

Are there shared neural correlates between dyslexia and ADHD?
A meta-analysis of voxel-based morphometry studies – Open-Data Replication

Supplementary Material

DATASET CONSTRUCTION

Table S1. VBM experiments included in the original coordinate-based meta-analysis by McGrath and Stoodley (2019): methodological details for the attention-deficit/hyper-activity disorder (A) and dyslexia (B) datasets ...**page 3**

Table S2. VBM experiments with null results and not included in the original coordinate-based meta-analysis by McGrath and Stoodley (2019): methodological details for the attention-deficit/hyper-activity disorder (A) and dyslexia (B) datasets ...**page 6**

REPLICATION ANALYSIS

Table S3. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (replication analysis) ...**page 7**

Figure S1. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (replication analysis) ...**page 8**

Table S4. Brain clusters of gray matter variation in dyslexia compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (replication analysis) ...**page 9**

ADDITIONAL ANALYSIS

Table S5. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (additional analysis) ...**page 10**

Figure S2. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (additional analysis) ...**page 11**

Table S6. Brain clusters of gray matter variation in dyslexia compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (additional analysis) ...**page 12**

BRAIN VOLUME SUB-ANALYSIS

Table S7. Brain clusters of gray matter variation in dyslexia compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (brain volume sub-analysis) ...**page 13**

Figure S3. Brain clusters of gray matter variation in dyslexia compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (brain volume sub-analysis) ...**page 14**

Table S8. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (brain volume sub-analysis) ...**page 15**

Figure S4. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (brain volume sub-analysis) ...**page 17**

References ...page 18

DATASET CONSTRUCTION

Table S1. VBM experiments included in the original coordinate-based meta-analysis by McGrath and Stoodley (2019): methodological details for the attention-deficit/hyper-activity disorder (A) and dyslexia (B) datasets.

Experiments	GM variations		P value (correction)	VBM software	Thickness (mm)	Smoothing (FWHM)	Scanner (Tesla)	Original data
	TDCs > PZ	PZ > TDCs						
(A) ADHD								
Ahrendts et al., 2011	2	0	p < 0.05 corrected for multiple comparisons using FDR	SPM 2	1	12 mm	1.5	MNI
Bonath et al., 2018	12	0	p < 0.001 uncorrected on the voxel level p < 0.05 corrected for multiple comparisons using FDR	SPM 8	1	8 mm	3.0	BRETT
Bralten et al., 2016	5	0	p < 0.05 corrected for multiple comparisons using FWE	SPM	N/A	8 mm	1.5	MNI
Brieber et al., 2007	9	6	p < 0.001 uncorrected for multiple comparisons	SPM 2	1	12 mm	1.5	MNI
Carmona et al., 2005	17	0	p < 0.05 corrected for multiple comparisons using FWE	SPM 2	N/A	12 mm	1.5	MNI
He et al., 2015	4	0	p < 0.05 corrected for multiple comparisons using FWE	SPM 8	1	8 mm	3.0	MNI
Iannaccone et al., 2015	3	2	p < 0.05 corrected for multiple comparisons using cluster extent correction	SPM 8	1	8 mm	3.0	MNI
Johnston et al., 2014	12	0	p < 0.05 corrected for multiple comparisons using FWE	SPM 8	1	8 mm	1.5	MNI
Kappel et al., 2015 (adults)	4	0	p < 0.05 corrected for multiple comparisons using FWE	SPM 8	1	6 mm	3.0	MNI
Kappel et al., 2015 (children)	1	4	p < 0.05 corrected for multiple comparisons using FWE	SPM 8	1	6 mm	3.0	MNI
Kaya et al., 2018	0	7	p < 0.001 uncorrected for multiple comparisons	SPM 8	N/A	8 mm	1.5	MNI
Kobel et al. 2010	1	0	p < 0.001 uncorrected	SPM 5	N/A	12 mm	3.0	TAL
Kumar et al., 2017	4	0	p < 0.05 corrected for multiple comparisons using FDR	SPM 8	N/A	12 mm	3.0	OTHER
Lim et al., 2013	6	0	p < 0.05 corrected for multiple comparisons using FWE	SPM 8	N/A	8 mm	3.0	TAL
McAlonan et al., 2007	8	0	p < 0.001 uncorrected for volume differences p < 0.05 corrected for multiple comparisons using FWE	BAMM	3	4.4 mm	1.5	TAL
Montes et al., 2010	2	0	p < 0.01 corrected for multiple comparisons using FDR and FWE	SPM 5	1	8 mm	1.0	MNI

