Supplementary material

Sleep duration, brain structure, and psychiatric and cognitive problems in children

Molecular Psychiatry 2020 https://doi.org/10.1038/s41380-020-0663-2

Wei Cheng PhD[1,2,#,*], Edmund Rolls DSc[1,3,4,#,*], Weikang Gong PhD[5,#], Jingnan Du PhD[1], Jie Zhang PhD[1,2], Xiao-Yong Zhang PhD[1,2], Fei Li MD[6], and Jianfeng Feng PhD[1,2,3,*]

1. Institute of Science and Technology for Brain-inspired Intelligence, Fudan University, Shanghai, 200433, China
2. Key Laboratory of Computational Neuroscience and Brain-Inspired Intelligence, Fudan University, Ministry of Education, Shanghai, 200433, China
3. Department of Computer Science, University of Warwick, Coventry CV4 7AL, UK
4. Oxford Centre for Computational Neuroscience, Oxford, UK
5. Centre for Functional MRI of the Brain (FMRIB), Nuffield Department of Clinical Neurosciences, Wellcome Centre for Integrative Neuroimaging, University of Oxford, Oxford, UK.
6. Department of Developmental and Behavioral Pediatric & Child Primary Care/MOE-Shanghai Key Laboratory of Children's Environmental Health, Xin Hua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai, China

Data preprocessing

We obtained preprocessed structural imaging data (T1 and T2) using the ABCD pipeline, with all the data preprocessing procedures performed by the ABCD team as described in their image processing paper[1]. The data preprocessing included the following procedures: 1) T1w and T2w structural images were corrected for gradient nonlinearity distortions; 2) T2w images were registered to T1w images; 3) intensity normalization and B1 inhomogeneity correction; 4) images were rigidly registered and resampled into alignment with a custom, in-house atlas created by the ABCD data preprocessing team for participants of this age; 5) FreeSurfer (version: v5.3.0) was used for cortical surface reconstruction and subcortical segmentation which included skull-stripping, white matter segmentation, initial mesh creation, correction of topological defects, generation of optimal white and pial surfaces, and nonlinear registration to a spherical surface-based atlas based on the alignment of sulcal/gyral patterns; 6) images were registered to a spherical atlas based on surface-based nonlinear registration, and the cerebral cortex was parcellated into 34 regions per hemisphere; 7) subcortical structures were labeled using an automated, atlas-based, volumetric segmentation procedure.

Sleep duration

In the questionnaire 'Sleep Disturbances Scale for Children', there are 26 questions which are divided into six 'component' scores (i.e. Disorders of initiating and maintaining sleep, Sleep Breathing Disorders, Disorders of arousal, Sleep-Wake Transition Disorders, Disorders of excessive somnolence and Sleep Hyperhydrosis)[2].

The question for sleep duration is: 'How many hours of sleep does your child get on most nights?' The value range for this question is 1, 2, 3, 4, 5, where 1 indicates that a child sleeps 9-11 hours per night; 2 indicates that a child sleeps 8-9 hours per night; 3 indicates that a child sleeps 7-8 hours per night; 4 indicates that a child sleeps 5-7 hours per night; and 5 indicates that a child sleeps less than 5 hours per night. The score considers the past 6 months of the child's life.

Mental health assessments

The Parent Child Behavior Checklist Scores (abcd_cbcls01) were used to assess the dimensional psychopathology and adaptive functioning in children[3]. CBCL has high test-retest stability and good internal consistency, and comprises of 113 items that measure broad scopes of child behavior across the past six months[4]. Each item was rated using a three-point rating scale (not true, somewhat or sometimes true, very often or always true). It contains ten empirically-based syndrome scales related to psychiatric problems: anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule-breaking behavior, aggressive behavior, internalizing broad band score and externalizing broad band score; and a psychiatric problems total score. Six DSM-Oriented Scales including the Depressive Problems CBCL DSM5 Scale, Anxiety Problems CBCL DSM5 Scale, Somatic Problems CBCL DSM5 Scale, ADHD CBCL DSM5 Scale, Oppositional Defiant Problems CBCL DSM5 Scale, and Conduct Problems CBCL DSM5 Scale, were also calculated based on the questionnaire.

Table S1. All measures used in this study.

