CHARACTERIZATION OF THALAMIC FUNCTIONAL COMPONENTS AND THEIR CONNECTIONS WITH CEREBRAL CORTEX : A DTI AND RS fMRI STUDY

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TARGET AUDIENCE: Basic scientists and clinicians with an interest in thalamo-cortical connections.

PURPOSE A previous study combined diffusion tractography and resting state (RS) fMRI to investigate the correspondence between structural and functional thalamo-cortical connections in the same group of healthy individuals, showing only a partial correspondence between the information derived from the 2 methods (1). To provide additional evidence that the mechanisms behind functional connectivity are more complex than just expressing structural connectivity, here we implement a novel approach to recursively compare anatomical and functional thalamic connections. Using Indipendent Component Analysis (ICA) of thalamic RS fMRI data we first identify discrete functional subunits of this structure as in (2). We then use these functional components as ROI to identify cortical regions structurally and functionally correlated to each thalamic portion.

MATERIAL AND METHODS 30 healthy subjects [M/F=16/15; mean (SD) age=50.51(13.33) years], had an MRI examination at 3.0 T, including: 1) MDEFT (TR=1338 ms, TE=2.4 ms) 2) Diffusion weighted EPI (TR= 7 s, TE=85 ms, number of diffusion directions=61; max b factor=1000 smm^{-2}); 3) T2-weighted EPI sensitized to BOLD contrast (TR=2080 ms, TE=30 ms, 32 axial slices, 220 volumes). ***fMRI analysis*** The RS-fMRI data were preprocessed in SPM8, including correction for motion and slice timing, and normalisation. In-house software was used to remove other sources of bias (global temporal drift, realignment parameters, global signal). Data were band-pass filtered to remove high frequency variations. ***DTI analysis*** DTI images were processed using the Camino toolkit (www.camino.org.uk), to yield fractional anisotropy (FA) maps. The standard template used for RS data normalization was co-registered with each participant's FA map, using ANTS (http://stnava.github.io/ANTs/). **CONNECTIVITY ANALYSES** ***STEP1: ICA thalamic segmentation*** ICA was performed on the pre-processed fMRI data, after masking them to isolate the thalamus, using a binary version of the Oxford Thalamic Atlas. The resulting ICs were used to segment the thalamus using a winner-takes-all (WTA) strategy. ***STEP2: SBA*** A seed-based analysis was performed for each of the 11 thalamic regions identified by ICA on a subject by subject basis. The contrast images were fed into a 2nd level analysis using a one-sample T-Test, to yield a group-level map of the cortical connections to each thalamic subcluster. ***STEP3: Connectivity-based segmentation of the cortex*** Diffusion data were processed using the probabilistic index of connectivity (PICo,) (3) to identify the most likely thalamic connection for each voxel of the cortex. Cortical parcellation was thus obtained as in (4) but swapping seed and target, i.e., using the cortex as seed, and the 11 thalamic regions identified by ICA as tagerts. ***STEP4: connectivity-based segmentation of the thalamus.*** Thalamic parcellation was achieved as in (3,5), but using the cortical labels derived by the analysis described in STEP2, instead of manually defined ones.

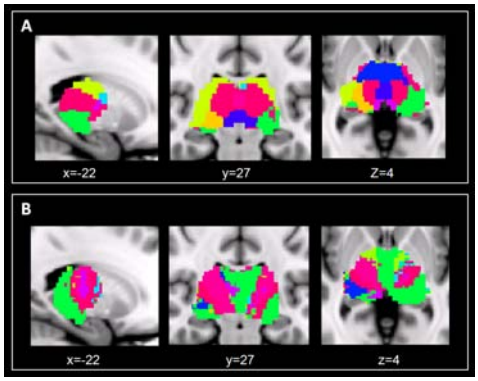

Fig1: Group averaged thalamic parcellated mask resulting from ICA (panel A) and probalistic tractography.

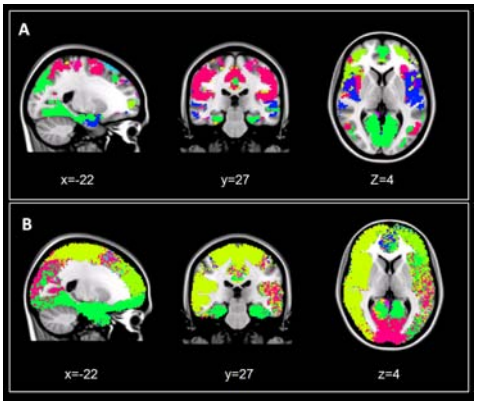

Fig2: Group averaged cortical parcellated mask resulting from SBA (panel A) and probalistic tractography (B).

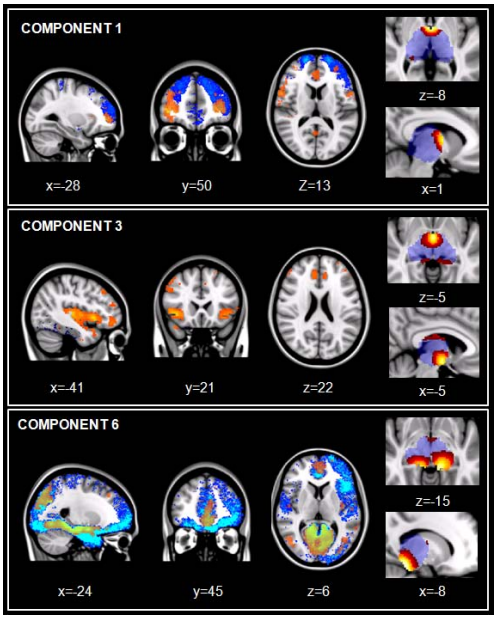

Fig3: Thalamic ICA components (on the right) and their functional (orange) and structural (light-blue) correlations.

RESULTS ICA detected symmetric functional components that represent temporal coactivation at rest among voxels within the thalamus (Fig.1 panel A). Functional correlations obtained with SBA are consistent with this symmetric pattern (Fig.2 panel A), while an evident asymmetry was found when considering structural correlation (Fig.2 panel B). We found different degrees of overlap between functional and structural correlations with each thalamic portion: some examples are reported in Fig.3. Thalamic parcellation using the cortical labels derived by the SBA shows minimal consistency with that obtained using ICA of RS fmri data..

CONCLUSION This study provide new evidence of the partial overall correspondence between structural and functional connections, in the same group of healthy individuals, thus suggesting that the two approaches provide complementary and not overlapping information.

REFERENCES 1. Mastropasqua et al. 2013 (submitted) 2. Kim et al. Hum Brain Mapp. 2013 3. Parker et al. (2003) Inf Process Med Imag 18:684-695.4. Behrens et al. (2003) Nature Neuroscience 7:750-757