Supplementary material

Supplementary Table 1 | Population demographics

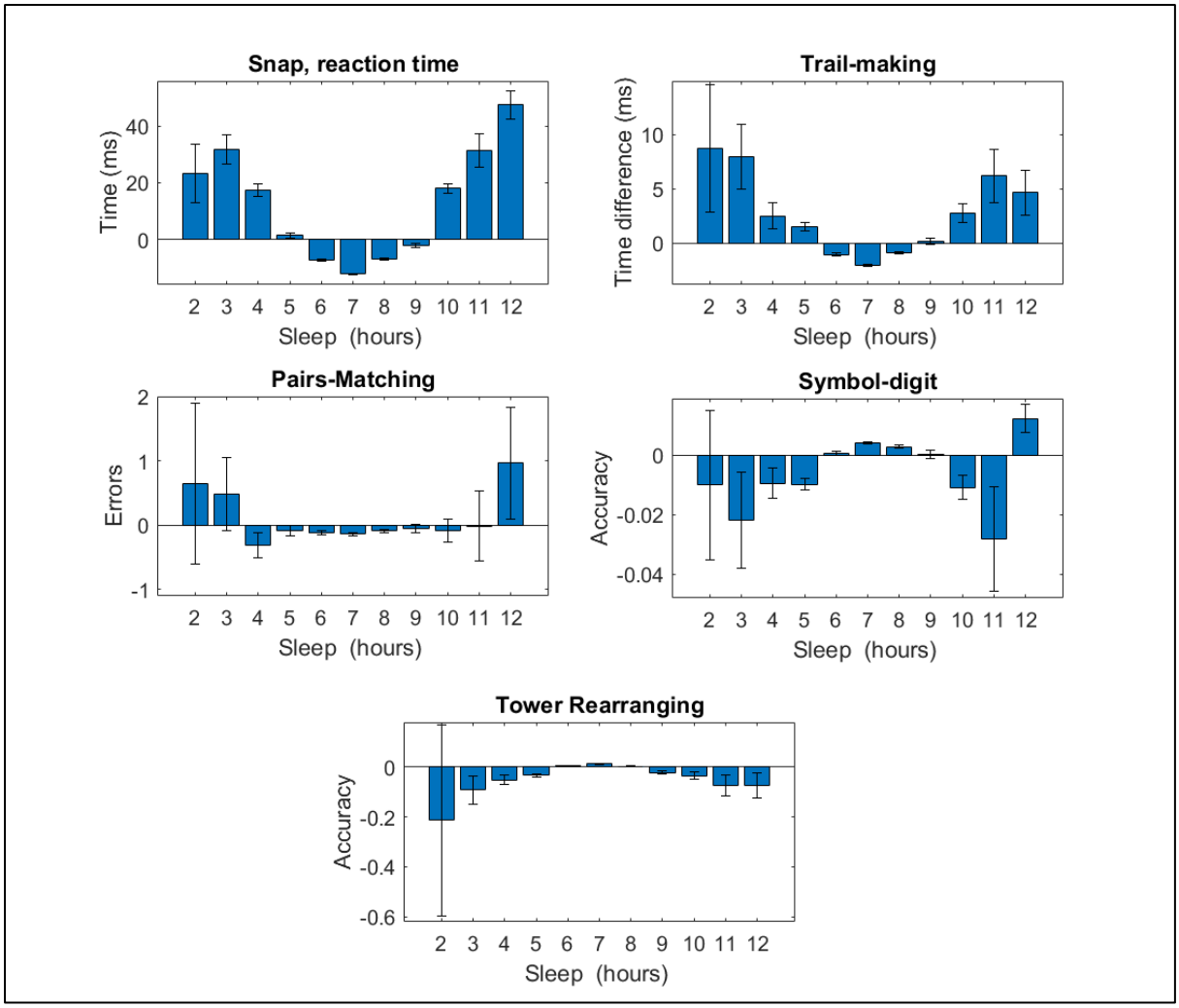
Total N	479 420
Sex	
Number Female (%)	262 777 (54.8)
Number Male (%)	216 643 (45.2)
Mean age at baseline assessment (SD)	57.4 (8.0)
Mean age at Imaging assessment (SD)	65.1 (7.7)
Median Townsend Index (IQR)	-2.2 (3.1)
Median sleep duration in hours (range)	7 (1-22)
Medication at baseline assessment:	
Blood pressure medication ON (%)	28 894 (13.4)
Cholesterol lowering medication ON (%)	38 069 (17.7)
Diabetes medication ON (%)	1659 (1.0)
Smoking status	
Number never smoked (%)	369 906 (77.2)
Number 1-20 pack years (%)	63 461 (13.2)
Number >20 pack years (%)	46 054 (9.6)
***APOE* ε Status**	
Number of ε3/3 (%)	230 829 (69.4)
Number of ε3/4 (%)	92 716 (27.9)
Number of ε4/4 (%)	9314 (1.9)
Mean Body mass Index (SD)	27.4 (4.8)
Male	27.8 (4.2)
Female	27.1 (5.2)

