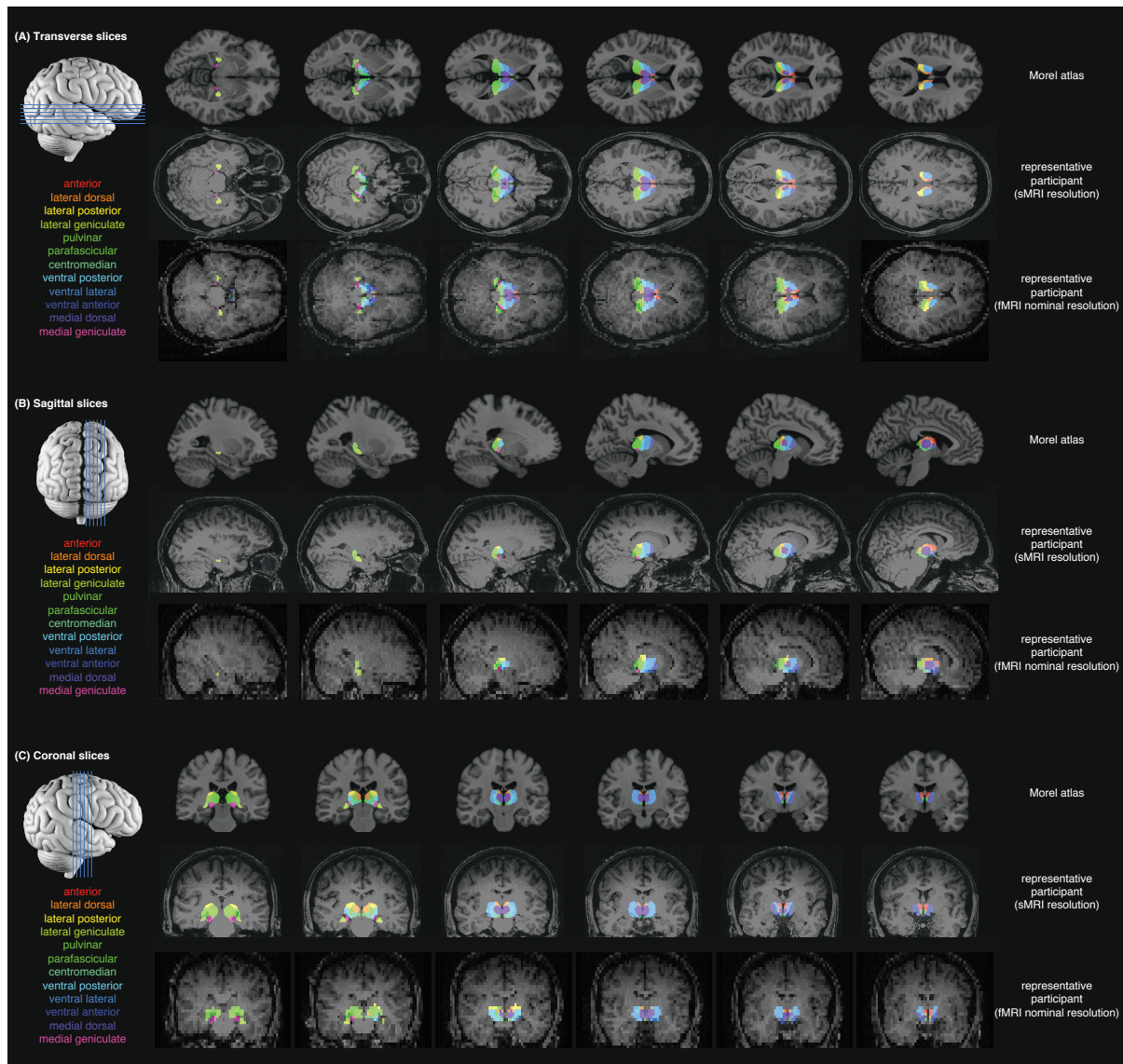# SUPPLEMENTAL MATERIALS

Figure S1. Thalamus parcellation. Based on Morel atlas (Morel et al., 1997, Krauth et al., 2010), the thalamus was parcellated into anterior, lateral dorsal, lateral posterior, lateral geniculate, pulvinar, parafascicular, centromedian, ventral posterior, ventral lateral, ventral anterior, medial dorsal, and medial geniculate subregions. The parcellation was performed through spatial transformation of Morel atlas (in MNI152 space) to individual participants' structural MRI data (in subject-native space). The results of thalamus parcellation, performed on the higher-resolution structural MRI data, were then co-registered and re-sliced to the lower-resolution functional MRI data. Illustrated are the Morel atlas in MNI152 space and the parcellation results of a representative participant.
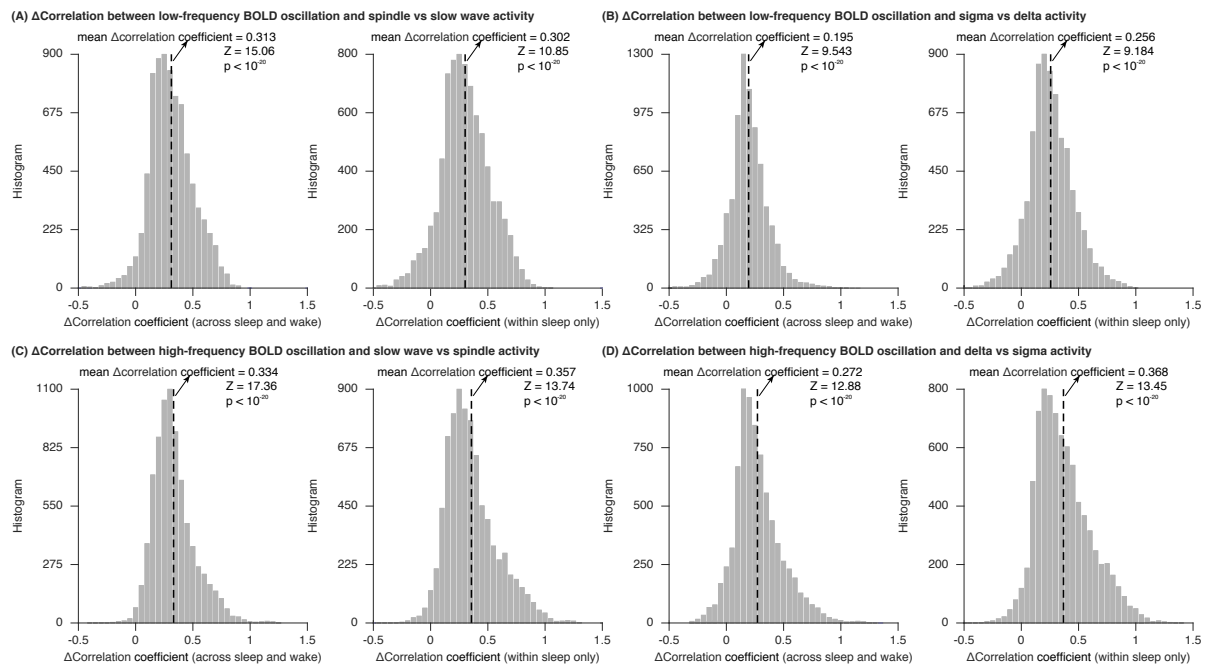
Figure S2. Selective correlation between BOLD oscillations and sleep spindles versus slow waves. The time course of low-frequency or high-frequency BOLD oscillation power was correlated against the time course of spindle or sigma activity versus the time course of slow wave or delta activity, and the difference in correlation coefficient was calculated, on a participant-by-participant, ROI-by-ROI basis, across sleep and wake (N = 1500 time points), or within sleep only (N = 1000 time points). The distributions of difference in correlation coefficient across all participants and ROIs were plotted, where each value reflected the result from a single participant and a single ROI. Low-frequency BOLD oscillation correlated significantly stronger with spindle or sigma activity than with slow wave or delta activity (T > 9.183, $p < 10^{-20}$). By contrast, high-frequency BOLD oscillation correlated significantly stronger with slow wave or delta activity than with spindle or sigma activity (T > 12.878, $p < 10^{-20}$). The figure shows the average results of two hemispheres across participants S1 to S36.
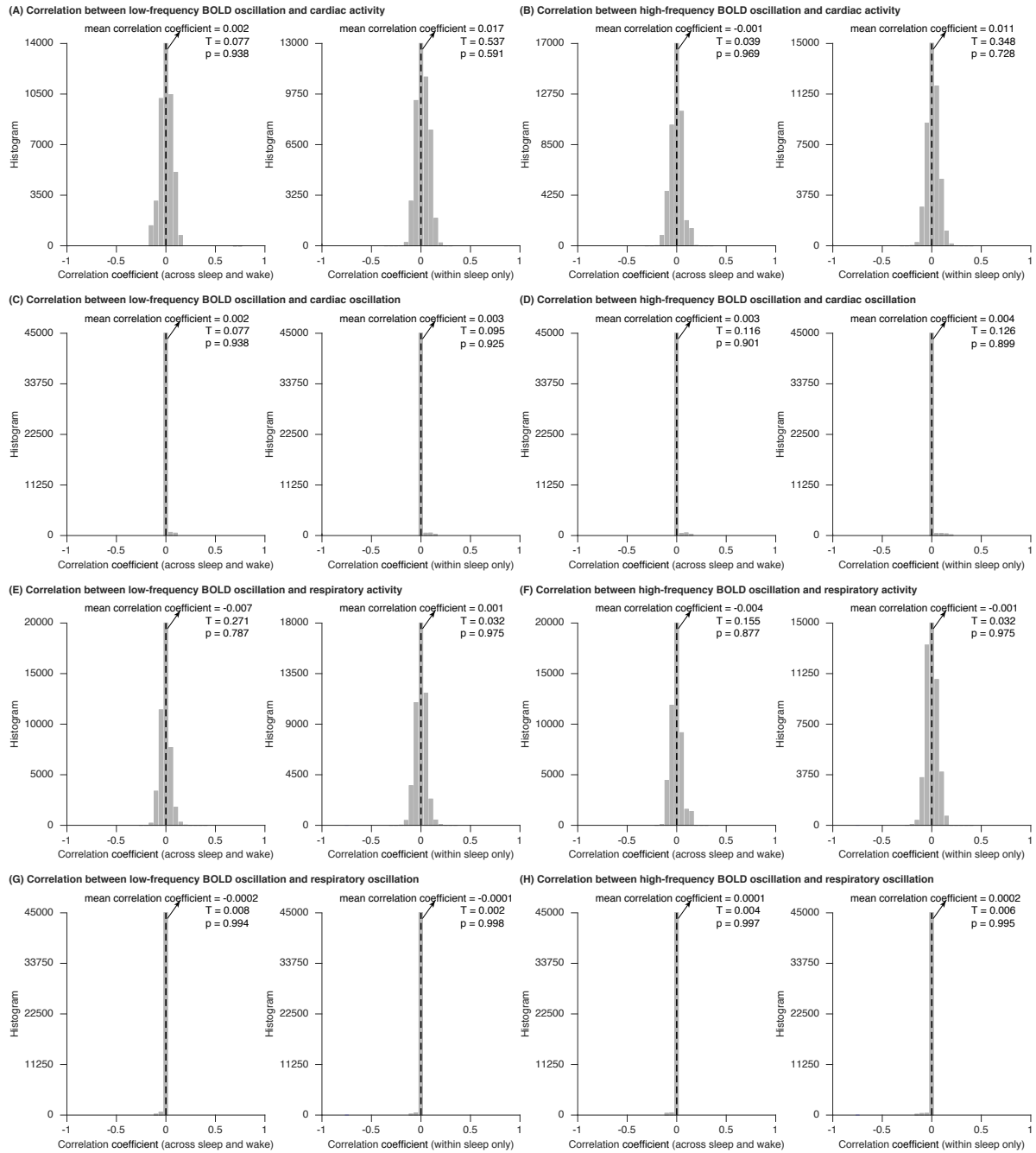
Figure S3. Relation between BOLD oscillations and cardiac or respiratory activity. The time course of low-frequency or high-frequency BOLD oscillation power was correlated against the time course of cardiac or respiratory activity (derived from respiration and pulse oximetry data) or the time course of cardiac or respiratory oscillation power (derived from FFT analysis to cardiac and respiratory time series), on a participant-by-participant, ROI-by-ROI basis, across sleep and wake (N = 1500 time points), or within sleep only (N = 1000 time points). The distributions of correlation coefficient across all participants and ROIs were plotted, where each