Beyond binary parcellation of the vestibular cortex – A dataset

V. Kirsch, R. Boegle, D. Keeser, E. Kierig, B. Ertl-Wagner, T. Brandt, M. Dieterich

Article info
Article history:
Received 8 May 2018
Received in revised form 1 January 2019
Accepted 7 January 2019

Abstract
The data-set presented in this data article is supplementary to the original publication, doi:10.1016/j.neuroimage.2018.05.018 (Kirsch et al., 2018). Named article describes handedness-dependent organizational patterns of functional subunits within the human vestibular cortical network that were revealed by functional magnetic resonance imaging (fMRI) connectivity parcellation. 60 healthy volunteers (30 left-handed and 30 right-handed) were examined on a 3T MR scanner using resting state fMRI. The multisensory (non-binary) nature of the human (vestibular) cortex was addressed by using masked binary and non-binary variations of independent component analysis.
component analysis (ICA). The data have been made publicly available via github (https://github.com/RainerBoegle/BeyondBinaryParcellationData).

© 2019 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

### Specifications table

| Subject area                | Neuroscience, Vestibular system |
|-----------------------------|---------------------------------|
| More specific subject area  | Handedness-dependent organizational patterns of (lateralized and non-lateralized) functional subunits within the human vestibular cortical network |
| Type of data                | Tables, figures, text file, data set |
| How data were acquired      | 3T Magnetic resonance imaging (MRI) data, 32-channel head coil, T2*-weighted echo-planar imaging (EPI) sequence, T1-weighted magnetization-prepared rapid gradient echo (MP-RAGE) sequence, task-free resting state. |
| Data format                 | Analyzed, Nifti *.nii files, MATLAB *.mat files, Portable Network Graphics *.png files, Text *.txt files |
| Experimental factors       | 30 healthy right-handed (RH) volunteers and 30 age- and gender-matched healthy left-handed (LH) volunteers with a verified sound vestibular system (semicircular and otolith function) |
| Experimental features      | The multisensory (non-binary) nature of the human (vestibular) cortex was addressed by using binary and non-binary variations of independent component analysis (ICA) to separate its functional subunits. |
| Data source location       | Munich, Germany, Latitude 48°06′22.20″ N, Longitude 11°28′5.99″ E |
| Data accessibility         | The analyzed data are available within this article, the used dataset can be downloaded from the GitHub Link: https://github.com/RainerBoegle/BeyondBinaryParcellationData |

### Value of the data

- Proposition of a functional connectivity based parcellation (fCBP) approach that addresses the multisensory (non-binary) nature of the human vestibular cortex, here vestibular.
- Two variations of independent component analysis (ICA) are used: The traditional (binary) ICA approach, where each functional sub-unit must be spatially distinct (and voxels are forced to choose a sub-unit). And a variation, the multivariate (non-binary) ICA approach where functional-subunits can overlap (and voxels can to be part of multiple sub-units with their various behavioral interpretations).
- This non-binary methodical approach might be able to reflect multiple signals at the same spatial location, e.g. in multiple populations of neurons or a single multisensory population.

### 1. Data

This data set aims to identify handedness-dependent organizational patterns of functional sub-units within the human vestibular cortex whilst addressing its multisensory (non-binary) nature. To that end, 60 healthy volunteers (30 left-handed and 30 right-handed) were analyzed using a masked binary and non-binary fCBP (functional connectivity based parcellation) approach. This mask was
data-driven (composed of whole brain independent components) and specific to the vestibular cortical system as the used independent components (ICs) were required to include vestibular reference coordinates derived from two meta-analyses of vestibular neuroimaging experiments pinpointing the vestibular cortex [2,3].

2. Experimental design, materials and methods

Age- and gender-matched 30 left-handed (LH; 14 females; aged 20–65 years, mean age 26.1 ± 8.6 years) and 30 right-handed (RH; 17 females; aged 20–67 years, mean age 26.7 ± 8.3 years) healthy volunteers with a verified sound vestibular system (semicircular and otolith function) were examined on a 3T MR scanner (Magnetom Verio, Siemens Healthcare, Erlangen, Germany) using task free resting state functional MRI (fMRI) (Tables 1–3C).

After Preprocessing, the data were analyzed in four major steps using a functional connectivity based parcellation (fCBP) approach: (1) independent component analysis (ICA) on a whole brain level to identify different resting state networks (RSN); (2) creation of a vestibular informed mask from four whole brain ICs that included reference coordinates of the vestibular network extracted from meta-analyses of vestibular neuroimaging experiments; (3) Re-ICA confined to the vestibular informed mask; (4) cross-correlation of the activated voxels within the vestibular subunits (parcels) to each other (P-to-P) and to the whole-brain RSN (P-to-RSN). For a flowchart of the used functional connectivity based parcellation (fCBP) methods please view Fig. 1 of [1] (Figs. 1–4).

All details as well as further explanations of the methods can be viewed in the original publication, https://doi.org/10.1016/j.neuroimage.2018.05.018 [1].

Table 1
Overview of used behavioral Interpretations of intrinsic whole brain resting-state networks (RSN).

| Whole brain ICs | RSN | Name and anatomical allocation | Functional interpretation of networks                 |
|-----------------|-----|--------------------------------|-------------------------------------------------------|
| IC60, IC67      | 1   | Limbic and medial-temporal areas | * Discrimination of emotional faces and pictures     |
|                 |     | BA 28/34/25/26/38, parahippocampal gyri | * Interoceptive processing                             |
| IC60, IC67      | 2   | Subgenual ACC and OFC           | * Olfaction, gustation                                |
|                 |     | BA 25/10/12                    | * Emotion                                              |
| IC45, IC75      | 3   | Bilateral basal ganglia and thalamus | * Wide range of mental processes [reward, non-painful thermal stimulation and interoceptive functions] |
| IC15, IC17      | 4   | Bilateral anterior insula/frontal opercula & anterior aspect of the cingulate gyrus | * Relevant to motor, pain, and somatosensory processing |
|                 |     | (BA13/16 and BA24)             | * Complex set of language, executive function, affective, and interoceptive processes, as well as auditory, pain, and gustatory processes |
| IC31, IC32, IC35, IC38, IC48 | 6 | Superior and middle frontal gyri | * Sensorimotor functions and autonomic processes |
|                 |     | Premotor & supplementary motor cortices | * Interoceptive stimulation                            |
|                 |     | SMA; BA 6 and FEFs (BA 8/9)     |                                                       |
| IC20, IC10, IC37, IC39 | 7 | Midserebral gyri and superior parietal lobules | * Visuospatial processing and reasoning |
|                 |     | Dorsolateral prefrontal (BA 46) & posterior parietal cortices (BA 7) | * Adaptive control and stable maintenance functions |
| IC41, IC40, IC45, IC52 | 8 | Ventral precentral gyr, central sulci, postcentral gyr, superior and inferior cerebellum | * Action and somesthesia corresponding to hand movements |
|                 |     | incl. primary sensorimotor cortices for upper extremities (M1; S1; BA 4/3/1/2) |                                                       |
| IC42, IC43, IC44 | 9 | Superior parietal lobe | * Motor execution and learning                        |
|                 |     | incl. medial posterior parietal association area (BA 5) |                                                       |
| IC47, IC50, IC66 | 10 | Middle and inferior temporal gyr | * Viewing complex, often emotional stimuli |
|                 |     | incl. the middle temporal visual association area (MT, | * Mental rotation and the discrimination of locations in space. |
RSN1-20 was characterized as per Laird et al. [4]. Here, RSN 1-5 were accorded to "emotional and autonomic processes, perception"; RSN 6-9 to "mixture of functions related to motor and visuospatial integration, coordination, and execution"; RSN 10-12 to "Networks related to visual perception". RSN10-18 to "divergent networks". (*) RSN19-20 was defined as frequent artifacts. In addition, seven further RSN were defined using anatomical knowledge if they did not fit any of the Laird atlas RSN components. To assign a sound function to these 7 extra RSNs the maximum xyz-MNI-coordinates were entered in the Neurosynth platform (neurosynth.org) with a radius of 4 mm. The most plausible associations given by this automated synthesis with large-scale human functional neuroimaging data [5] were chosen and specified using main concept terms such as "emotional processing". Each of the 27 RSNs was assigned to a separate color (cp. color scale), which matches the colors used for RSN-affiliations of whole brain IC maps in Fig. 2 of [1].

