SUPPLEMENTARY INFORMATION

Resting State Changes In Aging and Parkinson's Disease Are Shaped by Underlying Neurotransmission – A Normative Modeling Study

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Supplementary Methods

Preprocessing of resting-state functional imaging data

Initial preprocessing performed by the UK Biobank team consisted of primary T1 quality control, gradient distortion correction, motion correction, grand-mean intensity normalization, high-pass temporal filtering, echo planar imaging unwarping, gradient distortion correction unwarping, and the removal of structural artefacts via ICA+FIX. The resulting images were labeled "filtered_func_data_clean.nii" Further processing was conducted with SPM12[1], the FMIRB Software Library (FSL v5.0[2]), and the CONN toolbox[3] implemented in MATLAB (v2020b). Functional images were transformed into MNI space using a general reference template provided by FSL and a subject specific warping image. After resampling (3mm^3 isotropic) and smoothing (Gaussian kernel with 4 mm FWHM) with SPM, we applied a bandpass filter (0.008 – 0.09 Hz) to the BOLD signal, discarded the first five frames to ensure signal equilibrium, and regressed out 24 parameters of motion[4], as well as the mean signal from white matter and cerebrospinal fluid using CONN. Distorted images and artifacts were identified by low correlations ($r < 0.9$) between individual and a reference, preprocessed mean rs-fMRI image of 200 subjects. Visual inspection confirmed that failed spatial normalization or insufficient brain coverage in individual images were responsible for low correlation coefficients. We additionally excluded data from subjects with excessive in-scanner motion (maximum frame-wise rotation > 2° and movement > 3 mm).

Measures of local brain activity and synchronicity

We derived three complementary measures of local brain activity and synchronicity using the CONN toolbox. fALFF[5] is defined as the power ratio of low-frequency (0.008 – 0.09 Hz) oscillations to the total detectable frequency range in the BOLD signal. Local correlation (LCOR[6]) is the normalized sum of correlation coefficients of the BOLD signal in the voxel of interest with other voxels in its vicinity, with distances weighted by a Gaussian kernel (25 mm FWHM). Global correlation (GCOR[7]) is calculated in the same way as LCOR, but without distance-dependent weighting of the individual correlation coefficients. Thus, GCOR represents a measure of the global synchronicity of a voxel, whereas LCOR represents a measure of local coherence. Unlike fALFF, LCOR and GCOR do not depend on the amplitude of the BOLD signal, but rather on the similarity of the BOLD time series of all considered voxels. These three metrics provide a complementary characterization of the BOLD signal providing information about local neural activity as well as local and global functional connectivity.

Functional alterations in Parkinson's Disease and regional contribution to deviations from normative models

An estimation of disease duration was computed by the difference between the date of first occurrence of ICD-10 G20, (Data-Field 131022) and the date of imaging (Data-Field 53, Instance 2). For the significant ($P_{FDR} < 0.05$) deviations, we tested which regions contributed strongest to the observed deviations by repeating the spatial correlation analyses in the data of PD utilizing a leaving-one-region-out approach. As a measure of regional contribution to the deviation we calculated differences in squared correlation coefficients ($\Delta\rho^2$) between the reduced ($n_{Regions} = 118$: ρ_{LOO}^2) and the full ($n_{Regions} = 119$: ρ_{Total}^2) set of regions. We set $\Delta\rho^2$ positive if omitting this specific region resulted in a more normal correlation coefficient (closer to the mean of the normative model), and negative if omitting led to stronger deviation from the normative model. We further evaluated whether these regional contributions to the observed co-localization strengths were spatially related to regional alterations in fALFF, LCOR, or GCOR by computing Pearson correlations between maps of $\Delta\rho^2$ and the regional effect size (Cohen's d) in fALFF, LCOR, GCOR for differences between PD and an age- and sex-matched subgroup of HC (n = 17 400). In order to evaluate the extent of significant functional alterations in PD, regions with significant differences in fALFF, LCOR, and GCOR in PD compared with the matched controls were identified using the Mann-Whitney-U test.

Preparation of individual structural data & correction of atrophy

To control for aging-related atrophy, we generated normalized and smoothed grey matter volumes. For this purpose, we warped individual T1-weighted images (*T1_brain_pve_1.nii.gz*) with individual warping coefficients (*T1_to_MNI_warp_coef.nii.gz*) (both provided by the UK Biobank) and normalized the warped images to MNI space using a template provided by FSL. We then changed the dimensions of the structural images to fit the functional data (using SPM: ImCalc) and smoothed them with a Gaussian kernel (4 mm FWHM). Next, the linear effects of grey matter signals from all fALFF, LCOR, and GCOR maps were regressed voxel-wise.

Normative modeling of brain function - neurotransmitter co-localization

The normative modeling was performed using the PCNtoolkit[8]. We modeled the co-localization level (i.e., the Spearman correlation coefficient) derived from spatial correlation analyses between neurotransmitter systems (n = 19) and individual brain functional measures (fALFF, LCOR, and GCOR) of all healthy controls. To account for non-linear trajectories and non-Gaussian variance of the normal co-localization levels, we used Bayesian linear regression (5 knot basis splines and sinh-arcsinh warping) with age and sex as covariates. For the illustration of the normative models (Figure 1F, 4A, Supplementary Figures 7 and 8), we predicted the normal co-localization levels and uncertainty for two artificial dummy subjects (male and female) in the age range of the sample [44.58 – 81.98] years and a sampling frequency of 0.2 years. Further details on the toolbox and guidance for conducting research can be found on the official website of PCNtoolkit provided by Marquand et al.[9].

Supplementary Tables

Supplementary Table 1: List of exclusion criteria for the control group.

	Subgroup	**ICD-10**
Mental and Behavioural disorders (F-labeled)	Physiological conditions	F01 - F03
	Psychoactive substance use	F10 – F19
	Schizophrenia, schizotypal, delusional, and schizoaffective disorder	F20 - F22, F25
	Mood affective disorders	F31, F33
	Intellectual disabilities	F70 – F72
Diseases of the central nervous system (G-labeled)	Inflammatory diseases	G04 – G07
	Systematic atrophies	G10 - G13, G14
	Extrapyramidal and movement disorders	G20 – G25
	Other degenerative diseases	G30-G32
	Demyelinating diseases	G35-G37
	Episodic and paroxysmal disorders	G40, G41, G45
Neoplasms (C-labeled)	Malignant neoplasm of the brain	C71

Supplementary Table 2: Characteristics of neurotransmitter PET maps used.

Atlas	Tracer	Sample size	% Male	Age (μ +- σ)	Source DOI
5-HT1a	[11C]CUMI-101	8	37.50	28.4 +- 8.8	10.1523/JNEUROSCI.2830-16.2016
5-HT1b	[11C]P943	65	75.38	33.7 +- 9.7	10.1038/jcbfm.2009.195
5-HT2a	[11C]CIMBI-36	29	51.72	22.6 +- 2.7	10.1523/JNEUROSCI.2830-16.2016
5-HT4	[11C]SB207145	59	69.49	25.9 +- 5.3	10.1523/JNEUROSCI.2830-16.2016
5-HT6	[11C]GSK215083	30	100	36.6 +- 9	10.2967/jnumed.117.206516
SERT	[11C]DASB	100	29	25.1 +- 5.8	10.1523/JNEUROSCI.2830-16.2016
D1	[11C]SCH23390	13	46	33 +- 13	10.1007/s00259-017-3645-0
D2	[11C]FLB457	55	47.27	32.5 +- 9.7	10.1038/jcbfm.2014.237
DAT	[123I]FP-CIT	174	62.64	61 +- 11	10.1038/s41598-018-22444-0
H3	[11C]GSK189254	8	87.5	31.7 +- 9	10.1177/0271678X16650697
NET	[11C]MRB	77	64.94	33.4 +- 9.2	10.1002/syn.20696
M1	[11C]LSN3172176	24	54.17	40.50 +- 11.7	10.2967/jnumed.120.246967
A4B2	[18F]FLUBATINE	30	66.67	33.5 +- 10.7	10.1016/j.neuroimage.2016.07.026
VAChT	[18F]FEOBV	18	27.78	66.8 +- 6.8	10.1038/mp.2017.183
mGluR5	[11C]ABP688	73	34.25	19.9 +- 3.04	10.1007/s00259-018-4252-4
NMDA	[18F]GE-179	29	72	41 +- 13	10.1101/2021.12.04.21267226
CB1	[11C]OMAR	77	63.64	30 +- 8.9	10.1038/jcbfm.2015.46
Opioid mu	[11C]CARFENTANIL	204	64.71	32.3 +- 10.8	10.1038/mp.2017.183
GABAa	[11C]FLUMAZENIL	6	100	43+-4	10.1038/s41598-018-22444-0

Supplementary Table 3: Regions covered by cluster of significant aging effects in fALFF, LCOR, and GCOR – *before atrophy correction*.

Anatomical region	Cluster size	Cluster p-values (corrected)	Peak T-values	Peak MNI-Coordinates
fALFF: Decreasing with age				
Bilateral: Superior frontal gyrus (dorsolateral), Middle temporal gyrus, Middle frontal gyrus, Postcentral gyrus, Middle occipital gyrus, Inferior temporal gyrus, Precuneus, Precentral gyrus, Superior temporal gyrus, Fusiform gyrus, Superior frontal gyrus (medial), Cerebellum (Crus 1), Inferior frontal gyrus (pars triangularis), Calcarine fissure and surrounding cortex, Inferior parietal gyrus, Lingual gyrus, Supplementary motor area, Cerebellum (8), Middle cingulate & paracingulate gyri, Insula, Cerebellum (6), Supramarginal gyrus, Superior parietal gyrus, Cerebellum (Crus 2), Cuneus, Angular gyrus, Rolandic operculum, Parahippocampal gyrus, Superior occipital gyrus, Inferior frontal gyrus (pars opercularis), Cerebellum (4,5), Superior temporal gyrus (pole), Putamen, Paracentral lobule, Hippocampus, Inferior occipital gyrus, Superior frontal gyrus (medial orbital), Cerebellum (9), Middle temporal gyrus (pole), Caudate nucleus, Anterior cingulate cortex (supracallosal), Gyrus rectus, Inferior frontal gyrus (pars orbitalis), Medial orbital gyrus, Anterior cingulate cortex (pregenual), Posterior orbital gyrus, Anterior orbital gyrus, Cerebellum (7b), Vermis (4,5), Olfactory cortex, Vermis (6), Amygdala, Posterior cingulate gyrus, Vermis (8), Heschl's gyrus, Lateral orbital gyrus, Thalamus (pulvinar medial), Vermis (9), Anterior cingulate cortex (subgenual), Ventral striatum, Vermis (7), Cerebellum (3), Vermis (3), Thalamus (mediodorsal medial magnocellular), Pallidum, Thalamus (ventral posterolateral), Thalamus (mediodorsal lateral parvocellular), Thalamus (ventral lateral), Vermis (1,2), Thalamus (pulvinar inferior), Thalamus (pulvinar anterior), Vermis (10), Thalamus (pulvinar lateral), Thalamus (lateral posterior), Thalamus (anteroventral nucleus), Thalamus (lateral geniculate), Thalamus (intralaminar), Substantia nigra pars compacta, Raphe nucleus, Thalamus (medial geniculate), Red nucleus, Cerebellum (10) **Left:** Ventral tegmental area, Thalamus (ventral anterior)	48649	<0.001	49.3	**45 0 -3**
fALFF: Increasing with age				
Left: Angular gyrus, Middle occipital gyrus, Inferior parietal gyrus, Middle temporal gyrus	118	<0.001	20.83	**-36 -54 24**
Right: Supramarginal gyrus, Angular gyrus	33	<0.001	11.39	**30 -45 36**
LCOR: Decreasing with age				
Bilateral: Middle temporal gyrus, Superior frontal gyrus (dorsolateral), Postcentral gyrus, Precentral gyrus, Superior temporal gyrus, Fusiform gyrus, Middle frontal gyrus, Calcarine fissure and surrounding cortex, Lingual gyrus, Supplementary motor area, Inferior frontal gyrus (pars triangularis), Inferior temporal gyrus, Superior frontal gyrus (medial), Cerebellum (8), Insula, Cerebellum (6), Cerebellum (Crus 1), Middle occipital gyrus, Rolandic operculum, Cuneus, Middle cingulate & paracingulate gyri, Parahippocampal gyrus, Supramarginal gyrus, Inferior frontal gyrus (pars opercularis), Cerebellum (4,5), Cerebellum (Crus 2), Putamen, Superior temporal gyrus (pole), Paracentral lobule, Inferior parietal gyrus, Hippocampus, Inferior occipital gyrus, Precuneus, Cerebellum (9), Caudate nucleus, Superior occipital gyrus, Anterior cingulate cortex (supracallosal), Superior parietal gyrus,	38017	<0.001	44.64	**45 3 -6**

Inferior frontal gyrus (pars orbitalis), Anterior cingulate cortex (pregenual), Middle temporal gyrus (pole), Superior frontal gyrus (medial orbital), Posterior orbital gyrus, Cerebellum (7b), Vermis (4,5), Gyrus rectus, Vermis (6), Amygdala, Olfactory cortex, Vermis (8), Heschl's gyrus, Vermis (9), Thalamus (pulvinar medial), Anterior cingulate cortex (subgenual), Vermis (7), Cerebellum (3), Vermis (3), Medial orbital gyrus, Thalamus (mediodorsal medial magnocellular), Ventral striatum, Pallidum, Lateral orbital gyrus, Thalamus (ventral posterolateral), Thalamus (mediodorsal lateral parvocellular), Anterior orbital gyrus, Thalamus (ventral lateral), Vermis (1,2), Thalamus (pulvinar inferior), Thalamus (pulvinar anterior), Vermis (10), Thalamus (pulvinar lateral), Thalamus (lateral posterior), Thalamus (anteroventral nucleus), Thalamus (lateral geniculate), Thalamus (intralaminar), Substantia nigra pars compacta, Raphe nucleus, Thalamus (medial geniculate), Red nucleus, Cerebellum (10) **Left:** Angular gyrus, Ventral tegmental area, Thalamus (ventral anterior)				
LCOR: Increasing with age				
Bilateral: Precuneus, Angular gyrus, Inferior parietal gyrus, Posterior cingulate gyrus, Middle occipital gyrus, Middle cingulate & paracingulate gyri, Superior parietal gyrus, Cuneus, Supramarginal gyrus, Middle temporal gyrus, Superior occipital gyrus, Postcentral gyrus **Left**: Calcarine fissure and surrounding cortex	1796	<0.001	24.87	**-33 -57 33**
Left: Gyrus rectus	27	<0.001	8.25	**-6 21 -30**
GCOR: Decreasing with age				
Bilateral: Middle temporal gyrus, Superior frontal gyrus (dorsolateral), Postcentral gyrus, Middle frontal gyrus, Precentral gyrus, Superior temporal gyrus, Inferior temporal gyrus, Superior frontal gyrus (medial), Fusiform gyrus, Inferior frontal gyrus (pars triangularis), Supplementary motor area, Middle occipital gyrus, Inferior parietal gyrus, Cerebellum (8), Insula, Lingual gyrus, Precuneus, Supramarginal gyrus, Middle cingulate & paracingulate gyri, Superior parietal gyrus, Cerebellum (6), Calcarine fissure and surrounding cortex, Rolandic operculum, Inferior frontal gyrus (pars opercularis), Cerebellum (4,5), Parahippocampal gyrus, Superior temporal gyrus (pole), Cuneus, Paracentral lobule, Superior occipital gyrus, Hippocampus, Middle temporal gyrus (pole), Angular gyrus, Cerebellum (9), Superior frontal gyrus (medial orbital), Anterior cingulate cortex (supracallosal), Inferior occipital gyrus, Putamen, Inferior frontal gyrus (pars orbitalis), Cerebellum (Crus 1), Anterior cingulate cortex (pregenual), Cerebellum (Crus 2), Gyrus rectus, Vermis (4,5), Caudate nucleus, Posterior orbital gyrus, Cerebellum (7b), Vermis (6), Amygdala, Vermis (8), Heschl's gyrus, Anterior cingulate cortex (subgenual), Olfactory cortex, Lateral orbital gyrus, Vermis (9), Vermis (7), Vermis (3), Cerebellum (3), Posterior cingulate gyrus, Thalamus (pulvinar medial), Ventral striatum, Pallidum, Medial orbital gyrus, Thalamus (mediodorsal medial magnocellular), Thalamus (ventral posterolateral), Vermis (1,2), Thalamus (pulvinar inferior), Anterior orbital gyrus, Thalamus (pulvinar anterior), Vermis (10), Thalamus (lateral geniculate), Thalamus (pulvinar lateral), Thalamus (intralaminar), Raphe nucleus, Thalamus (medial geniculate), Thalamus (mediodorsal lateral parvocellular), Cerebellum (10) **Left**: Thalamus (lateral posterior)	38929	<0.001	33.04	**45 9 -9**
GCOR: Increasing with age				

Bilateral: Thalamus (mediodorsal medial magnocellular), Caudate nucleus, Thalamus (ventral lateral), Thalamus (pulvinar medial), Thalamus (mediodorsal lateral parvocellular), Thalamus (anteroventral nucleus), Thalamus (lateral posterior), Hippocampus, Thalamus (intralaminar) **Left**: Thalamus (ventral anterior) **Right**: Thalamus (pulvinar anterior), Thalamus (pulvinar lateral), Posterior cingulate gyrus	206	<0.001	22.15	**-3 -3 9**
Left: Angular gyrus, Middle occipital gyrus	45	<0.001	16.7	**-33 -57 33**
Left: Cerebellum (Crus 1), Cerebellum (Crus 2), Cerebellum (6)	350	<0.001	15.56	**-45 -72 -30**
Bilateral: Precuneus, Superior parietal gyrus **Right**: Angular gyrus, Superior occipital gyrus, Cuneus	217	<0.001	13.5	**18 -60 45**
Bilateral: Posterior cingulate gyrus **Right**: Middle cingulate & paracingulate gyri	70	<0.001	12.07	**0 -24 27**
Right: Cerebellum (Crus 1), Lingual gyrus, Cerebellum (6), Calcarine fissure and surrounding cortex	164	<0.001	10.23	**12 -99 -12**

Supplementary Table 4: Regions covered by cluster of significant aging effects in fALFF, LCOR, and GCOR – *after atrophy correction*.

Anatomical region	**Cluster size**	**Cluster p-values (corrected)**	**Peak T-values**	**Peak MNI-Coordinates**
fALFF: Decreasing with age				
Bilateral: Superior frontal gyrus (dorsolateral), Middle frontal gyrus, Middle temporal gyrus, Postcentral gyrus, Middle occipital gyrus, Precentral gyrus, Inferior temporal gyrus, Precuneus, Superior temporal gyrus, Superior frontal gyrus (medial), Fusiform gyrus, Cerebellum (Crus 1), Inferior parietal gyrus, Inferior frontal gyrus (pars triangularis), Calcarine fissure and surrounding cortex, Lingual gyrus, Supplementary motor area, Cerebellum (8), Middle cingulate & paracingulate gyri, Insula, Cerebellum (6), Supramarginal gyrus, Superior parietal gyrus, Cerebellum (Crus 2), Angular gyrus, Cuneus, Rolandic operculum, Parahippocampal gyrus, Inferior frontal gyrus (pars opercularis), Superior occipital gyrus, Cerebellum (4,5), Superior temporal gyrus (pole), Putamen, Paracentral lobule, Hippocampus, Inferior occipital gyrus, Superior frontal gyrus (medial orbital), Middle temporal gyrus (pole), Cerebellum (9), Caudate nucleus, Anterior cingulate cortex (supracallosal), Gyrus rectus, Inferior frontal gyrus (pars orbitalis), Medial orbital gyrus, Anterior cingulate cortex (pregenual), Posterior orbital gyrus, Anterior orbital gyrus, Cerebellum (7b), Vermis (4,5), Posterior cingulate gyrus, Olfactory cortex, Vermis (6), Amygdala, Vermis (8), Heschl's gyrus, Lateral orbital gyrus, Thalamus (pulvinar medial), Vermis (9), Anterior cingulate cortex (subgenual), Ventral striatum, Vermis (7), Cerebellum (3), Vermis (3), Thalamus (mediodorsal medial magnocellular), Pallidum, Thalamus (ventral posterolateral), Thalamus (mediodorsal lateral parvocellular), Thalamus (ventral lateral), Vermis (1,2), Thalamus (pulvinar inferior), Thalamus	49470	<0.001	42.83	**0 -36 24**

(pulvinar anterior), Vermis (10), Thalamus (pulvinar lateral), Thalamus (lateral posterior), Thalamus (anteroventral nucleus), Thalamus (lateral geniculate), Thalamus (intralaminar), Substantia nigra pars compacta, Raphe nucleus, Thalamus (medial geniculate), Red nucleus, Cerebellum (10). **Left**: Ventral tegmental area, Thalamus (ventral anterior)				
fALFF: Increasing with age				
Bilateral: Gyrus rectus	30	<0.001	7.87	**6 21 -30**
LCOR: Decreasing with age				
Bilateral: Middle temporal gyrus, Superior frontal gyrus (dorsolateral), Postcentral gyrus, Precentral gyrus, Superior temporal gyrus, Middle frontal gyrus, Fusiform gyrus, Calcarine fissure and surrounding cortex, Lingual gyrus, Supplementary motor area, Inferior frontal gyrus (pars triangularis), Inferior temporal gyrus, Superior frontal gyrus (medial), Cerebellum (8), Insula, Cerebellum (6), Middle occipital gyrus, Cerebellum (Crus 1), Rolandic operculum, Middle cingulate & paracingulate gyri, Cuneus, Inferior frontal gyrus (pars opercularis), Parahippocampal gyrus, Supramarginal gyrus, Cerebellum (4,5), Putamen, Superior temporal gyrus (pole), Cerebellum (Crus 2), Paracentral lobule, Hippocampus, Inferior parietal gyrus, Inferior occipital gyrus, Cerebellum (9), Caudate nucleus, Precuneus, Superior occipital gyrus, Anterior cingulate cortex (supracallosal), Inferior frontal gyrus (pars orbitalis), Superior parietal gyrus, Anterior cingulate cortex (pregenual), Middle temporal gyrus (pole), Superior frontal gyrus (medial orbital), Posterior orbital gyrus, Cerebellum (7b), Vermis (4,5), Vermis (6), Gyrus rectus, Amygdala, Olfactory cortex, Vermis (8), Heschl's gyrus, Vermis (9), Thalamus (pulvinar medial), Anterior cingulate cortex (subgenual), Vermis (7), Cerebellum (3), Ventral striatum, Vermis (3), Thalamus (mediodorsal medial magnocellular), Medial orbital gyrus, Pallidum, Lateral orbital gyrus, Thalamus (ventral posterolateral), Anterior orbital gyrus, Thalamus (mediodorsal lateral parvocellular), Thalamus (ventral lateral), Vermis (1,2), Thalamus (pulvinar inferior), Thalamus (pulvinar anterior), Vermis (10), Thalamus (pulvinar lateral), Thalamus (lateral posterior), Thalamus (anteroventral nucleus), Thalamus (lateral geniculate), Thalamus (intralaminar), Substantia nigra pars compacta, Raphe nucleus, Thalamus (medial geniculate), Red nucleus, Cerebellum (10) **Left**: Angular gyrus, Ventral tegmental area, Thalamus (ventral anterior)	38027	<0.001	34.38	**48 6 -9**
LCOR: Increasing with age				
Bilateral: Precuneus, Angular gyrus, Inferior parietal gyrus, Posterior cingulate gyrus, Middle occipital gyrus, Middle cingulate & paracingulate gyri, Superior parietal gyrus, Cuneus **Left**: Middle temporal gyrus, Calcarine fissure and surrounding cortex **Right**: Supramarginal gyrus, Superior occipital gyrus	1670	<0.001	16.87	**-33 -60 33**
Left: Gyrus rectus	30	<0.001	8.23	**-6 21 -30**
Right: Anterior orbital gyrus, Medial orbital gyrus	26	<0.001	7.7	**30 51 -18**
GCOR: Decreasing with age				

