Functional Network Topology in Children with ADHD Symptoms

By

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1. Introduction

During childhood, the brain undergoes significant organization into functional networks that adapt and interact in response to incoming cognitive demands (Fair et al., 2009; Yeo et al., 2011). Studies have demonstrated the modular organization of the human brain, such that networks contain modules, or groups of densely interconnected nodes, that are thought to be efficient for information processing and specialized functions (Sporns & Betzel, 2016). In typical development, functional modules become more distinct across childhood and adolescence; within-module connectivity increases while connectivity between modules decreases (Baum et al., 2017; Fair et al., 2009; Satterthwaite et al., 2013). Yet deviations from typical development can result in large-scale network dysfunction which is thought to contribute to a range of psychopathology symptoms (Davis et al., 2013; Fekete et al., 2014; Griffiths et al., 2021; Wang et al., 2015; Xia et al., 2018).

Currently, the diagnostic classification system for psychopathology heavily relies on traditional categorical diagnoses. However, several issues accompany this system. Traditional diagnoses are often marked by transdiagnostic symptoms, a high degree of disorder comorbidity, neurobiological non-specificity, and inconsistent treatment response (Barzilay et al., 2019; Cubillo & Rubia, 2010; Dalsgaard et al., 2020; Hermens et al., 2011; Kotov et al., 2017; Martin et al., 2007; Monroe et al., 2019; Sinyor et al., 2010). Despite these concerns, traditional diagnoses often guide psychopathology research through the employment of case-control methods, which compare healthy controls to individuals who meet diagnostic criteria. This design overlooks the continuous nature of psychopathology symptoms, in which clinical symptomatology exists on a spectrum rather than finite groupings (Griffiths et al., 2021; Lee et al., 2007; Sato et al., 2013).

A growing body of literature indicates that psychopathology is better captured by a hierarchical dimensional model that identifies a common factor representing general symptoms across all disorders, also called the psychopathology or p factor, and factors of specific psychological problems (Kaczkurkin et al., 2019; Kotov et al., 2017; Lahey et al., 2017, 2021) Previous studies have revealed neurostructural associations with these general and specific psychopathology dimensions during development; reduced gray matter volume has been associated with general and attention-deficit/ hyperactivity disorder (ADHD)-specific psychopathology dimensions, and white matter integrity has been linked to ADHD- and conduct problems-specific dimensions (Cardenas-Iniguez et al., 2021; Durham et al., 2021; Kaczkurkin et al., 2019). Research is just beginning to link functional network architecture with dimensions of psychopathology. Xia and colleagues (2018) examined resting-state functional connectivity as it related to dimensions of mood, fear, psychosis, and externalizing behaviors, finding loss of network segregation common across all dimensions (Xia et al., 2018). However, this study was limited to a resting-state task and did not use hierarchical modeling of psychopathology symptoms. To build upon this work, the present study sought to examine psychopathology dimensions and network properties beyond rest conditions.

In a data-driven, exploratory analysis of a large sample of children ages 9-to-10 years from the Adolescent Brain Cognitive Development Study (ABCD Study; N = 3,568), we used a hierarchical model established in our prior work (Moore et al., 2020) to define a general factor of psychopathology and three specific factors of internalizing symptoms, conduct problems, and ADHD symptoms. We examined each dimension's association with functional network attributes using structural equation modeling. We characterized functional neural network topology with graph theory metrics—a mathematical framework for quantifying within- and between-network properties—during rest and three functional magnetic resonance imaging (fMRI) tasks: a monetary incentive delay task of reward processing, a stop signal task of inhibition, and an emotional n-back task of affective working memory (Sporns, 2018). These tasks are particularly relevant as critical cognitive states of executive functioning and reward processing. Notably, research has yet to examine hierarchical psychopathology dimensions and functional networks as captured by graph theory in a large sample of children across multiple cognitive states. This could deepen our understanding of network-level deficits that are common across disorders, or specific to varying forms of psychopathology.

2. Study 1

Study 1 sought to examine the topology of functional networks in association with four psychopathology dimensions— general, internalizing, conduct problems, and ADHD— in a sample of 3,568 children from the ABCD Study. To this end, Study 1 calculated local and global graph theory metrics during tasks of reward processing, inhibition, working memory, and rest.

2.1 Methods

2.1.1 Participants

Study 1 used data from the ABCD Study Wave 1 (release 3.0), a study of youth brain development, which obtained consent from all participants. Vanderbilt University's Institutional Review Board approved the use of this dataset. Garavan and colleagues (2018) thoroughly detail the ABCD Study participant recruitment process (Garavan et al., 2018). Briefly, there were 21 ABCD Study-designated sites across the United States, each with independent catchment areas. Within each catchment area, researchers engaged in probability sampling of schools to recruit eligible children. Sociodemographic factors were considered in sample recruitment, including age, gender, race/ethnicity, socio-economic status, and urbanicity. Target numbers for each of these factors came from: (1) the American Community Survey (ACS), a large annual survey by the U.S. Census Bureau; and (2) the National Center for Education Statistics' school enrollment data. Although the 21 ABCD Study sites do not perfectly reflect the U.S. population, each site implemented the same unbiased recruitment. Post-stratification weights derived by the researchers of the ABCD Study were used to adjust the sample to be more representative of the US population. Participants included N = 11,875 9- and 10-year-old children recruited from 21 sites across the United States. In the present study, we excluded participants based on missing data, failed quality assurance (QA) measures, and motion parameters (Figure 1).

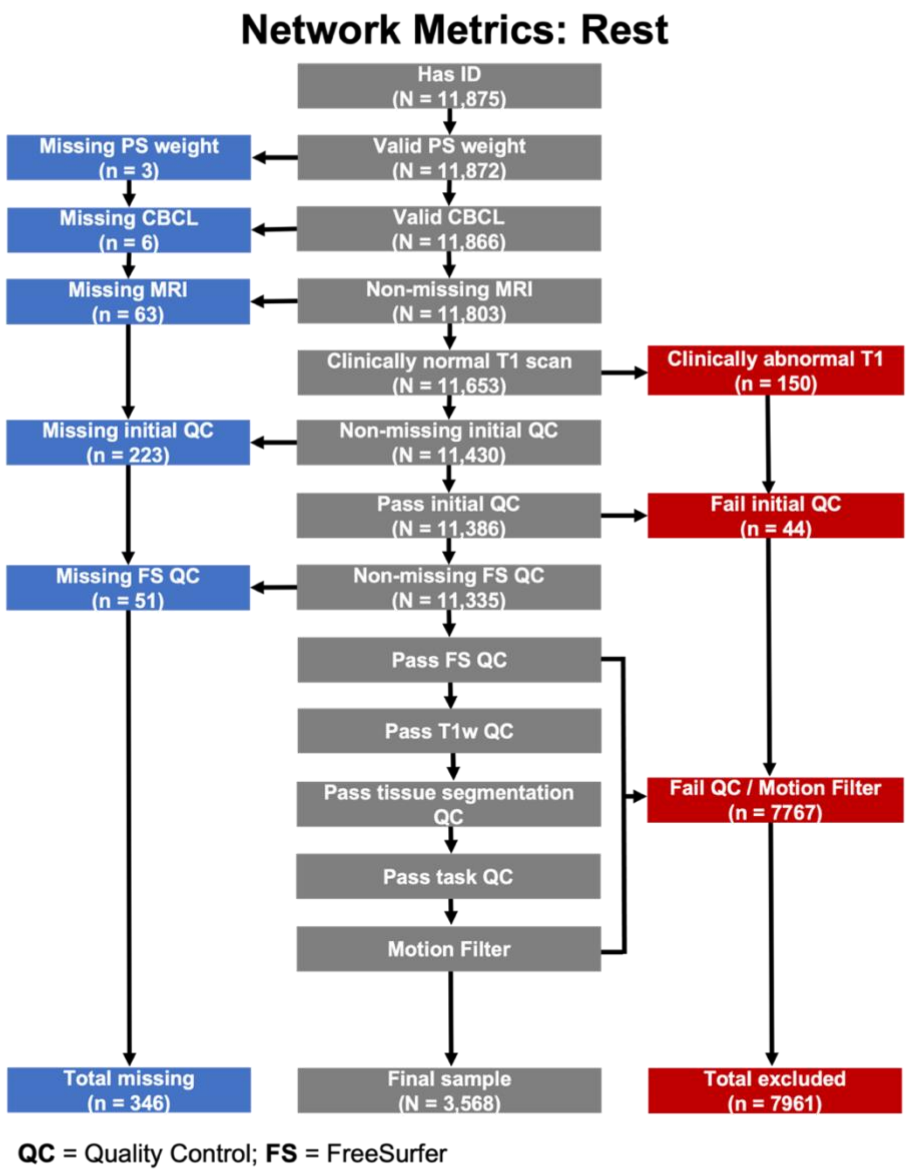

Figure 1. Flowchart indicating exclusions for primary analyses with psychopathology dimensions and network efficiency metrics on resting state.

Stringent QA and motion parameters were necessary to ensure adequately clean data for the graph theory network metrics (see the Image acquisition, processing, and quality assurance section for additional details). Final sample sizes for the four tasks were as follows: rest (N = 3,568), monetary incentive delay (N = 1,708), emotional n-back (N = 1,652), and stop signal task (N = 1,694). A summary of demographics based on the final sample can be found in Table 1.

Table 1. *Demographics of the sample (N = 3568)*

	Mean	***SD***
Age (in years)	9.98	.63
	N	***(%)***
Sex		
Female	1856	52.0
Male	1712	48.0
Race/Ethnicity		
White	2079	58.3
Hispanic	712	20.0
Black	359	10.0
Other	418	11.7
Household Income		
<$5000	82	2.3
$5,000 - $11,999	82	2.3
$12,000 - $15,999	76	2.1
$16,000 - $24,999	135	3.8
$25,000 - $34,999	174	4.9
$35,000 - $49,999	283	7.9
$50,000 - $74,999	468	13.1
$75,000 - $99,999	547	15.3
$100,000 - $199,999	1117	31.3
≥ $200,000	384	10.8
Missing	220	6.2
Parent Education		
No degree	125	3.5
High school/ GED	371	10.4
Some College	554	15.5
Associate degree	460	12.9
Bachelor’s degree	1138	31.9
Master’s degree	694	19.5
Professional/ Doctoral	226	6.3

Note. The “Other” Race/Ethnicity category includes those who were identified by their parent as American Indian/Native American, Alaska Native, Native Hawaiian, Guamanian, Samoan, Other Pacific Islander, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Other Asian, or Other Race.
SD, Standard Deviation; GED, General Education Development

2.1.2 Measures of psychopathology

The Child Behavior Checklist (CBCL) was used to assess psychopathology via parent-reported emotional and behavioral problems (Achenbach, 2009). The CBCL is normed for children ages 6-18 and consists of 119 items related to various emotions and behaviors. Items are rated on a 3-point scale: 0 = not true (as far as you know), 1 = somewhat or sometimes true, and 2 = very true or often true.

2.1.3 Hierarchical models of psychopathology

As previously described in Moore et al. (2020), our data was split into two samples for an exploratory SEM analysis and a confirmatory bifactor analysis. CBCL items that did not reflect the most strongly associated aspects of psychopathology were removed (Moore et al., 2020). Reasons for item elimination included: (1) items that did not reflect symptoms of psychopathology (e.g., constipation); (2) items that were more age appropriate for certain ages over others (e.g., substance use items); (3) items that showed lack of sufficient endorsement (ratings above 0) within the sample; and (4) items that reflected similar behaviors to another item, in which case a composite was created. As a result, only items that were strongly associated with psychopathology were included in these analyses. The exploratory SEM analysis identified three factors of psychopathology: internalizing problems, ADHD symptoms, and conduct problems. In the second half of the data, a confirmatory bifactor analysis modeled these three factors plus a general psychopathology factor to define shared psychopathology symptoms across all participants. In total, these four orthogonal factors represent shared and dissociable dimensions of psychopathology (Figure 2a). Each CBCL item loads onto the general psychopathology factor, as well as one of the three specific factors. The psychometric properties of the factors met all standards for construct reliability and factor determinacy recommended for bifactor models, and each factor demonstrated adequate criterion validity. Additional details regarding the calculations, bifactor modeling results, and validity and reliability of the psychopathology dimensions are published elsewhere (Bornovalova et al., 2020; Moore et al., 2020; Rodriguez et al., 2016).

2.1.4 fMRI tasks

The present study examined resting state and three functional tasks: the stop-signal task, the emotional n-back, and the monetary incentive delay. The stop-signal task probes inhibition and impulse control. Participants see a "go" signal, as indicated by an arrow pointing to the left or right of the screen. At this signal, participants are instructed to indicate the direction of the arrow via button press, except when a "stop" signal appears, as indicated by an upright arrow. Responses are evaluated for speed and accuracy during two runs, approximately six minutes each. Performance is measured as reaction time, quantified as the mean stop-signal delay subtracted from the mean reaction time on correct go trials, and the proportion correct on 'go' trials (Casey et al., 2018; Hagler et al., 2018). As per ABCD Study's quantification, stop signal reaction times are reverse scored, so that higher scores indicate better performance.

The emotional n-back task probes working memory and emotion regulation processes. Participants performed an emotional n-back task with memory loads varying from low (0-back) to high (2-back). During 0-back conditions, participants are shown a target stimulus (faces of varying emotions) and instructed to indicate whether subsequent stimuli match or do not match the target. During 2-back conditions, participants are instructed to press "match" when a picture is identical to the one seen two trials back. Data are collected during two runs, approximately five minutes each. Performance is based on rate of accuracy for 2-back trials.

The monetary incentive delay task probes aspects of reward processing, including anticipation and motivation. At the start of each trial, participants are informed that, depending on their performance, they will win $.20 or $5, lose $.20 or $5, or earn $0. After 1500-4000 ms, a target stimulus appears for 150-500 ms. Participants are instructed to press a button within that time period in order to receive the reward or avoid the loss for that trial. Data are collected during two runs, approximately 5.5 minutes each. Performance is based on total monetary earnings.

2.1.5 Image acquisition, processing, and quality assurance

Imaging Acquisition. The present study used an imaging protocol developed by the Adolescent Brain Cognitive Development (ABCD) Study Data Analysis and Informatics Center (DAIC) and the ABCD Imaging Acquisition Workgroup. The protocol was harmonized across all scanner platforms and sites. Imaging data was collected on a number of models of 3 tesla (3T) scanners from three different vendors: General Electric Discovery MR750, Siemens Prisma, Siemens Prisma Fit, Phillips Achieva dStream, and Phillips Ingenia. Resting state data was acquired with four rs-fMRI series and task-based data was acquired with two fMRI series for each of the three tasks. All fMRI acquisitions were multiband EPI (2.4 mm isotropic, TR=800 ms, slice acceleration factor 6) and included fieldmap scans for B0 distortion correction.

Participants completed scanning during one to two sessions; this included 3D T1- and 3D T2-weighted images of brain structure, a localizer, resting state scan, diffusion tensor imaging (DTI), and task-based scans. Task-based scans included rest, emotional n-back (two runs, ~five minutes each), monetary incentive delay (two runs, ~5.5 minutes each), and the stop signal task (two runs, ~six minutes each). Imaging parameters are described in detail in (Casey et al., 2018).

Data processing. Those scanned on the Phillips brand scanner were excluded because of an error that occurred in the phase encoding direction when converting files from DICOM to NIFTI. Structural and functional MRI scans were downloaded from the ABCD Study data portal (https://nda.nih.gov/abcd) and underwent minimal processing including motion correction, B_0 distortion correction, gradient warping correction and resampling to an isotropic space (Hagler et al., 2018; Kardan et al., 2021; Stier et al., 2021). Data were preprocessed with a custom version of FMRIPREP, a Nipype based tool (Esteban et al., 2019; Gorgolewski et al., 2011; Kardan et al., 2021; Stier et al., 2021). Each structural T1w (T1-weighted) scan was first defaced with pydeface (Gulban et al., 2019). Each participant's T1w volume had been previously skull-stripped and underwent correction for intensity non-uniformity (INU) via N4BiasFieldCorrection v2.1.0 (Tustison et al., 2010). Spatial normalization to the standard MNI template included with FSL—the MNI152 non-linear 6th generation template—was performed through nonlinear registration via the ANTs v2.1.0's antsRegistration tool; this used brain-extracted versions of T1w volume and template (Avants et al., 2008). Brain tissue segmentation of cerebrospinal fluid (CSF), white-matter (WM) and gray-matter (GM) was performed on the brain-extracted T1w using FSL v5.0.9's fast (Zhang et al., 2001). Functional data was co-registered to the respective T1w anatomical image using FSL's flirt boundary-based registration with six degrees of freedom (Greve & Fischl, 2009). Motion correcting transformations (based on minimally processed data motion parameters), BOLD-to-T1w transformation, and T1w-to-template (MNI) warp were concatenated and applied in a single step via ANTs v2.1.0's antsApplyTransforms using Lanczos interpolation. Physiological noise regressors were extracted and applied from tissue masks (Power et al., 2014). Framewise displacement was calculated for each functional run using the implementation of Nipype. See https://fmriprep.readthedocs.io for further detail of the pipeline.

Furthermore, 36 parameter confound regressions were performed including the timecourses of mean CSF signal, mean global signal, mean WM signal, the 6 standard affine motion parameters (x, y, z, pitch, roll and yaw), their squares, their derivatives, and the squared derivatives of these signals. Linear and quadratic trends were simultaneously regressed out in order to remove drift-related signals, followed up by the application of a bandpass filter with a highpass cutoff of .008 Hz and a lowpass cutoff of .12 Hz via the 3dBandpass command in AFNI (Cox, 1996). The cleaned volumetric BOLD images were spatially averaged into the Shen-268 atlas. For the Siemens scanners, the first eight volumes were removed because they were used as the multiband reference. For those GE scanners using DV25 software, five volumes were removed; the first 12 volumes were used as the multiband reference and then combined into a single volume and saved as the initial TR leaving a total of five frames to be discarded. For those GE scanners running DV26 software, 16 volumes were removed (Rosenberg et al., 2020). Runs included 362 whole-brain volumes following the discarding of these acquisitions.

Finally, all structural and functional scans were visually inspected for scanner abnormalities, and to assess the accuracy of the registration and tissue segmentation processes. Participants were included for analysis if they had passing structural scans and at least one passing functional scan.

2.1.6 Deriving the functional networks

We analyzed the topology of networks derived from the Shen-268 atlas, which partitions the brain into 268 previously defined parcels based on group-level patterns of statistical similarities between brain region dynamics; we note that this parcellation was not defined in the ABCD sample. This parcellation method has been used to study various disorders, development stages, cognitive states and processes (Chen et al., 2021; Ghanbari et al., 2022; Kwon et al., 2021; Rosenberg et al., 2015; Saberi et al., 2021). Using the group-level Shen-268 atlas, we analyzed the topology of subcortical-cerebellar, motor, medial frontal, frontoparietal, default mode, visual I, visual II, and visual association networks (Finn et al., 2015; Shen et al., 2013).

2.1.7 Graph Theory Analyses

All graph theoretic measures were computed using the python package *networkx* (Hagberg et al., 2008).

Connectivity Matrix Thresholding: In order to derive functional networks from correlation matrices of signal between brain regions, we applied four thresholds to evaluate only the strongest 10%, 16.67%, 23% and 30% connections between node pairs. Thus, we retained positive and negative connections that were stronger than each separate threshold within each network and within each task. Connections were binarized before all graph theoretic calculations.

Measures of network efficiency. The present analysis examined the following graph theory metrics, as described in prior literature (Rubinov & Sporns, 2010; Sporns, 2018). Metrics are described below. A network can be represented graphically by *G(N, K)*, where *N* indicates the number of nodes, and *K* indicates the number of edges.

Average shortest path length is defined by the average number of edges along the shortest path for all possible node pairs.

$L = \frac{1}{N*(N-1)} * \sum_{i \neq j} d(i,j)$, where *d(i, j)* represents the shortest path between two vertices of the graph.

Local efficiency of node *i* is defined by how well information is transferred by a node neighborhood when node *i* is removed.

$E_{loc} = \frac{1}{N} \Sigma_{i \in N} E_{loc,i} = \frac{1}{N} \Sigma_{i \in N} \frac{\Sigma_{j,h \in N, j \neq i} a_{ij} a_{ih} [d_{jh}(\mathrm{N}_i)]^{-1}}{k_i(k_i - 1)}$, where $E_{loc,i}$ is the efficiency of node *i*, $d_{jh}(N_i)$ is the length of the shortest path between *j* and *h* that contains only neighbors of node *i*, and a_{ij} is the i^{th} row and j^{th} column element of adjacency matrix *A*.

Diameter is a measure of the overall size of the graph and is calculated as the maximum eccentricity across all nodes. For a single node the eccentricity is the maximum distance from that node to all other nodes in the graph.

$D = max_j max_i (d(i,j))$, where *d(i,j)* is the shortest distance between nodes *i* and *j*.

Sigma metrics benchmark clustering and shortest path lengths against random reference graphs, whereas omega metrics benchmark clustering against a reference lattice graph but benchmarks shortest path length against a random reference graph. Thus, omega metrics further allow the characterization of whether graphs are more random or more lattice-like in their deviations from ‘perfect’ small-worldness. Sigma is defined as:

$\sigma = \frac{CC_r}{LL_r}$, where C and L are the clustering coefficient and shortest path length respectively and C_r and L_r are the same for the random reference graph.

Omega is defined as:

$\omega = \frac{L}{L_r} - \frac{C}{C_l}$, where C and L are the clustering coefficient and shortest path length respectively and C_l and L_r are the same for, respectively, the lattice reference graph and the random reference graph.

Modularity is a measure of a system’s balance of within-network communication and between-network communication via the degree to which a network can be subdivided into distinct and separate communities. It is defined by the strength of division of a network into modules.

$Q = \Sigma_{c=1}^{n} \left[\frac{L_c}{m} - \left(\frac{k_c}{2m}\right)^2\right]$, where m is the total number of edges in the graph, L_c is the number of intra-community edges for community c, k_c is the sum of degrees of nodes in community c, and n is the total number of communities in the partition.