Measure	NDA Short Name	Description
Physical and Mental Health		
ABCD Youth Anthropometrics Modified From PhenX (ANT)	abcd_ant01	Height, weight, waist circumference
Adult Self Report Scores	abcd_asrs01	Adult Self Report summary scores
ABCD Youth Behavioral Inhibition/Behavioral Approach System Scales Modified from PhenX (BIS/BAS)	abcd_bisbas01	Inhibition and reward seeking
ABCD Parent Child Behavior Checklist Raw Scores Aseba (CBCL)	abcd_cbcl01	Dimensional psychopathology, adaptive functioning
Child Behavior Check List Scores	abcd_cbcls01	Child Behavior Check List summary scores
ABCD Youth Edinburgh Handedness Inventory Short Form (EHIS)	abcd_ehis01	Handedness, laterality quotient
ABCD Youth Diagnostic Interview for DSM-5 (KSADS-5)	abcd_ksad501	Mental health diagnosis - youth questions
ABCD Parent Diagnostic Interview for DSM-5 Full (KSADS-5)	abcd_ksad01	Mental health diagnosis - parent questions
ABCD Sum Scores Mental Health Parent	abcd_mhp01	Mental Health summary scores - parent surveys
ABCD Parent Medical History Questionnaire (MHX)	abcd_mx01	Medical history and health services utilization
ABCD Parent Ohio State Traumatic Brain Injury Screen-Short Modified (OTBI)	abcd_otbi01	Traumatic brain injury of youth
ABCD Parent General Behavior Inventory-Mania (PGBI)	abcd_pgbi01	Subsyndromal mania
ABCD Parent Pubertal Development Scale and Menstrual Cycle Survey History (PDMS)	abcd_ppdms01	Pubertal stage and menstrual phase (for postmenarchal girls) - parent survey
ABCD Parent Sports and Activities Involvement Questionnaire (SAIQ)	abcd_saiq02	Involvement in sports, music and hobbies, TBI risk
ABCD Parent Sleep Disturbance Scale for Children (SDS)	abcd_sds01	Sleep and sleep disorders
ABCD Youth Screen Time Survey (STQ)	abcd_stq01	Screen time utilization - youth
ABCD Youth Snellen Vision Screener (SVS)	abcd_svs01	Vision screening
ABCD Sum Scores Traumatic Brain Injury	abcd_tbi01	Traumatic brain injury of youth summary scores
UPPS-P for Children Short Form (ABCD-version)	abcd_upps01	Impulsivity
ABCD Youth Diagnostic Interview for DSM-5 Background Items (KSADS-5)	abcd_yksad01	School, sexual orientation
ABCD Youth Pubertal Development Scale and Menstrual Cycle Survey History (PDMS)	abcd_ypdms01	Pubertal stage and menstrual phase (for postmenarcheal girls) - youth survey
ABCD Youth Risk Behavior Survey Exercise Physical Activity (YRB)	abcd_yrb01	Physical exercise
ABCD Youth Resilience Scale (YRS)	abcd_ysr01	Resilience (religiosity, friends)
ABCD Developmental History Questionnaire	dhx01	Prenatal exposure before and during pregnancy - medications, drugs alcohol, tobacco
ABCD Parent Diagnostic Interview for DSM-5 Background Items Full (KSADS-5)	dibf01	School, family, social relations
ABCD Family History Assessment Part 1	fhxp101	Family history of psychopathology and substance use (for biological or adoptive parent)
ABCD Family History Assessment Part 2	fhxp201	Family history of psychopathology and substance use (for biological or adoptive parent)
ABCD Parent Medications Survey Inventory Modified from PhenX (PMP)	medsy01	Medications taken in the last two weeks
ABCD Parent Adult Self Report Raw Scores Aseba (ASR)	pasr01	Parent dimensional psychopathology
ABCD Parent Demographics Survey?	pdem01	Demographics, race, gender, family structure, SES, education, occupation (includes Native American Acculturation Scale)
ABCD Prodromal Psychosis Scale	pps01	Prodromal psychosis levels
ABCD Parent Screen Time Survey (STQ)	stq01	Screen time utilization - parent
ABCD Sum Scores Physical Health Parent	abcd_ssphp01	Physical health summary scores - parent surveys
ABCD Summary Scores Brief Problem Monitor-Teacher Form for Ages 6-18	abcd_ssbpmtf01	Normed multi-informant monitoring of children's functioning/ teacher report
Substance Use		
ABCD Parent Community Risk and Protective Factors (CRPF)	abcd_crpf01	Beliefs about drug availability (alcohol, nicotine, marijuana, ?other? drugs) along with questions about access and exposure to medical marijuana
ABCD Youth Participant Last Use Survey Day 1 2 3 4 (PLUS)	abcd_plus01	Tobacco/caffeine/medication usage in the last 24 hours - youth answers
ABCD Youth Substance Use Interview	abcd_ysu01	Measures included in Substance Use Interview are described below
ABCD Parent Participant Last Use Survey Day 2 3 4 (PLUS)	plus01	Tobacco/caffeine/medication usage in the last 24 hours - parent answers
ABCD Parental Rules on Substance Use	prq01	Parental substance use approval and rules
Culture and Environment		
ABCD Youth Family Environment Scale-Family Conflict Subscale Modified from PhenX (FES)	abcd_fes01	Family dynamics, cohesion, expressiveness, conflict
ABCD Parent Multi-Group Ethnic Identity-Revised Survey (MEIM)	abcd_meim01	Cultural affiliation
ABCD Youth Neighborhood Safety/Crime Survey Modified from PhenX (NSC)	abcd_nsc01	Neighborhood risk and protective factors, crime
ABCD Parent Neighborhood Safety/Crime Survey Modified from PhenX (NSC)	abcd_pnsc01	Neighborhood risk and protective factors, crime
Youth Prosocial Behavior Survey	abcd_psb01	Resilience
ABCD Sum Scores Culture & Environment Parent	abcd_sscep01	Culture and environment summary scores - parent surveys
ABCD Sum Scores Culture & Environment Youth	abcd_sscey01	Culture and environment summary scores - youth surveys
ABCD Parent Vancouver Index of Acculturation-Short Survey (VIA)	abcd_via01	Acculturation
ABCD Children's Report of Parental Behavioral Inventory	crpbi01	Environment- family and religion
ABCD Parent Family Environment Scale-Family Conflict Subscale Modified from PhenX (FES)	fes02	Family dynamics, cohesion, expressiveness, conflict
ABCD Parent Mexican American Cultural Values Scale Modified (MACV)	macv01	Familism, religion, independence, self-reliance
ABCD Parent Acculturation Survey Modified from PhenX (ACC)	pacc01	Cultural factors