value reflected the result from a single participant and a single ROI. At a data length of 1500 and 1000 time points, the threshold correlation coefficient for establishing statistical significance are 0.051 and 0.062 (before correction for multiple comparisons) or 0.136 and 0.166 (after Bonferroni correction for 374976 comparisons), respectively. The correlations between BOLD oscillation power and cardiac or respiratory regressors were much smaller than the threshold correlation coefficient, and corresponded to T < 0.233, p > 0.815. The figure shows the average results of two hemispheres across participants S1 to S36.

Table 1. Sleep architecture of participants

Participants with Sustained Epochs of N2 or N3 Sleep					
Participant	%N1	%N2	%N3	%N1/2/3	%N2/3
S1	19.47	18.20	48.53	86.20	66.73
S2	20.20	28.33	35.53	84.07	63.87
S3	35.60	21.13	0.00	56.73	21.13
S4	22.81	29.30	5.82	57.93	35.12
S5	6.73	26.00	0.00	32.73	26.00
S6	14.40	24.47	0.00	38.87	24.47
S7	27.67	39.20	0.00	66.87	39.20
S8	46.53	16.33	0.00	62.87	16.33
S9	8.73	28.80	0.00	37.53	28.80
S10	31.84	10.57	0.00	42.41	10.57
S11	13.93	44.13	26.00	84.07	70.13
S12	28.80	46.13	0.00	74.93	46.13
S13	27.89	23.21	0.00	51.10	23.21
S14	5.87	41.33	45.13	92.33	86.47
S15	20.20	39.33	0.00	59.53	39.33
S16	21.33	46.47	10.53	78.33	57.00
S17	18.27	23.20	42.60	84.07	65.80
S18	14.47	23.47	38.53	76.47	62.00
S19	13.47	32.67	14.87	61.00	47.53
S20	13.47	43.80	33.60	90.87	77.40
S21	21.13	35.00	27.93	84.07	62.93
S22	14.27	9.60	25.00	48.87	34.60
S23	22.33	20.00	0.00	42.33	20.00
S24	34.67	33.13	0.00	67.80	33.13
S25	18.13	26.87	24.07	69.07	50.93
S26	30.53	14.47	0.00	45.00	14.47
S27	36.40	55.87	0.00	92.27	55.87
S28	21.67	33.80	8.00	63.47	41.80
S29	6.73	19.27	66.73	92.73	86.00
S30	13.60	29.73	0.00	43.33	29.73
S31	23.14	13.51	39.53	76.19	53.04
S32	23.87	14.47	0.00	38.33	14.47
S33	17.67	19.27	28.87	65.80	48.13
S34	7.73	19.27	50.93	77.93	70.20
S35	31.73	55.27	0.00	87.00	55.27
S36	18.20	63.93	0.00	82.13	63.93
Participants without Sustained Epochs of N2 or N3 Sleep					
Participant	%N1	%N2	%N3	%N1/2/3	%N2/3
S37	1.93	0.00	0.00	1.93	0.00
S38	51.87	7.73	0.00	59.60	7.73
S39	90.87	0.00	0.00	90.87	0.00
S40	3.87	0.00	0.00	3.87	0.00
S41	14.40	0.00	0.00	14.40	0.00
S42	93.67	0.00	0.00	93.67	0.00
S43	6.27	0.00	0.00	6.27	0.00
S44	50.53	0.00	0.00	50.53	0.00
S45	14.87	0.00	0.00	14.87	0.00
S46	2.87	0.00	0.00	2.87	0.00
S47	22.34	0.00	0.00	22.34	0.00
S48	5.87	0.00	0.00	5.87	0.00
S49	5.67	0.00	0.00	5.67	0.00
S50	0.00	0.00	0.00	0.00	0.00
S51	43.07	4.80	0.00	47.87	4.80
S52	1.87	0.00	0.00	1.87	0.00
S53	25.00	0.00	0.00	25.00	0.00
S54	20.67	0.00	0.00	20.67	0.00
S55	68.20	4.80	0.00	73.00	4.80
S56	7.82	0.00	0.00	7.82	0.00
S57	20.60	3.87	0.00	24.47	3.87
S58	13.53	0.00	0.00	13.53	0.00