2.1.8 Statistical analysis

We examined associations between four orthogonal dimensions of psychopathology, defined by our previous works’ hierarchical model—general psychopathology, and specific internalizing, conduct problems, and ADHD—and functional network properties, including modularity, average shortest path length, local efficiency, diameter, small world sigma, and small world omega (Moore et al., 2020). The data were weighted by the post-stratification weights provided by the ABCD Study to make the sample more representative of the U.S. population, stratified based on site to control for site differences, and clustered based on family membership to account for siblings and multiple births. We performed analyses with eight functional networks across four cognitive tasks and included age, sex, race/ethnicity, and MRI scanner model as covariates. Scanner model was added as a covariate due to differences found between the scanners even after accounting for site differences. For each of the networks, four tasks, and four thresholds, we investigated associations between the dimensions of psychopathology and metrics via structural equation modeling as follows:

$$\text{Network}_{\text{Task, threshold, metric}} = \beta \times \text{age} + \beta \times \text{sex} + \beta \times \text{race/ethnicity} + \beta \times \text{MRI scanner model}$$
$$+ \beta \times \text{general psychopathology} + \beta \times \text{internalizing} + \beta \times \text{ADHD} + \beta \times \text{conduct problems}$$

Of note, this equation exemplifies one network combination; however, all networks were tested simultaneously in one structural equation model for a given threshold and task. Due to their orthogonality, the four psychopathology dimensions could be included together in the same model without concerns of multicollinearity. We controlled for the false discovery rate ($q < 0.05$) using the stats package in R version 3.6.1 (http://www.r-project.org/).

Additionally, we conducted analyses of behavioral measures to examine the associations between performance on working memory, reward processing, and inhibition tasks and the psychopathology dimensions, while covarying for sex and race and ethnicity. We also performed sensitivity analyses with parental education and medication (whether participants reported taking current medications or not) as an additional covariate to determine whether associations between network properties and psychopathology sustain when accounting for a proxy for socioeconomic status and medication status. Finally, we examined interactions with sex to test for sex differences in the relationship between network metrics and psychopathology.

2.1.9 Data and Code Availability

The ABCD Study data in the current is available through the NIMH Data Archive (https://nda.nih.gov/abcd). The Mplus and R code and a corresponding wiki for analytic procedures can be found at https://github.com/VU-BRAINS-lab/Reimann_Network_Metrics.

2.2 Results

Graph theory metrics were considered reliable if they were significant across at least three consecutive thresholds. That is, results will be referred to as significant if a significant association occurred across at least three consecutive thresholds for that network/task. Results will be referred to as inconsistent if significant associations may have occurred in individual networks and/or tasks but were not seen across at least three consecutive thresholds.

2.2.1 Link between whole-brain modularity and the specific psychopathology dimensions

The specific factor of ADHD was significantly associated with atypical modularity across the whole brain, such that higher levels of the specific ADHD dimension were associated with lower whole-brain modularity. Lower modularity exists when there are dense connections between modules, but sparse connections within modules (Figure 2b), and is associated with poorer cognitive scores (Baum et al., 2017; Bertolero et al., 2018). This was apparent across all four thresholds during rest and the three functional tasks (Figure 2c; Table 2).

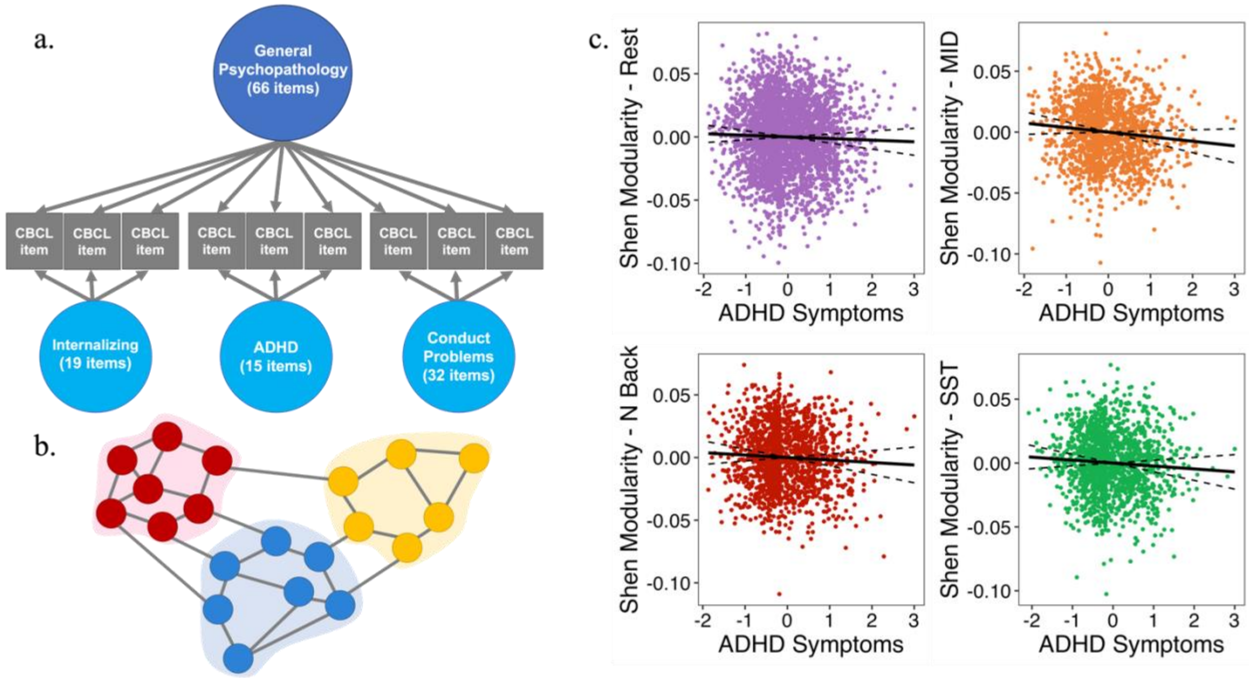

Figure 2. A hierarchical approach to examining modularity under varying cognitive demands. a. Hierarchical model comprised of a general factor which represents the commonalities across all symptoms and three orthogonal specific factors of internalizing, attention-deficit/hyperactivity disorder (ADHD), and conduct problems. **b.** Visual depiction of the graph theory metric of modularity; circles indicate nodes, and their colors indicate various networks. Connecting lines indicate edges or "steps" between the nodes. Modularity quantifies the degree to which nodes form connections within or between modules (i.e., clusters of nodes shown by different colored areas). **c.** Correlations between the ADHD dimension of psychopathology and its associated network modularity across tasks. Correlations display significance at the 30% threshold. CBCL = Child Behavioral Checklist; MID = monetary incentive delay; SST = stop signal task.

Findings also showed that those with elevated levels on the specific conduct problems dimension displayed lower whole-brain modularity, but only during tasks of reward processing and affective working memory (Table 2). This association was not seen at rest or during the inhibition task. The general psychopathology factor and internalizing specific factor were not consistently associated with modularity across any task (Table 2).

2.2.2 Specific ADHD is associated with deficits in the motor network at rest

Greater ADHD symptoms were significantly associated with lower local efficiency in the motor network during rest (Tables 3a-3d), indicating reduced within-network efficiency without interruption if one of its nodes is removed. The specific factor of ADHD was not consistently associated with the average shortest path, diameter, or small world metrics (Tables 4-7), nor local efficiency in other networks. General psychopathology, conduct problems, and internalizing symptoms were not consistently associated with these graph theory metrics across networks (Tables 3-7).

2.2.3 Task performance and the specific dimensions

Given the association between network metrics and ADHD symptoms and conduct problems, we next examined the relationship between these psychopathology dimensions and behavioral measures derived from the various cognitive tasks. Findings showed that ADHD symptoms negatively predicted total earnings on the monetary incentive delay task ($p < .001$), the proportion of correct responses across 2-back trials on the emotional n-back task ($p < .001$), and the proportion of correct 'Go' trials on the stop signal task ($p < .001$). ADHD was not predictive of the mean response time for all correct 'Go' trials during the stop signal task ($p = .071$). Further, the conduct problems specific factor negatively predicted the proportion of correct responses across 2-back trials on the emotional n-back ($p < .001$) but not monetary incentive delay total earnings ($p = .071$).

2.2.4 Sensitivity analyses

We performed sensitivity analyses to test the robustness of our findings. First, we controlled for medication, as well as parent education to account for a proxy of socioeconomic status (Table 8). Results showed that the specific ADHD factor retained significance for motor local efficiency at rest ($p = .002$) and whole-brain modularity during the monetary incentive delay task (p = .003), emotional n-back task (p = .009), stop signal task (p = .002) and at rest (p = .011). After controlling for parent education and medication, the conduct problems factor did not retain significance for whole-brain modularity during the emotional n-back task (p = .082) and monetary incentive delay task (p = .06). Finally, based on the known sex differences in the prevalence rates of ADHD (Arnett et al., 2015), we examined sex differences in our ADHD results. As expected, males endorsed greater ADHD symptoms than females ($p < .001$). However, there were no significant interactions between the specific factor of ADHD and sex across motor local efficiency at rest or whole-brain modularity during any of the four tasks (*p-values* ≥ .21).

2.3 Discussion

Study 1 utilized a large subsample of children from the ABCD Study to examine associations between four orthogonal dimensions of psychopathology—general psychopathology, internalizing symptoms, ADHD symptoms, and conduct problems—and functional network efficiency at rest and during tasks of reward processing, inhibition, and affective working memory. Overall, findings provide evidence that altered network topology is consistent across rest and during various cognitive demands in those with greater externalizing symptomatology defined as ADHD symptoms and conduct problems. The ADHD factor was significantly associated with lower whole-brain modularity across all four tasks and reduced local efficiency in the motor network at rest. The conduct problems factor was associated with reduced whole-brain modularity during affective working memory and reward processing tasks; however, these results were less robust than ADHD results. No consistent associations were found between network metrics and general psychopathology or internalizing symptoms.

Studies in the last decade have placed great emphasis on the conceptualization of the brain as having a modular organization that develops early in life and continues across childhood

(Bertolero et al., 2015; Power et al., 2011; Yeo et al., 2011). There has been considerable interest in how network properties can provide insight into psychopathology, with studies linking structural and functional network modularity to executive functioning and clinical symptoms (Baum et al., 2017; Xia et al., 2018). Of note, Xia and colleagues (2018) found lower network segregation associated with externalizing behaviors, which was a composite of ADHD and conduct-related behaviors (Xia et al., 2018). The present findings are consistent with Xia et al.'s (2018) finding that modularity deficits are associated with externalizing behaviors, and we expand upon this finding to show that ADHD and conduct problem network deficits are present when defined in a hierarchical model of psychopathology (Xia et al., 2018). Given this linkage between functional topology and clinical presentations, it is becoming evident that network architecture can critically inform the ways in which atypical circuits give rise to psychiatric symptoms. Overall, this avenue of research is essential for understanding network features of psychopathology, which may help to advance our classification of mental health disorders and aid in biologically driven interventions.

Modularity findings emerged as the most consistent association with ADHD, revealing significant associations across all four tasks and across all four thresholds. Lower modularity indicates a bias towards global communication (connections between modules) at the expense of local communication (connections within modules); this has been associated with poorer cognitive functioning (Baum et al., 2017; Bertolero et al., 2018; Fair et al., 2009). The lack of segregation found in the current study may suggest that ADHD is associated with nonoptimal within-network communication and a lack of distinct hubs of information exchange. This is substantiated by our finding of reduced local efficiency in the motor cortex at rest, which also suggests local communication deficits. In addition, we found that increased ADHD symptoms were associated with poorer cognitive performance. Taken together, our results suggest that

ADHD is associated with deficits in the development of segregated network modules in the brain, which may negatively impact cognitive functioning.

The neural findings of the present study align with and extend the research on network deficits in externalizing behaviors, especially for ADHD symptoms. Prior resting state findings have reported a link between greater ADHD symptoms and lower modularity (Qian et al., 2019). In addition to rest, we reveal reduced modularity present during reward processing, affective working memory, and inhibition tasks. Robust modularity findings across every task and threshold provide evidence for a broad modularity deficit in children with elevated levels of ADHD symptoms. Overall, the significant association between modularity and ADHD could suggest that the neural systems of those with ADHD have not optimized communication on a local level. Given prior findings suggesting a developmental lag in ADHD functional networks, this local communication deficit may reflect a maturational delay (Sripada et al., 2014). Additionally, our findings revealed that in the absence of any cognitive demands, the ADHD motor network shows lower resilience to local failures in information exchange. Prior studies have shown that children with ADHD often display alterations in the functional connectivity strength of the motor network both within and between hemispheres, and behavioral impairments during tasks of motor coordination (McLeod et al., 2016; Mokobane et al., 2019). Considering our findings, motor network alterations may reflect reduced efficiency of within-network communication which may contribute to motor disorganization.

Additionally, our results revealed a significant association between conduct problems and whole-brain modularity under affective working memory and reward processing demands. Prior studies report working memory deficits and abnormal neural signatures during reward processing in individuals with conduct disorder and/or oppositional defiant disorder (Hawes et al., 2021; Schoorl et al., 2018). Given the high comorbidity between ADHD and conduct disorder, the overlap in modularity deficits between conduct problems and ADHD may be expected (Angold et al., 1999). However, the lack of network segregation associated with conduct problems was not as robust across tasks as the ADHD results, nor did conduct problems findings persist when accounting for parental education and medication status. This suggests that deficits in whole-brain modularity may confer greater risk for ADHD than conduct problems.

3. Study 2

Results from Study 1 detail robust associations between the ADHD specific factor and functional network properties. However, ADHD is thought to be a heterogeneous disorder composed of three subtypes: predominantly inattentive, predominantly hyperactive/impulsive, and a combined profile (Regier et al., 2013). This begs the question, does reduced network efficiency represent a broad characteristic of ADHD? Rather, does a specific ADHD subtype drive these differences? In light of these questions, Study 2 sought to parse the neurobiological heterogeneity of ADHD to examine mechanisms specific to the disorder subtypes. First, this study aimed to examine whether latent constructs of ADHD symptoms could adequately capture, and therefore operationalize, inattentive and hyperactive/impulsive subtypes as continuous factors of symptoms rather than dichotomous groups. By applying these factors to graph theory metrics, Study 2 aimed to analyze whether inattentive and hyperactive/impulsive subtypes reflect distinct neural signatures in network topology.

3.1 Methods

3.1.1 Participants

Study 2 used from the ABCD Study Wave 1 (neuroimaging data - release 3.0; CBCL data – release 4.0). As previously stated, the ABCD Study protocol obtained consent from all participants, and Vanderbilt University's Institutional Review Board approved the use of this dataset. Participants included 11,875 9–10-year-old children recruited from 21 sites across the

United States. As outlined below (Section 3.1.3), all participants were used for a confirmatory factor analysis (CFA) to establish continuous factors of inattentive and hyperactive/impulsive ADHD subtypes. In regard to analysis with brain network properties (following latent factor identification), exclusion criteria were identical to Study 1; the final sample sizes for the four fMRI tasks were rest (N = 3,568), monetary incentive delay (N = 1,708), emotional n-back (N = 1,652), and stop signal task (N = 1,694).

3.1.2 Measures of psychopathology

The CBCL was used to assess psychopathology via parent-reported emotional and behavioral problems (Achenbach, 2009). For additional details on this measure, see Study 1.

3.1.3 fMRI tasks

Study 2 fMRI tasks are identical to and previously described in Study 1, Section 2.1.4 (Casey et al., 2018; Hagler et al., 2018). Briefly, the stop-signal task probes inhibition and impulse control. Performance is measured as reaction time and the proportion correct on 'go' trials. The emotional n-back task probes working memory and emotion regulation processes. Performance is based on rate of accuracy for 2-back trials. Lastly, the monetary incentive delay task probes aspects of reward processing, including anticipation and motivation. Performance is based on total monetary earnings.

3.1.4 Image acquisition, processing, and quality assurance

Image acquisition, processing and quality assurance are identical to and previously described in Study 1 Section 2.1.5.

3.1.5 Deriving the functional networks

Derivation of functional networks is identical to and previously described in Study 1 Section 2.1.6. Briefly, we analyzed the topology of networks derived from the Shen-268 parcellation to construct the following networks: subcortical cerebellar, motor, medial frontal, frontoparietal, default mode, visual I, visual II, and visual association networks.

3.1.6 Graph Theory Analyses

Graph theory calculation is identical to and previously described in Study 1 Section 2.1.7. Briefly, graph theory metrics—including average shortest path length, small world sigma, small world omega, diameter, local efficiency, and modularity—were evaluated across all tasks, networks, and thresholds.

3.1.7 Statistical Analysis

3.1.8.1 Confirmatory Factor Analysis

A CFA was conducted in Mplus to evaluate continuous latent factors of inattention and hyperactivity/impulsivity (N = 11,875). Table 9 exhibits the CBCL items that contributed to the initial and final CFA models. Items were chosen given their relevance to ADHD behavioral symptoms (e.g., *Inattentive or easily distracted, Talks too much*). R's ICLUST function was used to assess for correlated and redundant CBCL items. The following criteria with widely accepted thresholds were used to determine the adequacy of model fit to the data: a Comparative Fit Index (CFI) ≥ 0.9, root mean square error of approximation (RMSEA) $\leq .06$, and standardized root mean square residual (SRMR) $\leq .08$ (Jackson et al., 2009; McDonald & Ho, 2002).

3.1.8.2 Structural Equation Modeling

Structural equation modeling was employed to examine the associations between network properties and inattentive and hyperactive/impulsive factors obtained from the aforementioned CFA model. Analyses examined 8 functional networks derived from the Shen-268 atlas across four fMRI conditions, and included age, sex, race, ethnicity, and MRI scanner model as covariates. The data were weighted by the post-stratification weights provided by the ABCD Study, stratified based on site, and clustered based on family membership. Scanner model was added as a covariate to control for differences between scanners. For each of the networks, four tasks, and four thresholds, we investigated associations between the dimensions of psychopathology and metrics via structural equation modeling as follows:

$$\text{Network}_{\text{Task, threshold, metric}} = \beta \times \text{age} + \beta \times \text{sex} + \beta \times \text{race/ethnicity} + \beta \times \text{MRI scanner model} + \beta \times \text{Inattentive} + \beta \times \text{Hyperactive/Impulsive}$$

This equation exemplifies one network combination; however, all networks were tested in one structural equation model for a given threshold and task. We controlled for the false discovery rate ($q < 0.05$) using the stats package in R version 3.6.1 (http://www.r-project.org/).

3.2 Results

Note that graph theory results will be referred to as significant only if a significant association occurred across at least three consecutive thresholds for that network/task/metric.

3.2.1 Confirmatory Factor Analysis of ADHD Subtypes

Prior to entering items into the CFA, it was determined that all items had sufficient endorsement and were not highly correlated with one another. Initial CFA with 18 items did not achieve adequate fit (CFI = .87; RMSEA = .05; SRMR = .05). R’s ICLUST function was used to identify variables forming composites. Three pairs of items were found to be redundant; *Can’t concentrate/ pay attention for long* and *Inattentive or easily distracted*, *Confused or seems to be in a fog* and *Stares blankly*, and *Gets hurt a lot/ accident prone* and *Poorly coordinated or clumsy*. Items with greater variability were selected for the model. As a result, three items were removed (*Can’t concentrate/ pay attention for long, Confused or seems to be in a fog*, *Poorly coordinated or clumsy*). Final CFA model included 15 items and achieved adequate fit (CFI = .91, RMSEA = .04, SRMR = .04). Table 9 displays initial and final inattentive and hyperactive/ impulsive factors via the CFA.

Table 9. *CBCL items contributing to the initial and final CFA models*

Inattentive Items	**Hyperactive/Impulsive Items**
Fails to finish things	Acts too young for age
Inattentive or easily distracted	Can't sit still, restless, or hyperactive
Daydreams or gets lost in thoughts	Disobedient at home
Poor schoolwork	Disobedient at school
Stares blankly	Gets hurt a lot, accident prone
Confused or seems to be in a fog*	Impulsive or acts without thinking
Can't concentrate/ pay attention for long*	Nervous movements or twitching
	Unusually loud
	Showing off or clowning
	Talks too much
	Poorly coordinated or clumsy *
** Indicates items that were included in the initial model but not in the final model*	
CFA Initial Model Fit: CFI = .87; RMSEA = .05; SRMR = .05	
CFA Final Model: CFI = .91; RMSEA = .04; SRMR = .04	

3.2.2 Distinct subtype characteristics in primary visual networks during reward processing

Inattentive symptoms were significantly associated with reduced small world sigma in the visual II network during the monetary incentive delay task of reward processing ($p < .001$; Table 6a-6c). In contrast, greater hyperactive/impulsive symptoms were associated with *greater* small world sigma in the visual II network during the monetary incentive delay task ($p < .001$; Table 6a-6c). Greater small world properties indicate greater network efficiency by means of tightly interconnected small clusters of nodes with short average path lengths. The inattentive and hyperactive/impulsive factors were not consistently associated with average shortest path, diameter, local efficiency, modularity, or small world metrics in other networks across any other task (Tables 3-7).

3.2.3 Task performance and the latent dimensions

Based on the association between network metrics and inattention and hyperactivity/ impulsivity factors, we next examined the relationship between these ADHD dimensions and behavioral measures derived from the monetary incentive delay reward processing cognitive task. Findings showed that the inattention factor negatively predicted total earnings on the monetary incentive delay task (*p* = .008). However, the hyperactivity/impulsivity factor was not predictive of total earnings on the monetary incentive delay task (*p* = .394).

3.2.4 Sensitivity analyses

Next, sensitivity analyses tested the robustness of the associations between inattention and hyperactivity/impulsivity factors and small world sigma in the visual II network during reward processing. We controlled for medication as well as parent education as a proxy for socioeconomic status (Table 8). Results showed that significance was retained for the inattentive factor (*p* = .008) as well as the hyperactivity/impulsivity factor (*p* = .010). Finally, we examined sex differences in the inattention and hyperactive/impulsivity factors. Males endorsed greater inattentive (*p* <.001) and hyperactive/impulsive features than females (*p* <.001). However, there were no significant interactions between the two factors and sex in visual II small world sigma during the reward processing task (*p-values* ≥ .53).

3.3 Discussion

Study 2 sought to delineate the neurobiological mechanisms of ADHD by examining the functional network topology of two ADHD dimensions—inattention and hyperactivity/impulsivity—in a sample of over 3,000 children from the ABCD Study. This study leveraged local and global graph theory metrics calculated at rest and during tasks of reward processing, inhibition, and working memory. Overall, findings indicated that inattention and hyperactivity/impulsivity features of ADHD largely overlap in functional network properties. However, findings suggest that greater inattentive features were associated with poorer efficiency as measured by lower small worldness in the visual II network during the reward processing task; alternatively, greater hyperactivity/impulsivity features were associated with greater small worldness in the visual II network. Beyond this association, no consistent results were found between network metrics and inattention and hyperactivity/impulsivity dimensions.