Moreno-Alcázar et al., 2016	3	1	p < 0.001 uncorrected on the voxel level p < 0.05 corrected for multiple comparisons using FWE	FSL	1	9.4 mm	1.5	MNI
Overmeyer et al., 2001	9	0	p < 0.025 uncorrected	N/A	3	N/A	1.5	TAL
Roman-Urrestarazu et al., 2016	2	0	p < 0.05 corrected for multiple comparisons using FWE	FSL-VBM	1	3 mm	1.5	MNI
Sasayama et al., 2010	14	0	p < 0.05 corrected for multiple comparisons using FDR	SPM 2	1	12 mm	1.5	MNI
van Wingen et al., 2013	2	2	p < 0.05 corrected for multiple comparisons using FWE	SPM 8	1.2	8 mm	3.0	MNI
Villemonteix et al., 2015 (med naïve group)	2	0	p < 0.001 uncorrected for multiple comparisons	SPM 8	N/A	5 mm	3.0	MNI
Villemonteix et al., 2015 (med group)	2	0	p < 0.001 uncorrected for multiple comparisons	SPM 8	N/A	5 mm	3.0	MNI
Yang et al., 2008	6	0	p < 0.001 uncorrected for multiple comparisons p < 0.05 corrected for multiple comparisons	SPM 2	5	8 mm	1.5	MNI
(B) DYSLEXIA								
Brambati et al., 2004	9	0	p < 0.05 corrected for small brain volume	SPM 2	1.5	12 mm	1.5	TAL
Brown et al., 2001	8	0	p < 0.05 corrected for multiple comparisons	SPM 99	2	8 mm	1.5	TAL
Eckert et al., 2005	5	1	p < 0.001 uncorrected significance levels	SPM2b	N/A	12 mm	1.5	MNI
Evans et al., 2014 (male adults)	2	0	p < 0.001 uncorrected for statistical map generation p < 0.05 extent threshold utilizing a non-stationary correction	SPM 8	1	8 mm	1.5/3.0	TAL
Evans et al., 2014 (female adults)	2	0	p < 0.001 uncorrected for statistical map generation p < 0.05 extent threshold utilizing a non-stationary correction	SPM 8	1	8 mm	1.5/3.0	TAL
Evans et al., 2014 (male children)	1	0	p < 0.001 uncorrected for statistical map generation p < 0.05 extent threshold utilizing a non-stationary correction	SPM 8	1	8 mm	1.5/3.0	TAL
Evans et al., 2014 (female children)	3	0	p < 0.001 uncorrected for statistical map generation p < 0.05 extent threshold utilizing a non-stationary correction	SPM 8	1	8 mm	1.5/3.0	TAL
Hoefl et al., 2007	6	0	p < 0.01 corrected for whole brain analysis	SPM 2	N/A	8 mm	3.0	TAL
Jednoróg et al., 2015	1	0	p < 0.05 corrected for multiple comparisons	SPM 8	1	4 mm	1.5/3.0	MNI
Kronbichler et al., 2008	11	8	p < 0.05 corrected for multiple comparisons using FDR	SPM 2	1.3	12mm	1.5	MNI
Liu et al., 2013	8	0	p < 0.001 with clusters corrected for nonisotropic smoothness	SPM 5	1	12 mm	3.0	MNI
Silani et al., 2005	1	1	p < 0.05 corrected for whole brain	SPM 2	1.5	12 mm	1.5/2.0	TAL

Siok et al., 2008	3	0	p < 0.05 corrected for multiple comparisons using FWE	SPM 2	2	10 mm	2.0	MNI
Steinbrink et al., 2008	2	0	p < 0.05 corrected for multiple comparisons using FDR	SPM 5	N/A	12 mm	3.0	MNI
Tamboer et al., 2015	8	3	p < 0.05 corrected for multiple comparisons using random field theory	FSL-VBM	N/A	4 mm	3.0	MNI
Vinckenbosch et al., 2005	1	1	p < 0.001 uncorrected for multiple comparisons p < 0.05 corrected for multiple comparisons using FDR and FWE	SPM99	1	8 mm	1.5	TAL
Xia et al., 2016	3	0	p < 0.001 uncorrected for multiple comparisons p < 0.05 corrected for multiple comparisons using FWE	SPM8	1.33	8 mm	3.0	MNI
Yang et al., 2016	7	3	p < 0.001 corrected by Alpha Sim correction	SPM8	4	8 mm	1.5	MNI

