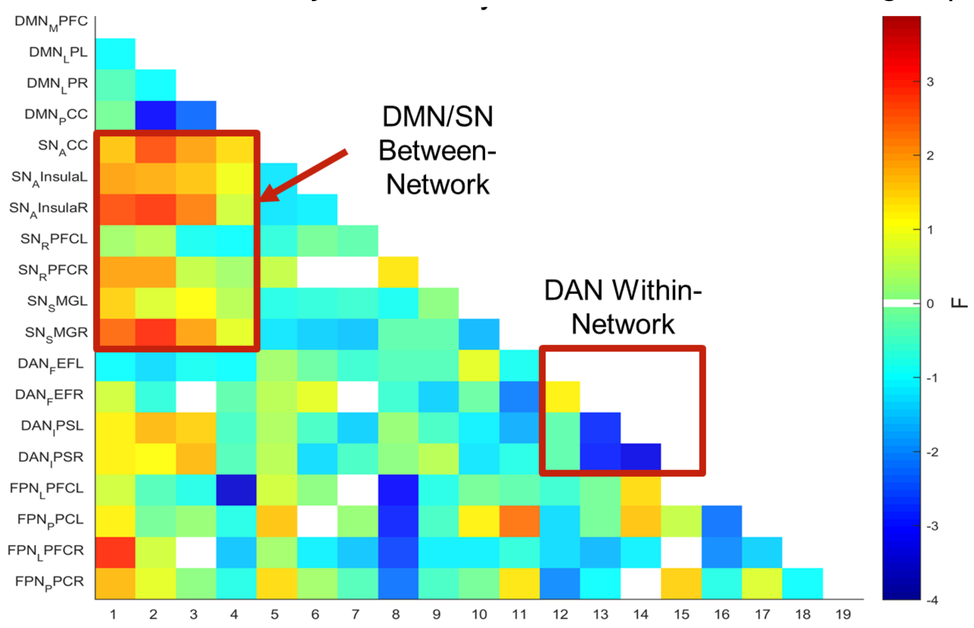
The development of functional connectivity is often described as changing from local to distributed connections which give rise to the functional brain networks observed in adulthood. In contrast to the well-explored pattern found in functional connectivity, no research has been published describing effective connectivity development. Also, there is a plethora of literature describing functional connectivity patterns in a variety of neurodevelopmental and internalizing disorders, but there is little consistency in the connectivity patterns discovered for each disorder. this study aimed to describe functional and effective resting-state connectivity during adolescent development in a typically developing adolescent group and to determine how adolescents with comorbid neurodevelopmental disorders differed.

Methods and Results

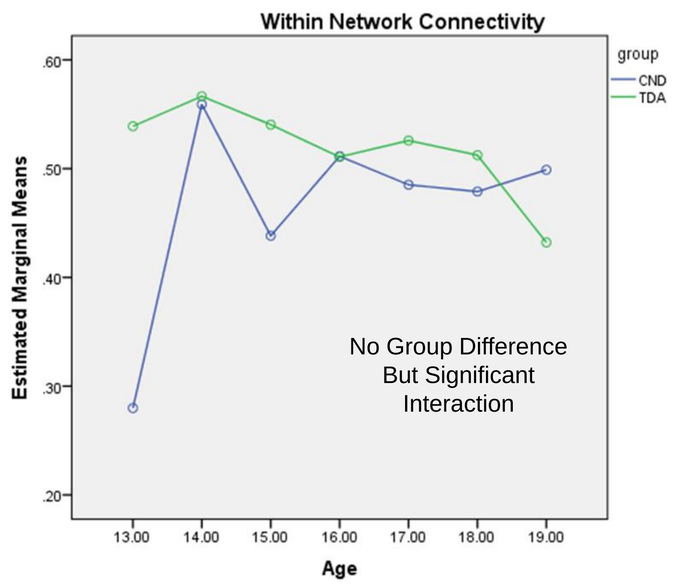
Participants - This study included two participant groups: the Typically Developing Adolescents group (N = 129) and the Comorbid Neurodevelopmental Disorders group (N = 47). The Typically Developing Adolescents (TDA) group included participants from the ABIDE database as well as from Carbondale, IL. The Comorbid Neurodevelopmental Disorders (CND) group includes adolescences from a preparatory school in Carbondale, IL (Brehm Preparatory School) with various neurodevelopmental and internalizing disorders. Both groups are adolescents between the ages of 13 and 19 years old. Both groups were similar in gender and age, but the TDA group, on average, had significantly higher IQ (M = 110.26, SD = 1.69) compared to the CND group (M = 93.36, SD 13.66).