Findings suggest largely comparable functional topology across ADHD subtypes. While Study 1 showed broad modularity deficits associated with ADHD, subtypes did not differ in this metric during Study 2. This suggests that modularity may be an overarching feature of ADHD. Clinically, past work has shown cognitive training may alter modularity in typically developing and clinical populations (Gallen & D'Esposito, 2019). Findings from the present study reflect a possible cognitive training target that addresses an explicit deficit across inattentive and hyperactive/impulsive ADHD subtypes. Overall, these null findings suggest that inattentive and hyperactive/impulsive subtypes share similar neural signatures in network topology.

Notably, findings from Study 2 suggest divergent atypical topological features in the visual II network (i.e., the primary visual cortex) associated with inattentive and hyperactive/ impulsive features of ADHD. Past studies have found significant bilaterally reduced gray matter volume only in the early visual cortex in individuals with ADHD (Ahrendts et al., 2011). Further, Xia and colleagues (2014) identified reduced local and nodal efficiency in occipital regions in ADHD (Xia et al., 2014). Yet these studies examine general ADHD, rather than separate subtypes.

Study 2's atypical small world properties in visual areas align with and expand upon the previous structural and functional ADHD literature by identifying unique topological patterns of ADHD subtypes. Subtype distinctions in the visual II network have interesting implications for the origin of ADHD atypicalities. The primary visual cortex supports visual information processing and transfer to specialized parts of the brain, and occipital regions interact with dorsal attention networks in order to maintain and suppress attention as needed (Ahrendts et al., 2011; Posner & Gilbert, 1999; Xia et al., 2014). Impaired function in this network can contribute to failed suppression of irrelevant external stimuli, a feature of inattentive ADHD. In line with Study 2's findings, inattentive features were associated with poorer visual II network efficiency as well as worse behavioral performance on the monetary incentive delay. It is plausible that these findings reflect a processing deficit specific to ADHD's inattentive subtype but not hyperactive/impulsive subtype. Further exploration may be needed to determine whether visual II network abnormalities in ADHD relate to its linkage to the dorsal attentional network.

4. General Discussion

ADHD is among the most common neurodevelopmental conditions, affecting more than six million children nationally (CDC, 2021). In addition to diminished psychosocial, academic, and occupational well-being, estimates suggest societal costs of ADHD are greater than 124 billion dollars in the United States alone (Zhao et al., 2019). While pharmacological interventions exist, treatment response and adverse side effects are significant issues for adherence (Gajria et al., 2014). These economic and humanistic burdens underscore the significance of clarifying ADHD's etiology and potential biological targets.

Diagnosis of ADHD and its subtypes—predominantly inattentive, predominantly hyperactive/impulsive, and a combined profile—relies heavily on self- and observer-reported symptomatology (Regier et al., 2013). Yet this approach neglects the continuous nature of ADHD, in which inattentive and hyperactive/impulsive features exist on a spectrum, rather than discrete groups. Study 1 examined functional network properties associated with continuous orthogonal factors of psychopathology; findings suggest robust neurobiological mechanisms in ADHD. Further parcellation of this factor in Study 2 shows that inattentive and hyperactive/impulsive features of ADHD largely overlap in functional network properties, with the exception of the primary visual network.

Evidence from Study 2 shows neurobiological commonalities of ADHD subtypes, contributing support to the inclusion of subtypes under one broader ADHD diagnosis. However, it is worth noting that some researchers question the optimality of current ADHD subtypes. For example, findings from Karalunas and colleagues (2018) suggest that temperament-based subtypes provide superior classification of ADHD heterogeneity over traditional ADHD classification, as informed by biological mechanisms and data driven techniques (Karalunas et al., 2014). For this reason, future studies may consider moving away from analyses driven by clinical symptomatology. Instead, machine learning techniques can be used to identify neurobiologically-informed subtypes based on network properties and further can be analyzed for similarities in psychopathology and cognitive abilities (Baller et al., 2021; Kaczkurkin et al., 2019).

Several methodological strengths of the present study differ from and extend upon previous network studies. First, both studies presented use a dimensional approach. Study 1's approach operationalizes psychopathology as hierarchically organized, orthogonal continuous factors, granting the ability to identify network properties specific to ADHD and conduct problems after general psychopathology is extracted. This is notable given that our approach accounts for the high rate of comorbidity among psychological disorders and still suggests a shared relationship between ADHD symptoms and conduct problems in terms of network deficits. Study 2's approach extends this work by separating the inattentive and hyperactive/impulsive features of ADHD to further probe for network deficits while remaining in a dimensional framework. This allowed us to uncover a divergence between inattention and hyperactivity/impulsivity in the early visual network. Second, low in-scanner motion is necessary for reliable network estimates; our study's large sample allowed us to implement stringent motion parameters which has not always been the case in previous work. Third, where prior studies report network topology mainly at rest, the present study analyzed topological properties at rest, inhibition, reward processing, and affective working memory conditions to probe varying cognitive demands (Wang et al., 2015). Taken together, our dimensional approach was applied in a large sample of 9-to-10-year-old girls and boys using network metrics derived from four different cognitive conditions. This represents an important advance over prior work by providing both greater power to detect effects and more reliable results.

There are several issues to consider in interpreting the current results. First, decisions surrounding exclusion from analyses were largely based on the degree of in-scanner motion, given the impact of motion on estimates (Satterthwaite et al., 2013). Because hyperactivity is defined by greater motion, the results of the current study may underestimate the actual effects for the upper end of the hyperactivity spectrum. Despite this, the current study still shows a robust link between deficits in network communication and ADHD symptoms. Secondly, this study's cross-sectional design limits our capacity to make inferences about developmental processes or trajectories. Longitudinal analyses of future ABCD Study waves will be useful in tracking changes in ADHD and network efficiency throughout development. Further, Study 2 only modeled two of the three ADHD subtypes. The delineation of subtype mechanisms may have benefited from conceptualizing ADHD as a bifactor model (as in Study 1) in which the general factor reflects the combined presentation, and the specific factors reflect the inattentive, hyperactive, and impulsive features of ADHD. We acknowledge that this could allow for greater specificity of the inattentive and hyperactive/impulsive factors by extracting common variance. Lastly, the effect sizes of the present findings are relatively small in magnitude. However, prior studies using large samples have consistently yielded brain-behavior associations that are small but reliable (Paulus & Thompson, 2019). Ultimately, the current findings lay the foundation for future work on network efficiency deficits in externalizing behaviors including ADHD symptoms and conduct problems by demonstrating these associations in a large, well-defined sample of children.

References

Achenbach, T. (2009). Achenbach System of Empirically Based Assessment (ASEBA): Development, Findings, Theory, and Applications. In *Encyclopedia of Autism Spectrum Disorders*.

Ahrendts, J., Rüsch, N., Wilke, M., Philipsen, A., Eickhoff, S. B., Glauche, V., Perlov, E., Ebert, D., Hennig, J., & Tebartz Van Elst, L. (2011). Visual cortex abnormalities in adults with ADHD: A structural MRI study. *World Journal of Biological Psychiatry*, *12*(4). https://doi.org/10.3109/15622975.2010.518624

Angold, A., Costello, E. J., & Erkanli, A. (1999). Comorbidity. In *J. Child Psychol. Psychiat* (Vol. 40, Issue 1).

Avants, B. B., Epstein, C. L., Grossman, M., & Gee, J. C. (2008). Symmetric diffeomorphic image registration with cross-correlation: Evaluating automated labeling of elderly and neurodegenerative brain. *Medical Image Analysis*, *12*(1). https://doi.org/10.1016/j.media.2007.06.004

Baller, E. B., Kaczkurkin, A. N., Sotiras, A., Adebimpe, A., Bassett, D. S., Calkins, M. E., Chand, G. B., Cui, Z., Gur, R. E., Gur, R. C., Linn, K. A., Moore, T. M., Roalf, D. R., Varol, E., Wolf, D. H., Xia, C. H., Davatzikos, C., & Satterthwaite, T. D. (2021). Neurocognitive and functional heterogeneity in depressed youth. *Neuropsychopharmacology*, *46*(4). https://doi.org/10.1038/s41386-020-00871-w

Barzilay, R., Calkins, M. E., Moore, T. M., Boyd, R. C., Jones, J. D., Benton, T. D., Oquendo, M. A., Gur, R. C., & Gur, R. E. (2019). Neurocognitive functioning in community youth with suicidal ideation: Gender and pubertal effects. *British Journal of Psychiatry*, *215*(3). https://doi.org/10.1192/bjp.2019.55

Baum, G. L., Ciric, R., Roalf, D. R., Betzel, R. F., Moore, T. M., Shinohara, R. T., Kahn, A. E., Vandekar, S. N., Rupert, P. E., Quarmley, M., Cook, P. A., Elliott, M. A., Ruparel, K., Gur, R. E., Gur, R. C., Bassett, D. S., & Satterthwaite, T. D. (2017). Modular Segregation of Structural Brain Networks Supports the Development of Executive Function in Youth. *Current Biology*, *27*(11). https://doi.org/10.1016/j.cub.2017.04.051

Bertolero, M. A., Thomas Yeo, B. T., & D'Esposito, M. (2015). The modular and integrative functional architecture of the human brain. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(49). https://doi.org/10.1073/pnas.1510619112

Bertolero, M. A., Yeo, B. T. T., Bassett, D. S., & D'Esposito, M. (2018). A mechanistic model of connector hubs, modularity and cognition. In *Nature Human Behaviour* (Vol. 2, Issue 10). https://doi.org/10.1038/s41562-018-0420-6

Bornovalova, M. A., Choate, A. M., Fatimah, H., Petersen, K. J., & Wiernik, B. M. (2020). Appropriate Use of Bifactor Analysis in Psychopathology Research: Appreciating Benefits and Limitations. *Biological Psychiatry* (Vol. 88, Issue 1). https://doi.org/10.1016/j.biopsych.2020.01.013

Cardenas-Iniguez, C., Moore, T. M., Kaczkurkin, A. N., Meyer, F. A. C., Satterthwaite, T. D., Fair, D. A., White, T., Blok, E., Applegate, B., Thompson, L. M., Rosenberg, M. D., Hedeker, D., Berman, M. G., & Lahey, B. B. (2021). Direct and Indirect Associations of Widespread Individual Differences in Brain White Matter Microstructure With Executive Functioning and General and Specific Dimensions of Psychopathology in Children. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*. https://doi.org/10.1016/j.bpsc.2020.11.007

Casey, B. J., Cannonier, T., Conley, M. I., Cohen, A. O., Barch, D. M., Heitzeg, M. M., Soules,

M. E., Teslovich, T., Dellarco, D. V., Garavan, H., Orr, C. A., Wager, T. D., Banich, M. T., Speer, N. K., Sutherland, M. T., Riedel, M. C., Dick, A. S., Bjork, J. M., Thomas, K. M., … Dale, A. M. (2018). The Adolescent Brain Cognitive Development (ABCD) study: Imaging acquisition across 21 sites. In *Developmental Cognitive Neuroscience* (Vol. 32). https://doi.org/10.1016/j.dcn.2018.03.001

CDC. (2021). *Data and Statistics About ADHD*. https://www.cdc.gov/ncbddd/adhd/data.html

Chen, Y. L., Tu, P. C., Huang, T. H., Bai, Y. M., Su, T. P., Chen, M. H., & Wu, Y. Te. (2021). Identifying subtypes of bipolar disorder based on clinical and neurobiological characteristics. *Scientific Reports*, *11*(1). https://doi.org/10.1038/s41598-021-96645-5

Cox, R. W. (1996). AFNI: Software for analysis and visualization of functional magnetic resonance neuroimages. *Computers and Biomedical Research*, *29*(3). https://doi.org/10.1006/cbmr.1996.0014

Cubillo, A., & Rubia, K. (2010). Structural and functional brain imaging in adult attention-deficit/ hyperactivity disorder. In *Expert Review of Neurotherapeutics* (Vol. 10, Issue 4, pp. 603–620). https://doi.org/10.1586/ern.10.4

Dalsgaard, S., Thorsteinsson, E., Trabjerg, B. B., Schullehner, J., Plana-Ripoll, O., Brikell, I., Wimberley, T., Thygesen, M., Madsen, K. B., Timmerman, A., Schendel, D., McGrath, J. J., Mortensen, P. B., & Pedersen, C. B. (2020). Incidence Rates and Cumulative Incidences of the Full Spectrum of Diagnosed Mental Disorders in Childhood and Adolescence. *JAMA Psychiatry*, *77*(2). https://doi.org/10.1001/jamapsychiatry.2019.3523

Davis, F. C., Knodt, A. R., Sporns, O., Lahey, B. B., Zald, D. H., Brigidi, B. D., & Hariri, A. R. (2013). Impulsivity and the modular organization of resting-state neural networks. *Cerebral Cortex*, *23*(6), 1444–1452. https://doi.org/10.1093/cercor/bhs126

Durham, E. L., Jeong, H. J., Moore, T. M., Dupont, R. M., Cardenas-Iniguez, C., Cui, Z., Stone, F. E., Berman, M. G., Lahey, B. B., & Kaczkurkin, A. N. (2021). Association of gray matter volumes with general and specific dimensions of psychopathology in children. *Neuropsychopharmacology*, *46*(7), 1333–1339. doi.org/10.1038/s41386-020-00952-w

Esteban, O., Markiewicz, C. J., Blair, R. W., Moodie, C. A., Isik, A. I., Erramuzpe, A., Kent, J. D., Goncalves, M., DuPre, E., Snyder, M., Oya, H., Ghosh, S. S., Wright, J., Durnez, J., Poldrack, R. A., & Gorgolewski, K. J. (2019). fMRIPrep: a robust preprocessing pipeline for functional MRI. *Nature Methods*, *16*(1). https://doi.org/10.1038/s41592-018-0235-4

Fair, D. A., Cohen, A. L., Power, J. D., Dosenbach, N. U. F., Church, J. A., Miezin, F. M., Schlaggar, B. L., & Petersen, S. E. (2009). Functional brain networks develop from a "local to distributed" organization. *PLoS Computational Biology*, *5*(5). https://doi.org/10.1371/journal.pcbi.1000381

Fekete, T., Beacher, F. D. C. C., Cha, J., Rubin, D., & Mujica-Parodi, L. R. (2014). Small-world network properties in prefrontal cortex correlate with predictors of psychopathology risk in young children: A NIRS study. *NeuroImage*, *85*. doi.org/10.1016/j.neuroimage.2013.07.022

Finn, E. S., Shen, X., Scheinost, D., Rosenberg, M. D., Huang, J., Chun, M. M., Papademetris, X., & Constable, R. T. (2015). Functional connectome fingerprinting: Identifying individuals using patterns of brain connectivity. *Nature Neuroscience*, *18*(11). https://doi.org/10.1038/nn.4135

Gajria, K., Lu, M., Sikirica, V., Greven, P., Zhong, Y., Qin, P., & Xie, J. (2014). Adherence, persistence, and medication discontinuation in patients with attention-deficit/hyperactivity disorder - A systematic literature review. In *Neuropsychiatric Disease and Treatment* (Vol. 10). https://doi.org/10.2147/NDT.S65721

Gallen, C. L., & D'Esposito, M. (2019). Brain Modularity: A Biomarker of Intervention-related Plasticity. In *Trends in Cognitive Sciences* (Vol. 23, Issue 4). https://doi.org/10.1016/j.tics.2019.01.014

Garavan, H., Bartsch, H., Conway, K., Decastro, A., Goldstein, R. Z., Heeringa, S., Jernigan, T., Potter, A., Thompson, W., & Zahs, D. (2018). Recruiting the ABCD sample: Design considerations and procedures. *Developmental Cognitive Neuroscience*, *32*, 16–22. https://doi.org/10.1016/j.dcn.2018.04.004

Ghanbari, M., Soussia, M., Jiang, W., Wei, D., Yap, P.-T., Shen, D., & Zhang, H. (2022). Alterations of dynamic redundancy of functional brain subnetworks in Alzheimer's disease and major depression disorders. *NeuroImage: Clinical*, *33*. https://doi.org/10.1016/j.nicl.2021.102917

Gorgolewski, K., Burns, C. D., Madison, C., Clark, D., Halchenko, Y. O., Waskom, M. L., & Ghosh, S. S. (2011). Nipype: A flexible, lightweight and extensible neuroimaging data processing framework in Python. *Frontiers in Neuroinformatics*, *5*. https://doi.org/10.3389/fninf.2011.00013

Greve, D. N., & Fischl, B. (2009). Accurate and robust brain image alignment using boundary-based registration. *NeuroImage*, *48*(1). https://doi.org/10.1016/j.neuroimage.2009.06.060

Griffiths, K. R., Braund, T. A., Kohn, M. R., Clarke, S., Williams, L. M., & Korgaonkar, M. S. (2021). Structural brain network topology underpinning ADHD and response to methylphenidate treatment. *Translational Psychiatry*, *11*(1). doi.org/10.1038/s41398-021-01278-x

Gulban, O. F., Nielson, D., Poldrack, R., Lee, J., Gorgolewski, C., Vanessasaurus, & Ghosh, S. (2019). *poldracklab/pydeface: v2.0.0 Zenodo.*

Hagberg, A. A., Schult, D. A., & Swart, P. J. (2008). Exploring network structure, dynamics, and function using NetworkX. *7th Python in Science Conference (SciPy 2008)*.

Hagler, D., Hatton, S., Makowski, C., Cornejo, M. D., Fair, D., Dick, A. S., Sutherland, M., Casey, B., Barch, D., Harms, M., Watts, R., Bjork, J., Garavan, H., Hilmer, L., Pung, C., Sicat, C., Kuperman, J., Bartsch, H., Xue, F., … Dale, A. (2018). Image processing and analysis methods for the Adolescent Brain Cognitive Development Study. *BioRxiv*. https://doi.org/10.1101/457739

Hawes, S. W., Waller, R., Byrd, A. L., Bjork, J. M., Dick, A. S., Sutherland, M. T., Riedel, M. C., Tobia, M. J., Thomson, N., Laird, A. R., & Gonzalez, R. (2021). Reward processing in children with disruptive behavior disorders and callous-unemotional traits in the ABCD study. *American Journal of Psychiatry*, *178*(4). doi.org/10.1176/appi.ajp.2020.19101092

Hermens, D. F., Redoblado Hodge, M. A., Naismith, S. L., Kaur, M., Scott, E., & Hickie, I. B. (2011). Neuropsychological clustering highlights cognitive differences in young people presenting with depressive symptoms. *Journal of the International Neuropsychological Society*, *17*(2). https://doi.org/10.1017/S1355617710001566

Jackson, D. L., Gillaspy, J. A., & Purc-Stephenson, R. (2009). Reporting Practices in Confirmatory Factor Analysis: An Overview and Some Recommendations. *Psychological Methods*, *14*(1). https://doi.org/10.1037/a0014694

Kaczkurkin, A. N., Park, S. S., Sotiras, A., Moore, T. M., Calkins, M. E., Cieslak, M., Rosen, A. F. G., Ciric, R., Xia, C. H., Cui, Z., Sharma, A., Wolf, D. H., Ruparel, K., Pine, D. S., Shinohara, R. T., Roalf, D. R., Gur, R. C., Davatzikos, C., Gur, R. E., & Satterthwaite, T. D. (2019). Evidence for dissociable linkage of dimensions of psychopathology to brain structure in youths. *American Journal of Psychiatry*, *176*(12).

doi.org/10.1176/appi.ajp.2019.18070835

Karalunas, S. L., Fair, D., Musser, E. D., Aykes, K., Iyer, S. P., & Nigg, J. T. (2014). Subtyping attention-deficit/hyperactivity disorder using temperament dimensions: Toward biologically based nosologic criteria. *JAMA Psychiatry*, *71*(9). doi.org/10.1001/jamapsychiatry.2014.763

Kardan, O., Stier, A. J., Cardenas-Iniguez, C., Pruin, J. C., Schertz, K. E., Deng, Y., Chamberlain, T., Meredith, W. J., Zhang, X., Bowman, J. E., Lakhtakia, T., Tindel, L., Avery, E. W., Lin, Q., Yoo, K., Chun, M. M., Berman, M. G., & Rosenberg, M. D. (2021). Adult neuromarkers of sustained attention and working memory predict inter- and intra-individual differences in these processes in youth. *BioRxiv*.