| RSN | Function and region | Color | 
|-----|---------------------|-------|
| IC07, IC09, IC16 | Lateral and medial posterior occipital cortices | 31 | Simple visual stimuli & higher-level visual processing, Weak loadings across many fields, such as behavioral domain |
| IC08, IC11, IC27, IC44 | Primary, secondary, and posterior visual cortices (V1, V2, V3; BA 17/18/19) | 32 | |
| IC14, IC22, IC26, IC53, IC59 | Medial prefrontal and posterior cingulate/precuneus areas | 33 | Default mode network, Theory of mind and social cognition tasks |
| IC51, IC62, IC70, IC74 | Cerebellum | 34 | Action and somesthesia, Range of sensorimotor, autonomic, and cognitive functions |
| IC12, IC25, IC28 | Right-lateralized fronto-parietal regions | 35 | Multiple cognitive processes |
| IC03, IC24 | Transverse temporal gyri | 36 | Audition (including tone and pitch discrimination), music and speech |
| IC01, IC40 | Dorsal precentral gyri, central sulci, postcentral gyri, superior and inferior cerebellum | 37 | Action and somesthesia corresponding to speech |
| IC18, IC23, IC55, IC60 | Left-lateralized fronto-parietal regions | 38 | Language, Memory, incl. working memory |
| IC20 | Artifacts* | 39 | Template mismatch errors, Algorithmic abnormality occurring during spatial normalization |
| IC13 | Posterior and middle insula | 40 | Emotional processing, Vestibular processing |
| IC21, IC29, IC42 | Temporal pole, frontal orbital cortex and inferior frontal gyrus | 41 | Semantic, word/language production & comprehension, Memory functions, Emotion, inhibition, theory of mind |
| IC30, IC63 | Middle temporal gyrus, angular gyrus, supramarginal gyrus | 42 | Face recognition, mentalizing, Audio-visual processing |
| IC32 | Lateral occipital cortex | 43 | Visual processing, observation, motion, eye movements |
| IC43, IC49, IC54, IC56, IC61, IC64, IC68, IC69, IC71-73, IC76-80 | Frontal pole | 44 | Executive functions, inhibition, Memory functions, Social cognition, Mentalizing, default mode network |
| IC46 | Middle frontal gyrus | 45 | Decision making, autobiographical, self-referential |
| IC58 | Rolandic operculum | 46 | Emotional processing, Pain, somatosensory, social interaction |

RSN1-20 was characterized as per Laird et al. [4]. Here, RSN 1-5 were accorded to "emotional and autonomic processes, perception"; RSN 6-9 to "mixture of functions related to motor and visuospatial integration, coordination, and execution"; RSN 10-12 to "Networks related to visual perception". RSN10-18 to "divergent networks". (*) RSN19-20 was defined as frequent artifacts. In addition, seven further RSN were defined using anatomical knowledge if they did not fit any of the Laird atlas RSN components. To assign a sound function to these 7 extra RSNs the maximum xyz-MNI-coordinates were entered in the Neurosynth platform (neurosynth.org) with a radius of 4 mm. The most plausible associations given by this automated synthesis with large-scale human functional neuroimaging data [5] were chosen and specified using main concept terms such as "emotional processing". Each of the 27 RSNs was assigned to a separate color (cp. color scale), which matches the colors used for RSN-affiliations of whole brain IC maps in Fig. 2 of [1].

Abr.: A1 = primary auditory cortex; ACC = anterior cingulate cortex, BA = Brodmann area, FEF = frontal eye fields, IC = independent component; M1 = primary motor cortex; MST = medial superior temporal area; MT = middle temporal area; OFC = orbitofrontal cortex, RSN = resting-state network; S1 = primary somatosensory cortex; SMA = supplementary motor area, V1-5 = primary, secondary and tertiary visual cortices.
Table 2A
Characterization of “asymmetrical and less connected” parcels.

| LH | Correlation to whole brain RSN | Anatomical location and cytoarchitectonic allocation | RH | Correlation to whole brain RSN | Anatomical location and cytoarchitectonic allocation |
|----|-------------------------------|---------------------------------|----|-------------------------------|---------------------------------|
|    |                               | V | L4 | P | V | L4 |                               | V | L4 | P | V | L4 |                               |
| 4, 6, 22, 23, 25 | 55% Inferior frontal gyrus R | 309 | 1 | + | - | 1 | 396 | 1 | 1 | - | 1 | 1 | 55% Inferior frontal gyrus L |
| 6, 8, 13, 14, 16, 18, 22, 23, 25 | 62% Inferior frontal gyrus L | 371 | -95 | - | + | 97 | 188 | 1 | - | 1 | 1 | 1 | 58% Inferior frontal gyrus R |
| 6, 12, 16, 22, 23 | 35% Superior temporal gyrus R | 578 | 66 | 4 | - | 76 | 650 | 1 | 1 | 1 | 1 | 1 | 30% Middle temporal gyrus R |
| 22 | 16% Planum polare R | 92 | 93 | 5 | - | 88 | 103 | 1 | 1 | 1 | 1 | 1 | 42% Insular cortex L |
| 21 | 31% Temporal pole L | 97 | -51 | 13 | + | 46 | 217 | 1 | 1 | 1 | 1 | 1 | 28% Frontal orbital cortex L |
| 4, 6, 7, 8, 9, 15, 16, 18, 21, 22, 23, 25 | 19% Temporal pole L | 217 | 24 | 17 | - | 57 | 216 | 1 | 1 | 1 | 1 | 1 | 17% Planum temporale L |
| 12, 13, 18, 21 | 54% Insular cortex L/R | 211 | 62 | 23 | + | 42 | 159 | 1 | 1 | 1 | 1 | 1 | 15% Temporal pole L |
| 3, 4, 6, 8, 12, 15, 16, 18, 21, 23, 27 | 18% Insular cortex L/R | 668 | -40 | 28 | + | 12 | 514 | 1 | 1 | 1 | 1 | 1 | 15% Precentral gyrus L |
| 6 | 20% Superior marginal gyrus L | 386 | -18 | 30 | - | 8 | 375 | 1 | 1 | 1 | 1 | 1 | 18% Central opercular cortex L |
| 21, 25 | 80% Temporal pole R | 45 | 93 | 14 | + | 100 | 43 | 1 | 1 | 1 | 1 | 1 | 81% Temporal pole L |
| 3, 7, 11, 12, 15, 21 | 82% Temporal pole L | 87 | -96 | 19 | + | 92 | 49 | 1 | 1 | 1 | 1 | 1 | 67% Temporal pole L |
| 1, 3, 6, 17 | 30% Temporal pole R | 23 | 23 | - | + | 23 | 64% Temporal pole L |
| 3, 11, 12, 15, 21 | 21% Parahippocampal gyrus R | 23 | 23 | - | + | 23 | 64% Temporal pole L |
Table 2A (continued)

