Lifestyle Risks Associated with Brain Functional Connectivity and Structure

Human Brain Mapping (2023) doi: 10.1002/hbm.26225

Supplementary Material

Edmund T Rolls[1,2,4,] , Ruiqing Feng[1] and Jianfeng Feng[1,2,3]

1. Department of Computer Science, University of Warwick, Coventry CV4 7AL, UK
2. Institute of Science and Technology for Brain-inspired Intelligence, Fudan University, Shanghai, 200433, China
3. Key Laboratory of Computational Neuroscience and Brain-Inspired Intelligence, Fudan University, Ministry of Education, Shanghai, 200433, China
4. Oxford Centre for Computational Neuroscience, Oxford, UK

Table S1. Regions defined in the modified Human Connectome Project atlas (Glasser, et al., 2016). L=left hemisphere, R=right. The column 'Reordered region ID' is that used in Figs. 2-6, and is a reordering of that based on suggestions in the Supplementary Information of Glasser et al (2016). In that Supplementary Information of that paper, the 360 regions are grouped based on geographic proximity and functional similarities, which was reorganized and provided by Dr Dianne Patterson of the University of Arizona at https://neuroimaging-core-docs.readthedocs.io/en/latest/pages/atlases.html with the HCP-MMP1_UniqueRegionList.csv and is shown in the column labelled CortexID in Table S1. The volumes are in mm^3. This modified atlas with the reordering is described elsewhere (Huang, et al., 2022).

Reordered ID (L, R)	**Region**	**RegionLongName**	**Cortical Division**	**Cortex ID**	**Original ID**	**Voxel numbers ($1mm^3$) (L,R)**
1, 181	V1	Primary_Visual_Cortex	Primary_Visual	1	1	13812, 13406
2, 182	V2	Second_Visual_Area	Early_Visual	2	4	9515, 9420
3, 183	V3	Third_Visual_Area	Early_Visual	2	5	7106, 7481
4, 184	V4	Fourth_Visual_Area	Early_Visual	2	6	4782, 4537
5, 185	IPS1	IntraParietal_Sulcus_Area_1	Dorsal_Stream_Visual	3	17	1751, 1750
6, 186	V3A	Area_V3A	Dorsal_Stream_Visual	3	13	2191, 2212
7, 187	V3B	Area_V3B	Dorsal_Stream_Visual	3	19	639, 731
8, 188	V6	Sixth_Visual_Area	Dorsal_Stream_Visual	3	3	1402, 1559
9, 189	V6A	Area_V6A	Dorsal_Stream_Visual	3	152	904, 734
10, 190	V7	Seventh_Visual_Area	Dorsal_Stream_Visual	3	16	1005, 1041
11, 191	FFC	Fusiform_Face_Complex	Ventral_Stream_Visual	4	18	3848, 4402
12, 192	PIT	Posterior_InferoTemporal_complex	Ventral_Stream_Visual	4	22	1392, 1386
13, 193	V8	Eighth_Visual_Area	Ventral_Stream_Visual	4	7	1361, 1175
14, 194	VMV1	VentroMedial_Visual_Area_1	Ventral_Stream_Visual	4	153	939, 1219
15, 195	VMV2	VentroMedial_Visual_Area_2	Ventral_Stream_Visual	4	160	639, 923
16, 196	VMV3	VentroMedial_Visual_Area_3	Ventral_Stream_Visual	4	154	941, 1242
17, 197	VVC	Ventral_Visual_Complex	Ventral_Stream_Visual	4	163	2487, 2753
18, 198	FST	Area_FST	MT+_Complex	5	157	1324, 1683
19, 199	LO1	Area_Lateral_Occipital_1	MT+_Complex	5	20	619, 909
20, 200	LO2	Area_Lateral_Occipital_2	MT+_Complex	5	21	1179, 1062
21, 201	LO3	Area_Lateral_Occipital_3	MT+_Complex	5	159	438, 915
22, 202	MST	Medial_Superior_Temporal_Area	MT+_Complex	5	2	794, 1036
23, 203	MT	Middle_Temporal_Area	MT+_Complex	5	23	620, 1005
24, 204	PH	Area_PH	MT+_Complex	5	138	3453, 3205
25, 205	V3CD	Area_V3CD	MT+_Complex	5	158	876, 1222
26, 206	V4t	Area_V4t	MT+_Complex	5	156	1037, 1249

27, 207	1	Area_1	SomaSens_Motor	6	51	6590, 5925
28, 208	2	Area_2	SomaSens_Motor	6	52	4278, 4727
29, 209	3a	Area_3a	SomaSens_Motor	6	53	2247, 2286
30, 210	3b	Primary_Sensory_Cortex	SomaSens_Motor	6	9	5451, 4350
31, 211	4	Primary_Motor_Cortex	SomaSens_Motor	6	8	10776, 10254
32, 212	23c	Area_23c	ParaCentral_MidCing	7	38	2259, 2498
33, 213	24dd	Dorsal_Area_24d	ParaCentral_MidCing	7	40	2665, 2820
34, 214	24dv	Ventral_Area_24d	ParaCentral_MidCing	7	41	1076, 1349
35, 215	5L	Area_5L	ParaCentral_MidCing	7	39	2249, 2327
36, 216	5m	Area_5m	ParaCentral_MidCing	7	36	1483, 2079
37, 217	5mv	Area_5m_ventral	ParaCentral_MidCing	7	37	1651, 1996
38, 218	6ma	Area_6m_anterior	ParaCentral_MidCing	7	44	3941, 4251
39, 219	6mp	Area_6mp	ParaCentral_MidCing	7	55	3701, 3105
40, 220	SCEF	Supplementary_and_Cingulate_Eye_Field	ParaCentral_MidCing	7	43	3500, 3371
41, 221	55b	Area_55b	Premotor	8	12	2422, 1537
42, 222	6a	Area_6_anterior	Premotor	8	96	4233, 3752
43, 223	6d	Dorsal_area_6	Premotor	8	54	2916, 2909
44, 224	6r	Rostral_Area_6	Premotor	8	78	3029, 3981
45, 225	6v	Ventral_Area_6	Premotor	8	56	2075, 2516
46, 226	FEF	Frontal_Eye_Fields	Premotor	8	10	1787, 1889
47, 227	PEF	Premotor_Eye_Field	Premotor	8	11	1006, 1258
48, 228	43	Area_43	Posterior_Opercular	9	99	1889, 1678
49, 229	FOP1	Frontal_Opercular_Area_1	Posterior_Opercular	9	113	879, 932
50, 230	OP1	Area_OP1-SII	Posterior_Opercular	9	101	1275, 1072
51, 231	OP2-3	Area_OP2-3-VS	Posterior_Opercular	9	102	943, 792
52, 232	OP4	Area_OP4-PV	Posterior_Opercular	9	100	2332, 2409
53, 233	52	Area_52	Early_Auditory	10	103	725, 580
54, 234	A1	Primary_Auditory_Cortex	Early_Auditory	10	24	1023, 796
55, 235	LBelt	Lateral_Belt_Complex	Early_Auditory	10	174	820, 901
56, 236	MBelt	Medial_Belt_Complex	Early_Auditory	10	173	1242, 1236
57, 237	PBelt	ParaBelt_Complex	Early_Auditory	10	124	1719, 1439
58, 238	PFcm	Area_PFcm	Early_Auditory	10	105	1486, 1485
59, 239	RI	RetroInsular_Cortex	Early_Auditory	10	104	1149, 1334
60, 240	A4	Auditory_4_Complex	Auditory_Association	11	175	3514, 3610
61, 241	A5	Auditory_5_Complex	Auditory_Association	11	125	3346, 3881
62, 242	STGa	Area_STGa	Auditory_Association	11	123	2509, 2187
63, 243	STSda	Area_STSd_anterior	Auditory_Association	11	128	1944, 2389
64, 244	STSdp	Area_STSd_posterior	Auditory_Association	11	129	1994, 2605
65, 245	STSva	Area_STSv_anterior	Auditory_Association	11	176	1694, 1900
66, 246	STSvp	Area_STSv_posterior	Auditory_Association	11	130	2898, 2515
67, 247	TA2	Area_TA2	Auditory_Association	11	107	1518, 1726
68, 248	AAIC	Anterior_Agranular_Insula_Complex	Insula_FrontalOperc	12	112	1859, 1691

69, 249	AVI	Anterior_Ventral_Insular_Area	Insula_FrontalOperc	12	111	1446, 1792
70, 250	FOP2	Frontal_Opercular_Area_2	Insula_FrontalOperc	12	115	750, 720
71, 251	FOP3	Frontal_Opercular_Area_3	Insula_FrontalOperc	12	114	754, 614
72, 252	FOP4	Frontal_Opercular_Area_4	Insula_FrontalOperc	12	108	2522, 1678
73, 253	FOP5	Area_Frontal_Opercular_5	Insula_FrontalOperc	12	169	1297, 1365
74, 254	Ig	Insular_Granular_Complex	Insula_FrontalOperc	12	168	841, 1077
75, 255	MI	Middle_Insular_Area	Insula_FrontalOperc	12	109	2102, 1960
76, 256	PI	Para-Insular_Area	Insula_FrontalOperc	12	178	1033, 1058
77, 257	Pir	Piriform_Cortex	Insula_FrontalOperc	12	110	2287, 1856
78, 258	PoI1	Area_Posterior_Insular_1	Insula_FrontalOperc	12	167	1811, 1835
79, 259	PoI2	Posterior_Insular_Area_2	Insula_FrontalOperc	12	106	2747, 2675
80, 260	H	Hippocampus	Medial_Temporal	13	120	4283, 3626
81, 261	PreS	PreSubiculum	Medial_Temporal	13	119	1817, 1558
82, 262	EC	Entorhinal_Cortex	Medial_Temporal	13	118	2127, 2110
83, 263	PeEc	Perirhinal_Ectorhinal_Cortex	Medial_Temporal	13	122	4826, 4755
84, 264	TF	Area_TF	Medial_Temporal	13	135	3986, 4752
85, 265	PHA1	ParaHippocampal_Area_1	Medial_Temporal	13	126	1281, 1168
86, 266	PHA2	ParaHippocampal_Area_2	Medial_Temporal	13	155	783, 771
87, 267	PHA3	ParaHippocampal_Area_3	Medial_Temporal	13	127	2023, 1122
88, 268	PHT	Area_PHT	Lateral_Temporal	14	137	4182, 3410
89, 269	TE1a	Area_TE1_anterior	Lateral_Temporal	14	132	5227, 4180
90, 270	TE1m	Area_TE1_Middle	Lateral_Temporal	14	177	3339, 3429
91, 271	TE1p	Area_TE1_posterior	Lateral_Temporal	14	133	7116, 6010
92, 272	TE2a	Area_TE2_anterior	Lateral_Temporal	14	134	5691, 5753
93, 273	TE2p	Area_TE2_posterior	Lateral_Temporal	14	136	4115, 3040
94, 274	TGd	Area_TG_dorsal	Lateral_Temporal	14	131	10192, 10269
95, 275	TGv	Area_TG_Ventral	Lateral_Temporal	14	172	3694, 4515
96, 276	PSL	PeriSylvian_Language_Area	TPO	15	25	2154, 2759
97, 277	STV	Superior_Temporal_Visual_Area	TPO	15	28	2322, 2294
98, 278	TPOJ1	Area_TemporoParietoOccipital_Junction_1	TPO	15	139	2102, 3938
99, 279	TPOJ2	Area_TemporoParietoOccipital_Junction_2	TPO	15	140	1930, 2068
100, 280	TPOJ3	Area_TemporoParietoOccipital_Junction_3	TPO	15	141	1290, 1277
101, 281	7AL	Lateral_Area_7A	Superior_Parietal	16	42	2134, 2030
102, 282	7Am	Medial_Area_7A	Superior_Parietal	16	45	2995, 2379
103, 283	7PC	Area_7PC	Superior_Parietal	16	47	3151, 3415
104, 284	7Pl	Lateral_Area_7P	Superior_Parietal	16	46	1695, 1363
105, 285	7Pm	Medial_Area_7P	Superior_Parietal	16	29	1601, 1308
106, 286	AIP	Anterior_IntraParietal_Area	Superior_Parietal	16	117	1999, 2542
107, 287	LIPd	Area_Lateral_IntraParietal_dorsal	Superior_Parietal	16	95	1008, 869
108, 288	LIPv	Area_Lateral_IntraParietal_ventral	Superior_Parietal	16	48	1681, 1783