Kotov, R., Waszczuk, M. A., Krueger, R. F., Forbes, M. K., Watson, D., Clark, L. A., Achenbach, T. M., Althoff, R. R., Ivanova, M. Y., Michael Bagby, R., Brown, T. A., Carpenter, W. T., Caspi, A., Moffitt, T. E., Eaton, N. R., Forbush, K. T., Goldberg, D., Hasin, D., Hyman, S. E., … Zimmerman, M. (2017). The hierarchical taxonomy of psychopathology (HiTOP): A dimensional alternative to traditional nosologies. *Journal of Abnormal Psychology*, *126*(4). https://doi.org/10.1037/abn0000258

Kwon, Y. H., Yoo, K., Nguyen, H., Jeong, Y., & Chun, M. M. (2021). Predicting multilingual effects on executive function and individual connectomes in children: An ABCD study. *Proceedings of the National Academy of Sciences*, *118*(49). doi.org/10.1073/pnas.2110811118

Lahey, B. B., Krueger, R. F., Rathouz, P. J., Waldman, I. D., & Zald, D. H. (2017). A hierarchical causal taxonomy of psychopathology across the life span. *Psychological Bulletin*, *143*(2). https://doi.org/10.1037/bul0000069

Lahey, B. B., Moore, T. M., Kaczkurkin, A. N., & Zald, D. H. (2021). Hierarchical models of psychopathology: empirical support, implications, and remaining issues. *World Psychiatry*, *20*(1). https://doi.org/10.1002/wps.20824

Lee, W., Bindman, J., Ford, T., Glozier, N., Moran, P., Stewart, R., & Hotopf, M. (2007). Bias in psychiatric case-control studies. Literature survey. In *British Journal of Psychiatry* (Vol. 190, Issue MAR.). https://doi.org/10.1192/bjp.bp.106.027250

Martin, J. L. R., Sainz-Pardo, M., Furukawa, T. A., Martin-Sanchez, E., Seoane, T., & Galan, C. (2007). Review: Benzodiazepines in generalized anxiety disorder: Heterogeneity of outcomes based on a systematic review and meta-analysis of clinical trials. In *Journal of Psychopharmacology* (Vol. 21, Issue 7). https://doi.org/10.1177/0269881107077355

McDonald, R. P., & Ho, M. H. R. (2002). Principles and practice in reporting structural equation analyses. *Psychological Methods*, *7*(1). https://doi.org/10.1037/1082-989X.7.1.64

McLeod, K. R., Langevin, L. M., Dewey, D., & Goodyear, B. G. (2016). Atypical within- and between-hemisphere motor network functional connections in children with developmental coordination disorder and attention-deficit/hyperactivity disorder. *NeuroImage: Clinical*, *12*, 157–164. https://doi.org/10.1016/j.nicl.2016.06.019

Mokobane, M., Pillay, B. J., & Meyer, A. (2019). Fine motor deficits and attention deficit hyperdisorder in primary school children. *South African Journal of Psychiatry*, *25*. https://doi.org/10.4102/sajpsychiatry.v25i0.1232

Monroe, S. M., Anderson, S. F., & Harkness, K. L. (2019). Life Stress and Major Depression: The Mysteries of Recurrences. *Psychological Review*. https://doi.org/10.1037/rev0000157

Moore, T. M., Kaczkurkin, A. N., Durham, E. L., Jeong, H. J., McDowell, M. G., Dupont, R. M., Applegate, B., Tackett, J. L., Cardenas-Iniguez, C., Kardan, O., Akcelik, G. N., Stier, A. J., Rosenberg, M. D., Hedeker, D., Berman, M. G., & Lahey, B. B. (2020). Criterion validity and relationships between alternative hierarchical dimensional models of general and specific psychopathology. *Journal of Abnormal Psychology*, *129*(7). https://doi.org/10.1037/abn0000601

Paulus, M. P., & Thompson, W. K. (2019). The Challenges and Opportunities of Small Effects: The New Normal in Academic Psychiatry. In *JAMA Psychiatry*. https://doi.org/10.1001/jamapsychiatry.2018.4540

Posner, M. I., & Gilbert, C. D. (1999). Attention and primary visual cortex. *Proceedings of the National Academy of Sciences of the United States of America*, *96*(6). https://doi.org/10.1073/pnas.96.6.2585

Power, J. D., Cohen, A. L., Nelson, S. M., Wig, G. S., Barnes, K. A., Church, J. A., Vogel, A. C., Laumann, T. O., Miezin, F. M., Schlaggar, B. L., & Petersen, S. E. (2011). Functional Network Organization of the Human Brain. *Neuron*, *72*(4). doi.org/10.1016/j.neuron.2011.09.006

Power, J. D., Mitra, A., Laumann, T. O., Snyder, A. Z., Schlaggar, B. L., & Petersen, S. E. (2014). Methods to detect, characterize, and remove motion artifact in resting state fMRI. *NeuroImage*, *84*. https://doi.org/10.1016/j.neuroimage.2013.08.048

Qian, X., Castellanos, F. X., Uddin, L. Q., Loo, B. R. Y., Liu, S., Koh, H. L., Poh, X. W. W., Fung, D., Guan, C., Lee, T. S., Lim, C. G., & Zhou, J. (2019). Large-scale brain functional network topology disruptions underlie symptom heterogeneity in children with attention-deficit/hyperactivity disorder. *NeuroImage: Clinical*, *21*. doi.org/10.1016/j.nicl.2018.11.010

Regier, D. A., Kuhl, E. A., & Kupfer, D. J. (2013). The DSM-5: Classification and criteria changes. *World Psychiatry*, *12*(2). https://doi.org/10.1002/wps.20050

Rodriguez, A., Reise, S. P., & Haviland, M. G. (2016). Evaluating bifactor models: Calculating and interpreting statistical indices. *Psychological Methods*, *21*(2). doi.org/10.1037/met0000045

Rosenberg, M. D., Finn, E. S., Scheinost, D., Papademetris, X., Shen, X., Constable, R. T., & Chun, M. M. (2015). A neuromarker of sustained attention from whole-brain functional connectivity. *Nature Neuroscience*, *19*(1). https://doi.org/10.1038/nn.4179

Rosenberg, M. D., Martinez, S. A., Rapuano, K. M., Conley, M. I., Cohen, A. O., Daniela Cornejo, M., Hagler, D. J., Meredith, W. J., Anderson, K. M., Wager, T. D., Feczko, E., Earl, E., Fair, D. A., Barch, D. M., Watts, R., & Casey, B. J. (2020). Behavioral and Neural Signatures of Working Memory in Childhood. *Journal of Neuroscience*, *40*(26). https://doi.org/10.1523/JNEUROSCI.2841-19.2020

Rubinov, M., & Sporns, O. (2010). Complex network measures of brain connectivity: Uses and interpretations. *NeuroImage*, *52*(3). https://doi.org/10.1016/j.neuroimage.2009.10.003

Saberi, M., Khosrowabadi, R., Khatibi, A., Misic, B., & Jafari, G. (2021). Requirement to change of functional brain network across the lifespan. *PLoS ONE*, *16*(11 November). https://doi.org/10.1371/journal.pone.0260091

Sato, J. R., Takahashi, D. Y., Hoexter, M. Q., Massirer, K. B., & Fujita, A. (2013). Measuring network's entropy in ADHD: A new approach to investigate neuropsychiatric disorders. *NeuroImage*, *77*. https://doi.org/10.1016/j.neuroimage.2013.03.035

Satterthwaite, T. D., Wolf, D. H., Ruparel, K., Erus, G., Elliott, M. A., Eickhoff, S. B., Gennatas, E. D., Jackson, C., Prabhakaran, K., Smith, A., Hakonarson, H., Verma, R., Davatzikos, C., Gur, R. E., & Gur, R. C. (2013). Heterogeneous impact of motion on fundamental patterns of developmental changes in functional connectivity during youth. *NeuroImage, 83*. https://doi.org/10.1016/j.neuroimage.2013.06.045

Schoorl, J., van Rijn, S., de Wied, M., van Goozen, S., & Swaab, H. (2018). Boys with Oppositional Defiant Disorder/Conduct Disorder Show Impaired Adaptation During Stress: An Executive Functioning Study. *Child Psychiatry and Human Development*, *49*(2). https://doi.org/10.1007/s10578-017-0749-5

Shen, X., Tokoglu, F., Papademetris, X., & Constable, R. T. (2013). Groupwise whole-brain parcellation from resting-state fMRI data for network node identification. *NeuroImage*, *82*. https://doi.org/10.1016/j.neuroimage.2013.05.081

Sinyor, M., Schaffer, A., & Levitt, A. (2010). The Sequenced Treatment Alternatives to Relieve Depression (STAR*D) trial: A review. In *Canadian Journal of Psychiatry* (Vol. 55, Issue 3). https://doi.org/10.1177/070674371005500303

Sporns, O. (2018). Graph theory methods: Applications in brain networks. *Dialogues in Clinical Neuroscience*, *20*(2). https://doi.org/10.31887/DCNS.2018.20.2/OSPORNS

Sporns, O., & Betzel, R. F. (2016). Modular brain networks. *Annual Review of Psychology*.

Sripada, C. S., Kessler, D., & Angstadt, M. (2014). Lag in maturation of the brain's intrinsic functional architecture in attention-deficit/hyperactivity disorder. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(39). https://doi.org/10.1073/pnas.1407787111

Stier, A. J., Cardenas-Iniguez, C., Kardan, O., Moore, T. M., Meyer, F. A. C., Rosenberg, M. D., Kaczkurkin, A. N., Lahey, B. B., & Berman, M. G. (2021). A Scale-Free Gradient of Cognitive Resource Disruptions in Childhood Psychopathology. *BioRxiv*.

Thomas Yeo, B. T., Krienen, F. M., Sepulcre, J., Sabuncu, M. R., Lashkari, D., Hollinshead, M., Roffman, J. L., Smoller, J. W., Zöllei, L., Polimeni, J. R., Fisch, B., Liu, H., & Buckner, R. L. (2011). The organization of the human cerebral cortex estimated by intrinsic functional connectivity. *Journal of Neurophysiology*, *106*(3). https://doi.org/10.1152/jn.00338.2011

Tustison, N. J., Avants, B. B., Cook, P. A., Zheng, Y., Egan, A., Yushkevich, P. A., & Gee, J. C. (2010). N4ITK: Improved N3 bias correction. *IEEE Transactions on Medical Imaging*, *29*(6). https://doi.org/10.1109/TMI.2010.2046908

Wang, R., Lin, P., & Wu, Y. (2015). *Exploring Dynamic Temporal-Topological Structure of Brain Network Within ADHD*. https://doi.org/10.1007/978-94-017-9548-7_13

Xia, C. H., Ma, Z., Ciric, R., Gu, S., Betzel, R. F., Kaczkurkin, A. N., Calkins, M. E., Cook, P. A., García de la Garza, A., Vandekar, S. N., Cui, Z., Moore, T. M., Roalf, D. R., Ruparel, K., Wolf, D. H., Davatzikos, C., Gur, R. C., Gur, R. E., Shinohara, R. T., … Satterthwaite, T. D. (2018). Linked dimensions of psychopathology and connectivity in functional brain networks. *Nature Communications*, *9*(1). https://doi.org/10.1038/s41467-018-05317-y

Xia, S., Foxe, J. J., Sroubek, A. E., Branch, C., & Li, X. (2014). Topological organization of the "small-world" visual attention network in children with attention deficit/hyperactivity disorder (ADHD). *Frontiers in Human Neuroscience*, *8*(MAR). https://doi.org/10.3389/fnhum.2014.00162

Zhang, Y., Brady, M., & Smith, S. (2001). Segmentation of brain MR images through a hidden Markov random field model and the expectation-maximization algorithm. *IEEE Transactions on Medical Imaging*, *20*(1). https://doi.org/10.1109/42.906424

Zhao, X., Page, T. F., Altszuler, A. R., Pelham, W. E., Kipp, H., Gnagy, E. M., Coxe, S., Schatz, N. K., Merrill, B. M., Macphee, F. L., & Pelham, W. E. (2019). Family Burden of Raising a Child with ADHD. *Journal of Abnormal Child Psychology*, *47*(8). https://doi.org/10.1007/s10802-019-00518-5

Supplement

Table 2. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and whole-brain Shen modularity across 10%, 16.67% 23%, and 30% thresholds.*

		Study 1									**Study 2**				
	Brain network Threshold 10%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	*β*	p_{fdr}	*β*	p_{fdr}	*β*	p_{fdr}	R^2	*β*	p_{fdr}	*β*	p_{fdr}	R^2
10%	Rest	0.007	.982	-0.051	.064	0.024	.356	-0.081	**.010**	0.07	-0.002	.972	-0.038	.590	0.06
	En-back	0.036	.286	-0.086	**.048**	0.019	.619	-0.130	**.009**	0.14	-0.014	.903	-0.028	.957	0.12
	MID	0.001	.983	-0.106	**.014**	-0.020	.754	-0.140	**.001**	0.15	0.040	.756	-0.116	.320	0.12
	SST	0.072	.079	-0.081	.057	0.000	.995	-0.170	**<.001**	0.09	-0.024	.801	-0.004	.967	0.05
16.67%	Rest	0.004	.982	-0.056	.059	0.022	.356	-0.082	**.010**	0.07	0.004	.972	-0.047	.590	0.06
	En-back	0.043	.252	-0.084	**.048**	0.019	.619	-0.134	**.008**	0.15	-0.030	.903	-0.006	.957	0.12
	MID	0.006	.983	-0.113	**.011**	-0.015	.754	-0.141	**.001**	0.15	0.040	.756	-0.113	.320	0.12
	SST	0.064	.079	-0.083	.057	0.012	.975	-0.165	**<.001**	0.09	-0.028	.801	-0.006	.967	0.05
23%	Rest	-0.001	.982	-0.057	.059	0.024	.356	-0.081	**.010**	0.07	0.009	.972	-0.055	.590	0.06
	En-back	0.047	.252	-0.085	**.048**	0.017	.619	-0.135	**.008**	0.15	-0.046	.903	0.013	.957	0.12
	MID	0.007	.983	-0.114	**.011**	-0.013	.754	-0.142	**.001**	0.15	0.035	.756	-0.108	.320	0.12
	SST	0.062	.079	-0.080	.057	0.020	.975	-0.161	**<.001**	0.09	-0.028	.801	-0.006	.967	0.06
30%	Rest	-0.003	.982	-0.058	.059	0.024	.356	-0.080	**.010**	0.06	0.012	.972	-0.061	.590	0.06
	En-back	0.049	.252	-0.085	**.048**	0.016	.619	-0.136	**.008**	0.14	-0.051	.903	0.021	.957	0.12
	MID	0.008	.983	-0.115	**.011**	-0.010	.754	-0.141	**.001**	0.15	0.033	.756	-0.107	.320	0.12
	SST	0.060	.079	-0.079	.057	0.024	.975	-0.159	**<.001**	0.09	-0.024	.801	-0.012	.967	0.06

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 3a. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network local efficiency at threshold 10%*

	Brain network Threshold 10%	**Study 1** General		Specific Conduct		Specific Internalizing		Specific ADHD			**Study 2** Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.008	.977	-0.062	.432	0.027	.696	-0.131	**<.001**	0.05	0.089	.645	-0.152	.392	0.04
	Motor	-0.004	.977	0.032	.781	0.047	.563	-0.104	.091	0.04	-0.106	.645	0.061	.764	0.03
	Medial Frontal	-0.016	.977	-0.075	.472	0.014	.878	-0.025	.781	0.01	0.132	.645	-0.173	.550	0.01
	Frontoparietal	0.151	.52	-0.168	.432	0.047	.878	-0.303	.091	0.21	0.325	.645	-0.373	.550	0.09
	Default Mode	-0.001	.977	0.095	.432	-0.055	.563	-0.016	.781	0.04	-0.073	.753	0.072	.764	0.03
	Visual 2	-0.039	.520	0.006	.977	0.004	.878	0.039	.390	0.05	0.119	.645	-0.130	.392	0.05
	Visual 1	0.002	.977	0.013	.977	0.044	.563	-0.036	.557	0.03	-0.038	.821	0.013	.918	0.03
	Visual Association	0.036	.977	0.002	.979	-0.023	.878	-0.072	.390	0.03	0.012	.918	-0.012	.918	0.02
En-back	Subcortical Cerebellar	0.038	.958	-0.002	.997	-0.012	.757	-0.130	.144	0.06	-0.200	.268	0.178	.349	0.05
	Motor	0.008	.958	0.092	.549	0.034	.702	-0.133	.200	0.06	-0.170	.412	0.112	.571	0.04
	Medial Frontal	0.120	.958	-0.107	.674	0.059	.702	-0.131	.377	0.10	0.211	.437	-0.213	.527	0.06
	Frontoparietal	-0.046	.958	-0.043	.997	-0.054	.702	-0.293	.200	0.16	-0.675	.248	0.537	.323	0.18
	Default Mode	-0.017	.958	0.133	.549	0.098	.680	0.009	.904	0.12	-0.233	.285	0.264	.323	0.11
	Visual 2	0.016	.958	0.000	.997	0.029	.702	0.031	.648	0.07	0.335	**.040**	-0.314	.072	0.09
	Visual 1	0.002	.958	0.091	.549	-0.025	.702	0.065	.377	0.03	0.195	.268	-0.159	.349	0.02
	Visual Association	0.004	.958	0.074	.674	-0.039	.702	0.089	.377	0.08	0.146	.437	-0.063	.736	0.07
MID	Subcortical Cerebellar	0.049	.474	-0.135	**.024**	0.041	.475	-0.081	.752	0.09	0.235	.216	-0.257	.136	0.08
	Motor	-0.029	.869	-0.003	.965	0.031	.587	-0.032	.896	0.02	-0.051	.750	0.004	.979	0.02
	Medial Frontal	-0.227	**.024**	0.331	**.008**	0.222	**.032**	-0.005	.962	0.26	-0.102	.750	-0.107	.824	0.09
	Frontoparietal	0.194	.059	0.128	.414	-0.085	.496	0.100	.752	0.27	0.084	.750	0.128	.824	0.23
	Default Mode	0.142	**.024**	-0.040	.655	0.072	.298	-0.072	.752	0.13	-0.128	.750	0.201	.432	0.11
	Visual 2	-0.005	.903	-0.141	**.024**	0.065	.298	-0.003	.962	0.07	0.181	.412	-0.207	.268	0.06
	Visual 1	0.011	.896	0.014	.899	0.057	.298	0.053	.752	0.03	0.077	.750	-0.057	.824	0.02
	Visual Association	0.022	.896	0.079	.424	-0.030	.696	0.040	.896	0.07	-0.154	.750	0.201	.662	0.07
SST	Subcortical Cerebellar	-0.022	.840	-0.013	.950	0.059	.648	-0.092	.222	0.04	0.001	.992	-0.071	.859	0.03
	Motor	-0.009	.856	0.234	**<.001**	0.021	.939	0.092	.258	0.08	0.237	.524	-0.198	.859	0.03
	Medial Frontal	0.054	.840	0.008	.950	0.006	.939	-0.297	**<.001**	0.13	-0.312	.524	0.241	.859	0.07
	Frontoparietal	0.063	.840	-0.157	.420	0.186	.648	-0.172	.372	0.33	0.192	.938	-0.262	.859	0.27
	Default Mode	0.067	.840	-0.059	.752	0.018	.939	-0.067	.449	0.07	-0.010	.992	0.011	.944	0.05
	Visual 2	0.078	.840	0.053	.752	0.019	.939	0.016	.783	0.04	0.038	.992	0.057	.859	0.04
	Visual 1	0.040	.840	-0.005	.950	-0.004	.939	-0.104	.222	0.06	-0.125	.938	0.109	.859	0.06
	Visual Association	0.019	.840	-0.038	.950	-0.043	.939	-0.135	.222	0.04	-0.104	.938	0.058	.863	0.02

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 3b. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network local efficiency at threshold 16.67%*

		Study 1									**Study 2**				
	Brain network Threshold 16.67%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.016	.582	-0.037	.485	0.037	.824	-0.078	.096	0.06	0.010	.884	-0.072	.674	0.05
	Motor	0.049	.168	-0.025	.654	0.034	.824	-0.113	**.008**	0.07	-0.083	.783	0.068	.674	0.05
	Medial Frontal	0.059	.168	-0.061	.485	0.002	.952	-0.081	.125	0.03	-0.053	.783	0.050	.674	0.02
	Frontoparietal	0.042	.279	0.015	.842	-0.010	.901	-0.059	.347	0.07	-0.062	.783	0.076	.674	0.07
	Default Mode	0.050	.168	-0.057	.485	-0.007	.901	-0.025	.601	0.05	0.070	.783	-0.050	.674	0.04
	Visual 2	-0.043	.170	-0.036	.538	-0.008	.901	0.051	.230	0.04	0.135	.592	-0.147	.344	0.04
	Visual 1	0.008	.799	0.015	.842	-0.019	.901	-0.003	.946	0.03	-0.058	.783	0.040	.674	0.03
	Visual Association	-0.045	.214	0.003	.933	0.009	.901	-0.024	.601	0.03	-0.012	.884	-0.035	.674	0.03
En-back	Subcortical Cerebellar	0.066	.616	-0.026	.749	-0.029	.906	-0.106	.096	0.07	-0.085	.581	0.090	.559	0.05
	Motor	0.049	.616	-0.006	.904	-0.026	.906	-0.153	**.024**	0.05	-0.213	.252	0.170	.360	0.04
	Medial Frontal	-0.014	.819	0.037	.749	0.020	.906	-0.008	.919	0.03	-0.242	.382	0.239	.384	0.05
	Frontoparietal	0.019	.819	-0.152	.184	0.012	.906	-0.110	.264	0.06	-0.160	.422	0.097	.559	0.02
	Default Mode	0.029	.819	-0.053	.749	-0.003	.938	-0.066	.420	0.09	-0.075	.603	0.068	.569	0.08
	Visual 2	0.021	.819	0.022	.749	0.046	.906	0.026	.816	0.06	0.220	.252	-0.194	.360	0.07
	Visual 1	-0.010	.819	0.025	.749	-0.033	.906	0.045	.664	0.01	0.201	.269	-0.193	.360	0.01
	Visual Association	0.059	.616	0.037	.749	-0.018	.906	0.005	.919	0.04	-0.031	.812	0.105	.559	0.04
MID	Subcortical Cerebellar	0.054	.443	-0.097	.300	0.022	.826	-0.089	.504	0.09	0.142	.490	-0.160	.396	0.07
	Motor	-0.054	.443	-0.002	.960	-0.033	.682	0.011	.945	0.04	0.064	.713	-0.115	.544	0.04
	Medial Frontal	-0.035	.643	0.071	.592	0.012	.826	-0.016	.945	0.03	-0.211	.490	0.158	.544	0.03
	Frontoparietal	0.057	.443	-0.019	.935	0.021	.826	0.001	.987	0.03	0.079	.713	-0.045	.925	0.03
	Default Mode	0.042	.443	0.019	.935	0.064	.682	-0.035	.945	0.06	-0.139	.490	0.151	.544	0.06
	Visual 2	0.018	.643	-0.071	.315	0.044	.682	-0.022	.945	0.06	0.241	.160	-0.252	.112	0.07
	Visual 1	0.039	.443	-0.010	.935	-0.008	.826	-0.014	.945	0.03	0.040	.713	-0.015	.925	0.03
	Visual Association	0.022	.643	-0.109	.300	-0.046	.682	-0.043	.945	0.06	-0.041	.713	0.011	.925	0.04
SST	Subcortical Cerebellar	-0.030	.685	-0.028	.899	0.107	**.024**	-0.072	.365	0.06	0.039	.893	-0.111	.678	0.05
	Motor	0.013	.861	0.014	.950	0.011	.781	-0.009	.860	0.03	0.113	.856	-0.114	.678	0.04
	Medial Frontal	-0.112	.104	-0.075	.747	0.016	.781	-0.113	.232	0.05	-0.104	.856	-0.031	.951	0.04
	Frontoparietal	0.042	.685	0.008	.950	0.092	.267	0.030	.754	0.04	-0.159	.856	0.194	.678	0.04
	Default Mode	0.034	.685	-0.027	.899	0.011	.781	-0.063	.448	0.05	0.015	.893	-0.026	.951	0.05
	Visual 2	0.024	.729	0.058	.747	0.013	.781	-0.049	.486	0.03	-0.095	.856	0.103	.678	0.03
	Visual 1	0.064	.560	-0.003	.950	-0.032	.781	-0.034	.754	0.01	-0.033	.893	0.070	.909	0.01
	Visual Association	0.006	.900	-0.061	.747	0.073	.267	-0.107	.252	0.04	-0.045	.893	-0.008	.953	0.03

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 3c. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network local efficiency at threshold 23%*