Bilateral: Middle temporal gyrus, Superior frontal gyrus (dorsolateral), Postcentral gyrus, Middle frontal gyrus, Precentral gyrus, Superior temporal gyrus, Inferior temporal gyrus, Superior frontal gyrus (medial), Inferior frontal gyrus (pars triangularis), Fusiform gyrus, Middle occipital gyrus, Supplementary motor area, Inferior parietal gyrus, Insula, Cerebellum (8), Lingual gyrus, Precuneus, Supramarginal gyrus, Middle cingulate & paracingulate gyri, Superior parietal gyrus, Calcarine fissure and surrounding cortex, Cerebellum (6), Rolandic operculum, Inferior frontal gyrus (pars opercularis), Cerebellum (4,5), Parahippocampal gyrus, Cuneus, Superior temporal gyrus (pole), Paracentral lobule, Superior occipital gyrus, Hippocampus, Middle temporal gyrus (pole), Angular gyrus, Cerebellum (9), Inferior occipital gyrus, Superior frontal gyrus (medial orbital), Anterior cingulate cortex (supracallosal), Inferior frontal gyrus (pars orbitalis), Putamen, Anterior cingulate cortex (pregenual), Cerebellum (Crus 2), Gyrus rectus, Cerebellum (Crus 1), Vermis (4,5), Posterior orbital gyrus, Caudate nucleus, Cerebellum (7b), Vermis (6), Amygdala, Vermis (8), Heschl's gyrus, Olfactory cortex, Anterior cingulate cortex (subgenual), Lateral orbital gyrus, Vermis (9), Vermis (3), Cerebellum (3), Vermis (7), Posterior cingulate gyrus, Thalamus (pulvinar medial), Medial orbital gyrus, Ventral striatum, Pallidum, Thalamus (mediodorsal medial magnocellular), Thalamus (ventral posterolateral), Vermis (1,2), Thalamus (pulvinar inferior), Anterior orbital gyrus, Thalamus (pulvinar anterior), Thalamus (lateral geniculate), Vermis (10), Thalamus (pulvinar lateral), Thalamus (intralaminar), Raphe nucleus, Thalamus (medial geniculate), Thalamus (mediodorsal lateral parvocellular) **Left**: Cerebellum (10), Thalamus (lateral posterior	39066	<0.001	28.32	**45 9 -12**
GCOR: Increasing with age				
Bilateral: Thalamus (mediodorsal medial magnocellular), Caudate nucleus, Thalamus (ventral lateral), Thalamus (pulvinar medial), Thalamus (mediodorsal lateral parvocellular), Thalamus (anteroventral nucleus), Thalamus (lateral posterior), Hippocampus, Thalamus (intralaminar) **Left**: Thalamus (ventral anterior) **Right**: Thalamus (pulvinar anterior), Posterior cingulate gyrus	206	<0.001	19.61	**3 -12 12**
Left: Cerebellum (Crus 1), Cerebellum (Crus 2), Cerebellum (6)	380	<0.001	15.75	**-45 -72 -30**
Bilateral: Precuneus **Left**: Superior parietal gyrus **Right**: Superior occipital gyrus, Cuneus	180	<0.001	12.52	**15 -63 42**
Bilateral: Posterior cingulate gyrus´ **Right**: Middle cingulate & paracingulate gyri	68	<0.001	12.14	**0 -24 27**
Right: Cerebellum (Crus 1), Cerebellum (6), Cerebellum (Crus 2), Lingual gyrus, Fusiform gyrus, Calcarine fissure and surrounding cortex	199	<0.001	11.78	**12 -99 -12**

Supplementary Table 5: Co-localization of **aging in brain functional measures** (unthresholded voxel-wise maps of annual change) and neurotransmitter systems – *before atrophy correction*.

	fALFF		LCOR		GCOR	
Neurotransmitter system	Rho	P_{FDR}	Rho	P_{FDR}	Rho	P_{FDR}
5-HT1a	0.1	0.6343	0.1	0.6216	0.1	0.1429
5-HT1b	-0.15	0.5644	-0.15	0.5798	-0.15	0.659
5-HT2a	-0.12	0.592	-0.12	0.5798	-0.12	0.9195
5-HT4	**0.24**	**0.0399**	0.24	0.5798	0.24	0.5239
5-HT6	**-0.31**	**0.0044**	-0.31	0.3043	-0.31	0.5239
A4B2	-0.05	0.7282	-0.05	0.9755	-0.05	0.9195
CB1	0.17	0.5644	0.17	0.5798	0.17	0.9195
D1	0.05	0.7282	0.05	0.8403	0.05	0.1178
D2	**0.23**	**0.0421**	0.23	0.5798	0.23	0.9739
DAT	0.02	0.8802	**0.02**	**0.0006**	0.02	0.7522
GABAa	**-0.39**	**0.0038**	-0.39	0.5798	-0.39	0.1985
H3	<0.01	0.9941	<0.01	0.6836	<0.01	0.9195
M1	-0.14	0.5644	-0.14	0.5798	-0.14	0.7522
Mu	0.31	0.2216	0.31	0.5798	0.31	0.8353
NET	**-0.5**	**0.0038**	**-0.5**	**0.0209**	**-0.5**	**0.0171**
NMDA	**-0.34**	**0.0421**	**-0.34**	**0.0033**	-0.34	0.9195
SERT	-0.09	0.5644	**-0.09**	**0.0006**	-0.09	0.9195
VAChT	-0.03	0.833	**-0.03**	**0.0006**	-0.03	0.1411
mGluR5	-0.3	0.1183	-0.3	0.6216	-0.3	0.1411

Bold numbers highlight significant correlations. Rho: Spearman correlation coefficient.

Supplementary Table 6: Co-localization of **aging in brain functional measures** (unthresholded voxel-wise maps of annual change) and neurotransmitter systems – *after atrophy correction*.

	fALFF		LCOR		GCOR	
Neurotransmitter system	Rho	P_{FDR}	Rho	P_{FDR}	Rho	P_{FDR}
5-HT1a	0.09	0.6088	0.09	0.6497	0.09	0.1254
5-HT1b	-0.17	0.4982	-0.17	0.5704	-0.17	0.6017
5-HT2a	-0.14	0.6017	-0.14	0.5704	-0.14	0.8934
5-HT4	**0.23**	**0.0407**	0.23	0.5704	0.23	0.6017
5-HT6	**-0.29**	**0.0095**	-0.29	0.3616	-0.29	0.6017
A4B2	-0.06	0.6088	-0.06	0.9926	-0.06	0.9099
CB1	0.15	0.6017	0.15	0.5704	0.15	0.8934
D1	0.07	0.6017	0.07	0.9573	0.07	0.0703
D2	**0.24**	**0.0337**	0.24	0.5704	0.24	0.9762

DAT	0.05	0.6387	**0.05**	**0.0006**	0.05	0.6017
GABAa	**-0.38**	**0.0038**	-0.38	0.5704	-0.38	0.2346
H3	<0.01	0.9796	<0.01	0.729	<0.01	0.8934
M1	-0.13	0.6017	-0.13	0.5704	-0.13	0.7047
Mu	0.29	0.2878	0.29	0.5704	0.29	0.8381
NET	**-0.48**	**0.0085**	**-0.48**	**0.0228**	**-0.48**	**0.0114**
NMDA	-0.31	0.0731	**-0.31**	**0.0057**	-0.31	0.8934
SERT	-0.08	0.6017	**-0.08**	**0.0006**	-0.08	0.8934
VAChT	-0.01	0.9232	**-0.01**	**0.0006**	-0.01	0.1254
mGluR5	-0.28	0.1664	-0.28	0.6497	-0.28	0.1254

Bold numbers highlight significant correlations. Rho: Spearman correlation coefficient.

Supplementary Table 7: Anatomical regions covered by sex-differences (T-contrasts) - *before atrophy correction*.

Anatomical region	Cluster size	Cluster p-values (corrected)	Peak T-values	Peak MNI-Coordinates
FALFF: Female < Male				
Bilateral: Postcentral gyrus, middle frontal gyrus, precentral gyrus, middle occipital gyrus, superior temporal gyrus (incl. pole), calcarine fissure and surrounding cortex, dorsolateral and medial superior frontal gyrus, lingual gyrus, middle temporal gyrus (incl. pole), inferior parietal gyrus, insula, supplementary motor area, fusiform gyrus, supramarginal gyrus, inferior frontal gyrus (pars triangularis & orbitalis), inferior temporal gyrus, superior parietal gyrus, rolandic operculum, cuneus, superior occipital gyrus, cerebellum (4,5,6,7b,8,9,10) crus1, crus2), vermis (4,5,6,8) middle cingulate gyrus, paracentral lobule, inferior occipital gyrus, putamen, precuneus, orbital gyrus (posterior, medial, anterior, lateral), parahippocampal gyrus, anterior cingulate cortex (subgenual, pregenual, supracallosal), hippocampus, Heschl gyrus, angular gyrus, amygdala, gyrus rectus, thalamus (pulvinar medial, mediodorsal medial magnocellular, ventral posterolateral, mediodorsal lateral parvocellular, pulvinar lateral, ventral lateral, pulvinar anterior, anteroventral nucleus, intralaminar, lateral geniculate, medial geniculate), caudate, pallidum, olfactory cortex, ventral striatum, raphe nucleus (dorsal), substantia nigra (pars compacta), red nucleus, **Left**: Thalamus (ventral anterior), Ventral tegmental area	29898	<0.001	29.31	**-57 -3 15**
Right: Cerebellum (7b, 8, crus1, crus2)	58	<0.001	19.43	**54 -54 -42**
Right: Caudate	47	<0.001	11.11	**18 -9 27**
FALFF: Female > Male				
Bilateral: Cerebellum 9, Vermis 9	182	<0.001	23.01	**0 -54 -51**

Bilateral: Frontal gyrus (medial pars orbitalis, superior dorsolateral & medial), gyrus rectus, anterior cingulate gyrus (subgenual), orbital gyrus (anterior & medial) **Right**: Anterior cingulate gyrus (pregenual)	497	<0.001	22.65	**-15 69 9**
Bilateral: Precuneus, cingulate gyrus (middle & posterior), calcarine fissure and surrounding cortex, vermis (4,5) **Left:** Cuneus **Right:** Lingual gyrus	974	<0.001	20.82	**6 -57 21**
Right: Temporal gyrus (inferior, middle, superior)	574	<0.001	19.08	**66 -15 -15**
Bilateral: Superior frontal gyrus (medial) **Left:** Frontal gyrus (superior, middle), supplementary motor area	369	<0.001	15.14	**-27 18 57**
Bilateral: Superior frontal gyrus (medial) **Left:** Frontal gyrus (superior, middle), supplementary motor area	390	<0.001	15.03	**30 18 57**
Bilateral: Vermis (7) **Right:** Cerebellum (6, 7b, 8, crus1, crus2)	421	<0.001	12.17	**27 -75 -33**
Left: Temporal gyrus (middle & inferior)	319	<0.001	11.98	**-69 -27 -9**
Left: Cerebellum (6,7b,8, crus1, crus2)	315	<0.001	11.63	**-36 -63 -39**
Left: Parietal gyrus (superior & inferior), occipital gyrus (middle), angular gyrus	104	<0.001	11.51	**-36 -72 39**
Right: Gyrus rectus, orbital gyrus (medial)	24	<0.001	10.29	**9 21 -24**
Right: Angular gyrus, occipital gyrus (middle)	51	<0.001	10.00	**45 -66 33**
Left: Frontal gyrus (superior, middle, inferior pars orbitalis)	37	<0.001	9.96	**-27 36 -9**
Left: Orbital gyrus (medial), gyrus rectus	20	<0.001	9.93	**-12 21 -24**
Left: Parahippocampal gyrus, fusiform gyrus, temporal gyrus (inferior)	34	<0.001	9.05	**-33 -39 -9**
Right: Parahippocampal gyrus, fusiform gyrus, hippocampus	28	<0.001	8.98	**33 -36 -12**
Right: Frontal gyrus (middle, inferior pars orbitalis), orbital gyrus (anterior)	25	<0.001	8.00	**33 39 -6**
LCOR: Female < Male				
Bilateral: Middle frontal gyrus, Postcentral gyrus, Middle occipital gyrus, Middle temporal gyrus, Precentral gyrus, Superior frontal gyrus (dorsolateral), Superior temporal gyrus, Inferior parietal gyrus, Inferior frontal gyrus (pars triangularis), Precuneus, Fusiform gyrus, Supplementary motor area, Calcarine fissure and surrounding cortex, Lingual gyrus, Insula, Supramarginal gyrus, Superior parietal gyrus, Cerebellum (Crus 1), Cerebellum (6), Middle cingulate & paracingulate gyri, Cerebellum (8), Superior frontal gyrus (medial), Cuneus, Angular gyrus, Cerebellum (Crus 2), Rolandic operculum, Inferior frontal gyrus (pars opercularis), Superior occipital gyrus, Cerebellum (4,5), Inferior temporal gyrus, Putamen, Superior temporal gyrus (pole), Paracentral lobule, Inferior occipital gyrus, Parahippocampal gyrus, Inferior frontal gyrus (pars orbitalis), Cerebellum (9), Middle temporal gyrus (pole), Cerebellum (7b), Anterior cingulate cortex (supracallosal), Anterior	37792	<0.001	30.05	**48 -15 15**

cingulate cortex (pregenual), Posterior orbital gyrus, Vermis (4,5), Hippocampus, Vermis (8), Heschl's gyrus, Vermis (6), Amygdala, Lateral orbital gyrus, Anterior orbital gyrus, Vermis (7), Cerebellum (3), Vermis (9), Pallidum, Thalamus (pulvinar medial), Medial orbital gyrus, Vermis (3), Thalamus (mediodorsal medial magnocellular), Thalamus (ventral posterolateral), Caudate nucleus, Thalamus (mediodorsal lateral parvocellular), Thalamus (pulvinar anterior), Thalamus (ventral lateral), Thalamus (intralaminar), Thalamus (pulvinar lateral), Thalamus (pulvinar inferior), Thalamus (medial geniculate), Thalamus (lateral geniculate), Olfactory cortex, Vermis (10), Vermis (1,2), Cerebellum (10) **Right:** Gyrus rectus, Superior frontal gyrus (medial orbital), Thalamus (lateral posterior), Thalamus (anteroventral nucleus), Posterior cingulate gyrus				
Bilateral: Substantia nigra pars compacta, Red nucleus **Left**: Ventral tegmental area		<0.001	9.79	**0 -18 -12**
LCOR: Female > Male				
Bilateral: Superior frontal gyrus (medial orbital), Superior frontal gyrus (dorsolateral), Gyrus rectus, Caudate nucleus, Superior frontal gyrus (medial), Medial orbital gyrus, Anterior cingulate cortex (subgenual), Anterior orbital gyrus, Middle frontal gyrus, Olfactory cortex, Thalamus (lateral posterior) **Left**: Anterior cingulate cortex (pregenual), Anterior cingulate cortex (supracallosal), Ventral striatum, Thalamus (pulvinar medial), Thalamus (ventral lateral), Thalamus (anteroventral nucleus)	1465	<0.001	34.53	**15 69 6**
Right: Middle temporal gyrus, Inferior temporal gyrus, Cerebellum (Crus 1), Cerebellum (6), Superior temporal gyrus, Fusiform gyrus, Cerebellum (Crus 2), Middle temporal gyrus (pole)	491	<0.001	22.7	69 -21 -18
Left: Hippocampus, Parahippocampal gyrus	51	<0.001	16.17	-33 -39 -3
Left: Inferior temporal gyrus, Middle temporal gyrus, Cerebellum (Crus 1), Cerebellum (7b), Cerebellum (6)	508	<0.001	15.84	-66 -27 -21
Right: Hippocampus, Parahippocampal gyrus	46	<0.001	14.41	33 -36 0
Bilateral: Cerebellum (9), Vermis (9)	47	<0.001	13.55	0 -48 -48
Right: Thalamus (mediodorsal medial magnocellular)	24	<0.001	13.14	0 -18 0
Bilateral: Precuneus, Posterior cingulate gyrus, Middle cingulate & paracingulate gyri, Calcarine fissure and surrounding cortex **Left**: Cuneus	269	<0.001	12.06	-9 -54 18
Right: Medial orbital gyrus, Olfactory cortex, Gyrus rectus, Posterior orbital gyrus	83	<0.001	11.58	9 15 -24
Left: Medial orbital gyrus, Olfactory cortex, Posterior orbital gyrus, Gyrus rectus, Parahippocampal gyrus	66	<0.001	10.09	-12 15 -24
GCOR: Female < Male				
Bilateral: Middle temporal gyrus, Middle frontal gyrus, Superior frontal gyrus (dorsolateral), Postcentral gyrus, Precuneus, Middle occipital gyrus, Precentral gyrus, Superior temporal gyrus, Inferior parietal gyrus, Superior frontal gyrus (medial), Inferior frontal gyrus (pars triangularis), Fusiform gyrus, Supplementary motor area, Calcarine fissure and surrounding cortex, Middle cingulate & paracingulate gyri, Lingual gyrus, Inferior temporal gyrus, Insula, Supramarginal gyrus, Cerebellum (8), Superior parietal gyrus, Angular gyrus, Cuneus, Cerebellum (6), Rolandic operculum, Inferior frontal gyrus (pars opercularis), Superior occipital gyrus, Cerebellum (4,5), Superior temporal gyrus (pole), Putamen, Parahippocampal gyrus, Paracentral lobule, Inferior occipital gyrus, Anterior cingulate cortex (supracallosal), Inferior frontal gyrus (pars orbitalis), Cerebellum (9), Superior frontal gyrus (medial orbital), Anterior cingulate cortex (pregenual), Hippocampus, Middle temporal gyrus (pole), Cerebellum (Crus 2), Anterior orbital gyrus, Posterior orbital gyrus, Vermis (4,5), Cerebellum (7b), Posterior cingulate gyrus, Caudate nucleus, Gyrus rectus, Medial orbital gyrus, Heschl's gyrus, Vermis (8), Vermis (6), Cerebellum (Crus 1), Amygdala, Lateral orbital gyrus, Thalamus (pulvinar medial), Vermis (9), Cerebellum (3), Ventral striatum, Anterior cingulate cortex (subgenual), Pallidum, Vermis (7), Vermis (3), Thalamus (mediodorsal medial magnocellular), Olfactory cortex, Thalamus (ventral posterolateral), Thalamus (mediodorsal lateral parvocellular), Thalamus (pulvinar inferior), Thalamus (pulvinar anterior), Thalamus (ventral lateral), Thalamus (pulvinar lateral), Thalamus (intralaminar), Thalamus (lateral geniculate), Substantia nigra pars compacta, Vermis (1,2), Thalamus (medial geniculate), Thalamus (lateral posterior), Thalamus (anteroventral nucleus), Vermis (10), Red nucleus, Raphe nucleus, Cerebellum (10)	43115	<0.001	26.55	**45 -15 9**

Left: Ventral tegmental area, Thalamus (ventral anterior)				
GCOR: Female > Male				
Right: Caudate nucleus	65	<0.001	18.82	**12 0 21**
Left: Hippocampus	42	<0.001	17.68	**-30 -39 3**
Left: Caudate nucleus, Thalamus (lateral posterior), Thalamus (pulvinar medial)	63	<0.001	16.76	**-12 -6 21**
Right: Superior frontal gyrus (medial), Superior frontal gyrus (dorsolateral), Superior frontal gyrus (medial orbital)	60	<0.001	15.08	**15 69 3**
Right: Hippocampus	33	<0.001	14.35	**33 -36 0**
Left: Superior frontal gyrus (dorsolateral), Superior frontal gyrus (medial), Superior frontal gyrus (medial orbital)	47	<0.001	13.77	**-12 69 6**
Left: Cerebellum (Crus 1), Cerebellum (Crus 2), Cerebellum (7b)	305	<0.001	12.84	**-51 -66 -30**
Right: Cerebellum (Crus 1), Cerebellum (Crus 2), Cerebellum (7b), Inferior temporal gyrus, Cerebellum (6)	194	<0.001	12.78	**54 -60 -33**
Bilateral: Cerebellum (9)	25	<0.001	10.74	**0 -51 -54**
Left: Medial orbital gyrus, Posterior orbital gyrus, Olfactory cortex, Parahippocampal gyrus, Gyrus rectus	29	<0.001	8.71	**-12 12 -24**
Right: Medial orbital gyrus, Olfactory cortex, Gyrus rectus	23	<0.001	8.02	**12 12 -24**

Supplementary Table 8: Anatomical regions covered by sex-differences (T-contrasts) - *after atrophy correction.*

Anatomical region	Cluster size	Cluster p-values (corrected)	Peak T-values	Peak MNI-Coordinates
FALFF: Female < Male				
Bilateral: Postcentral gyrus, Middle frontal gyrus, Precentral gyrus, Middle occipital gyrus, Superior temporal gyrus, Calcarine fissure and surrounding cortex, Superior frontal gyrus (dorsolateral), Lingual gyrus, Middle temporal gyrus, Inferior parietal gyrus, Insula, Fusiform gyrus, Supplementary motor area, Supramarginal gyrus, Inferior frontal gyrus (pars triangularis), Inferior temporal gyrus, Superior parietal gyrus, Rolandic operculum, Cuneus, Superior occipital gyrus, Cerebellum (6), Inferior frontal gyrus (pars opercularis), Middle cingulate & paracingulate gyri, Cerebellum (8), Paracentral lobule, Cerebellum (4,5), Inferior occipital gyrus, Superior temporal gyrus (pole), Putamen, Precuneus, Cerebellum (Crus 1), Superior frontal gyrus (medial), Middle temporal gyrus (pole), Inferior frontal gyrus (pars orbitalis), Parahippocampal gyrus, Posterior orbital gyrus, Vermis (4,5), Cerebellum (9), Cerebellum (Crus 2), Anterior orbital gyrus, Caudate nucleus, Hippocampus, Anterior cingulate cortex (supracallosal), Medial orbital gyrus, Anterior cingulate cortex (pregenual), Vermis (8), Heschl's gyrus, Angular gyrus, Amygdala, Vermis (6), Gyrus rectus, Cerebellum (7b), Lateral orbital gyrus, Thalamus (pulvinar medial), Thalamus (mediodorsal medial magnocellular), Cerebellum (3), Pallidum, Olfactory cortex, Vermis (9), Vermis (7), Ventral striatum, Vermis (3), Thalamus (ventral posterolateral), Thalamus (mediodorsal lateral	30583	<0.001	29.07	**48 -15 9**

parvocellular), Superior frontal gyrus (medial orbital), Thalamus (pulvinar inferior), Thalamus (ventral lateral), Thalamus (pulvinar anterior), Thalamus (anteroventral nucleus), Thalamus (pulvinar lateral), Thalamus (intralaminar), Vermis (10), Thalamus (lateral geniculate), Thalamus (lateral posterior), Substantia nigra pars compacta, Raphe nucleus, Anterior cingulate cortex (subgenual), Thalamus (medial geniculate), Red nucleus, Cerebellum (10) **Left**: Ventral tegmental area, Thalamus (ventral anterior)				
fALFF: Female > Male				
Bilateral: Superior frontal gyrus (medial orbital), Superior frontal gyrus (dorsolateral), Superior frontal gyrus (medial), Gyrus rectus, Anterior cingulate cortex (subgenual), Anterior orbital gyrus, Medial orbital gyrus **Left**: Anterior cingulate cortex (pregenual), Olfactory cortex	494	<0.001	22.53	**15 69 6**
Bilateral: Precuneus, Middle cingulate & paracingulate gyri, Posterior cingulate gyrus, Cuneus, Calcarine fissure and surrounding cortex, Vermis (4,5) **Right**: Lingual gyrus	934	<0.001	21.06	**6 -57 21**
Bilateral: Cerebellum (9)	147	<0.001	20.43	**-3 -54 -48**
Right: Middle temporal gyrus, Inferior temporal gyrus, Superior temporal gyrus	597	<0.001	20.27	**63 -15 -15**
Bilateral: Superior frontal gyrus (medial) **Right**: Superior frontal gyrus (dorsolateral), Middle frontal gyrus, Supplementary motor area	361	<0.001	14.73	**30 18 57**
Left: Superior frontal gyrus (dorsolateral), Middle frontal gyrus, Supplementary motor area, Superior frontal gyrus (medial)	356	<0.001	14.72	**-30 18 57**
Left: Middle temporal gyrus, Inferior temporal gyrus	384	<0.001	12.76	**-69 -27 -9**
Right: Cerebellum (Crus 1), Cerebellum (Crus 2), Cerebellum (7b), Cerebellum (6), Cerebellum (8)	286	<0.001	11.02	**30 -75 -33**
Right: Gyrus rectus, Medial orbital gyrus	23	<0.001	10.87	**12 21 -27**
Right: Angular gyrus, Middle occipital gyrus	49	<0.001	10.75	**45 -66 30**
Left: Inferior parietal gyrus, Angular gyrus, Middle occipital gyrus, Superior parietal gyrus	80	<0.001	10.49	**-36 -72 39**
Left: Cerebellum (Crus 2), Cerebellum (Crus 1), Cerebellum (7b), Cerebellum (8), Cerebellum (6)	178	<0.001	10.25	**-30 -75 -33**
Left: Inferior frontal gyrus (pars orbitalis), Middle frontal gyrus, Superior frontal gyrus (dorsolateral)	24	<0.001	7.68	**-27 39 -9**
LCOR: Female < Male				
Bilateral: Middle frontal gyrus, Postcentral gyrus, Middle occipital gyrus, Middle temporal gyrus, Precentral gyrus, Superior frontal gyrus (dorsolateral), Superior temporal gyrus, Inferior parietal gyrus, Inferior frontal gyrus (pars triangularis), Precuneus, Fusiform gyrus, Calcarine fissure and surrounding cortex, Supplementary motor area, Lingual gyrus, Insula, Supramarginal gyrus, Superior parietal gyrus, Cerebellum (Crus 1), Cerebellum (6), Middle cingulate & paracingulate gyri, Cerebellum (8), Superior frontal gyrus (medial), Cuneus,	38244	<0.001	32.67	**45 -15 12**