ABCD Parental Monitoring Survey	pmq01	Parental monitoring and supervision
Parent Prosocial Behavior Survey	psb01	Resilience
ABCD School Risk and Protective Factors Survey	srpf01	School risk and protective factors
ABCD Youth Acculturation Survey Modified from PhenX (ACC)	yacc01	Cultural factors
Neurocognition		
ABCD Pearson Scores	absd_ps01	Measures included in Pearson Scores are described below
ABCD Youth NIH TB Summary Scores	abcd_tbss01	Measures included in NIH TB Summary Scores are described below
ABCD TBX Demo	abcddemo01	Demographics - age only
ABCD Little Man Task	lmtp201	Visuospatial processing flexibility, attention
Others		
ABCD Youth Hair Sample	abcd_hers01	Information collected by RAs at the time of collecting ~100 strands of hair for metabolites indicating substance use in past month or longer (e.g. time of day of collection)
ABCD Sum Scores Mental Health Youth	Sum_Scores_mhy01	Mental Health summary scores - youth surveys
ABCD MRI Behavior MID	abcd_mid01	Behavioral performance measures for MID task fMRI
ABCD Youth Monetary Incentive Delay (MID) Task Survey Post Scan Questionnaire	abcd_monet01	Ratings of mood when viewing the different cues and receiving the different outcomes during the MID task to determine the effectiveness and value of wins and losses
MR Findings	abcd_mrfindings01	Neuroradiology reports - scores, hydrocephalus and herniation
ABCD RA Scanning Checklist and Notes	abcd_ra01	Checklist used by site coordinators/research assistants prior to and during scanning sessions
Residential History Derived Scores	abcd_rhds01	Environmental risk
ABCD Screener	abcd_screen01	Eligibility screener and screener risk measures
ABCD MRI Behavior SST	abcd_sst01	Behavioral performance measures for SST task fMRI
ABCD Youth Genetic Saliva (RUCDR)	abcd_ygs01	Information collected by RAs at the time of saliva collection for genetics studies (e.g., time of day of collection)
ABCD Youth Pre Scan Questionnaire 1	abcd_ypre101	Current mood ratings before completing MRI scan
ABCD Youth Post Scan Questionnaire 1	abcd_ypsq101	Current mood ratings after completing MRI scan
ABCD Youth Toxicology Test	abcd_ytt01	Past day drug use - Oral Fluid Drager
ACS Post Stratification Weights	acspsw01	ACS post stratification weights for demographic and socioeconomic measures, and family relationships table
ABCD Youth Genetic Blood (RUCDR)	biocf01	Information collected by RAs at the time of venipuncture blood collection for genetics studies (e.g., time of day of collection)
Processed MRI Data?used for minimally processed data)	fmriresults01	Index of minimally processed data
ABCD Pubertal Hormone Saliva	sph01	Information collected by RAs at the time of collecting oral fluid to indicate current estradiol, testosterone, and DHEA levels (e.g., time of day of collection)

Table S2. The correlation between the volume of subcortical brain areas and sleep duration, the cognitive total score, and the depressive problems score.