		Study 1									**Study 2**				
	Brain network Threshold 23%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	*β*	p_{fdr}	*β*	p_{fdr}	*β*	p_{fdr}	R^2	*β*	p_{fdr}	*β*	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.029	.387	-0.043	.365	0.035	.520	-0.061	.232	0.06	0.039	.781	-0.105	.392	0.06
	Motor	0.033	.378	-0.008	.882	0.045	.464	-0.106	**.008**	0.06	-0.055	.781	0.035	.707	0.05
	Medial Frontal	-0.001	.965	-0.019	.788	0.008	.887	-0.043	.520	0.02	0.001	.986	-0.026	.749	0.02
	Frontoparietal	0.012	.857	0.049	.365	-0.015	.877	-0.014	.685	0.06	-0.098	.781	0.111	.392	0.06
	Default Mode	0.033	.378	-0.026	.699	0.003	.893	-0.017	.685	0.05	-0.030	.781	0.046	.707	0.05
	Visual 2	-0.032	.378	-0.057	.365	0.008	.887	0.036	.520	0.04	0.148	.344	-0.168	.144	0.04
	Visual 1	-0.003	.965	-0.025	.699	-0.034	.549	-0.014	.685	0.03	-0.058	.781	0.040	.707	0.03
	Visual Association	-0.049	.378	-0.004	.887	0.022	.834	0.023	.685	0.03	0.030	.781	-0.062	.707	0.03
En-back	Subcortical Cerebellar	0.065	.288	-0.050	.436	-0.014	.754	-0.131	**.024**	0.08	-0.103	.467	0.097	.530	0.06
	Motor	0.014	.867	0.030	.624	-0.025	.728	-0.099	.152	0.05	-0.198	.224	0.160	.386	0.05
	Medial Frontal	0.035	.650	-0.036	.624	-0.037	.728	0.024	.836	0.02	-0.06	.737	0.084	.701	0.02
	Frontoparietal	-0.012	.867	-0.095	.144	0.026	.728	-0.009	.836	0.03	0.110	.467	-0.133	.386	0.02
	Default Mode	0.054	.376	-0.086	.144	-0.017	.754	-0.087	.267	0.09	-0.060	.737	0.050	.726	0.07
	Visual 2	-0.006	.871	0.011	.811	0.035	.728	0.012	.836	0.04	0.238	.224	-0.255	.200	0.06
	Visual 1	0.065	.288	-0.109	.144	-0.038	.728	-0.039	.836	0.02	0.201	.224	-0.184	.386	0.01
	Visual Association	0.041	.650	0.030	.624	0.011	.779	0.022	.836	0.02	0.001	.993	0.046	.726	0.02
MID	Subcortical Cerebellar	0.022	.713	-0.120	.056	0.034	.676	-0.135	**.016**	0.12	-0.017	.867	-0.047	.734	0.09
	Motor	-0.057	.378	-0.002	.957	-0.011	.933	0.000	.999	0.04	0.068	.611	-0.120	.418	0.04
	Medial Frontal	-0.015	.834	-0.072	.402	-0.004	.933	-0.103	.168	0.03	-0.191	.340	0.096	.637	0.03
	Frontoparietal	0.049	.378	-0.072	.387	-0.012	.933	-0.004	.999	0.03	0.100	.536	-0.073	.637	0.03
	Default Mode	0.054	.378	-0.007	.957	0.054	.517	-0.059	.406	0.07	-0.158	.340	0.164	.418	0.07
	Visual 2	0.001	.973	-0.066	.387	0.048	.517	-0.035	.572	0.06	0.226	.184	-0.252	.104	0.07
	Visual 1	0.044	.378	-0.045	.428	-0.005	.933	-0.095	.096	0.03	-0.018	.867	0.001	.996	0.02
	Visual Association	0.023	.713	-0.058	.402	-0.052	.517	-0.042	.572	0.04	-0.138	.340	0.131	.418	0.04
SST	Subcortical Cerebellar	-0.039	.469	-0.058	.539	0.065	.464	-0.067	.372	0.07	0.191	.496	-0.282	**.040**	0.07
	Motor	0.030	.579	0.002	.965	0.037	.585	-0.004	.929	0.04	0.016	.912	0.001	.995	0.04
	Medial Frontal	-0.052	.469	-0.045	.539	0.008	.851	-0.099	.372	0.03	-0.040	.912	-0.047	.955	0.02
	Frontoparietal	0.085	.264	-0.042	.539	0.047	.585	0.043	.445	0.05	0.014	.912	0.070	.826	0.04
	Default Mode	0.038	.469	-0.036	.539	0.028	.585	-0.043	.445	0.07	0.081	.912	-0.084	.826	0.06
	Visual 2	0.022	.655	0.040	.539	0.027	.585	-0.058	.372	0.03	-0.082	.912	0.079	.826	0.03
	Visual 1	0.049	.469	0.005	.965	0.011	.851	-0.048	.445	0.02	0.013	.912	0.001	.995	0.01
	Visual Association	0.001	.981	-0.044	.539	0.057	.464	-0.093	.372	0.04	0.031	.912	-0.095	.826	0.03

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 3d. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network local efficiency at threshold 30%*

		Study 1									**Study 2**				
	Brain network Threshold 30%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.026	.371	-0.060	.296	0.028	.402	-0.070	.088	0.08	0.057	.613	-0.125	.203	0.07
	Motor	0.032	.371	-0.012	.868	0.035	.397	-0.109	**.008**	0.06	-0.101	.387	0.079	.360	0.05
	Medial Frontal	-0.028	.371	-0.018	.868	0.022	.402	0.005	.987	0.02	0.069	.613	-0.098	.308	0.02
	Frontoparietal	0.047	.371	0.041	.435	-0.049	.296	-0.040	.424	0.05	-0.116	.387	0.147	.203	0.05
	Default Mode	0.029	.371	-0.032	.520	0.023	.402	-0.038	.424	0.06	-0.032	.838	0.037	.789	0.05
	Visual 2	-0.019	.480	-0.058	.320	0.002	.938	0.005	.987	0.03	0.108	.387	-0.127	.203	0.03
	Visual 1	-0.007	.781	-0.006	.868	-0.045	.312	0.012	.987	0.02	-0.021	.838	0.014	.849	0.02
	Visual Association	-0.031	.371	-0.005	.868	0.026	.402	0.001	.987	0.03	-0.015	.838	-0.016	.849	0.03
En-back	Subcortical Cerebellar	0.109	**.016**	-0.039	.802	-0.022	.578	-0.161	**<.001**	0.09	-0.119	.429	0.138	.468	0.06
	Motor	0.016	.758	0.033	.842	-0.024	.578	-0.069	.397	0.04	-0.208	.429	0.191	.320	0.04
	Medial Frontal	0.038	.484	-0.006	.903	-0.010	.786	-0.015	.901	0.01	-0.076	.592	0.086	.468	0.01
	Frontoparietal	0.010	.781	-0.104	.256	0.030	.578	-0.047	.694	0.03	0.124	.429	-0.143	.468	0.02
	Default Mode	0.038	.484	-0.073	.324	-0.037	.578	-0.092	.296	0.08	-0.111	.429	0.094	.468	0.06
	Visual 2	-0.035	.484	0.009	.903	0.053	.578	-0.004	.937	0.05	0.155	.429	-0.197	.320	0.05
	Visual 1	0.080	.108	-0.043	.802	-0.028	.578	-0.019	.901	0.01	0.141	.429	-0.092	.468	0.01
	Visual Association	0.040	.484	0.005	.903	-0.033	.578	-0.032	.838	0.02	-0.064	.592	0.093	.468	0.02
MID	Subcortical Cerebellar	0.001	.969	-0.101	.088	0.035	.516	-0.123	**.024**	0.11	-0.041	.697	-0.034	.871	0.09
	Motor	-0.015	.907	-0.021	.746	0.004	.897	0.018	.651	0.04	0.097	.622	-0.109	.771	0.04
	Medial Frontal	-0.032	.907	-0.029	.711	0.032	.516	-0.142	**.024**	0.04	-0.151	.525	0.032	.871	0.03
	Frontoparietal	0.072	.272	-0.085	.140	0.006	.897	-0.022	.651	0.03	0.058	.697	-0.016	.871	0.02
	Default Mode	0.025	.907	-0.003	.941	0.049	.516	-0.046	.497	0.06	-0.135	.525	0.113	.771	0.06
	Visual 2	-0.003	.969	-0.124	.088	0.039	.516	-0.042	.497	0.07	0.247	.064	-0.282	**.024**	0.07
	Visual 1	0.047	.628	-0.052	.376	-0.028	.516	-0.074	.155	0.04	0.051	.697	-0.052	.871	0.03
	Visual Association	0.018	.907	-0.085	.140	-0.054	.516	-0.057	.384	0.04	-0.068	.697	0.048	.871	0.03
SST	Subcortical Cerebellar	-0.044	.376	-0.089	.288	0.064	.456	-0.068	.396	0.09	0.181	.304	-0.274	**.048**	0.09
	Motor	0.029	.567	-0.015	.805	0.013	.887	-0.046	.469	0.04	-0.100	.423	0.106	.483	0.04
	Medial Frontal	-0.083	.132	-0.034	.728	0.004	.908	-0.101	.312	0.04	-0.100	.423	-0.015	.896	0.04
	Frontoparietal	0.055	.307	-0.008	.863	0.029	.887	0.001	.981	0.04	-0.115	.422	0.164	.301	0.04
	Default Mode	0.044	.376	-0.024	.728	0.020	.887	-0.055	.396	0.06	0.076	.431	-0.087	.501	0.06
	Visual 2	-0.016	.773	0.032	.728	0.010	.887	-0.054	.396	0.03	-0.112	.422	0.074	.501	0.03
	Visual 1	0.123	**.008**	-0.073	.572	0.019	.887	-0.038	.517	0.03	0.186	.304	-0.112	.483	0.02
	Visual Association	-0.010	.773	-0.051	.589	0.012	.887	-0.045	.497	0.03	0.162	.422	-0.209	.301	0.04

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 4a. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network average shortest path length at threshold 10%*

		Study 1									Study 2				
	Brain network Threshold 10%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.034	.419	0.094	**.032**	-0.058	.140	0.077	.224	0.05	-0.054	.803	0.125	.331	0.04
	Motor	0.001	.982	0.067	.411	-0.061	.210	0.064	.248	0.04	-0.116	.803	0.145	.331	0.03
	Medial Frontal	0.013	.914	0.064	.656	-0.043	.561	0.055	.350	0.02	-0.115	.803	0.172	.509	0.02
	Frontoparietal	-0.183	.232	0.429	**<.001**	0.198	.140	-0.070	.325	0.39	0.064	.893	-0.028	.970	0.12
	Default Mode	-0.042	.419	0.021	.830	0.063	.210	-0.046	.358	0.03	0.110	.803	-0.130	.509	0.03
	Visual 2	0.026	.419	-0.024	.677	0.014	.717	-0.033	.358	0.06	-0.167	.264	0.178	.120	0.06
	Visual 1	0.066	.232	0.008	.853	-0.040	.394	0.011	.786	0.04	0.022	.893	0.056	.751	0.04
	Visual Association	-0.044	.419	0.035	.677	0.001	.980	-0.037	.358	0.03	-0.017	.893	-0.005	.970	0.03
En-back	Subcortical Cerebellar	-0.064	.301	0.031	.863	0.059	.532	0.132	**.048**	0.07	0.185	.320	-0.183	.352	0.05
	Motor	-0.041	.742	-0.116	.708	-0.031	.751	0.056	.680	0.08	0.167	.676	-0.186	.552	0.07
	Medial Frontal	-0.184	.301	0.179	.708	0.121	.532	0.109	.680	0.15	-0.149	.763	0.098	.732	0.07
	Frontoparietal	0.103	.630	-0.174	.723	-0.096	.751	0.127	.680	0.20	0.649	**.044**	-0.565	.120	0.22
	Default Mode	0.084	.301	-0.045	.863	-0.045	.751	-0.018	.999	0.05	-0.063	.763	0.121	.714	0.04
	Visual 2	0.014	.863	-0.005	.999	-0.024	.751	-0.003	.999	0.08	-0.298	**.044**	0.321	.056	0.10
	Visual 1	-0.014	.863	-0.028	.863	-0.013	.854	-0.064	.680	0.04	-0.095	.750	0.046	.732	0.04
	Visual Association	-0.081	.999	-0.100	.999	0.019	.999	-0.100	.999	0.09	-0.059	.763	-0.101	.732	0.08
MID	Subcortical Cerebellar	0.005	.999	0.126	.420	-0.022	.790	0.094	.810	0.10	-0.125	.728	0.204	.260	0.09
	Motor	0.033	.999	0.039	.620	0.011	.920	-0.002	.999	0.05	-0.037	.886	0.065	.755	0.05
	Medial Frontal	0.047	.999	-0.064	.999	0.001	.999	0.144	.999	0.08	0.039	.886	0.096	.755	0.07
	Frontoparietal	-0.240	.180	0.177	.620	0.214	.250	-0.085	.999	0.24	-0.282	.728	0.084	.755	0.14
	Default Mode	-0.121	.180	0.093	.620	0.043	.790	0.108	.860	0.07	0.023	.886	-0.073	.755	0.04
	Visual 2	-0.004	.999	0.117	.520	-0.075	.250	-0.001	.999	0.06	-0.190	.496	0.197	.260	0.05
	Visual 1	0.009	.999	-0.056	.620	-0.024	.790	-0.007	.999	0.03	-0.052	.886	0.060	.755	0.03
	Visual Association	-0.100	.576	-0.083	.620	0.084	.790	-0.086	.999	0.07	0.162	.886	-0.304	.520	0.07
SST	Subcortical Cerebellar	0.042	.880	0.114	.128	-0.096	.136	0.121	.148	0.07	-0.117	.694	0.232	.471	0.05
	Motor	0.019	.880	-0.035	.904	-0.085	.232	0.030	.874	0.05	-0.065	.739	0.118	.471	0.04
	Medial Frontal	0.028	.880	0.058	.904	0.034	.950	0.256	.104	0.12	-0.076	.739	0.221	.471	0.07
	Frontoparietal	-0.030	.880	0.062	.904	-0.238	.232	0.120	.874	0.23	0.206	.694	-0.215	.471	0.17
	Default Mode	-0.011	.880	0.161	.164	0.01	.950	-0.028	.874	0.04	-0.225	.694	0.226	.471	0.03
	Visual 2	-0.065	.880	0.003	.967	-0.015	.950	0.009	.881	0.03	-0.064	.739	0.002	.983	0.03
	Visual 1	-0.016	.880	-0.023	.904	0.004	.950	0.020	.874	0.05	-0.051	.739	0.042	.891	0.05
	Visual Association	-0.036	.880	0.021	.904	0.036	.950	0.141	.171	0.03	0.288	.694	-0.250	.471	0.03

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 4b. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network average shortest path length at threshold 16.7%*

		Study 1									**Study 2**				
	Brain network Threshold 16.67%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.017	.821	0.055	.560	-0.021	.545	0.077	.224	0.04	-0.052	.958	0.116	.301	0.04
	Motor	0.012	.821	0.014	.768	-0.045	.32	0.064	.248	0.05	-0.016	.977	0.065	.618	0.05
	Medial Frontal	-0.026	.821	0.044	.632	-0.010	.741	0.055	.350	0.02	0.022	.977	-0.005	.959	0.02
	Frontoparietal	-0.020	.821	-0.051	.632	0.036	.545	-0.070	.325	0.03	0.007	.977	-0.061	.743	0.03
	Default Mode	0.005	.960	0.021	.768	0.029	.545	-0.046	.358	0.02	0.002	.977	-0.009	.959	0.02
	Visual 2	0.026	.821	0.034	.632	0.021	.545	-0.033	.358	0.04	-0.166	.192	0.169	.136	0.05
	Visual 1	0.001	.960	0.018	.768	0.060	.312	0.011	.786	0.02	0.108	.491	-0.086	.570	0.02
	Visual Association	0.050	.821	-0.001	.974	-0.017	.643	-0.037	.358	0.03	-0.127	.476	0.156	.228	0.03
En-back	Subcortical Cerebellar	-0.072	.360	0.024	.978	-0.003	.934	0.083	.592	0.06	0.092	.592	-0.107	.531	0.05
	Motor	-0.001	.985	-0.042	.978	-0.029	.934	0.014	.896	0.04	0.172	.346	-0.164	.370	0.05
	Medial Frontal	-0.047	.602	-0.002	.978	-0.016	.934	0.086	.896	0.02	0.253	.346	-0.272	.370	0.03
	Frontoparietal	0.013	.912	0.092	.788	-0.031	.934	-0.020	.896	0.06	-0.079	.646	0.105	.567	0.05
	Default Mode	0.035	.602	0.001	.978	0.004	.934	0.000	.999	0.02	0.083	.592	-0.065	.615	0.02
	Visual 2	0.024	.763	-0.016	.978	-0.049	.934	0.015	.896	0.06	-0.225	.344	0.257	.192	0.07
	Visual 1	-0.034	.602	0.013	.978	0.021	.934	-0.016	.896	0.03	-0.197	.346	0.165	.370	0.04
	Visual Association	-0.049	.602	-0.116	.304	0.004	.934	-0.045	.896	0.03	-0.021	.886	-0.065	.661	0.02
MID	Subcortical Cerebellar	-0.041	.645	0.124	.080	-0.008	.822	0.094	.432	0.11	-0.169	.336	0.202	.152	0.09
	Motor	0.055	.645	0.033	.537	0.010	.822	0.006	.897	0.08	-0.117	.416	0.165	.203	0.08
	Medial Frontal	0.008	.866	-0.063	.537	0.042	.822	0.080	.452	0.03	0.163	.416	-0.101	.823	0.02
	Frontoparietal	-0.036	.760	-0.065	.435	0.042	.822	-0.055	.595	0.04	-0.052	.677	-0.009	.946	0.04
	Default Mode	-0.013	.848	-0.083	.152	0.015	.822	0.027	.744	0.03	0.070	.677	-0.066	.823	0.02
	Visual 2	-0.018	.848	0.064	.256	-0.020	.822	0.019	.761	0.06	-0.236	.120	0.238	.112	0.07
	Visual 1	-0.025	.760	-0.018	.722	0.014	.822	0.044	.595	0.02	-0.064	.677	0.057	.823	0.02
	Visual Association	-0.057	.645	0.111	.176	0.061	.822	0.067	.573	0.05	0.051	.677	-0.039	.846	0.03
SST	Subcortical Cerebellar	0.036	.820	0.100	.152	-0.073	.320	0.119	.056	0.08	-0.134	.645	0.241	.144	0.07
	Motor	0.049	.760	0.038	.639	-0.051	.472	0.078	.269	0.09	-0.043	.760	0.142	.677	0.09
	Medial Frontal	0.139	**.016**	0.094	.152	-0.021	.935	0.186	**<.001**	0.08	0.157	.645	0.044	.847	0.05
	Frontoparietal	-0.017	.979	0.059	.639	-0.013	.935	-0.009	.881	0.06	0.062	.760	-0.096	.735	0.06
	Default Mode	-0.024	.867	-0.008	.860	-0.002	.953	-0.039	.491	0.01	-0.128	.645	0.099	.735	0.02
	Visual 2	-0.004	.979	-0.040	.639	-0.027	.935	0.049	.487	0.03	0.075	.749	-0.063	.735	0.03
	Visual 1	-0.034	.820	-0.026	.677	0.017	.935	-0.053	.487	0.02	-0.037	.760	-0.009	.943	0.01
	Visual Association	-0.001	.979	0.065	.416	-0.071	.360	0.078	.362	0.04	-0.092	.749	0.141	.677	0.03

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 4c. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network average shortest path length at threshold 23%*

		Study 1									**Study 2**				
	Brain network Threshold 23%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.022	.918	0.058	.368	-0.033	.456	0.073	.104	0.06	-0.041	.805	0.108	.392	0.05
	Motor	0.002	.929	0.015	.957	-0.045	.304	0.070	.104	0.07	-0.024	.805	0.064	.545	0.06
	Medial Frontal	0.013	.918	0.012	.957	-0.013	.719	-0.006	.857	0.01	-0.054	.805	0.070	.545	0.01
	Frontoparietal	0.007	.918	-0.033	.829	0.015	.719	-0.048	.413	0.04	0.082	.792	-0.102	.392	0.04
	Default Mode	0.007	.918	0.000	.991	0.003	.912	-0.022	.691	0.02	0.018	.805	-0.017	.821	0.02
	Visual 2	0.008	.918	0.035	.829	0.017	.719	-0.013	.782	0.04	-0.179	.096	0.183	.064	0.05
	Visual 1	-0.013	.918	-0.023	.957	0.048	.304	-0.044	.413	0.02	0.024	.805	-0.051	.570	0.02
	Visual Association	0.024	.918	0.007	.957	-0.028	.590	-0.037	.413	0.02	-0.094	.772	0.097	.392	0.02
En-back	Subcortical Cerebellar	-0.092	.072	0.043	.529	0.019	.842	0.104	.176	0.08	0.048	.659	-0.066	.543	0.06
	Motor	0.011	.989	-0.040	.529	-0.018	.842	0.026	.984	0.06	0.095	.453	-0.068	.543	0.06
	Medial Frontal	-0.007	.989	-0.069	.529	0.008	.842	0.019	.984	0.01	0.273	.256	-0.273	.132	0.03
	Frontoparietal	0.081	.144	0.041	.529	-0.007	.842	-0.080	.288	0.06	-0.120	.387	0.148	.344	0.05
	Default Mode	0.000	.989	-0.015	.839	0.018	.842	0.023	.984	0.02	0.108	.453	-0.097	.543	0.02
	Visual 2	0.034	.804	-0.054	.529	-0.043	.842	0.000	.992	0.06	-0.189	.277	0.235	.132	0.07
	Visual 1	-0.046	.496	0.048	.529	0.026	.842	0.002	.992	0.02	-0.165	.304	0.132	.394	0.02
	Visual Association	-0.006	.989	-0.008	.874	-0.015	.842	-0.092	.323	0.02	-0.233	.277	0.189	.344	0.02
MID	Subcortical Cerebellar	-0.002	.961	0.095	.188	-0.023	.704	0.104	.123	0.11	-0.032	.855	0.098	.732	0.09
	Motor	0.028	.961	0.034	.742	0.016	.704	0.030	.741	0.07	-0.049	.855	0.085	.732	0.07
	Medial Frontal	0.039	.961	0.048	.710	0.015	.720	0.096	.123	0.02	0.168	.408	-0.066	.796	0.02
	Frontoparietal	-0.014	.961	-0.007	.996	0.084	.064	-0.012	.830	0.06	-0.038	.855	0.008	.965	0.05
	Default Mode	-0.021	.961	-0.067	.301	0.023	.704	0.057	.426	0.04	0.194	.304	-0.181	.432	0.04
	Visual 2	-0.011	.961	0.088	.188	-0.017	.704	0.010	.830	0.05	-0.262	**.048**	0.270	**.040**	0.06
	Visual 1	-0.017	.961	0.000	.996	0.021	.704	0.091	.123	0.04	0.014	.898	0.005	.965	0.03
	Visual Association	-0.002	.961	0.009	.996	0.056	.544	0.026	.747	0.03	0.068	.855	-0.059	.796	0.03
SST	Subcortical Cerebellar	0.050	.662	0.098	.144	-0.062	.576	0.101	.085	0.08	-0.218	.256	0.333	**.008**	0.08
	Motor	0.007	.918	0.053	.350	-0.026	.928	0.095	.085	0.09	0.103	.693	-0.040	.885	0.08
	Medial Frontal	0.081	.352	0.058	.350	-0.005	.962	0.132	**.048**	0.04	0.033	.881	0.098	.885	0.03
	Frontoparietal	-0.028	.810	0.060	.350	-0.018	.962	-0.069	.298	0.06	-0.089	.693	0.033	.885	0.05
	Default Mode	-0.037	.662	-0.023	.620	0.028	.928	-0.012	.853	0.01	0.016	.881	-0.046	.885	0.01
	Visual 2	0.004	.918	-0.052	.400	-0.041	.928	0.060	.298	0.03	0.079	.693	-0.046	.885	0.03
	Visual 1	-0.035	.662	-0.036	.458	-0.004	.962	-0.009	.853	0.02	-0.036	.881	0.011	.917	0.01
	Visual Association	0.016	.879	0.071	.350	-0.002	.962	0.064	.301	0.04	-0.118	.693	0.187	.500	0.04