Cerebellum (Crus 2), Angular gyrus, Rolandic operculum, Inferior frontal gyrus (pars opercularis), Superior occipital gyrus, Cerebellum (4,5), Inferior temporal gyrus, Superior temporal gyrus (pole), Putamen, Paracentral lobule, Inferior occipital gyrus, Parahippocampal gyrus, Inferior frontal gyrus (pars orbitalis), Cerebellum (9), Middle temporal gyrus (pole), Anterior cingulate cortex (supracallosal), Cerebellum (7b), Anterior cingulate cortex (pregenual), Hippocampus, Posterior orbital gyrus, Vermis (4,5), Vermis (6), Vermis (8), Heschl's gyrus, Amygdala, Anterior orbital gyrus, Lateral orbital gyrus, Vermis (9), Vermis (7), Cerebellum (3), Pallidum, Thalamus (pulvinar medial), Medial orbital gyrus, Vermis (3), Thalamus (mediodorsal medial magnocellular), Thalamus (ventral posterolateral), Thalamus (mediodorsal lateral parvocellular), Caudate nucleus, Thalamus (pulvinar anterior), Thalamus (ventral lateral), Thalamus (pulvinar inferior), Thalamus (intralaminar), Vermis (10), Thalamus (pulvinar lateral), Thalamus (lateral geniculate), Thalamus (medial geniculate), Olfactory cortex, Vermis (1,2), Cerebellum (10) **Right**: Gyrus rectus, Superior frontal gyrus (medial orbital), Thalamus (lateral posterior), Thalamus (anteroventral nucleus), Posterior cingulate gyrus				
Bilateral: Substantia nigra pars compacta, Red nucleus **Left**: Ventral tegmental area	36	<0.001	9.74	**0 -18 -12**
LCOR: Female > Male				
Bilateral: Superior frontal gyrus (medial orbital), Superior frontal gyrus (dorsolateral), Gyrus rectus, Superior frontal gyrus (medial), Anterior cingulate cortex (subgenual), Medial orbital gyrus, Anterior orbital gyrus, Middle frontal gyrus, Olfactory cortex **Left**: Anterior cingulate cortex (pregenual)	1171	<0.001	34.43	**-15 69 6**
Right: Middle temporal gyrus, Inferior temporal gyrus, Cerebellum (Crus 1), Cerebellum (6), Superior temporal gyrus, Fusiform gyrus, Cerebellum (Crus 2), Middle temporal gyrus (pole)	487	<0.001	22.36	**69 -21 -18**
Bilateral: Caudate nucleus, Thalamus (lateral posterior) **Left:** Ventral striatum, Thalamus (pulvinar medial), Thalamus (ventral lateral), Thalamus (anteroventral nucleus)	270	<0.001	17	**-3 -6 15**
Left: Middle temporal gyrus, Inferior temporal gyrus, Cerebellum (Crus 1), Cerebellum (6), Cerebellum (7b)	489	<0.001	15.81	**-66 -24 -21**
Left: Hippocampus, Parahippocampal gyrus	46	<0.001	14.74	**-33 -36 -3**
Right: Hippocampus, Parahippocampal gyrus	37	<0.001	13.22	**33 -36 0**
Bilateral: Precuneus, Posterior cingulate gyrus, Middle cingulate & paracingulate gyri, Calcarine fissure and surrounding cortex **Left**: Cuneus	269	<0.001	12.87	**-9 -54 18**
Right: Medial orbital gyrus, Olfactory cortex, Gyrus rectus, Posterior orbital gyrus	80	<0.001	11.73	**9 15 -27**
Left: Medial orbital gyrus, Olfactory cortex, Posterior orbital gyrus, Gyrus rectus, Parahippocampal gyrus	69	<0.001	10.75	**-12 15 -24**

Bilateral: Cerebellum (9)	22	<0.001	10.71	**0 -48 -48**
GCOR: Female < Male				
Bilateral: Middle temporal gyrus, Middle frontal gyrus, Superior frontal gyrus (dorsolateral), Postcentral gyrus, Precuneus, Middle occipital gyrus, Precentral gyrus, Superior temporal gyrus, Inferior parietal gyrus, Superior frontal gyrus (medial), Inferior frontal gyrus (pars triangularis), Fusiform gyrus, Supplementary motor area, Calcarine fissure and surrounding cortex, Middle cingulate & paracingulate gyri, Lingual gyrus, Inferior temporal gyrus, Insula, Supramarginal gyrus, Cerebellum (8), Superior parietal gyrus, Angular gyrus, Cuneus, Cerebellum (6), Rolandic operculum, Inferior frontal gyrus (pars opercularis), Superior occipital gyrus, Cerebellum (4,5), Superior temporal gyrus (pole), Putamen, Parahippocampal gyrus, Paracentral lobule, Inferior occipital gyrus, Anterior cingulate cortex (supracallosal), Cerebellum (9), Inferior frontal gyrus (pars orbitalis), Superior frontal gyrus (medial orbital), Hippocampus, Anterior cingulate cortex (pregenual), Middle temporal gyrus (pole), Cerebellum (Crus 2), Anterior orbital gyrus, Posterior orbital gyrus, Vermis (4,5), Cerebellum (7b), Posterior cingulate gyrus, Caudate nucleus, Gyrus rectus, Medial orbital gyrus, Cerebellum (Crus 1), Vermis (6), Heschl's gyrus, Amygdala, Vermis (8), Lateral orbital gyrus, Thalamus (pulvinar medial), Vermis (9), Anterior cingulate cortex (subgenual), Cerebellum (3), Ventral striatum, Vermis (7), Pallidum, Vermis (3), Thalamus (mediodorsal medial magnocellular), Olfactory cortex, Thalamus (ventral posterolateral), Thalamus (mediodorsal lateral parvocellular), Thalamus (pulvinar inferior), Thalamus (pulvinar anterior), Thalamus (ventral lateral), Thalamus (pulvinar lateral), Vermis (10), Thalamus (intralaminar), Thalamus (lateral geniculate), Substantia nigra pars compacta, Vermis (1,2), Thalamus (medial geniculate), Thalamus (anteroventral nucleus), Red nucleus, Thalamus (lateral posterior), Raphe nucleus, Cerebellum (10) **Left**: Ventral tegmental area, Thalamus (ventral anterior)	43309	<0.001	28.94	**45 -15 9**
GCOR: Female > Male				
Right: Caudate nucleus	63	<0.001	17.97	**12 0 21**
Left: Hippocampus	41	<0.001	16.75	**-30 -39 3**
Left Caudate nucleus, Thalamus (lateral posterior), Thalamus (pulvinar medial)	60	<0.001	16.34	**-15 -12 24**
Right: Superior frontal gyrus (medial), Superior frontal gyrus (dorsolateral), Superior frontal gyrus (medial orbital)	60	<0.001	15.82	**15 69 3**
Left: Superior frontal gyrus (dorsolateral), Superior frontal gyrus (medial), Superior frontal gyrus (medial orbital)	46	<0.001	13.85	**-12 69 6**
Right: Hippocampus	32	<0.001	13.59	**30 -36 6**
Left: Cerebellum (Crus 1), Cerebellum (Crus 2), Cerebellum (7b)	295	<0.001	12.94	**-45 -42 -39**
Right: Cerebellum (Crus 1), Cerebellum (Crus 2), Cerebellum (7b), Inferior temporal gyrus, Cerebellum (6)	170	<0.001	12.55	**54 -63 -33**
Left: Medial orbital gyrus, Posterior orbital gyrus, Olfactory cortex, Gyrus rectus	29	<0.001	8.35	**-12 12 -24**
Right: Medial orbital gyrus, Olfactory cortex, Gyrus rectus	22	<0.001	8.07	**12 12 -24**

Supplementary Table 9: Co-localization of **sex differences in brain functional measures** (unthresholded voxel-wise T-maps) and neurotransmitter systems – *before atrophy correction*.

	fALFF		LCOR		GCOR	
Neurotransmitter system	Rho	P_{FDR}	Rho	P_{FDR}	Rho	P_{FDR}
5-HT1a	0.01	0.9855	0.01	0.8937	0.01	0.5794
5-HT1b	0.12	0.6393	0.12	0.4761	0.12	0.1514
5-HT2a	0.08	0.7707	0.08	0.8735	0.08	0.5682
5-HT4	-0.13	0.3764	-0.13	0.0574	-0.13	0.0809
5-HT6	0.21	0.084	**0.21**	**0.0019**	**0.21**	**0.0005**
A4B2	<0.01	0.9855	<0.01	0.2618	<0.01	0.2429
CB1	-0.12	0.7283	-0.12	0.9522	-0.12	0.7879
D1	-0.07	0.6826	-0.07	0.252	-0.07	0.9835
D2	0.01	0.9855	0.01	0.554	0.01	0.6187
DAT	0.11	0.4722	0.11	0.8735	0.11	0.6838
GABAa	0.25	0.0522	**0.25**	**0.0009**	**0.25**	**0.0005**
H3	-0.01	0.9855	-0.01	0.9522	-0.01	0.5682
M1	0.13	0.6254	0.13	0.5209	0.13	0.2896
Mu	-0.22	0.5527	-0.22	0.5209	-0.22	0.5794
NET	**0.57**	**0.0038**	**0.57**	**0.0009**	**0.57**	**0.0005**
NMDA	0.29	0.1086	0.29	0.252	0.29	0.113
SERT	0.21	0.084	0.21	0.9522	0.21	0.5794
VAChT	0.23	0.057	0.23	0.252	0.23	0.5794
mGluR5	0.25	0.2611	**0.25**	**0.0043**	**0.25**	**0.0005**

Bold numbers highlight significant correlations. Rho: Spearman correlation coefficient.

Supplementary Table 10: Co-localization of **sex differences in brain functional measures** (unthresholded voxel-wise T-maps) and neurotransmitter systems – *after atrophy correction*.

	fALFF		LCOR		GCOR	
Neurotransmitter system	Rho	P_{FDR}	Rho	P_{FDR}	Rho	P_{FDR}
5-HT1a	-0.01	0.9831	-0.01	0.9168	-0.01	0.5968
5-HT1b	0.1	0.6522	0.1	0.52	0.1	0.1485
5-HT2a	0.07	0.8329	0.07	0.9019	0.07	0.5706
5-HT4	-0.15	0.2344	-0.15	0.0483	-0.15	0.0711
5-HT6	0.2	0.1194	**0.2**	**0.0025**	**0.2**	**0.0005**
A4B2	<0.01	0.9831	<0.01	0.2677	<0.01	0.2705
CB1	-0.14	0.6522	-0.14	0.9168	-0.14	0.8053
D1	-0.08	0.6413	-0.08	0.2434	-0.08	0.9567
D2	-0.01	0.9831	-0.01	0.5261	-0.01	0.6028
DAT	0.11	0.5023	0.11	0.9019	0.11	0.7061
GABAa	0.25	0.0503	**0.25**	**0.0009**	**0.25**	**0.0005**
H3	-0.03	0.9164	-0.03	0.9168	-0.03	0.5706
M1	0.12	0.6413	0.12	0.5261	0.12	0.281
Mu	-0.23	0.5023	-0.23	0.5261	-0.23	0.5968
NET	**0.57**	**0.0019**	**0.57**	**0.0009**	**0.57**	**0.0005**
NMDA	0.28	0.1194	0.28	0.2434	0.28	0.1086
SERT	0.19	0.1194	0.19	0.9168	0.19	0.5968
VAChT	0.22	0.0849	0.22	0.2434	0.22	0.5968
mGluR5	0.25	0.2344	**0.25**	**0.0047**	**0.25**	**0.0005**

Bold numbers highlight significant correlations. Rho: Spearman correlation coefficient.

Supplementary Table 11: Co-localization strength of **fALFF** with neurotransmitter systems and the effects of age and sex – *before atrophy correction*.

	Co-localization strength*			Linear aging effects**			Sex differences**		
Neurotransmitter system	Median rho	IQR rho	Mean Fisher's z(rho)	Pearson r	Slope	P_{BH}	T	Cohen's d	P_{BH}
5-HT1a	-0.21	0.09	-0.2	0.11	0.0011	<0.001	11.26	0.14	<0.001
5-HT1b	0.43	0.07	0.46	-0.02	-0.0002	0.1079	-3.57	-0.04	0.0069
5-HT2a	0.4	0.09	0.42	0.08	0.0008	<0.001	8.18	0.1	<0.001
5-HT4	-0.29	0.09	-0.29	0.08	0.0008	<0.001	12.37	0.15	<0.001
5-HT6	0.27	0.08	0.27	-0.06	-0.0005	<0.001	-3.74	-0.05	0.0035
A4B2	0.1	0.1	0.11	0.02	0.0003	0.0027	5.91	0.07	<0.001
CB1	-0.14	0.14	-0.13	0.09	0.0013	<0.001	13.24	0.17	<0.001
D1	-0.42	0.08	-0.44	0.04	0.0004	<0.001	9.16	0.11	<0.001
D2	-0.47	0.09	-0.51	0.04	0.0005	<0.001	-0.81	-0.01	1
DAT	-0.68	0.06	-0.82	-0.07	-0.0009	<0.001	-9.61	-0.12	<0.001
GABAa	0.4	0.07	0.43	-0.06	-0.0005	<0.001	-7.43	-0.09	<0.001
H3	-0.28	0.11	-0.27	0.01	0.0002	0.3196	1.96	0.02	0.9435
M1	0.33	0.07	0.34	-0.02	-0.0001	0.2195	1.34	0.02	1
μ	-0.5	0.13	-0.53	0.11	0.0019	<0.001	13.58	0.17	<0.001
NET	0.51	0.12	0.57	-0.13	-0.0019	<0.001	-29.86	-0.37	<0.001
NMDA	-0.13	0.07	-0.13	-0.17	-0.0013	<0.001	-19.67	-0.25	<0.001
SERT	-0.5	0.07	-0.54	-0.17	-0.0015	<0.001	-25.48	-0.32	<0.001
VAChT	-0.56	0.11	-0.63	-0.05	-0.0008	<0.001	-14.58	-0.18	<0.001
mGluR5	0.3	0.1	0.32	<0.01	0.0001	1	-1.27	-0.02	1

* The distribution of all Fisher's z-transformed Spearman correlation coefficients (Rho) regarding a specific neurotransmitter system were all significantly (one-sample t-test, P_{BH}<0.0001) different from a null-distribution.

**Aging effects and sex differences based on linear regression and comparison (t-test, alpha=0.05), respectively, between men and women in individual Fisher's z-transformed Spearman correlation coefficients. Not significant aging effects and sex differences are highlighted in red. P_{BH}: Bonferroni-Holm corrected P-value

Supplementary Table 12: Co-localization strength of **LCOR** with neurotransmitter systems and the effects of age and sex – *before atrophy correction*.

	Co-localization strength*			Linear aging effects**			Sex differences**		
Neurotransmitter system	Median rho	IQR rho	Mean Fisher's z(rho)	Pearson r	Slope	P_{BH}	T	Cohen's d	P_{BH}
5-HT1a	-0.3	0.1	-0.31	-0.01	-0.0001	1	-1.57	-0.02	1
5-HT1b	0.32	0.11	0.33	0.12	0.0015	<0.001	5.78	0.07	<0.001
5-HT2a	0.2	0.11	0.2	0.13	0.0015	<0.001	9.1	0.11	<0.001
5-HT4	-0.4	0.1	-0.42	0.01	0.0001	1	5.99	0.07	<0.001
5-HT6	0.29	0.12	0.31	-0.06	-0.0008	<0.001	-3.68	-0.05	0.0045
A4B2	0.03	0.1	0.04	0.06	0.0007	<0.001	2.74	0.03	0.1164
CB1	-0.25	0.13	-0.25	0.07	0.0009	<0.001	7.17	0.09	<0.001
D1	-0.26	0.14	-0.25	-0.08	-0.0013	<0.001	0.83	0.01	1
D2	-0.43	0.13	-0.46	-0.11	-0.0018	<0.001	-6.78	-0.08	<0.001
DAT	-0.39	0.16	-0.41	-0.2	-0.0037	<0.001	-10.78	-0.14	<0.001
GABAa	0.49	0.09	0.54	-0.06	-0.0007	<0.001	-1.72	-0.02	1
H3	-0.21	0.16	-0.2	-0.06	-0.001	<0.001	-2.68	-0.03	0.1421
M1	0.22	0.11	0.23	0.05	0.0006	<0.001	7.7	0.1	<0.001
μ	-0.51	0.13	-0.54	0.02	0.0004	0.0071	7.9	0.1	<0.001
NET	0.59	0.13	0.67	-0.11	-0.002	<0.001	-23.75	-0.3	<0.001
NMDA	0.15	0.14	0.15	-0.2	-0.0029	<0.001	-12.5	-0.16	<0.001
SERT	-0.29	0.15	-0.3	-0.21	-0.0033	<0.001	-15.87	-0.2	<0.001
VAChT	-0.33	0.19	-0.34	-0.17	-0.0035	<0.001	-14.03	-0.18	<0.001
mGluR5	0.38	0.14	0.41	-0.04	-0.0008	<0.001	-3.3	-0.04	0.0183

* The distribution of all Fisher's z-transformed Spearman correlation coefficients (Rho) regarding a specific neurotransmitter system were all significantly (one-sample t-test, P_{BH}<0.0001) different from a null-distribution. IQR: Interquartile range of Spearman correlation coefficients.

**Aging effects and sex differences based on linear regression and comparison (t-test, alpha=0.05), respectively, between men and women in individual Fisher's z-transformed Spearman correlation coefficients. Not significant aging effects and sex differences are highlighted in red. P_{BH}: Bonferroni-Holm corrected P-value

Supplementary Table 13: Co-localization strength of **GCOR** with neurotransmitter systems and the effects of age and sex – *before atrophy correction*.

	Co-localization strength*			Linear aging effects**			Sex differences**		
Neurotransmitter system	Median rho	IQR rho	Mean Fisher's z(rho)	Pearson r	Slope	P_{BH}	T	Cohen's d	P_{BH}
5-HT1a	-0.24	0.21	-0.24	-0.1	-0.0023	<0.001	-9.21	-0.12	<0.001
5-HT1b	0.14	0.16	0.14	0.09	0.0015	<0.001	-11.82	-0.15	<0.001
5-HT2a	0.1	0.17	0.1	0.02	0.0003	0.0405	-1.57	-0.02	1
5-HT4	-0.28	0.16	-0.28	-0.01	-0.0002	1	1.87	0.02	1
5-HT6	0.19	0.19	0.19	-0.05	-0.001	<0.001	-15.69	-0.2	<0.001
A4B2	0.08	0.2	0.08	<0.01	-0.0001	1	-4.11	-0.05	0.0007
CB1	-0.26	0.22	-0.25	-0.04	-0.0009	<0.001	-9.82	-0.12	<0.001
D1	-0.2	0.22	-0.2	-0.01	-0.0002	1	-7.96	-0.1	<0.001
D2	-0.29	0.21	-0.29	-0.07	-0.0016	<0.001	-9.41	-0.12	<0.001
DAT	-0.23	0.22	-0.23	-0.07	-0.0015	<0.001	-8.61	-0.11	<0.001
GABAa	0.31	0.16	0.32	-0.04	-0.0007	<0.001	-14.42	-0.18	<0.001
H3	-0.17	0.28	-0.17	-0.04	-0.0012	<0.001	-10.8	-0.14	<0.001
M1	0.09	0.14	0.09	0.06	0.0009	<0.001	-7.28	-0.09	<0.001
μ	-0.36	0.25	-0.37	-0.01	-0.0003	1	-2.01	-0.03	0.8398
NET	0.5	0.23	0.53	-0.11	-0.0032	<0.001	-19.34	-0.24	<0.001
NMDA	0.16	0.19	0.16	-0.07	-0.0013	<0.001	-11.4	-0.14	<0.001
SERT	-0.17	0.18	-0.18	-0.08	-0.0014	<0.001	-8.72	-0.11	<0.001
VAChT	-0.15	0.28	-0.15	-0.12	-0.0032	<0.001	-11.21	-0.14	<0.001
mGluR5	0.27	0.27	0.28	-0.09	-0.0025	<0.001	-18.49	-0.23	<0.001

* The distribution of all Fisher's z-transformed Spearman correlation coefficients (Rho) regarding a specific neurotransmitter system were all significantly (one-sample t-test, P_{BH}<0.0001) different from a null-distribution. IQR: Interquartile range of Spearman correlation coefficients.

**Aging effects and sex differences based on linear regression and comparison (t-test, alpha=0.05), respectively, between men and women in individual Fisher's z-transformed Spearman correlation coefficients. Not significant aging effects and sex differences are highlighted in red. P_{BH}: Bonferroni-Holm corrected P-value

Supplementary Table 14: Co-localization strength of **fALFF** with neurotransmitter systems and the effects of age and sex – *after atrophy correction*.

	Co-localization strength*			Linear aging effects**			Sex differences**		
Neurotransmitter system	Median rho	IQR rho	Mean Fisher's z(rho)	Pearson r	Slope	P_{BH}	T	Cohen's d	P_{BH}
5-HT1a	-0.21	0.09	-0.2	0.1	0.001	<0.0001	11.86	0.15	<0.0001
5-HT1b	0.43	0.07	0.46	-0.02	-0.0002	0.0992	-3	-0.04	0.0512
5-HT2a	0.4	0.09	0.42	0.08	0.0007	<0.0001	8.91	0.11	<0.0001
5-HT4	-0.29	0.09	-0.29	0.07	0.0007	<0.0001	13.28	0.17	<0.0001
5-HT6	0.26	0.08	0.27	-0.04	-0.0003	<0.0001	-4.02	-0.05	0.0011
A4B2	0.1	0.1	0.11	0.02	0.0002	0.0699	6.24	0.08	<0.0001
CB1	-0.14	0.14	-0.13	0.08	0.0011	<0.0001	13.85	0.17	<0.0001
D1	-0.42	0.08	-0.44	0.06	0.0006	<0.0001	8.53	0.11	<0.0001
D2	-0.47	0.08	-0.51	0.05	0.0005	<0.0001	-0.49	-0.01	1
DAT	-0.68	0.06	-0.82	-0.04	-0.0005	<0.0001	-10.81	-0.14	<0.0001
GABAa	0.4	0.07	0.43	-0.03	-0.0003	<0.0001	-8.64	-0.11	<0.0001
H3	-0.28	0.11	-0.27	0.02	0.0002	0.0665	2.15	0.03	0.6061
M1	0.33	0.07	0.34	0	0	1	1.61	0.02	1
µ	-0.5	0.13	-0.53	0.09	0.0016	<0.0001	14.11	0.18	<0.0001
NET	0.51	0.12	0.57	-0.11	-0.0016	<0.0001	-30.12	-0.38	<0.0001
NMDA	-0.13	0.07	-0.13	-0.13	-0.001	<0.0001	-20.97	-0.26	<0.0001
SERT	-0.5	0.06	-0.54	-0.14	-0.0012	<0.0001	-26.31	-0.33	<0.0001
VAChT	-0.56	0.1	-0.63	-0.04	-0.0006	<0.0001	-14.69	-0.18	<0.0001
mGluR5	0.3	0.1	0.32	0.02	0.0002	0.0218	-1.76	-0.02	1

* The distribution of all Fisher's z-transformed Spearman correlation coefficients (Rho) regarding a specific neurotransmitter system were all significantly (one-sample t-test, P_{BH}<0.0001) different from a null-distribution. IQR: Interquartile range of Spearman correlation coefficients.

**Aging effects and sex differences based on linear regression and comparison (t-test, alpha=0.05), respectively, between men and women in individual Fisher's z-transformed Spearman correlation coefficients. Not significant aging effects and sex differences are highlighted in red. P_{BH}: Bonferroni-Holm corrected P-value

Supplementary Table 15: Co-localization strength of **LCOR** with neurotransmitter systems and the effects of age and sex – *after atrophy correction*.