| 16% Inferior frontal gyrus R | 15% Frontal orbital cortex R | 7% N/A | 24% Hippocampus entorhinal cortex R | 22% Amygdala lateralobasal and superficial group R | 17% Broca’s area BA44 + BA45 R | 4% Insula l. R | 179 | 89 | - | 100 | 97 | 22% Frontal orbital cortex R | 41% Hippocampus entorhinal cortex R | 30% N/A | 20% Amygdala lateralobasal and superficial group R | 2% Insula l. R |
| 63% Temporal pole R | 18% Superior temporal gyrus R | 16% Insular cortex R | 89% N/A | 2% Hippocampus entorhinal cortex R | | | 57 | 100 | + | 92 | 79 | 59% Temporal pole L | 28% Planum polare | 61% N/A | 9% Insula l. L | 5% Hippocampus entorhinal cortex L |
| 71% Temporal pole L | 14% Frontal orbital cortex L | 6% Superior temporal gyrus L | 2% Insular cortex L | 83% N/A | | | 70 | 86 | + | 79 | 38 | 34% Temporal pole R | 24% Frontal orbital cortex R | 11% Insular cortex L | 8% Superior temporal gyrus R | 57% N/A |
| 81% Temporal pole R | 14% Frontal orbital cortex L | 97% N/A | 2% Hippocampus entorhinal cortex R | | | | 43 | 91 | + | -91 | 65 | 66% Temporal pole L | 14% Frontal orbital cortex L | 58% N/A | 32% Amygdala lateralobasal and superficial group L | 12% Hippocampus entorhinal cortex L |
| 38% Temporal pole l/R | 12% Postcentral gyrus R | 11% Frontal orbital cortex L | 63% N/A | 19% Amygdala lateralobasal and superficial group L | 15% Hippocampus entorhinal cortex L | 4% Primary somatosensory cortex BA1 R | 169 | -31 | + | 40 | 43 | 63% Temporal pole R | 23% Planum polare | 5% Insular cortex L | 67% N/A | 21% Insula l. L/R | 14% Amygdala lateralobasal group R |

Table 2B

| LH | Correlation to whole brain RSN | Anatomical location and cytarchitectonic allocation | V | P | L-I | RH | Anatomical location and cytarchitectonic allocation | Correlation to whole brain RSN |
|---|---|---|---|---|---|---|---|---|---|
| 3, 4, 6, 9, 10, 13, 15, 18, 21, 22, 25 | 47% Insular cortex L/R | 41% Frontal orbital cortex l/R | 10% Temporal pole l/R | 89% N/A | 5% Broca’s area BA44 and BA45 R | 163 | -4 | + | 76 | 295 | 21% Frontal orbital cortex R/L | 25% Insular cortex R/L | 19% Frontal opercular cortex L/R | 32% Temporal pole R | 58% N/A | 25% Broca’s area BA44 and BA45 R |
| 3, 4, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 21, 22, 23, 24, 25 | 50% Insular cortex L/R | 21% Frontal opercular cortex L/R | 8% Frontal orbital cortex R | 52% N/A | 29% Broca’s area BA44 L/R and BA45 L/R | 401 | -29 | + | -8 | 285 | 70% Insular cortex L/R | 7% Frontal opercular cortex L | 6% Central opercular cortex L | 48% N/A | 25% Broca’s area BA44 L/R |
| 1, 3, 4, 6, 7, 9, 11, 12, 13, 14, 15, 16, 17, 18, 21, 22, 24, 25 | 51% Postcentral gyrus L/R | 33% Precentral gyrus L/R | 22% Secondary somatosensory cortex OP4 L/R | 27% Primary somatosensory cortex BA3a+b R/L | 9% Primary somatosensory cortex BA1 L/R | 23% Primary motor cortex BM4p L/R | 23% Premotor cortex BA6 L/R | 29% Broca’s area BA44 L/R | 13% Inferior frontal gyrus R | 32 Temporal pole R | 14% Central opercular cortex R | 47% Temporal pole l/R | 15% Superior temporal gyrus L | 4% Planum polare l/R | 3, 4, 6, 7, 9, 10, 11, 12, 15, 16, 18, 21, 22, 23, 25 | 888 | 1 | 1 | -1 | 780 | 57% Postcentral gyrus L/R | 30% Precentral gyrus L/R | 22% Secondary somatosensory cortex OP4 L/R | 30% Primary somatosensory cortex BA3p+b L/R | 10% Primary somatosensory cortex BA1 L/R | 6% Premotor cortex BA6 L/R | 5% Primary motor cortex BM4p L/R |
| 3, 4, 6, 8, 9, 12, 14, 15, 16, 17, 18, 22, 24, 27 | 51% Precentral gyrus L/R | 46% Postcentral gyrus L/R | 22% Primary somatosensory cortex BA1 L/R | 23 Premotor cortex BA6 R/L | 17% Primary motor cortex BA4p+a L/R | 8% Primary somatosensory cortex BA3a+b L | 888 | 1 | 1 | -1 | 780 | 57% Postcentral gyrus L/R | 30% Precentral gyrus L/R | 22% Secondary somatosensory cortex OP4 L/R | 30% Primary somatosensory cortex BA3p+b L/R | 10% Primary somatosensory cortex BA1 L/R | 6% Premotor cortex BA6 L/R | 5% Primary motor cortex BM4p L/R | 3, 4, 6, 7, 8, 9, 11, 12, 14, 15, 16, 17, 21, 22, 24, 27 | 353 | -10 | -3 | -19 | 532 | 53% Precentral gyrus L/R | 37% Postcentral gyrus L/R | 22% Primary somatosensory cortex BA1 L/R | 14% Premotor cortex BA6 L/R | 24% Primary somatosensory cortex BA3ap+b L/R | 15% Primary somatosensory cortex BA3b L/R |