SD: standard deviation; IQR: interquartile range; APOE: apolipoprotein E.

Supplementary Table 2. Biobank showcase for information for variables

Variable	Field ID	Biobank showcase link	Instance
Year of birth	34	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=34	0
Date of attending assessment centre	53	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=53	0,2
Sleep duration	1160	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=1160	0, 2
Sleep chronotype	1180	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=1180	0,2
Report of sleeplessness/ insomnia	1200	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=1200	0,2
Report of snoring	1210	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=1210	0,2
Report of daytime sleepiness	1220	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=1220	0,2
Reaction time	20023	http://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=20023	0
Pairs matching accuracy	399	http://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=399	0
Trail making numeric path duration	6348	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=6348	2
Trail making alphanumeric path duration	6350	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=6350	2
Tower Rearranging number of puzzles correct	21004	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=21004	2
Tower Rearranging number of puzzles attempted	6383	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=6383	2
Symbol-digit substitution number correct	23323	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=23323	2
Symbol-digit substitution number attempted	23324	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=23324	2
Townsend deprivation index (at recruitment)	189	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=189	0
Cholesterol lowering medication	6177	http://biobank.ctsu.ox.ac.uk/showcase/field.cgi?id=6177	0
Blood pressure medication	6177	http://biobank.ctsu.ox.ac.uk/showcase/field.cgi?id=6177	0
Diabetes medication	6177	http://biobank.ctsu.ox.ac.uk/showcase/field.cgi?id=6177	0

Body Mass Index	23104	https://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=23104	0,2
Number of cigarettes smoked daily (current smokers)	2887	http://biobank.ctsu.ox.ac.uk/crystal/field.cgi?id=2887	0
Number of cigarettes smoked daily (previous smokers)	6183	http://biobank.ctsu.ox.ac.uk/crystal/field.cgi?id=6183	0
Age started smoking (current smokers)	3436	http://biobank.ctsu.ox.ac.uk/crystal/field.cgi?id=3436	0
Age started smoking (former smokers)	2867	http://biobank.ctsu.ox.ac.uk/crystal/field.cgi?id=2867	0
Ever tried to stop smoking	3486	http://biobank.ctsu.ox.ac.uk/crystal/field.cgi?id=3486	1
Stopped smoking (>6 months)	2907	http://biobank.ctsu.ox.ac.uk/crystal/field.cgi?id=2907	1
Age stopped smoking	2897	http://biobank.ctsu.ox.ac.uk/crystal/field.cgi?id=2897	1
Regional grey matter volumes (FAST)	1101	https://biobank.ndph.ox.ac.uk/showcase/label.cgi?id=1101	2
Subcortical volumes (FIRST)	1102	https://biobank.ndph.ox.ac.uk/showcase/label.cgi?id=1102	2
White matter hyperintensity volume	25781	http://biobank.ndph.ox.ac.uk/showcase/field.cgi?id=25781	2