109, 289	MIP	Medial_IntraParietal_Area	Superior_Parietal	16	50	1872, 2403
110, 290	VIP	Ventral_IntraParietal_Complex	Superior_Parietal	16	49	1890, 1577
111, 291	IP0	Area_IntraParietal_0	Inferior_Parietal	17	146	1203, 1239
112, 292	IP1	Area_IntraParietal_1	Inferior_Parietal	17	145	1692, 1632
113, 293	IP2	Area_IntraParietal_2	Inferior_Parietal	17	144	2102, 1861
114, 294	PF	Area_PF_Complex	Inferior_Parietal	17	148	5457, 5251
115, 295	PFm	Area_PFm_Complex	Inferior_Parietal	17	149	8220, 8141
116, 296	PFop	Area_PF_Opercular	Inferior_Parietal	17	147	1797, 1783
117, 297	PFt	Area_PFt	Inferior_Parietal	17	116	1983, 2039
118, 298	PGi	Area_PGi	Inferior_Parietal	17	150	4791, 4970
119, 299	PGp	Area_PGp	Inferior_Parietal	17	143	2501, 3740
120, 300	PGs	Area_PGs	Inferior_Parietal	17	151	4552, 3366
121, 301	23d	Area_23d	Posterior_Cingulate	18	32	1261, 1513
122, 302	31a	Area_31a	Posterior_Cingulate	18	162	1260, 1116
123, 303	31pd	Area_31pd	Posterior_Cingulate	18	161	1428, 864
124, 304	31pv	Area_31p_ventral	Posterior_Cingulate	18	35	950, 1022
125, 305	7m	Area_7m	Posterior_Cingulate	18	30	2128, 2067
126, 306	d23ab	Area_dorsal_23_a+b	Posterior_Cingulate	18	34	1607, 1106
127, 307	DVT	Dorsal_Transitional_Visual_Area	Posterior_Cingulate	18	142	1806, 2176
128, 308	PCV	PreCuneus_Visual_Area	Posterior_Cingulate	18	27	2245, 2416
129, 309	POS1	Parieto-Occipital_Sulcus_Area_1	Posterior_Cingulate	18	31	2531, 2727
130, 310	POS2	Parieto-Occipital_Sulcus_Area_2	Posterior_Cingulate	18	15	3261, 3093
131, 311	ProS	ProStriate_Area	Posterior_Cingulate	18	121	1222, 1055
132, 312	RSC	RetroSplenial_Complex	Posterior_Cingulate	18	14	2830, 3067
133, 313	v23ab	Area_ventral_23_a+b	Posterior_Cingulate	18	33	916, 1089
134, 314	10r	Area_10r	AntCing_MedPFC	19	65	1589, 1053
135, 315	10v	Area_10v	AntCing_MedPFC	19	88	3906, 2667
136, 316	25	Area_25	AntCing_MedPFC	19	164	1911, 2135
137, 317	33pr	Area_33_prime	AntCing_MedPFC	19	58	1354, 1316
138, 318	8BM	Area_8BM	AntCing_MedPFC	19	63	3122, 3436
139, 319	9m	Area_9_Middle	AntCing_MedPFC	19	69	6338, 5881
140, 320	a24	Area_a24	AntCing_MedPFC	19	61	2085, 2152
141, 321	a24pr	Anterior_24_prime	AntCing_MedPFC	19	59	1095, 1474
142, 322	a32pr	Area_anterior_32_prime	AntCing_MedPFC	19	179	1759, 1118
143, 323	d32	Area_dorsal_32	AntCing_MedPFC	19	62	2228, 2374
144, 324	p24	Area_posterior_24	AntCing_MedPFC	19	180	2394, 2442
145, 325	p24pr	Area_Posterior_24_prime	AntCing_MedPFC	19	57	1422, 1724
146, 326	p32	Area_p32	AntCing_MedPFC	19	64	1180, 1765
147, 327	p32pr	Area_p32_prime	AntCing_MedPFC	19	60	1569, 1305
148, 328	pOFC	Posterior_OFC_Complex	AntCing_MedPFC	19	166	2486, 2836
149, 329	s32	Area_s32	AntCing_MedPFC	19	165	604, 1015
150, 330	10d	Area_10d	OrbPolaFrontal	20	72	3644, 3096
151, 331	10pp	Polar_10p	OrbPolaFrontal	20	90	1997, 2487

152, 332	11l	Area_11l	OrbPolaFrontal	20	91	3531, 3793
153, 333	13l	Area_13l	OrbPolaFrontal	20	92	2429, 1757
154, 334	47m	Area_47m	OrbPolaFrontal	20	66	799, 781
155, 335	47s	Area_47s	OrbPolaFrontal	20	94	2795, 3080
156, 336	a10p	Area_anterior_10p	OrbPolaFrontal	20	89	1964, 1748
157, 337	OFC	Orbital_Frontal_Complex	OrbPolaFrontal	20	93	4560, 5232
158, 338	p10p	Area_posterior_10p	OrbPolaFrontal	20	170	2116, 2365
159, 339	44	Area_44	Inferior_Frontal	21	74	2435, 2589
160, 340	45	Area_45	Inferior_Frontal	21	75	3762, 2962
161, 341	47l	Area_47l_(47_lateral)	Inferior_Frontal	21	76	2527, 2592
162, 342	a47r	Area_anterior_47r	Inferior_Frontal	21	77	4167, 3763
163, 343	IFJa	Area_IFJa	Inferior_Frontal	21	79	1513, 1405
164, 344	IFJp	Area_IFJp	Inferior_Frontal	21	80	960, 740
165, 345	IFSa	Area_IFSa	Inferior_Frontal	21	82	2057, 2641
166, 346	IFSp	Area_IFSp	Inferior_Frontal	21	81	1589, 1730
167, 347	p47r	Area_posterior_47r	Inferior_Frontal	21	171	2133, 1761
168, 348	46	Area_46	Dorsolateral_Prefrontal	22	84	4863, 4394
169, 349	8Ad	Area_8Ad	Dorsolateral_Prefrontal	22	68	3386, 3492
170, 350	8Av	Area_8Av	Dorsolateral_Prefrontal	22	67	4807, 5902
171, 351	8BL	Area_8B_Lateral	Dorsolateral_Prefrontal	22	70	3377, 4078
172, 352	8C	Area_8C	Dorsolateral_Prefrontal	22	73	4085, 3134
173, 353	9-46d	Area_9-46d	Dorsolateral_Prefrontal	22	86	4534, 4666
174, 354	9a	Area_9_anterior	Dorsolateral_Prefrontal	22	87	3706, 3048
175, 355	9p	Area_9_Posterior	Dorsolateral_Prefrontal	22	71	3426, 2488
176, 356	a9-46v	Area_anterior_9-46v	Dorsolateral_Prefrontal	22	85	3314, 2628
177, 357	i6-8	Inferior_6-8_Transitional_Area	Dorsolateral_Prefrontal	22	97	1764, 2418
178, 358	p9-46v	Area_posterior_9-46v	Dorsolateral_Prefrontal	22	83	2871, 4635
179, 359	s6-8	Superior_6-8_Transitional_Area	Dorsolateral_Prefrontal	22	98	1336, 2132
180, 360	SFL	Superior_Frontal_Language_Area	Dorsolateral_Prefrontal	22	26	3873, 3055

Column 1 (Reordered ID) shows the order in HCPex based on the HCP-MMP1_UniqueRegionList.csv, as described in the Methods, of the 360 cortical regions originally defined by Glasser et al (2016). The names of the cortical divisions shown in column 4 come from the same .csv file. The sixth column shows the original order used by Glasser et al (2016). Abbreviations: L=left hemisphere, R=right. MT+_Complex, MT+_Complex_and_Neighboring_Visual_Areas; SomaSens_Motor, Somatosensory_and_Motor; ParaCentral_MidCing, Paracentral_Lobular_and_Mid_Cingulate; Insula_FrontalOperc, Insular_and_Frontal_Opercular; TPO, Temporo-Parieto-Occipital_Junction; AntCing_MedPFC, Anterior_Cingulate_and_Medial_Prefrontal; OrbPolaFrontal, Orbital_and_Polar_Frontal.

Fig. S1-1. Example coronal slices showing regions defined in the HCPex atlas and added subcortical regions (Huang, et al., 2022). The abbreviations are as in Table S1. The y values for the coronal slices are in MNI coordinates.

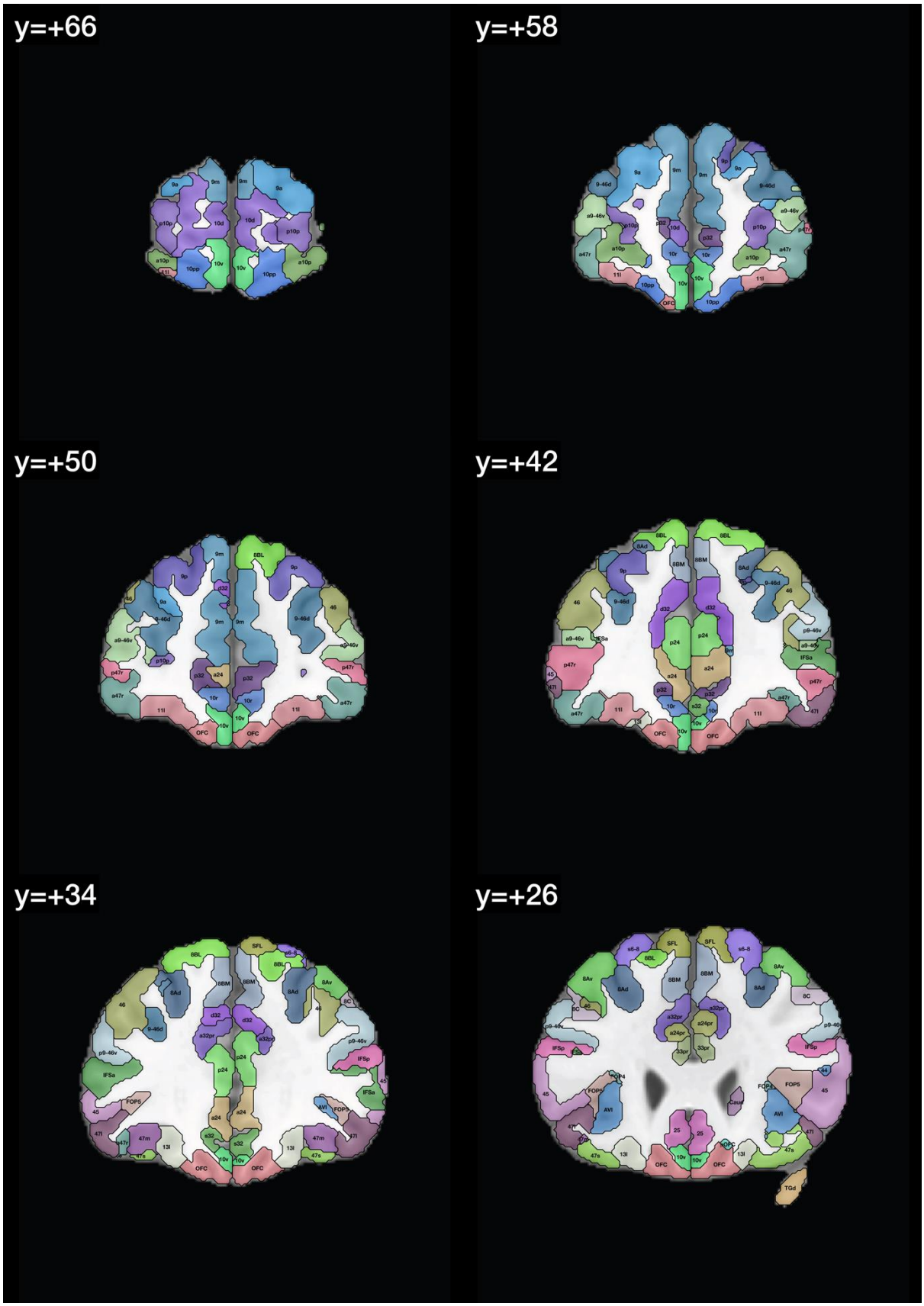


Fig. S1-2. Example coronal slices showing regions defined in the HCPex atlas and added subcortical regions. The abbreviations are as in Table S1. The y values for the coronal slices are in MNI coordinates.