	Co-localization strength*			Linear aging effects**			Sex differences**		
Neurotransmitter system	Median rho	IQR rho	Mean Fisher's z(rho)	Pearson r	Slope	P_{BH}	T	Cohen's d	P_{BH}
5-HT1a	-0.3	0.1	-0.31	0	-0.0001	1	-1.91	-0.02	1
5-HT1b	0.32	0.11	0.33	0.11	0.0013	<0.0001	6.45	0.08	<0.0001
5-HT2a	0.2	0.11	0.2	0.12	0.0014	<0.0001	9.47	0.12	<0.0001
5-HT4	-0.4	0.1	-0.42	0.01	0.0002	0.4093	6.14	0.08	<0.0001
5-HT6	0.29	0.12	0.31	-0.05	-0.0006	<0.0001	-3.92	-0.05	0.0017
A4B2	0.04	0.1	0.04	0.06	0.0006	<0.0001	3.15	0.04	0.0312
CB1	-0.25	0.13	-0.25	0.06	0.0009	<0.0001	7.21	0.09	<0.0001
D1	-0.26	0.14	-0.25	-0.07	-0.001	<0.0001	0.2	0	1
D2	-0.43	0.13	-0.46	-0.09	-0.0015	<0.0001	-7.34	-0.09	<0.0001
DAT	-0.39	0.16	-0.41	-0.17	-0.0032	<0.0001	-11.62	-0.15	<0.0001
GABAa	0.49	0.09	0.54	-0.04	-0.0005	<0.0001	-2.53	-0.03	0.2167
H3	-0.21	0.16	-0.2	-0.05	-0.0008	<0.0001	-2.91	-0.04	0.0689
M1	0.22	0.11	0.23	0.06	0.0007	<0.0001	7.82	0.1	<0.0001
μ	-0.51	0.13	-0.54	0.02	0.0003	0.041	7.89	0.1	<0.0001
NET	0.59	0.12	0.67	-0.1	-0.0017	<0.0001	-23.99	-0.3	<0.0001
NMDA	0.15	0.14	0.15	-0.18	-0.0026	<0.0001	-13.3	-0.17	<0.0001
SERT	-0.29	0.15	-0.3	-0.19	-0.003	<0.0001	-16.56	-0.21	<0.0001
VAChT	-0.33	0.19	-0.34	-0.15	-0.0032	<0.0001	-14.51	-0.18	<0.0001
mGluR5	0.38	0.14	0.41	-0.03	-0.0005	0.0001	-3.83	-0.05	0.0025

* The distribution of all Fisher's z-transformed Spearman correlation coefficients (Rho) regarding a specific neurotransmitter system were all significantly (one-sample t-test, P_{BH}<0.0001) different from a null-distribution. IQR: Interquartile range of Spearman correlation coefficients.

**Aging effects and sex differences based on linear regression and comparison (t-test, alpha=0.05), respectively, between men and women in individual Fisher's z-transformed Spearman correlation coefficients. Not significant aging effects and sex differences are highlighted in red. P_{BH}: Bonferroni-Holm corrected P-value

Supplementary Table 16: Co-localization strength of **GCOR** with neurotransmitter systems and the effects of age and sex – *after atrophy correction*.

	Co-localization strength*			Linear aging effects**			Sex differences**		
Neurotransmitter system	Median rho	IQR rho	Mean Fisher's z(rho)	Pearson r	Slope	P_{BH}	T	Cohen's d	P_{BH}
5-HT1a	-0.24	0.21	-0.24	-0.1	-0.0021	<0.0001	-9.63	-0.12	<0.0001
5-HT1b	0.14	0.16	0.14	0.08	0.0013	<0.0001	-11.41	-0.14	<0.0001
5-HT2a	0.1	0.17	0.1	0.02	0.0003	0.1381	-1.41	-0.02	1
5-HT4	-0.28	0.16	-0.28	-0.01	-0.0002	0.8886	2	0.03	0.8675
5-HT6	0.19	0.19	0.19	-0.04	-0.0007	<0.0001	-16.16	-0.2	<0.0001
A4B2	0.08	0.2	0.08	-0.01	-0.0001	1	-3.85	-0.05	0.0023
CB1	-0.26	0.22	-0.25	-0.04	-0.0009	<0.0001	-9.9	-0.12	<0.0001
D1	-0.2	0.22	-0.2	0	0.0001	1	-8.6	-0.11	<0.0001
D2	-0.29	0.21	-0.3	-0.06	-0.0014	<0.0001	-9.96	-0.12	<0.0001
DAT	-0.23	0.22	-0.23	-0.05	-0.0011	<0.0001	-9.43	-0.12	<0.0001
GABAa	0.31	0.16	0.32	-0.02	-0.0004	0.02	-15.39	-0.19	<0.0001
H3	-0.17	0.28	-0.17	-0.04	-0.001	<0.0001	-11.03	-0.14	<0.0001
M1	0.09	0.14	0.09	0.07	0.0009	<0.0001	-7.33	-0.09	<0.0001
μ	-0.37	0.25	-0.37	-0.01	-0.0004	0.5992	-2	-0.03	0.8633
NET	0.5	0.23	0.53	-0.1	-0.0028	<0.0001	-19.76	-0.25	<0.0001
NMDA	0.16	0.19	0.16	-0.05	-0.0008	<0.0001	-12.25	-0.15	<0.0001
SERT	-0.17	0.18	-0.18	-0.06	-0.0011	<0.0001	-9.47	-0.12	<0.0001
VAChT	-0.15	0.28	-0.15	-0.1	-0.0028	<0.0001	-11.69	-0.15	<0.0001
mGluR5	0.27	0.27	0.28	-0.08	-0.002	<0.0001	-19.23	-0.24	<0.0001

* The distribution of all Fisher's z-transformed Spearman correlation coefficients (Rho) regarding a specific neurotransmitter system were all significantly (one-sample t-test, P_{BH}<0.0001) different from a null-distribution. IQR: Interquartile range of Spearman correlation coefficients.

**Aging effects and sex differences based on linear regression and comparison (t-test, alpha=0.05), respectively, between men and women in individual Fisher's z-transformed Spearman correlation coefficients. Not significant aging effects and sex differences are highlighted in red. P_{BH}: Bonferroni-Holm corrected P-value

Supplementary Table 17: Statistical key figures of the White- and Goldfeld-Quandt-test for heteroskedasticity in the co-localizations (Fisher's z-transformed Spearman correlation coefficients) – *before atrophy correction*.

	White-test						Goldfeld-Quandt-test					
	fALFF		LCOR		GCOR		fALFF		LCOR		GCOR	
Neurotrans-mitter system	F	pFDR	F	pFDR	F	pFDR	F	pFDR	F	pFDR	F	pFDR
5-HT1a	**13.43**	**<0.0001**	2.78	0.07	**23.07**	**<0.0001**	**1.11**	**6.5E-07**	-	-	0.88	1
5-HT1b	**4.01**	**0.025**	2.79	0.07	**4.81**	**0.015**	0.95	0.99	-	-	**1.06**	**0.013**
5-HT2a	**4.66**	**0.015**	**7.46**	**0.0008**	0.49	0.68	**1.06**	**0.025**	**1.05**	**0.022**	-	-
5-HT4	**14.68**	**<0.0001**	**28.91**	**<0.0001**	1.16	0.40	**1.10**	**<0.0001**	**1.15**	**<0.0001**	-	-
5-HT6	1.03	0.40	**7.88**	**0.0006**	**4.76**	**0.015**	-	-	**1.08**	**0.0003**	**1.05**	**0.021**
A4B2	1.13	0.38	2.64	0.07	**22.04**	**<0.0001**	-	-	-	-	0.86	1
CB1	**4.63**	**0.015**	**7.9**	**0.0006**	**6.66**	**0.003**	**1.04**	**0.027**	**1.08**	**0.0003**	0.92	1
D1	**16.01**	**<0.0001**	**4.52**	**0.014**	1.79	0.24	**1.13**	**<0.0001**	**1.06**	**0.003**	-	-
D2	**19.55**	**<0.0001**	**16.12**	**<0.0001**	0.22	0.80	**1.14**	**<0.0001**	**1.13**	**<0.0001**	-	-
DAT	**14.98**	**<0.0001**	**13.47**	**<0.0001**	1.27	0.38	**1.14**	**<0.0001**	**1.09**	**<0.0001**	-	-
GABAa	**6.19**	**0.004**	**11.34**	**<0.0001**	1.95	0.22	1.04	0.06	**1.10**	**<0.0001**	-	-
H3	**13.53**	**<0.0001**	**16.36**	**<0.0001**	0.44	0.68	**1.10**	**<0.0001**	**1.13**	**<0.0001**	-	-
M1	0.45	0.67	**4.78**	**0.011**	**10.46**	**0.0001**	-	-	1.03	0.07	**1.10**	**<0.0001**
μ-opioid	**4.1**	**0.02**	3.13	0.052	**29.49**	**<0.0001**	1.03	0.13	-	-	0.86	1
NET	**13.24**	**<0.0001**	**50.27**	**<0.0001**	**9.07**	**0.0004**	**1.09**	**<0.0001**	**1.22**	**<0.0001**	**1.09**	**0.0004**
NMDA	2.42	0.11	**17.32**	**<0.0001**	**7.51**	**0.002**	-	-	**1.10**	**<0.0001**	**1.06**	**0.013**
SERT	0.13	0.88	**14.51**	**<0.0001**	**4.97**	**0.015**	-	-	**1.07**	**0.002**	**1.05**	**0.020**
VAChT	**37.62**	**<0.0001**	**18.68**	**<0.0001**	0.59	0.66	**1.18**	**<0.0001**	**1.11**	**<0.0001**	-	-
mGluR5	**10.91**	**<0.0001**	**25.01**	**<0.0001**	**7.29**	**0.002**	**1.10**	**<0.0001**	**1.18**	**<0.0001**	**1.05**	**0.020**

Bold numbers highlight significant results. F: F-statitstic.

Supplementary Table 18: Statistical key figures of the White- and Goldfeld-Quandt-test for heteroskedasticity in the co-localizations (Fisher's z-transformed Spearman correlation coefficients) – *after atrophy correction*.

	White-test						Goldfeld-Quandt-test					
	fALFF		LCOR		GCOR		fALFF		LCOR		GCOR	
Neurotrans-mitter system	F	pFDR	F	pFDR	F	pFDR	F	pFDR	F	pFDR	F	pFDR
5-HT1a	**11.59**	**<0.0001**	2.16	0.12	**26.28**	**<0.0001**	**1.11**	**<0.0001**	-	-	0.87	1
5-HT1b	**3.77**	**0.034**	3.12	0.053	3.6	0.058	0.95	0.99	-	-	-	-
5-HT2a	**4.9**	**0.013**	**6.59**	**0.002**	0.18	0.83	**1.07**	**0.001**	1.04	0.051	-	-
5-HT4	**12.72**	**<0.0001**	**23.09**	**<0.0001**	0.49	0.74	**1.09**	**<0.0001**	**1.14**	**<0.0001**	-	-
5-HT6	0.77	0.52	**6.29**	**0.003**	2.67	0.12	-	-	**1.07**	**0.001**	-	-
A4B2	1.05	0.42	1.61	0.20	**25.34**	**<0.0001**	-	-	-	-	0.85	1
CB1	**3.95**	**0.030**	**6.89**	**0.002**	**7.28**	**0.003**	**1.04**	**0.042**	**1.07**	**0.001**	0.92	1
D1	**13.64**	**<0.0001**	**3.31**	**0.046**	0.83	0.63	**1.12**	**<0.0001**	**1.05**	**0.012**	-	-
D2	**17.44**	**<0.0001**	**12.64**	**<0.0001**	0.78	0.63	**1.13**	**<0.0001**	**1.11**	**<0.0001**	-	-
DAT	**15.27**	**<0.0001**	**9.5**	**0.0002**	0.41	0.75	**1.14**	**<0.0001**	**1.07**	**0.001**	-	-
GABAa	**5.54**	**0.007**	**8.01**	**0.0006**	0.33	0.76	1.03	0.07	**1.08**	**0.0002**	-	-
H3	**11.57**	**<0.0001**	**14.99**	**<0.0001**	0.4	0.75	**1.09**	**<0.0001**	**1.12**	**<0.0001**	-	-
M1	0.34	0.75	**3.64**	**0.036**	**7.87**	**0.002**	-	-	1.02	0.13	**1.09**	**0.0003**
μ-opioid	**3.46**	**0.042**	3.04	0.054	**29.43**	**<0.0001**	1.02	0.18	-	-	0.86	1
NET	**10.95**	**<0.0001**	**37.38**	**<0.0001**	**5.24**	**0.017**	**1.08**	**0.0002**	**1.19**	**<0.0001**	**1.06**	**0.008**
NMDA	2.62	0.09	**12.42**	**<0.0001**	**4**	**0.044**	-	-	**1.08**	**0.0004**	1.04	0.13
SERT	0.06	0.94	**10.68**	**<0.0001**	2.92	0.10	-	-	**1.05**	**0.018**	-	-
VAChT	**35.68**	**<0.0001**	**15.35**	**<0.0001**	0.94	0.62	**1.18**	**<0.0001**	**1.09**	**<0.0001**	-	-
mGluR5	**11.86**	**<0.0001**	**22.69**	**<0.0001**	**4.03**	**0.044**	**1.11**	**<0.0001**	**1.17**	**<0.0001**	1.03	0.13

Bold numbers highlight significant results. F: F-statitstic.

Supplementary Table 19: Deviation scores of subjects with manifest PD compared to normative models – *before atrophy correction*.

	fALFF		LCOR		GCOR	
Neurotransmitter system	Median Z	P_{FDR}	Median Z	P_{FDR}	Median Z	P_{FDR}
5-HT1a	-0.13	0.4435	0.07	0.797	0.01	0.775
5-HT1b	**-0.4**	**0.0043**	**-0.29**	**0.0478**	**-0.29**	**0.0163**
5-HT2a	-0.26	0.1052	0	0.7309	-0.01	0.5572
5-HT4	-0.16	0.9167	-0.08	0.2989	-0.22	0.2844
5-HT6	**-0.47**	**0.0043**	**-0.39**	**0.0056**	**-0.51**	**0.0001**
A4B2	-0.07	0.9167	0.13	0.2677	-0.19	0.3655
CB1	-0.2	0.4435	-0.28	0.1216	-0.18	0.139
D1	-0.21	0.6035	**-0.29**	**0.0056**	**-0.43**	**0.0019**
D2	0.03	0.3857	**-0.56**	**0.0021**	**-0.45**	**0.0005**
DAT	-0.39	0.4435	**-0.45**	**0.0212**	**-0.37**	**0.0118**
GABAa	**-0.52**	**0.0089**	**-0.5**	**<0.0001**	**-0.64**	**0.0019**
H3	-0.25	0.0805	**-0.3**	**0.0245**	**-0.29**	**0.0306**
M1	**-0.56**	**0.0031**	-0.17	0.1156	**-0.52**	**0.0005**
Mu	-0.26	0.3275	-0.27	0.2523	0	0.5121
NET	-0.18	0.2474	**-0.46**	**0.0011**	**-0.31**	**0.0306**
NMDA	-0.09	0.9167	**-0.38**	**0.0021**	**-0.5**	**0.0005**
SERT	-0.25	0.9167	-0.41	0.0772	**-0.37**	**0.0337**
VAChT	-0.23	0.3319	**-0.26**	**0.0478**	-0.22	0.1279
mGluR5	**-0.43**	**0.0061**	**-0.43**	**0.0023**	**-0.33**	**0.0005**

Bold numbers highlight significant correlations. Median Z: Median deviation score of all subjects with manifest Parkinson's disease.

Supplementary Table 20: Deviation scores of subjects with manifest PD compared to normative models – *after atrophy correction*.

	fALFF		LCOR		GCOR	
Neurotransmitter system	Median Z	P_{FDR}	Median Z	P_{FDR}	Median Z	P_{FDR}
5-HT1a	-0.18	0.3879	0.05	0.8283	0.01	0.803
5-HT1b	**-0.38**	**0.0052**	-0.31	0.0512	**-0.38**	**0.0137**
5-HT2a	-0.21	0.101	-0.01	0.729	-0.01	0.5539
5-HT4	-0.2	0.9584	-0.11	0.299	-0.22	0.3222
5-HT6	**-0.45**	**0.0058**	**-0.41**	**0.0066**	**-0.43**	**0.0001**
A4B2	-0.09	0.9584	0.13	0.2565	-0.16	0.3484
CB1	-0.22	0.3805	-0.29	0.1182	-0.24	0.123
D1	-0.17	0.7212	**-0.38**	**0.0066**	**-0.49**	**0.002**
D2	0	0.3805	**-0.52**	**0.0023**	**-0.47**	**0.0007**
DAT	-0.31	0.4792	**-0.47**	**0.0244**	**-0.26**	**0.014**
GABAa	**-0.58**	**0.0128**	**-0.48**	**0.0001**	**-0.6**	**0.002**
H3	-0.29	0.0753	**-0.31**	**0.0256**	**-0.3**	**0.0347**
M1	**-0.59**	**0.0032**	-0.21	0.1203	**-0.59**	**0.0006**
Mu	-0.26	0.3115	-0.29	0.2242	0	0.4845
NET	-0.13	0.3805	**-0.48**	**0.0012**	**-0.29**	**0.0347**
NMDA	-0.09	0.962	**-0.35**	**0.0023**	**-0.46**	**0.0006**
SERT	-0.25	0.9584	-0.41	0.0813	**-0.35**	**0.043**
VAChT	-0.19	0.3805	-0.24	0.0512	-0.22	0.1384
mGluR5	**-0.42**	**0.0058**	**-0.39**	**0.0027**	**-0.3**	**0.0007**

Bold numbers highlight significant correlations. Median Z: Median deviation score of all subjects with manifest Parkinson's disease.

Supplementary Table 21: Correlation between deviation scores and reported disease duration in subjects with manifest PD – *before atrophy correction*.

	fALFF		LCOR		GCOR	
Neurotransmitter system	Pearson r	P_{FDR}	Pearson r	P_{FDR}	Pearson r	P_{FDR}
5-HT1a	-	-	-	-	-	-
5-HT1b	-0.16	0.3969	-0.2	0.6141	-0.13	0.9659
5-HT2a	-	-	-	-	-	-
5-HT4	-	-	-	-	-	-
5-HT6	-0.06	0.7641	-0.11	0.7756	-0.03	0. 9659
A4B2	-	-	-	-	-	-
CB1	-	-	-	-	-	-
D1	-	-	-0.16	0.6141	-0.07	0. 9659
D2	-	-	-0.03	0.9121	0.02	0. 9659
DAT	-	-	-0.01	0.9121	-0.02	0. 9659
GABAa	-0.16	0. 3969	**-0.38**	**0.0317**	-0.11	0. 9659
H3	-	-	-0.02	0.9121	0.01	0. 9659
M1	-0.22	0. 3969	-	-	-0.21	0. 9659
Mu	-	-	-	-	-	-
NET	-	-	0.13	0.7508	0.02	0. 9659
NMDA	-	-	-0.02	0.9121	-0.06	0. 9659
SERT	-	-	-	-	0.07	0. 9659
VAChT	-	-	0.18	0.6141	-	-
mGluR5	0.04	0. 7641	-0.09	0.8153	0.01	0. 9659

Bold numbers highlight significant correlations. Empty cells indicate pairs of functional measure and neurotransmitter system whose co-localization in PD was not significantly different from the norm.

Supplementary Table 22: Correlation between deviation scores and reported disease duration in subjects with manifest PD – *after atrophy correction*.

	fALFF		LCOR		GCOR	
Neurotransmitter system	Pearson r	P_{FDR}	Pearson r	P_{FDR}	Pearson r	P_{FDR}
5-HT1a	-	-	-	-	-	-
5-HT1b	-0.14	0.4986	-	-	-0.12	0.9744
5-HT2a	-	-	-	-	-	-
5-HT4	-	-	-	-	-	-
5-HT6	-0.05	0.7495	-0.09	0.9335	-0.03	0. 9744
A4B2	-	-	-	-	-	-
CB1	-	-	-	-	-	-
D1	-	-	-0.16	0. 9335	-0.07	0. 9744
D2	-	-	-0.02	0. 9335	0.03	0. 9744
DAT	-	-	-0.02	0. 9335	-0.02	0. 9744
GABAa	-0.16	0. 4986	**-0.38**	**0.0295**	-0.10	0. 9744
H3	-	-	-0.01	0. 9335	0.004	0. 9744
M1	-0.20	0. 4986	-	-	-0.20	0. 9744
Mu	-	-	-	-	-	-
NET	-	-	0.13	0. 9335	0.02	0. 9744
NMDA	-	-	-0.02	0. 9335	-0.06	0. 9744
SERT	-	-	-	-	0.07	0. 9744
VAChT	-	-	-	-	-	-
mGluR5	0.04	0. 7495	-0.08	0. 9335	0.01	0. 9744

Bold numbers highlight significant correlations. Empty cells indicate pairs of functional measure and neurotransmitter system whose co-localization in PD was not significantly different from the norm.

Supplementary Table 23: Correlation between deviation scores and cognitive scores in subjects with manifest PD – fALFF, *before atrophy correction*.

fALFF	Fluid intelligence (DF: 20016)		Numeric memory (DF: 4282)		Associated learning (DF: 20197)		Prospective memory (DF: 20018)		Reaction time (DF: 20023)		Symbol digit modality test (DF: 23324)		Trail making test, AN (DF: 6350)	
Neurotransmitter system	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}
5-HT1b	-0.03	0.96	-0.11	0.84	0.03	0.96	0.35	0.54	0.07	0.92	-0.21	0.75	0.08	0.92
5-HT6	-0.02	0.96	-0.13	0.82	-0.05	0.96	-0.05	0.96	0.13	0.75	-0.19	0.75	0.21	0.75
GABAa	-0.18	0.75	-0.35	0.54	0.04	0.96	0	0.98	0.21	0.75	-0.05	0.96	0.26	0.75
M1	-0.16	0.75	-0.11	0.84	0.15	0.75	0.13	0.75	-0.01	0.96	-0.18	0.75	0.09	0.91
mGluR5	-0.13	0.75	-0.26	0.75	-0.02	0.96	-0.1	0.84	0.17	0.75	-0.25	0.75	0.25	0.75

DF: Datafield of cognitive score (instance 2: imaging visit) used for correlation analysis (cf.https://biobank.ndph.ox.ac.uk/showcase/).
AN: Trail making test, alphanumeric path.

Supplementary Table 24: Correlation between deviation scores and cognitive scores in subjects with manifest PD – fALFF, *after atrophy correction*.

fALFF	Fluid intelligence (DF: 20016)		Numeric memory (DF: 4282)		Associated learning (DF: 20197)		Prospective memory (DF: 20018)		Reaction time (DF: 20023)		Symbol digit modality test (DF: 23324)		Trail making test, AN (DF: 6350)	
Neurotransmitter system	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}
5-HT1b	-0.02	0.98	-0.12	0.79	0.03	0.98	0.34	0.57	0.08	0.83	-0.21	0.7	0.07	0.9
5-HT6	-0.03	0.98	-0.15	0.74	-0.09	0.83	-0.01	0.98	0.16	0.7	-0.2	0.7	0.19	0.7
GABAa	-0.21	0.7	-0.32	0.7	0.01	0.98	0.04	0.98	0.23	0.7	-0.09	0.83	0.27	0.7
M1	-0.18	0.7	-0.11	0.81	0.14	0.74	0.12	0.74	0.02	0.98	-0.18	0.7	0.11	0.81
mGluR5	-0.13	0.74	-0.24	0.7	0	0.98	-0.11	0.79	0.14	0.74	-0.23	0.7	0.23	0.7

DF: Datafield of cognitive score (instance 2: imaging visit) used for correlation analysis (cf.https://biobank.ndph.ox.ac.uk/showcase/).
AN: Trail making test, alphanumeric path.

Supplementary Table 25: Correlation between deviation scores and cognitive scores in subjects with manifest PD - LCOR, *before atrophy correction*.

LCOR	Fluid intelligence (DF: 20016)		Numeric memory (DF: 4282)		Associated learning (DF: 20197)		Prospective memory (DF: 20018)		Reaction time (DF: 20023)		Symbol digit modality test (DF: 23324)		Trail making test, AN (DF: 6350)	
Neurotransmitter system	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}
5-HT1b	-0.06	0.99	-0.01	0.99	0.19	0.99	0.02	0.99	-0.1	0.99	-0.15	0.99	0.14	0.99
5-HT6	0.04	0.99	0	0.99	0.05	0.99	0.03	0.99	0.02	0.99	-0.17	0.99	0.01	0.99
D1	0.13	0.99	-0.19	0.99	0.07	0.99	0.04	0.99	0.07	0.99	-0.13	0.99	0.06	0.99
D2	-0.03	0.99	-0.01	0.99	0.04	0.99	-0.04	0.99	0.18	0.99	-0.1	0.99	-0.03	0.99
DAT	0.14	0.99	-0.31	0.99	-0.22	0.99	-0.01	0.99	0.08	0.99	0	0.99	-0.09	0.99
GABAa	0.03	0.99	-0.16	0.99	0.07	0.99	0.19	0.99	0.13	0.99	-0.04	0.99	0.03	0.99
H3	0.05	0.99	-0.22	0.99	0.06	0.99	0.12	0.99	0.02	0.99	-0.17	0.99	0.07	0.99
NET	-0.2	0.99	-0.2	0.99	-0.22	0.99	-0.04	0.99	0.28	0.99	-0.24	0.99	-0.1	0.99
NMDA	0.16	0.99	-0.25	0.99	-0.23	0.99	0.06	0.99	0.13	0.99	-0.07	0.99	-0.13	0.99
VAChT	0.11	0.99	-0.36	0.99	-0.25	0.99	-0.03	0.99	0.01	0.99	-0.04	0.99	-0.02	0.99
mGluR5	-0.03	0.99	-0.17	0.99	0.03	0.99	0.09	0.99	0.1	0.99	-0.2	0.99	0.12	0.99

DF: Datafield of cognitive score (instance 2: imaging visit) used for correlation analysis (cf.https://biobank.ndph.ox.ac.uk/showcase/).
AN: Trail making test, alphanumeric path.