Brain region	Sleep duration			Depressive score			Cognitive score		
	Cohen's d	p value	FDR value	Cohen's d	p value	FDR value	Cohen's d	p value	FDR value
ASEG ROI left-cerebral-white-matter	0.107	1.99E-08	2.42E-06	-0.086	6.46E-06	1.26E-04	0.255	<1.0E-10	<1.0E-10
ASEG ROI left-lateral-ventricle	0.084	9.13E-06	1.17E-04	-0.002	9.26E-01	9.65E-01	-0.005	7.78E-01	7.95E-01
ASEG ROI left-inf-lat-vent	0.059	2.03E-03	5.90E-03	-0.025	1.87E-01	2.64E-01	0.023	2.27E-01	2.48E-01
ASEG ROI left-cerebellum-white-matter	0.032	8.95E-02	1.36E-01	-0.042	2.75E-02	5.37E-02	0.143	1.29E-13	3.79E-13
ASEG ROI left-cerebellum-cortex	0.069	2.66E-04	1.12E-03	-0.074	9.36E-05	7.37E-04	0.187	<1.0E-10	<1.0E-10
ASEG ROI left-thalamus-proper	0.078	4.26E-05	3.03E-04	-0.069	3.00E-04	1.66E-03	0.209	<1.0E-10	<1.0E-10
ASEG ROI left-caudate	0.091	1.84E-06	4.69E-05	-0.065	6.08E-04	2.65E-03	0.204	<1.0E-10	<1.0E-10
ASEG ROI left-putamen	0.040	3.77E-02	6.53E-02	-0.035	6.75E-02	1.14E-01	0.169	<1.0E-10	<1.0E-10
ASEG ROI left-pallidum	0.046	1.53E-02	3.03E-02	-0.038	4.79E-02	8.65E-02	0.165	<1.0E-10	<1.0E-10
ASEG ROI 3rd-ventricle	0.051	7.32E-03	1.67E-02	0.000	9.88E-01	9.92E-01	0.044	2.17E-02	2.63E-02
ASEG ROI 4th-ventricle	0.035	6.69E-02	1.05E-01	-0.011	5.69E-01	6.40E-01	0.073	1.54E-04	2.23E-04
ASEG ROI brain-stem	0.075	8.64E-05	5.02E-04	-0.096	4.34E-07	3.53E-05	0.216	<1.0E-10	<1.0E-10
ASEG ROI left-hippocampus	0.039	3.94E-02	6.73E-02	-0.052	6.78E-03	1.80E-02	0.164	<1.0E-10	<1.0E-10
ASEG ROI left-amygdala	0.028	1.42E-01	2.02E-01	-0.050	8.79E-03	2.17E-02	0.104	5.94E-08	1.11E-07
ASEG ROI csf	0.064	7.48E-04	2.52E-03	-0.019	3.07E-01	3.94E-01	0.071	2.23E-04	3.20E-04
ASEG ROI left-accumbens-area	0.087	4.95E-06	8.62E-05	-0.093	1.07E-06	5.64E-05	0.156	6.66E-16	2.08E-15
ASEG ROI left-ventraldc	0.073	1.22E-04	5.83E-04	-0.076	7.22E-05	6.29E-04	0.223	<1.0E-10	<1.0E-10
ASEG ROI right-cerebral-white-matter	0.101	1.02E-07	6.21E-06	-0.091	1.70E-06	5.92E-05	0.250	<1.0E-10	<1.0E-10
ASEG ROI right-lateral-ventricle	0.067	4.71E-04	1.71E-03	-0.006	7.33E-01	7.78E-01	-0.006	7.68E-01	7.87E-01
ASEG ROI right-inf-lat-vent	0.054	4.37E-03	1.12E-02	0.007	7.31E-01	7.78E-01	-0.009	6.40E-01	6.62E-01
ASEG ROI right-cerebellum-white-matter	0.036	5.78E-02	9.36E-02	-0.048	1.17E-02	2.75E-02	0.136	1.74E-12	4.57E-12
ASEG ROI right-cerebellum-cortex	0.070	2.35E-04	1.00E-03	-0.076	6.78E-05	6.13E-04	0.189	<1.0E-10	<1.0E-10
ASEG ROI right-thalamus-proper	0.074	1.11E-04	5.48E-04	-0.067	4.17E-04	2.07E-03	0.211	<1.0E-10	<1.0E-10
ASEG ROI right-caudate	0.089	2.66E-06	4.99E-05	-0.062	1.13E-03	4.23E-03	0.190	<1.0E-10	<1.0E-10
ASEG ROI right-putamen	0.055	3.73E-03	9.92E-03	-0.049	1.07E-02	2.57E-02	0.191	<1.0E-10	<1.0E-10
ASEG ROI right-pallidum	0.090	2.27E-06	4.69E-05	-0.052	6.78E-03	1.80E-02	0.232	<1.0E-10	<1.0E-10
ASEG ROI right-hippocampus	0.032	9.71E-02	1.44E-01	-0.067	4.41E-04	2.07E-03	0.163	<1.0E-10	<1.0E-10
ASEG ROI right-amygdala	0.029	1.31E-01	1.90E-01	-0.069	2.95E-04	1.66E-03	0.080	3.26E-05	4.87E-05
ASEG ROI right-accumbens area	0.060	1.63E-03	4.90E-03	-0.079	3.71E-05	3.62E-04	0.142	1.41E-13	4.10E-13
ASEG ROI right-ventraldc	0.105	3.49E-08	2.84E-06	-0.065	6.05E-04	2.65E-03	0.231	<1.0E-10	<1.0E-10
ASEG ROI wm-hypointensities	0.004	8.52E-01	8.85E-01	-0.014	4.48E-01	5.36E-01	0.071	2.40E-04	3.41E-04
ASEG ROI CC-Posterior	0.054	4.58E-03	1.15E-02	-0.043	2.31E-02	4.58E-02	0.116	1.44E-09	3.04E-09
ASEG ROI CC-Mid_Posterior	0.024	2.06E-01	2.81E-01	-0.031	1.08E-01	1.72E-01	0.089	3.89E-06	6.24E-06
ASEG ROI CC-Central	-0.009	6.32E-01	6.98E-01	-0.024	1.98E-01	2.73E-01	0.054	4.72E-03	5.97E-03
ASEG ROI CC-Mid_Anterior	0.014	4.60E-01	5.47E-01	-0.033	8.73E-02	1.41E-01	0.025	1.99E-01	2.25E-01
ASEG ROI CC-Anterior	0.066	5.07E-04	1.79E-03	-0.043	2.30E-02	4.58E-02	0.042	2.84E-02	3.35E-02
ASEG ROI wholebrain	0.110	6.97E-09	1.70E-06	-0.104	4.21E-08	1.03E-05	0.267	<1.0E-10	<1.0E-10
ASEG ROI latventricles	0.083	1.15E-05	1.23E-04	-0.006	7.36E-01	7.78E-01	-0.004	8.20E-01	8.33E-01
ASEG ROI allventricles	0.085	8.40E-06	1.14E-04	-0.007	7.09E-01	7.65E-01	0.004	8.33E-01	8.39E-01
ASEG ROI intracranialvolume	0.067	4.02E-04	1.51E-03	-0.061	1.44E-03	4.99E-03	0.180	<1.0E-10	<1.0E-10

Figure S1. A) Brain regions with their cortical volume significantly associated with sleep duration (FDR corrected, p<0.005). The red color indicates brain regions with high volume positively associated with longer sleep duration. **B) Brain regions with their volume significantly associated with the cognitive total score** (FDR corrected, p<0.005). The red color indicates brain regions where high volume is positively correlated with a higher cognitive score. Here, we only shown the regions with Cohen's d larger than 0.15. **C) Brain regions with their volume significantly associated with the depressive problems score** (FDR corrected, p<0.005). Blue indicates brain regions with a negative correlation between volume and the depressive problems score (i.e. a low volume is associated with depressive problems). **D) Brain regions with their volume associated with both sleep duration and the cognitive total score.** The regions shown are the overlap of what is shown in A and B. **E) Brain regions with their volume associated with both sleep duration and the depressive problems score.** The regions shown are the overlap of what is shown in A and C.