Imaging – All participants included in this study participated in both a structural MRI scan and a resting state fMRI scan. The resting state fMRI parameters varied between imaging sites. Using resting state fMRI, functional and effective connectivity between and within these four networks were calculated: the Default Mode Network (DMN), the Salience Network (SN), the Dorsal Attention Network (DAN), and the Frontal Parietal Control Network (FPCN). Functional Connectivity was measured using the CONN Toolbox and effective connectivity was measured using spectral Dynamic Causal Modeling in the SPM toolbox.

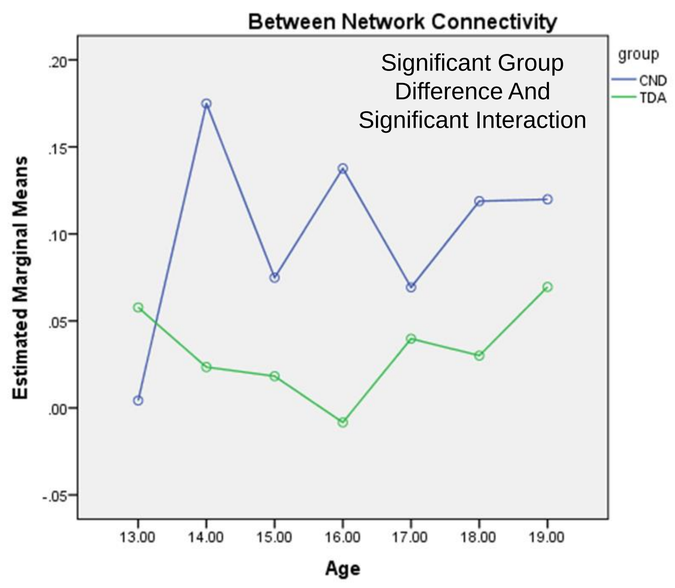
Functional Connectivity Between All Connections in the TDA group



Functional Connectivity Within Versus Between Networks in the TDA and CND Groups

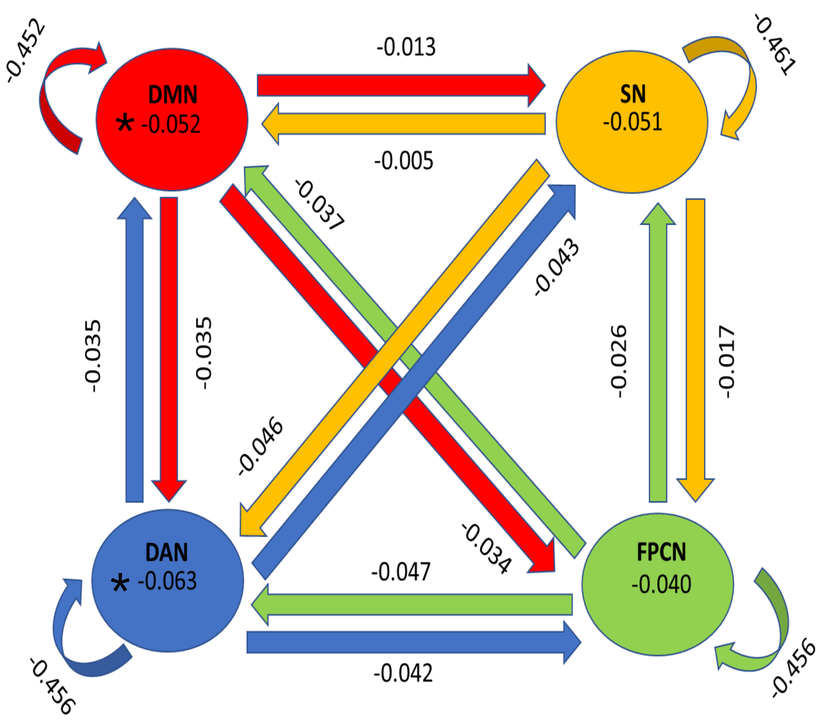


Covariates appearing in the model are evaluated at the following values: gender = .7558, mean motion = .0045457, mock scanner = 1.4477