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 4d. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network average shortest path length at threshold 30%*

		Study 1									**Study 2**				
	Brain network Threshold 30%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.018	.950	0.072	.120	-0.024	.374	0.086	**.028**	0.06	-0.053	.688	0.118	.336	0.05
	Motor	-0.003	.987	0.042	.491	-0.029	.374	0.090	**.028**	0.07	0.036	.688	0.009	.900	0.06
	Medial Frontal	0.023	.950	0.031	.549	-0.034	.374	0.010	.872	0.01	-0.049	.688	0.080	.445	0.01
	Frontoparietal	-0.024	.950	-0.028	.549	0.046	.374	-0.021	.684	0.03	0.040	.688	-0.072	.445	0.03
	Default Mode	0.003	.987	-0.009	.776	-0.005	.839	-0.025	.684	0.02	0.009	.896	-0.015	.900	0.02
	Visual 2	0.008	.987	0.049	.488	0.029	.374	0.002	.938	0.04	-0.153	.216	0.166	.112	0.04
	Visual 1	0.000	.987	-0.019	.776	0.034	.374	-0.046	.547	0.01	0.061	.688	-0.083	.445	0.01
	Visual Association	0.020	.950	0.008	.776	-0.025	.374	-0.025	.684	0.02	-0.094	.688	0.106	.368	0.02
En-back	Subcortical Cerebellar	-0.100	**.040**	0.058	.281	0.025	.688	0.119	.056	0.09	0.103	.367	-0.120	.288	0.06
	Motor	0.006	.908	-0.066	.281	-0.031	.688	0.022	.875	0.06	0.151	.250	-0.138	.288	0.06
	Medial Frontal	-0.024	.721	-0.057	.281	-0.012	.944	-0.012	.875	0.01	0.162	.250	-0.183	.288	0.01
	Frontoparietal	0.024	.721	0.064	.281	0.002	.944	-0.018	.875	0.04	-0.136	.348	0.148	.288	0.04
	Default Mode	-0.004	.908	0.026	.526	0.034	.688	0.053	.875	0.03	0.197	.250	-0.175	.288	0.03
	Visual 2	0.034	.721	-0.057	.281	-0.055	.688	-0.016	.875	0.06	-0.189	.250	0.224	.248	0.07
	Visual 1	-0.046	.704	0.040	.477	0.007	.944	-0.047	.875	0.03	-0.190	.250	0.134	.288	0.03
	Visual Association	-0.032	.721	-0.059	.281	0.044	.688	0.009	.875	0.02	-0.008	.948	-0.036	.775	0.01
MID	Subcortical Cerebellar	0.008	.926	0.082	.268	-0.029	.836	0.095	.144	0.10	-0.029	.876	0.098	.822	0.09
	Motor	0.015	.926	0.032	.766	-0.002	.973	0.015	.795	0.07	-0.059	.876	0.078	.822	0.07
	Medial Frontal	0.000	.999	0.071	.288	0.001	.973	0.109	.144	0.03	0.093	.876	-0.014	.936	0.02
	Frontoparietal	-0.025	.926	0.006	.901	0.057	.608	-0.040	.590	0.05	-0.055	.876	0.009	.936	0.05
	Default Mode	-0.026	.926	-0.058	.408	0.015	.896	0.062	.380	0.04	0.182	.352	-0.166	.516	0.04
	Visual 2	-0.034	.926	0.104	.192	-0.032	.836	0.012	.795	0.06	-0.263	**.048**	0.250	.064	0.06
	Visual 1	-0.024	.926	-0.011	.901	0.021	.890	0.075	.237	0.04	-0.030	.876	0.041	.936	0.03
	Visual Association	-0.009	.926	0.021	.832	0.032	.836	0.028	.689	0.04	0.016	.876	-0.008	.936	0.03
SST	Subcortical Cerebellar	0.047	.386	0.094	.152	-0.059	.664	0.080	.192	0.08	-0.220	.256	0.322	.016	0.08
	Motor	0.013	.942	0.043	.673	-0.034	.931	0.067	.192	0.08	0.141	.400	-0.095	.913	0.08
	Medial Frontal	0.119	**.016**	0.031	.673	0.001	.987	0.105	.160	0.04	0.192	.304	-0.056	.913	0.04
	Frontoparietal	-0.009	.942	0.030	.673	-0.003	.987	-0.040	.544	0.04	-0.010	.922	-0.021	.913	0.03
	Default Mode	-0.050	.386	-0.010	.896	0.015	.987	0.000	.993	0.01	-0.013	.922	-0.011	.913	0.01
	Visual 2	-0.003	.942	-0.042	.673	-0.023	.987	0.086	.160	0.04	0.074	.628	-0.031	.913	0.03
	Visual 1	-0.067	.252	-0.006	.896	0.004	.987	-0.033	.595	0.02	-0.152	.400	0.086	.913	0.02
	Visual Association	0.003	.942	0.047	.673	0.031	.931	0.068	.240	0.03	-0.087	.628	0.133	.913	0.03

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 5a. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network diameter at threshold 10%*

		Study 1									**Study 2**				
	Brain network Threshold 10%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.018	.801	0.021	.801	-0.030	.392	0.071	.224	0.01	0.099	.544	-0.060	.837	0.01
	Motor	0.033	.801	-0.018	.801	-0.055	.288	0.011	.899	0.02	-0.200	.288	0.241	.080	0.03
	Medial Frontal	0.027	.801	0.094	.801	-0.017	.751	-0.020	.899	0.02	-0.247	.528	0.274	.356	0.03
	Frontoparietal	-0.034	.851	0.028	.801	0.393	**<.001**	0.226	.224	0.33	0.189	.785	-0.148	.837	0.13
	Default Mode	-0.006	.863	-0.020	.801	0.082	.152	0.008	.899	0.02	0.081	.785	-0.076	.837	0.02
	Visual 2	0.024	.801	-0.013	.801	0.032	.392	-0.021	.899	0.02	-0.014	.875	0.017	.837	0.02
	Visual 1	0.059	.536	-0.044	.801	-0.044	.392	0.023	.899	0.03	0.041	.785	0.034	.837	0.03
	Visual Association	-0.035	.801	-0.014	.801	0.015	.751	0.060	.699	0.02	-0.054	.785	0.059	.837	0.02
En-back	Subcortical Cerebellar	-0.062	.363	0.008	.996	0.102	**.008**	0.050	.857	0.03	0.182	.424	-0.212	.272	0.02
	Motor	-0.020	.915	-0.003	.996	-0.016	.999	0.022	.864	0.05	-0.012	.942	-0.008	.992	0.05
	Medial Frontal	-0.057	.915	0.163	.421	0.002	.999	0.060	.857	0.10	-0.126	.942	0.171	.704	0.07
	Frontoparietal	0.151	.363	-0.255	.232	0.024	.999	-0.122	.857	0.29	-0.152	.942	0.201	.704	0.21
	Default Mode	0.130	.144	-0.152	.304	0.002	.999	-0.035	.857	0.09	-0.028	.942	0.118	.704	0.06
	Visual 2	-0.005	.915	0.002	.996	-0.024	.999	0.029	.857	0.04	-0.245	.344	0.263	.232	0.05
	Visual 1	0.006	.915	-0.060	.638	-0.002	.999	-0.097	.592	0.03	-0.042	.942	-0.001	.992	0.02
	Visual Association	-0.090	.915	-0.021	.996	0.000	.999	-0.114	.930	0.08	0.023	.942	-0.200	.704	0.09
MID	Subcortical Cerebellar	0.001	.977	0.095	.160	-0.047	.720	0.025	.915	0.02	-0.123	.755	0.165	.712	0.02
	Motor	0.069	.392	-0.056	.635	0.004	.929	-0.073	.915	0.07	0.005	.970	0.007	.958	0.05
	Medial Frontal	0.030	.977	-0.030	.978	0.122	.837	0.162	.915	0.09	0.110	.755	0.021	.958	0.06
	Frontoparietal	-0.213	.224	0.138	.635	0.173	.480	-0.064	.915	0.21	-0.248	.755	0.091	.958	0.15
	Default Mode	-0.083	.336	0.027	.906	0.055	.736	-0.004	.957	0.05	-0.160	.755	0.066	.958	0.05
	Visual 2	0.024	.907	0.097	.160	-0.077	.384	0.029	.915	0.04	-0.057	.755	0.096	.958	0.03
	Visual 1	-0.003	.977	-0.013	.906	0.007	.929	-0.003	.957	0.02	-0.053	.755	0.055	.958	0.02
	Visual Association	-0.096	.392	-0.098	.635	0.047	.837	-0.062	.915	0.06	0.330	.755	-0.465	.384	0.09
SST	Subcortical Cerebellar	-0.051	.546	0.095	.592	-0.079	.268	0.053	.798	0.03	-0.054	.743	0.039	.843	0.01
	Motor	-0.032	.805	-0.004	.995	-0.024	.989	0.064	.768	0.04	-0.043	.743	0.063	.843	0.04
	Medial Frontal	-0.025	.974	0.051	.995	-0.011	.989	0.198	.996	0.08	-0.292	.397	0.355	.292	0.07
	Frontoparietal	-0.157	.536	0.054	.995	-0.080	.989	-0.001	.996	0.29	0.220	.743	-0.392	.550	0.31
	Default Mode	0.033	.868	0.063	.995	-0.022	.989	-0.117	.768	0.04	-0.428	.104	0.415	.144	0.07
	Visual 2	-0.092	.536	0.019	.995	-0.014	.989	0.016	.996	0.02	-0.191	.397	0.122	.550	0.03
	Visual 1	-0.072	.546	-0.014	.995	0.006	.989	-0.007	.996	0.06	-0.058	.743	-0.018	.903	0.06
	Visual Association	0.005	.974	-0.008	.995	0.113	.224	0.088	.768	0.05	0.243	.470	-0.213	.550	0.04

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 5b. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network diameter at threshold 16.67%*

		Study 1									**Study 2**				
	Brain network Threshold 16.67%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	*β*	p_{fdr}	*β*	p_{fdr}	*β*	p_{fdr}	R^2	*β*	p_{fdr}	*β*	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.015	.668	0.035	.682	-0.010	.893	0.001	.975	0.01	-0.003	.982	-0.006	.941	0.01
	Motor	0.029	.668	0.028	.691	-0.029	.684	0.030	.667	0.02	-0.081	.927	0.136	.536	0.03
	Medial Frontal	-0.022	.668	0.024	.691	0.005	.893	0.021	.701	0.01	0.002	.982	-0.009	.941	0.01
	Frontoparietal	-0.016	.668	-0.043	.682	0.027	.798	-0.045	.667	0.03	0.083	.927	-0.126	.563	0.03
	Default Mode	0.014	.668	0.071	.368	0.027	.684	-0.035	.667	0.03	-0.042	.927	0.051	.752	0.02
	Visual 2	0.020	.668	0.017	.691	0.029	.684	-0.029	.667	0.01	-0.053	.927	0.053	.752	0.01
	Visual 1	0.019	.668	-0.005	.903	0.061	.184	0.024	.701	0.02	0.141	.760	-0.104	.563	0.02
	Visual Association	0.058	.368	-0.037	.682	-0.004	.893	-0.030	.667	0.02	-0.036	.927	0.062	.752	0.01
En-back	Subcortical Cerebellar	-0.046	.533	0.036	.683	-0.011	.835	0.008	.956	0.02	-0.045	.916	0.014	.989	0.01
	Motor	-0.041	.554	-0.001	.989	-0.016	.835	0.003	.956	0.01	0.012	.982	-0.040	.985	0.01
	Medial Frontal	-0.045	.637	-0.009	.989	-0.036	.835	0.129	.232	0.03	0.128	.908	-0.128	.800	0.01
	Frontoparietal	0.015	.937	0.072	.683	-0.035	.835	0.028	.921	0.04	-0.071	.916	0.097	.800	0.03
	Default Mode	0.072	.272	-0.010	.989	-0.013	.835	-0.089	.232	0.04	0.002	.982	0.001	.989	0.02
	Visual 2	0.003	.937	0.049	.683	-0.040	.835	0.035	.822	0.04	-0.124	.908	0.150	.800	0.04
	Visual 1	-0.008	.937	-0.046	.683	-0.009	.835	-0.035	.822	0.02	-0.146	.908	0.130	.800	0.02
	Visual Association	-0.065	.488	-0.079	.683	0.012	.835	-0.043	.822	0.02	0.107	.908	-0.204	.800	0.02
MID	Subcortical Cerebellar	-0.040	.737	0.082	.200	0.020	.764	0.048	.812	0.03	-0.116	.634	0.121	.734	0.03
	Motor	0.013	.737	0.058	.338	0.078	.216	0.004	.935	0.05	-0.052	.917	0.075	.734	0.05
	Medial Frontal	0.026	.737	-0.058	.632	0.033	.764	0.010	.935	0.01	0.191	.634	-0.167	.734	0.02
	Frontoparietal	-0.038	.737	-0.106	.187	0.048	.764	-0.030	.812	0.03	0.032	.917	-0.076	.734	0.01
	Default Mode	0.016	.737	-0.078	.187	-0.002	.946	-0.035	.812	0.02	0.041	.917	-0.054	.734	0.02
	Visual 2	-0.013	.737	-0.009	.845	0.013	.805	0.023	.812	0.01	-0.108	.634	0.109	.734	0.02
	Visual 1	-0.023	.737	0.028	.675	0.040	.764	0.068	.684	0.02	0.009	.935	-0.002	.987	0.01
	Visual Association	-0.065	.737	0.141	.187	0.035	.764	0.118	.264	0.06	0.121	.634	-0.091	.734	0.03
SST	Subcortical Cerebellar	-0.022	.933	0.068	.765	-0.008	.992	0.092	.268	0.02	-0.115	.890	0.142	.918	0.01
	Motor	0.085	.192	-0.041	.765	0.004	.992	0.044	.438	0.04	0.062	.890	0.038	.918	0.04
	Medial Frontal	0.087	.356	0.040	.765	0.000	.992	0.050	.409	0.02	-0.011	.932	0.091	.918	0.01
	Frontoparietal	0.004	.949	-0.007	.912	0.058	.992	0.045	.464	0.07	0.048	.890	-0.050	.918	0.06
	Default Mode	-0.054	.395	-0.011	.912	-0.008	.992	-0.083	.275	0.03	-0.147	.890	0.058	.918	0.03
	Visual 2	-0.016	.933	-0.021	.912	-0.054	.992	0.070	.280	0.03	0.050	.890	-0.029	.918	0.02
	Visual 1	-0.005	.949	-0.045	.765	-0.004	.992	-0.107	.268	0.02	-0.033	.890	-0.007	.949	0.01
	Visual Association	-0.020	.933	0.037	.765	-0.010	.992	0.082	.280	0.03	0.066	.890	-0.038	.918	0.02

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 5c. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network diameter at threshold 23%*

		Study 1									**Study 2**				
	Brain network Threshold 23%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	*β*	p_{fdr}	*β*	p_{fdr}	*β*	p_{fdr}	R^2	*β*	p_{fdr}	*β*	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.013	.858	0.003	.958	-0.024	.763	0.030	.598	0.01	-0.085	.584	0.118	.484	0.01
	Motor	0.001	.977	0.011	.958	-0.014	.763	0.029	.598	0.02	-0.013	.883	0.033	.701	0.02
	Medial Frontal	-0.013	.858	-0.028	.958	-0.003	.945	-0.019	.698	0.01	-0.119	.584	0.100	.484	0.01
	Frontoparietal	-0.008	.858	0.009	.958	0.016	.763	-0.049	.547	0.03	0.029	.883	-0.054	.655	0.03
	Default Mode	0.042	.680	-0.002	.958	-0.002	.945	-0.042	.547	0.02	-0.031	.883	0.056	.655	0.02
	Visual 2	0.008	.858	0.016	.958	0.033	.763	0.006	.866	0.01	-0.077	.584	0.091	.484	0.01
	Visual 1	-0.017	.858	0.009	.958	0.044	.712	-0.017	.698	0.01	0.011	.883	-0.029	.701	0.01
	Visual Association	0.019	.858	-0.017	.958	-0.020	.763	-0.047	.547	0.01	-0.112	.584	0.103	.484	0.01
En-back	Subcortical Cerebellar	-0.044	.716	0.038	.808	0.049	.384	-0.015	.919	0.02	-0.004	.973	-0.025	.879	0.01
	Motor	0.002	.945	-0.021	.950	0.001	.998	0.013	.919	0.01	0.035	.854	-0.017	.879	0.01
	Medial Frontal	0.008	.945	-0.167	**.008**	-0.036	.722	0.000	.997	0.03	0.158	.421	-0.158	.506	0.01
	Frontoparietal	0.066	.640	-0.017	.950	0.000	.998	-0.093	.236	0.04	-0.134	.421	0.138	.506	0.03
	Default Mode	0.022	.945	-0.092	.184	0.000	.998	-0.083	.269	0.03	-0.056	.840	0.033	.879	0.01
	Visual 2	0.007	.945	-0.010	.950	-0.083	.120	-0.040	.611	0.03	-0.119	.421	0.115	.506	0.03
	Visual 1	-0.011	.945	-0.039	.808	0.024	.870	-0.044	.611	0.01	-0.188	.421	0.164	.506	0.02
	Visual Association	0.017	.945	-0.002	.967	-0.060	.384	-0.135	.192	0.03	-0.186	.421	0.143	.506	0.01
MID	Subcortical Cerebellar	0.004	.911	0.069	.566	-0.025	.515	0.027	.763	0.07	-0.105	.449	0.136	.442	0.01
	Motor	0.018	.911	-0.082	.400	-0.025	.515	0.047	.522	0.04	0.150	.413	-0.128	.442	0.03
	Medial Frontal	0.044	.911	-0.006	.957	0.059	.426	0.013	.888	0.01	0.107	.449	-0.062	.665	0.01
	Frontoparietal	-0.009	.911	-0.059	.566	0.050	.426	0.007	.889	0.03	0.091	.494	-0.123	.456	0.03
	Default Mode	-0.052	.911	0.048	.566	0.058	.426	0.089	.284	0.03	0.121	.449	-0.113	.468	0.02
	Visual 2	-0.010	.911	0.042	.566	-0.001	.975	0.031	.763	0.02	-0.161	.413	0.182	.442	0.02
	Visual 1	-0.027	.911	0.010	.957	0.036	.498	0.108	.160	0.03	0.063	.559	-0.044	.689	0.02
	Visual Association	0.014	.911	0.003	.957	0.047	.426	0.051	.522	0.02	0.156	.413	-0.135	.442	0.03
SST	Subcortical Cerebellar	-0.007	.836	0.083	.232	-0.021	.908	0.102	.200	0.03	-0.108	.813	0.173	.488	0.02
	Motor	0.032	.836	-0.028	.659	0.017	.908	0.046	.644	0.06	0.052	.813	0.003	.974	0.06
	Medial Frontal	0.043	.836	-0.053	.547	-0.027	.908	-0.061	.547	0.02	-0.139	.813	0.141	.691	0.02
	Frontoparietal	-0.019	.836	0.095	.232	-0.027	.908	-0.002	.966	0.05	-0.086	.813	0.084	.691	0.04
	Default Mode	-0.010	.836	0.019	.745	0.006	.908	-0.037	.648	0.01	-0.104	.813	0.091	.691	0.01
	Visual 2	0.010	.836	-0.046	.547	-0.030	.908	0.068	.400	0.02	-0.013	.891	0.063	.691	0.01
	Visual 1	-0.029	.836	-0.043	.547	-0.013	.908	-0.022	.883	0.02	-0.040	.813	0.015	.974	0.01
	Visual Association	0.015	.836	0.005	.911	-0.005	.908	-0.012	.937	0.02	-0.052	.813	0.083	.691	0.02

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 5d. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network diameter at threshold 30%*