Masked Binary and non-binary fCBP (functional connectivity brain parcellation) resulted in 30 different parcels, which were categorized by means of “spatial symmetry”, “number of parcels to systems correlations” and “predominant anatomical landmark”. This resulted in two different types of parcels: “Asymmetrical and less connected” (Table 2A) and “symmetrical and connected” (Table 2B) voxels (V). Each of the 30 parcels (P) was assigned to a separate color (cp. color scale Fig. 3 of [1]), which was the same in both LH (left-handed) and RH (right-handed) subgroups. “Asymmetrical” parcels were highlighted in grey. Parcels were anatomically characterized using the Harvard-Oxford structural cortical atlas in bold letters [6,7] and the Jülich histological (cyto- and myeloarchitectonic) atlas in regular letters [8,9]. Handedness-dependency (+/-) was calculated using a laterality index. If the laterality-index (L-I) per parcel and in between LH and RH changed concordant it was termed handedness-independent (-). An inverse laterality-index was termed handedness-dependent (+).
Table 2B (continued)

| Masked Binary and non-binary fCBP (functional connectivity brain parcellation) | 3/4, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 21, 22, 23, 24, 25, 27 | 3/4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 27 |
|---|---|---|
| Masked Binary and non-binary fCBP (functional connectivity brain parcellation) resulted in 30 different parcels, which were categorized by means of "spatial symmetry", "number of parcels to systems correlations" and "predominant anatomical landmark". This resulted in two different types of parcels: "Asymmetrical and less connected" (Table 2A) and "symmetrical and connected" (Table 2B) voxels. Each of the 30 parcels (P) was assigned to a separate color (cp. color scale Fig. 3 of [1]), which was the same in both LH (left-handed) and RH (right-handed) subgroups. "Asymmetrical" parcels were highlighted in grey. Parcels were anatomically characterized using the Harvard- Oxford structural cortical atlas in bold letters [6,7] and the Jülich histological (cyto- and myeloarchitectonic) atlas in regular letters [8,9]. Handedness-dependency (+/-) was calculated using a laterality index. If the laterality-index (L-I) per parcel and in between LH and RH changed concordantly it was termed handedness-independent (-). An inverse laterality-index was termed handedness-dependent (+).

| 13% Insular cortex R | 4% Frontal orbital cortex R | 39% N/A |
|---|---|---|
| 32% Broca's area BA44 R | 7% Secondary somatosensory cortex OP4 R | 6% Frontal orbital cortex L |
| 4% Insular cortex L | 63% N/A | 14% Primary auditory cortex TE1.2 L |
| 16% Broca's area BA44 L | 14% Primary auditory cortex TE1.2 L | 14% Primary auditory cortex TE1.2 R |

| 46% Superior temporal gyrus L/R | 23% Planum temporale L | 30% Superior temporal gyrus L/R |
|---|---|---|
| 8% Middle temporal gyrus R | 8% Middle temporal gyrus L | 20% Middle temporal gyrus L/R |
| 45% N/A | 10% Superior parietal lobule P1 L | 30% Temporal pole R/L |
| 32% Secondary somatosensory cortex OP1/4 L | 15% Secondary somatosensory cortex OP1/4 L | 65% N/A |
| 10% Inferior parietal lobule P1 L | 7% Primary auditory cortex TE1.0 L | 9% Secondary somatosensory cortex OP1 L |
| 5% Primary auditory cortex TE1.0 L | 7% Inferior parietal lobule PF R | 7% Primary auditory cortex TE1.0 L |

| 33% Superior temporal gyrus R | 21% Planum polare R | 42% N/A |
|---|---|---|
| 33% Planum temporale R | 7% Planum temporale R | 8% Middle temporal gyrus L |
| 32% Secondary auditory cortex TE 1.0 R + TE1.2 R | 32% Secondary auditory cortex TE 1.0 R + TE1.2 R | 45% N/A |
| 11% Secondary somatosensory cortex OP4 R | 11% Secondary somatosensory cortex OP4 R | 12% Secondary somatosensory cortex OP4 R |

| 40% Postcentral gyrus L/R | 18% Planum polare L | 52% Superior temporal gyrus L/R |
|---|---|---|
| 8% Parietal operculum cortex L | 8% Superior parietal lobule P1 L | 25% Planum temporale R/L |
| 7% Planum temporale R | 7% Planum temporale R | 25% Temporal pole R/L |
| 12% Secondary somatosensory cortex OP4 R | 12% Secondary somatosensory cortex OP4 R | 12% Secondary somatosensory cortex OP4 R |

| 252% | Superior temporal gyrus L/R | 8% Middle temporal gyrus R |
|---|---|---|
| 31% Inferior parietal lobule PF R | 31% Inferior parietal lobule PF R | 31% N/A |
| 8% Secondary somatosensory cortex OP4 R | 8% Secondary somatosensory cortex OP4 R | 31% Secondary somatosensory cortex OP4 R |

| 35% Middle temporal gyrus L | 15% Insular cortex L | 52% Superior temporal gyrus L |
|---|---|---|
| 12% Middle temporal gyrus L | 9% Planum temporale L | 11% Primary auditory cortex BA1+BA2 L |
| 6% Central opercular cortex L | 6% Central opercular cortex L | 11% Primary auditory cortex BA1+BA2 L |
| 6% Insula's gyrus L | 6% Insula's gyrus L | 5% Primary somatosensory cortex BA1 L |
| 45% N/A | 3% Primary somatosensory cortex BA1 L | 23% Primary auditory cortex TE1.2 + 3.0 L |
| 12% Secondary somatosensory cortex OP4 R | 12% Secondary somatosensory cortex OP4 R | 12% Secondary somatosensory cortex OP4 R |

| 20% Central opercular cortex R | 15% Planum polare R | 34% Central opercular cortex R |
|---|---|---|
| 12% Postcentral gyrus R | 15% Superior temporal gyrus R | 15% Superior temporal gyrus R |
| 7% Postcentral gyrus R | 5% Superior temporal gyrus R | 14% Postcentral gyrus R |
| 32% Secondary somatosensory cortex OP4 R | 73% N/A | 31% N/A |
| 19% Secondary somatosensory cortex OP4 R | 19% Secondary somatosensory cortex OP4 R | 31% Secondary somatosensory cortex OP4 R |

| 32% Parietal operculum cortex L/R | 26% Planum temporale L/R | 32% Parietal operculum cortex L/R |
|---|---|---|
| 26% Planum temporale L/R | 6% Central opercular cortex L/R | 26% Central opercular cortex L/R |
| 32% Secondary somatosensory cortex OP1 R/L | 25% Secondary somatosensory cortex OP1 R/L | 20% Superior parietal lobule P1 R/L |
| 16% Primary auditory cortex TE1.0 + TE1.1 R/L | 11% Inferior parietal lobule PF R + PFop L | 16% Primary auditory cortex TE1.0 + TE1.1 R/L |

| 39% Precentral gyrus L | 11% Inferior frontal gyrus R | 45% Precentral gyrus L/R |
|---|---|---|
| 11% Inferior frontal gyrus R | 11% Superior precentral gyrus R | 24% Supramarginal gyrus R |
| 10% Supramarginal gyrus R | 10% Superior frontal gyrus R | 15% Precentral gyrus R |
| 8% Insular cortex L | 8% Insular cortex R | 4% Insular cortex L/R |
| 30% Broca's area BA44 R | 30% Broca's area BA44 R | 43% Inferior parietal lobule PFop + PFI L/R |
| 14% Premotor cortex BA6 R | 14% Premotor cortex BA6 R | 9% Broca's area BA44 R |
| 12% Secondary somatosensory cortex OP3 R | 12% Secondary somatosensory cortex OP3 R | 5% Secondary somatosensory cortex OP3 R |
| 15% Inferior parietal lobule P1L, P1, PFCm R | 15% Inferior parietal lobule P1L, P1, PFCm R | 4% Premotor cortex BA6 R |

| 23% Precentral gyrus R | 12% Central opercular cortex L | 34% Central opercular cortex R |
|---|---|---|
| 10% Precentral gyrus R | 25% Central opercular cortex R | 20% Precentral gyrus L/R |
| 25% Central opercular cortex L | 10% Precentral gyrus R | 20% Precentral gyrus L/R |
| 15% Secondary somatosensory cortex OP4 L/R | 15% Secondary somatosensory cortex OP4 L/R | 10% Precentral gyrus R |
| 3% Primary auditory cortex TE1.2 L/R | 3% Primary auditory cortex TE1.2 L/R | 3% Primary auditory cortex TE1.2 L/R |