ADHD, attention-deficit/hyper-activity disorder; FDR, false discovery rate; FWE, family-wise error; FWHM, full width at half maximum; MNI, Montreal Neurological Institute; N/A, data not available; PZ, patients; TAL, Talairach; TDCs, typically developing controls; VBM, voxel-based morphometry.

Table S2. VBM experiments with null results and not included in the original coordinate-based meta-analysis by McGrath and Stoodley (2019): methodological details for the attention-deficit/hyper-activity disorder (A) and dyslexia (B) datasets.

Experiments	P value (correction)	VBM software	Thickness (mm)	Smoothing (FWHM)	Scanner (Tesla)	Original data
(A) ADHD						
Amico et al., 2011	p < 0.05 corrected for multiple comparisons using FWE	SPM5	1.5	8 mm	1.5	TAL
Depue et al., 2010	p < 0.05 corrected for multiple comparisons	FSL-VBM	1.7	4.6 mm	N/A	MNI
Maier et al., 2016	p < 0.05 corrected for multiple comparisons using FWE	SPM12	N/A	8 mm	N/A	OTHER
Onnink et al., 2014	p < 0.05 corrected for multiple comparisons using FDR	SPM8	N/A	8 mm	1.5	MNI
Saad et al., 2017	p < 0.05 corrected for multiple comparisons using FDR	SPM8	1	N/A	3.0	MNI
Seidman et al., 2011	p < 0.05 corrected for multiple comparisons using FWE	FSL-VBM	1.33	7.05 mm	1.5	MNI
Villemonteix et al., 2015	p < 0.05 corrected for multiple comparisons using FWE	SPM8	N/A	12 mm	3.0	MNI
(B) DYSLEXIA						
Eckert et al., 2016	p < 0.05 corrected for multiple comparisons using FDR	SPM8	N/A	8 mm	1.5/3.0	MNI
Pernet et al., 2009	p < 0.05 corrected for multiple comparisons using FDR	SPM5	N/A	8 mm	1.5	MNI

ADHD, attention-deficit/hyper-activity disorder; FDR, false discovery rate; FWE, family-wise error; FWHM, full width at half maximum; MNI, Montreal Neurological Institute; N/A, data not available; PZ, patients; TAL, Talairach; TDCs, typically developing controls; VBM, voxel-based morphometry.

REPLICATION ANALYSIS

Table S3. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (replication analysis).

Region	MNI coordinate			SDM	$P < 0.005$	Voxels	Cluster breakdown (Voxels)
	x	y	z	Z score	(Uncorrected)		
ADHD > TDCs							
No cluster found							
ADHD < TDCs							
Right superior frontal gyrus, medial orbital (BA 11)	6	24	-10	-3.708	0.0001	127	Right SFG (66) Right gyrus rectus (32) Right olfactory cortex (15) Bilateral ACC (12) Right Striatum (2)
Right lenticular nucleus (Putamen)	30	0	-2	-3.385	0.0003	82	Right Putamen (65) Right Striatum (17)
Left lobule VI (Cerebellum)	-34	-46	-34	-2.783	0.002	22	Left lobule VI (16) Left crus I (6)
Left postcentral gyrus (BA 6)	-46	-14	50	-2.942	0.001	12	Left PoCG (12)
Right gyrus rectus (BA 11)	4	38	-24	-2.781	0.002	10	Right gyrus rectus (10)

Abbreviations: ADHD, attention-deficit/hyper-activity disorder; TDCs, typically developing controls; BA, Brodmann area; MNI, Montreal Neurological Institute; SDM, Seed-based d Mapping; SFG, superior frontal gyrus; ACC, anterior cingulate cortex; PoCG, posterior central gyrus.

