Tractotron: a new toolbox to estimate white matter disconnection in stroke patients.

Introduction
Fifty years ago, Norman Geschwind published his historical contribution to clinical-neuroanatomical correlations entitled 'Disconnexion syndromes in animals and man' (Geschwind, 1965a, 1965b, fig. 1). His aim was to apply the network models to disorders of the brain. However, for a long time, we have been unable to map lesions onto discrete circuits due to a lack of methods for visualising single tracts in the living human brain (Catani & ffytche, 2005). As a tribute to Norman Geschwind seminal work, we provide a new tool called "Tractotron" that allows interpreting local white matter lesions as disconnections between several distant areas.

Methods
Tractotron (http://sourceforge.net/projects/tractotrond; fig. 2) is a FMRIB software library (FSL) toolbox. Tractotron uses recently published white matter tract atlases (Catani & ffytche, 2005; Rojkova et al., submitted; Thiebaut de Schotten et al., 2011) in the MNI152 referential to determine the pattern of disconnection induced by a lesion at the individual level (fig. 3). For a given lesion, Tractotron provides a probability of disconnection for all tested tracts. Tract results are exported as an excel file ready to be analysed with any statistical software distribution.

Results
Preliminary studies using Tractotron already revealed a significant association between hemianopia and disconnection of the optic radiations, between hemispatial neglect and a disconnection of the superior longitudinal fasciculus (Thiebaut de Schotten et al., 2014, fig. 4.), and between working memory and a disconnection of the arcuate fasciculus (Chechlacz et al., 2014).

Conclusion
Tractotron provides anatomical information on how lesions can be associated with a disconnection of specific white matter pathways, thus filling the gap of the lesion approach in considering connections between brain regions. Studies using the lesion approach (including voxel-based ones) generally assume that discrete anatomical modules handle specific cognitive functions (Rorden & Karnath, 2004). Consequently, analyses to determine the effect of brain lesions on behavior are usually performed via statistical tests completed independently at each of the intersubjects aligned voxel (voxel-wise or topological statistics), with poor attempt to capture correlations across them (Catani, 2007; Husain & Nachev, 2007). However, 2 voxels cannot be considered as independent if they share common anatomical features. While 2 distant voxels cannot share the same neuronal soma, several voxels can pertain to the same axon (fig. 3).

References

50th anniversary

Fig. 1: 50 years anniversary of Norman Geschwind’s ‘Disconnexion syndromes in animals and man’ bipartite review.

Fig. 2: Tractotron interface.

Fig. 3: Example of three distant brain lesions presenting subcortical extent disrupting the right inferior fronto-occipital fasciculus linking the occipital lobe to the anterior frontal areas.

Fig. 4: Track-wise (hodotopic) lesion-deficit analysis. (a) Percentages of patients with and without left spatial neglect, with disconnection of each of the examined white matter tracts. (b) Percentage of hemianopic patients and patients without visual field defects, with disconnection of each of the examined white matter tracts. (c) The performance on the line bisection task (mean + 95% confidence intervals) for patients with and without left spatial neglect, with disconnection of each of the examined white matter tracts. (d) The performance on the letter cancellation task (mean + 95% confidence intervals) for patients with or without disconnection of each of the examined white matter tracts. (e) Performance on the line bisection task (mean + 95% confidence intervals) for patients with or without visual field defects, with disconnection of each of the examined white matter tracts. (f) The performance on the letter cancellation task (mean + 95% confidence intervals) for patients with or without disconnection of each of the examined white matter tracts. *Tracts significantly involved when covarying out the presence of chronic neglect and the lesion size. Only results that survived Bonferroni correction are reported.

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