| 41% | Superior frontal gyrus L | 3% Primary auditory cortex TE1.2 R |
|---|---|---|
| 21% Precentral gyrus L | 21% Precentral gyrus L | 3% Primary auditory cortex TE1.2 R |
| 11% Inferior parietal lobule L | 11% Inferior parietal lobule L | 3% Primary auditory cortex TE1.2 R |
| 12% Central opercular cortex L | 12% Central opercular cortex L | 3% Primary auditory cortex TE1.2 R |
| 6% Broca's area BA44 L | 6% Broca's area BA44 L | 6% Broca's area BA44 L |
| 12% Inferior parietal lobule PFop, PF, PFI L | 12% Inferior parietal lobule PFop, PF, PFI L | 12% Inferior parietal lobule PFop, PF, PFI L |
| 6% Premotor cortex BA6 L | 6% Premotor cortex BA6 L | 6% Premotor cortex BA6 L |
| 6% Secondary somatosensory cortex OP4 L | 6% Secondary somatosensory cortex OP4 L | 6% Secondary somatosensory cortex OP4 L |
Table 3A
Characterization of “unique voxels” within parcels, type “asymmetric and less connected”.

| LH | RH |
|----|----|
| **Anatomical location and cytoarchitectonic allocation** |
| 68 % Inferior frontal gyrus R 15% Middle temporal gyrus R 8% Angular Gyrus R 62% Broca’s area BA45 R 23% Inferior parietal lobule PFm, Pga R | **V** | L-I | **U +/-** | L-I | **V** |
| 72 | 100 | + | -100 | 129 |
| 75% Inferior frontal gyrus L 19% Frontal operculum gyrus 54% Broca’s area BA45 L 38% Broca’s area BA44 L |
| 56% Inferior frontal gyrus L 15% Middle temporal gyrus L 6% Frontal orbital cortex L 5% Superior temporal gyrus L 41% N/A 34% Broca’s area BA44 L 22% Broca’s area BA45 L | 149 | -100 | + | 100 | 95 |
| 88% Inferior frontal gyrus R 6% Frontal operculum Cortex R 48% Broca’s area BA44 R 48% Broca’s area BA45 R |
| 49% Superior temporal gyrus R 19% Supramarginal gyrus R 8% Middle temporal gyrus R 52% N/A 13% Inferior parietal lobule PF R 11% Insula Id1 R | 191 | 80 | - | 100 | 244 |
| 31% Superior temporal gyrus R 28% Supramarginal gyrus R 28% Middle temporal gyrus R 52% N/A 36% Inferior parietal lobule PF, PFm, Pga R 5% Insula Id1 R |
| **Middle and posterior insula** |
| **U13** | 100 | 16 |
| 69% Insular cortex L 25% Frontal orbital cortex L 6 % Temporal pole L 87% N/A |
| **U17** | 100 | + | -40 | 60 |
| 20% Insular cortex L 20% Planum polare L 18% N/A 5% Superior temporal gyrus L |
| **U25** | 100 | 16 |
| 48% Insula Id1 L/R 5% Amygdala centromedian group L |
| 6 % Hippocampus cornu ammonis R 48% Inferior frontal gyrus R 6% Frontal pole R 87% Broca’s area BA45 R 12% N/A |
Table 3A (continued)

| Masked non-binary fCBP (functional connectivity based parcellation) enabled the distinction of spatial uniqueness (Tables 3A and 3B) and commonality (3C) of independent components that form parcels. Analog to Tables 2A and 2B “unique voxels” (U) were left in the previous categorization in two types of “unique” voxels: Type previously “asymmetric and less connected” (Table 3A, highlighted in grey) and type previously “symmetric and connected” (Table 3B). An inverse laterality-index (L-I) was termed handedness-dependent (+), a concordant laterality-index meant handedness-independency (-). Common “voxels” were defined as voxels that overlapped in between parcels. To enable visualization of the “common” voxels, 9 groups of 2-6 spatially similar parcels (“common clusters”; C) were defined and correlated to whole brain RSN.
| Masked non-binary fCBP (functional connectivity based parcellation) enabled the distinction of spatial uniqueness (Tables 3A and 3B) and commonality (3C) of independent components that form parcels. Analog to Tables 2A and 2B “unique voxels” (U) were left in the previous categorization in two types of “unique” voxels: Type previously “asymmetric and less connected” (Table 3A, highlighted in grey) and type previously “symmetric and connected” (Table 3B). An inverse laterality-index (L-I) was termed handedness-dependent (+), a concordant laterality-index meant handedness-independency (-). Common “voxels” were defined as voxels that overlapped in between parcels. To enable visualization of the “common” voxels, 9 groups of 2-6 spatially similar parcels (“common clusters”; C) were defined and correlated to whole brain RSN. For a depiction of “unique” voxels please view Fig. 6A in [1], and for the “common clusters” view Fig. 6B in [1]. Each of the 30 parcels (P) was assigned to a separate color (cp. color scale Fig. 3 in [1]), which was also used for the parcel’s “unique voxels”. The colors match between (left-handed) LH and right-handed (RH) subgroups. This color-code can also be seen in Table 3C, where each color represents one of the parcels included in the “common” cluster. U and C were anatomically characterized using the Harvard–Oxford structural cortical atlas in bold letters [6,7] and the Jülich histological (cyto- and myelo-architectonic) atlas in regular letters [8,9].

| 87% Temporal pole R | 13% Frontal orbital cortex R | 100% N/A | 15 | 100 | U27 | + | -100 | 16 |
| 50% Temporal pole L | 44% Frontal orbital cortex L | 6% Parahippocampal gyrus L | 68% N/A | 19% Hippocampus entorhinal cortex L | 6% Amygdala laterobasal group L |
| 47% Temporal pole L | 26% Parahippocampal gyrus L | 24% Frontal orbital cortex L | 37% N/A | 36% Hippocampus entorhinal cortex L | 21% Amygdala laterobasal + superficial group L |
| 26% Insular cortex L/R | 12% Heschl’s gyrus L/R | 10% Planum polare L/R | 10% Supramarginal gyrus L | 7% Superior temporal gyrus L | 5% N/A | 25% Insula Id1 L/R + Ig2 L/R | 19% N/A | 8% Inferior parietal lobule PFcm L |
| 323 | 45 | + | 45 | 184 |
| 18% Middle temporal gyrus R | 24% Central opercular cortex R/L | 23% Temporal pole R/L | 11% N/A | 5% Insular cortex R 43% N/A | 8% Secondary somatosensory cortex OP4 R | 5% Secondary somatosensory cortex OP3 R | 8% Secondary somatosensory cortex OP1 L | 8% Amygdala superficial group R |
| 27% Central opercular cortex L | 10% Planum polare L | 10% Angular gyrus L | 10% Precentral gyrus R | 8% Supramarginal gyrus L | 7% Insular cortex L | 5% Middle temporal gyrus R | 5% Superior temporal gyrus R | 27% N/A | 27% Secondary somatosensory cortex OP4 L | 5% Amygdala laterobasal group R | 4% Insula Id1 R |
| 40 | 11 | 83 |

| “Inferior insula” |
| 30% Temporal pole R | 30% Frontal orbital cortex R | 30% Parahippocampal gyrus R | 44% Amygdala laterobasal R | 30% Hippocampus entorhinal cortex R |
| 56% Parahippocampal gyrus R | 25% Temporal pole R | 19% Frontal orbital cortex R | 65% Hippocampus entorhinal cortex R | 23% Amygdala laterobasal group R |
| 27 | 100 | U23 | - | 100 | 32 |
Table 3B
Characterization of “unique voxels” within parcels, type “symmetric and connected”.