Table S1. Sleep architecture of participants. Simultaneous fMRI and polysomnographic EEG recordings were acquired from 58 non-sleep-deprived participants. Recordings started at around 20:00 and lasted for 50 minutes. 36 out of 58 participants displaying sustained epochs of N2 and N3 sleep were included in subsequent analyses. Listed in the table are the % time spent in N1, N2, N3 sleep or their combinations.

Table S2. Regional distribution of low-frequency BOLD oscillation

Fine atlas			
Cortex	**Power**		**Frequency**
	% Increase	**T Statistics**	**Hz**
25	405.39	9.983	0.0570
V6	348.36	14.679	0.0522
V1	303.87	13.854	0.0523
52	299.65	12.808	0.0555
DVT	294.37	13.405	0.0530
MBelt	292.60	12.560	0.0549
LBelt	281.82	13.261	0.0533
V6A	272.95	13.298	0.0533
PBelt	269.18	13.105	0.0530
V2	265.80	13.274	0.0531
POS2	260.26	13.327	0.0527
A1	259.49	13.425	0.0533
ProS	256.86	13.503	0.0542
POS1	251.73	12.997	0.0539
7m	250.16	12.944	0.0532
MT	248.19	12.838	0.0540
31pd	247.57	12.231	0.0539
V3A	243.99	12.764	0.0536
VMV1	240.37	13.048	0.0543
a24	240.16	9.844	0.0560
IPS1	237.73	13.365	0.0534
V7	237.33	12.376	0.0536
IP0	234.35	12.340	0.0540
TPOJ1	233.18	12.563	0.0546
7PL	232.79	12.670	0.0524
MST	231.27	12.601	0.0540
V3	230.39	12.552	0.0538
RI	230.15	12.706	0.0548
A4	229.80	12.397	0.0528
7Pm	228.02	13.058	0.0529
V8	224.71	12.679	0.0544
TPOJ2	222.22	11.976	0.0543
VMV3	220.83	12.600	0.0544
VIP	220.59	12.155	0.0546
LO3	220.01	12.430	0.0542
v23ab	219.60	13.082	0.0532
7Am	217.92	11.925	0.0538
OP1	217.45	11.124	0.0561
VVC	216.56	11.429	0.0557
V3B	215.59	12.806	0.0539
MIP	211.34	12.160	0.0538
RSC	209.76	11.662	0.0551
PIT	209.68	11.886	0.0542
TPOJ3	209.37	12.649	0.0544
LO1	209.04	12.193	0.0545
3b	208.65	11.552	0.0542
OP2-3	208.21	10.686	0.0574
PCV	207.92	11.756	0.0542
STSvp	206.98	11.434	0.0542
3a	206.80	11.729	0.0549
23c	206.52	12.044	0.0543
V4	206.10	11.857	0.0545
V3CD	206.07	11.832	0.0546

p24pr	206.00	12.015	0.0549
Ig	205.92	11.886	0.0561
10r	205.36	9.246	0.0553
STV	204.67	12.094	0.0548
PI	204.33	11.099	0.0567
VMV2	204.15	12.496	0.0551
PSL	203.79	11.659	0.0544
TA2	203.65	11.833	0.0543
31a	202.98	12.150	0.0538
PreS	202.94	11.928	0.0556
6d	201.81	11.241	0.0556
IFJa	201.60	10.210	0.0553
31pv	201.53	11.220	0.0540
FFC	201.32	11.854	0.0551
47m	198.54	10.175	0.0563
24dd	198.31	11.206	0.0561
MI	198.12	11.248	0.0559
5m	196.69	11.790	0.0563
PoI1	196.65	11.007	0.0568
a24pr	193.33	11.143	0.0557
s32	191.87	9.917	0.0561
24dv	191.25	11.019	0.0560
PGp	190.45	11.290	0.0549
PFt	189.10	11.561	0.0545
IP1	189.06	11.315	0.0541
d23ab	189.00	11.695	0.0539
PHA1	188.49	10.964	0.0566
FST	188.11	11.447	0.0548
LIPd	188.07	11.481	0.0544
IP2	188.02	10.754	0.0548
STGa	187.04	10.971	0.0556
AAIC	187.00	10.387	0.0567
5L	186.89	10.881	0.0560
7AL	186.65	11.579	0.0552
6r	185.63	10.188	0.0553
A5	185.04	11.568	0.0556
10pp	185.03	8.321	0.0560
PH	184.97	11.060	0.0554
PFcm	184.93	10.868	0.0561
PHT	184.93	10.888	0.0551
LIPv	184.62	11.868	0.0545
EC	184.01	9.676	0.0579
1	183.51	10.859	0.0555
STSdp	182.55	10.774	0.0567
FOP2	181.86	10.694	0.0577
STSva	181.03	10.832	0.0558
V4t	180.84	12.109	0.0548
Pir	179.56	10.190	0.0573
7PC	178.47	11.492	0.0545
PEF	178.45	11.377	0.0555
6v	178.12	10.805	0.0556
47s	178.10	10.351	0.0563
LO2	176.86	11.422	0.0547
AIP	176.73	11.203	0.0548
PGi	176.30	10.843	0.0550
H	175.78	10.588	0.0565
23d	175.75	11.150	0.0548
IFJp	175.67	11.205	0.0550

