Subdivision of the occipital lobes with tractography

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Introduction. Tractography allows segregating a brain area into subregions defined by a similar connectivity pattern. For instance, the supplementary motor area (SMA) and the pre-SMA (*1*) or Brodmann areas 44 and 45 (*2*) can be distinguished using tractography because they exhibit sharp changes in their connectivity. Here we applied tractography-based parcellation to the left and right occipital lobes in 18 healthy participants and compared the result with the parcellation obtained from post-mortem approaches.

Material and methods. We used an acquisition sequence fully optimised for tractography of diffusion-weighted imaging (DWI), which provided an isotropic (2 × 2 × 2 mm) resolution, 60 directions and a b-value of 1500 sec mm−2. For each participant, a 'connectivity' matrix between occipital ROIs and each other ROIs of the brain was derived from the data using probabilistic tractography modelling for two populations of fibre per voxel (*1*). Each value of the 'connectivity' matrix obtained from the tractography was converted into a z score and entered into a principal component analysis using SPSS software (SPSS, Chicago, IL). Following the Scree test approach (*3*), we obtained 8 clusters for each lobe (Figure 1).

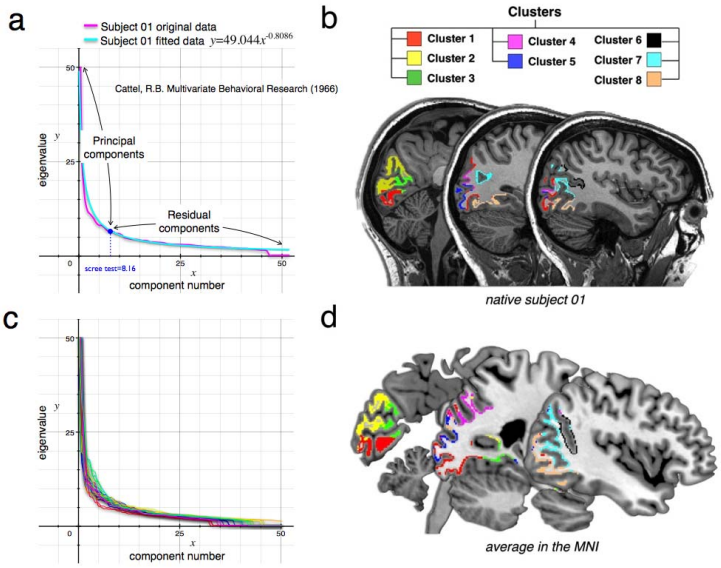

Figure 1. Individual and group parcellation of the left occipital lobe. (a) Graph of the principal components (x) according to their eigenvalue sizes (y) for one representative subject. Original data is represented in purple and fitted data in cyan. (b) Cluster extracted from the principal component analysis in one representative subject. (c) Graph of the principal components (x) according to their eigenvalue sizes (y) for all subjects. Different colours are used for each subject. (d) Group parcellation of the left occipital lobe obtained from averaging the result of the 18 participants.

Results. Probabilistic tractography combined with principal component analysis statistical framework revealed 8 clusters sharply segregated. Each of these clusters had a specific pattern of 'anatomical connectivity' with the rest of the brain (Figure 1).

Discussion and Conclusion. Tractography-based parcellation allows segregating in the human living brain areas showing sharp differences in their connectivity with the rest of the brain. Using this approach we revealed 8 different areas in each occipital lobe. This parcellation does not correspond to classical myelogenetic (*4*) cytoarchitectonic (*5*) or myeloarchitectonic (*6*) subdivisions of the occipital lobe. However, the lateral view shows some similitude with the classical description of the identified visual areas in humans (*7*). Our results did not show a clear delineation of V1 in the medial occipital region. Instead 3 clusters seemed to separate areas dedicated to foveal (green on figure 1a) from peripheral (yellow and red) vision and lower visual field (yellow) from superior visual field (red). Differences in the afferent and efferent connections of these areas are reported in the literature (*8, 9*). However, we cannot exclude that a crossing issue, which occurs between the splenium of the corpus callosum, associations pathways and the optic radiations, may also explain this result. Further tractrography-based parcellation using new algorithm resolving complex fibre crossing organisation (>3 crossing) (*10*) may resolve this issue.

(1) Johansen-Berg et al., *Proc Natl Acad Sci USA* (2004). (2) Anwander et al. *Cereb Cortex* (2007). (3) Cattell. *Multivariate Behavioral Research* (1966). (4) Flechsig, *Anatomie des menschlichen Gehirns und Rückenmarks auf myelogenetischer Grundlage.* (1920). (5) Amuntse et al. *NeuroImage* (2000). (6) Smith *J Anat* (1907). (7) Van Essen, *in The Visual Neurosciences* (2003). (8) Curcio et al. *Science* (1987). (9) Meissirel et al. *Proc Natl Acad Sci U S A* (1997). (10) Dell'acqua et al. *Neuroimage* (2010).