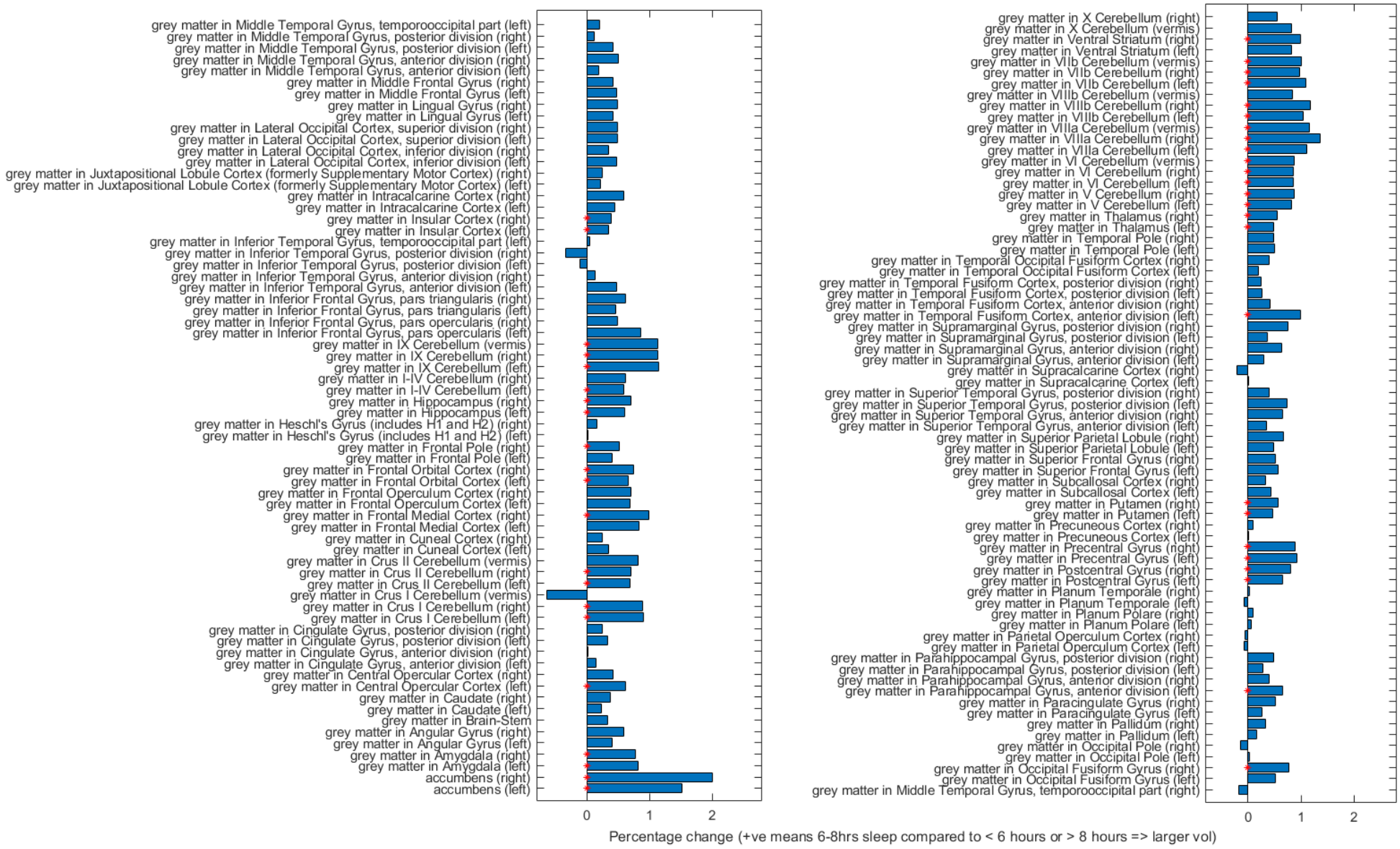
Supplementary Figure 1. Relationship between sleep duration and individual cognitive tasks

The performance on individual cognitive tasks (age-residuals) across different sleep durations showed a quadratic, inverted 'u'-shape relationship with better performance associated with seven hours of sleep, as seen with the latent variable of executive function, in all cognitive tasks apart from pairs-matching.