PHA2	175.13	11.015	0.0573
47l	174.16	10.077	0.0554
5mv	173.33	11.255	0.0555
STSda	172.83	10.336	0.0570
FOP3	172.55	10.581	0.0575
33pr	172.31	11.371	0.0565
PoI2	171.75	11.168	0.0562
43	170.93	10.634	0.0566
IFSp	170.69	10.360	0.0549
TGd	170.57	9.423	0.0564
OP4	170.53	10.838	0.0563
4	170.52	10.602	0.0565
FEF	170.20	10.296	0.0560
TE1p	169.66	10.194	0.0560
10v	169.47	8.941	0.0551
6mp	169.14	10.477	0.0563
p24	168.63	10.177	0.0560
TE1m	168.14	10.046	0.0572
p32pr	167.87	10.145	0.0570
AVI	167.19	10.231	0.0566
PF	166.92	10.365	0.0556
PHA3	166.62	11.068	0.0562
2	165.14	10.730	0.0558
PFop	162.75	11.183	0.0557
45	162.54	10.034	0.0561
55b	161.30	10.566	0.0558
SCEF	159.78	9.836	0.0567
p47r	159.69	9.384	0.0556
PFm	159.46	10.360	0.0550
PGs	156.93	10.111	0.0549
44	156.61	10.195	0.0559
6a	155.24	9.768	0.0564
10d	154.62	8.816	0.0543
SFL	154.55	8.614	0.0556
TE2p	154.23	9.777	0.0574
a10p	153.41	9.288	0.0550
a9-46v	153.10	9.030	0.0552
FOP1	152.71	10.086	0.0577
pOFC	152.17	9.433	0.0577
13l	150.69	9.471	0.0569
FOP5	150.68	9.791	0.0581
6ma	150.50	8.875	0.0565
a47r	150.46	8.945	0.0558
9m	150.27	8.737	0.0558
a32pr	150.15	9.685	0.0573
OFC	150.12	9.093	0.0572
PeEc	149.24	9.134	0.0582
TE1a	148.68	9.585	0.0565
8Ad	147.48	9.097	0.0564
FOP4	146.79	9.937	0.0575
11l	146.54	8.893	0.0568
p9-46v	146.14	9.709	0.0559
TGv	144.63	9.281	0.0580
s6-8	143.70	9.514	0.0565
8BL	143.65	7.804	0.0558
46	143.25	9.154	0.0555
p32	142.76	9.518	0.0562
IFSa	142.57	9.595	0.0551

9p	142.53	8.629	0.0557
9-46d	141.47	9.040	0.0557
8Av	141.16	8.626	0.0564
8C	141.04	9.495	0.0567
p10p	140.07	8.701	0.0550
TF	140.04	9.390	0.0581
9a	139.42	8.609	0.0552
TE2a	138.42	9.062	0.0582
i6-8	136.11	8.699	0.0562
8BM	133.16	8.882	0.0569
d32	132.63	9.412	0.0569

Subcortex	Power		Frequency
	% Increase	T Statistics	Hz
Hypothalamus	217.46	9.774	0.0572
Thalamus (Anterior)	215.18	10.412	0.0568
Thalamus (Parafascicular)	211.07	10.925	0.0578
Thalamus (Medial Dorsal)	203.08	10.447	0.0579
Thalamus (Lateral Dorsal)	198.81	10.756	0.0579
Basal Forebrain	191.58	9.572	0.0573
Thalamus (Pulvinar)	190.12	10.530	0.0578
Cerebellum (HX)	187.77	10.334	0.0577
Cerebellum (HIIIV)	184.38	9.953	0.0585
Cerebellum (HV)	181.73	9.366	0.0582
Midbrain	179.24	10.313	0.0577
Cerebellum (HVIIIb)	177.49	9.397	0.0573
Thalamus (Ventral Posterior)	175.30	10.237	0.0581
Thalamus (Ventral Lateral)	174.20	9.879	0.0581
Striatum (Parietal Network)	173.78	10.068	0.0581
Cerebellum (HIX)	167.01	9.340	0.0581
Medulla	165.14	9.255	0.0587
Amygdala	164.15	9.658	0.0572
Cerebellum (HVIIIa)	163.70	9.096	0.0573
Pons	163.19	9.043	0.0585
Thalamus (Medial Geniculate)	161.50	9.926	0.0566
Striatum (Central Network)	161.48	9.837	0.0585
Thalamus (Ventral Anterior)	160.88	10.098	0.0576
Hippocampus	160.11	9.735	0.0576
Thalamus (Lateral Posterior)	151.83	9.988	0.0586
Cerebellum (HVIIb)	150.45	8.738	0.0581
Cerebellum (Dentate)	147.12	9.308	0.0579
Thalamus (Lateral Geniculate)	146.85	8.902	0.0575
Cerebellum (HVI)	146.11	8.981	0.0580
Striatum (Frontal Network)	145.93	9.278	0.0581
Striatum (Limbic Network)	144.16	9.439	0.0575
Cerebellum (CrusI)	141.40	8.521	0.0580
Cerebellum (CrusII)	140.45	8.117	0.0584
Thalamus (Centromedian)	137.37	9.587	0.0574
Striatum (Temporal Network)	125.65	8.778	0.0579
Striatum (Occipital Network)	123.60	8.851	0.0586

Coarse atlas			
Cortex	Power		Frequency
	% Increase	T Statistics	Hz
Pericalcarine (V1)	338.03	14.460	0.0526

	Power		Frequency
	% Increase	T Statistics	Hz
Cuneus (V2)	312.90	14.392	0.0522
Transverse Temporal (A1)	278.44	12.814	0.0538
Lingual (V2)	259.42	13.497	0.0531
Precuneus	220.46	12.227	0.0534
Isthmus Cingulate	208.30	11.699	0.0540
Rostral Anterior Cingulate	205.85	9.543	0.0564
Superior Parietal	199.61	11.657	0.0538
Superior Temporal Sulcus	199.15	11.192	0.0547
Medial Orbitofrontal	197.48	8.971	0.0562
Superior Temporal	192.18	11.104	0.0550
Lateral Occipital	190.52	11.357	0.0544
Paracentral	180.25	11.018	0.0561
Parahippocampal	180.21	10.389	0.0572
Posterior Cingulate	177.62	11.196	0.0548
Postcentral (S1)	177.13	10.782	0.0554
Caudal Anterior Cingulate	177.04	10.610	0.0561
Fusiform	174.27	10.655	0.0561
Inferior Parietal	172.51	10.679	0.0547
Insula	171.75	10.550	0.0565
Supra Marginal	170.69	10.652	0.0554
Middle Temporal	167.72	10.034	0.0558
Precentral	163.87	10.323	0.0560
Pars Opercularis	154.00	9.683	0.0559
Entorhinal	153.56	9.028	0.0581
Lateral Orbitofrontal	148.36	8.987	0.0569
Pars Triangularis	146.17	9.546	0.0559
Inferior Temporal	144.65	9.482	0.0572
Pars Orbitalis	143.90	8.995	0.0560
Rostral Middle Frontal	141.55	8.720	0.0555
Superior Frontal	136.01	8.496	0.0562
Caudal Middle Frontal	133.74	8.697	0.0566

	Power		Frequency
Subcortex	% Increase	T Statistics	Hz
Hypothalamus	217.46	9.774	0.0572
Basal Forebrain	191.58	9.572	0.0573
Striatum	186.52	10.716	0.0576
Thalamus	183.27	10.874	0.0575
Midbrain	179.24	10.313	0.0577
Medulla	165.14	9.255	0.0587
Amygdala	164.15	9.658	0.0572
Pons	163.19	9.043	0.0585
Hippocampus	160.11	9.735	0.0576
Cerebellum	149.40	8.715	0.0580

Table S2. Regional distributions of low-frequency BOLD oscillation. BOLD power spectrogram was acquired on a voxel-level and the power spectrogram of each ROI was calculated as the normalized average across all voxels within this ROI. Based on the power spectrogram, we identified the spectral peaks in lower-frequency and higher-frequency ranges, traced the time courses of oscillation power, calculated the increase in oscillation power from wake to sleep, and the statistical difference (T value) in oscillation power between wake and sleep. Listed in the table are the spectral peak (Hz) and oscillation power (% increase from wake to sleep, statistical difference between wake and sleep) of low-frequency BOLD oscillation, averaged across two hemispheres and participants S1 to S36.