Supplementary Table 26: Correlation between deviation scores and cognitive scores in subjects with manifest PD - LCOR, *after atrophy correction*.

LCOR	Fluid intelligence (DF: 20016)		Numeric memory (DF: 4282)		Associated learning (DF: 20197)		Prospective memory (DF: 20018)		Reaction time (DF: 20023)		Symbol digit modality test (DF: 23324)		Trail making test, AN (DF: 6350)	
Neurotransmitter system	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}
5-HT1b	-0.07	0.99	-0.01	0.99	0.19	0.99	0.01	0.99	-0.09	0.99	-0.15	0.99	0.13	0.99
5-HT6	0.02	0.99	0	0.99	0.06	0.99	0.03	0.99	0.04	0.99	-0.19	0.99	0.03	0.99
D1	0.13	0.99	-0.2	0.99	0.07	0.99	0.05	0.99	0.07	0.99	-0.11	0.99	0.05	0.99
D2	-0.03	0.99	-0.02	0.99	0.07	0.99	-0.02	0.99	0.21	0.99	-0.09	0.99	-0.05	0.99
DAT	0.15	0.99	-0.29	0.99	-0.21	0.99	-0.01	0.99	0.09	0.99	-0.01	0.99	-0.11	0.99
GABAa	0.03	0.99	-0.14	0.99	0.1	0.99	0.2	0.99	0.17	0.99	-0.05	0.99	0	0.99
H3	0.04	0.99	-0.21	0.99	0.08	0.99	0.12	0.99	0.04	0.99	-0.19	0.99	0.09	0.99
NET	-0.19	0.99	-0.21	0.99	-0.2	0.99	-0.04	0.99	0.27	0.99	-0.24	0.99	-0.11	0.99
NMDA	0.16	0.99	-0.24	0.99	-0.22	0.99	0.05	0.99	0.15	0.99	-0.08	0.99	-0.12	0.99
VAChT	0.11	0.99	-0.34	0.99	-0.24	0.99	-0.02	0.99	0.02	0.99	-0.04	0.99	-0.02	0.99
mGluR5	-0.03	0.99	-0.15	0.99	0.04	0.99	0.11	0.99	0.13	0.99	-0.21	0.99	0.13	0.99

DF: Datafield of cognitive score (instance 2: imaging visit) used for correlation analysis (cf.https://biobank.ndph.ox.ac.uk/showcase/).
AN: Trail making test, alphanumeric path.

Supplementary Table 27: Correlation between deviation scores and cognitive scores in subjects with manifest PD - GCOR, *before atrophy correction*.

GCOR	Fluid intelligence (DF: 20016)		Numeric memory (DF: 4282)		Associated learning (DF: 20197)		Prospective memory (DF: 20018)		Reaction time (DF: 20023)		Symbol digit modality test (DF: 23324)		Trail making test, AN (DF: 6350)	
Neurotransmitter system	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}
5-HT1b	-0.38	0.44	-0.24	0.63	-0.04	0.95	-0.06	0.95	0.04	0.95	-0.14	0.95	0.35	0.55
5-HT6	-0.27	0.63	-0.27	0.63	-0.1	0.95	0.04	0.95	0.14	0.91	-0.31	0.63	0.37	0.47
D1	0.04	0.95	-0.26	0.63	0.16	0.91	0.04	0.95	-0.02	0.95	-0.02	0.96	0.15	0.95
D2	-0.06	0.95	0.12	0.95	0.26	0.63	0.08	0.95	0.02	0.95	-0.03	0.95	-0.09	0.95
DAT	0.11	0.95	-0.16	0.91	0.06	0.95	-0.03	0.95	0.06	0.95	0.02	0.95	0.01	0.96
GABAa	-0.17	0.8	-0.39	0.44	-0.26	0.63	-0.14	0.91	0.05	0.95	-0.05	0.95	0.11	0.95
H3	-0.09	0.95	-0.24	0.63	0.03	0.95	0.11	0.95	0	0.99	-0.2	0.76	0.26	0.63
M1	-0.09	0.95	0.01	0.96	0.19	0.8	-0.04	0.95	-0.05	0.95	0.08	0.95	-0.03	0.95
NET	-0.15	0.91	-0.23	0.69	-0.44	0.44	-0.02	0.95	0.26	0.63	-0.22	0.69	0.2	0.8
NMDA	0.12	0.95	-0.24	0.63	-0.28	0.63	-0.06	0.95	0.1	0.95	-0.03	0.95	0.11	0.95
SERT	0.12	0.95	-0.27	0.63	0.05	0.95	0.04	0.95	0.11	0.95	0.02	0.95	-0.09	0.95
mGluR5	-0.19	0.76	-0.27	0.63	-0.09	0.95	0.11	0.95	0.05	0.95	-0.21	0.75	0.26	0.63

DF: Datafield of cognitive score (instance 2: imaging visit) used for correlation analysis (cf.https://biobank.ndph.ox.ac.uk/showcase/).
AN: Trail making test, alphanumeric path.

Supplementary Table 28: Correlation between deviation scores and cognitive scores in subjects with manifest PD - GCOR, *after atrophy correction*.

GCOR	Fluid intelligence (DF: 20016)		Numeric memory (DF: 4282)		Associated learning (DF: 20197)		Prospective memory (DF: 20018)		Reaction time (DF: 20023)		Symbol digit modality test (DF: 23324)		Trail making test, AN (DF: 6350)	
Neurotransmitter system	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}	r	P_{FDR}
5-HT1b	-0.37	0.32	-0.26	0.66	-0.05	0.99	-0.06	0.99	0.02	0.99	-0.15	0.83	0.36	0.52
5-HT6	-0.29	0.62	-0.25	0.66	-0.11	0.94	0.01	0.99	0.14	0.82	-0.34	0.56	0.41	0.32
D1	0.03	0.99	-0.25	0.66	0.19	0.77	0.04	0.99	0	0.99	-0.03	0.99	0.17	0.81
D2	-0.05	0.99	0.15	0.83	0.28	0.66	0.08	0.97	0.02	0.99	-0.03	0.99	-0.1	0.97
DAT	0.1	0.94	-0.14	0.83	0.05	0.99	-0.03	0.99	0.07	0.98	0	0.99	0.03	0.99
GABAa	-0.18	0.74	-0.37	0.47	-0.25	0.66	-0.16	0.77	0.06	0.99	-0.07	0.99	0.13	0.9
H3	-0.11	0.94	-0.24	0.66	0.02	0.99	0.11	0.91	0.01	0.99	-0.21	0.74	0.27	0.66
M1	-0.12	0.9	0	0.99	0.18	0.77	-0.05	0.99	-0.02	0.99	0.06	0.99	0.02	0.99
NET	-0.17	0.77	-0.23	0.67	-0.44	0.32	-0.01	0.99	0.25	0.66	-0.23	0.67	0.19	0.77
NMDA	0.08	0.97	-0.25	0.66	-0.25	0.66	-0.06	0.99	0.13	0.83	-0.06	0.99	0.17	0.81
SERT	0.11	0.91	-0.22	0.67	0.09	0.97	0.04	0.99	0.15	0.81	0.03	0.99	-0.09	0.97
mGluR5	-0.19	0.72	-0.26	0.66	-0.09	0.97	0.1	0.94	0.04	0.99	-0.22	0.67	0.27	0.66

DF: Datafield of cognitive score (instance 2: imaging visit) used for correlation analysis (cf.https://biobank.ndph.ox.ac.uk/showcase/).
AN: Trail making test, alphanumeric path.

Supplementary Table 29: Statistics on the correlation of effect sizes (Cohen's d) in fALFF, LCOR, and GCOR between PD and HCmatched and the regional contributions ($\Delta\rho^2$) – *before atrophy correction*. This analysis was performed only for the pairs of brain measure and neurotransmitter system in which PD deviated significantly from the norm.

	fALFF		LCOR		GCOR	
Neurotransmitter map	Pearson r	P_{FDR}	Pearson r	P_{FDR}	Pearson r	P_{FDR}
5-HT1b	0.02	0.80	|r|<0.01	0.98	-0.1	0.42
5-HT6	0.11	0.48	0.12	0.34	0.15	0.31
D1	-	-	0.05	0.72	|r|<0.01	0.97
D2	-	-	-0.06	0.68	-0.05	0.69
DAT	-	-	0.16	0.28	0.14	0.31
GABAa	0.07	0.57	0.14	0.28	0.06	0.69
H3	-	-	-0.09	0.55	-0.02	0.91
M1	0.19	0.21	-	-	-0.11	0.39
NET	-	-	0.14	0.28	0.11	0.39
NMDA	-	-	**0.37**	**0.0003**	**0.44**	**<0.0001**
SERT	-	-	**-**	**-**	0.20	0.11
VAChT	-	-	-0.04	0.72	-	-
mGluR5	-0.10	0.48	**-0.28**	**0.013**	**0.28**	**0.014**

Bold numbers highlight significant correlation between effect sizes and regional contribution.

Supplementary Table 30: Statistics on the correlation of effect sizes (Cohen's d) in fALFF, LCOR, and GCOR between PD and HCmatched and the regional contributions ($\Delta\rho^2$) – *after atrophy correction*. This analysis was performed only for the pairs of brain measure and neurotransmitter system in which PD deviated significantly from the norm.

	fALFF		LCOR		GCOR	
Neurotransmitter map	Pearson r	P_{FDR}	Pearson r	P_{FDR}	Pearson r	P_{FDR}
5-HT1b	0.02	0.80	-	-	-0.13	0.27
5-HT6	0.12	0.49	0.10	0.48	**0.25**	**0.04**
D1	-	-	0.06	0.52	0.01	0.98
D2	-	-	-0.07	0.52	-0.06	0.63
DAT	-	-	0.17	0.20	0.14	0.27
GABAa	0.04	0.79	0.06	0.52	0.12	0.31
H3	-	-	-0.08	0.52	|r|<0.01	0.98
M1	**0.25**	**0.03**	-	-	-0.08	0.50
NET	-	-	0.12	0.44	0.14	0.27
NMDA	-	-	**0.35**	**0.0009**	**0.42**	**<0.0001**
SERT	-	-	**-**	**-**	0.20	0.10
VAChT	-	-	-	-	-	-
mGluR5	-0.09	0.48	**-0.28**	**0.0092**	0.22	0.06

Bold numbers highlight significant correlation between effect sizes and regional contribution.

Supplementary Table 31: Statistics on regional differences in fALFF, LCOR, and GCOR between PD and HCmatched assessed using the Mann-Whitney-U test – *before atrophy correction*.

	fALFF				LCOR				GCOR			
	Left		Right		Left		Right		Left		Right	
Region	U statistic	P_{FDR}	U statistic	P_{FDR}	U statistic	P_{FDR}	U statistic	P_{FDR}	U statistic	P_{FDR}	U statistic	P_{FDR}
Accumbens	1.64	0.4662	1.11	0.6261	**4.1**	**0.0013**	1.85	0.1216	**3.47**	**0.0087**	**2.56**	**0.0199**
Caudate	2.18	0.3162	1.69	0.4662	**3.12**	**0.0119**	1.81	0.1302	**3.95**	**0.0084**	**3.22**	**0.0101**
Putamen	1.26	0.5564	0.55	0.8665	**3.97**	**0.0017**	**2.66**	**0.0322**	**3.81**	**0.0084**	**3.11**	**0.0101**
Pallidum	1.25	0.5564	0.09	0.996	**3.4**	**0.0047**	2.22	0.0622	**2.63**	**0.0186**	**2.91**	**0.011**
Amygdala	0.67	0.8421	-0.13	0.996	**2.46**	**0.0475**	0.89	0.4933	**2.6**	**0.019**	2.03	0.0509
Hippocampus	0.72	0.8345	-0.08	0.996	**2.66**	**0.0322**	0.93	0.4761	**3.52**	**0.0087**	**2.13**	**0.0418**
Ant Cing Gyrus	0.96	0.7272	0.76	0.8139	1.96	0.0981	2.04	0.084	**2.38**	**0.0289**	**2.75**	**0.0152**
Mid Cing Gyrus	0.7	0.8421	0.63	0.8421	1.23	0.3314	1.32	0.287	**2.96**	**0.0106**	**3.03**	**0.0101**
Post Cing Gyrus	-0.16	0.996	-0.03	0.996	0.85	0.5198	0.56	0.6829	**2.21**	**0.0372**	**2.55**	**0.0199**
Parahip. Gyrus	-0.07	0.996	0.87	0.7707	1.58	0.1947	1.52	0.2104	**2.42**	**0.0267**	**2.6**	**0.019**
Subcallosal Area	0.21	0.996	0.24	0.996	2.23	0.0622	-0.35	0.8179	**2.07**	**0.0467**	0.48	0.63
Thalamus	1.21	0.5573	0.66	0.8421	1.69	0.157	0.99	0.4458	**2.76**	**0.015**	**2.3**	**0.0326**
Basal Forebrain	0.15	0.996	1.26	0.5564	**2.4**	**0.0496**	2.38	0.0504	**2.1**	**0.0445**	**2.87**	**0.0121**
Frontal Pole	0.37	0.9503	-0.19	0.996	0.51	0.7019	0.3	0.8449	0.78	0.4404	0.94	0.3558
Gyrus Rectus	0.43	0.9185	-0.08	0.996	1.08	0.4018	-0.07	0.9763	1.38	0.1815	**2.58**	**0.0195**
Frontal Operculum	1.81	0.4662	1.51	0.4874	**3.03**	**0.0134**	2.21	0.0622	**3.12**	**0.0101**	**2.56**	**0.0199**
Ant Orbital	1.39	0.5339	0.8	0.7994	**2.62**	**0.0347**	2.2	0.0622	**2.93**	**0.0109**	**2.14**	**0.0409**
Lat Orbital	1.57	0.4662	1.45	0.5282	**3.04**	**0.0134**	**3.06**	**0.0133**	**3.06**	**0.0101**	**2.84**	**0.0123**
Med Orbital	0.79	0.7994	0.93	0.7346	2.24	0.0622	**2.39**	**0.0496**	1.75	0.0917	**2.91**	**0.011**
Post Orbital	1.41	0.5339	1.24	0.5564	**2.72**	**0.0297**	2.35	0.0532	**2.61**	**0.019**	**2.34**	**0.03**
Frontal (Inf Tri)	1.76	0.4662	2.49	0.217	**2.87**	**0.0202**	**2.52**	**0.043**	**2.66**	**0.0179**	**2.9**	**0.0112**
Frontal (Inf Oper)	1.76	0.4662	1.24	0.5564	**2.43**	**0.0493**	**2.98**	**0.0147**	**2.35**	**0.0299**	**2.46**	**0.0241**
Frontal (Inf Orbit)	1.67	0.4662	1.95	0.4647	**2.61**	**0.0347**	**2.4**	**0.0496**	**3.14**	**0.0101**	**2.6**	**0.019**
Frontal (Med)	1.33	0.5564	0.63	0.8421	**2.5**	**0.0443**	1.36	0.2773	**2.23**	**0.0365**	**2.38**	**0.0289**
Frontal (Mid)	0.99	0.7108	0.67	0.8421	1.51	0.2131	1.78	0.1351	**2.55**	**0.0199**	**2.21**	**0.0372**
Frontal (Sup med)	0.86	0.7707	1.17	0.5875	2.32	0.0554	2.25	0.0622	**2.23**	**0.0365**	**2.66**	**0.0179**
Frontal (Sup)	-0.01	0.996	-0.15	0.996	0.27	0.8477	0.14	0.9356	**2.15**	**0.0409**	1.65	0.1107
SMA	1.0	0.7108	0.52	0.8748	1.11	0.3891	0.82	0.5302	**2.61**	**0.019**	**2.38**	**0.0289**
Precentral (Med)	-0.16	0.996	0.29	0.9944	0.6	0.656	0.79	0.5442	1.33	0.1941	1.36	0.1859
Precentral	0.64	0.8421	0.49	0.894	1.34	0.2822	2.17	0.0654	**2.36**	**0.0293**	**2.51**	**0.0217**
Postcentral (Med)	0.39	0.9402	-0.18	0.996	1.18	0.3473	0.64	0.6366	2.03	0.0509	1.25	0.2195
Postcentral	0.57	0.8643	-0.14	0.996	1.23	0.3314	1.55	0.2033	**2.28**	**0.0334**	**2.24**	**0.0365**

Central Operculum	2.67	0.1977	2.22	0.3118	**3.62**	**0.003**	**3.81**	**0.0028**	**3.21**	**0.0101**	**3.08**	**0.0101**
Parietal Operculum	2.28	0.3092	3.07	0.1977	**3.68**	**0.003**	**4.43**	**0.001**	**2.97**	**0.0104**	**2.85**	**0.0123**
Angular Gyrus	-0.01	0.996	0.79	0.7994	**2.46**	**0.0475**	**3.45**	**0.0044**	**3.08**	**0.0101**	**3.44**	**0.0087**
Supramarginal	0.73	0.8345	0.99	0.7108	**2.67**	**0.0322**	**4.23**	**0.001**	**3.49**	**0.0087**	**3.29**	**0.0101**
Parietal (Sup)	-0.91	0.7457	-0.59	0.8598	1.87	0.1192	2.06	0.0824	**3.11**	**0.0101**	**2.82**	**0.0129**
Precuneus	0.14	0.996	0.32	0.9797	**2.26**	**0.0622**	2.34	0.0532	**3.03**	**0.0101**	**3.17**	**0.0101**
Insula (Ant)	1.43	0.5339	1.34	0.5564	**2.76**	**0.0273**	**2.42**	**0.0493**	**3.48**	**0.0087**	**2.97**	**0.0104**
Insula (Post)	2.49	0.217	1.76	0.4662	**3.72**	**0.003**	**3.08**	**0.013**	**3.26**	**0.0101**	**2.98**	**0.0104**
Entorhinal	0.46	0.9028	0.01	0.996	1.71	0.1513	0.45	0.7488	**1.77**	**0.088**	**2.34**	**0.0302**
Fusiform Gyrus	-0.06	0.996	0.01	0.996	2.0	0.0927	1.2	0.3402	**3.02**	**0.0101**	**3.16**	**0.0101**
Temporal (Inf)	0.08	0.996	-0.2	0.996	2.21	0.0622	0.34	0.8185	**2.23**	**0.0365**	1.51	0.1456
Temporal (Mid)	0.53	0.8748	0.59	0.8598	2.08	0.0789	2.22	0.0622	**2.55**	**0.0199**	**3.03**	**0.0101**
Temporal (Sup)	1.28	0.5564	1.92	0.4647	2.19	0.0634	**3.44**	**0.0044**	**3.06**	**0.0101**	**3.1**	**0.0101**
Temporal Pole	0.55	0.8665	-0.16	0.996	1.85	0.1216	1.38	0.2682	**2.73**	**0.0154**	**2.16**	**0.0402**
Transverse temporal	2.27	0.3092	1.74	0.4662	**3.66**	**0.003**	**3.61**	**0.003**	**3.18**	**0.0101**	**2.93**	**0.0109**
Planum Polare	2.64	0.1977	2.07	0.3776	**3.71**	**0.003**	**3.46**	**0.0044**	**3.24**	**0.0101**	**3.47**	**0.0087**
Planum Temporale	2.89	0.1977	2.77	0.1977	**3.48**	**0.0044**	**4.22**	**0.001**	**2.7**	**0.0163**	**2.54**	**0.0199**
Calcarine Fissure	-1.57	0.4662	-1.22	0.5573	-0.21	0.8828	0.06	0.9763	**2.18**	**0.0387**	**2.31**	**0.0321**
Cuneus	-1.63	0.4662	-1.6	0.4662	0.03	0.9763	0.26	0.8556	**2.83**	**0.0126**	**2.65**	**0.0179**
Lingual Gyrus	-0.93	0.7346	-0.42	0.9204	0.04	0.9763	0.44	0.7493	1.91	0.0651	**2.23**	**0.0365**
Occipital fusiform	-1.12	0.6261	-0.81	0.7994	-0.1	0.9582	0.79	0.5442	2.01	0.0519	**2.37**	**0.0293**
Occipital (Inf)	-1.39	0.5339	-1.28	0.5564	0.04	0.9763	0.71	0.5947	2.03	0.0509	**3.0**	**0.0104**
Occipital (Mid)	-1.54	0.4786	-0.65	0.8421	1.0	0.4458	0.9	0.4927	**3.06**	**0.0101**	**2.73**	**0.0154**
Occipital (Sup)	-1.71	0.4662	-1.71	0.4662	0.54	0.6917	0.28	0.8477	**2.2**	**0.0372**	1.98	0.056
Occipital Pole	-1.73	0.4662	-1.59	0.4662	-0.7	0.6021	-0.93	0.4761	1.28	0.2103	1.4	0.1777
Cerebellum Exterior	-0.05	0.996	0.46	0.9028	1.8	0.1302	1.77	0.1372	**2.15**	**0.0409**	**2.14**	**0.041**
Vermis I-V	-0.35	0.9567	-	-	0.52	0.7002	-	-	1.39	0.1791	-	-
Vermis VI-VII	-0.04	0.996	-	-	0.68	0.6113	-	-	1.04	0.31	-	-
Vermis VIII-X	-0.01	0.996	-	-	1.02	0.4354	-	-	0.75	0.4562	-	-

Bold numbers highlight regions with significant differences in a specific measure (fALFF, LCOR, or GCOR) between PD and the matched subgroup of HC.