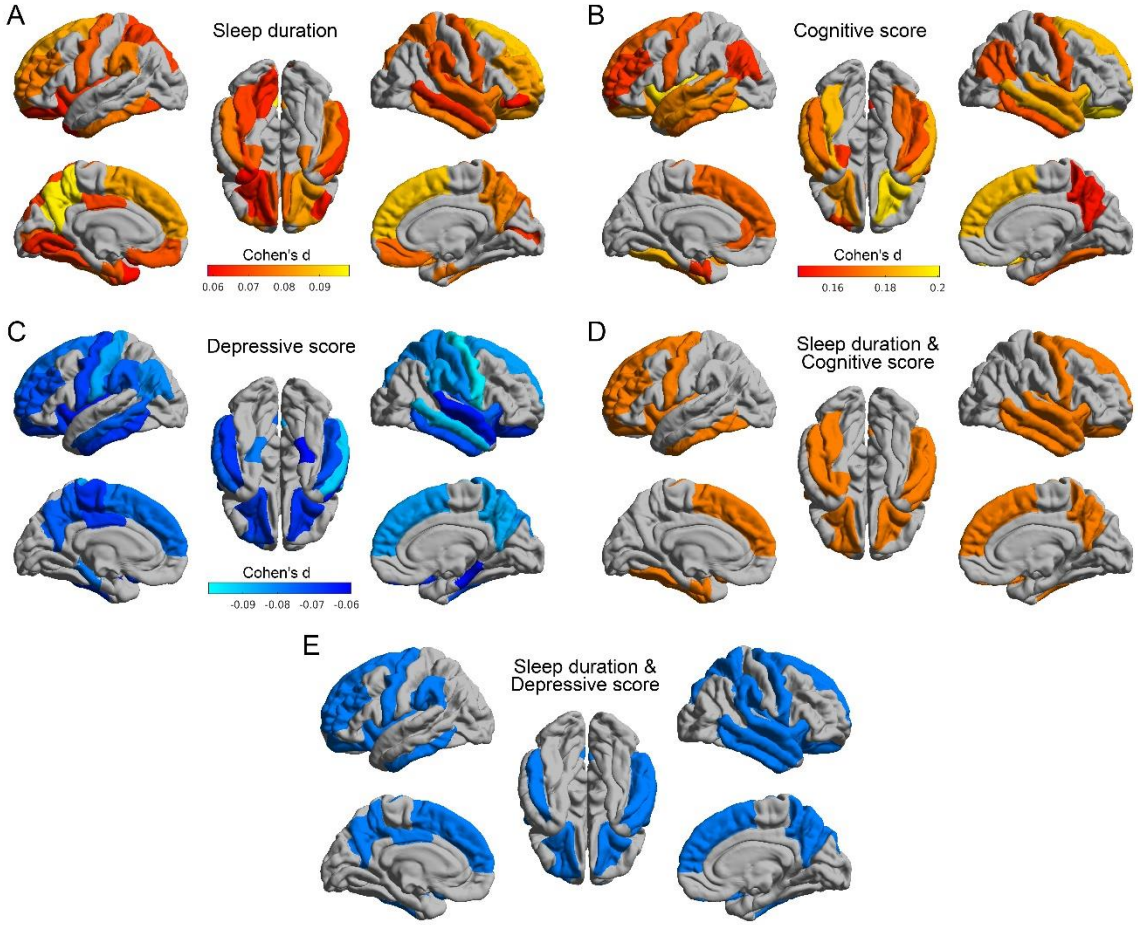


Figure S2. A) Brain regions with their cortical area significantly associated with the psychiatric problems total score (FDR corrected, p<0.005). Blue indicates brain regions with a negative correlation between area and the psychiatric problems score (i.e. a low area is associated with psychiatric problems). Here, we show only the regions with Cohen's d less than -0.1. **B) Brain regions with their cortical volume significantly associated with the psychiatric problems total score** (FDR corrected, p<0.005). Blue indicates brain regions with a negative correlation between volume and the psychiatric problems score (i.e. a low volume is associated with psychiatric problems). Here, we only shown the regions with Cohen's d less than -0.1.