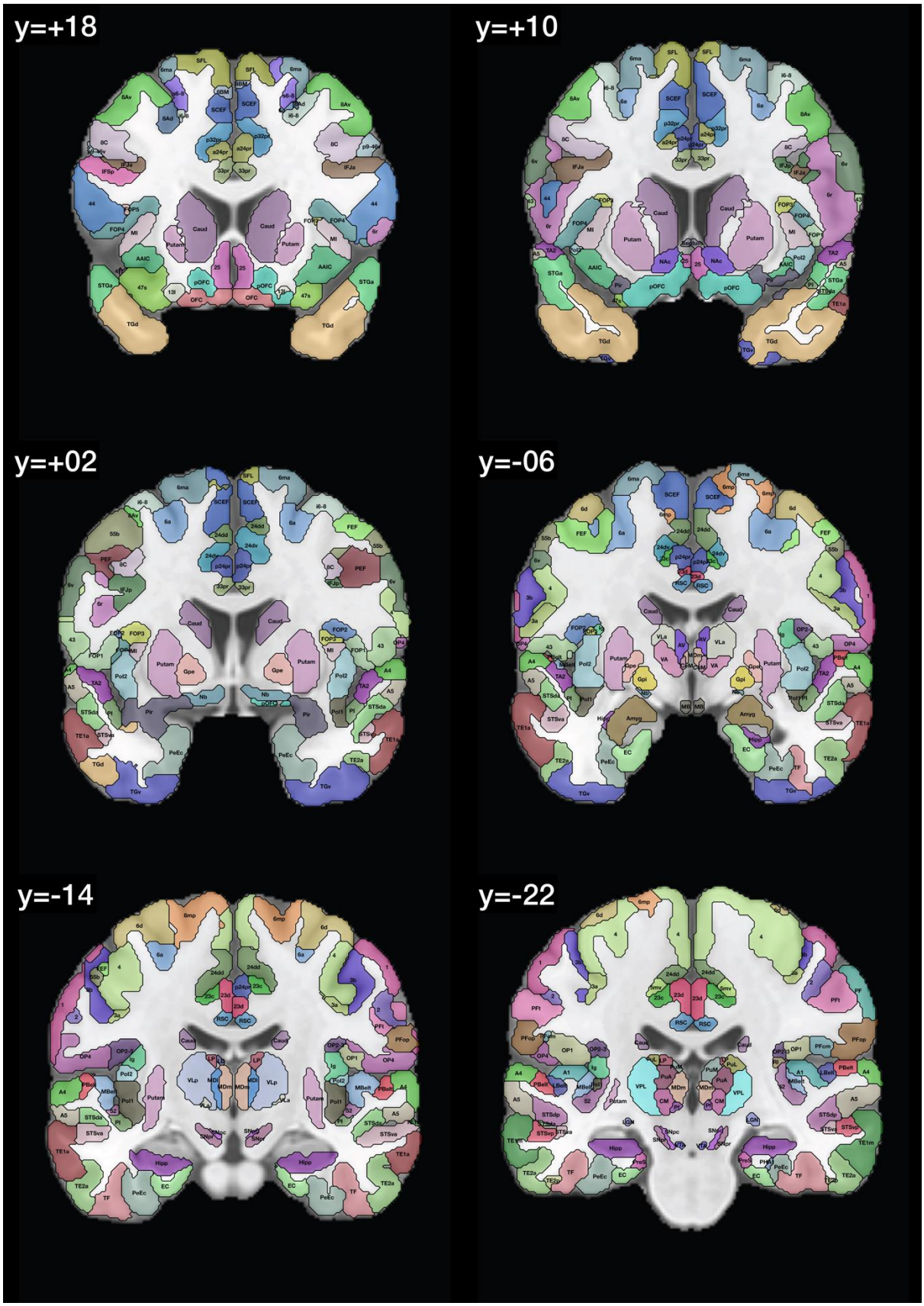


Fig. S1-3. Example coronal slices showing regions defined in the HCPex atlas and added subcortical regions. The abbreviations are as in Table S1. The y values for the coronal slices are in MNI coordinates.

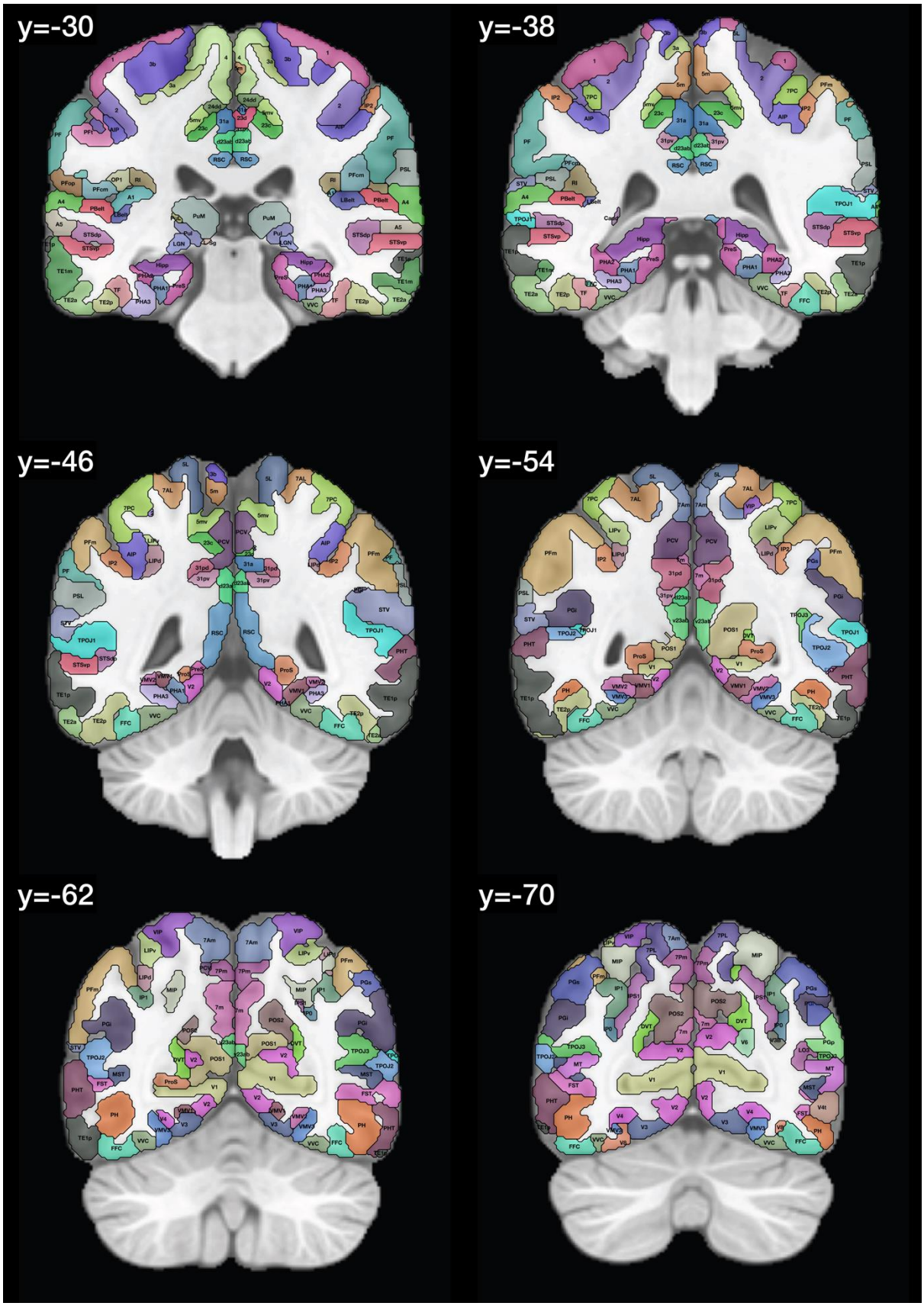


Fig. S1-4. Example coronal slices showing regions defined in the HCPex atlas and added subcortical regions. The abbreviations are as in Table S1. The y values for the coronal slices are in MNI coordinates.

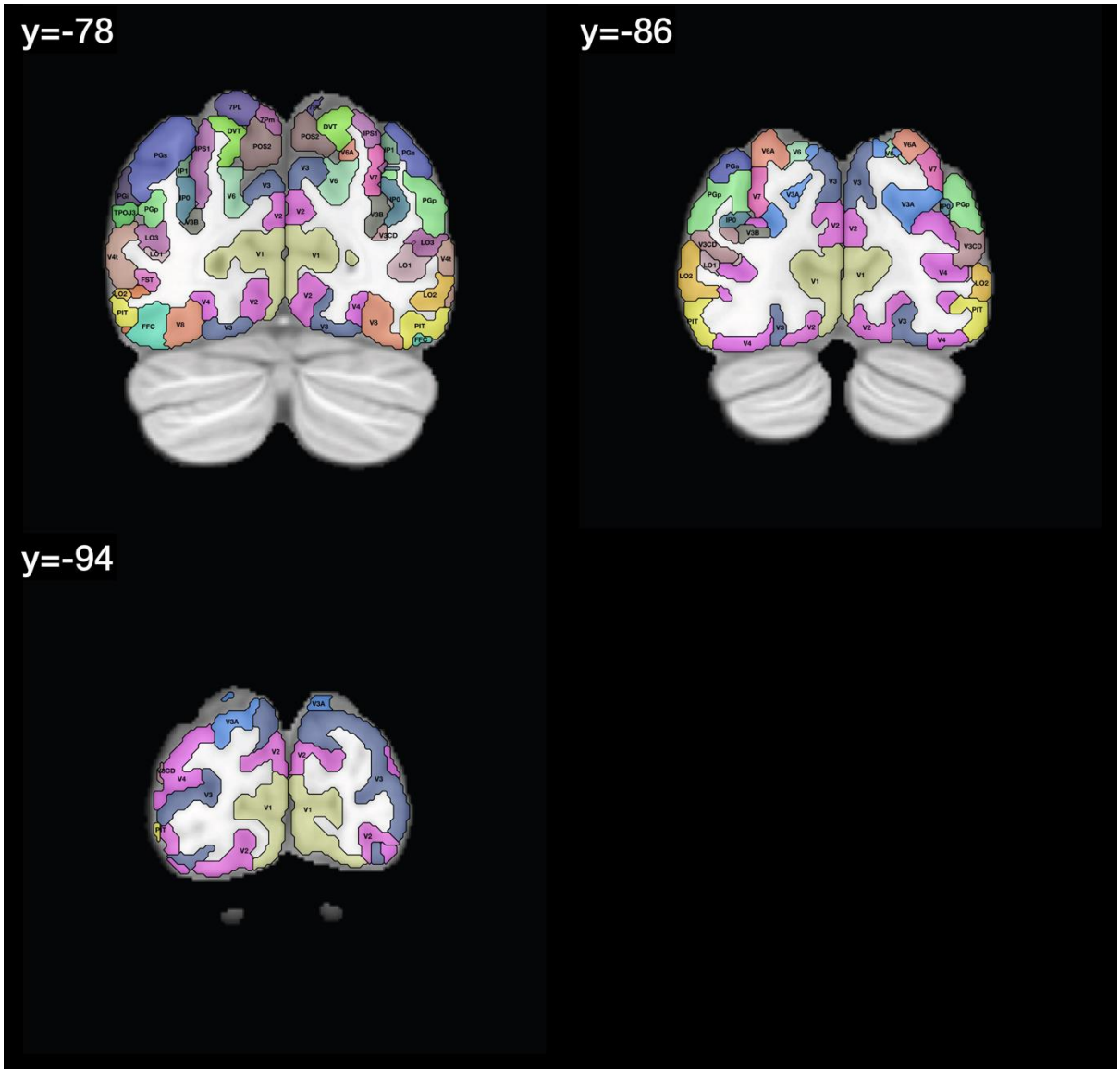
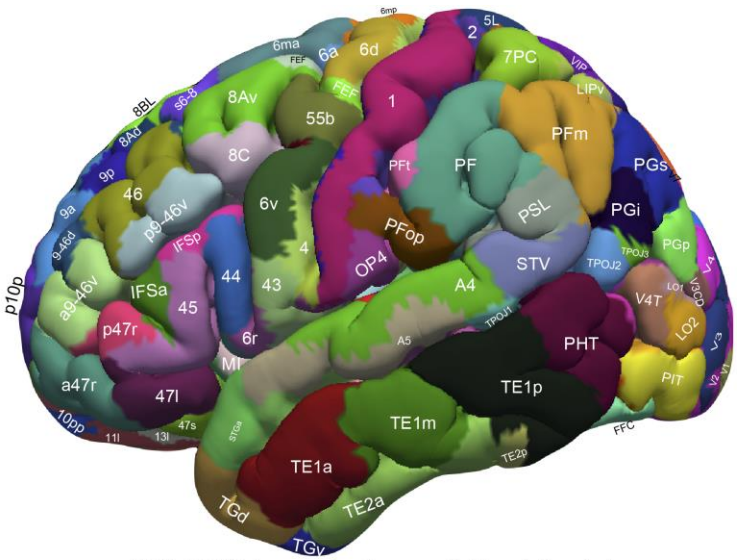
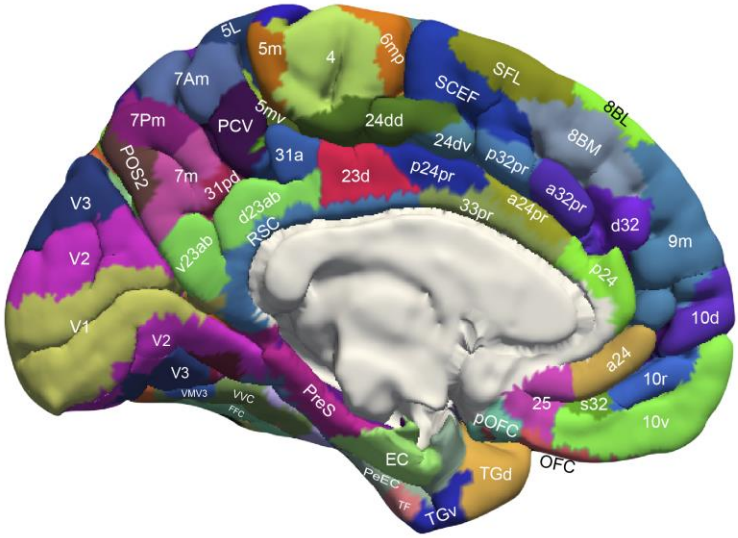


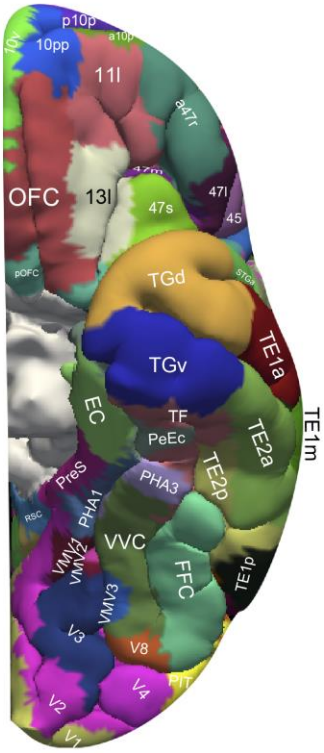
Fig. S1-5. Anatomical regions of the human cortical regions as defined in the HCP-MMP atlas (Glasser, et al., 2016), and in its extended version HCPex (Huang, et al., 2022). The regions are shown on images of the human brain without the sulci expanded to show which cortical HCP-MMP regions are normally visible, for comparison with Fig. S1-6. (The ICBM153 MNI T1 image was used to prepare this figure.) Abbreviations are provided in Table S1.