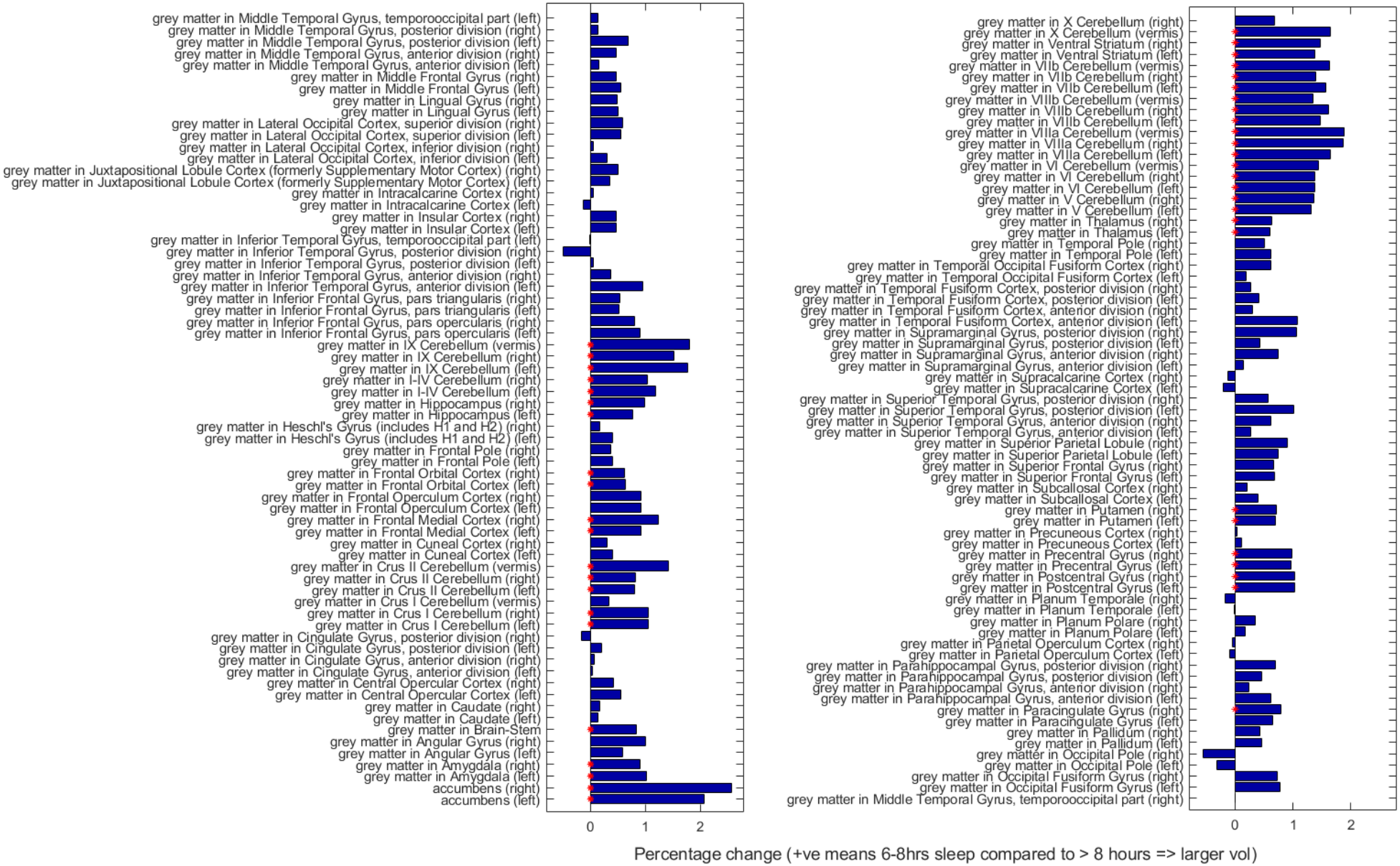
Supplementary Table 3. Association between volume of sleep-related brain regions with sleep duration (6-8 hours), sleep characteristics, obstructive sleep apnoea traits and baseline characteristics of vascular status, genetic risk and socioeconomic status.

	Unstandardized beta estimate	Standard Error	t	p
Sleep band 6-8 hours	**0.063**	**0.028**	**2.24**	***0.025**
Sleep chronotype				
Intermediate (baseline)	--	--	--	--
Morning	0.021	0.021	1.00	0.316
Evening	-0.028	0.030	-0.94	0.346
Report of insomnia	0.010	0.012	0.84	0.400
Obstructive sleep apnoea traits				
Daytime sleepiness	-0.026	0.017	-1.51	0.130
Report of snoring	-0.049	0.018	-2.66	***0.008**
Smoking pack years	-0.003	0.001	-5.05	***<0.001**
Vascular comorbidity	-0.054	0.013	-4.31	***<0.001**
APOE ε status	-0.001	0.017	-0.05	0.957
Body mass index (BMI)	-0.021	0.003	-7.91	***<0.001**
Socio-economic status	-0.005	0.003	-1.39	0.164