Table S3. Regional distribution of high-frequency BOLD oscillation

Cortex	Power		Frequency
	% Increase	T Statistics	Hz
25	344.03	11.8912	0.1730
PI	321.37	13.1483	0.1683
EC	303.17	12.4000	0.1738
Pir	297.46	11.8269	0.1704
PreS	297.38	12.9346	0.1690
10r	285.20	11.1225	0.1729
V6A	283.65	12.2329	0.1689
TA2	274.59	12.4598	0.1698
VMV2	274.08	12.2558	0.1723
47s	265.97	12.0338	0.1728
10v	263.88	11.2910	0.1745
TGd	261.67	11.5398	0.1745
PBelt	261.56	12.6764	0.1677
STGa	257.18	12.1507	0.1723
FOP1	254.38	11.8067	0.1705
PHA1	249.42	12.0579	0.1709
10pp	248.78	11.4472	0.1760
PHA2	246.60	11.9925	0.1713
Ig	246.05	11.4416	0.1694
VMV1	245.58	12.0403	0.1692
A4	245.29	12.7759	0.1687
6d	243.66	12.0341	0.1717
V8	243.60	11.9106	0.1692
a10p	242.97	11.3384	0.1747
10d	242.39	11.3141	0.1751
SFL	241.84	11.3300	0.1736
STSva	240.82	11.8870	0.1710
VVC	239.93	11.7786	0.1709
PHA3	239.61	11.4799	0.1716
7PL	239.38	11.7475	0.1693
VIP	237.49	11.5620	0.1693
A1	236.67	12.5086	0.1676
6ma	234.82	11.2418	0.1732
d32	234.52	11.1155	0.1713
p10p	234.23	11.4408	0.1744
PIT	233.66	11.7412	0.1698
V7	233.57	11.6141	0.1689
pOFC	233.53	11.1618	0.1743
PoI2	233.39	11.9871	0.1698
FFC	233.01	11.7779	0.1716
AAIC	231.84	11.5292	0.1704
p24	231.21	11.8338	0.1706
52	230.06	12.4282	0.1680
a24	230.01	11.2710	0.1710
PGp	225.92	11.2826	0.1704
V1	225.19	12.0635	0.1651
TE2p	225.06	12.7326	0.1728
LBelt	225.06	11.4890	0.1669
PoI1	224.99	11.8680	0.1690
7Pm	224.64	11.5834	0.1682
PGs	224.55	11.2974	0.1700
MBelt	222.81	12.5194	0.1680
8BL	222.42	11.1726	0.1761

STSda	222.35	11.7037	0.1710
TPOJ3	221.51	11.3535	0.1692
13l	220.92	10.9157	0.1729
a9-46v	220.67	11.3963	0.1739
1	220.50	11.5252	0.1716
PeEc	220.20	11.3965	0.1738
7Am	219.87	11.2666	0.1689
ProS	219.46	12.2738	0.1687
RSC	219.42	11.4177	0.1684
DVT	219.26	11.8262	0.1676
PSL	218.95	11.9705	0.1689
IP1	218.89	11.3250	0.1694
STV	218.65	11.5968	0.1701
p32	218.36	11.2104	0.1722
9-46d	218.31	11.2019	0.1731
23d	217.58	11.2992	0.1688
p47r	216.87	11.5804	0.1732
6mp	216.44	11.1454	0.1710
p24pr	216.25	11.7479	0.1690
IP0	214.58	11.3411	0.1685
FOP5	214.54	11.3581	0.1710
AVI	214.16	11.3859	0.1709
s32	214.03	11.1490	0.1730
TF	213.86	11.1954	0.1727
POS2	213.60	11.7008	0.1663
V3B	213.36	12.1153	0.1676
A5	213.04	11.8113	0.1707
8Av	212.71	11.2145	0.1740
TPOJ1	212.62	12.0461	0.1697
MI	212.32	11.7167	0.1700
POS1	211.74	12.0110	0.1676
IPS1	211.73	11.4875	0.1681
24dv	211.68	11.3154	0.1694
a47r	211.66	11.3538	0.1738
33pr	211.59	11.8635	0.1703
OP2-3	211.32	11.5286	0.1699
VMV3	211.16	12.3646	0.1688
5mv	211.05	11.2909	0.1689
i6-8	210.91	11.5346	0.1735
V3A	210.84	11.3521	0.1685
TE1p	210.65	11.6089	0.1714
V2	210.57	11.6881	0.1668
V6	209.19	11.8470	0.1655
TE1a	208.54	11.6521	0.1726
3b	208.32	11.3749	0.1692
TPOJ2	208.28	11.6333	0.1692
MST	208.03	11.8935	0.1682
47l	207.35	11.5884	0.1723
LO1	206.88	11.7990	0.1693
LO3	206.51	11.9749	0.1695
s6-8	206.33	11.8442	0.1738
STSdp	206.21	11.4933	0.1704
TGv	206.17	11.4353	0.1739
FOP2	206.02	11.8773	0.1710
31a	205.82	11.5237	0.1678
H	205.49	12.3485	0.1704
45	205.22	11.3101	0.1717
V3	205.14	11.3914	0.1680

LO2	205.14	11.5277	0.1698
9a	204.88	11.1462	0.1749
PHT	204.88	11.2728	0.1707
p32pr	204.22	11.2789	0.1704
V4	204.09	11.4711	0.1692
31pd	204.06	11.6400	0.1676
47m	204.01	11.6015	0.1718
OFC	203.97	11.4106	0.1735
7m	203.92	11.7779	0.1674
7AL	203.01	11.2544	0.1699
STSvp	202.66	11.5435	0.1700
AIP	201.52	11.4222	0.1692
31pv	201.50	11.5633	0.1681
RI	200.45	11.8961	0.1680
PFcm	200.38	11.5955	0.1699
PH	200.12	11.5250	0.1709
V3CD	199.02	11.3479	0.1692
p9-46v	198.36	11.0261	0.1728
PGi	198.33	11.1157	0.1694
24dd	198.11	11.1354	0.1694
TE1m	198.08	11.3872	0.1717
TE2a	197.86	11.1450	0.1724
MT	197.09	11.5017	0.1689
44	196.85	11.3204	0.1711
a24pr	196.77	11.5053	0.1694
v23ab	196.48	11.9916	0.1674
55b	196.32	11.5999	0.1712
7PC	196.29	11.2828	0.1705
6v	196.03	11.0759	0.1706
PEF	195.90	11.1990	0.1702
4	195.14	11.0332	0.1702
PFt	195.11	11.8055	0.1701
11l	194.69	11.1421	0.1734
8Ad	194.47	11.0944	0.1731
MIP	194.35	11.2122	0.1682
9p	194.21	11.0981	0.1744
9m	194.08	10.8206	0.1733
46	193.29	10.8964	0.1732
IFJp	192.87	11.8451	0.1702
2	192.72	11.3017	0.1701
6r	192.66	11.2014	0.1702
LIPv	192.62	11.4557	0.1695
PCV	191.02	11.4175	0.1678
d23ab	190.52	11.6778	0.1680
OP4	190.29	11.3430	0.1701
FST	189.52	11.5585	0.1693
PFm	189.49	11.1967	0.1700
43	188.11	11.4582	0.1702
FOP3	188.07	11.7135	0.1715
23c	188.01	11.1665	0.1682
IFSa	187.27	11.1631	0.1720
IFJa	186.54	11.3607	0.1707
IFSp	186.50	11.2415	0.1711
FOP4	186.46	11.5456	0.1711
PFop	186.26	11.6663	0.1705
3a	184.70	11.6747	0.1690
5m	184.45	11.0378	0.1696
PF	181.65	11.4194	0.1703

