STRUCTURAL CONNECTIVITY OF THE LEFT ANTERIOR TEMPORAL LOBE: A DIFFUSION TENSOR IMAGING STUDY

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INTRODUCTION

The anterior temporal lobe (ATL) is crucial for higher order language functions, such as semantic memory, and it is involved in behavioral regulation [1,2,3]. Evidences of ATL damage are found in many neurological diseases, but little is known about the structural connections of this area with the rest of the brain. The aim of this study was to explore the architecture of the left ATL connectivity with many ipsilateral regions of the brain (in particular the areas known to have a key role in language) and to segment the left ATL based on these connectivity patterns, by using diffusion tensor imaging (DTI).

MATERIALS AND METHODS

Data Acquisition: Using a 3 T Siemens Trio Tim scanner equipped with a eight-channel multi receive system, 21 healthy subjects recruited through the Memory and Aging Center at UCSF (8m, 13f, mean age 65.3 ± 3.6 years) underwent a standard T1-weighted structural acquisition (3D MPRA, 1x1x1 mm3) and a diffusion weighted image (DWI) acquisition (2D SE-EPI sequence, 55 axial slices, resolution 2.22 mm3, TR/TE 8000/109 ms, b-value= 2000 s/mm2, GRAPPA acceleration factor 2, 1 image without diffusion sensitizing gradient (b0) and 64 DWI with gradients along independent directions).

Data Analysis: All data analyses were performed using the FMRIb’s FSL library tools (http://www.fmrib.ox.ac.uk/fsl/). 9 regions of interest (ROIs) including cortical gray matter (GM) and the underlying white matter (WM) were defined in the MNI-space using the FSL Harvard-Oxford (H-O) cortical structures atlas. The ROIs selected in the left hemisphere for this study were: the ATL, the posterior inferior temporal gyrus (ITG), the posterior middle temporal gyrus (MTG), the posterior superior temporal gyrus (STG), the posterior fusiform gyrus (Fus), the angular and supramarginal gyri (AG/SmaG), and the occipital pole (OP). In parallel, connectivity distributions (hereafter called tracts) were obtained by using the probabilistic algorithm implemented in FSL (probt) and based on Bayesian estimation of diffusion parameters (bedpostx) [4,5].

RESULTS

No part of the ATL was found to be more connected to the IFG or AG/SmaG ROIs than to the other 6 target ROIs. The following patterns were defined in the segmentation (Fig.1): besides an anterior dorsal part of the left ATL connected to the OFC (through the uncinate fasciculus (UF)) and a more lateral and inferior region connected to the occipital pole through the inferior longitudinal fasciculus (ILF), 4 regions of the ATL were found to be mainly connected with the posterior sections of Fus, ITG, MTG and STG. Regarding the tracts (Fig.2), besides the UF and the ILF (not reported in figure, but basically parallel to the ATL-ITG connection reported in red), 3 tracts of interest were evidenced: a connection of the ATL with the SmaG/AG regions that remains in the STG WM (supporting the existence of the middle longitudinal fascicle in humans [6]), a long connection between the ATL and the IFG (that passes through the MTG and that could be an extension of the arcuate fasciculus to the ATL), and a posterior temporo-parietal connection between the posterior ITG and the AG/SmaG areas (that could correspond to the temporo-parietal subsection of the SLF previously described [7, 8]).

DISCUSSION AND CONCLUSIONS

Using DTI on a group of 21 healthy subjects, possible connections of the left ATL with areas involved in language processing (middle/superior temporal gyr, angular gyrus, supramarginal gyrus, inferior frontal gyrus) were evidenced. We think the architecture of these possible connections and the ATL segmentation based on them can offer new insights into the understanding of the involvement of the left ATL in many higher order brain functions.


Figure 1 (left): Segmentation of the left ATL (21 subjects, MNI space) based on the highest probability of connectivity to 6 targets ROIs: light blue=Fus, red=ITG, yellow=MTG, green=STG, pink=OP, blue=OFC.

Figure 2 (right): High probability levels of connectivity of the left ATL (21 subjects, MNI space) with the ipsilateral OFC (violet), AG/SmaG (green), IFG (yellow), posterior ITG (red). In blue the connection of the lateral ventral posterior temporal pole with the parietal AG and SmaG regions is reported.