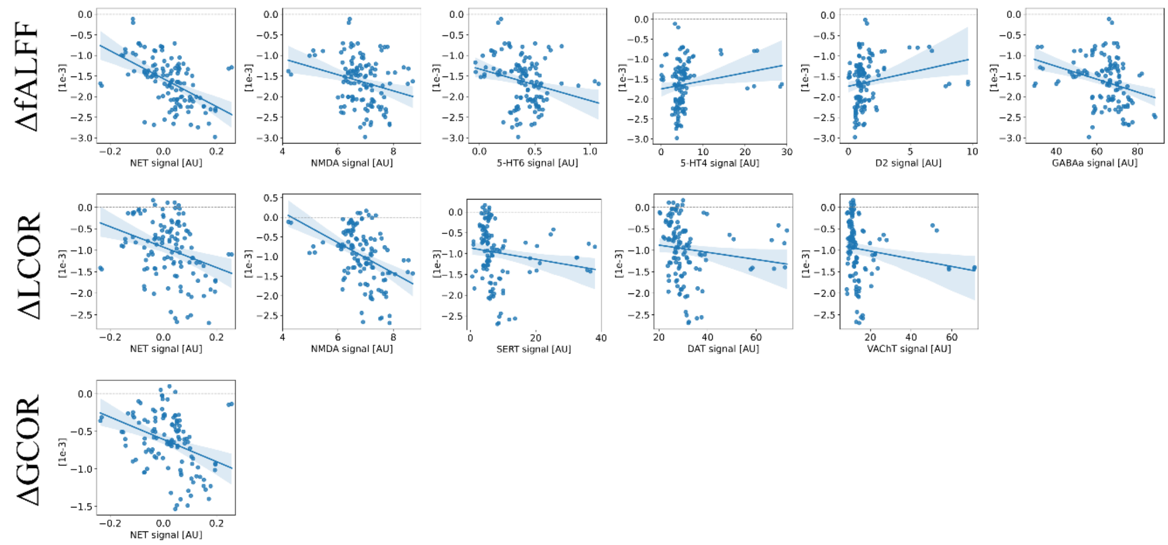
Supplementary Table 32: Statistics on regional differences in fALFF, LCOR, and GCOR between PD and HCmatched assessed using the Mann-Whitney-U test – *after atrophy correction*.

	fALFF				LCOR				GCOR			
	Left		Right		Left		Right		Left		Right	
Region	U statistic	P_{FDR}	U statistic	P_{FDR}	U statistic	P_{FDR}	U statistic	P_{FDR}	U statistic	P_{FDR}	U statistic	P_{FDR}
Accumbens	1.64	0.4111	1.09	0.6462	**4.08**	**0.0013**	1.81	0.1329	**3.47**	**0.0103**	**2.54**	**0.0206**
Caudate	2.07	0.4111	1.63	0.4111	**2.86**	**0.021**	1.66	0.1709	**3.8**	**0.0087**	**3.19**	**0.0103**
Putamen	1.32	0.5456	0.56	0.8821	**3.98**	**0.0016**	**2.65**	**0.0347**	**3.8**	**0.0087**	**3.11**	**0.0103**
Pallidum	1.26	0.5714	0.1	0.9934	**3.42**	**0.0052**	2.23	0.0629	**2.66**	**0.0183**	**2.92**	**0.011**
Amygdala	0.64	0.8632	-0.14	0.9934	2.43	0.0515	0.87	0.5169	**2.58**	**0.02**	2.03	0.051
Hippocampus	0.55	0.8821	-0.2	0.9934	2.41	0.0515	0.83	0.5323	**3.31**	**0.0103**	2.02	0.0519
Ant Cing Gyrus	0.95	0.7393	0.79	0.8157	1.98	0.0971	2.07	0.08	**2.39**	**0.0291**	**2.77**	**0.0146**
Mid Cing Gyrus	0.76	0.8191	0.65	0.8632	1.26	0.3172	1.32	0.2931	**2.97**	**0.011**	**3.03**	**0.0103**
Post Cing Gyrus	-0.19	0.9934	-0.03	0.9934	0.86	0.5178	0.57	0.6759	**2.21**	**0.0385**	**2.55**	**0.0206**
Parahip. Gyrus	-0.15	0.9934	0.8	0.8112	1.51	0.2193	1.48	0.2264	**2.37**	**0.0299**	**2.53**	**0.0206**
Subcallosal Area	0.23	0.9934	0.26	0.9934	2.29	0.0593	-0.34	0.8207	**2.06**	**0.0481**	0.47	0.6365
Thalamus	1.16	0.6016	0.64	0.8632	1.63	0.1783	0.95	0.4721	**2.73**	**0.0156**	**2.29**	**0.0338**
Basal Forebrain	0.09	0.9934	1.2	0.5797	2.34	0.0577	2.29	0.0593	**2.06**	**0.0481**	**2.77**	**0.0146**
Frontal Pole	0.38	0.9431	-0.16	0.9934	0.48	0.723	0.29	0.8306	0.76	0.4553	0.94	0.3567
Gyrus Rectus	0.41	0.943	-0.09	0.9934	1.04	0.4274	-0.07	0.9743	1.35	0.193	**2.58**	**0.02**
Frontal Operculum	1.77	0.4111	1.49	0.5098	**3.0**	**0.0153**	2.21	0.0633	**3.1**	**0.0103**	**2.54**	**0.0206**
Ant Orbital	1.38	0.5419	0.8	0.8112	**2.63**	**0.0349**	2.27	0.0606	**2.94**	**0.011**	**2.19**	**0.0388**
Lat Orbital	1.63	0.4111	1.44	0.5406	**3.07**	**0.0142**	**3.04**	**0.0142**	**3.05**	**0.0103**	**2.85**	**0.0127**
Med Orbital	0.76	0.8191	0.93	0.7401	2.25	0.062	2.4	0.0515	1.71	0.0987	**2.93**	**0.011**
Post Orbital	1.41	0.5419	1.21	0.5797	**2.7**	**0.0321**	2.32	0.0583	**2.6**	**0.0196**	**2.33**	**0.0312**
Frontal (Inf Tri)	1.73	0.4111	2.4	0.2822	**2.87**	**0.021**	**2.49**	**0.0471**	**2.66**	**0.0183**	**2.91**	**0.011**
Frontal (Inf Oper)	1.76	0.4111	1.25	0.5714	2.4	0.0515	**2.99**	**0.0153**	**2.33**	**0.0312**	**2.45**	**0.0247**
Frontal (Inf Orbit)	1.71	0.4111	1.91	0.4111	**2.62**	**0.0351**	2.38	0.0524	**3.14**	**0.0103**	**2.6**	**0.0196**
Frontal (Med)	1.36	0.5419	0.58	0.8821	**2.52**	**0.0444**	1.32	0.2931	**2.23**	**0.038**	**2.34**	**0.0312**
Frontal (Mid)	0.93	0.7401	0.59	0.8821	1.5	0.2193	1.74	0.1467	**2.55**	**0.0206**	**2.2**	**0.0388**
Frontal (Sup med)	0.84	0.7973	1.16	0.6016	2.31	0.0593	2.23	0.0629	**2.22**	**0.038**	**2.64**	**0.0185**
Frontal (Sup)	0.01	0.9934	-0.14	0.9934	0.29	0.8306	0.17	0.9147	**2.15**	**0.0411**	1.69	0.1023
SMA	1.02	0.7021	0.5	0.887	1.12	0.3805	0.81	0.5409	**2.62**	**0.0192**	**2.38**	**0.0294**
Precentral (Med)	-0.19	0.9934	0.21	0.9934	0.58	0.6715	0.74	0.5916	1.32	0.1981	1.33	0.1959
Precentral	0.54	0.8821	0.39	0.9431	1.29	0.3065	2.12	0.0757	**2.32**	**0.0313**	**2.46**	**0.0247**
Postcentral (Med)	0.35	0.9582	-0.17	0.9934	1.17	0.3627	0.66	0.6204	2.03	0.0512	1.29	0.2048
Postcentral	0.53	0.8821	-0.19	0.9934	1.21	0.343	1.51	0.2193	**2.24**	**0.0373**	**2.2**	**0.0388**

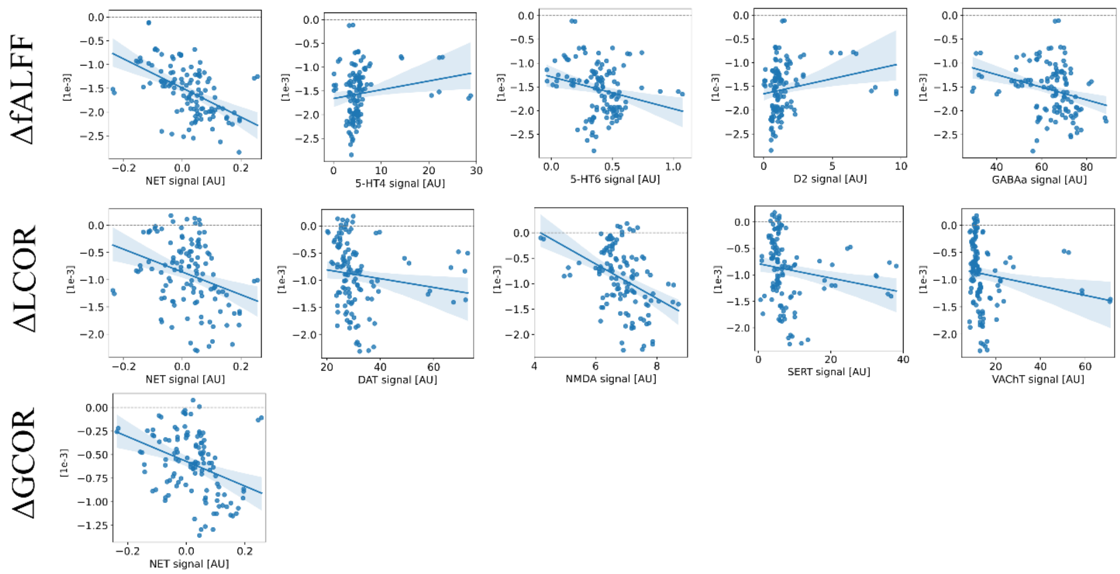
Central Operculum	2.61	0.2126	2.22	0.3521	**3.57**	**0.0035**	**3.81**	**0.0027**	**3.19**	**0.0103**	**3.09**	**0.0103**
Parietal Operculum	2.25	0.3521	3.03	0.2126	**3.63**	**0.0035**	**4.4**	**0.0013**	**2.92**	**0.011**	**2.81**	**0.0137**
Angular Gyrus	-0.17	0.9934	0.53	0.8821	2.4	0.0515	**3.35**	**0.0056**	**3.07**	**0.0103**	**3.41**	**0.0103**
Supramarginal	0.64	0.8632	0.84	0.7973	**2.65**	**0.0347**	**4.17**	**0.0013**	**3.49**	**0.0103**	**3.26**	**0.0103**
Parietal (Sup)	-0.98	0.7201	-0.72	0.8502	1.83	0.1284	1.99	0.095	**3.06**	**0.0103**	**2.79**	**0.0143**
Precuneus	0.03	0.9934	0.23	0.9934	2.2	0.0633	2.28	0.0593	**3.02**	**0.0103**	**3.17**	**0.0103**
Insula (Ant)	1.38	0.5419	1.32	0.5456	**2.72**	**0.0307**	2.43	0.0515	**3.44**	**0.0103**	**2.97**	**0.011**
Insula (Post)	2.41	0.2822	1.65	0.4111	**3.67**	**0.0035**	**3.05**	**0.0142**	**3.22**	**0.0103**	**2.94**	**0.011**
Entorhinal	0.47	0.9075	0.05	0.9934	1.71	0.1537	0.48	0.723	1.75	0.0924	**2.33**	**0.0312**
Fusiform Gyrus	-0.2	0.9934	-0.08	0.9934	1.87	0.1227	1.13	0.3781	**2.91**	**0.011**	**3.1**	**0.0103**
Temporal (Inf)	0.02	0.9934	-0.23	0.9934	2.08	0.08	0.29	0.8306	**2.18**	**0.0392**	1.5	0.1492
Temporal (Mid)	0.5	0.887	0.52	0.887	2.08	0.08	2.2	0.0633	**2.56**	**0.0206**	**3.02**	**0.0103**
Temporal (Sup)	1.22	0.5797	1.82	0.4111	2.14	0.0718	**3.39**	**0.0056**	**3.03**	**0.0103**	**3.05**	**0.0103**
Temporal Pole	0.67	0.8632	-0.08	0.9934	1.85	0.1242	1.37	0.2739	**2.72**	**0.0156**	**2.17**	**0.0395**
Transverse temporal	2.17	0.3536	1.65	0.4111	**3.59**	**0.0035**	**3.57**	**0.0035**	**3.1**	**0.0103**	**2.89**	**0.0114**
Planum Polare	2.62	0.2126	2.04	0.4111	**3.67**	**0.0035**	**3.48**	**0.0046**	**3.23**	**0.0103**	**3.47**	**0.0103**
Planum Temporale	2.77	0.2126	2.63	0.2126	**3.37**	**0.0056**	**4.12**	**0.0013**	**2.62**	**0.0192**	**2.49**	**0.0232**
Calcarine Fissure	-1.71	0.4111	-1.32	0.5456	-0.29	0.8306	-0.01	0.9917	**2.11**	**0.0445**	**2.25**	**0.037**
Cuneus	-1.67	0.4111	-1.68	0.4111	0.02	0.9917	0.24	0.8628	**2.83**	**0.0131**	**2.65**	**0.0185**
Lingual Gyrus	-1.01	0.7059	-0.54	0.8821	-0.01	0.9917	0.37	0.809	1.86	0.0722	**2.18**	**0.0392**
Occipital fusiform	-1.14	0.6093	-0.9	0.7516	-0.14	0.9293	0.72	0.596	2.01	0.0528	**2.35**	**0.0307**
Occipital (Inf)	-1.36	0.5419	-1.29	0.5565	0.02	0.9917	0.7	0.5995	**2.06**	**0.0481**	**3.01**	**0.0104**
Occipital (Mid)	-1.67	0.4111	-0.71	0.8506	0.97	0.4633	0.89	0.5055	**3.06**	**0.0103**	**2.73**	**0.0156**
Occipital (Sup)	-1.74	0.4111	-1.77	0.4111	0.54	0.6931	0.29	0.8306	**2.19**	**0.0388**	1.98	0.0556
Occipital Pole	-1.74	0.4111	-1.57	0.4442	-0.7	0.5995	-0.92	0.4885	1.29	0.2048	1.42	0.17
Cerebellum Exterior	-0.05	0.9934	0.46	0.9075	1.78	0.1385	1.77	0.1407	**2.11**	**0.0445**	**2.12**	**0.0441**
Vermis I-V	-0.38	0.9431	-	-	0.48	0.723	-	-	1.35	0.1916	-	-
Vermis VI-VII	-0.05	0.9934	-	-	0.66	0.6204	-	-	1.01	0.3212	-	-
Vermis VIII-X	0.01	0.9934	-	-	1.03	0.4299	-	-	0.75	0.4557	-	-

Bold numbers highlight regions with significant differences in a specific measure (fALFF, LCOR, or GCOR) between PD and the matched subgroup of HC.

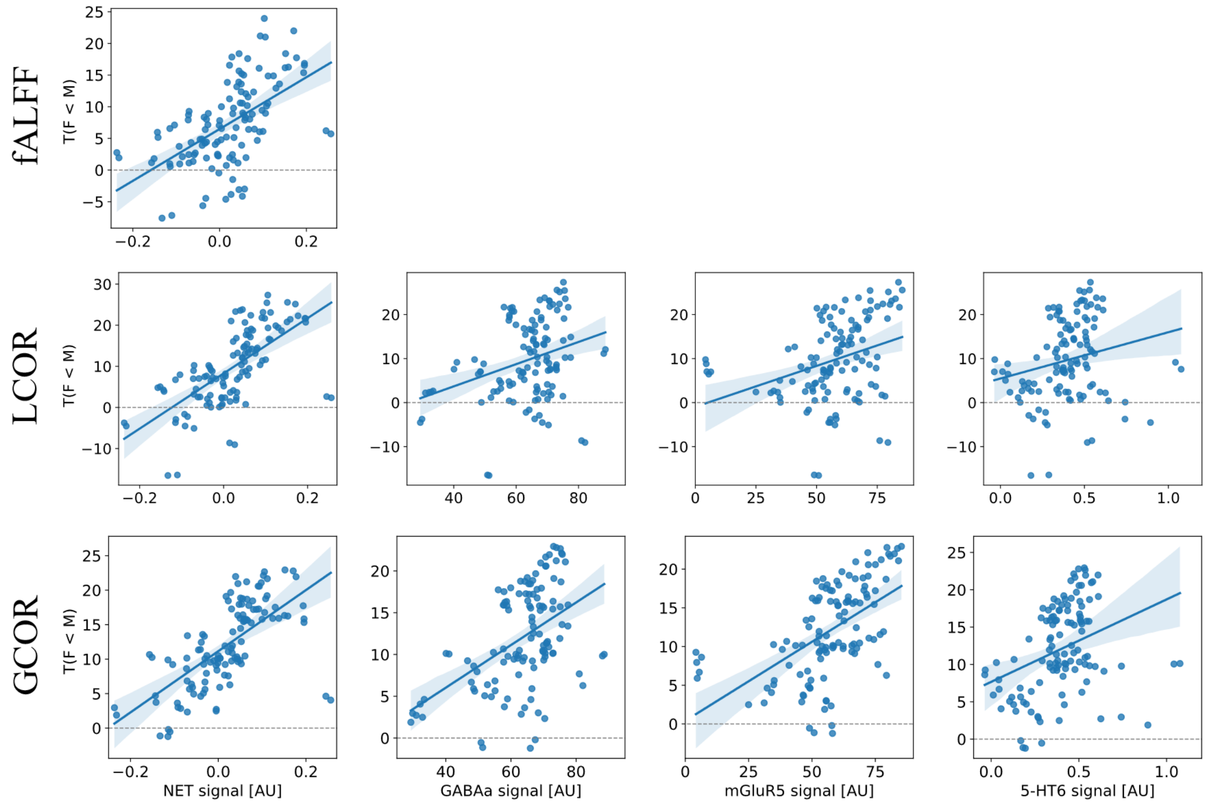
Supplementary Figures



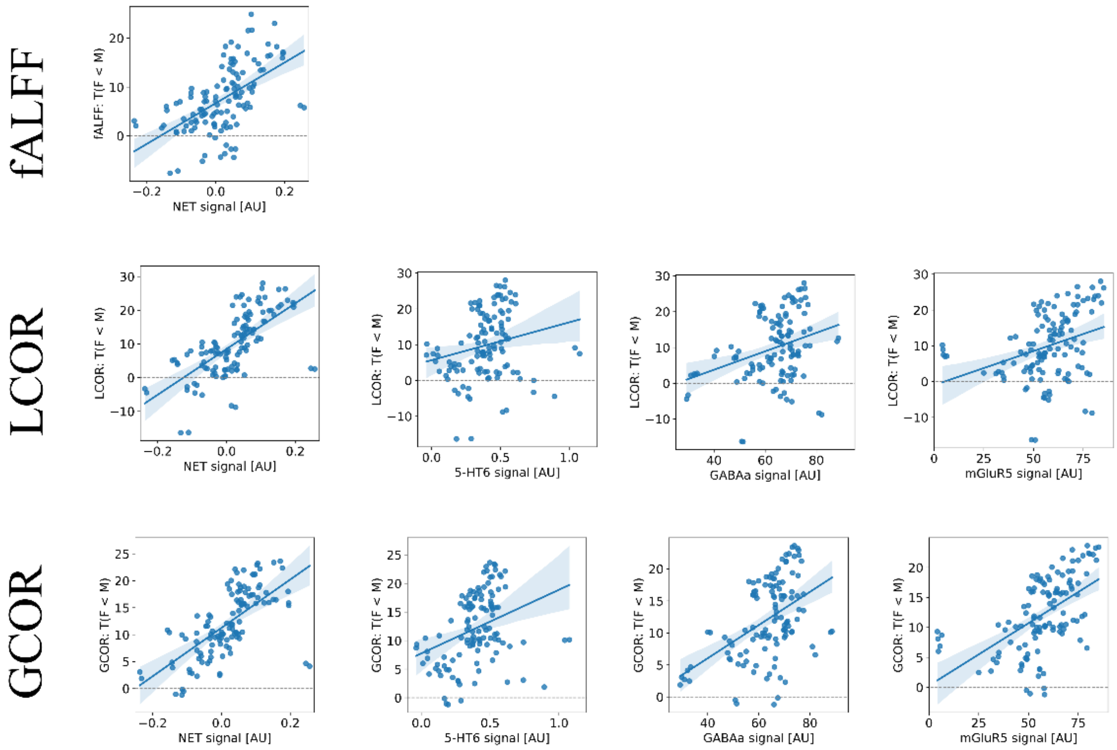
Supplementary Figure 1: Significant linear correlations between unthresholded age-effect (slope) maps in fALFF, LCOR, and GCOR, and neurotransmitter systems – *before atrophy correction*. Corresponding correlation coefficients are visualized in Figure 2B. ΔMeasure corresponds to the annual rate of in- or decrease in the respective measure of brain function (fALFF, LCOR, or GCOR) within one region.



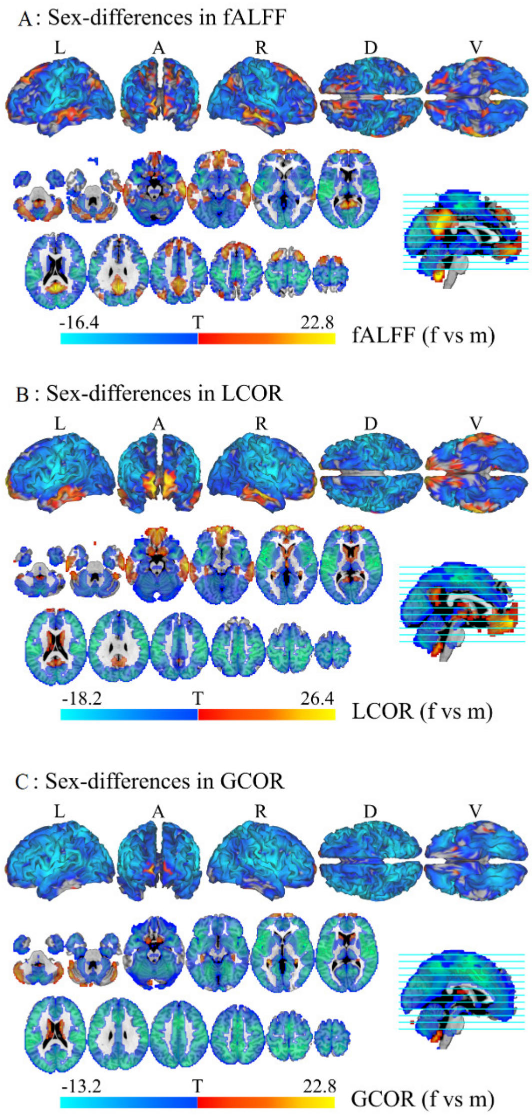
Supplementary Figure 2: Significant linear correlations between of unthresholded age-effects (slope maps) in fALFF, LCOR, and GCOR, and multiple neurotransmitter systems – *after atrophy correction*. ΔMeasure corresponds to the annual rate of in- or decrease in the respective measure of brain function (fALFF, LCOR, or GCOR) within one region.



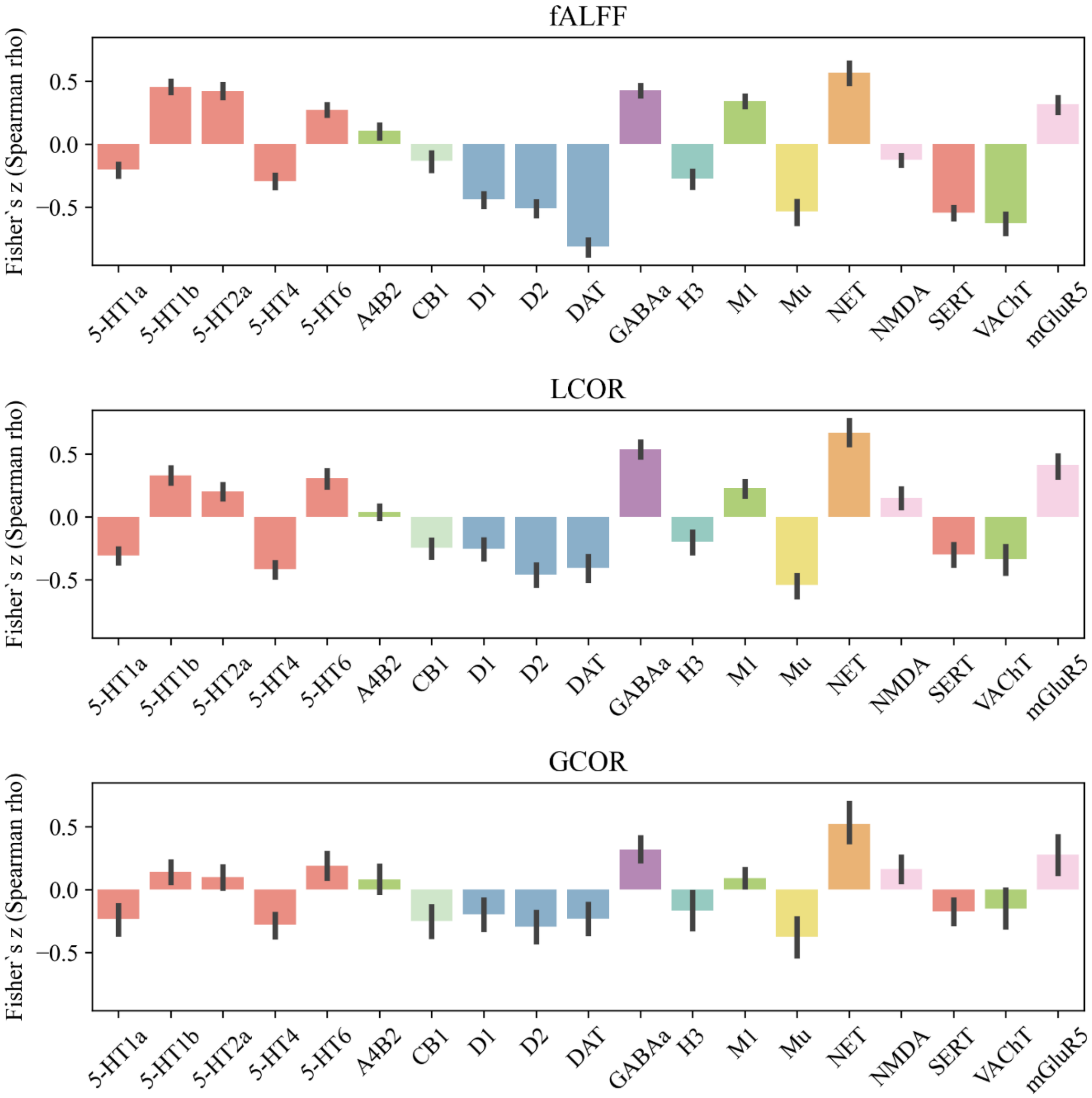
Supplementary Figure 3: Significant linear correlations of unthresholded sex effects (T-values) in fALFF, LCOR, and GCOR and NET, GABAa, mGluR5, and 5-HT6 availability – *before atrophy correction*.