	Power		Frequency
8C	181.29	10.7894	0.1718
OP1	180.58	11.4355	0.1700
LIPd	180.27	11.0688	0.1683
V4t	180.15	11.7202	0.1695
5L	178.26	11.2967	0.1702
FEF	177.72	11.2246	0.1711
IP2	177.71	11.0644	0.1694
8BM	175.74	11.0164	0.1711
a32pr	173.91	11.2006	0.1709
6a	170.90	10.8008	0.1705
SCEF	168.47	10.8592	0.1703

Subcortex	Power		**Frequency**
	% Increase	**T Statistics**	**Hz**
Thalamus (Parafascicular)	428.23	12.3498	0.1728
Thalamus (Lateral Dorsal)	365.21	11.4822	0.1706
Thalamus (Anterior)	341.62	12.0021	0.1693
Hypothalamus	340.18	11.7229	0.1733
Cerebellum (HX)	328.31	12.2171	0.1729
Thalamus (Medial Dorsal)	306.96	11.8852	0.1712
Thalamus (Medial Geniculate)	293.95	12.1211	0.1696
Cerebellum (HIX)	284.69	12.0195	0.1752
Basal Forebrain	268.41	12.0110	0.1732
Cerebellum (HVIIIa)	266.21	11.5614	0.1762
Amygdala	265.19	11.5314	0.1728
Cerebellum (HVIIIb)	258.40	11.9961	0.1760
Thalamus (Ventral Posterior)	251.03	11.5005	0.1711
Medulla	239.55	11.0568	0.1715
Midbrain	239.41	11.8140	0.1717
Thalamus (Pulvinar)	236.16	11.5566	0.1709
Hippocampus	236.10	11.3878	0.1722
Cerebellum (HIIV)	236.06	11.3452	0.1730
Cerebellum (HVIIb)	233.26	11.1379	0.1752
Thalamus (Ventral Lateral)	231.36	11.3785	0.1712
Thalamus (Centromedian)	227.77	11.4987	0.1717
Thalamus (Lateral Posterior)	227.66	10.9321	0.1704
Striatum (Limbic Network)	226.00	11.2582	0.1736
Cerebellum (HVI)	224.30	10.9621	0.1725
Pons	222.48	10.8429	0.1723
Thalamus (Ventral Anterior)	221.00	11.6988	0.1718
Cerebellum (HV)	215.43	11.0370	0.1726
Cerebellum (CrusII)	214.12	10.6736	0.1735
Cerebellum (CrusI)	213.92	10.6474	0.1731
Cerebellum (Dentate)	213.54	11.1972	0.1751
Striatum (Frontal Network)	208.56	11.1691	0.1719
Striatum (Parietal Network)	207.04	11.1188	0.1702
Thalamus (Lateral Geniculate)	202.26	11.3764	0.1723
Striatum (Occipital Network)	202.16	9.8077	0.1717
Striatum (Central Network)	192.40	11.0254	0.1695
Striatum (Temporal Network)	186.65	10.8316	0.1733

Coarse atlas			
Cortex	Power		**Frequency**

	% Increase	T Statistics	Hz
Parahippocampal	247.85	11.8621	0.1715
Entorhinal	245.86	11.4860	0.1745
Medial Orbitofrontal	244.46	10.9848	0.1734
Superior Temporal	237.45	11.7668	0.1699
Rostral Anterior Cingulate	231.50	11.3533	0.1713
Pericalcarine (V1)	228.08	12.4096	0.1640
Cuneus (V2)	226.34	12.0146	0.1652
Transverse Temporal (A1)	224.88	12.5212	0.1679
Insula	217.90	11.4613	0.1699
Lingual (V2)	217.30	11.8974	0.1670
Pars Orbitalis	211.82	11.4288	0.1735
Fusiform	209.49	11.3824	0.1716
Isthmus Cingulate	207.72	11.5835	0.1680
Lateral Orbitofrontal	203.62	11.0561	0.1731
Superior Parietal	200.54	11.0222	0.1690
Superior Temporal Sulcus	200.27	11.3735	0.1696
Middle Temporal	199.48	11.2383	0.1714
Pars Triangularis	198.06	11.1687	0.1722
Rostral Middle Frontal	197.60	10.8487	0.1737
Inferior Temporal	196.40	11.1225	0.1723
Caudal Anterior Cingulate	196.28	11.4254	0.1700
Inferior Parietal	194.64	10.9589	0.1696
Superior Frontal	193.54	10.7116	0.1730
Lateral Occipital	193.06	11.1835	0.1694
Postcentral (S1)	191.64	11.1276	0.1703
Caudal Middle Frontal	190.88	10.9138	0.1726
Precuneus	188.53	11.1705	0.1672
Supra Marginal	187.49	11.2627	0.1700
Precentral	187.38	10.9731	0.1706
Pars Opercularis	182.56	11.1264	0.1709
Posterior Cingulate	181.68	11.1875	0.1688
Paracentral	180.86	10.7427	0.1697
Subcortex	**Power**		**Frequency**
	% Increase	T Statistics	Hz
Hypothalamus	340.18	11.7229	0.1733
Basal Forebrain	268.41	12.0110	0.1732
Amygdala	265.19	11.5314	0.1728
Striatum	242.13	12.0794	0.1718
Medulla	239.55	11.0568	0.1715
Midbrain	239.41	11.8140	0.1717
Hippocampus	236.10	11.3878	0.1722
Thalamus	231.95	11.5374	0.1693
Pons	222.48	10.8429	0.1723
Cerebellum	221.25	10.7883	0.1735

Table S3. Regional distributions of high-frequency BOLD oscillation. BOLD power spectrogram was acquired on a voxel-level and the power spectrogram of each ROI was calculated as the normalized average across all voxels within this ROI. Based on the power spectrogram, we identified the spectral peaks in lower-frequency and higher-frequency ranges, traced the time courses of oscillation power, calculated the increase in oscillation power from wake to sleep, and the statistical difference (T value) in oscillation power between wake and sleep. Listed in the table are the spectral peak (Hz) and oscillation power (% increase from wake to sleep, statistical difference between wake and sleep) of high-frequency BOLD oscillation, averaged across two hemispheres and participants S1 to S36.

Table S4. Number of voxels in individual ROIs

Fine atlas	
Cortex	**Number of Voxels**
V1	487
MST	60
V6	86
V2	469
V3	346
V4	237
V8	70
4	399
3b	243
FEF	101
PEF	67
55b	91
V3A	116
RSC	87
POS2	157
V7	54
IPS1	89
FFC	146
V3B	49
LO1	51
LO2	52
PIT	74
MT	65
A1	58
PSL	109
SFL	129
PCV	114
STV	104
7Pm	63
7m	112
POS1	126
23d	79
v23ab	49
d23ab	59
31pv	64
5m	75
5mv	95
23c	127
5L	93
24dd	121
24dv	75
7AL	100
SCEF	150
6ma	162
7Am	138
7PL	70
7PC	111
LIPv	77
VIP	76
MIP	101
1	248
2	219
3a	118
6d	113

6mp	155
6v	104
p24pr	71
33pr	45
a24pr	62
p32pr	83
a24	84
d32	112
8BM	144
p32	69
10r	90
47m	60
8Av	202
8Ad	150
9m	256
8BL	152
9p	133
10d	157
8C	177
44	138
45	158
47l	130
a47r	216
6r	187
IFJa	80
IFJp	58
IFSp	104
IFSa	164
p9-46v	172
46	227
a9-46v	151
9-46d	240
9a	171
10v	135
a10p	109
10pp	111
11l	180
13l	106
OFC	149
47s	102
LIPd	50
6a	161
i6-8	98
s6-8	77
43	102
OP4	120
OP1	80
OP2-3	59
52	42
RI	73
PFcm	81
PoI2	114
TA2	78
FOP4	113
MI	97
Pir	70
AVI	92
AAIC	74