HCP-MMP1 human brain parcellation: lateral view

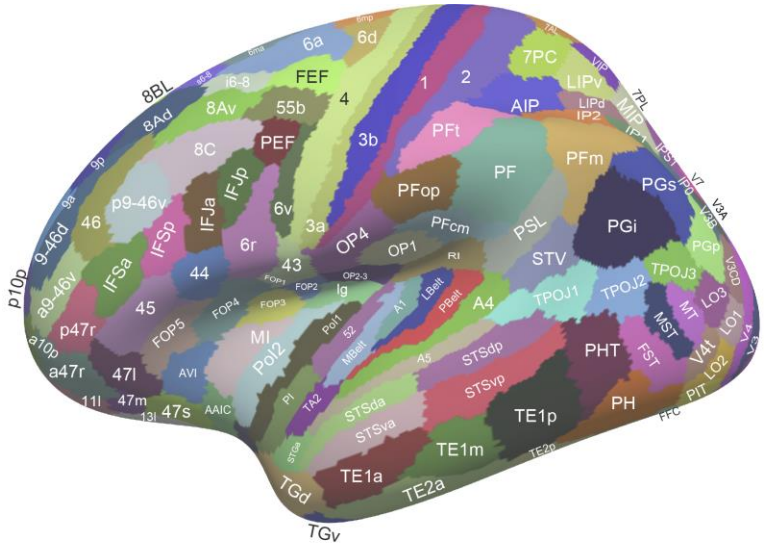


HCP-MMP1 human brain parcellation: medial view

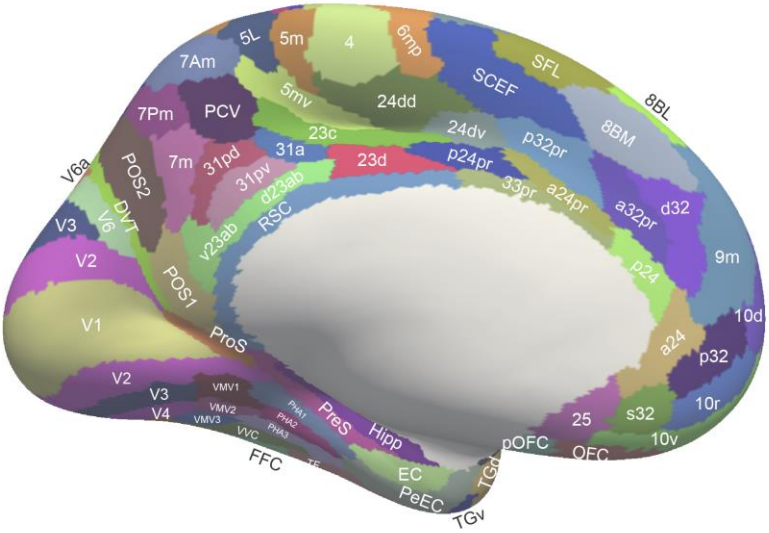


Inferior view

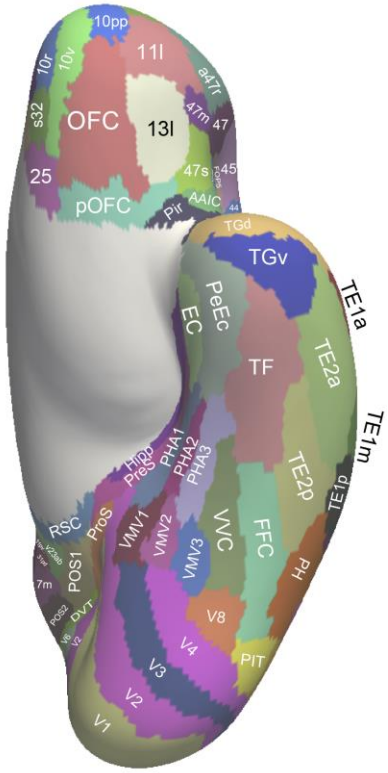
Fig. S1-6. Regions in the Human Connectome Project Multimodal Parcellation atlas (HCP-MMP) (Glasser, et al., 2016) and its extended version HCPex (Huang, et al., 2022). The regions are shown on images of the human brain with the sulci expanded sufficiently to allow the regions within the sulci to be shown. Abbreviations are provided in Table S1. For comparison, a version of this diagram without the sulci expanded is provided in Fig. S1-5. (HCPBrainMaster4bLC.eps)



HCP-MMP1 human brain parcellation: lateral view



HCP-MMP1 human brain parcellation: medial view



Inferior view

Methods

Healthy Lifestyle Phenotypes

The following provides some additional information to that in the main paper. Seven lifestyle factors were used in this study, including alcohol consumption, alcohol frequency, diet, physical activity, smoking status, mobile phone time, and leisure or social activity. The formation of a combined lifestyle measure was a sum risk score for what could potentially be a risk factor, with each lifestyle measure for an individual having a binary code, 0 or 1, with 1 the lifestyle that was more likely to be a risk to health.

For physical activity, participants were asked “In the last four weeks, did you spend any time doing the following: walking for pleasure, light DIY (do-it-yourself, i.e., home maintenance and improvement and gardening activities), heavy DIY (e.g., using heavy tools, weeding, lawn mowing, digging, carpentry), strenuous sports (i.e., sports that make you sweat or breathe hard), other exercises (e.g., swimming, cycling, keep fit, bowling); none of the above.” The intensity was expressed in terms of standardised metabolic equivalent of task (MET) values (Ainsworth, et al., 2000). The total weekly leisure-time physical activity (MET-minutes/week) was calculated by multiplying the frequency, duration, and the MET values (Ainsworth, et al., 2000). Then the participants with less than 500 MET-minutes/ week were given a score of 1 indicating a potentially unhealthy lifestyle (https://www.nhs.uk/live-well/exercise/).

For smoking status, which comes from the field 20116, This field summarises the current/past smoking status of the participant, smoking was categorised as not a current smoker as health group (set 1) or current smoker at the time of assessment (set 0).

For mobile phone time, the participants asked, "Over the last 3 months, on average how much time per week did you spend making or receiving calls on a mobile phone?" (Field ID: 1120), we split the data to half, the participants with <=1 hour/week over the last 3 month grouped as health.

For leisure or social activity, which come from the field ID: 6160, the participants asked "Which of the following do you attend once a week or more often? (You can select more than one)". The participants with >=1 activities were grouped as health (set 1) (Bittner, et al., 2019).

Statistical Analysis

Correlation between the lifestyle factors

Firstly, the Spearman partial correlation was used to test the correlation between the 7 lifestyle factors (N=19,415), with age, gender, BMI, qualification of education and Townsend index regressed out as covariates of no interest. The result is shown in Table S2. The correlations between the lifestyle factors are quite low, which indicate that a single brain correlate with all does not seem likely.

Table S2. The association between the lifestyle factors

r/p	alcohol consumption	diet	physical activity	smoking status	mobile phone time	leisure/social activity
alcohol consumption	1.00	-0.04/2.25E-12	0.01/0.02	0.20/4.67E-236	0.06/2.93E-20	0.04/1.57E-08
diet	-0.04/2.25E-12	1.00	0.13/ 6.21E-99	0.01/0.05	0.00/0.27	0.03/1.18E-05
physical activity	0.01/0.02	0.13/ 6.21E-99	1.00	-0.02/6.00E-02	0.00/0.76	0.20/8.0E-219
smoking status	0.20/4.67E-236	0.01/0.05	0.02/6.00E-02	1.00	0.04/6.57E-11	-0.02/1.8E-03
mobile phone time	0.06/2.93E-20	0.00/0.27	0.00/0.76	0.04/6.57E-11	1.00	0.03/ 1.26E-05
leisure/social activity	0.04/1.57E-08	0.03/1.18E-05	0.20/8.0E-219	-0.02/1.8E-03	0.03/ 1.26E-05	1.00

Association between Functional Connectivities and the sum risk score for a poor lifestyle

Fig. 1 in the main paper shows the association between the sum risk score of lifestyles (the sum risk level for a potentially poor lifestyle, including low alcohol consumption, low alcohol frequency, non-smoking status, poor diet, low physical activity, low mobile phone time, and low leisure / social activity) and functional connectivities in the left hemisphere. Table S3 provided next shows the top 50 functional connectivity links with the most significant correlations in that analysis.

Table S3. Top 50 Functional Connectivity links correlated with the sum risk score for a poor lifestyle summarized for Fig. 1), including alcohol consumption, alcohol frequency, smoking status, diet, physical activity, mobile phone time, and leisure or social activity). r and p values are shown, with the covariates in the method regressed out. A negative r value indicates that the functional connectivity is negatively associated with the sum risk score. Bonferroni corrected significance for the test involving 5,343 functional connectivities at $p<0.05$ is reached with $p<10^{-4}$.

Label_1	Region_1	Label_2	Region_2	r_value	p_value
L_STSva	Auditory_Association	R_PFop	Inferior_Parietal	-0.06	3.58E-18
L_47l	Inferior_Frontal	R_7Am	Superior_Parietal	-0.06	3.79E-18
L_STSda	Auditory_Association	R_PFop	Inferior_Parietal	-0.06	8.88E-18
L_STSdp	Auditory_Association	R_PFop	Inferior_Parietal	-0.06	1.64E-17
L_47l	Inferior_Frontal	R_PCV	Posterior_Cingulate	-0.06	2.55E-17
L_STSdp	Auditory_Association	R_OP4	Posterior_Opercular	-0.06	1.33E-16
L_STSda	Auditory_Association	R_24dv	Paracentral_Lobular_and _Mid_Cingulate	-0.06	2.56E-16
L_STSvp	Auditory_Association	R_7Am	Superior_Parietal	-0.06	2.63E-16
R_STSda	Auditory_Association	R_PFt	Inferior_Parietal	-0.06	2.94E-16
L_STSda	Auditory_Association	R_24dd	Paracentral_Lobular_and _Mid_Cingulate	-0.06	3.00E-16
R_STSda	Auditory_Association	R_PFop	Inferior_Parietal	-0.06	3.29E-16
L_TE1a	Lateral_Temporal	R_PFop	Inferior_Parietal	-0.06	3.91E-16
L_STSva	Auditory_Association	R_PFt	Inferior_Parietal	-0.06	4.14E-16
L_STSva	Auditory_Association	L_PFop	Inferior_Parietal	-0.06	4.21E-16
L_A4	Auditory_Association	L_STSda	Auditory_Association	-0.06	7.94E-16
L_STSdp	Auditory_Association	R_24dd	Paracentral_Lobular_and _Mid_Cingulate	-0.06	8.86E-16
L_STSda	Auditory_Association	R_A4	Auditory_Association	-0.06	1.10E-15
L_STSdp	Auditory_Association	R_A5	Auditory_Association	-0.06	1.12E-15
L_OP4	Posterior_Opercular	L_STSdp	Auditory_Association	-0.06	1.13E-15
L_STGa	Auditory_Association	R_7Am	Superior_Parietal	-0.06	1.20E-15
L_47l	Inferior_Frontal	R_7Pm	Superior_Parietal	-0.06	1.38E-15
L_STGa	Auditory_Association	R_PFop	Inferior_Parietal	-0.06	1.39E-15
L_STSva	Auditory_Association	R_24dd	Paracentral_Lobular_and _Mid_Cingulate	-0.06	1.43E-15