| LH | RH |
|----|----|
| Anatomical location and cytoarchitectonic allocation | V | L-I | U +/- | L-I | V | Anatomical location and cytoarchitectonic allocation |
| “Anterior insula” | | | | | | |
| U6 | 100 | 76 | 54% Frontal orbital cortex R | 31% Insular cortex R/L | 9% Inferior frontal gyrus R | 56% N/A | 17% Broca’s area BA45 R |
| | 28% Insular cortex R | 21% Frontal operculum cortex R | 11% Frontal orbital cortex R | 32% N/A |
| 17% Amygdala superficial group R | 18% Broca’s area BA44 and BA 45 R |
| 54 | 100 | U14 | + | 108 | 66% Insular cortex L/R | 17% Central opercular cortex L | 17% 21% Frontal operculum cortex L/R | 43% Broca’s area BA44 L/R | 34% N/A |
| “Sensorimotor” | | | | | | |
| 55% Postcentral gyrus L/R | 26% Precentral gyrus L/R | 28% Secondary somatosensory cortex OP4 L/R | 40% Primary somatosensory cortex BA3a+b R/L |
| 276 | 10 | U1 | + | 147 | 61% Postcentral gyrus L/R | 22% Precentral gyrus L/R | 17% Central opercular cortex L/R | 28% Secondary somatosensory cortex OP4 L/R | 35% Primary somatosensory cortex BA3a+b L/R |
| 58% Precentral gyrus L/R | 41% Postcentral gyrus L/R | 26% Primary somatosensory cortex BA1 L/R | 16% Premotor cortex BA6 R/L | 15% Primary somatosensory cortex BA3a+b L/R | 28% Primary motor cortex BA4p L/R +a a L |
| 141 | 10 | U3 | + | 207 | 53% Postcentral gyrus L/R | 45% Precentral gyrus L/R | 28% Primary somatosensory cortex BA3a+b L/R | 20% Primary motor cortex BA4a+p L | 14% Premotor cortex BA6 L/R |
| 10% Primary somatosensory cortex BA1 L |
| “STG” | | | | | | |
| U10 | -100 | 34 | 64% Temporal pole L | 24% Superior temporal gyrus L | 8% Planum polare L/R | 62% N/A |
| 23% Primary auditory cortex TE1.2 L |
| U12 | -36 | 205 | 20% Superior temporal gyrus L | 28% Temporal pole R/L | 13% Middle temporal gyrus L/R |
| | | | 60% N/A | 4% Inferior parietal lobule PF L | 2% Primary auditory cortex TE1.0 L |
| U15 | 100 | 18 | 50% Superior temporal gyrus R | 44% N/A | 6% Precentral gyrus |
| 95% N/A | 6% Primary auditory cortex TE1.2 R |
| 36% Middle temporal gyrus R | 27% Postcentral gyrus L | 13% Temporal pole R | 7% Central opercular cortex L | 7% Parietal opercular cortex L | 65% N/A | 14% Secondary somatosensory cortex OP1 L |
| 189 | 2 | U16 | - | 100 | 33 | 55% Superior temporal gyrus R | 42% Planum temporale R | 3 % Heschl’s Gyrus |
| 56% N/A | 33% Primary auditory cortex TE1.0+ 1.1 R |
| U20 | -100 | 27 | 78% Superior temporal gyrus L | 31% Planum polare L | 7% Central opercular cortex L | 48% N/A | 22% Primary auditory cortex TE1.2 L | 22% Secondary somatosensory cortex OP4 L |
Masked non-binary fCBP (functional connectivity based parcellation) enabled the distinction of spatial uniqueness (Tables 3A and 3B) and commonality (Table 3C) of independent components that form parcels. Analog to Tables 2A and 2B “unique voxels” (U) were left in the previous categorization in two types of “unique” voxels: Type previously “asymmetric and less connected” (Table 3A, highlighted in grey) and type previously “symmetric and connected” (Table 3B). An inverse laterality-index (L-I) was termed handedness-dependent (+), a concordant laterality-index meant handedness-independency (-). Common voxels were defined as voxels that overlapped in between parcels. To enable visualization of the “common” voxels, 9 groups of 2-6 spatially similar parcels (“common clusters”: C) were defined and correlated to whole brain RSN. For a depiction of “unique” voxels please view Fig. 6A in [1], and for the “common clusters” view Fig. 6B in [1]. Each of the 30 parcels (P) was assigned to a separate color (cp. color scale Fig. 3 in [1]), which was also used for the parcel’s “unique voxels”. The colors match between (left-handed) LH and right-handed (RH) subgroups. This color-code can also be seen in Table 3C, where each color represents one of the parcels included in the “common” cluster. U and C were anatomically characterized using the Harvard-Oxford structural cortical atlas in bold letters [6,7] and the Jülich histological (cyto- and myelo-architectonic) atlas in regular letters [8,9].

Table 3B (continued)

| Masked non-binary fCBP (functional connectivity based parcellation) enabled the distinction of spatial uniqueness (Tables 3A and 3B) and commonality (Table 3C) of independent components that form parcels. Analog to Tables 2A and 2B “unique voxels” (U) were left in the previous categorization in two types of “unique” voxels: Type previously “asymmetric and less connected” (Table 3A, highlighted in grey) and type previously “symmetric and connected” (Table 3B). An inverse laterality-index (L-I) was termed handedness-dependent (+), a concordant laterality-index meant handedness-independency (-). Common voxels were defined as voxels that overlapped in between parcels. To enable visualization of the “common” voxels, 9 groups of 2-6 spatially similar parcels (“common clusters”: C) were defined and correlated to whole brain RSN. For a depiction of “unique” voxels please view Fig. 6A in [1], and for the “common clusters” view Fig. 6B in [1]. Each of the 30 parcels (P) was assigned to a separate color (cp. color scale Fig. 3 in [1]), which was also used for the parcel’s “unique voxels”. The colors match between (left-handed) LH and right-handed (RH) subgroups. This color-code can also be seen in Table 3C, where each color represents one of the parcels included in the “common” cluster. U and C were anatomically characterized using the Harvard-Oxford structural cortical atlas in bold letters [6,7] and the Jülich histological (cyto- and myelo-architectonic) atlas in regular letters [8,9]. |
Table 3C
Characterization of “common” clusters (C).