	Brain network Threshold 30%	Study 1 General		Specific Conduct		Specific Internalizing		Specific ADHD			Study 2 Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.002	.921	-0.013	.989	-0.004	.993	0.015	.732	0.01	-0.004	.952	0.006	.995	0.01
	Motor	0.009	.921	0.048	.632	-0.006	.993	0.050	.560	0.03	0.021	.952	0.013	.995	0.02
	Medial Frontal	-0.024	.628	-0.004	.989	0.003	.993	0.021	.732	0.01	-0.006	.952	0.000	.995	0.01
	Frontoparietal	0.004	.921	-0.032	.821	0.006	.993	-0.023	.732	0.03	0.047	.952	-0.056	.773	0.02
	Default Mode	0.024	.628	0.042	.632	0.000	.993	-0.024	.732	0.02	-0.031	.952	0.045	.773	0.01
	Visual 2	0.030	.628	-0.024	.872	0.011	.993	-0.011	.732	0.01	-0.060	.952	0.076	.773	0.01
	Visual 1	-0.017	.829	0.001	.989	0.024	.993	-0.053	.560	0.01	0.020	.952	-0.056	.773	0.01
	Visual Association	0.026	.628	0.002	.989	-0.035	.993	-0.011	.732	0.01	-0.037	.952	0.060	.773	0.01
En-back	Subcortical Cerebellar	-0.069	.999	0.118	.999	0.057	.999	0.019	.999	0.03	0.022	.958	-0.056	.691	0.01
	Motor	0.009	.999	-0.078	.999	-0.091	.999	-0.001	.999	0.03	0.061	.791	-0.062	.691	0.01
	Medial Frontal	-0.003	.999	-0.104	.999	-0.004	.999	0.018	.999	0.02	0.167	.493	-0.169	.341	0.02
	Frontoparietal	0.071	.999	-0.012	.999	-0.019	.999	-0.025	.999	0.02	-0.139	.493	0.173	.341	0.02
	Default Mode	0.034	.999	0.067	.999	0.021	.999	-0.038	.999	0.02	-0.001	.997	0.022	.852	0.01
	Visual 2	-0.020	.999	-0.007	.999	-0.090	.999	-0.096	.999	0.03	-0.280	.112	0.221	.341	0.03
	Visual 1	-0.018	.999	0.025	.999	0.025	.999	-0.049	.999	0.01	-0.126	.493	0.096	.682	0.01
	Visual Association	0.030	.999	-0.098	.999	0.019	.999	-0.072	.999	0.02	-0.126	.493	0.098	.682	0.01
MID	Subcortical Cerebellar	-0.045	.515	0.044	.678	-0.058	.737	-0.043	.742	0.02	-0.174	.404	0.126	.872	0.02
	Motor	-0.013	.965	0.067	.429	-0.027	.737	0.005	.919	0.03	-0.035	.966	0.039	.872	0.02
	Medial Frontal	0.004	.965	0.017	.819	0.031	.737	-0.010	.919	0.01	-0.010	.966	0.028	.872	0.01
	Frontoparietal	0.048	.515	-0.203	**<.001**	-0.020	.737	-0.111	.072	0.08	-0.109	.731	0.091	.872	0.02
	Default Mode	0.047	.515	-0.069	.429	0.013	.737	-0.022	.919	0.02	-0.006	.966	0.027	.872	0.01
	Visual 2	-0.017	.965	0.005	.913	-0.030	.737	-0.009	.919	0.01	-0.204	.392	0.184	.592	0.02
	Visual 1	-0.036	.616	0.033	.750	0.023	.737	0.075	.420	0.02	-0.004	.966	0.017	.872	0.01
	Visual Association	0.002	.965	0.025	.785	0.006	.875	0.037	.742	0.02	0.043	.966	-0.025	.872	0.02
SST	Subcortical Cerebellar	0.021	.755	0.071	.445	-0.022	.930	0.020	.846	0.02	-0.076	.820	0.113	.984	0.02
	Motor	0.045	.624	-0.061	.445	-0.043	.930	0.052	.720	0.04	0.106	.820	-0.049	.984	0.03
	Medial Frontal	0.079	.312	-0.059	.445	0.012	.930	-0.009	.847	0.02	0.116	.820	-0.072	.984	0.01
	Frontoparietal	-0.036	.624	0.012	.791	-0.003	.930	-0.018	.846	0.02	-0.080	.820	0.036	.984	0.02
	Default Mode	0.024	.755	-0.039	.525	0.024	.930	-0.015	.846	0.01	0.026	.820	-0.007	.984	0.01
	Visual 2	0.015	.770	-0.043	.445	-0.005	.930	0.054	.720	0.02	0.021	.820	0.020	.984	0.01
	Visual 1	-0.041	.624	-0.053	.445	-0.008	.930	-0.052	.720	0.02	-0.056	.820	-0.002	.984	0.02
	Visual Association	-0.009	.812	0.025	.674	0.016	.930	0.049	.720	0.01	0.031	.820	-0.011	.984	0.01

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 6a. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network small world sigma at threshold 10%*

		Study 1									**Study 2**				
	Brain network Threshold 10%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.034	.683	0.013	.936	-0.043	.849	0.041	.643	0.06	-0.042	.873	0.088	.669	0.06
	Motor	-0.021	.683	0.038	.852	-0.021	.849	0.060	.643	0.02	-0.042	.873	0.032	.880	0.01
	Medial Frontal	0.033	.999	0.085	.999	-0.022	.999	0.030	.999	0.02	-0.035	.911	0.092	.781	0.02
	Frontoparietal	-0.096	.683	-0.028	.936	-0.054	.849	0.055	.714	0.10	-0.452	.732	0.410	.669	0.13
	Default Mode	-0.027	.683	0.013	.936	-0.016	.849	0.040	.714	0.02	0.002	.990	-0.014	.916	0.02
	Visual 2	0.003	.999	0.055	.800	0.008	.849	0.037	.643	0.05	-0.165	.416	0.191	.120	0.05
	Visual 1	0.025	.683	0.062	.800	-0.031	.849	0.026	.714	0.02	0.066	.873	-0.027	.880	0.02
	Visual Association	-0.033	.683	-0.079	.800	0.030	.849	0.043	.714	0.04	-0.091	.873	0.085	.781	0.03
En-back	Subcortical Cerebellar	-0.062	.999	-0.026	.999	0.017	.999	0.108	.999	0.05	0.163	.388	-0.182	.290	0.04
	Motor	-0.006	.999	-0.057	.999	0.011	.999	0.041	.999	0.02	0.115	.633	-0.087	.769	0.02
	Medial Frontal	-0.077	.999	-0.150	.999	-0.036	.999	-0.048	.999	0.16	0.261	.494	-0.355	.290	0.16
	Frontoparietal	-0.022	.999	0.198	.999	-0.030	.999	0.446	.999	0.36	1.099	**.008**	-0.954	**.032**	0.41
	Default Mode	-0.153	.999	0.284	.999	0.029	.999	0.231	.999	0.25	0.227	.388	-0.225	.290	0.11
	Visual 2	0.085	.999	-0.163	.999	-0.056	.999	-0.057	.999	0.09	-0.194	.160	0.251	.080	0.06
	Visual 1	0.091	.999	-0.211	.999	0.026	.999	-0.020	.999	0.07	0.033	.757	0.016	.869	0.02
	Visual Association	0.007	.999	-0.096	.999	-0.018	.999	-0.059	.999	0.03	-0.063	.757	0.034	.869	0.02
MID	Subcortical Cerebellar	0.007	.999	0.032	.999	0.000	.999	0.046	.999	0.08	-0.146	.221	0.166	.179	0.09
	Motor	0.002	.999	0.100	.999	0.048	.999	0.014	.999	0.03	-0.012	.930	0.028	.832	0.02
	Medial Frontal	0.111	.999	-0.290	.999	-0.035	.999	0.085	.999	0.15	-0.202	.391	0.336	.179	0.08
	Frontoparietal	-0.142	.999	-0.116	.999	0.162	.999	0.133	.999	0.18	0.341	.344	-0.417	.205	0.15
	Default Mode	-0.055	.999	0.067	.999	0.022	.999	0.180	.999	0.12	0.508	**.016**	-0.460	**.020**	0.14
	Visual 2	-0.014	.999	0.051	.999	-0.031	.999	-0.078	.999	0.03	-0.337	**.028**	0.282	**.035**	0.05
	Visual 1	0.035	.999	-0.046	.999	-0.025	.999	-0.053	.999	0.02	-0.222	**.032**	0.236	**.020**	0.03
	Visual Association	0.087	.999	-0.319	.999	0.007	.999	-0.189	.999	0.17	-0.323	.221	0.265	.205	0.05
SST	Subcortical Cerebellar	0.159	<**.001**	-0.037	.745	-0.018	.873	0.045	.499	0.09	0.023	.866	0.156	.557	0.10
	Motor	0.088	.252	-0.167	.200	-0.163	**.016**	-0.073	.499	0.08	0.156	.524	-0.126	.619	0.02
	Medial Frontal	0.063	.252	-0.022	.745	0.017	.873	0.081	.123	0.07	0.015	.866	0.076	.619	0.07
	Frontoparietal	-0.276	.996	0.270	.999	-0.244	.996	-0.011	.999	0.27	-0.330	.524	0.118	.747	0.11
	Default Mode	-0.124	.252	0.098	.628	0.059	.872	0.237	**.020**	0.12	0.435	**.040**	-0.431	.072	0.09
	Visual 2	0.020	.859	-0.029	.745	-0.017	.873	0.033	.499	0.03	0.022	.866	-0.011	.900	0.03
	Visual 1	0.049	.645	-0.055	.745	-0.046	.872	-0.192	**.020**	0.06	-0.226	.476	0.185	.557	0.02
	Visual Association	-0.002	.996	-0.167	.675	-0.089	.872	0.119	.499	0.07	0.233	.536	-0.168	.619	0.03

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 6b. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network small world sigma at threshold 16.67%*

	Brain network Threshold 16.67%	Study 1 General		Study 1 Specific Conduct		Study 1 Specific Internalizing		Study 1 Specific ADHD			Study 2 Inattention		Study 2 Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.043	.260	0.023	.609	-0.031	.475	0.012	.799	0.05	-0.110	.256	0.158	.056	0.06
	Motor	-0.020	.533	0.020	.609	-0.038	.475	0.052	.424	0.01	-0.057	.807	0.068	.622	0.01
	Medial Frontal	0.004	.906	0.051	.609	0.002	.942	0.047	.424	0.02	-0.042	.807	0.078	.622	0.02
	Frontoparietal	-0.039	.426	-0.055	.609	0.063	.475	-0.039	.691	0.02	-0.062	.807	0.006	.952	0.01
	Default Mode	-0.073	.056	0.037	.609	0.006	.942	0.083	.208	0.04	0.022	.807	-0.036	.893	0.03
	Visual 2	0.029	.426	-0.033	.609	-0.013	.891	-0.014	.799	0.05	-0.179	.096	0.196	**.032**	0.06
	Visual 1	-0.031	.426	0.005	.897	0.004	.942	-0.031	.691	0.01	-0.021	.807	-0.016	.952	0.01
	Visual Association	0.016	.605	0.024	.609	0.023	.772	0.006	.856	0.02	-0.116	.236	0.141	.059	0.02
En-back	Subcortical Cerebellar	-0.043	.428	-0.034	.627	0.024	.940	0.059	.46	0.06	0.118	.544	-0.136	.474	0.05
	Motor	-0.004	.923	-0.007	.895	0.003	.940	0.049	.528	0.03	0.166	.445	-0.143	.474	0.03
	Medial Frontal	-0.089	.124	0.096	.246	0.127	**.008**	0.154	.152	0.08	0.125	.630	-0.120	.613	0.03
	Frontoparietal	0.014	.906	0.008	.895	-0.057	.685	-0.052	.528	0.05	-0.010	.950	0.015	.923	0.04
	Default Mode	-0.062	.296	0.117	.083	-0.004	.940	0.135	.072	0.07	-0.027	.949	0.047	.923	0.04
	Visual 2	0.087	.124	-0.207	**<.001**	-0.051	.476	-0.066	.432	0.10	-0.181	.292	0.217	.168	0.05
	Visual 1	-0.018	.693	0.058	.416	0.003	.940	-0.036	.528	0.04	-0.267	.080	0.235	.168	0.05
	Visual Association	-0.039	.632	-0.132	.083	-0.008	.940	-0.025	.691	0.03	-0.066	.840	0.024	.923	0.01
MID	Subcortical Cerebellar	0.016	.851	0.038	.405	-0.043	.710	0.057	.600	0.06	-0.122	.406	0.171	.219	0.06
	Motor	0.043	.682	0.077	.184	0.021	.710	0.040	.654	0.04	-0.186	.156	0.242	**.032**	0.04
	Medial Frontal	0.077	.232	-0.045	.405	0.009	.808	0.082	.072	0.04	0.076	.675	0.042	.778	0.04
	Frontoparietal	-0.038	.682	0.095	.184	0.057	.710	-0.041	.669	0.07	0.039	.854	-0.078	.756	0.06
	Default Mode	-0.033	.694	0.053	.344	0.027	.710	0.106	.092	0.05	0.208	.160	-0.171	.274	0.04
	Visual 2	-0.039	.682	0.083	.194	0.018	.710	-0.011	.820	0.05	-0.375	**<.001**	0.347	**<.001**	0.07
	Visual 1	-0.002	.976	-0.094	.184	-0.027	.710	-0.013	.820	0.02	-0.039	.854	0.026	.814	0.01
	Visual Association	0.001	.976	0.073	.280	0.047	.710	0.039	.654	0.02	-0.014	.878	0.051	.756	0.02
SST	Subcortical Cerebellar	0.124	**<.001**	-0.013	.931	-0.091	**.028**	0.060	.428	0.09	-0.077	.848	0.224	.144	0.08
	Motor	0.042	.957	0.072	.360	-0.063	.272	0.095	.200	0.04	0.083	.848	0.021	.919	0.03
	Medial Frontal	0.103	.957	0.085	.931	-0.042	.913	0.184	.892	0.07	0.284	**.008**	-0.100	.779	0.05
	Frontoparietal	-0.034	.957	-0.016	.931	-0.051	.512	-0.081	.428	0.07	0.070	.901	-0.147	.790	0.07
	Default Mode	-0.002	.957	0.063	.360	0.050	.430	0.103	.200	0.05	0.074	.848	-0.012	.919	0.03
	Visual 2	0.002	.957	-0.077	.360	0.004	.913	0.003	.942	0.03	0.012	.948	-0.023	.919	0.02
	Visual 1	-0.007	.957	-0.055	.598	-0.004	.913	-0.022	.892	0.01	0.007	.948	-0.037	.919	0.01
	Visual Association	0.016	.957	0.008	.931	-0.144	**<.001**	-0.008	.942	0.03	-0.236	.192	0.245	.152	0.02

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 6c. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network small world sigma at threshold 23%*

		Study 1									**Study 2**				
	Brain network Threshold 23%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.034	.312	0.058	.304	-0.047	.240	0.010	.848	0.05	-0.057	.754	0.098	.347	0.04
	Motor	0.012	.601	0.008	.797	-0.042	.240	0.041	.563	0.01	-0.045	.845	0.076	.437	0.01
	Medial Frontal	0.040	.299	0.032	.642	-0.044	.240	0.003	.926	0.03	-0.013	.869	0.058	.609	0.02
	Frontoparietal	-0.018	.579	-0.021	.642	0.027	.388	-0.017	.804	0.04	0.014	.869	-0.038	.711	0.04
	Default Mode	-0.027	.422	-0.016	.642	-0.010	.762	0.043	.563	0.03	0.088	.754	-0.092	.416	0.03
	Visual 2	0.039	.299	0.025	.642	-0.001	.953	-0.015	.804	0.05	-0.139	.376	0.165	.096	0.05
	Visual 1	-0.025	.444	-0.034	.642	0.04	.240	-0.033	.714	0.01	-0.026	.869	-0.016	.839	0.01
	Visual Association	0.054	.299	0.038	.304	-0.039	.240	-0.041	.563	0.02	-0.058	.754	0.097	.347	0.02
En-back	Subcortical Cerebellar	-0.075	.999	-0.001	.999	0.037	.999	0.131	.999	0.07	0.163	.266	-0.174	.224	0.05
	Motor	-0.007	.999	-0.017	.999	-0.011	.999	0.027	.999	0.04	0.131	.320	-0.126	.354	0.04
	Medial Frontal	0.018	.999	-0.062	.999	0.039	.999	0.042	.999	0.02	0.299	**.036**	-0.272	.076	0.04
	Frontoparietal	0.027	.999	0.054	.999	-0.024	.999	-0.043	.999	0.06	-0.048	.765	0.058	.770	0.05
	Default Mode	-0.017	.999	0.094	.999	0.008	.999	0.102	.999	0.05	0.073	.729	-0.035	.774	0.03
	Visual 2	0.046	.999	-0.181	.999	-0.026	.999	-0.010	.999	0.08	-0.206	.112	0.251	.076	0.06
	Visual 1	-0.031	.999	-0.057	.999	-0.044	.999	-0.136	.999	0.04	-0.362	**.036**	0.258	.096	0.05
	Visual Association	-0.083	.999	-0.088	.999	0.013	.999	0.048	.999	0.02	0.003	.983	-0.052	.770	0.01
MID	Subcortical Cerebellar	0.014	.815	0.075	.253	-0.039	.832	0.071	.468	0.07	-0.05	.675	0.111	.558	0.06
	Motor	0.021	.815	0.078	.253	0.007	.832	0.017	.844	0.04	-0.108	.382	0.126	.558	0.03
	Medial Frontal	0.049	.815	0.028	.931	-0.008	.832	0.116	.128	0.04	0.157	.324	-0.04	.802	0.04
	Frontoparietal	-0.015	.815	0.009	.981	0.023	.832	-0.057	.587	0.09	-0.150	.324	0.104	.558	0.09
	Default Mode	0.023	.815	-0.001	.981	-0.007	.832	0.042	.710	0.02	0.149	.324	-0.103	.558	0.03
	Visual 2	0.007	.815	0.042	.672	-0.019	.832	-0.014	.844	0.03	-0.313	**<.001**	0.330	**<.001**	0.06
	Visual 1	0.033	.815	-0.071	.253	-0.048	.832	-0.007	.844	0.02	0.015	.867	-0.008	.934	0.02
	Visual Association	-0.013	.815	0.007	.981	0.019	.832	0.010	.844	0.06	0.073	.669	-0.074	.635	0.02
SST	Subcortical Cerebellar	0.093	**.048**	0.030	.666	-0.050	.640	0.064	.161	0.06	-0.151	.291	0.278	**.008**	0.07
	Motor	0.000	.991	0.088	.171	0.003	.945	0.063	.210	0.03	0.086	.555	-0.045	.765	0.02
	Medial Frontal	0.075	.264	0.126	**.008**	-0.019	.855	0.219	**<.001**	0.09	0.168	.291	0.015	.895	0.05
	Frontoparietal	-0.013	.944	0.022	.847	0.013	.855	-0.078	.161	0.08	0.015	.996	-0.070	.765	0.08
	Default Mode	-0.046	.458	-0.002	.965	0.016	.855	0.069	.161	0.04	0.131	.444	-0.127	.680	0.03
	Visual 2	-0.046	.458	-0.005	.965	0.015	.855	0.014	.766	0.02	0.001	.996	-0.046	.765	0.02
	Visual 1	0.007	.944	-0.023	.847	-0.046	.855	-0.096	.131	0.02	-0.091	.555	0.049	.765	0.01
	Visual Association	-0.017	.912	0.079	.171	0.024	.855	0.110	.072	0.02	-0.268	.088	0.321	**.008**	0.03

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 6d. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network small world sigma at threshold 30%*

	Brain network Threshold 30%	Study 1 General		Study 1 Specific Conduct		Study 1 Specific Internalizing		Study 1 Specific ADHD			Study 2 Inattention		Study 2 Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	0.044	.475	0.060	.323	-0.048	.110	0.028	.581	0.04	-0.056	.605	0.114	.228	0.03
	Motor	0.025	.604	0.044	.355	-0.029	.384	0.042	.557	0.02	-0.032	.734	0.077	.386	0.02
	Medial Frontal	0.030	.475	0.027	.469	-0.046	.110	-0.005	.876	0.01	-0.079	.605	0.110	.228	0.01
	Frontoparietal	-0.033	.475	-0.046	.323	0.050	.110	-0.009	.876	0.08	0.025	.734	-0.059	.482	0.08
	Default Mode	-0.015	.693	0.012	.754	0.015	.573	0.047	.544	0.02	0.063	.605	-0.050	.482	0.02
	Visual 2	0.007	.760	0.041	.355	0.001	.979	-0.019	.709	0.03	-0.165	.168	0.166	.120	0.04
	Visual 1	0.015	.693	-0.054	.323	0.016	.573	-0.071	.384	0.01	0.033	.734	-0.066	.482	0.01
	Visual Association	0.010	.760	0.008	.793	-0.051	.110	-0.030	.581	0.01	-0.123	.364	0.122	.228	0.01
En-back	Subcortical Cerebellar	-0.079	.072	0.001	.976	0.032	.674	0.101	.108	0.05	0.104	.490	-0.121	.592	0.04
	Motor	-0.009	.835	-0.058	.488	-0.053	.656	-0.030	.637	0.04	0.033	.805	-0.051	.630	0.04
	Medial Frontal	-0.050	.435	-0.046	.488	-0.019	.744	0.032	.637	0.02	0.237	.204	-0.272	.064	0.03
	Frontoparietal	0.021	.759	0.044	.501	-0.003	.937	-0.073	.354	0.06	-0.097	.621	0.083	.630	0.06
	Default Mode	-0.008	.835	0.052	.488	0.020	.744	0.096	.179	0.03	0.149	.466	-0.109	.618	0.02
	Visual 2	0.048	.435	-0.146	**.008**	-0.020	.744	-0.028	.637	0.07	-0.204	.204	0.246	.064	0.06
	Visual 1	-0.029	.435	-0.068	.488	-0.045	.656	-0.131	.108	0.05	-0.183	.448	0.066	.630	0.05
	Visual Association	-0.115	**.008**	-0.028	.605	0.042	.656	0.013	.802	0.02	0.032	.805	-0.132	.592	0.02
MID	Subcortical Cerebellar	0.007	.920	0.071	.403	-0.035	.677	0.082	.260	0.06	0.057	.634	-0.008	.933	0.05
	Motor	0.004	.920	0.086	.403	0.011	.759	0.018	.805	0.05	-0.093	.520	0.100	.475	0.04
	Medial Frontal	0.022	.920	0.023	.834	0.014	.759	0.126	.016	0.03	0.216	.102	-0.127	.434	0.03
	Frontoparietal	0.017	.920	-0.009	.834	0.047	.677	-0.066	.269	0.11	-0.196	.102	0.168	.356	0.11
	Default Mode	0.014	.920	-0.029	.834	0.027	.677	0.064	.286	0.02	0.194	.102	-0.148	.376	0.03
	Visual 2	-0.030	.920	0.070	.403	-0.038	.677	0.011	.805	0.04	-0.248	.056	0.236	.088	0.05
	Visual 1	-0.024	.920	-0.022	.834	-0.041	.677	0.042	.488	0.03	-0.037	.724	0.025	.906	0.02
	Visual Association	-0.035	.920	-0.014	.834	0.012	.759	0.018	.805	0.01	-0.072	.634	0.046	.900	0.01
SST	Subcortical Cerebellar	0.056	.267	0.018	.915	-0.058	.288	0.066	.201	0.05	-0.128	.382	0.218	.104	0.05
	Motor	0.022	.897	0.101	.056	-0.030	.664	0.087	.084	0.05	0.203	.168	-0.129	.541	0.05
	Medial Frontal	0.071	.267	0.106	**.048**	-0.027	.664	0.172	**<.001**	0.06	0.128	.382	0.020	.962	0.04
	Frontoparietal	0.005	.897	-0.004	.921	-0.001	.971	-0.069	.201	0.09	0.033	.860	-0.072	.962	0.09
	Default Mode	-0.015	.897	-0.007	.921	0.003	.971	0.048	.322	0.02	0.017	.860	0.001	.992	0.02
	Visual 2	-0.005	.897	0.014	.921	-0.025	.664	-0.002	.967	0.01	-0.034	.860	0.027	.962	0.01
	Visual 1	0.048	.267	-0.077	.216	0.073	.024	-0.114	.084	0.04	0.028	.860	-0.036	.962	0.01
	Visual Association	-0.017	.897	0.033	.882	0.033	.664	0.110	.084	0.02	-0.260	.152	0.312	**.040**	0.03