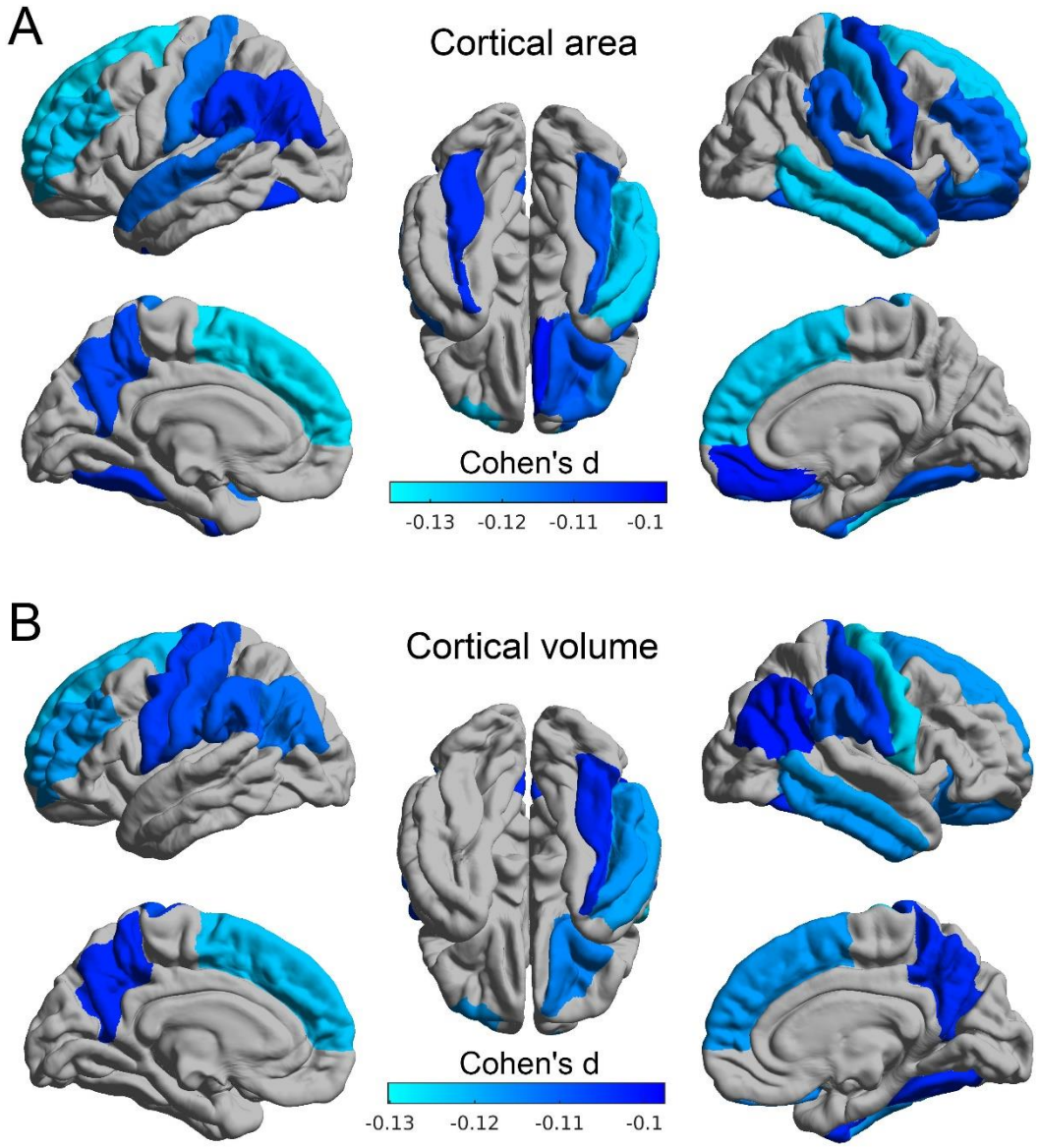


Figure S3. A) Brain regions with their cortical area significantly associated with sleep duration after regressing out the effects of intracranial volume (FDR corrected, p<0.05). The red color indicates brain regions with area positively associated with longer sleep duration. **B) Brain regions with their cortical volume significantly associated with sleep duration after regressing out the effects of intracranial volume** (FDR corrected, p<0.05). The red color indicates brain regions with volume positively associated with longer sleep duration. **C) Brain regions with their area significantly associated with the depressive problems score after regressing out the effects of intracranial volume** (FDR corrected, p<0.05). Blue indicates brain regions with a negative correlation between area and the depressive problems score. **D) Brain regions with their volume significantly associated with the depressive problems score after regressing out the effects of intracranial volume** (FDR corrected, p<0.05). Blue indicates brain regions with a negative correlation between volume and the depressive problems score. **E) Brain regions with their area significantly associated with the cognitive total score after regressing out the effects of intracranial volume** (FDR corrected, p<0.05). The red color indicates brain regions where high area is positively correlated with a higher cognitive score. Here, we only show the regions with Cohen's d larger than 0.1. **F) Brain regions with their volume significantly associated with the cognitive total score after regressing out the effects of intracranial volume** (FDR corrected, p<0.05). The red color indicates brain regions where high volume is positively correlated with a higher cognitive score. Here, we only show the regions with Cohen's d larger than 0.08.