| LH | Correlation to whole brain RSN | Anatomical location and cytoarchitectonic allocation | V | Common Cluster | V | Anatomical location and cytoarchitectonic allocation | Correlation to whole brain RSN |
|----|--------------------------------|-----------------------------------------------|---|----------------|---|-----------------------------------------------|-------------------------------|
|    | 7, 13, 16, 21, 27             | 48% Insular cortex L/R                         | 298| C1 “Posterior insula” | 133| 75% Insular cortex L/R                         | 1, 21                        |
|    | 53% Planum polare R/L         | 20% N/A                                       |   | 5 13 21 25        |   | 17% Temporal pole R                           |                              |
|    | 20% Insula id1 L             |                                               |   |                      |   | 60% N/A                                       |                              |
|    | 40% N/A                      |                                               |   |                      |   | 20% Insula id1 L/R                            |                              |
| 1, 21 | 48% Insular cortex L/R         | 33% Planum polare L/R                         | 200| C2 “Inferior insula” | 219| 81% Temporal pole L/R                        | 1, 4, 15, 18, 21            |
|    | 85% N/A                      | 3% Hippocampus entorhinal cortex R            |   | 18 19 24 26 27 29  |   | 80% N/A                                       |                              |
| 4, 6, 17, 21, 22, 23, 25, 27 | 62% Frontal orbital cortex L/R               |                                               | 269| C3 “IFG” | 282| 25% Inferior frontal gyrus L                  | 4, 6, 7, 8, 9, 14, 15, 16, 21, 22, 23, 25, 27 |
|    | 26% Inferior frontal gyrus L/R |                                               |   |                      |   | 37% Planum polare L/R                        |                              |
|    | 60% N/A                      | 25% Broca’s area BA44 L/R                     |   |                      |   | 25% Temporal pole L/R                        |                              |
|    | 25% Broca’s area 45 L/R       | 13% Temporal Pole L/R                        |   |                      |   | 12% Frontal orbital cortex R                  |                              |
| 3, 6, 7, 8, 9, 11, 12, 14, 15, 16, 17, 18, 22, 24, 27 | 61% Precentral gyrus L/R                   |                                               | 147| C4 “Sensorimotor” | 235| 64% Precentral gyrus L/R                     | 3, 8, 7, 12, 14, 15, 16, 17, 27 |
|    | 39% Postcentral gyrus L/R     |                                               |   |                      |   | 36% Precentral gyrus L/R                     |                              |
|    | 42% Primary somatosensory cortex L/R | BA1, BA3+1b | 20% Primary motor cortex BA44 L/R  |   |                      |   | 67% Primary somatosensory cortex L/R           |                              |
|    | 19% Premotor cortex BA 6 L/R  |                                               |   |                      |   | 14% Primary motor cortex BA44 L/R             |                              |
| 3, 6, 7, 8, 9, 11, 12, 14, 16, 17, 21, 22, 23, 24, 27 | 37% Superior temporal gyrus L/R               |                                               | 224| C5 “SIG” | 376| 44% Superior temporal gyrus L/R                | 3, 6, 7, 8, 9, 14, 15, 16, 21, 22, 23, 27 |
|    | 13% Temporal pole L/R         |                                               |   |                      |   | 27% Planum temporale L/R                     |                              |
|    | 12% Central opercular cortex R|                                               |   |                      |   | 9% Central opercular cortex R                 |                              |
|    | 7% Planum temporale R         |                                               |   |                      |   | 8% Planum polare R                            |                              |
|    | 53% N/A                      | 25% Sec. somatosensory cortex OP4 L/R         |   |                      |   | 45% N/A                                       |                              |
|    | 21% Primary auditory cortex TE1.2 L/R |                                               |   |                      |   | 32% Sec. somatosensory cortex OP4 L/R         |                              |
| 6, 12, 16, 17, 18, 22, 23, 27 | 63% Superior temporal gyrus L/R               |                                               | 126| C6 “S/MTG” | 126| 43% Superior temporal gyrus L/R                | 4, 8, 12, 11, 13, 15, 16, 22, 23, 27 |
|    | 27% Planum temporale L        |                                               |   |                      |   | 35% Middle temporal gyrus L/R                 |                              |
|    | 5% Middle temporal gyrus L    | 27% Sec. somatosensory cortex OP1 L/R         |   |                      |   | 17% Supramarginal gyrus L                     |                              |
|    | 47% N/A                      | 11% Primary auditory cortex TE1.1 L/R         |   |                      |   | 70% N/A                                       |                              |
|    | 11% Broca’s area BA44+45 L/R  |                                               |   |                      |   | 8% Inferior parietal lobe/PFm L               |                              |
| 3, 4, 6, 7, 8, 11, 13, 15, 18, 21, 22, 24, 25 | 65% Insular cortex L/R                  |                                               | 249| C7 “Anterior insula” | 123| 60% Insular cortex L/R                       | 3, 4, 6, 7, 8, 10, 12, 13, 15, 16, 18, 21, 22, 24, 27 |
|    | 7% Frontal opercular cortex R|                                               |   |                      |   | 24% Frontal opercular cortex R                |                              |
|    | 68% N/A                      |                                               |   |                      |   | 7% Temporal pole L/R                          |                              |
|    | 11% Broca’s area BA44+45 L/R  |                                               |   |                      |   | 56% N/A                                       |                              |
| 4, 6, 7, 8, 9, 11, 12, 14, 15, 16, 17, 18, 21, 22, 23, 24, 27 | 28% Planum temporale L/R               |                                               | 614| C8 “Heschl Gyrus” | 913| 15% Central opercular cortex L/R               | 4, 6, 7, 8, 9, 11, 12, 15, 16, 17, 18, 21, 22, 23, 24, 27 |
|    | 21% Heschl’s gyrus L/R        |                                               |   |                      |   | 11% Insular cortex L/R                        |                              |
|    | 9% Central opercular cortex L/R |                                               |   |                      |   | 11% Planum temporale L                        |                              |
|    | 8% Parietal operculum cortex L|                                               |   |                      |   | 11% Heschl’s gyrus L/R                       |                              |
|    | 8% Supramarginal gyrus L      |                                               |   |                      |   | 18% N/A                                       |                              |
| 4, 6, 8, 9, 13, 14, 15, 16, 17, 18, 21, 22, 23, 27 | 35% Precentral gyrus L/R                 |                                               | 337| C9 “temporo-parietal intersection” | 235| 47% Precentral gyrus L/R                     | 1, 4, 6, 8, 9, 10, 13, 14, 15, 16, 17, 18, 22, 23, 25, 27 |
|    | 45% Precentral gyrus L/R      |                                               |   |                      |   | 24% Supramarginal gyrus L                     |                              |
|    | 15% Frontal insular gyrus L/R |                                               |   |                      |   | 10% Postcentral gyrus L                       |                              |
|    | 4% Postcentral gyrus L        |                                               |   |                      |   | 32% Broca’s area BA44 L/R                     |                              |
|    | 53% Broca’s area BA44 L/R     |                                               |   |                      |   | 21% Inferior parietal lobule PFop, Pf, Pf1 L  |                              |
|    | 12% Sec. somatosensory cortex OP4 L/R |                                               |   |                      |   | 16% Sec. somatosensory cortex OP4 L/R         |                              |
|    | 9% Primary auditory cortex TE1.2 L/R |                                               |   |                      |   | 11% Premotor cortex BA6 L/R                   |                              |