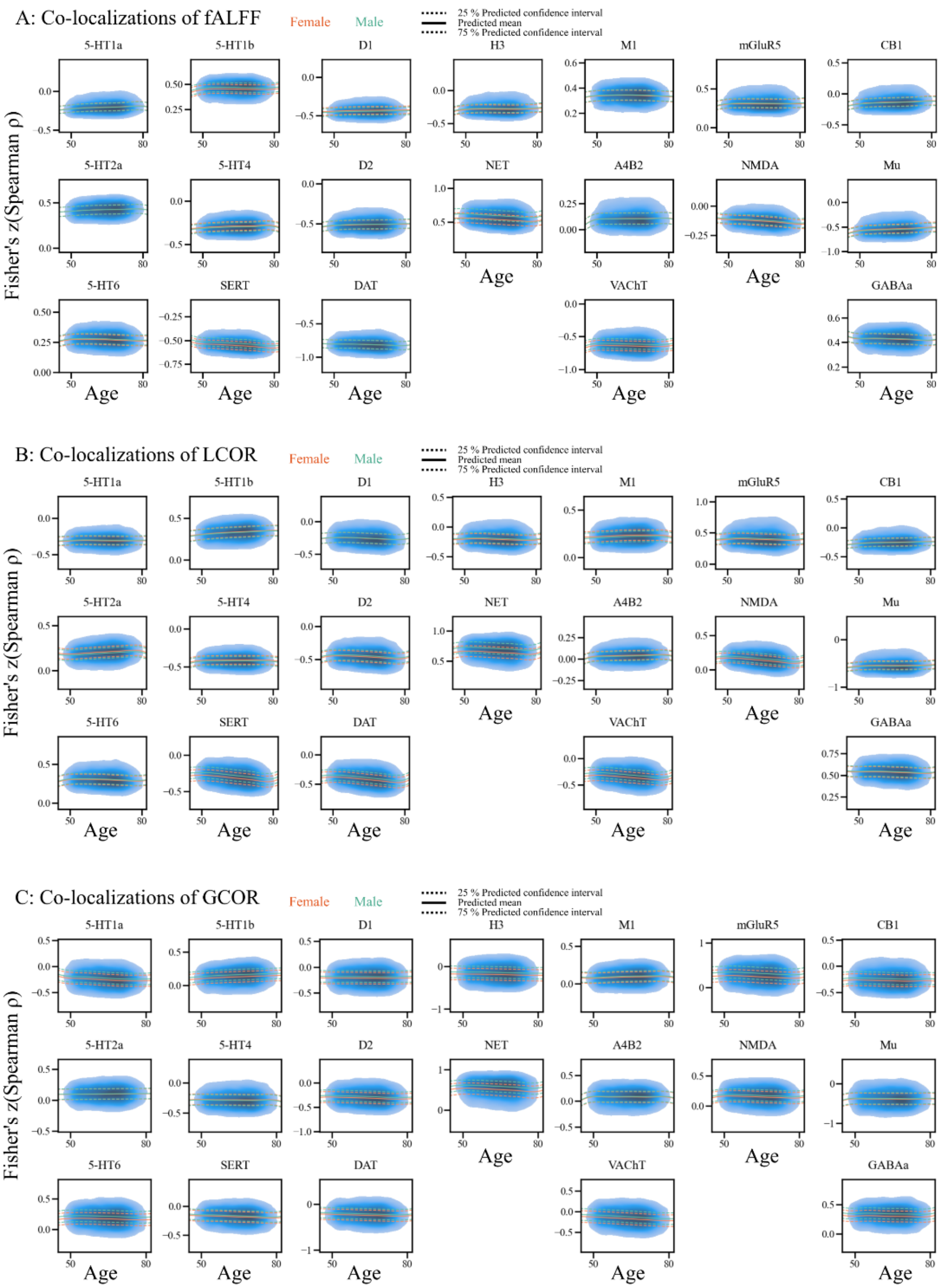
Supplementary Figure 4: Significant linear correlations of unthresholded sex effects (T-values) in fALFF, LCOR, and GCOR and NET, GABAa, mGluR5, and 5-HT6 availability – *after atrophy correction*.



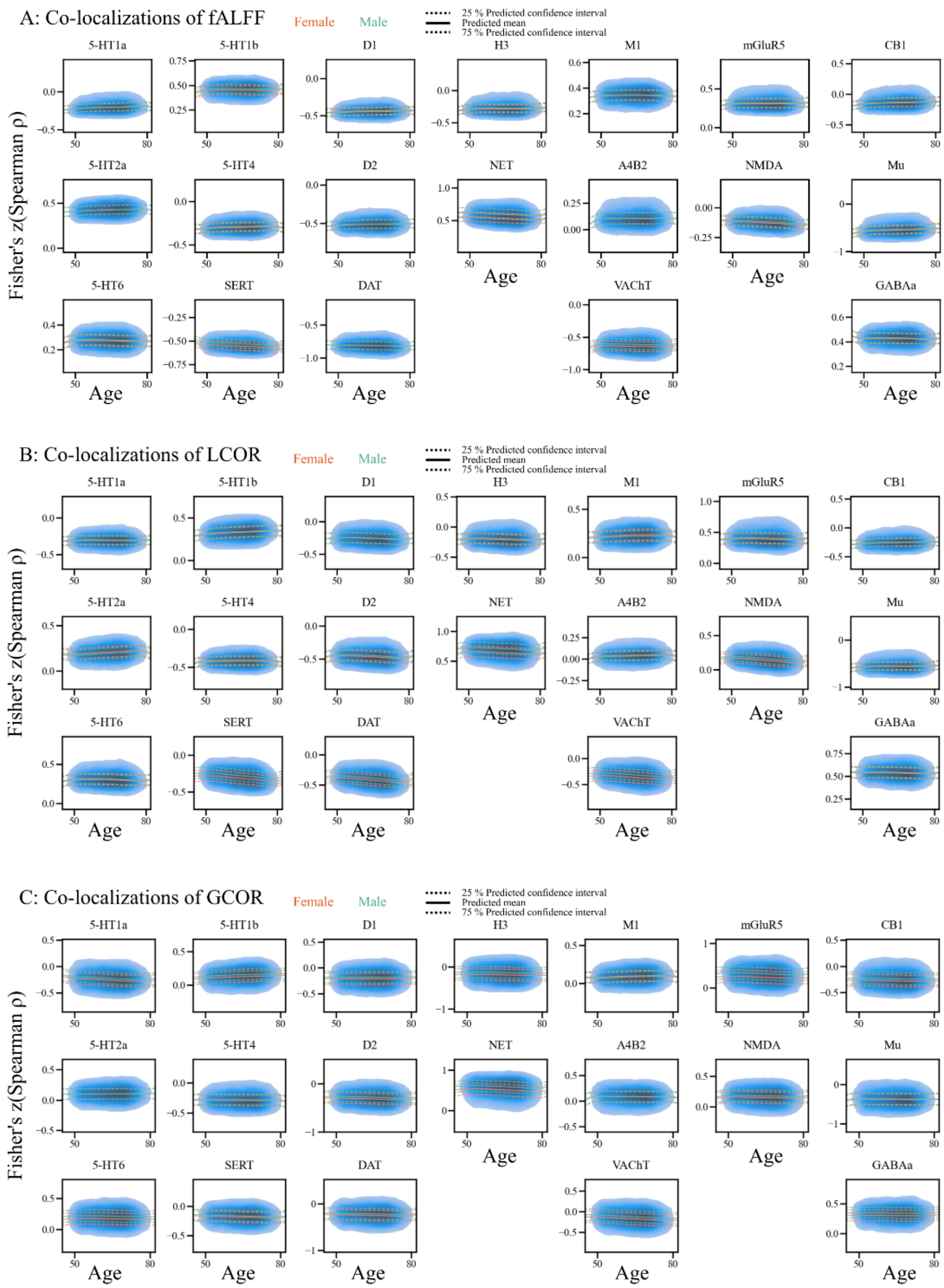
Supplementary Figure 5: Sex differences (T-values) in brain functional measures, thresholded. Red voxels indicate higher values in women compared to men and blue voxels indicate the inverse.



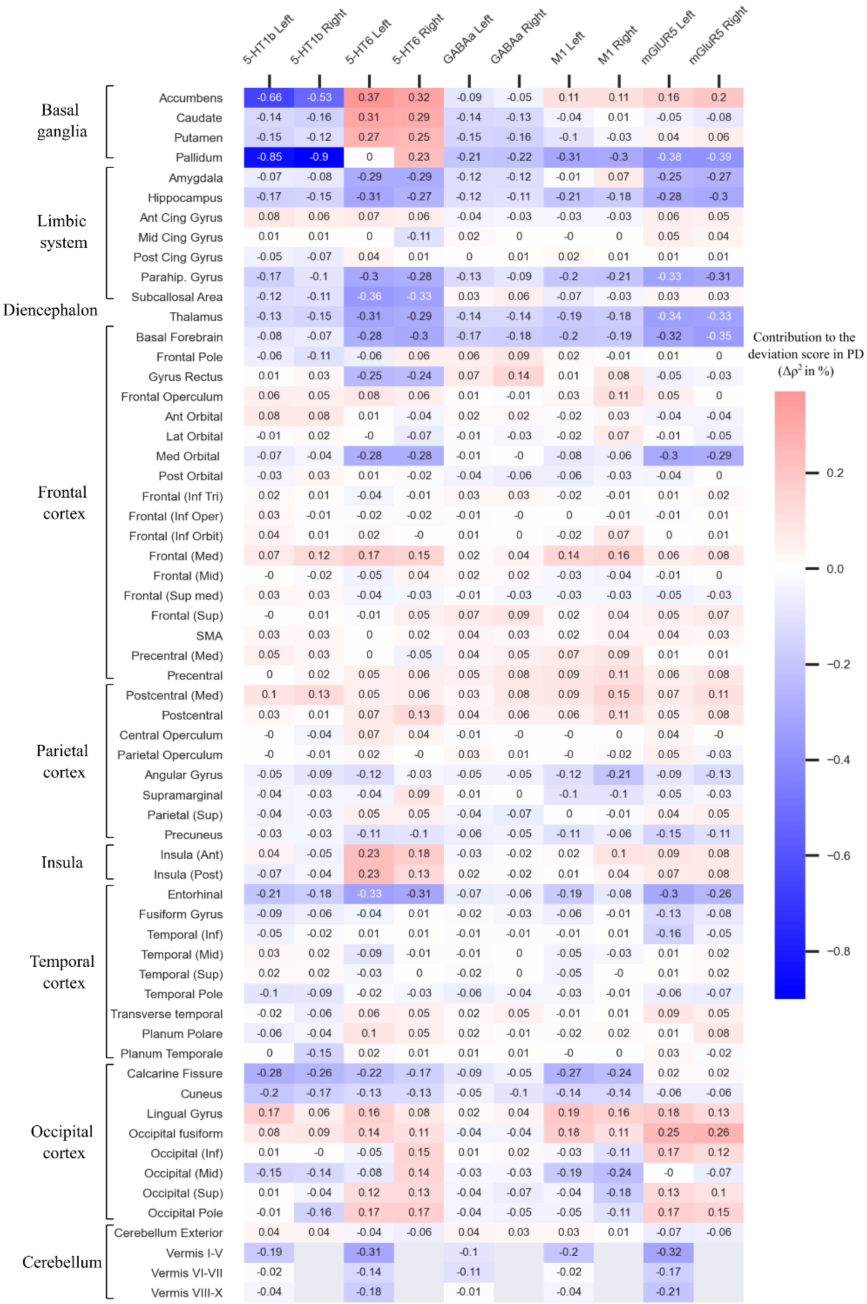
Supplementary Figure 6. Bar plots show the healthy control cohort's mean Fisher's z-transformed Spearman correlation coefficients. These coefficients were derived from the spatial correlation analyses of individual fALFF (top), LCOR (middle), and GCOR (bottom) maps and 19 PET maps of neurotransmitter systems. Vertical bars indicate the 50% quantile. Colors group receptors and transporters of the same neurotransmitter system, i.e., serotonin (red), dopamine (blue), acetylcholine (green), glutamate (pink) and GABA (purple), cannabinoid (mint), opioid (yellow), norepinephrine (orange), and histamine (turquoise).



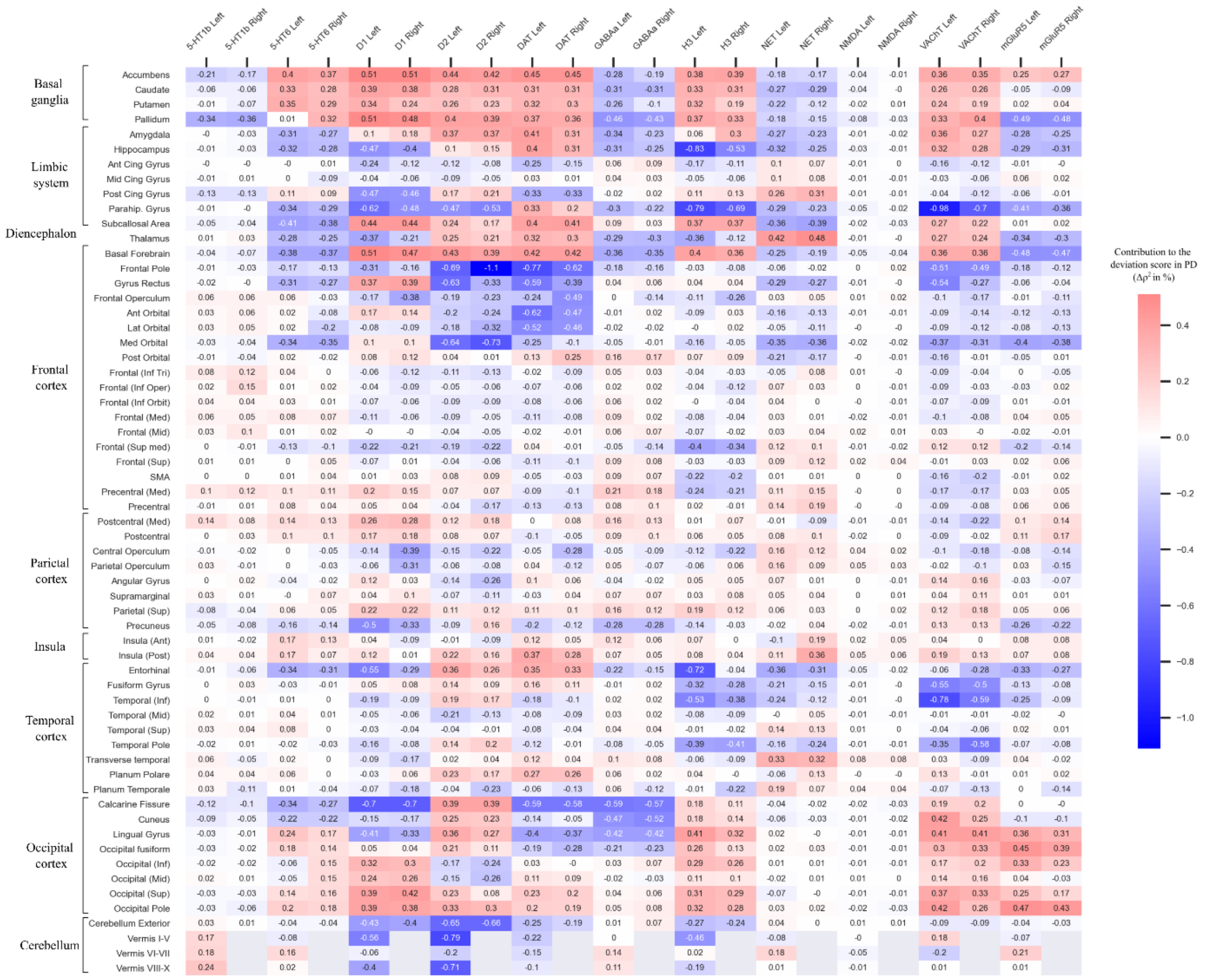
Supplementary Figure 7: Normative models of co-localizations between brain function (A: fALFF, B: LCOR, C: GCOR) and 19 PET maps – *before atrophy correction*. Within each subplot, the blue cloud (kernel density estimation) visualized the distribution of Fisher's z-transformed Spearman correlation coefficients of all healthy controls. Solid and dashed lines indicate the predicted median and 25 and 75% confidence interval of men (turquoise) and women (orange).



Supplementary Figure 8: Normative models of co-localizations between brain function (A: fALFF, B: LCOR, C: GCOR) and 19 PET maps – *after atrophy correction*. Within each subplot, the blue cloud (kernel density estimation) visualized the distribution of Fisher's z-transformed Spearman correlation coefficients of all healthy controls. Solid and dashed lines indicate the predicted median and 25 and 75% confidence interval of men (turquoise) and women (orange).

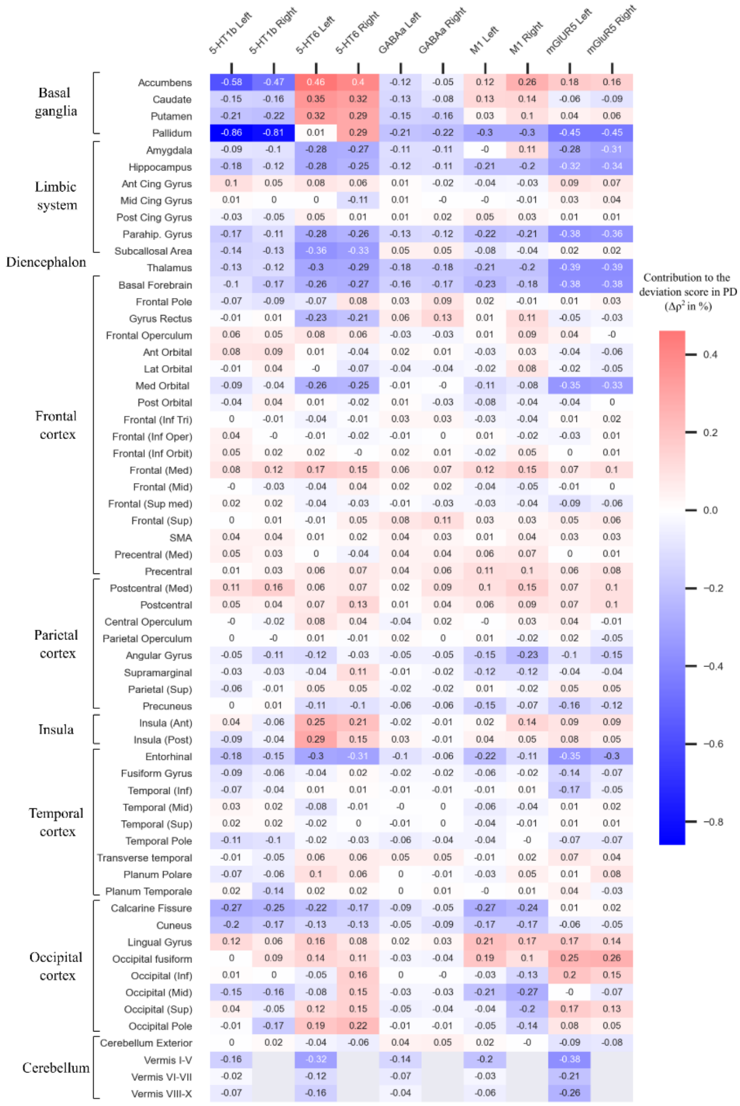


Supplementary Figure 9: Contribution of each region to the deviation in **fALFF** co-localizations in subjects with manifest Parkinson's disease – *before atrophy correction*. The contribution is quantified by the mean change in squared spatial correlation coefficient (mean $\Delta\rho^2$) after leaving the specific region out from the spatial correlation analysis. Values of regions of the left or right hemisphere are arranged next to each other (column-wise) for each neurotransmitter system. The rows are sorted from top to the bottom: Basal ganglia, limbic system, diencephalon, frontal cortex, motor area, parietal cortex, temporal cortex, occipital cortex, cerebellum. Red cells, i.e. positive values, indicate that leaving this specific region out in the individual co-localization analysis led to a correlation coefficient that was closer to the norm.

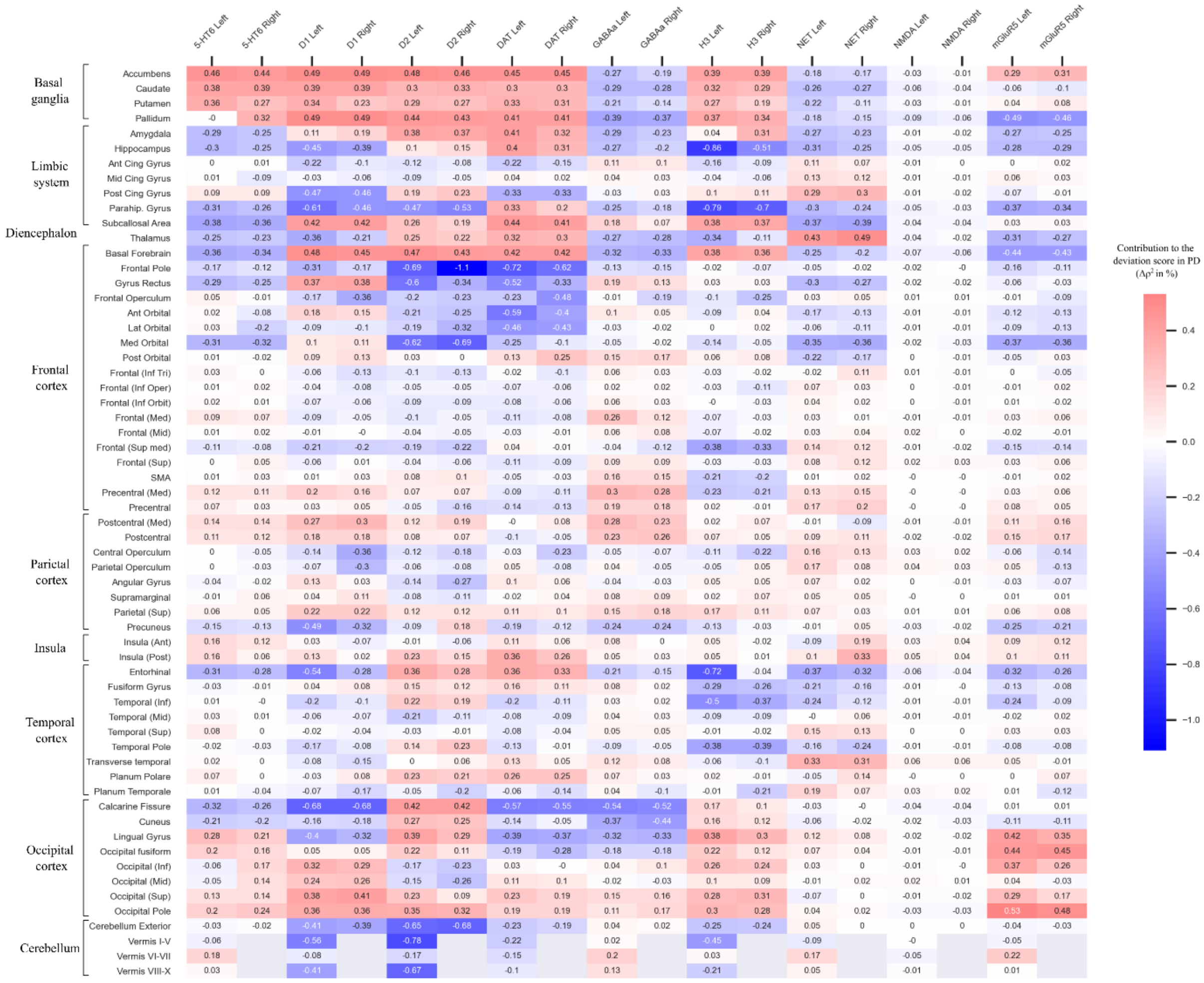


Supplementary Figure 10: Contribution of each region to the deviation in **LCOR** co-localizations in subjects with manifest Parkinson's disease – *before atrophy correction*. The contribution is quantified by the mean change in squared spatial correlation coefficient (mean $\Delta\rho^2$) after leaving the specific region out from the spatial correlation analysis. Values of regions of the left or right hemisphere are arranged next to each other (column-wise) for each neurotransmitter system. The rows are sorted from top to the bottom: Basal ganglia, limbic system, diencephalon, frontal cortex, parietal cortex, temporal cortex, occipital cortex, cerebellum. Red cells, i.e. positive values, indicate that leaving this specific region out in the individual co-localization analysis led to a correlation coefficient that was closer to the norm.

