Supplementary Information: Prefrontal atrophy, disrupted NREM slow waves, and impaired hippocampal-dependent memory in aging

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Supplementary Figures

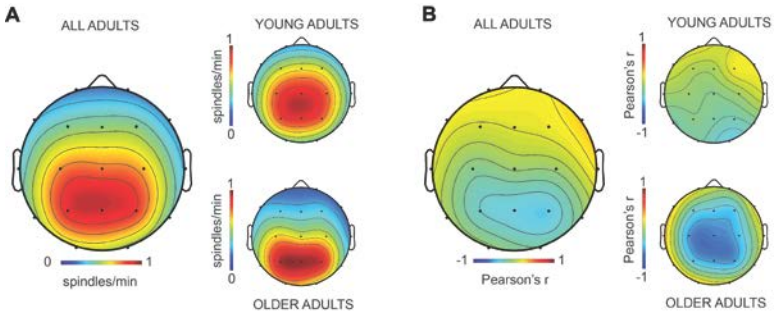

Figure S1. (**a**) EEG topographic plots of fast spindle density (13.5–15Hz) during stage 2 non-rapid eye movement (NREM) sleep in all adults collapsed and Young (top plot) and Older adults (bottom plot) separately. (**b**) Topographic plots of the association between fast spindle density (13.5–15Hz) during stage 2 non-rapid eye movement (NREM) sleep and associative episodic memory change in all participants collapsed and in Young (top plot) and Older (bottom plot) adults separately.

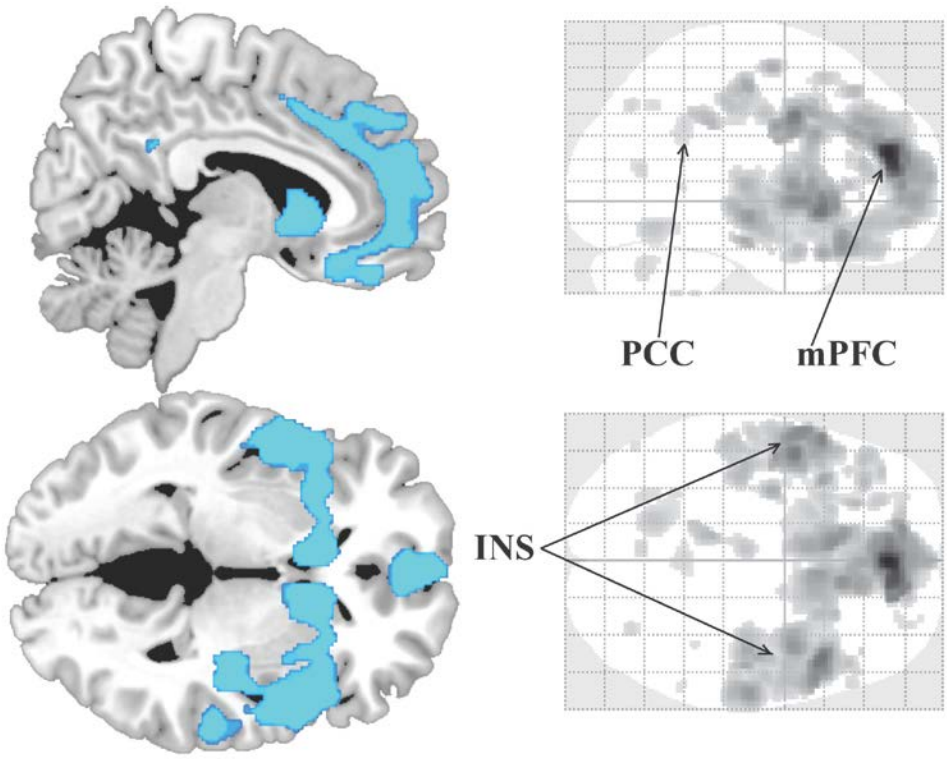

Figure S2. Sagittal and axial view of age effects (Older<Young adults) in grey matter volume, with sagittal and axial glass brain views to the right. Note effects present in medial prefrontal cortex (mPFC), bilateral insula (INS), and posterior cingulate cortex (PCC), defined using Brodmann's map[53]. Activations are displayed and considered significant at the voxel level of $P<0.05$ family-wise error (FWE) corrected for multiple comparisons across the whole brain volume. Cool colors represent the extent of reduced grey matter volume in Older relative to Young adults.