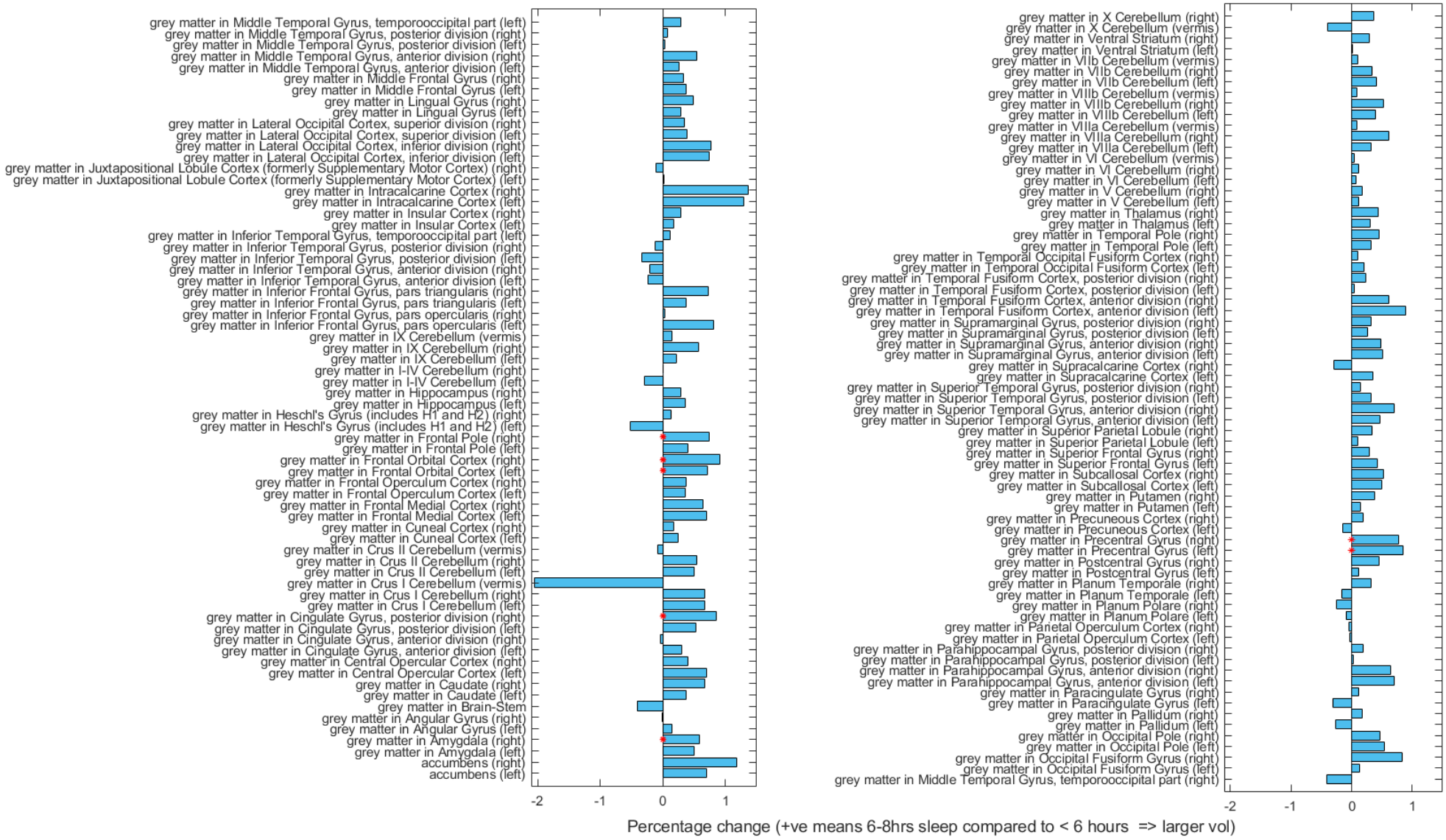
Summary volume measure was created based on 46 brain regions which had a significant quadratic relationship with sleep duration.