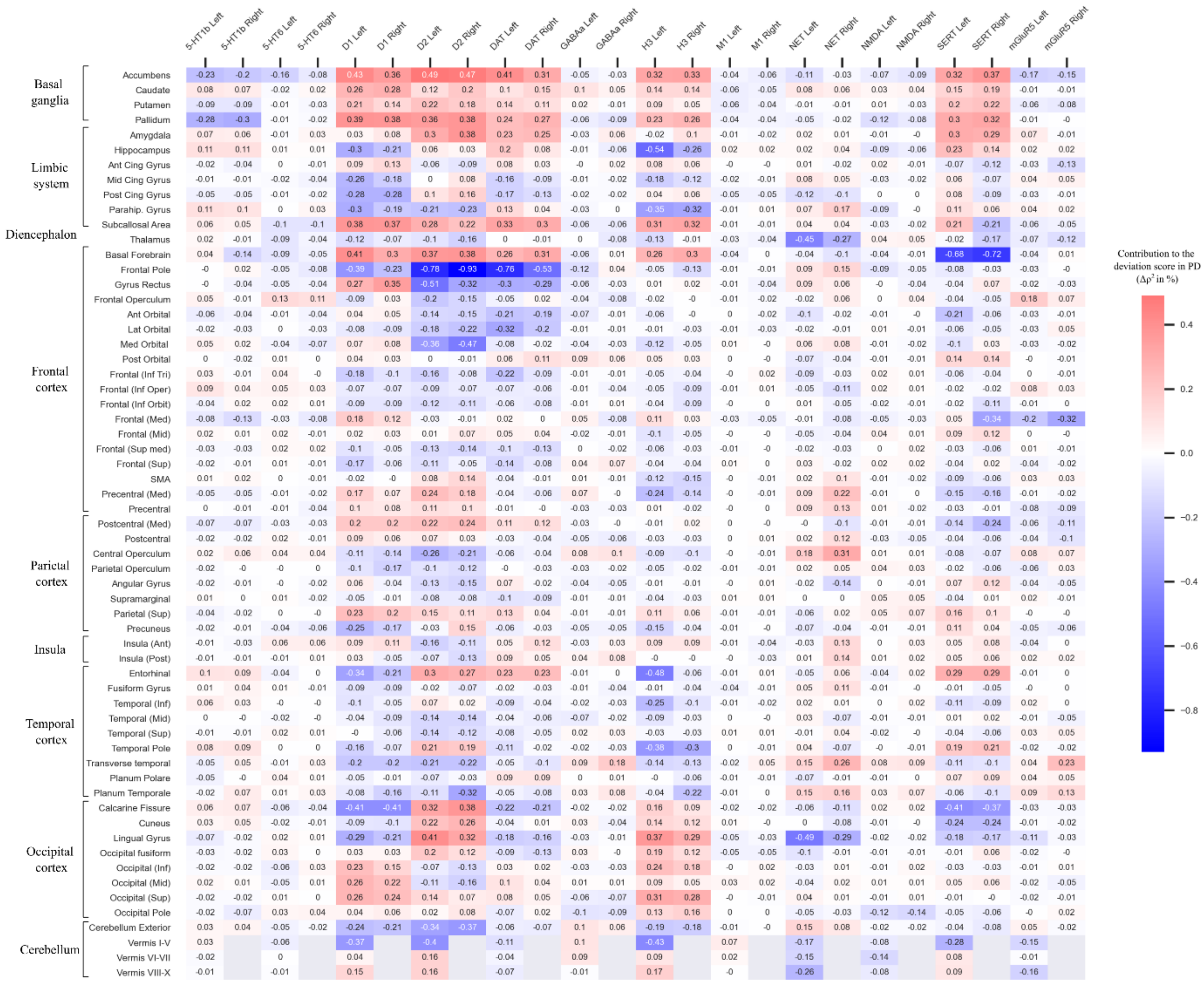
Supplementary Figure 11: Contribution of each region to the deviation in **GCOR** co-localizations in subjects with manifest Parkinson's disease – *before atrophy correction*. The contribution is quantified by the mean change in squared spatial correlation coefficient (mean $\Delta\rho^2$) after leaving the specific region out from the spatial correlation analysis. Values of regions of the left or right hemisphere are arranged next to each other (column-wise) for each neurotransmitter system. The rows are sorted from top to the bottom: Basal ganglia, limbic system, diencephalon, frontal cortex, parietal cortex, temporal cortex, occipital cortex, cerebellum. Red cells, i.e. positive values, indicate that leaving this specific region out in the individual co-localization analysis led to a correlation coefficient that was closer to the norm.



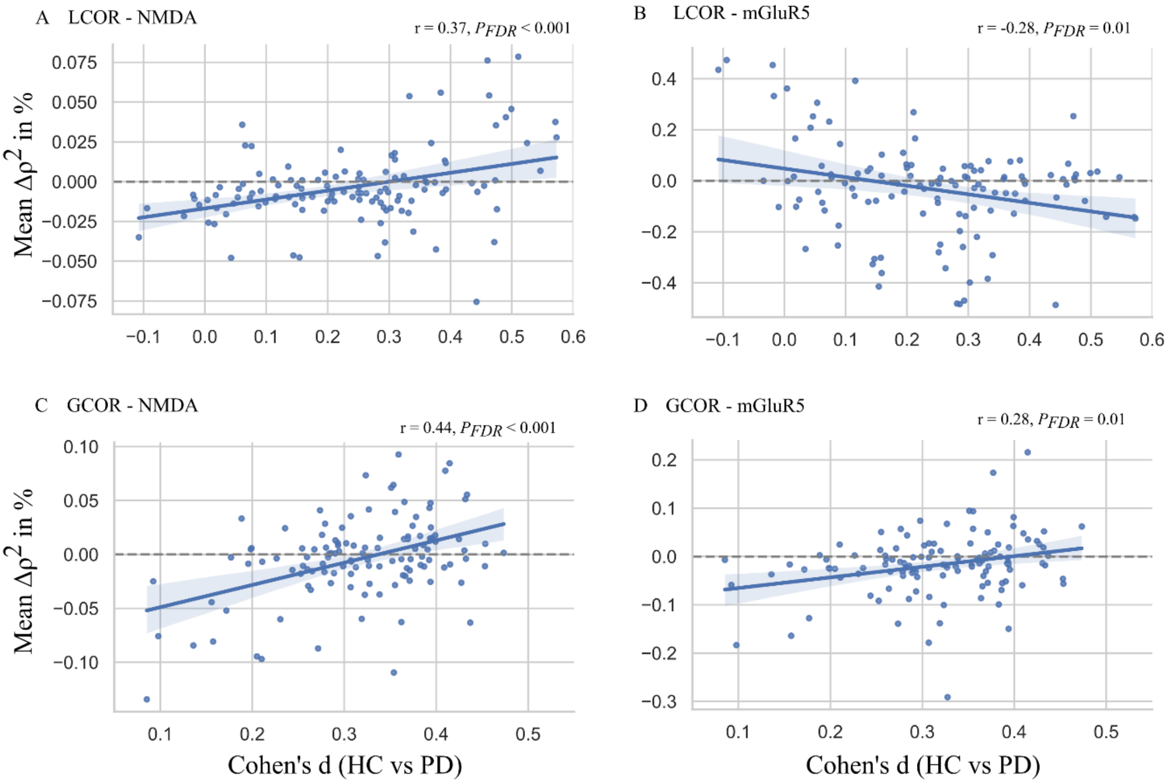
Supplementary Figure 12: Contribution of each region to the deviation in **fALFF** co-localizations in subjects with manifest Parkinson’s disease – *after atrophy correction*. The contribution is quantified by the mean change in squared spatial correlation coefficient (mean $\Delta\rho^2$) after leaving the specific region out from the spatial correlation analysis. Values of regions of the left or right hemisphere are arranged next to each other (column-wise) for each neurotransmitter system. The rows are sorted from top to the bottom: Basal ganglia, limbic system, diencephalon, frontal cortex, parietal cortex, temporal cortex, occipital cortex, cerebellum. Red cells, i.e. positive values, indicate that leaving this specific region out in the individual co-localization analysis led to a correlation coefficient that was closer to the norm.



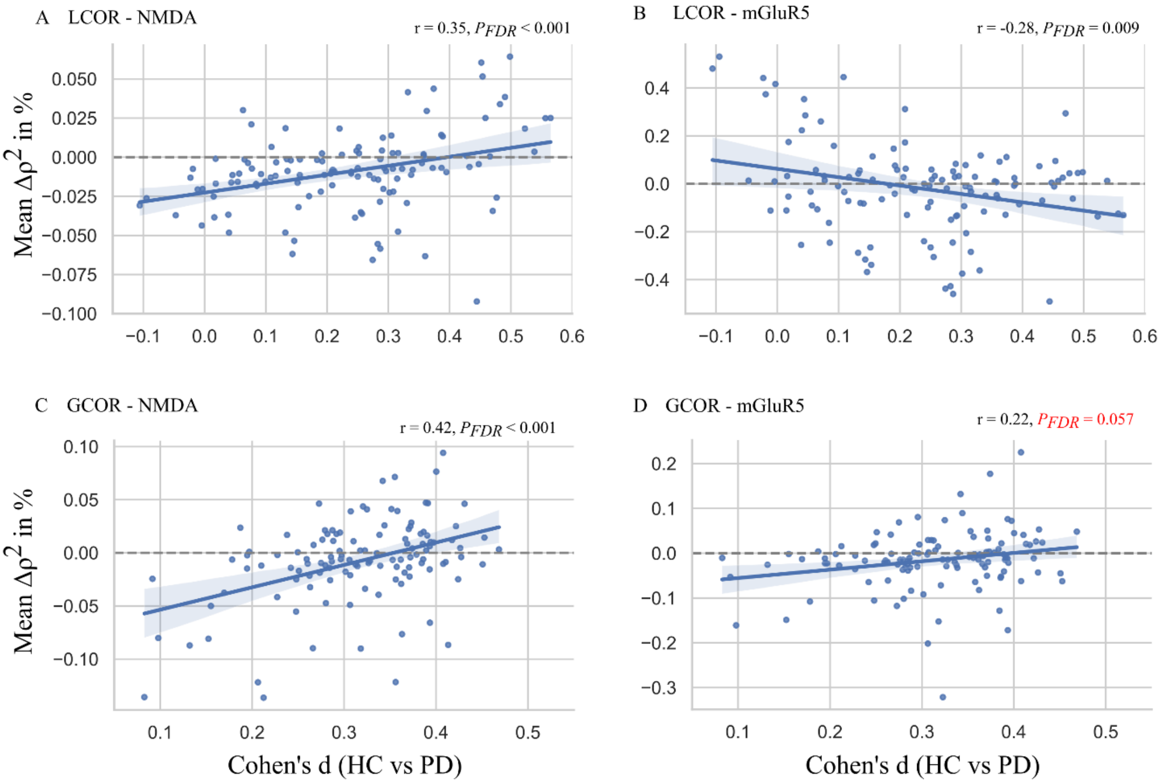
Supplementary Figure 13: Contribution of each region to the deviation in **LCOR** co-localizations in subjects with manifest Parkinson's disease – *after atrophy correction*. The contribution is quantified by the mean change in squared spatial correlation coefficient (mean $\Delta\rho^2$) after leaving the specific region out from the spatial correlation analysis. Values of regions of the left or right hemisphere are arranged next to each other (column-wise) for each neurotransmitter system. The rows are sorted from top to the bottom: Basal ganglia, limbic system, diencephalon, frontal cortex, parietal cortex, temporal cortex, occipital cortex, cerebellum. Red cells, i.e. positive values, indicate that leaving this specific region out in the individual co-localization analysis led to a correlation coefficient that was closer to the norm.



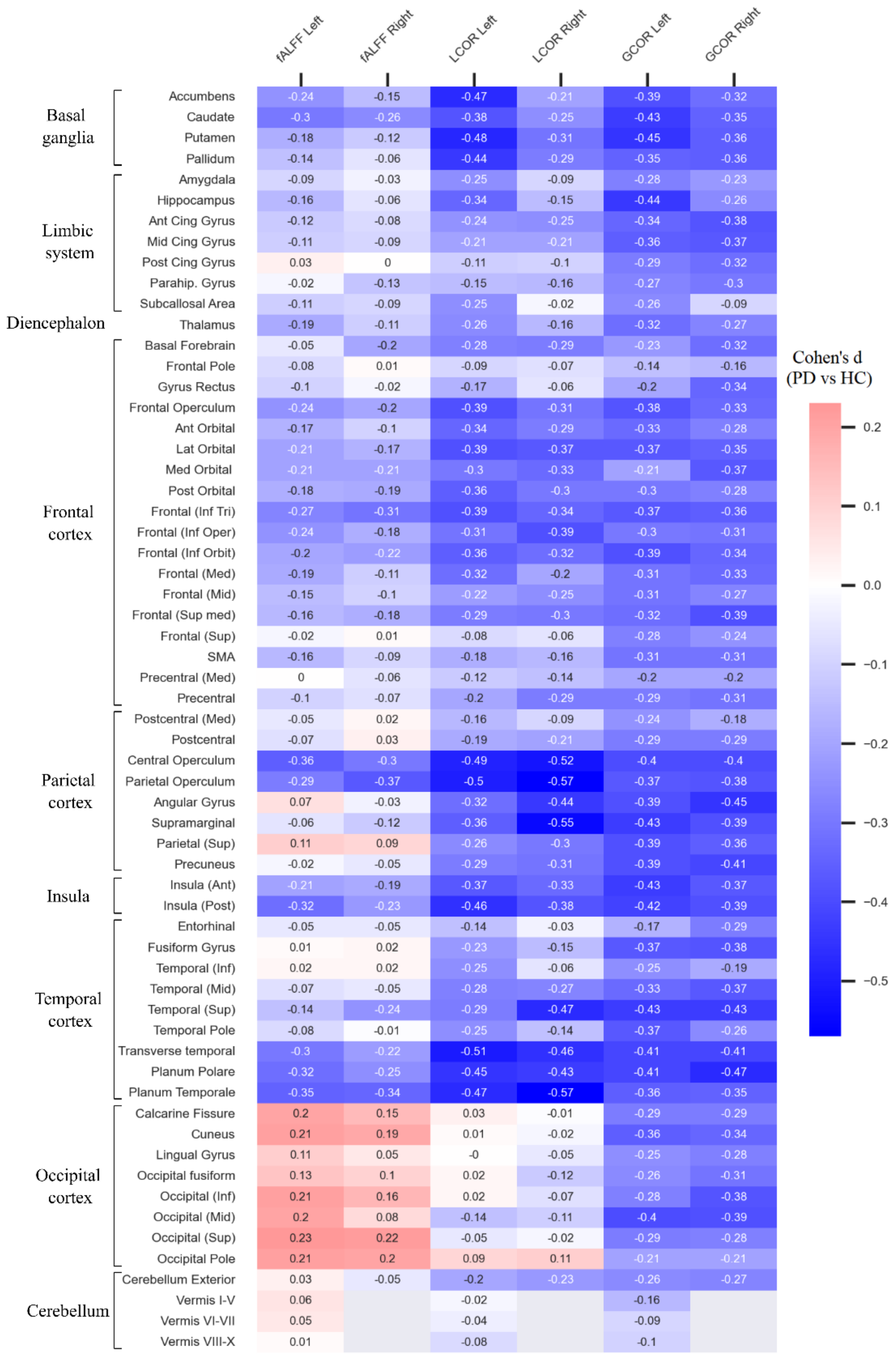
Supplementary Figure 14: Contribution of each region to the deviation in **GCOR** co-localizations in subjects with manifest Parkinson's disease – *after atrophy correction*. The contribution is quantified by the mean change in squared spatial correlation coefficient (mean $\Delta\rho^2$) after leaving the specific region out from the spatial correlation analysis. Values of regions of the left or right hemisphere are arranged next to each other (column-wise) for each neurotransmitter system. The rows are sorted from top to the bottom: Basal ganglia, limbic system, diencephalon, frontal cortex, parietal cortex, temporal cortex, occipital cortex, cerebellum. Red cells, i.e. positive values, indicate that leaving this specific region out in the individual co-localization analysis led to a correlation coefficient that was closer to the norm.



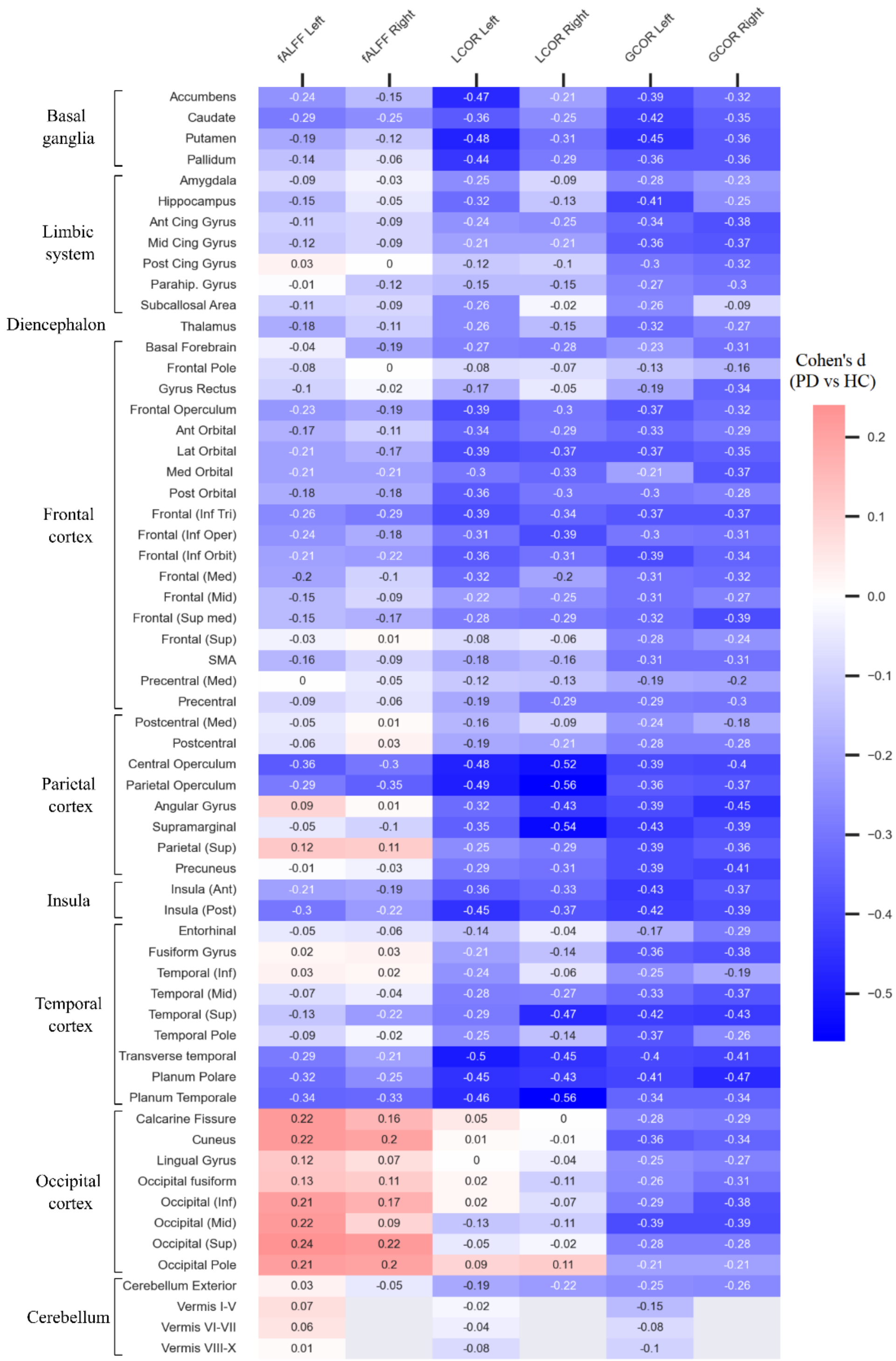
Supplementary Figure 15: Linear correlation of regional contribution (mean $\Delta\rho^2$) to the deviation score and functional differences (Cohen's d) between PD and the matched subcohort of healthy controls – *before atrophy correction*.



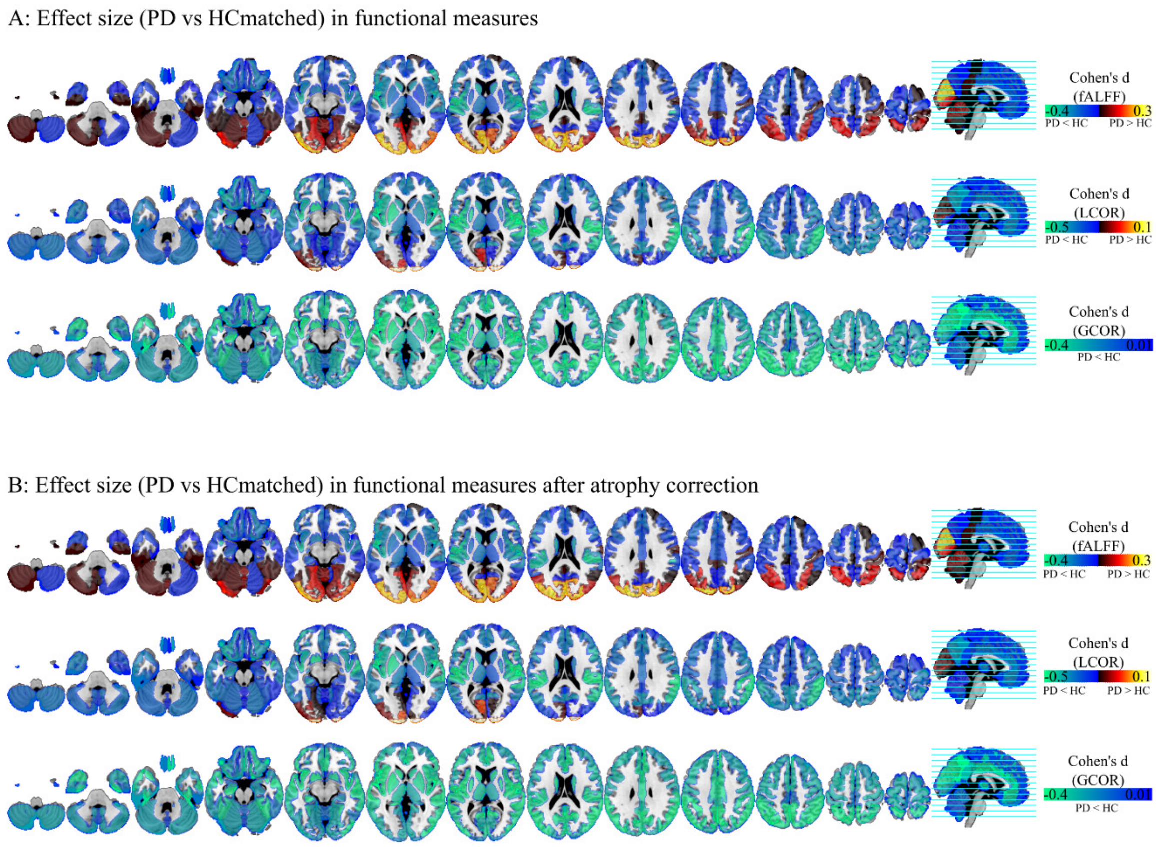
Supplementary Figure 16: Linear correlation of regional contribution (Mean $\Delta\rho^2$) to deviation score and functional differences (Cohen's d) between PD and the matched subcohort of healthy controls – *after atrophy correction*.



Supplementary Figure 17: Regional differences (effect sizes, Cohen's d) in fALFF, LCOR, and GCOR between manifest PD and the age- and sex-matched control group – *before atrophy correction*. Positive values (red cells) indicate higher values of brain functional measures in PD and negative values (blue cells) indicate the inverse. Values of regions of the left or right hemisphere are arranged next to each other (column-wise). The list is sorted from top to the bottom: Basal ganglia, limbic system, diencephalon, frontal cortex, parietal cortex, temporal cortex, occipital cortex, cerebellum. Regional values are visualized in Supplementary Figure 19A.



Supplementary Figure 18: Regional differences (effect sizes, Cohen's d) in fALFF, LCOR, and GCOR between the age- and sex-matched control group and PD – *after atrophy correction*. Positive values (red cells) indicate higher values of brain functional measures in PD and negative values (blue cells) indicate the inverse. Values of regions of the left or right hemisphere are arranged next to each other (column-wise). The list is sorted from top to the bottom: Basal ganglia, limbic system, diencephalon, frontal cortex, motor area, parietal cortex, temporal cortex, occipital cortex, cerebellum. Regional values are visualized in Supplementary Figure 19B.



Supplementary Figure 19: Maps of regional differences in fALFF, LCOR, and GCOR between the age- and sex-matched control group and PD. Values of regions correspond to those of Supplementary Figure 17 and 18 (atrophy corrected).

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