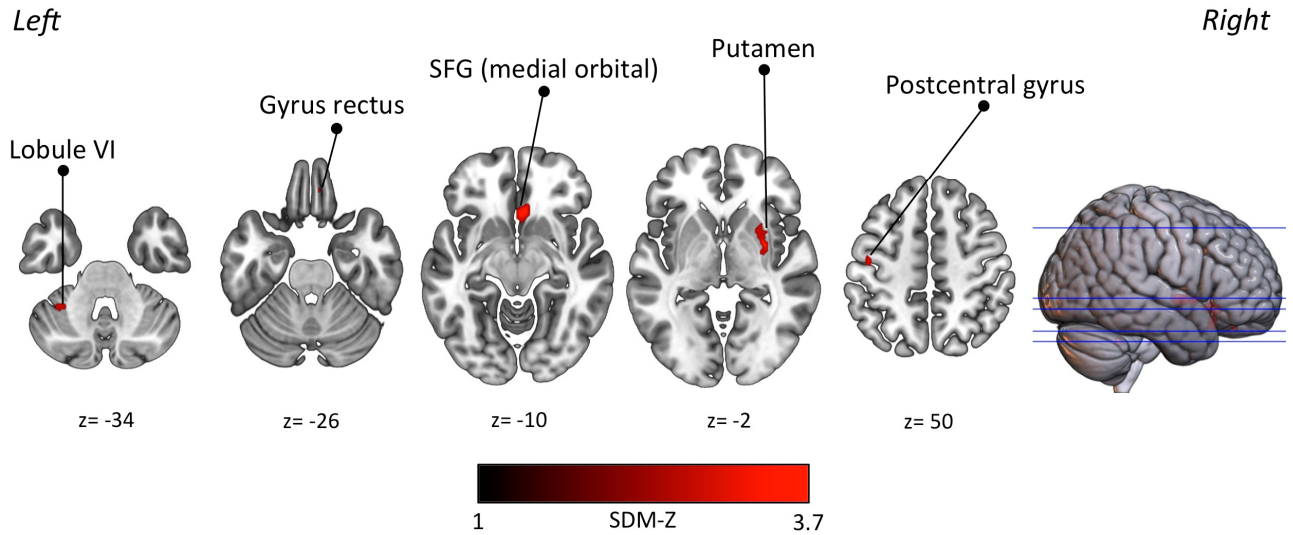


Figure S1. Brain clusters of gray matter variation in attention-deficit/hyperactivity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (replication analysis).

The PSI-SDM map is visualized as six axial slices (2-D cortical, subcortical, and cerebellar view). Colors from dark to light red represent voxels with a common pattern of neuroanatomical reduction (gray matter in attention-deficit/hyperactivity disorder < typically developmental controls). Brain slices are in neurological convention (i.e. Right is right, Left is left). SFG, superior frontal gyrus.

Table S4. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (replication analysis).

Region	MNI coordinate			SDM	$P < 0.005$	Voxels	Cluster breakdown
	x	y	z	Z score	(Uncorrected)		(Voxels)
Dyslexia > TDCs							
No cluster found							
Dyslexia < TDCs							
No cluster found							
Abbreviations: TDCs, typically developing controls; SDM, Seed-based d Mapping.							

ADDITIONAL ANALYSIS

Table S5. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (additional analysis).

Region	MNI coordinate			SDM	$P < 0.005$	Voxels	Cluster breakdown (Voxels)
	x	y	z	Z score	(Uncorrected)		
ADHD > TDCs							
No cluster found							
ADHD < TDCs							
Right superior frontal gyrus, medial orbital (BA 11)	6	24	-10	-4.051	0.00002	148	Right SFG (87) Right gyrus rectus (38) Right olfactory cortex (10) Bilateral ACC (9) Right Striatum (4)
Right lenticular nucleus (Putamen)	30	0	-2	-3.817	0.00006	152	Right Putamen (131) Right Striatum (21)
Left lobule VI (Cerebellum)	-34	-46	-34	-3.023	0.001	50	Left lobule VI (29) Left crus I (21)
Right gyrus rectus (BA 11)	4	38	-24	-3.281	0.0005	19	Right gyrus rectus (19)

Abbreviations: ADHD, attention-deficit/hyper-activity disorder; TDCs, typically developing controls; BA, Brodmann area; MNI, Montreal Neurological Institute; SDM, Seed-based d Mapping; SFG, superior frontal gyrus; ACC, anterior cingulate cortex.