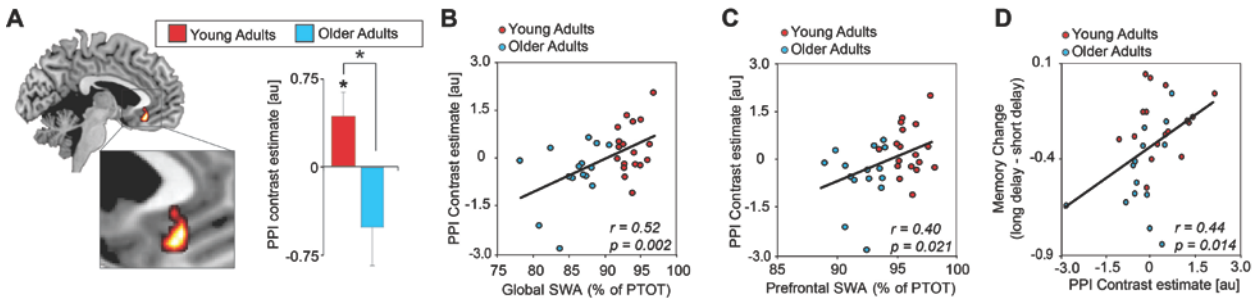

Figure S3. **(a)** Positive association across all participants between global slow wave activity (SWA) and psychophysiological interaction (PPI) effects relating left hippocampal activation from Figure 7 in the main text to medial prefrontal cortex activation (8mm-sphere ROI: [x=–2, y=32, z=–10])[18]) in the context of successful memory retrieval (Hits-Correct Rejections), with age effect in the cluster (Young>Older adults) plotted to the right. Regressions between global slow wave activity (**b**), defined as the average relative SWA across all electrode sites, and prefrontal SWA (**c**), defined as the average at Fp1 & Fp2 derivations and the mean medial prefrontal PPI effect, extracted using the Marsbar toolbox in SPM8[49]. Regression between episodic memory change (**d**) and the extracted medial prefrontal PPI effect. Activations are displayed and considered significant at the voxel level of $P<0.05$ family-wise error (FWE) corrected for multiple comparisons within the *a priori* medial prefrontal cortex regions of interest[8]. Hot colors represent the extent of the positive association between global SWA and PPI effects.

* denotes significance at $P<0.05$. Error bars indicate s.e.m.

Supplementary Tables

Table S1. Control group demographic and neuropsychological measures (mean±s.d.)

Variable	**Young (*n* =14)**	**Older (*n* = 11)**
Age (yr)	21.1 ±2.6	75.2±7.0***
Gender	8 Female	9 Female
Education (yr)	14.7±2.2	16.5±2.0
MMSE	29.4±0.5	29.3±0.9
Mean bed time	0:18±1:02	23:03±1:17*
Mean wake time	7:55±1:06	6:25±1:11**
Mean prestudy time in bed (hr)	7.90±0.49	7.53±0.92
Mean prestudy sleep time (hr)	7.32±0.75	6.82±1.03
Mean prestudy sleep latency (min)	26.5±30.7	22.7±24.3
Mean prestudy sleep efficiency (%)	92.7±7.9	90.6±8.2
Long delay testing relative to pre-study wake time	11:54±0:59	12:14±0:51
Short delay recognition (HR-LR-FAR)	0.62±0.08	0.40±0.08
Long delay recognition (HR-LR-FAR)	0.22±0.09	–0.22±0.13*
Memory Change (long-short delay)	–0.40±0.04	–0.62±0.09*
Neuropsychological Measures		
CVLT (long delay, # free recalled)		13.6±1.7
WMS (visual reproduction %)		89.4±17.6
Trailmaking B (seconds)		76.0±40.8
Stroop (# correct in 60 seconds)		51.1±13.5

*denotes *P<0.05, ** P<0.01, ***P<0.001*

Table S2. Sleep statistics (mean±s.e.m.)

Variable	**Young (*n* = 18)**	**Older (*n* = 15)**
Total Recording Time (min)	480.4±0.2	480.9±0.4
Total Sleep Time (min)	433.2±6.7	338.9±21.3***
Sleep Latency (min)	15.4±2.9	26.1±8.9
Wake After Sleep Onset	27.4±6.5	115.2±20.0***
Stage 1 (min)	14.5±1.8	23.0±1.9**
Stage 2 (min)	201.9±7.4	185.4±16.9
Slow Wave Sleep (min)	114.5±7.4	62.8±8.7***
Rapid Eye Movement Sleep (min)	102.3±6.0	67.6±8.2**
Sleep Efficiency (%)	91.1±1.4	70.7±4.5***

*denotes *P<0.05, ** P<0.01, ***P<0.001*

Table S3. Correlations between memory change and sleep stage variables

Variable	**r value**			***P* value**		
	All	Y	O	All	Y	O
Total Sleep Time (min)	0.40	-0.24	0.15	0.03*	0.35	0.60
Sleep Latency (min)	-0.26	-0.20	-0.18	0.16	0.45	0.53
Wake After Sleep Onset	-0.33	0.36	-0.03	0.07	0.15	0.93
Stage 1 (min)	-0.32	-0.17	0.09	0.08	0.51	0.75
Stage 1 (%)	-0.36	-0.15	0.05	0.05*	0.60	0.87
Stage 2 (min)	0.22	0.17	0.23	0.25	0.53	0.42
Stage 2 (%)	-0.11	0.27	0.16	0.57	0.29	0.58
Slow Wave Sleep (min)	0.23	0.05	-0.26	0.21	0.86	0.37
Slow Wave Sleep (%)	0.12	0.01	-0.26	0.51	0.98	0.37
Rapid Eye Movement Sleep (min)	0.26	-0.39	0.17	0.17	0.12	0.55
Rapid Eye Movement Sleep (%)	0.15	-0.37	0.12	0.42	0.14	0.68
Sleep Efficiency (%)	0.40	-0.26	0.14	0.03*	0.31	0.64

*denotes $P<0.05$

All denotes all adults combined, Y denotes Young adults, O denotes Older adults