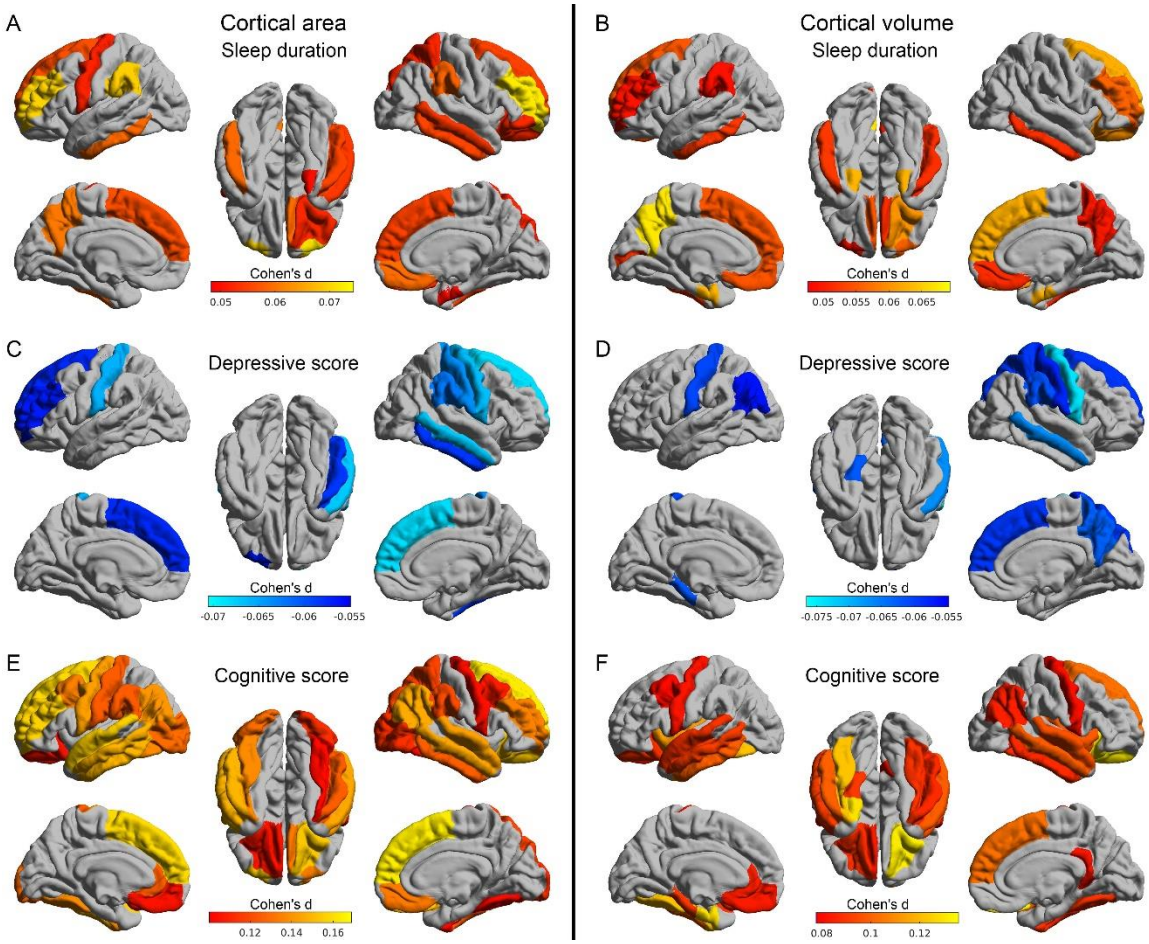


Figure S4. The longitudinal association between the psychiatric problems total score and the sleep duration revealed by structural equation modelling (using a two-wave cross-lagged panel model). The psychiatric problems total score was significantly associated with lower sleep duration measured one year later (β = -0.064, SE = 0.015, $p < 1\times10^{-4}$); and the reverse was not true (β = -0.01, SE = 0.011, p = 0.374).

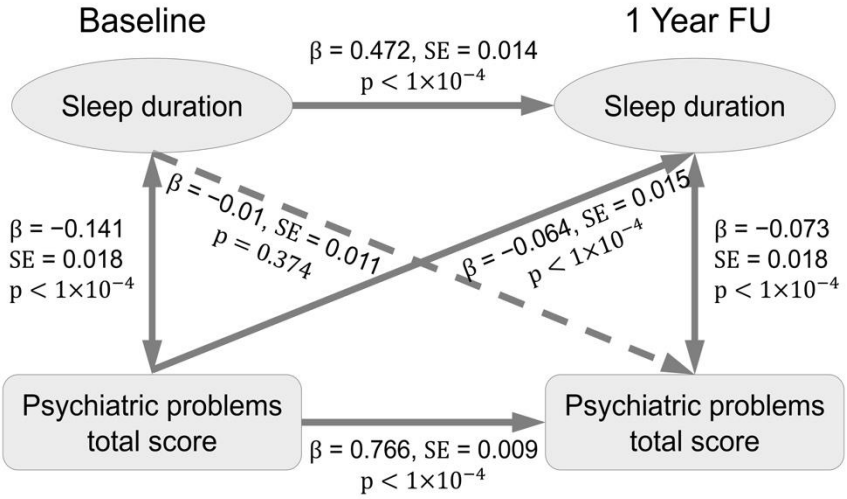


Figure S5. A) The mediation implemented by depressive problems from cortical volume on sleep duration was significant (β=0.015, p=1.7×10^{-10}). **B)** The mediation implemented by psychiatric problems from cortical area on sleep duration was significant (β=0.016 p=2.2×10^{-16}). **C)** The mediation implemented by psychiatric problems from cortical volume on sleep duration was significant (β=0.015, p=3.1×10^{-15}). **D)** The mediation implemented by sleep duration from the cortical volume on cognition was significant (β=0.034, p=9.4×10^{-5}).