L_STSvp	Auditory_Association	R_PFop	Inferior_Parietal	-0.06	1.71E-15
R_24dd	Paracentral_Lobular_and_Mid_Cingulate	R_STSda	Auditory_Association	-0.06	1.78E-15
L_A5	Auditory_Association	R_24dd	Paracentral_Lobular_and_Mid_Cingulate	-0.06	1.97E-15
R_OP4	Posterior_Opercular	R_STSda	Auditory_Association	-0.06	2.15E-15
L_STSdp	Auditory_Association	R_24dv	Paracentral_Lobular_and_Mid_Cingulate	-0.06	2.28E-15
L_PGi	Inferior_Parietal	R_PFop	Inferior_Parietal	-0.06	2.37E-15
L_STSda	Auditory_Association	R_OP4	Posterior_Opercular	-0.06	2.93E-15
L_A4	Auditory_Association	L_STSdp	Auditory_Association	-0.06	3.26E-15
L_10r	Anterior_Cingulate_and_Medial_Prefrontal	R_PFop	Inferior_Parietal	-0.06	3.46E-15
L_OP4	Posterior_Opercular	L_STSda	Auditory_Association	-0.06	3.77E-15
L_STSda	Auditory_Association	R_7Am	Superior_Parietal	-0.06	4.38E-15
L_47l	Inferior_Frontal	R_PFop	Inferior_Parietal	-0.06	4.44E-15
L_47l	Inferior_Frontal	R_PF	Inferior_Parietal	-0.06	4.59E-15
L_OP4	Posterior_Opercular	R_STSda	Auditory_Association	-0.06	4.85E-15
L_OP4	Posterior_Opercular	L_ProS	Posterior_Cingulate	-0.06	5.24E-15
L_STSda	Auditory_Association	L_PFop	Inferior_Parietal	-0.06	5.54E-15
L_STSdp	Auditory_Association	R_A4	Auditory_Association	-0.06	5.82E-15
L_STSva	Auditory_Association	R_24dv	Paracentral_Lobular_and_Mid_Cingulate	-0.06	6.51E-15
L_STSva	Auditory_Association	R_PF	Inferior_Parietal	-0.06	6.55E-15
L_STSda	Auditory_Association	L_PFt	Inferior_Parietal	-0.06	7.12E-15
L_A5	Auditory_Association	R_PFop	Inferior_Parietal	-0.06	7.20E-15
L_47l	Inferior_Frontal	R_23c	Paracentral_Lobular_and_Mid_Cingulate	-0.06	7.84E-15
L_OP4	Posterior_Opercular	L_STSva	Auditory_Association	-0.06	7.97E-15
L_5mv	Paracentral_Lobular_and_Mid_Cingulate	L_A5	Auditory_Association	-0.06	8.42E-15
L_STSdp	Auditory_Association	R_7Am	Superior_Parietal	-0.06	8.56E-15
L_A5	Auditory_Association	R_7Am	Superior_Parietal	-0.06	8.63E-15
L_STSva	Auditory_Association	L_PFt	Inferior_Parietal	-0.06	9.28E-15

Functional connectivities associated with the separate lifestyle risk factors

To investigate the association between functional connectivity and lifestyle factors separately, linear regression analysis was used, after removing 7 confounding variables: age, gender, BMI, qualification of education, Townsend index, imaging collection site and head motion with N=19,415. The following Figures and Tables supplement those provided in the main paper, and are referred to in the main paper.

Physical activity

It is shown by blue in Fig. 2 that a low physical activity was correlated with low functional connectivities between some cortical regions. The 30 most significant links are shown in Table S4 next.

Table S4. Top 30 Functional Connectivity links with r and p values for physical activity. A negative r value means a low physical activity was correlated with low FC.

Label_1	Region_1	Label_1	Region_1	r	p
L_MI	Insular_and_Frontal_Opercular	R_RSC	Posterior_Cingulate	-0.05	1.16E-20
L_FOP4	Insular_and_Frontal_Opercular	R_RSC	Posterior_Cingulate	-0.05	3.64E-20
L_FOP4	Insular_and_Frontal_Opercular	L_RSC	Posterior_Cingulate	-0.05	3.89E-20
L_PreS	Medial_Temporal	R_RI	Early_Auditory	-0.05	4.15E-20
L_PreS	Medial_Temporal	R_Ig	Insular_and_Frontal_Opercular	-0.05	7.05E-20
L_PreS	Medial_Temporal	R_OP1	Posterior_Opercular	-0.05	1.40E-19
R_3b	Somatosensory_and_Motor	R_5m	Paracentral_Lobular_and_Mid_Cingulate	-0.05	1.85E-19
L_PoI2	Insular_and_Frontal_Opercular	L_PreS	Medial_Temporal	-0.05	1.93E-19
R_OP1	Posterior_Opercular	R_PreS	Medial_Temporal	-0.05	3.10E-19
L_OP4	Posterior_Opercular	L_PreS	Medial_Temporal	-0.05	4.25E-19
L_PreS	Medial_Temporal	R_OP4	Posterior_Opercular	-0.05	5.80E-19
L_PreS	Medial_Temporal	R_PFcm	Early_Auditory	-0.05	1.07E-18
R_LBelt	Early_Auditory	R_PCV	Posterior_Cingulate	-0.05	1.39E-18
R_Ig	Insular_and_Frontal_Opercular	R_PreS	Medial_Temporal	-0.05	1.99E-18
L_OP4	Posterior_Opercular	L_7Am	Superior_Parietal	-0.05	2.88E-18
L_OP4	Posterior_Opercular	R_POS1	Posterior_Cingulate	-0.05	3.06E-18
L_MI	Insular_and_Frontal_Opercular	L_RSC	Posterior_Cingulate	-0.05	3.47E-18
L_3b	Somatosensory_and_Motor	R_OP1	Posterior_Opercular	-0.05	4.32E-18
L_23c	Paracentral_Lobular_and_Mid_Cingulate	R_OP4	Posterior_Opercular	-0.05	4.45E-18
L_FOP2	Insular_and_Frontal_Opercular	L_PreS	Medial_Temporal	-0.05	4.59E-18
L_23c	Paracentral_Lobular_and_Mid_Cingulate	L_OP4	Posterior_Opercular	-0.05	4.72E-18
L_5mv	Paracentral_Lobular_and_Mid_Cingulate	L_OP2-3	Posterior_Opercular	-0.05	6.17E-18
L_3a	Somatosensory_and_Motor	R_OP1	Posterior_Opercular	-0.05	6.56E-18
R_RI	Early_Auditory	R_PreS	Medial_Temporal	-0.05	7.22E-18
L_1	Somatosensory_and_Motor	R_OP1	Posterior_Opercular	-0.05	9.43E-18
R_24dv	Paracentral_Lobular_and_Mid_Cingulate	R_Hipp	Medial_Temporal	-0.05	9.91E-18
L_OP4	Posterior_Opercular	R_p24pr	Anterior_Cingulate_and_Medial_Prefrontal	-0.05	1.18E-17
L_OP4	Posterior_Opercular	R_7Am	Superior_Parietal	-0.05	1.49E-17
R_3a	Somatosensory_and_Motor	R_5m	Paracentral_Lobular_and_Mid_Cingulate	-0.05	1.57E-17
L_23c	Paracentral_Lobular_and_Mid_Cingulate	L_OP2-3	Posterior_Opercular	-0.05	2.32E-17

Leisure/social activity

It is shown by blue in Fig. 3 that a low leisure/social activity was correlated with low functional connectivities between some cortical regions. The 30 most significant links are shown in Table S5.

Table S5. Top 30 Functional Connectivity links with r, and p values for the leisure/social activity. A negative r value means a low leisure/social activity was correlated with low FC.

Label_1	Region_1	Label_1	Region_1	r	p
L_OP4	Posterior_Opercular	R_POS1	Posterior_Cingulate	-0.05	3.24E-20
L_RSC	Posterior_Cingulate	R_PF	Inferior_Parietal	-0.05	1.05E-19
R_3a	Somatosensory_and_Motor	R_3b	Somatosensory_and_Motor	-0.05	5.31E-18
L_FFC	Ventral_Stream_Visual	L_OP4	Posterior_Opercular	-0.05	6.35E-18
L_OP4	Posterior_Opercular	L_PreS	Medial_Temporal	-0.04	9.15E-18
L_MI	Insular_and_Frontal_Opercular	L_RSC	Posterior_Cingulate	-0.04	1.89E-17
L_PFop	Inferior_Parietal	R_RSC	Posterior_Cingulate	-0.04	2.59E-17
L_OP4	Posterior_Opercular	R_PGp	Inferior_Parietal	-0.04	3.06E-17
R_V3A	Dorsal_Stream_Visual	R_OP1	Posterior_Opercular	-0.04	3.07E-17
L_FOP1	Posterior_Opercular	L_PreS	Medial_Temporal	-0.04	4.24E-17
L_OP4	Posterior_Opercular	R_7PL	Superior_Parietal	-0.04	5.04E-17
L_RSC	Posterior_Cingulate	R_MI	Insular_and_Frontal_Opercul ar	-0.04	5.12E-17
R_3a	Somatosensory_and_Motor	R_4	Somatosensory_and_Motor	-0.04	5.22E-17
L_3b	Somatosensory_and_Motor	R_3a	Somatosensory_and_Motor	-0.04	6.26E-17
L_OP4	Posterior_Opercular	R_PreS	Medial_Temporal	-0.04	8.72E-17
L_OP4	Posterior_Opercular	L_IP0	Inferior_Parietal	-0.04	8.81E-17
R_3b	Somatosensory_and_Motor	R_4	Somatosensory_and_Motor	-0.04	9.99E-17
L_PFop	Inferior_Parietal	L_RSC	Posterior_Cingulate	-0.04	1.01E-16
L_FOP4	Insular_and_Frontal_Opercular	L_RSC	Posterior_Cingulate	-0.04	1.17E-16
R_PF	Inferior_Parietal	R_RSC	Posterior_Cingulate	-0.04	1.29E-16
L_RSC	Posterior_Cingulate	R_FOP4	Insular_and_Frontal_Opercul ar	-0.04	1.47E-16
L_RSC	Posterior_Cingulate	R_6r	Premotor	-0.04	1.76E-16
L_PoI2	Insular_and_Frontal_Opercular	R_RSC	Posterior_Cingulate	-0.04	1.82E-16
L_OP4	Posterior_Opercular	L_POS1	Posterior_Cingulate	-0.04	2.65E-16
L_FFC	Ventral_Stream_Visual	L_PFop	Inferior_Parietal	-0.04	2.85E-16
L_4	Somatosensory_and_Motor	R_3b	Somatosensory_and_Motor	-0.04	2.86E-16
L_3b	Somatosensory_and_Motor	R_3b	Somatosensory_and_Motor	-0.04	3.19E-16
L_MI	Insular_and_Frontal_Opercular	R_RSC	Posterior_Cingulate	-0.04	3.45E-16
R_FST	MT+_Complex_and_Neighboring_Visual_Are as	R_STGa	Auditory_Association	-0.04	3.86E-16
L_V4t	MT+_Complex_and_Neighboring_Visual_Are as	R_1	Somatosensory_and_Motor	-0.04	4.02E-16

Mobile phone time

It is shown by blue in Fig. 4 that a low mobile phone time use was correlated with low functional connectivities between some cortical regions. The 30 most significant links are shown in Table S6.

Table S6. Top 30 Functional Connectivity links with r, and p values for the mobile phone time. A negative r value means a low mobile phone time use was correlated with low FC.