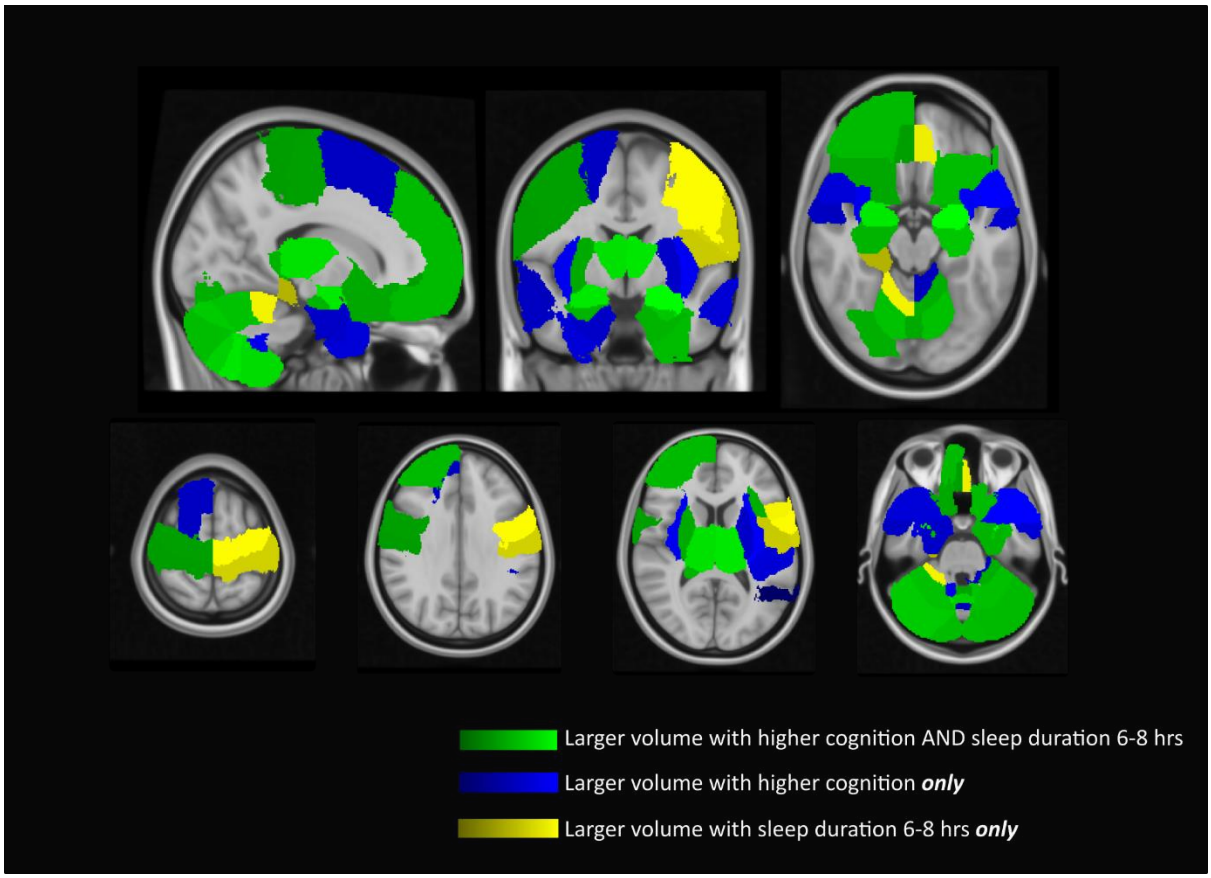
Supplementary Figure 2. Differences in brain volume across 139 cortical and subcortical brain regions in participants who slept between six-to-eight hours and all other sleep duration. Red stars (*) indicates brain volumes with significant difference, following multiple comparison.