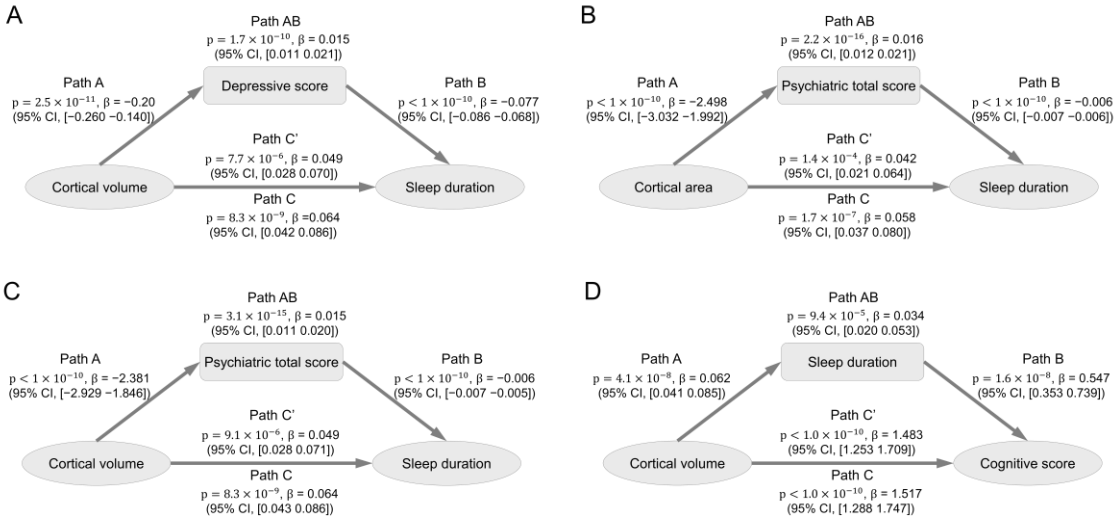
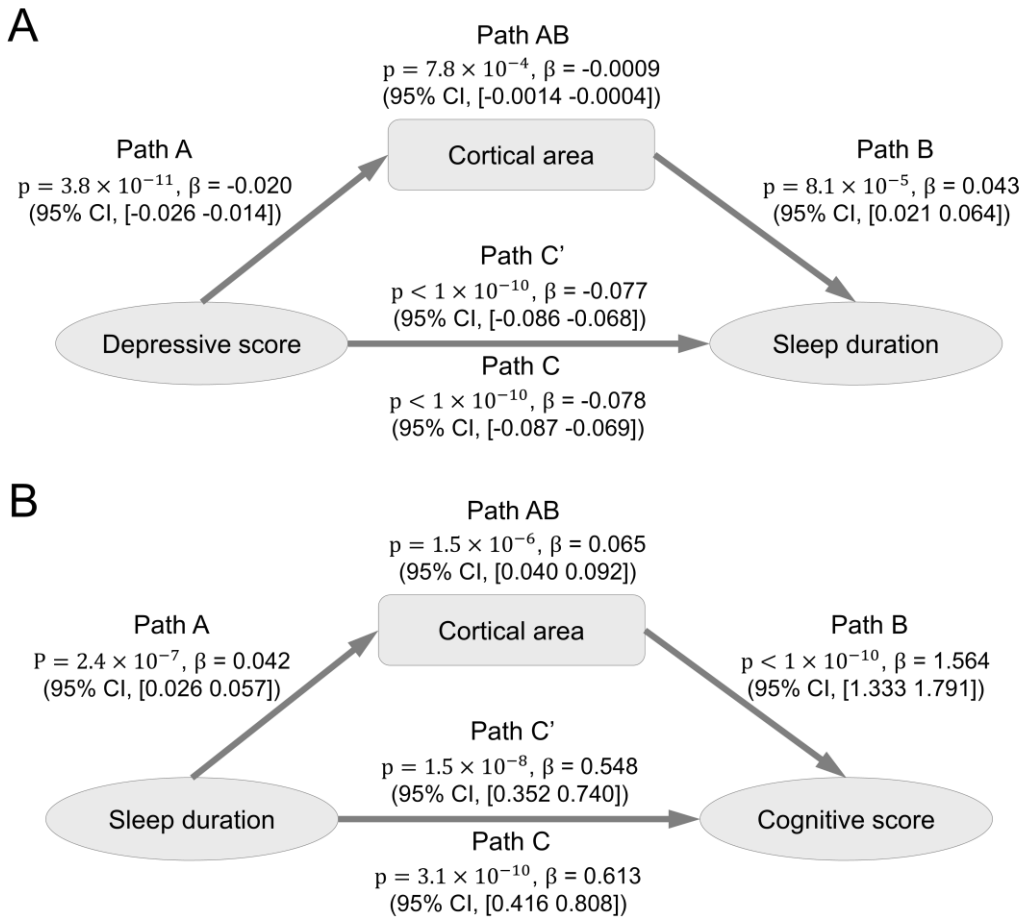


Figure S6. A) The mediation implemented by cortical area from depressive problems on sleep duration was significant (β=-0.0009, p=7.8×10^{-4}). **B)** The mediation implemented by cortical area from sleep duration on cognition was significant (β=0.065, p=1.5×10^{-6}).



References

1. Hagler DJ, Jr., Hatton SN, Makowski C. Image processing and analysis methods for the Adolescent Brain Cognitive Development Study. *BioRchiv* 2018**:** 457739.

2. Bruni O, Ottaviano S, Guidetti V, Romoli M, Innocenzi M, Cortesi F *et al.* The Sleep Disturbance Scale for Children (SDSC). Construction and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. *J Sleep Res* 1996; **5**(4)**:** 251-261.

3. Achenbach TM, Rescorla LA, Maruish ME. The Achenbach system of empirically based assessment (ASEBA) for ages 1.5 to 18 years. In: Maruish ME (ed). *The Use of Psychological Testing for Treatment Planning and Outcomes Assessment*, 3 edn, vol. 2. Erlbaum: Mahwah, N.J., 2004, pp 179-213.

4. Achenbach T, Rescorla L. *Achenbach system of empirically based assessment*. Springer2013.