



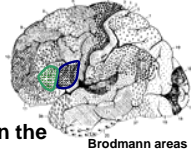
Differential connectivity of BA44 and BA45 measured with DTI fiber tracking

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Introduction

- Broca's area, in left inferior frontal gyrus, is activated in a variety of linguistic and non-linguistic tasks (e.g., verb generation, syntactic processing, semantic selection, rhythm judgment, sequencing).
- Recent fMRI studies (e.g., Amunts et al., 2004) suggest a functional segregation between the two major cytoarchitectonic subdivisions of Broca's area, Brodmann areas (BA) 44 and 45.
- In the current study, we aim to dissociate between the connectivity patterns of BA44 and BA45.
- Evidence from monkey anatomy (Pandya et al. 1996) shows differential projections to BA44 and BA45.
- In humans, no dissociation is known in connectivity patterns of BA44/45. The distinction between BA44 and BA45 connections may be beyond the resolution of post-mortem dissections.



Brodmann areas



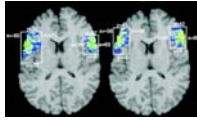
From Pandya and Yeterian (1996), Figure 5

Methods

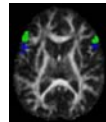
- DTI data were collected in 15 adults (age range: 19-53, mean: 31; 11 males).
- Data Acquisition**
- 48-54 axial slices, 2-mm-thick were collected using a 1.5T scanner, for two b values (0, 800). We used a diffusion-weighted, single-shot spin-echo EPI sequence [TE = 63ms; TR=6s; FOV=260mm; matrix size = 128 x 128; bandwidth=110 kHz; partial k-space acquisition; 8-14 repeats; 6 directions; voxel size: 2x2x2mm].
- Whole brain T1 scans were acquired (3D SPGR, 124 slices, 0.94 x 0.94 x 1.2 mm).

Analysis

- Preprocessing: (a) diffusion tensors were estimated using a custom program (Bammer, 2001). (b) b0 images were coregistered to the whole-brain anatomy with SPM2. (c) fibers were tracked from a whole brain mask (fa>0.2) using STT (Mori et al., 1999) with 4th order Runge Kutta correction.
- A smooth non-linear deformation was computed with SPM2 tools between the whole-brain anatomy and the MNI template. The reverse transformation was applied to the Probabilistic Cytoarchitectonic maps of BA44 and BA45 (Amunts et al., 1999).
- L/R BA44/45 ROIs were defined by thresholding the probability maps (p>0.5). To account for registration errors, ROIs were restricted to anatomical borders of Pars Opercularis (BA44) and Pars Triangularis (BA45) manually defined on sagittal slices in each brain.
- We selected fibers that had an endpoint within -1mm of the ROI, and manually pruned fibers that stopped in white matter or turned dorsally with the Corona Radiata. Some fibers may be missed due to reduced FA at crossing points and close to gray matter.



P-maps of BA44 and BA45 (Amunts, 1999)

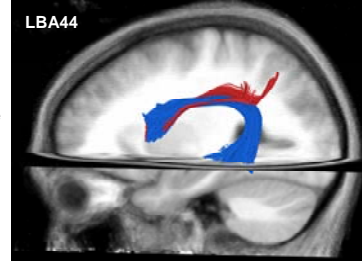


BA44 (blue) and BA45 (green) ROIs on FA background (S2, M, 28)

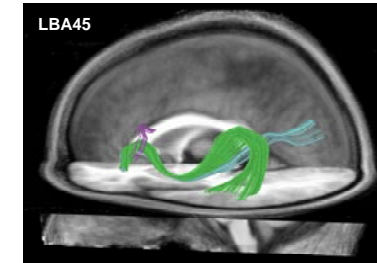
DTI analysis and visualization were done with Matlab and C++ based custom software.

Results - group data

Long range association fibers of left BA44 and BA45 in the average brain.

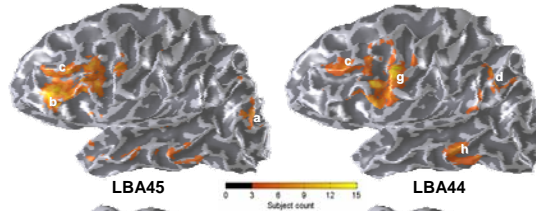


LBA44



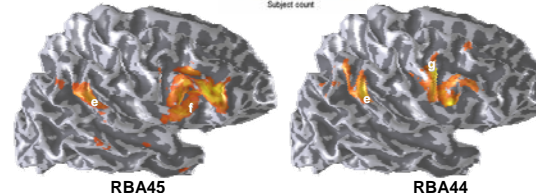
LBA45

Fibers of left BA45 pass through the external capsule and continue to the occipital or the temporal lobe (similar to the ventral group in Parker et al., 2005). Also shown are callosal fibers that terminate in RBA44/45.



LBA45

LBA44



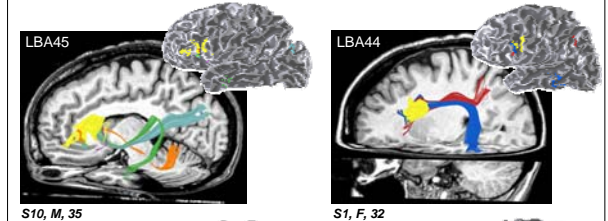
RBA45

RBA44

Cross-subject endpoint density maps shown on a single subject's inflated white matter surface. Regions with endpoints from 3 or more Ss are colored.

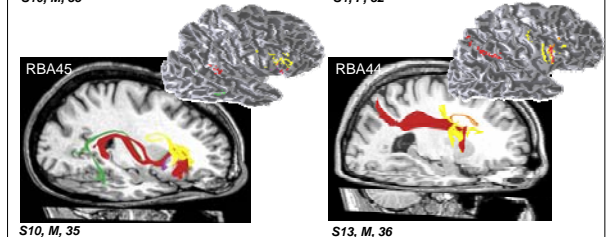
- a. LBA45 - occipital
- b. LBA45 - LBA47
- c. LBA44,45 - MFG
- d. LBA44 - inferior parietal
- e. Right BA44,45 - postSTG
- f. RBA45 - anterior insula
- g. L/RBA44 - precentral gyrus
- h. LBA44 - lateral MTG/ITS

Results - individual subjects



S10, M, 35

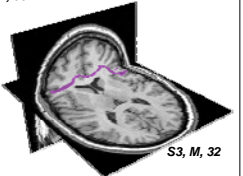
S1, F, 32



S10, M, 35

S13, M, 36

Segmented fiber tracts in 4 individual subjects (S1, 3, 10, and 13). Endpoints are presented on subjects' inflated white matter surface. Callosal fibers (right image) were found in 5/15 subjects (we find partial callosal fibers that stop in white matter in all subjects, probably because of crossing fibers). For frequencies of other major fiber tracts see table below.



S3, M, 32

	Arcuate, Temporal	Arcuate, Inferior parietal	External capsule, Temporal	External capsule, Occipital	Anterior insula	Precentral Gyrus	Middle Frontal Gyrus
Left 44	8/15	7/15	1/15	0/15	3/15	11/15	7/15
Left 45	1/15	2/15	10/15	9/15	5/15	8/15	8/15
Right 44	4/15	11/15	0/15	0/15	1/15	14/15	4/15
Right 45	0/15	2/15	6/15	6/15	8/15	5/15	3/15

Conclusion

Fiber tracts of BA44 and BA45 can be consistently separated by their route or by their target endpoints.

These anatomical findings support a functional segregation within Broca's region.

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