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 7a. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network small world omega at threshold 10%*

	Brain network Threshold 10%	**Study 1** General		Specific Conduct		Specific Internalizing		Specific ADHD			**Study 2** Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.022	.609	-0.049	.448	0.071	.128	-0.076	.064	0.04	-0.014	.850	-0.036	.625	0.03
	Motor	0.017	.609	-0.088	.448	0.004	.895	-0.071	.357	0.02	0.149	.420	-0.176	.236	0.01
	Medial Frontal	-0.031	.609	-0.029	.718	0.027	.843	-0.015	.829	0.02	0.158	.632	-0.205	.352	0.03
	Frontoparietal	0.138	.440	0.062	.718	-0.039	.843	-0.264	.272	0.13	0.539	.429	-0.544	.352	0.11
	Default Mode	0.074	.416	-0.068	.491	-0.022	.843	-0.053	.788	0.03	-0.049	.793	0.082	.625	0.02
	Visual 2	-0.028	.560	-0.024	.702	-0.009	.843	0.007	.829	0.05	0.129	.420	-0.152	.200	0.05
	Visual 1	-0.039	.440	-0.007	.851	0.034	.843	0.013	.829	0.02	0.051	.793	-0.091	.621	0.02
	Visual Association	0.022	.609	0.055	.684	-0.026	.843	-0.017	.829	0.02	0.077	.793	-0.071	.625	0.01
En-back	Subcortical Cerebellar	0.016	.999	-0.001	.999	-0.049	.999	-0.101	.999	0.03	-0.331	**.016**	0.324	**.016**	0.05
	Motor	0.104	.999	0.007	.999	-0.012	.999	-0.097	.999	0.05	-0.333	**.030**	0.387	**.016**	0.07
	Medial Frontal	0.099	.999	-0.144	.999	-0.170	.999	-0.139	.999	0.14	0.305	.104	-0.305	.125	0.08
	Frontoparietal	-0.090	.999	-0.055	.999	0.044	.999	-0.316	.999	0.23	-1.022	**.016**	0.877	**.016**	0.37
	Default Mode	0.076	.999	-0.221	.999	-0.012	.999	-0.120	.999	0.13	-0.009	.955	0.003	.987	0.06
	Visual 2	-0.069	.999	0.124	.999	0.068	.999	0.081	.999	0.09	0.288	**.016**	-0.312	**.016**	0.08
	Visual 1	-0.021	.999	0.077	.999	0.031	.999	0.050	.999	0.04	0.259	.051	-0.246	.074	0.05
	Visual Association	0.021	.999	0.104	.999	0.048	.999	0.071	.999	0.05	-0.212	.413	0.294	.239	0.05
MID	Subcortical Cerebellar	-0.012	.999	-0.024	.999	0.049	.999	-0.039	.999	0.07	0.104	.853	-0.139	.592	0.07
	Motor	-0.004	.999	-0.015	.999	-0.052	.999	-0.002	.999	0.03	0.040	.853	-0.029	.998	0.02
	Medial Frontal	-0.060	.999	0.155	.999	-0.008	.999	-0.029	.999	0.08	-0.048	.853	-0.026	.998	0.06
	Frontoparietal	0.196	.999	-0.102	.999	-0.284	.999	-0.090	.999	0.24	-0.100	.853	0.203	.851	0.12
	Default Mode	0.085	.999	-0.155	.999	-0.056	.999	-0.199	.999	0.10	-0.311	.172	0.269	.348	0.05
	Visual 2	0.023	.999	-0.100	.999	0.096	.999	0.019	.999	0.05	0.211	.172	-0.186	.348	0.05
	Visual 1	0.039	.999	0.035	.999	0.005	.999	-0.060	.999	0.02	0.064	.853	-0.069	.851	0.01
	Visual Association	-0.058	.999	0.257	.999	0.023	.999	0.207	.999	0.13	0.078	.853	-0.001	.998	0.04
SST	Subcortical Cerebellar	-0.091	.999	-0.001	.999	0.106	.999	-0.112	.999	0.07	-0.025	.999	-0.128	.461	0.06
	Motor	-0.015	.999	0.087	.999	0.090	.999	0.028	.999	0.04	0.016	.999	-0.031	.827	0.02
	Medial Frontal	-0.055	.999	-0.017	.999	0.018	.999	-0.203	.999	0.09	0.323	.171	-0.457	**.048**	0.10
	Frontoparietal	0.237	.999	-0.073	.999	0.214	.999	0.057	.999	0.25	0.000	.999	0.223	.537	0.19
	Default Mode	0.065	.999	-0.100	.999	-0.042	.999	-0.154	.999	0.06	-0.248	.302	0.229	.400	0.03
	Visual 2	0.063	.999	-0.074	.999	0.023	.999	-0.006	.999	0.03	0.295	.056	-0.248	.077	0.04
	Visual 1	-0.098	.999	0.052	.999	-0.002	.999	0.083	.999	0.04	0.113	.678	-0.132	.484	0.03
	Visual Association	0.032	.999	0.099	.999	0.002	.999	-0.111	.999	0.03	-0.464	.056	0.439	.056	0.06

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 7b. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network small world omega at threshold 16.67%*

		Study 1									**Study 2**				
	Brain network Threshold 16.67%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.034	.266	-0.025	.611	0.018	.536	-0.020	.597	0.03	0.075	.443	-0.118	.164	0.03
	Motor	0.003	.914	-0.047	.485	0.046	.222	-0.048	.517	0.01	0.137	.243	-0.164	.104	0.01
	Medial Frontal	0.021	.622	-0.042	.611	0.025	.547	-0.035	.517	0.02	0.017	.861	-0.026	.845	0.01
	Frontoparietal	0.042	.328	0.024	.715	-0.088	.184	0.038	.517	0.04	0.074	.558	-0.02	.845	0.03
	Default Mode	0.039	.266	-0.055	.485	-0.045	.222	-0.035	.517	0.03	-0.059	.558	0.064	.608	0.03
	Visual 2	-0.035	.266	-0.015	.715	-0.023	.536	0.035	.517	0.03	0.158	.192	-0.173	.072	0.03
	Visual 1	0.051	.266	-0.007	.846	-0.054	.222	-0.080	.232	0.02	-0.109	.366	0.114	.267	0.01
	Visual Association	-0.028	.496	-0.048	.485	0.007	.819	0.008	.826	0.03	0.143	.192	-0.174	.072	0.03
En-back	Subcortical Cerebellar	0.034	.490	0.023	.591	-0.008	.789	-0.062	.432	0.04	-0.128	.510	0.130	.503	0.04
	Motor	0.012	.840	-0.023	.591	0.030	.639	-0.031	.788	0.02	-0.101	.685	0.094	.503	0.02
	Medial Frontal	0.103	.240	0.081	.354	-0.036	.639	-0.202	**.008**	0.07	-0.526	**.008**	0.541	**.008**	0.08
	Frontoparietal	-0.089	.240	0.177	.064	0.088	.308	0.110	.432	0.12	0.062	.759	-0.099	.503	0.06
	Default Mode	0.008	.840	-0.079	.274	-0.022	.639	-0.057	.562	0.02	0.072	.717	-0.096	.503	0.01
	Visual 2	-0.071	.240	0.083	.212	0.063	.308	0.017	.788	0.06	0.249	**.040**	-0.300	**.008**	0.06
	Visual 1	0.067	.262	-0.050	.517	-0.038	.639	-0.015	.788	0.03	0.220	.267	-0.171	.503	0.04
	Visual Association	0.039	.521	0.099	.245	-0.032	.639	0.030	.788	0.02	-0.041	.774	0.099	.503	0.01
MID	Subcortical Cerebellar	0.033	.529	-0.094	.240	0.027	.603	-0.060	.468	0.08	0.132	.472	-0.155	.299	0.07
	Motor	-0.039	.529	-0.040	.613	-0.014	.711	-0.003	.941	0.05	0.222	.080	-0.245	**.040**	0.06
	Medial Frontal	-0.034	.529	0.070	.613	-0.030	.576	-0.077	.244	0.04	-0.151	.502	0.079	.745	0.03
	Frontoparietal	0.002	.959	-0.031	.613	-0.054	.516	0.084	.427	0.08	0.057	.686	-0.023	.851	0.07
	Default Mode	0.039	.529	0.035	.613	-0.060	.516	-0.089	.244	0.03	-0.101	.573	0.084	.745	0.02
	Visual 2	0.030	.529	-0.020	.629	0.011	.711	-0.009	.941	0.04	0.317	**<.001**	-0.296	**<.001**	0.07
	Visual 1	0.012	.787	0.109	.136	0.034	.516	-0.045	.523	0.03	0.042	.686	-0.047	.745	0.01
	Visual Association	0.052	.529	-0.048	.613	-0.061	.516	-0.023	.929	0.03	-0.061	.686	0.083	.745	0.02
SST	Subcortical Cerebellar	-0.073	.180	-0.064	.468	0.086	.056	-0.084	.277	0.05	0.106	.684	-0.225	.224	0.05
	Motor	-0.038	.843	-0.043	.584	0.068	.235	-0.071	.304	0.03	0.003	.979	-0.092	.756	0.03
	Medial Frontal	-0.111	**.048**	-0.081	.468	0.039	.632	-0.143	**.016**	0.05	-0.219	.408	0.049	.899	0.04
	Frontoparietal	0.000	.995	0.007	.950	0.027	.632	0.074	.402	0.08	-0.091	.914	0.148	.756	0.08
	Default Mode	0.004	.995	-0.041	.584	-0.029	.632	-0.051	.445	0.02	-0.044	.968	0.009	.943	0.02
	Visual 2	-0.006	.995	0.023	.844	0.029	.632	-0.031	.552	0.02	-0.019	.973	0.012	.943	0.01
	Visual 1	0.001	.995	0.072	.584	0.021	.632	0.106	.188	0.03	0.122	.684	-0.060	.899	0.02
	Visual Association	-0.001	.995	0.003	.950	0.132	**.008**	-0.029	.556	0.04	0.122	.684	-0.141	.756	0.02

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 7c. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network small world omega at threshold 23%*

		Study 1									**Study 2**				
	Brain network Threshold 23%	General		Specific Conduct		Specific Internalizing		Specific ADHD			Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.031	.844	-0.065	.152	0.042	.147	-0.030	.641	0.03	0.050	.668	-0.099	.300	0.03
	Motor	-0.036	.844	-0.013	.899	0.042	.147	-0.019	.641	0.01	0.053	.668	-0.101	.300	0.01
	Medial Frontal	-0.017	.986	-0.012	.899	0.046	.147	0.026	.641	0.01	0.058	.668	-0.071	.527	0.01
	Frontoparietal	0.000	.986	0.042	.587	-0.028	.348	0.036	.641	0.07	-0.037	.704	0.055	.527	0.07
	Default Mode	0.001	.986	-0.004	.899	-0.004	.870	-0.013	.699	0.03	-0.023	.757	0.015	.845	0.03
	Visual 2	-0.021	.986	-0.009	.899	-0.011	.759	0.029	.641	0.03	0.168	.144	-0.175	.056	0.03
	Visual 1	0.006	.986	0.048	.587	-0.048	.147	0.022	.641	0.01	-0.063	.668	0.081	.527	0.01
	Visual Association	-0.007	.986	-0.028	.820	0.058	.147	0.026	.641	0.02	0.100	.516	-0.097	.300	0.01
En-back	Subcortical Cerebellar	0.065	.156	-0.018	.911	-0.029	.920	-0.082	.304	0.03	-0.071	.787	0.089	.693	0.02
	Motor	-0.004	.995	0.050	.741	0.033	.920	-0.037	.658	0.04	-0.091	.742	0.071	.693	0.03
	Medial Frontal	-0.017	.995	0.094	.328	0.020	.920	-0.031	.658	0.02	-0.210	.200	0.185	.341	0.02
	Frontoparietal	-0.102	.088	0.007	.998	0.009	.920	0.093	.304	0.08	0.036	.851	-0.071	.693	0.07
	Default Mode	-0.012	.995	-0.031	.911	-0.011	.920	-0.034	.658	0.01	-0.072	.787	0.042	.748	0.01
	Visual 2	-0.056	.995	0.099	.998	0.013	.999	-0.015	.999	0.06	0.165	.200	-0.229	.128	0.06
	Visual 1	0.020	.995	-0.033	.911	-0.009	.920	0.037	.658	0.03	0.216	.200	-0.185	.232	0.04
	Visual Association	0.034	.973	0.152	.160	0.012	.920	0.039	.658	0.03	-0.004	.972	0.055	.741	0.01
MID	Subcortical Cerebellar	-0.004	.900	-0.082	.208	0.007	.962	-0.044	.546	0.06	0.096	.435	-0.136	.326	0.06
	Motor	-0.027	.900	-0.068	.238	0.002	.965	-0.012	.905	0.06	0.199	.176	-0.220	.092	0.06
	Medial Frontal	-0.040	.900	-0.014	.788	0.042	.642	-0.051	.546	0.02	-0.123	.435	0.050	.759	0.02
	Frontoparietal	-0.009	.900	0.016	.788	-0.067	.384	0.055	.546	0.11	0.151	.290	-0.118	.397	0.11
	Default Mode	-0.011	.900	0.101	.072	-0.033	.642	-0.042	.546	0.03	-0.183	.200	0.157	.326	0.03
	Visual 2	0.005	.900	-0.042	.443	0.030	.642	0.004	.925	0.03	0.229	.120	-0.231	.092	0.04
	Visual 1	0.025	.900	0.069	.208	0.034	.642	-0.048	.546	0.03	0.044	.694	-0.024	.830	0.02
	Visual Association	-0.005	.900	0.126	.072	-0.008	.962	0.033	.688	0.03	-0.066	.641	0.099	.508	0.02
SST	Subcortical Cerebellar	-0.055	.540	-0.072	.098	0.061	.504	-0.062	.246	0.04	0.190	.220	-0.282	**.040**	0.05
	Motor	0.015	.928	-0.110	.068	0.012	.777	-0.120	**.032**	0.05	-0.144	.379	0.087	.693	0.03
	Medial Frontal	-0.084	.256	-0.100	.068	0.011	.777	-0.150	**<.001**	0.05	-0.047	.737	-0.104	.693	0.03
	Frontoparietal	0.002	.979	-0.022	.643	-0.018	.777	0.074	.246	0.10	0.055	.737	-0.009	.929	0.10
	Default Mode	0.001	.979	0.024	.643	-0.015	.777	0.000	.992	0.02	-0.090	.737	0.084	.693	0.02
	Visual 2	0.045	.571	0.052	.459	0.010	.777	-0.034	.512	0.02	-0.003	.971	0.030	.862	0.02
	Visual 1	0.016	.928	-0.018	.643	-0.032	.777	-0.035	.499	0.02	-0.064	.737	0.060	.693	0.01
	Visual Association	0.020	.928	-0.086	.098	0.061	.504	-0.087	.235	0.03	0.207	.220	-0.252	.068	0.03

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 7d. *Results examining the relationship between Study 1 & Study 2 psychopathology dimensions and network small world omega at threshold 30%*

	Brain network Threshold 30%	**Study 1** General		Specific Conduct		Specific Internalizing		Specific ADHD			**Study 2** Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2	β	p_{fdr}	β	p_{fdr}	R^2
Rest	Subcortical Cerebellar	-0.020	.779	-0.051	.396	0.031	.392	-0.036	.906	0.02	0.071	.530	-0.110	.200	0.02
	Motor	-0.055	.112	-0.059	.396	0.006	.815	0.003	.961	0.01	0.069	.530	-0.128	.179	0.01
	Medial Frontal	-0.046	.112	-0.028	.555	0.054	.144	0.026	.906	0.01	0.076	.530	-0.111	.203	0.01
	Frontoparietal	0.020	.779	0.037	.428	-0.040	.213	0.033	.906	0.10	0.013	.927	0.020	.933	0.09
	Default Mode	-0.016	.779	0.010	.746	-0.024	.475	-0.002	.961	0.03	-0.011	.927	-0.006	.933	0.03
	Visual 2	-0.006	.828	-0.044	.428	-0.018	.568	0.024	.906	0.02	0.182	.072	-0.178	**.048**	0.03
	Visual 1	0.013	.812	0.026	.625	-0.021	.504	0.020	.950	0.01	0.007	.927	0.016	.933	0.01
	Visual Association	0.005	.828	-0.011	.746	0.049	.213	0.004	.961	0.01	0.178	.076	-0.177	.068	0.02
En-back	Subcortical Cerebellar	0.071	.256	-0.033	.700	-0.027	.890	-0.055	.514	0.03	-0.023	.976	0.044	.773	0.02
	Motor	-0.001	.983	0.083	.328	0.066	.440	0.056	.514	0.04	0.020	.976	0.008	.941	0.02
	Medial Frontal	0.016	.770	0.069	.328	0.026	.890	-0.007	.978	0.02	-0.217	.232	0.236	.188	0.03
	Frontoparietal	-0.055	.469	-0.018	.700	-0.021	.890	0.073	.514	0.07	0.137	.514	-0.146	.438	0.06
	Default Mode	-0.024	.770	-0.021	.700	-0.012	.890	-0.030	.829	0.01	-0.119	.563	0.079	.773	0.01
	Visual 2	-0.027	.770	0.066	.328	-0.002	.958	-0.001	.978	0.05	0.176	.275	-0.211	.188	0.06
	Visual 1	0.017	.770	-0.026	.700	0.009	.890	0.094	.440	0.03	0.212	.232	-0.152	.438	0.04
	Visual Association	0.051	.469	0.118	.064	-0.014	.890	0.027	.829	0.02	-0.003	.983	0.068	.773	0.01
MID	Subcortical Cerebellar	-0.001	.987	-0.030	.656	0.042	.584	-0.034	.665	0.03	0.021	.937	-0.041	.760	0.03
	Motor	-0.001	.987	-0.080	.304	0.006	.954	-0.020	.717	0.06	0.078	.650	-0.083	.752	0.06
	Medial Frontal	0.007	.987	-0.025	.656	-0.008	.954	-0.100	.141	0.02	-0.099	.650	0.039	.760	0.02
	Frontoparietal	-0.028	.987	0.051	.452	-0.076	.144	0.082	.141	0.13	0.167	.269	-0.134	.507	0.12
	Default Mode	-0.001	.987	0.060	.452	-0.054	.428	-0.082	.141	0.03	-0.218	.124	0.180	.320	0.03
	Visual 2	0.044	.987	-0.095	.304	0.025	.854	-0.017	.717	0.04	0.246	.072	-0.223	.136	0.04
	Visual 1	0.013	.987	0.046	.469	0.020	.954	-0.037	.665	0.03	-0.031	.937	0.037	.760	0.03
	Visual Association	-0.014	.987	-0.013	.743	0.002	.954	-0.028	.665	0.02	0.001	.991	-0.028	.760	0.02
SST	Subcortical Cerebellar	-0.034	.683	-0.090	.072	0.056	.464	-0.074	.214	0.04	0.201	.240	-0.280	**.032**	0.04
	Motor	-0.069	.328	-0.074	.220	0.031	.659	-0.079	.214	0.04	-0.128	.493	0.023	.908	0.04
	Medial Frontal	-0.129	**.008**	-0.022	.863	0.034	.659	-0.064	.214	0.04	-0.151	.493	0.026	.908	0.03
	Frontoparietal	-0.030	.683	0.003	.939	-0.006	.879	0.060	.263	0.10	0.063	.850	-0.054	.908	0.10
	Default Mode	0.006	.901	0.018	.863	-0.015	.751	-0.002	.970	0.03	0.011	.959	-0.013	.908	0.03
	Visual 2	0.004	.901	0.020	.863	0.029	.659	-0.054	.263	0.02	-0.005	.959	-0.017	.908	0.01
	Visual 1	-0.037	.675	0.068	.301	-0.022	.732	0.060	.263	0.04	-0.036	.959	0.042	.908	0.03
	Visual Association	0.013	.901	-0.013	.863	-0.054	.464	-0.086	.214	0.03	0.075	.850	-0.109	.908	0.02

Note: En-back, Emotional N-back; MID, Monetary Incentive Delay; SST, Stop Signal Task; ADHD Attention-Deficit/ Hyperactivity Disorder

Table 8. *Results examining the relationship between network variables and Study 1 & Study 2 psychopathology dimensions with parental education and medication as additional covariates at the 30% threshold.*

		Study 1											**Study 2**				
Task	Network/Metric	General		Specific Conduct		Specific Internalizing		Specific ADHD			Task	Network/ Metric	Inattention		Hyperactivity/ Impulsivity		
		β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	β	p_{fdr}	R^2			β	p_{fdr}	β	p_{fdr}	R^2
En-back	Shen Modularity	0.056	.173	-0.082	.082	0.022	.641	-0.127	**.009**	0.14	MID	V2 SWS	-0.240	**.008**	0.231	**.010**	0.05
MID	Shen Modularity	0.024	.572	-0.106	.060	-0.006	.861	-0.130	**.003**	0.14							
SST	Shen Modularity	0.074	.145	-0.075	.091	0.029	.641	-0.145	**.002**	0.09							
Rest	Shen Modularity	0.006	.791	-0.057	.082	0.019	.641	-0.079	**.011**	0.06							
Rest	Motor LE	0.037	.173	-0.015	.621	0.036	.641	-0.110	**.002**	0.06							

Note: En-back = emotional n-back; MID = monetary incentive delay; SST = stop signal task; ADHD = Attention-Deficit/ Hyperactivity Disorder.; V2 = Visual II; LE = Local Efficiency; SWS = Small world sigma