Label_1	Region_1	Label_2	Region_2	r	p
L_1	Somatosensory_and_Motor	L_3b	Somatosensory_and_Motor	-0.06	4.39E-30
R_1	Somatosensory_and_Motor	R_3b	Somatosensory_and_Motor	-0.06	1.41E-28
L_1	Somatosensory_and_Motor	R_3a	Somatosensory_and_Motor	-0.06	5.04E-27
L_1	Somatosensory_and_Motor	R_3b	Somatosensory_and_Motor	-0.06	7.36E-27
L_STGa	Auditory_Association	L_PFt	Inferior_Parietal	-0.06	8.10E-27
L_2	Somatosensory_and_Motor	R_STSda	Auditory_Association	-0.06	5.90E-26
R_2	Somatosensory_and_Motor	R_STSda	Auditory_Association	-0.06	5.99E-26
L_1	Somatosensory_and_Motor	L_STSda	Auditory_Association	-0.06	6.03E-26
L_A4	Auditory_Association	L_STSda	Auditory_Association	-0.06	6.15E-26
L_STGa	Auditory_Association	R_VIP	Superior_Parietal	-0.06	1.00E-25
L_STGa	Auditory_Association	R_PFt	Inferior_Parietal	-0.06	1.15E-25
R_2	Somatosensory_and_Motor	R_3a	Somatosensory_and_Motor	-0.06	1.63E-25
L_2	Somatosensory_and_Motor	L_STSda	Auditory_Association	-0.06	1.72E-25
L_STSda	Auditory_Association	R_FST	MT+_Complex_and_Neighboring_Visual_Areas	-0.06	2.32E-25
R_2	Somatosensory_and_Motor	R_3b	Somatosensory_and_Motor	-0.06	3.30E-25
L_STSda	Auditory_Association	R_2	Somatosensory_and_Motor	-0.06	6.68E-25
L_1	Somatosensory_and_Motor	R_STSda	Auditory_Association	-0.06	7.08E-25
L_3b	Somatosensory_and_Motor	R_3b	Somatosensory_and_Motor	-0.06	8.89E-25
L_OP4	Posterior_Opercular	L_STSda	Auditory_Association	-0.06	1.52E-24
L_STGa	Auditory_Association	R_TPOJ2	Temporo-Parieto-Occipital_Junction	-0.06	1.60E-24
L_1	Somatosensory_and_Motor	L_4	Somatosensory_and_Motor	-0.06	1.70E-24
L_2	Somatosensory_and_Motor	L_STGa	Auditory_Association	-0.06	2.54E-24
L_1	Somatosensory_and_Motor	L_3a	Somatosensory_and_Motor	-0.06	3.15E-24
R_STSda	Auditory_Association	R_7AL	Superior_Parietal	-0.06	3.87E-24
L_6mp	Paracentral_Lobular_and_Mid_Cingulate	L_STSda	Auditory_Association	-0.06	3.94E-24
L_1	Somatosensory_and_Motor	R_ProS	Posterior_Cingulate	-0.06	4.35E-24
L_STSda	Auditory_Association	R_24dd	Paracentral_Lobular_and_Mid_Cingulate	-0.06	5.06E-24
L_STGa	Auditory_Association	L_AIP	Superior_Parietal	-0.06	5.46E-24
L_STGa	Auditory_Association	L_7AL	Superior_Parietal	-0.06	5.84E-24
L_1	Somatosensory_and_Motor	R_5m	Paracentral_Lobular_and_Mid_Cingulate	-0.06	5.91E-24

Alcohol consumption

For alcohol consumption, in the UK Biobank participants (N=19,415), the top 30 significantly associated FC links with alcohol consumption are shown in Table S7 (and Figure S2 shows all 2,613 significantly associated FC links after Bonferroni correction with $p<0.05$, $p=7.7e-07$). As Figure S2 shows, most of the significant links are negatively associated with the alcohol consumption (2,579/2,613). Those links are significantly negatively associated with alcohol consumption involving the Dorsolateral_Prefrontal, the Anterior_Cingulate_and_Medial_Prefrontal and the Orbital_and_Polar_Frontal. In addition, there was also lower functional connectivity for the Lateral_Temporal, the Inferior_Frontal and the Inferior_Parietal.

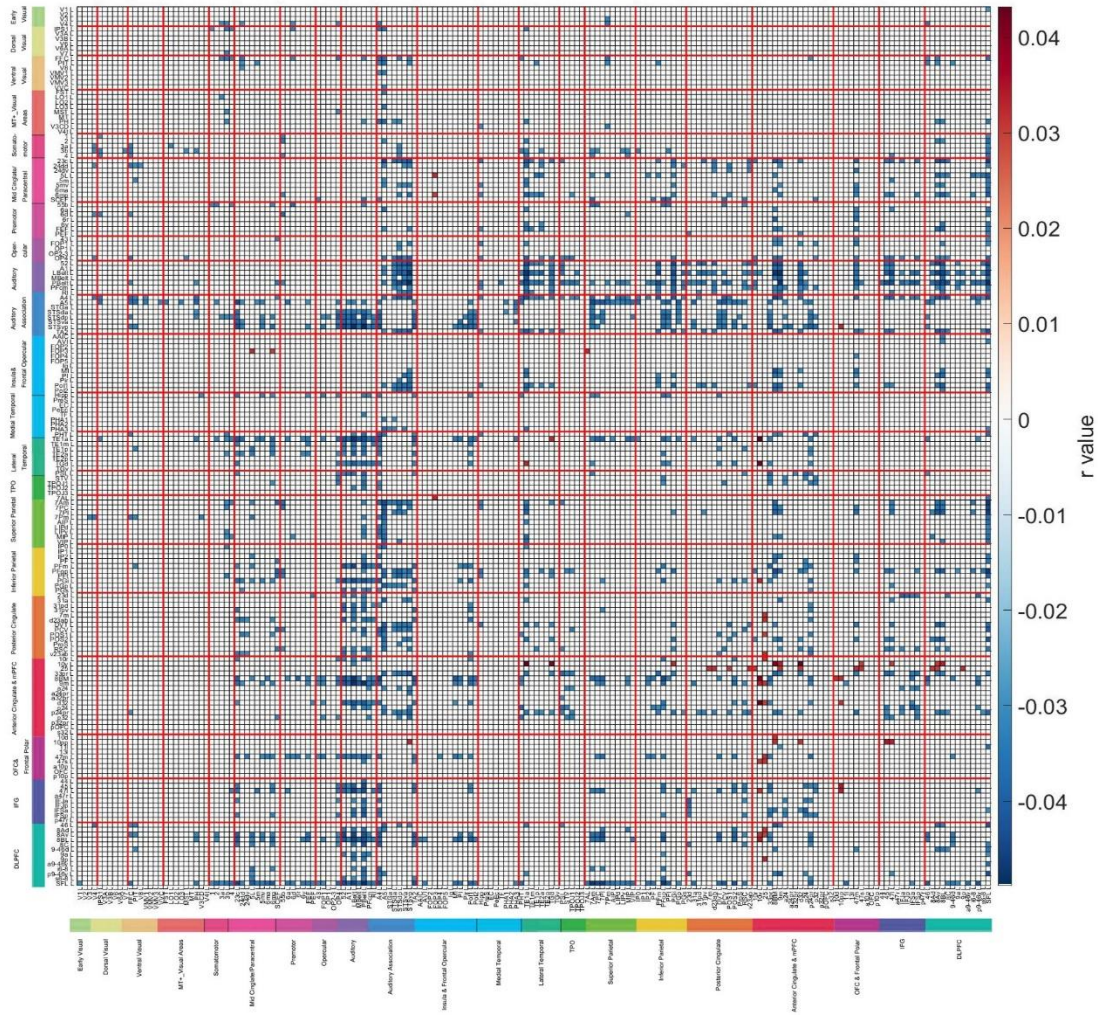
Table S7 shows the top 30 links, all of them are negatively associated with alcohol consumption. 12 of the top 30 links involved lower functional connectivity of the Anterior_Cingulate_and_Medial_Prefrontal, and 11 lower functional connectivity of the Dorsolateral_Prefrontal.

Table S7. Top 30 Functional Connectivity links with r and p values for alcohol consumption. Negative r values indicate that higher alcohol consumption is associated with low functional connectivity.

Label_1	Region_1	Label_2	Region_2	r	p
L_SFL	Dorsolateral_Prefrontal	R_PF	Inferior_Parietal	-0.05	1.57E-16
L_SFL	Dorsolateral_Prefrontal	R_PFop	Inferior_Parietal	-0.05	1.14E-15
L_SFL	Dorsolateral_Prefrontal	R_PBelt	Early_Auditory	-0.05	1.37E-15
L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	R_A4	Auditory_Association	-0.05	1.81E-15
L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	R_PSL	Temporo-Parieto-Occipital_Junction	-0.05	4.03E-15
L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	R_PF	Inferior_Parietal	-0.05	4.27E-15
L_PBelt	Early_Auditory	L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	-0.05	4.28E-15
L_PBelt	Early_Auditory	L_STSvp	Auditory_Association	-0.05	8.48E-15
L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	R_PBelt	Early_Auditory	-0.05	1.05E-14
L_PBelt	Early_Auditory	L_SFL	Dorsolateral_Prefrontal	-0.05	1.14E-14
L_SFL	Dorsolateral_Prefrontal	R_IFJa	Inferior_Frontal	-0.05	1.54E-14
L_PCV	Posterior_Cingulate	R_A5	Auditory_Association	-0.05	1.70E-14
L_LBelt	Early_Auditory	L_9m	Anterior_Cingulate_and_Medial_Prefrontal	-0.05	2.01E-14
L_LBelt	Early_Auditory	L_STSvp	Auditory_Association	-0.05	2.34E-14
L_A5	Auditory_Association	R_PCV	Posterior_Cingulate	-0.05	2.60E-14
L_LBelt	Early_Auditory	L_TE1a	Lateral_Temporal	-0.05	3.07E-14
L_LBelt	Early_Auditory	L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	-0.05	3.90E-14

L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	R_IFSa	Inferior_Frontal	-0.05	3.90E-14
L_PBelt	Early_Auditory	L_9m	Anterior_Cingulate_and_Medial_Prefrontal	-0.05	3.92E-14
L_SFL	Dorsolateral_Prefrontal	R_6r	Premotor	-0.05	4.41E-14
L_7Am	Superior_Parietal	L_SFL	Dorsolateral_Prefrontal	-0.05	6.29E-14
L_SFL	Dorsolateral_Prefrontal	R_PHT	Lateral_Temporal	-0.05	8.10E-14
L_PFop	Inferior_Parietal	L_SFL	Dorsolateral_Prefrontal	-0.05	8.28E-14
L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	R_6r	Premotor	-0.05	8.98E-14
L_IFJa	Inferior_Frontal	R_AAIC	Insular_and_Frontal_Opercular	-0.05	1.08E-13
L_9m	Anterior_Cingulate_and_Medial_Prefrontal	R_A4	Auditory_Association	-0.05	1.21E-13
L_LBelt	Early_Auditory	R_9m	Anterior_Cingulate_and_Medial_Prefrontal	-0.05	1.28E-13
L_SFL	Dorsolateral_Prefrontal	R_PCV	Posterior_Cingulate	-0.05	1.35E-13
L_STSvp	Auditory_Association	R_PBelt	Early_Auditory	-0.05	1.40E-13
L_SFL	Dorsolateral_Prefrontal	R_A4	Auditory_Association	-0.05	1.45E-13

Fig. S2 The association between alcohol consumption and functional connectivities in the left hemisphere. The matrix shows the 2,613 significant links after Bonferroni correction (Bonferroni corrected, $p<0.05$; $p=7.7e-07$) in the left hemisphere with r value. Negative r values (blue) indicate that higher alcohol consumption is associated with low functional connectivity. (fc_corr_AlcCon_left.jpg)



Alcohol frequency

For alcohol frequency, field 1558 in the UK Biobank participants (N=19,415), the participants were asked, "About how often do you drink alcohol?", and ranked as 1, Daily or almost daily; 2, Three or four times a week; 3, Once or twice a week; 4, One to three times a month; 5, Special occasions only; 6, Never. Participants who answered “1, Daily or almost daily” received a score of 1 for this lifestyle measure." The sign of this measure reversed in this analysis; the higher value means drink more frequently. The top 30 significantly associated FC links with alcohol frequency are shown in Table S8 (and Figure S3 shows all 859 significantly associated FC links after Bonferroni correction with $p<0.05$, $p=7.7e-07$).

489/859 of the significantly associated links are positively associated with alcohol frequency. Those links include orbitofrontal cortex 13l, ventromedial 10r, some posterior cingulate cortex regions.