Masked non-binary fCBP (functional connectivity based parcellation) enabled the distinction of spatial uniqueness (Tables 3A and 3B) and commonality (Table 3C) of independent components that form parcels. Analog to Tables 2A and 2B “unique voxels” (U) were left in the previous categorization in two types of “unique” voxels: Type previously “asymmetrically and less connected” (Table 3A, highlighted in grey) and type previously “symmetrically and connected” (Table 3B). An inverse laterality-index (L-I) was termed handedness-dependent (+), a concordant laterality-index meant handedness-independency (-). Common voxels were defined as voxels that overlapped in between parcels. To enable visualization of the “common” voxels, 9 groups of 2-6 spatially similar parcels (“common clusters”; C) were defined and correlated to whole brain RSN. For a depiction of “unique” voxels please view Fig. 6A in [1], and for the “common clusters” view Fig. 6B in [1]. Each of the 30 parcels (P) was assigned to a separate color (cp. color scale Fig. 3 in [1]), which was also used for the parcel’s “unique voxels”. The colors match between (left-handed) LH and right-handed (RH) subgroups. This color-code can also be seen in Table 3C, where each color represents one of the parcels included in the “common” cluster. U and C were anatomically characterized using the Harvard–Oxford structural cortical atlas in bold letters [6,7] and the Jülich histological (cyto- and myelo-architectonic) atlas in regular letters [8,9].
Fig. 1. Overlay of resulting 27 whole brain resting state networks (RSN). This overlay shows the spatial distribution of the 27 RSN systems. 80 dimensional whole brain ICA was performed on denoised fMRI data (LH and RH combined) using a whole brain mask. Each independent component (IC) was semi-automatically labeled to the 20 resting state network (RSN) atlas proposed by Laird et al. [4]. ICs that did not fit the Laird components (overall 7 of 80 or 8.75% of ICs) were checked visually and assigned to an anatomical label of the “Harvard-Oxford cortical structural atlas”. Here, sound behavioral interpretations to each IC (network) were determined by inserting their maximum xyz-MNI-coordinates in the large-scale, automated synthesis of human functional neuroimaging data platform Neurosynth (neurosynth.org), using a radius of 4 mm [5]. For an overview of these networks view Table 1. For an overview of the 80 dimensional whole brain ICA including their RSN attribution cp Fig. 2 in [1].
Fig. 2. Overview of 30 single parcels resulting from masked binary fCBP. To be able to compare LH and RH parcels we had to find analogous binary parcels between LH and RH. This approach was successful for interhemispheric symmetric parcels, but not for interhemispheric asymmetric parcels. Here, the parcels needed to be spatially flipped (mirrored) to correspond between LH and RH. This was done with respect to the x-axis, i.e. hemisphere-flip in x-direction in MNI-space. RH results are shown on the top row and the LH results in the lower row. Hemisphere-flips are depicted in the middle if necessary. The background colors represent the color of the parcel. The P number is indicated on the bottom right side of each overlap grouping. A more detailed depiction of spatially asymmetric and flipped parcels can be viewed in Fig. 4 of [1].
Fig. 3. P-to-RSN correlation matrix (FDR < 0.01). The x-axis (including colors) indicates the 30 parcels that resulted for LH and RH after masked binary fCBP (cp. Fig.3 in [1]). The third column represents differences between RH and LH. The y-axis (including colors) indicate the assignment to the 27 RSN systems as shown in Table 1. Note, that the number of RSN assignments to each parcel (P-to-RSN) did not differ between LH and RH. However, symmetrical parcels had significantly more RSN assignments than asymmetrical.

Fig. 4. C-to-RSN correlation matrix (FDR < 0.01). The x-axis indicates the 9 common clusters (C) that resulted for LH and RH after masked non-binary fCBP (cp. Fig. 6B in [1]). The third column represents differences between RH and LH. The y-axis (including colors) indicate the assignments of C to the 27 RSN systems as shown in Table 1. Please note, that apart from C1 “posterior insula” and C2 “inferior insula”, common clusters correlated with more than 5 RSN “systems”, which indicate manifold functionality.
Acknowledgements

Partially funded by the Society for the Advancement of Science and Research at the Medical Faculty of the Ludwig-Maximilians-Universität München (Verein zur Förderung von Wissenschaft und Forschung an der Medizinischen Fakultät der Ludwig-Maximilian Universität München), the Graduate School of Systemic Neurosciences (GSN), the German Foundation for Neurology (Deutsche Stiftung für Neurologie, DSN), the Hertie Foundation and the German Federal Ministry of Education and Research (German Center for Vertigo and Balance Disorders -IFBLMU, Grant code 01EO140). This is a part of the dissertation of E. Kierig.

Transparency document. Supporting information

Transparency document associated with this article can be found in the online version at https://doi.org/10.1016/j.dib.2019.01.014.

References

[1] V. Kirsch, R. Boegle, D. Keeser, E. Kierig, B. Ertl-Wagner, T. Brandt, M. Dieterich, Handedness-dependent functional organizational patterns within the bilateral vestibular cortical network revealed by fMRI connectivity based parcellation, Neuroimage 178 (2018) 224–237. https://doi.org/10.1016/j.neuroimage.2018.05.018.
[2] C. Lopez, O. Blanke, F.W. Mast, The human vestibular cortex revealed by coordinate-based activation likelihood estimation meta-analysis, Neuroscience 212 (2012) 159–179. https://doi.org/10.1016/j.neuroscience.2012.03.028.
[3] P. Zu Eulenburg, S. Caspers, C. Roski, S.B. Eickhoff, Meta-analytical definition and functional connectivity of the human vestibular cortex, Neuroimage 60 (2012) 162–169. https://doi.org/10.1016/j.neuroimage.2011.12.032.
[4] A.R. Laird, P.M. Fox, S.B. Eickhoff, J.A. Turner, K.L. Ray, D.R. McKay, D.C. Glahn, C.F. Beckmann, S.M. Smith, P.T. Fox, Behavioral interpretations of intrinsic connectivity networks, J. Cogn. Neurosci. 23 (2011) 4022–4037. https://doi.org/10.1162/jocn_a_00077.
[5] T. Yarkoni, R.A. Poldrack, T.E. Nichols, D.C. Van Essen, T.D. Wager, Large-scale automated synthesis of human functional neuroimaging data, Nat. Methods 8 (2011) 665–670. https://doi.org/10.1038/nmeth.1635.
[6] R.S. Desikan, F. Ségonne, B. Fischl, B.T. Quinn, B.C. Dickerson, D. Blacker, R.L. Buckner, A.M. Dale, R.P. Maguire, B.T. Hyman, M. S. Albert, R.J. Killiany, An automated labeling system for subdividing the human cerebral cortex on MRI scans into gyral based regions of interest, Neuroimage 31 (2006) 968–980. https://doi.org/10.1016/j.neuroimage.2006.01.021.
[7] N. Makris, J.M. Goldstein, D. Kennedy, S.M. Hodge, V.S. Cavaness, S.V. Faraone, M.T. Tsuang, L.J. Seidman, Decreased volume of left and total anterior insular lobule in schizophrenia, Schizophr. Res. 83 (2006) 155–171. https://doi.org/10.1016/j.schres.2005.11.020.
[8] S.B. Eickhoff, T. Faus, S. Caspers, M.H. Grosbras, A.C. Evans, K. Zilles, K. Amunts, Assignment of functional activations to probabilistic cytoarchitectonic areas revisited, Neuroimage 36 (2007) 511–521. https://doi.org/10.1016/j.neuroimage.2007.03.060.
[9] S.B. Eickhoff, K.E. Stephan, H. Mohlberg, C. Grefkes, G.R. Fink, K. Amunts, K. Zilles, A new SPM toolbox for combining probabilistic cytoarchitectonic maps and functional imaging data, Neuroimage 25 (2005) 1325–1335. https://doi.org/10.1016/j.neuroimage.2004.12.034.