INVESTIGATION OF CORTICO-STRIATAL CONNECTIVITY USING PROBABILISTIC DIFFUSION TRACTOGRAPHY

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INTRODUCTION

- Previous anatomical studies differentiated multiple striatal circuits in animals and suggested that anatomical sub-components of the striatum, although functionally related, project to distinct cortical areas (Ref.1, 2).
- We applied Diffusion Tensor Imaging (DTI) tractography to investigate cortical connections from the caudate and the putamen, as well as the segregation of different striatal circuits in humans.
- Understanding the segregation of striatal pathways has important functional implications for models of basal ganglia function.

DATA ACQUISITION

- 1.5 Tesla MRI Sonata scanner (Siemens) using echo-planar imaging
- Parameters for diffusion weighted data: Repetition time: 9300 ms; echo time: 94 ms; flip angle: 90°; slice thickness = 2.2 mm; number of Slices: 60; in-plane resolution: 2.1875 mm x 2.1875 mm; acquisition time approximately 9:30 minutes. Diffusion weighting was performed along 60 independent directions with a b-value of 1000 s/mm^2. A reference image with no diffusion weighting was also obtained.

IMAGE PROCESSING

- Raw DTI data was corrected for motion and eddy currents
- Probability distribution function was estimated on the principial fiber direction at each voxel using Bayesian Techniques (Ref. 3, 4)

A Studies 1 and 2:

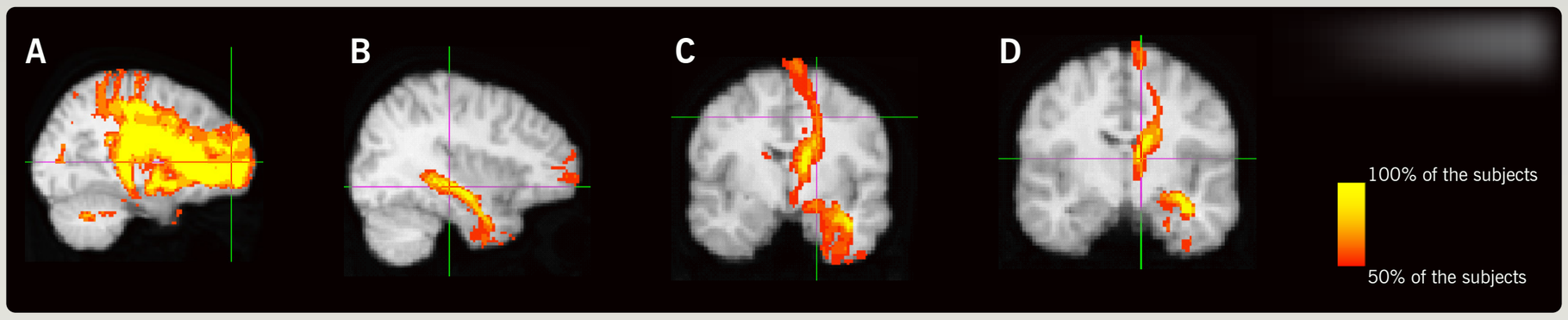
- Probabilistic fiber tracking was initiated from a seed mask of the caudate (Study 1) and the putamen (Study 2)
- Tracts were then registered to MNI standard stereotaxic space, thresholded, binarized and summed across subjects
- Results (Fig. 1 and Fig. 2) were displayed as a population map demonstrating tracts that were present in at least 50% of the subjects

B Studies 3 and 4:

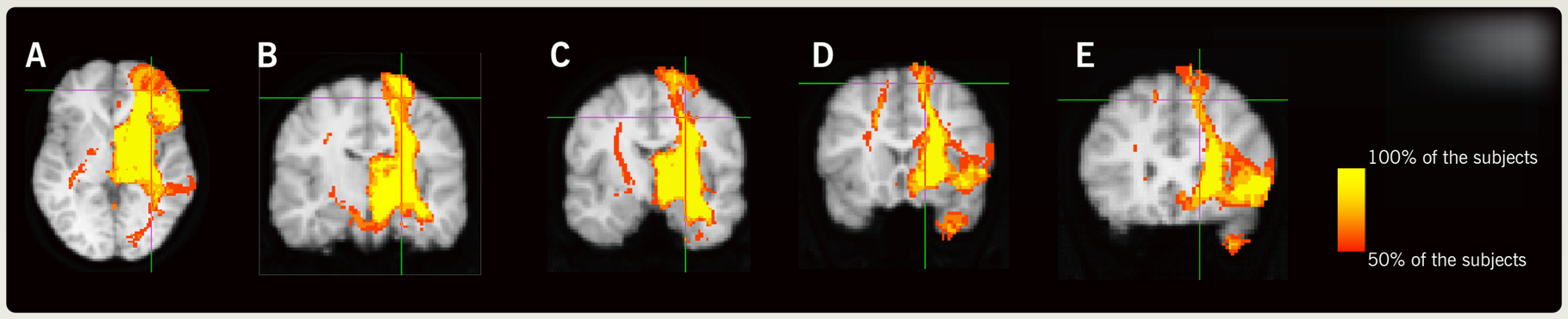
- A region of interest (Study 3: DLPFC, VLPFC; Study 4: SMA, premotor area, primary motor), identical in size across subjects, was defined 3-dimensionally on the subject's T1-weighted image of the left hemisphere
- A connectivity-based seed classification analysis and a hard segmentation on the outputs of the seeds to targets were performed to generate a segmentation