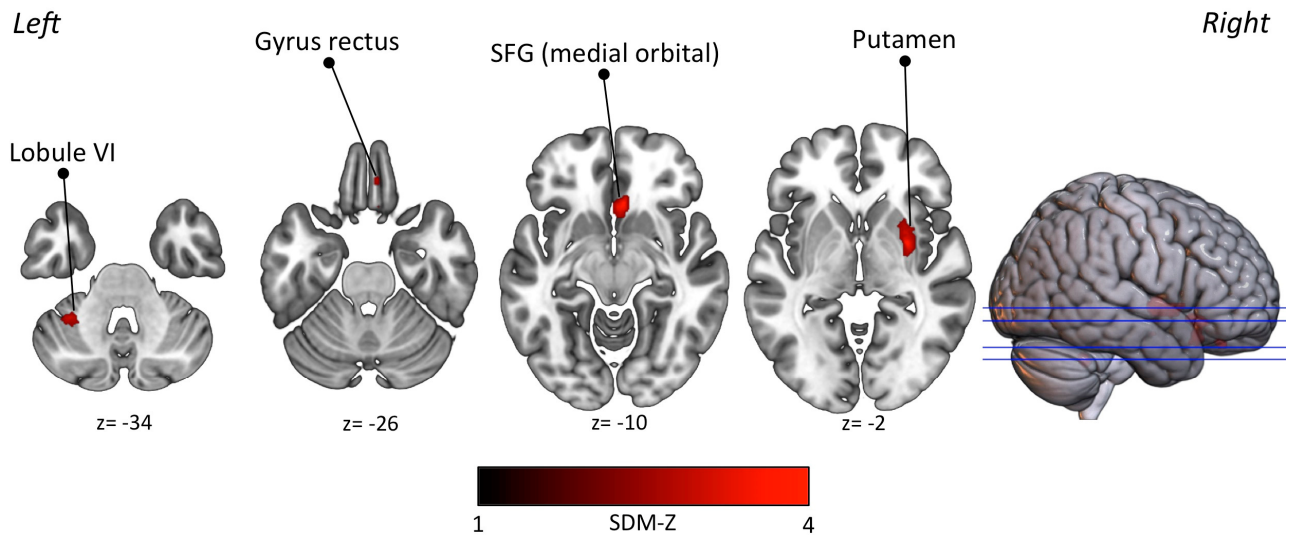


Figure S2. Brain clusters of gray matter variation in attention-deficit/hyperactivity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (additional analysis).

The PSI-SDM map is visualized as six axial slices (2-D cortical, subcortical, and cerebellar view). Colors from dark to light red represent voxels with a common pattern of neuroanatomical reduction (gray matter in attention-deficit/hyperactivity disorder < typically developmental controls). Brain slices are in neurological convention (i.e. Right is right, Left is left). SFG, superior frontal gyrus.

Table S6. Brain clusters of gray matter variation in dyslexia compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (replication analysis).

Region	MNI coordinate			SDM Z score	<i>P</i> < 0.005 (Uncorrected)	Voxels	Cluster breakdown (Voxels)
	x	y	z				
Dyslexia > TDCs							
No cluster found							
Dyslexia < TDCs							
No cluster found							
Abbreviations: TDCs, typically developing controls; SDM, Seed-based d Mapping.							

BRAIN VOLUME SUB-ANALYSIS

Table S7. Brain clusters of gray matter variation in dyslexia compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (brain volume sub-analysis).

Region	MNI coordinate			SDM	$P < 0.005$	Voxels	Cluster breakdown (Voxels)
	x	y	z	Z score	(Uncorrected)		
Dyslexia > TDCs							
No cluster found							
Dyslexia < TDCs							
Left superior temporal gyrus (BA 38)	-46	10	-14	-3.578	0.0001	207	Left STG (181) Left MTG (26)
Right lobule VI (Cerebellum)	36	-58	-24	-2.839	0.002	34	Right lobule VI (22) Right crus I (12)
Middle cerebellar peduncles	-24	-44	-32	-2.715	0.003	14	Middle cerebellar peduncles (14)

Abbreviations: TDCs, typically developing controls; BA, Brodmann area; MNI, Montreal Neurological Institute; SDM, Seed-based d Mapping; STG, superior temporal gyrus; MTG, middle temporal gyrus.