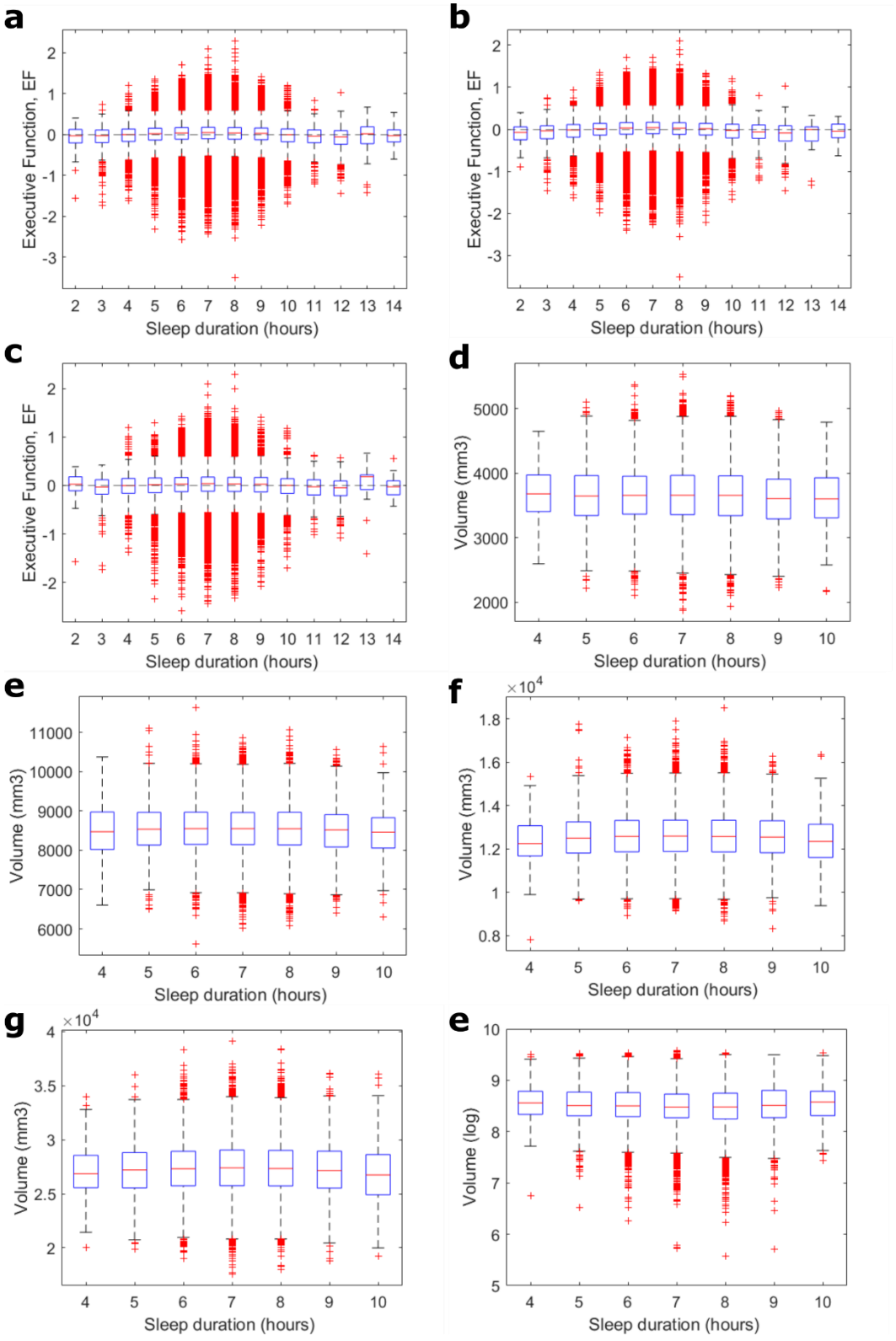
Supplementary Figure 3. Differences in brain volume across 139 cortical and subcortical brain regions in participants who slept between six-to-eight hours and more than eight hours duration. Red stars (*) indicates brain volumes with significant difference, following multiple comparison.



Supplementary Figure 4. Differences in brain volume across 139 cortical and subcortical brain regions in participants who slept between six-to-eight hours and less than eight hours duration. Red stars (*) indicates brain volumes with significant difference, following multiple comparison.



Supplementary Figure 5. Regional brain volumes which are significantly associated with a higher executive function score and sleep duration six-to-eight hours. Volume in 56 brain regions significantly predicted executive function while volume in 46 brain regions was higher with a six-to-eight sleep duration. Forty-one of these brain regions overlapped.



Supplementary Figure 6. Boxplot representations of data from main paper figures. The relationship between sleep duration and age-residual executive function scores in **a,** all participants, **b,** participants younger than 60 years and **c,** participants older than 60 years. Relationship between sleep duration and brain volume in **d,** orbital frontal cortex, **e,** precentral gyrus, **f,** Hippocampi, **g,** Cerebellar vermis regions and **e,** white matter hyperintensities. Centre of each box is the median, bottom and top edges indicate 25th and 75th percentile. Crosses are outliers.