RESULTS

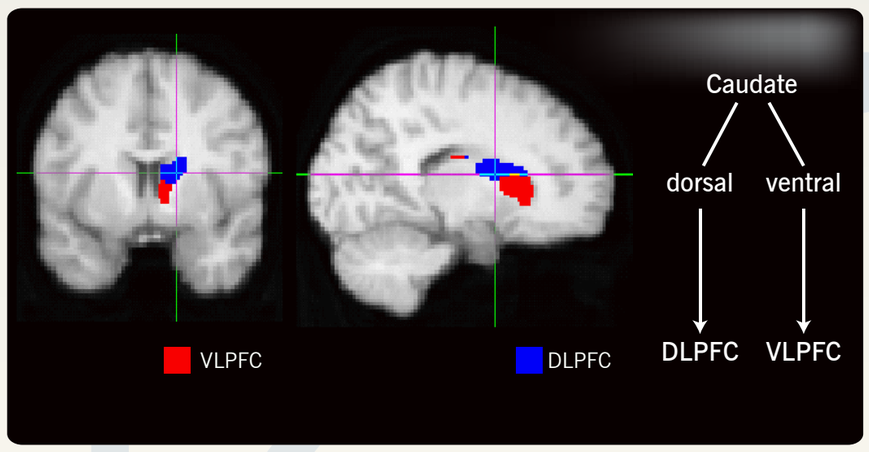
Study 1: Caudate Tractography (Fig. 1)
Reconstructed fiber tracts projected ipsilaterally to the *prefrontal cortex* (**A**; x=20, y=54, z=6, area 10; x=20, y=28, z=20, area9/46), *superior temporal gyrus* (**B**; x=34, y=-26, z=-8), *frontal eye fields* (FEF, Ref. 5; **C**; x = 24, y=-6to1, z =44 to 51) and *thalamus* (**D**; x=10, y=-12, z=64).



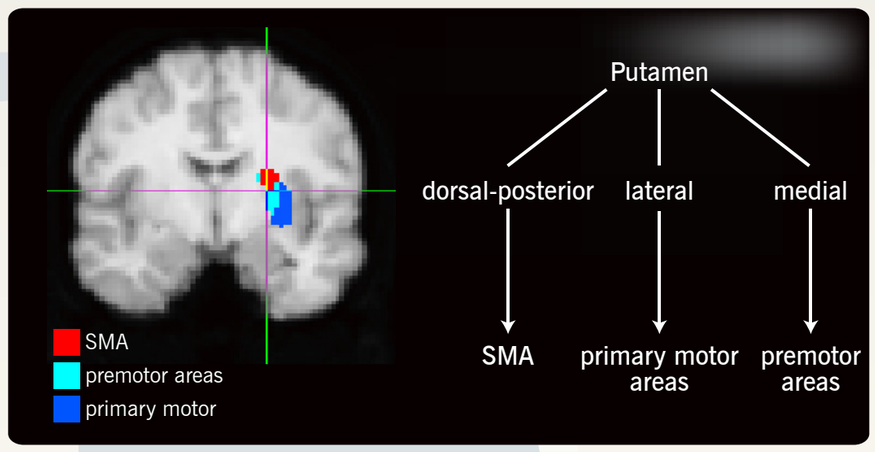
Study 2: Putamen Tractography (Fig. 2)
Reconstructed fiber tracts projected ipsilaterally to the *prefrontal cortex* (**A**; x=34, y=46, z=-2, area 10; x=34; y=28, z=20, area9/46; x=28, y=20, z=24, area 8), *primary motor area* (**B**; x=24, y=-16, z=64), *primary somato-sensory area* (**C**; x = 28, y=-32, z =66, area1), *supplementary motor area* (SMA, **D**; x =16, y=16, z=58) and *premotor area* (**E**; x=16, y=24, z=48).



Study 3: Caudate Connectivity (Fig. 3)
A connectivity-based seed qualification showed connections from the DLPFC to dorsal-posterior caudate and from the VLPFC to the ventral anterior caudate.



Study 4: Putamen Connectivity (Fig. 4)
A connectivity-based seed qualification showed connections from the SMA to dorsal-posterior putamen, from premotor areas to medial putamen, and from the primary motor areas to the lateral putamen.



CONCLUSIONS

- Reconstructed caudate tracts showed connections with prefrontal areas, FEF, thalamus and the superior temporal gyrus.
- Reconstructed putamen tracts showed connections with prefrontal areas, primary motor areas, primary somato-sensory areas, SMA and premotor areas.
- Dorsal-posterior parts of the caudate were predominantly connected with the DLPFC and ventral anterior parts were interconnected with the VLPFC.
- Dorsal-posterior parts of the putamen were predominantly interconnected with the SMA, medial parts of the putamen with premotor areas, and the lateral putamen with primary motor areas.
- These results are in accordance with previous studies in nonhuman primates (Ref. 5, 6).

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