FOP1	53
FOP3	39
FOP2	41
PFt	106
AIP	124
EC	82
PreS	78
H	112
ProS	54
PeEc	182
STGa	84
PBelt	91
A5	135
PHA1	95
PHA3	80
STSda	124
STSdp	118
STSvp	136
TGd	334
TE1a	174
TE1p	229
TE2a	250
TF	191
TE2p	137
PHT	175
PH	157
TPOJ1	154
TPOJ2	129
TPOJ3	73
DVT	100
PGp	123
IP2	97
IP1	130
IP0	79
PFop	104
PF	219
PFm	328
PGi	285
PGs	206
V6A	45
VMV1	76
VMV3	57
PHA2	48
V4t	42
FST	86
V3CD	62
LO3	53
VMV2	43
31pd	57
31a	53
VVC	118
25	46
s32	41
pOFC	86
PoI1	72
Ig	47
FOP5	77
p10p	134

p47r	122
TGv	129
MBelt	65
LBelt	54
A4	119
STSva	92
TE1m	127
PI	61
a32pr	75
p24	72

Subcortex	Number of Voxels
Hippocampus	298
Amygdala	100
Basal Forebrain	167
Hypothalamus	46
Midbrain	391
Pons	860
Medulla	247
Thalamus (Anterior)	34
Thalamus (Lateral Dorsal)	51
Thalamus (Lateral Posterior)	26
Thalamus (Lateral Geniculate)	23
Thalamus (Pulvinar)	103
Thalamus (Parafascicular)	22
Thalamus (Centromedian)	29
Thalamus (Ventral Posterior)	40
Thalamus (Ventral Lateral)	79
Thalamus (Ventral Anterior)	29
Thalamus (Medial Dorsal)	51
Thalamus (Medial Geniculate)	26
Striatum (Limbic Network)	165
Striatum (Occipital Network)	35
Striatum (Parietal Network)	133
Striatum (Central Network)	103
Striatum (Temporal Network)	31
Striatum (Frontal Network)	386
Cerebellum (HIIV)	323
Cerebellum (HV)	378
Cerebellum (HVI)	817
Cerebellum (CrusI)	986
Cerebellum (CrusII)	662
Cerebellum (HVIIb)	260
Cerebellum (HVIIIa)	235
Cerebellum (HVIIIb)	140
Cerebellum (HIX)	221
Cerebellum (HX)	57
Cerebellum (Dentate)	158

Coarse atlas	
Cortex	**Number of Voxels**
Superior Temporal Sulcus	239
Caudal Anterior Cingulate	171
Caudal Middle Frontal	548
Cuneus (V2)	244
Entorhinal	114
Fusiform	701
Inferior Parietal	1144
Inferior Temporal	756
Isthmus Cingulate	217

Lateral Occipital	862
Lateral Orbitofrontal	629
Lingual (V2)	594
Medial Orbitofrontal	417
Middle Temporal	862
Parahippocampal	184
Paracentral	327
Pars Opercularis	420
Pars Orbitalis	207
Pars Triangularis	364
Pericalcarine (V1)	200
Postcentral (S1)	866
Posterior Cingulate	279
Precentral	1139
Precuneus	826
Rostral Anterior Cingulate	200
Rostral Middle Frontal	1402
Superior Frontal	1768
Superior Parietal	1099
Superior Temporal	920
Supra Marginal	853
Transverse Temporal (A1)	108
Insula	562
Subcortex	Number of Voxels
Hippocampus	298
Amygdala	100
Basal Forebrain	167
Hypothalamus	46
Midbrain	391
Pons	860
Medulla	247
Thalamus	499
Striatum	851
Cerebellum	3991

Table S4. Number of voxels in individual ROIs. We parcellated the brain into 42 coarse ROIs, including 32 cortical regions and 10 subcortical regions (cerebellum, striatum, thalamus, medulla, pons, midbrain, hypothalamus, basal forebrain, amygdala and hippocampus), or 217 fine ROIs, including 180 cortical regions, 11 cerebellum lobules, 7 striatum divisions, 12 thalamic subregions, medulla, pons, midbrain, hypothalamus, basal forebrain, amygdala and hippocampus. Listed in the table are the number of voxels in individual ROIs, summed over two hemispheres and averaged across participants S1 to S36.

Table S5. Onset of BOLD oscillations

Onset of Low-frequency BOLD Oscillation			Onset of High-frequency BOLD Oscillation		
	Lead Time			Lead Time	
	Mean (sec)	SEM (sec)		Mean (sec)	SEM (sec)
Thalamus (Lateral Geniculate)	12.517	0.621	Midbrain	9.405	0.550
Thalamus (Medial Geniculate)	11.833	0.708	Thalamus (Medial Geniculate)	7.907	0.905
Thalamus (Pulvinar)	8.884	0.345	Amygdala	7.631	0.338
Thalamus (Lateral Posterior)	8.533	0.492	Parahippocampal	7.197	0.307
Thalamus (Ventral Lateral)	8.250	0.466	Thalamus (Lateral Dorsal)	6.438	0.368
Lateral Occipital	8.116	0.410	Pons	6.194	0.445
Hippocampus	8.011	0.249	Thalamus (Anterior)	6.186	1.013
Cuneus (V2)	7.871	0.355	Thalamus (Medial Dorsal)	6.095	0.549
Lingual (V2)	7.850	0.297	Basal Forebrain	5.892	0.549
Precuneus	7.811	0.242	Cerebellum	5.711	0.286
Parahippocampal	7.787	0.329	Medulla	5.548	0.781
Pericalcarine (V1)	7.559	0.441	Isthmus Cingulate	5.516	0.297
Thalamus (Ventral Posterior)	7.171	0.420	Thalamus (Ventral Lateral)	5.217	0.402
Basal Forebrain	7.051	0.374	Pars Triangularis	5.167	0.298
Isthmus Cingulate	7.013	0.396	Hypothalamus	4.988	0.808
Superior Parietal	6.990	0.303	Transverse Temporal (A1)	4.904	0.384
Postcentral (S1)	6.963	0.195	Superior Frontal	4.771	0.303
Superior Temporal	6.421	0.227	Hippocampus	4.744	0.291
Inferior Parietal	6.403	0.350	Superior Temporal	4.543	0.203
Striatum	6.253	0.459	Medial Orbitofrontal	4.524	0.369
Superior Temporal Sulcus	6.212	0.390	Thalamus (Ventral Posterior)	4.443	0.349
Fusiform	6.050	0.299	Rostral Middle Frontal	4.296	0.354
Supra Marginal	5.862	0.273	Thalamus (Lateral Geniculate)	3.990	0.584
Posterior Cingulate	5.719	0.290	Rostral Anterior Cingulate	3.888	0.360
Thalamus (Ventral Anterior)	5.455	0.535	Precentral	3.635	0.204
Thalamus (Medial Dorsal)	5.451	0.457	Superior Parietal	3.583	0.294
Precentral	5.440	0.258	Lateral Occipital	3.463	0.254
Midbrain	5.411	0.254	Striatum	3.385	0.432
Thalamus (Anterior)	5.052	0.687	Pars Opercularis	3.240	0.209
Paracentral	4.880	0.347	Caudal Middle Frontal	3.180	0.237
Rostral Anterior Cingulate	4.819	0.345	Posterior Cingulate	3.101	0.296
Thalamus (Centromedian)	4.780	0.772	Lingual (V2)	3.032	0.246
Thalamus (Lateral Dorsal)	4.488	0.535	Cuneus (V2)	2.885	0.318
Thalamus (Parafascicular)	4.218	0.581	Postcentral (S1)	2.868	0.235
Pars Orbitalis	4.183	0.488	Lateral Orbitofrontal	2.847	0.181
Transverse Temporal (A1)	4.006	0.490	Fusiform	2.823	0.256
Insula	3.823	0.251	Inferior Parietal	2.812	0.259
Entorhinal	3.821	0.586	Thalamus (Pulvinar)	2.803	0.265
Lateral Orbitofrontal	3.727	0.396	Insula	2.611	0.251
Middle Temporal	3.647	0.200	Supra Marginal	2.509	0.281
Caudal Anterior Cingulate	3.356	0.391	Pericalcarine (V1)	2.341	0.314
Cerebellum	3.333	0.309	Thalamus (Parafascicular)	2.328	0.720
Pons	2.835	0.482	Paracentral	2.214	0.341
Caudal Middle Frontal	2.742	0.281	Inferior Temporal	2.122	0.260
Rostral Middle Frontal	2.679	0.347	Thalamus (Ventral Anterior)	2.101	0.664
Superior Frontal	2.678	0.390	Thalamus (Lateral Posterior)	2.095	0.655
Medial Orbitofrontal	2.499	0.401	Precuneus	1.979	0.271
Pars Triangularis	2.322	0.434	Pars Orbitalis	1.567	0.417
Inferior Temporal	2.252	0.310	Entorhinal	1.485	0.457
Amygdala	1.982	0.493	Middle Temporal	1.008	0.293
Medulla	1.146	0.608	Caudal Anterior Cingulate	0.781	0.279
Pars Opercularis	0.994	0.403	Superior Temporal Sulcus	0.105	0.470
Hypothalamus	0.000	0.717	Thalamus (Centromedian)	0.000	0.606