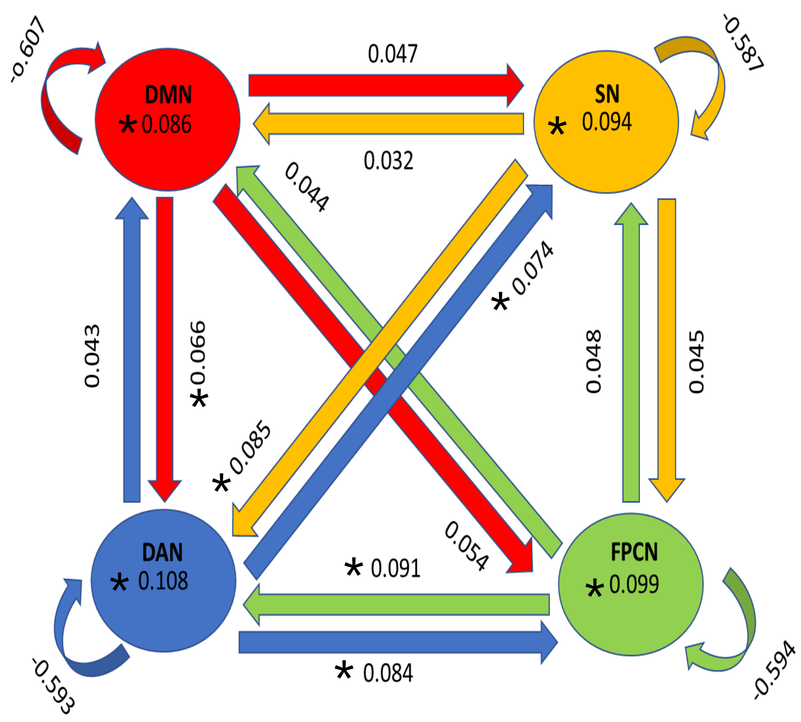


Covariates appearing in the model are evaluated at the following values: gender = .7558, mean motion = .0045457, mock scanner = 1.4477

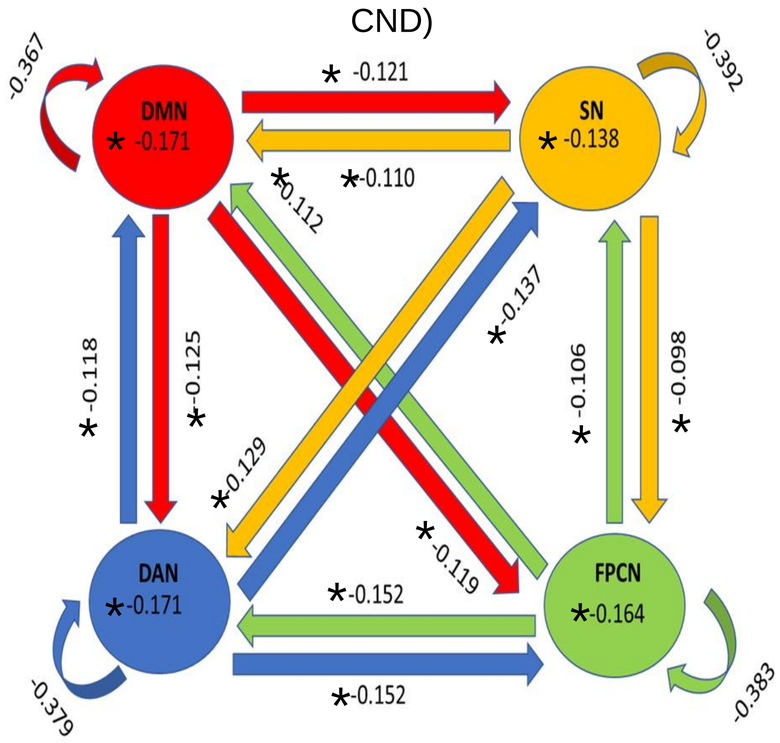
Effective Connectivity related to age in the TDA group



Mean Effective Connectivity in the TDA group



Group differences in Effective connectivity (TDA > CND)



* Signifies values that survived the non-zero criterion and a 99% posterior probability threshold

Discussion

The results from this study indicate that within-network connectivity decreased across age in the TDA group. The CND group displayed hyper-connectivity compared to the TDA group in between-network connectivity with no effect of age. The effective connectivity in the TDA group displayed decreasing connectivity within networks with increasing age, a novel effect not previously reported in the literature. The CND group's effective connectivity was hyper-connected overall (both within- and between-networks). The functional connectivity patterns in the TDA group suggest that functional connectivity undergoes a subtle developmental change during adolescence. The CND group consistently displayed functional and effective hyper-connectivity. Thus, the CND group, and perhaps similar comorbid groups, may have less efficient networks which could contribute to their disorder(s).