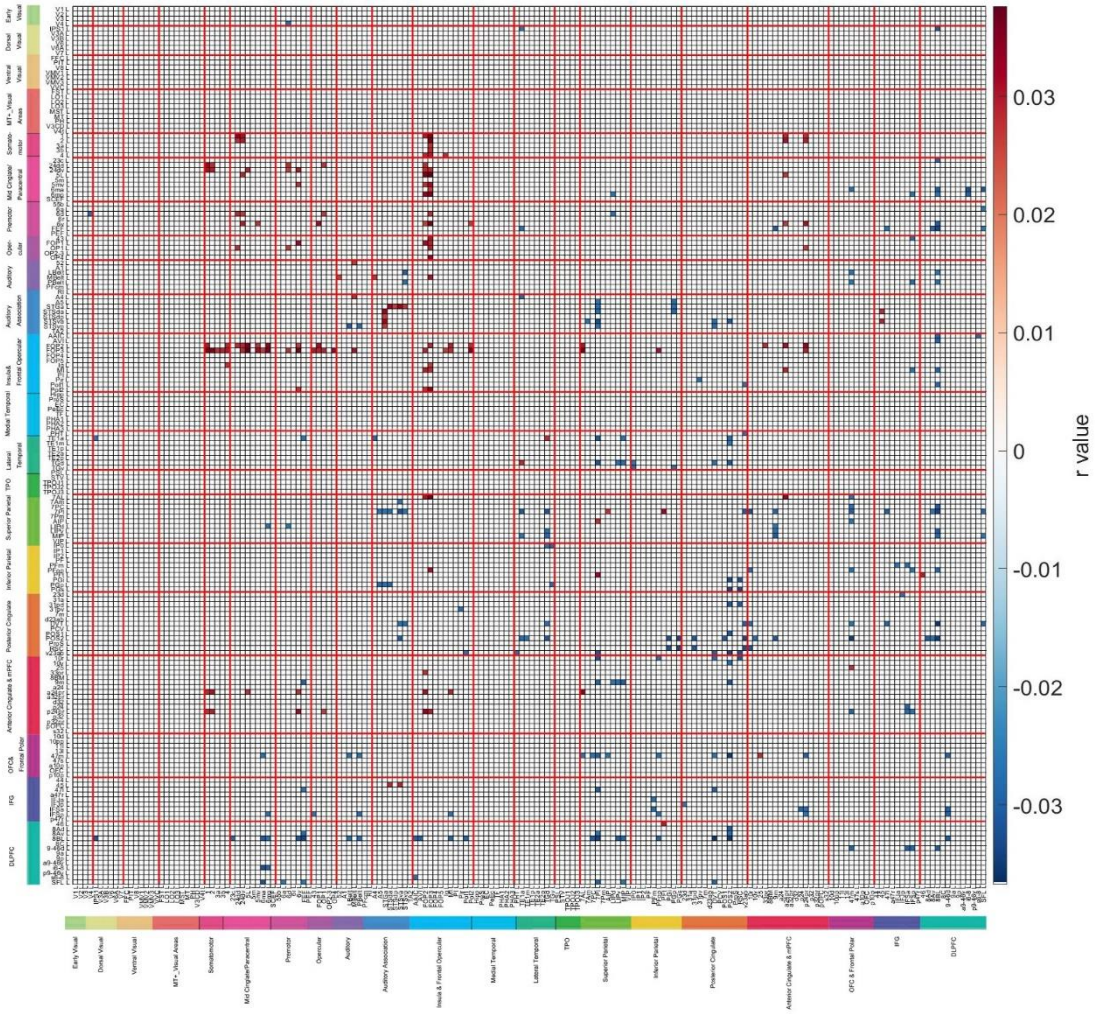
370/859 of the significantly associated links are negatively associated with alcohol frequency, and involved especially FOP2 and FOP3, frontal opercular areas probably associated with oral somatosensation and perhaps taste (Rolls, et al., 2023a; Rolls, et al., 2023b).

Table S8. Top 30 Functional Connectivity links with r and p values for alcohol frequency. Positive r values indicate higher functional connectivities positively associated with high frequency of alcohol use.

Label_1	Region_1	Label_2	Region_2	r	p
L_10r	Anterior_Cingulate_and_Medial_Prefrontal	R_POS2	Posterior_Cingulate	-0.04	4.01E-16
R_6v	Premotor	R_FOP3	Insular_and_Frontal_Opercular	0.04	1.11E-14
L_FOP3	Insular_and_Frontal_Opercular	R_7AL	Superior_Parietal	0.04	1.22E-14
L_FOP3	Insular_and_Frontal_Opercular	R_2	Somatosensory_and_Motor	0.04	2.51E-14
R_FOP3	Insular_and_Frontal_Opercular	R_7AL	Superior_Parietal	0.04	7.03E-14
L_PGs	Inferior_Parietal	R_POS2	Posterior_Cingulate	-0.04	1.50E-13
R_OP4	Posterior_Opercular	R_FOP3	Insular_and_Frontal_Opercular	0.04	1.87E-13
R_POS2	Posterior_Cingulate	R_v23ab	Posterior_Cingulate	-0.04	1.92E-13
L_6mp	Paracentral_Lobular_and_Mid_Cingulate	R_FOP2	Insular_and_Frontal_Opercular	0.04	2.41E-13
L_5L	Paracentral_Lobular_and_Mid_Cingulate	R_FOP2	Insular_and_Frontal_Opercular	0.04	2.41E-13
L_v23ab	Posterior_Cingulate	R_POS2	Posterior_Cingulate	-0.04	2.92E-13
R_6mp	Paracentral_Lobular_and_Mid_Cingulate	R_FOP2	Insular_and_Frontal_Opercular	0.04	4.77E-13
L_5mv	Paracentral_Lobular_and_Mid_Cingulate	R_FOP2	Insular_and_Frontal_Opercular	0.04	5.08E-13
L_5L	Paracentral_Lobular_and_Mid_Cingulate	L_FOP3	Insular_and_Frontal_Opercular	0.04	7.59E-13
L_a24pr	Anterior_Cingulate_and_Medial_Prefrontal	R_2	Somatosensory_and_Motor	0.04	7.81E-13

R_4	Somatosensory_and_Motor	R_FOP3	Insular_and_Frontal_Opercular	0.04	8.40E-13
R_2	Somatosensory_and_Motor	R_FOP3	Insular_and_Frontal_Opercular	0.04	1.18E-12
L_p24pr	Anterior_Cingulate_and_Medial_Prefrontal	R_FOP2	Insular_and_Frontal_Opercular	0.04	1.24E-12
L_FOP3	Insular_and_Frontal_Opercular	R_6v	Premotor	0.04	1.28E-12
R_FOP2	Insular_and_Frontal_Opercular	R_7AL	Superior_Parietal	0.04	1.33E-12
L_47m	Orbital_and_Polar_Frontal	R_POS2	Posterior_Cingulate	-0.04	1.55E-12
R_FOP3	Insular_and_Frontal_Opercular	R_PFop	Inferior_Parietal	0.04	2.13E-12
R_POS2	Posterior_Cingulate	R_47m	Orbital_and_Polar_Frontal	-0.04	2.30E-12
L_POS2	Posterior_Cingulate	L_10r	Anterior_Cingulate_and_Medial_Prefrontal	-0.04	2.53E-12
L_6v	Premotor	R_FOP3	Insular_and_Frontal_Opercular	0.04	2.66E-12
L_FOP3	Insular_and_Frontal_Opercular	L_7AL	Superior_Parietal	0.04	3.10E-12
L_6mp	Paracentral_Lobular_and_Mid_Cingulate	R_FOP3	Insular_and_Frontal_Opercular	0.04	3.67E-12
L_24dv	Paracentral_Lobular_and_Mid_Cingulate	R_2	Somatosensory_and_Motor	0.04	3.99E-12
L_5L	Paracentral_Lobular_and_Mid_Cingulate	R_FOP3	Insular_and_Frontal_Opercular	0.04	4.18E-12
R_6mp	Paracentral_Lobular_and_Mid_Cingulate	R_FOP3	Insular_and_Frontal_Opercular	0.04	4.91E-12

Fig. S3 The association between alcohol frequency and functional connectivities in the left hemisphere. The matrix shows the significant links after Bonferroni correction (Bonferroni corrected, $p<0.05$; $p=7.7e-07$) in the left hemisphere with r value. Positive r values (red) indicate higher functional connectivity is positively associated with high frequency of alcohol use.



Smoking status

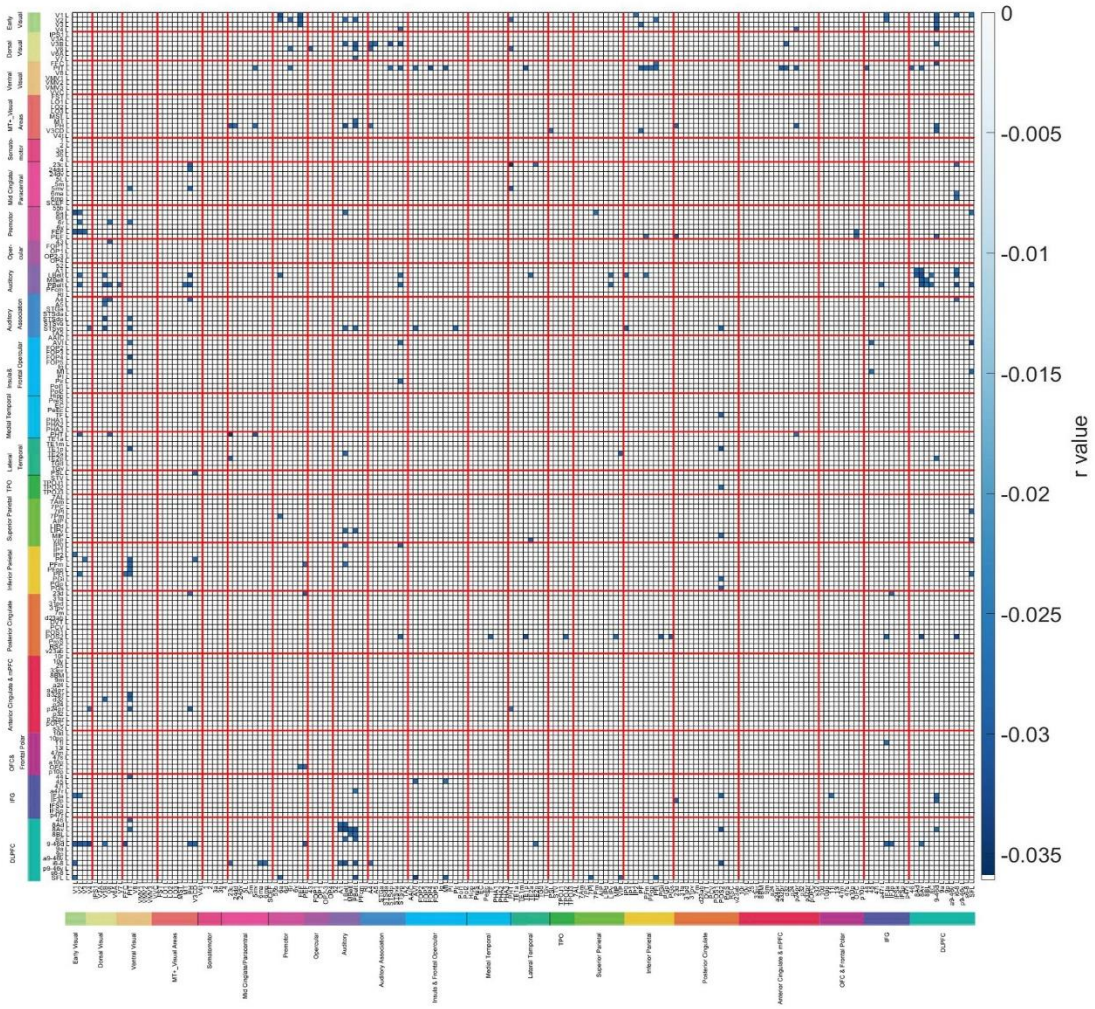
For smoking status, the association with functional connectivity is mainly negative, with 905 links significant (after Bonferroni correction p<0.05, p=7.7e-07) (Fig. S4), with the top 30 significantly associated links shown in Table S9 (N=19,415). A cluster of links involve connectivity between auditory cortex regions and prefrontal cortex area 8, which is implicated in tope-down attention (Rolls, et al., 2023a).

Table S9. Top 30 Functional Connectivity links with r and p values for smoking status. Negative r values indicate that lower functional connectivity is associated with more smoking.