Table S5. Onset of BOLD oscillations. Cross-correlation analysis was applied to estimate the temporal lag between different brain regions in the onset of BOLD oscillations at the transition from wake to sleep. Listed in the table are the mean and standard error mean (SEM) of the lag structure averaged across two hemispheres and participants S1 to S36.

Table S6. Offset of BOLD oscillations

Offset of low-frequency BOLD oscillation			Offset of high-frequency BOLD oscillation		
	Lag Time			**Lag Time**	
	Mean (sec)	**SEM (sec)**		**Mean (sec)**	**SEM (sec)**
Thalamus (Centromedian)	0.000	0.622	**Thalamus (Parafascicular)**	0.000	0.530
Thalamus (Anterior)	1.622	0.472	**Hypothalamus**	0.255	0.472
Thalamus (Parafascicular)	2.014	0.423	**Thalamus (Lateral Posterior)**	0.826	0.493
Medial Orbitofrontal	2.221	0.224	**Thalamus (Ventral Posterior)**	1.318	0.437
Pars Orbitalis	2.814	0.271	**Thalamus (Lateral Geniculate)**	1.988	0.579
Pars Triangularis	2.867	0.178	**Thalamus (Medial Dorsal)**	2.168	0.418
Thalamus (Medial Geniculate)	3.111	0.367	**Thalamus (Lateral Dorsal)**	2.193	0.287
Pars Opercularis	3.218	0.231	**Amygdala**	2.222	0.405
Rostral Middle Frontal	3.361	0.492	**Pars Orbitalis**	2.424	0.338
Caudal Middle Frontal	3.493	0.457	**Rostral Middle Frontal**	2.542	0.283
Hypothalamus	3.752	0.657	**Striatum**	2.670	0.316
Lateral Orbitofrontal	3.919	0.247	**Basal Forebrain**	2.846	0.393
Superior Parietal	4.214	0.187	**Superior Frontal**	3.168	0.248
Basal Forebrain	4.266	0.415	**Medial Orbitofrontal**	3.286	0.298
Lateral Occipital	4.387	0.299	**Midbrain**	3.390	0.372
Thalamus (Ventral Posterior)	4.497	0.198	**Caudal Anterior Cingulate**	3.621	0.206
Superior Temporal	4.502	0.125	**Medulla**	3.707	0.382
Hippocampus	4.534	0.221	**Rostral Anterior Cingulate**	3.844	0.314
Middle Temporal	4.619	0.159	**Hippocampus**	3.977	0.315
Superior Frontal	4.630	0.482	**Lateral Orbitofrontal**	4.327	0.271
Rostral Anterior Cingulate	4.759	0.224	**Entorhinal**	4.583	0.197
Fusiform	4.871	0.144	**Pons**	4.617	0.258
Midbrain	4.882	0.325	**Thalamus (Pulvinar)**	4.826	0.247
Pons	4.976	0.355	**Posterior Cingulate**	5.265	0.204
Precentral	5.116	0.107	**Caudal Middle Frontal**	5.502	0.240
Inferior Temporal	5.206	0.185	**Transverse Temporal (A1)**	5.613	0.279
Supra Marginal	5.228	0.173	**Middle Temporal**	5.645	0.267
Parahippocampal	5.250	0.263	**Lateral Occipital**	5.820	0.239
Thalamus (Pulvinar)	5.358	0.171	**Thalamus (Centromedian)**	5.826	0.460
Thalamus (Ventral Lateral)	5.432	0.351	**Parahippocampal**	5.836	0.182
Postcentral (S1)	5.441	0.171	**Thalamus (Medial Geniculate)**	5.926	0.714
Transverse Temporal (A1)	5.522	0.211	**Superior Temporal**	5.980	0.191
Thalamus (Medial Dorsal)	5.574	0.364	**Superior Parietal**	5.998	0.236
Entorhinal	5.750	0.361	**Thalamus (Ventral Lateral)**	6.049	0.336
Striatum	5.828	0.288	**Cerebellum**	6.080	0.191
Cerebellum	5.857	0.406	**Insula**	6.145	0.223
Amygdala	5.894	0.428	**Postcentral (S1)**	6.153	0.208
Insula	5.983	0.160	**Pars Triangularis**	6.161	0.226
Thalamus (Ventral Anterior)	6.329	0.388	**Fusiform**	6.200	0.219
Inferior Parietal	6.357	0.318	**Thalamus (Anterior)**	6.228	0.678
Thalamus (Lateral Geniculate)	6.373	0.418	**Precentral**	6.229	0.219
Caudal Anterior Cingulate	6.419	0.264	**Inferior Temporal**	6.296	0.232
Thalamus (Lateral Dorsal)	6.487	0.294	**Lingual (V2)**	6.403	0.221
Lingual (V2)	6.520	0.306	**Pars Opercularis**	6.523	0.236
Medulla	6.681	0.326	**Isthmus Cingulate**	6.598	0.190
Pericalcarine (V1)	6.724	0.380	**Supra Marginal**	6.637	0.241
Superior Temporal Sulcus	7.045	0.245	**Inferior Parietal**	6.707	0.236
Posterior Cingulate	7.439	0.283	**Superior Temporal Sulcus**	6.856	0.252
Isthmus Cingulate	7.529	0.285	**Paracentral**	6.938	0.273
Paracentral	7.541	0.341	**Precuneus**	7.044	0.255
Precuneus	7.648	0.314	**Cuneus (V2)**	7.426	0.326
Cuneus (V2)	7.744	0.521	**Thalamus (Ventral Anterior)**	7.540	0.611
Thalamus (Lateral Posterior)	10.030	0.377	**Pericalcarine (V1)**	7.821	0.284

Table S6. Offset of BOLD oscillations. Cross-correlation analysis was applied to estimate the temporal lag between different brain regions in the offset of BOLD oscillations at the transition from sleep to wake. Listed in the table are the mean and standard error mean (SEM) of the lag structure averaged cross two hemispheres and participants S1 to S36.