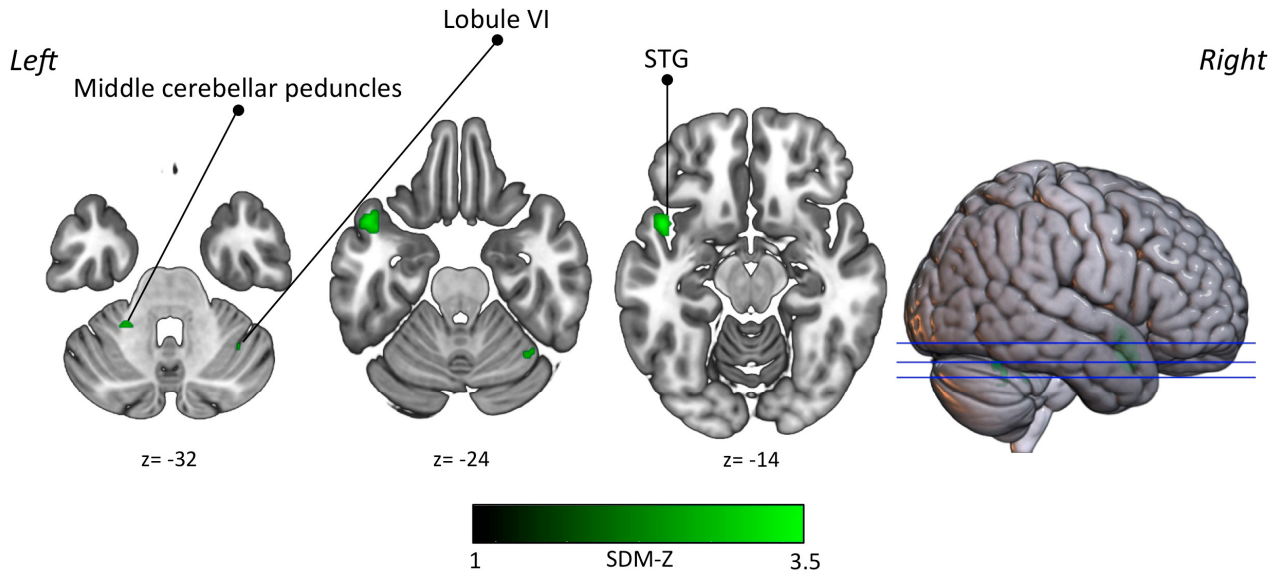


Figure S3. Brain clusters of gray matter variation in dyslexia compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (brain volume sub-analysis).

The PSI-SDM map is visualized as six axial slices (2-D cortical, subcortical, and cerebellar view). Colors from dark to light green represent voxels with a common pattern of neuroanatomical reduction (gray matter in dyslexia < typically developmental controls). Brain slices are in neurological convention (i.e. Right is right, Left is left). STG, superior temporal gyrus.

Table S8. Brain clusters of gray matter variation in attention-deficit/hyper-activity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (brain volume sub-analysis).

Region	MNI coordinate			SDM	$P < 0.005$	Voxels	Cluster breakdown (Voxels)
	x	y	z	Z score	(Uncorrected)		
ADHD > TDCs							
No cluster found							
ADHD < TDCs							
Left crus II (Cerebellum)	-22	-78	-36	-3.569	0.0001	693	Left crus II (372) Left crus I (199) Left lobule VIIIB (52) Left lobule VI (36) Left lobule VIII (34)
Left parahippocampal gyrus (BA 36)	-20	-12	-24	-4.468	0.000003	372	Left parahippocampus (247) Left hippocampus (55) Left medial cingulum (33) Left fusiform gyrus (22) Left amygdala (15)
Right caudate nucleus	16	14	10	-4.509	0.000003	276	Right caudate (276)
Left cuneus cortex (BA 17)	-10	-98	14	-4.362	0.000006	227	Left cuneus (135) Left SOG (78) Left MOG (7)
Left caudate nucleus	-12	20	6	-4.213	0.00001	157	Left caudate (152) Left striatum (5)
Right gyrus rectus (BA 11)	10	38	-24	-3.414	0.0003	165	Right gyrus rectus (153) Right SFG (12)
Right lenticular nucleus (Putamen)	30	-2	-4	-3.400	0.0003	136	Right putamen (108) Right striatum (28)
Left anterior cingulate cortex (BA 32)	-4	40	4	-3.218	0.0006	124	Left ACC (109) Right ACC (15)
Right lobule IX (Cerebellum)	10	-50	-50	-3.343	0.0004	104	Right lobule IX (104)
Left lobule IX (Cerebellum)	-10	-48	-52	-3.566	0.0001	58	Left lobule IX (58)