Label_1	Region_1	Label_2	Region_2	r	p
L_PIT	Ventral_Stream_Visual	L_9-46d	Dorsolateral_Prefrontal	-0.04	6.77E-12
R_V8	Ventral_Stream_Visual	R_AVI	Insular_and_Frontal_Opercular	-0.04	9.66E-12
R_SCEF	Paracentral_Lobular_and_Mid_Cingulate	R_6a	Premotor	-0.04	1.57E-11
L_V3B	Dorsal_Stream_Visual	R_LBelt	Early_Auditory	-0.04	1.83E-11
R_V8	Ventral_Stream_Visual	R_LBelt	Early_Auditory	-0.04	2.42E-11
L_43	Posterior_Opercular	R_V6	Dorsal_Stream_Visual	-0.04	2.52E-11
L_7Am	Superior_Parietal	R_PSL	Temporo-Parieto-Occipital_Junction	-0.04	2.55E-11
R_V3CD	MT+_Complex_and_Neighboring_Visual_Areas	R_LBelt	Early_Auditory	-0.03	3.48E-11
L_IFJa	Inferior_Frontal	R_PFm	Inferior_Parietal	-0.03	4.37E-11
L_23c	Paracentral_Lobular_and_Mid_Cingulate	L_PHT	Lateral_Temporal	-0.03	4.78E-11
L_IFJp	Inferior_Frontal	R_PFm	Inferior_Parietal	-0.03	4.94E-11
L_PHT	Lateral_Temporal	R_PSL	Temporo-Parieto-Occipital_Junction	-0.03	7.09E-11
L_i6-8	Dorsolateral_Prefrontal	R_SCEF	Paracentral_Lobular_and_Mid_Cingulate	-0.03	8.57E-11
L_6a	Premotor	R_8Av	Dorsolateral_Prefrontal	-0.03	1.09E-10
L_6a	Premotor	R_SCEF	Paracentral_Lobular_and_Mid_Cingulate	-0.03	1.62E-10
L_6a	Premotor	R_8C	Dorsolateral_Prefrontal	-0.03	1.87E-10
R_MIP	Superior_Parietal	R_SFL	Dorsolateral_Prefrontal	-0.03	2.79E-10
L_A4	Auditory_Association	R_V6	Dorsal_Stream_Visual	-0.03	3.31E-10
L_PBelt	Early_Auditory	R_V6	Dorsal_Stream_Visual	-0.03	3.53E-10
L_PH	MT+_Complex_and_Neighboring_Visual_Areas	R_PSL	Temporo-Parieto-Occipital_Junction	-0.03	3.64E-10
R_V6	Dorsal_Stream_Visual	R_OP4	Posterior_Opercular	-0.03	3.67E-10
L_PGp	Inferior_Parietal	R_PSL	Temporo-Parieto-Occipital_Junction	-0.03	4.06E-10
L_AVI	Insular_and_Frontal_Opercular	L_SFL	Dorsolateral_Prefrontal	-0.03	4.14E-10

R_V2	Early_Visual	R_44	Inferior_Frontal	-0.03	4.59E-10
R_V6	Dorsal_Stream_Visual	R_43	Posterior_Opercular	-0.03	4.69E-10
R_6ma	Paracentral_Lobular_and_Mid_Cingulate	R_IFJa	Inferior_Frontal	-0.03	4.83E-10
L_7PL	Superior_Parietal	R_SFL	Dorsolateral_Prefrontal	-0.03	5.21E-10
R_V3B	Dorsal_Stream_Visual	R_LBelt	Early_Auditory	-0.03	5.47E-10
L_LBelt	Early_Auditory	R_8C	Dorsolateral_Prefrontal	-0.03	5.47E-10
L_V4	Early_Visual	R_LBelt	Early_Auditory	-0.03	6.07E-10

Fig. S4 The association between the smoking and functional connectivities in the left hemisphere. The matrix shows the significant links after Bonferroni correction (Bonferroni corrected, p<0.05; p=7.7e-07) in the left hemisphere with r value. Negative r values (blue) indicate that lower functional connectivity is associated with more smoking. The number of significant links was 905. N=19,415 (fc_corr_SMS_left .jpg)



Diet

For diet (intake of vegetable and fruit per week), Fig. S5 shows that 156 links were significantly associated (after Bonferroni correction $p<0.05$, $p=7.7e-07$), and the top 30 are shown in Table S10 (N=19,415).

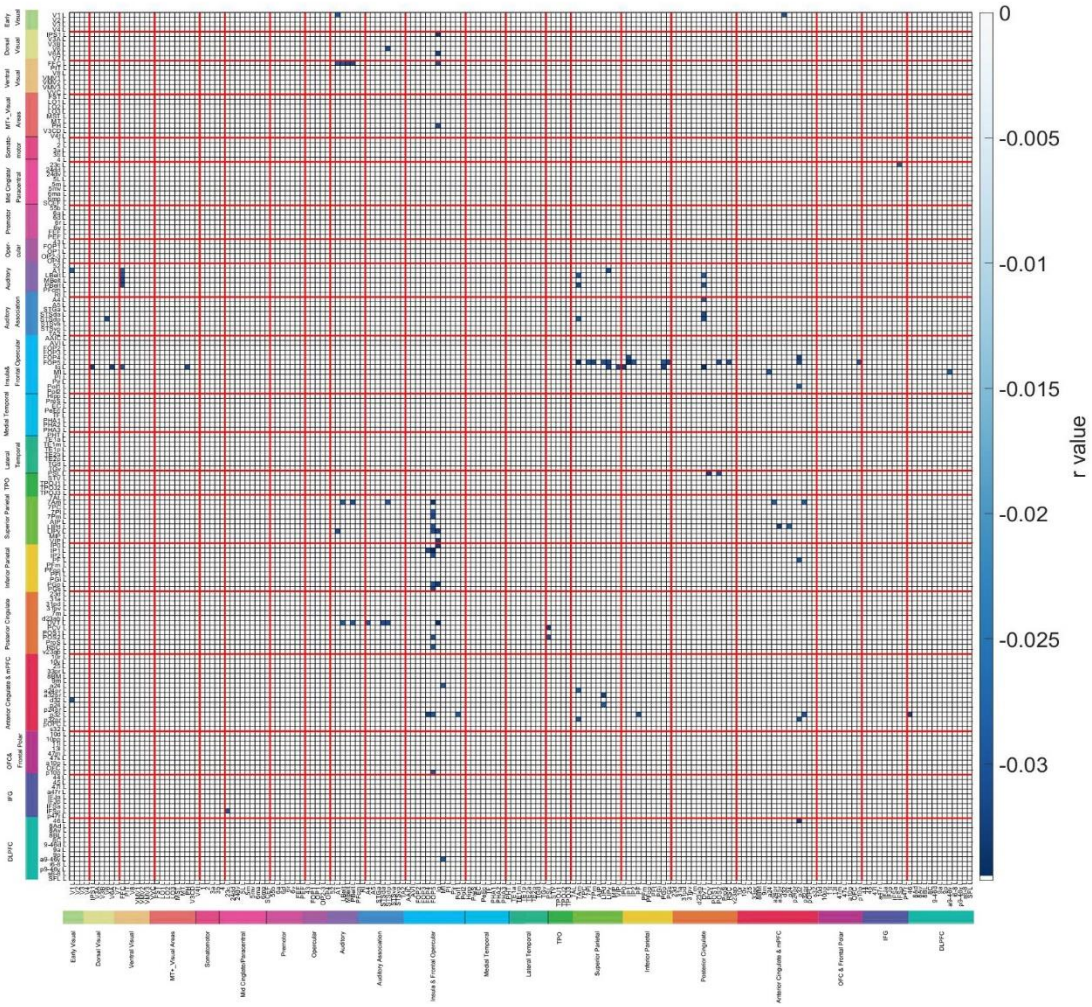
All the significantly association links are postively associated with diet, which is shown in Figure S5. Most of the links that are significantly positively associated with diet involved in the Insular_and_Frontal_Opercular, the Anterior_Cingulate_and_Medial_Prefrontal, the Superior_Parietal, and the Posterior_Cingulate, Orbital_and_Polar_Frontal. Table S10 shows the top 30 links.

Table S10. Top 30 Functional Connectivity links with r and p values for diet. A negative r value indicates that a poor diet with low vegetable and fruit is associated with lower functional connectivity.

Label_1	Region_1	Label_2	Region_2	r	p
L_p32	Anterior_Cingulate_and_Medial_Prefrontal	R_46	Dorsolateral_Prefrontal	-0.04	3.07E-11
L_p32	Anterior_Cingulate_and_Medial_Prefrontal	R_MI	Insular_and_Frontal_Opercular	-0.04	3.08E-10
L_MI	Insular_and_Frontal_Opercular	L_p32	Anterior_Cingulate_and_Medial_Prefrontal	-0.03	1.16E-09
L_Ig	Insular_and_Frontal_Opercular	L_DVT	Posterior_Cingulate	-0.03	1.85E-09
L_FOP5	Insular_and_Frontal_Opercular	L_IP1	Inferior_Parietal	-0.03	2.05E-09
L_FOP5	Insular_and_Frontal_Opercular	L_7Am	Superior_Parietal	-0.03	3.55E-09
L_Ig	Insular_and_Frontal_Opercular	R_FFC	Ventral_Stream_Visual	-0.03	3.97E-09
L_STSdp	Auditory_Association	R_7Am	Superior_Parietal	-0.03	4.09E-09
L_p32	Anterior_Cingulate_and_Medial_Prefrontal	R_7Am	Superior_Parietal	-0.03	4.38E-09
L_STSdp	Auditory_Association	R_DVT	Posterior_Cingulate	-0.03	4.43E-09
L_Ig	Insular_and_Frontal_Opercular	L_IP0	Inferior_Parietal	-0.03	7.95E-09
L_p32	Anterior_Cingulate_and_Medial_Prefrontal	R_IFSa	Inferior_Frontal	-0.03	9.52E-09
L_STSda	Auditory_Association	R_DVT	Posterior_Cingulate	-0.03	1.03E-08
L_p32pr	Anterior_Cingulate_and_Medial_Prefrontal	R_7Am	Superior_Parietal	-0.03	1.18E-08
L_PSL	Temporo-Parieto_Occipital_Junction	L_PCV	Posterior_Cingulate	-0.03	1.20E-08
L_IPS1	Dorsal_Stream_Visual	L_Ig	Insular_and_Frontal_Opercular	-0.03	1.22E-08

L_STV	Temporo-Parieto-Occipital_Junction	R_7Pm	Superior_Parietal	-0.03	1.42E-08
L_V6A	Dorsal_Stream_Visual	L_Ig	Insular_and_Frontal_Opercular	-0.03	1.49E-08
L_FOP5	Insular_and_Frontal_Opercular	R_7PL	Superior_Parietal	-0.03	1.55E-08
L_Ig	Insular_and_Frontal_Opercular	L_PGp	Inferior_Parietal	-0.03	1.71E-08
L_d32	Anterior_Cingulate_and_Medial_Prefrontal	R_DVT	Posterior_Cingulate	-0.03	1.75E-08
L_LIPd	Superior_Parietal	L_a32pr	Anterior_Cingulate_and_Medial_Prefrontal	-0.03	1.81E-08
L_p32	Anterior_Cingulate_and_Medial_Prefrontal	R_FOP4	Insular_and_Frontal_Opercular	-0.03	1.95E-08
L_FOP5	Insular_and_Frontal_Opercular	R_IP1	Inferior_Parietal	-0.03	2.17E-08
L_d32	Anterior_Cingulate_and_Medial_Prefrontal	R_7PL	Superior_Parietal	-0.03	2.21E-08
L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	R_13l	Orbital_and_Polar_Frontal	-0.03	2.33E-08
L_A5	Auditory_Association	R_7Am	Superior_Parietal	-0.03	2.57E-08
L_FOP4	Insular_and_Frontal_Opercular	L_p32	Anterior_Cingulate_and_Medial_Prefrontal	-0.03	2.85E-08
L_8BM	Anterior_Cingulate_and_Medial_Prefrontal	R_DVT	Posterior_Cingulate	-0.03	3.18E-08
L_Ig	Insular_and_Frontal_Opercular	R_LIPv	Superior_Parietal	-0.03	3.27E-08

Fig. S5 The association between the diet (intake of vegetable and fruit per week) and functional connectivities in the left hemisphere. The matrix shows the significant links after Bonferroni correction (Bonferroni corrected, $p<0.05$; $p=7.7e-07$) in the left hemisphere with r value. A negative r value (blue) indicates that a poor diet with low vegetable and fruit is associated with lower functional connectivity. The number of significant links was 156. N=19,415 (fc_corr_Diet_left.jpg)



References

Ainsworth, B.E., Haskell, W.L., Whitt, M.C., Irwin, M.L., Swartz, A.M., Strath, S.J., O Brien, W.L., Bassett, D.R., Schmitz, K.H., Emplaincourt, P.O. (2000) Compendium of physical activities: an update of activity codes and MET intensities. Medicine and science in sports and exercise, 32:S498-S504.

Bittner, N., Jockwitz, C., Muhleisen, T.W., Hoffstaedter, F., Eickhoff, S.B., Moebus, S., Bayen, U.J., Cichon, S., Zilles, K., Amunts, K., Caspers, S. (2019) Combining lifestyle risks to disentangle brain structure and functional connectivity differences in older adults. Nat Commun, 10:621.

Glasser, M.F., Coalson, T.S., Robinson, E.C., Hacker, C.D., Harwell, J., Yacoub, E., Ugurbil, K., Andersson, J., Beckmann, C.F., Jenkinson, M., Smith, S.M., Van Essen, D.C. (2016) A multi-modal parcellation of human cerebral cortex. Nature, 536:171-8.

Huang, C.C., Rolls, E.T., Feng, J., Lin, C.P. (2022) An extended Human Connectome Project multimodal parcellation atlas of the human cortex and subcortical areas. Brain Struct Funct, 227:763-778.

Rolls, E.T., Deco, G., Huang, C.-C., Feng, J. (2023a) Prefrontal and somatosensory-motor cortex effective connectivity in humans. Cereb. Cortex: doi: 10.1093/cercor/bhac391.

Rolls, E.T., Deco, G., Huang, C.C., Feng, J. (2023b) The human orbitofrontal cortex, vmPFC, and anterior cingulate cortex effective connectome: emotion, memory, and action. Cereb. Cortex, 33:330-359.