Right superior temporal gyrus (BA 38)	28	8	-26	-3.067	0.0007	38	Right STG (26) Right parahippocampal (12)
Right parahippocampal gyrus (BA 20)	30	-26	-24	-3.013	0.001	17	Right parahippocampal (17)
Left supplementary motor area (BA 6)	-8	-12	50	-3.645	0.0001	14	Left SMA (11)

Abbreviations: ADHD, attention-deficit/hyper-activity disorder; TDCs, typically developing controls; BA, Brodmann area; MNI, Montreal Neurological Institute; SDM, Seed-based d Mapping; SOG, superior occipital gyrus; MOG, middle occipital gyrus; ACC, anterior cingulate cortex; STG, superior temporal gyrus; SMA, supplementary motor area.

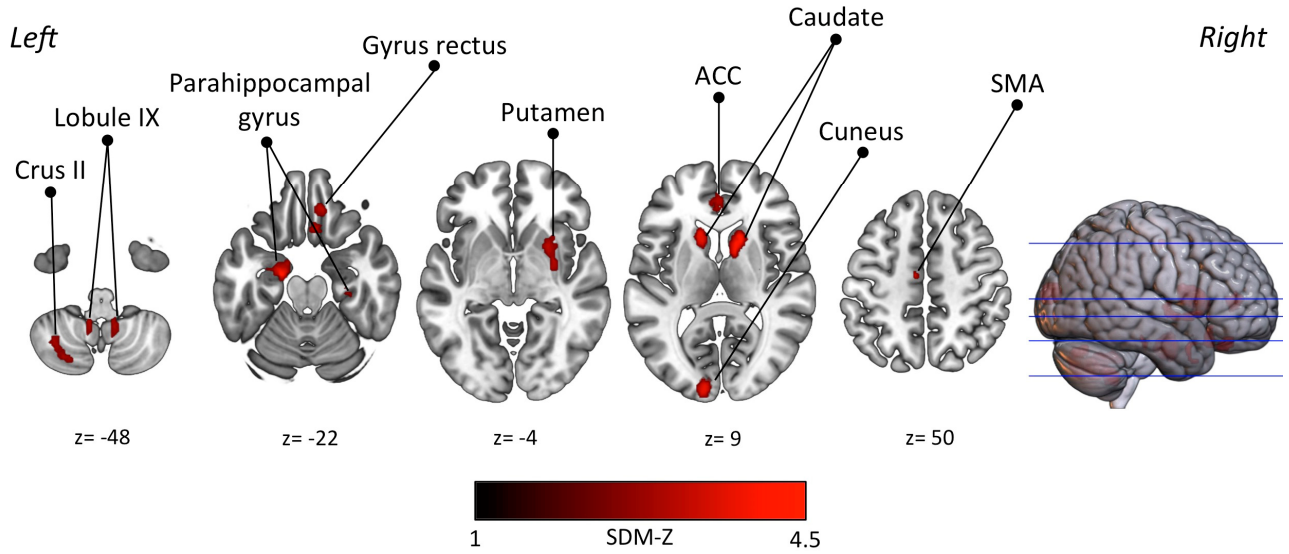


Figure S4. Brain clusters of gray matter variation in attention-deficit/hyperactivity disorder compared with typically developmental controls at $p_{\text{uncorrected}} < 0.0005$ and minimum cluster size = 10 voxels (brain volume sub-analysis).

The PSI-SDM map is visualized as six axial slices (2-D cortical, subcortical, and cerebellar view). Colors from dark to light red represent voxels with a common pattern of neuroanatomical reduction (gray matter in attention-deficit/hyperactivity disorder < typically developmental controls). Brain slices are in neurological convention (i.e. Right is right, Left is left). ACC, anterior cingulate cortex; SMA, supplementary motor area.

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