

# High-resolution 3T and 7T extension of the Colin27 atlas for deep-brain targeting

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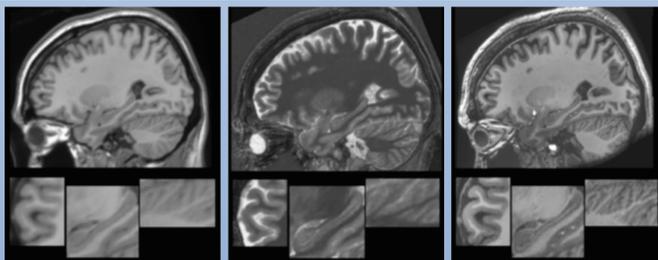
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## INTRODUCTION

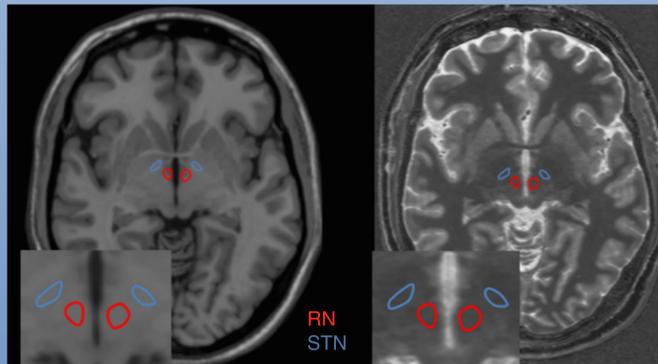
Deep brain stimulation (DBS) for Parkinson's disease is an effective treatment however challenges remain in accurate targeting of the deep brain structures. Existing indirect DBS targeting relies on registration of 2D histological atlases [1] since many deep brain structures are not clearly visible in traditional images. Gradient echo images obtained with ultra-high-field 7 Tesla MRI can reveal superior contrast of deep-brain structures, with a degree of detail rivaling histology [2]. Although pre-surgical imaging of patients at 7T for direct targeting has been demonstrated [3], cost and availability limit its feasibility, thus, registration of high-resolution 3D atlases depicting structural targets could provide cost-effective and improved indirect targeting in DBS planning.



1.5T T<sub>1</sub>-w

3T T<sub>1</sub> Map

7T T<sub>1</sub>-w



1.5T T<sub>1</sub>-w

3T T<sub>1</sub> Map

7T T<sub>1</sub>-w

7T T<sub>2</sub>\*-w

7T R<sub>2</sub>\* map

7T LFS Map

## RESULTS

Our atlases demonstrate significantly improved visualization of cortical and subcortical structures over the original Colin27, with the added benefit of providing quantitative T1 maps at 3T and R<sub>2</sub>\* maps at 7T. Figure 1 shows the comparison between our 7T MPRAGE and 3T T1 map with the original T1-w atlas. For investigating its applicability for targeting of deep brain structures, in Figure 2 we have shown axial slices comparing the various images with overlaid delineations of anatomical landmarks commonly used for DBS, namely the red nucleus (RN) and subthalamic nucleus (STN). We see that the R<sub>2</sub>\* and LFS maps reveal the best contrast for these and other surrounding deep brain structures. To quantify the contrast of the STN with respect to neighbouring structures we computed two-sample T-statistics between the intensities of the STN and prelemniscal radiations in Table 1.

## MRI SEQUENCES

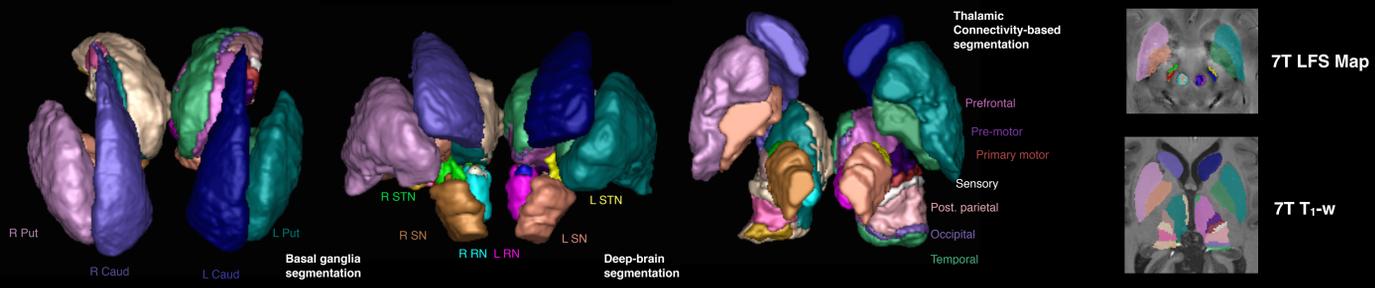
- 3T Discovery MR750 (GE, Waukesha WI)
- DESPOT1-HIFI [7]
  - 0.75 mm isotropic
  - Two 3D SPGR images (flip angles=4,18) and IR-SPGR for B1 mapping
  - Total scan time=20:00, N=4 sets of scans
- 7T MRI scanner (Agilent, Siemens) with a 16ch Tx 32ch Rx head coil array
- T1-w MPRAGE scans
  - 0.5mm isotropic
  - Scan time=5:00, N=11 scans
- Multi-echo gradient echo (T<sub>2</sub>\*-w)
  - Axial, 0.4mm in-plane, 1mm slice thickness
  - Scan time=11:00, N=4 scans
  - Maps for R<sub>2</sub>\* and local frequency shift (LFS)

## OBJECTIVE

The Colin27 single-subject atlas [4], generated from 27 averaged 1.5T scans, has been a cornerstone of neuroimaging research for the past two decades, acting as a high-definition template for segmentation, MRI simulation [5], and stereotaxic normalization [6]. The objective of this work is to extend this single-subject atlas with additional high-resolution, quantitative, averaged scans at both 3T and 7T, enriching new and existing applications of this single-subject atlas.

## IMAGE PROCESSING

- Affine registration
  - Block-matching technique (reg\_aladin, [8])
  - Align scans to the original Colin27 atlas
- Distortion correction
  - B-spline-based registration (NiftyReg, [9])
  - Spline spacing 10mm, bending energy 0.005
- Non-uniformity correction of MPRAGE with N4 [10]
- Labelling
  - Basal ganglia labels from Freesurfer were smoothed and manually-corrected
  - Thalamic connectivity-based parcellation
  - Deep/mid brain structures manually labelled: red nucleus (RN), substantial nigra (SN), sub thalamic nucleus (STN)



3D visualization of basal ganglia, deep brain, and thalamus labels relevant for DBS planning

	1.5 T	3T T	7T T	7T R	7T LFS
<b>T-statistic</b>	13.06	1.16	0.52	21.24	32.12
<b>P-value</b>	<0.0001	0.59	0.24	<0.0001	<0.0001

**Table 1:** Evaluation of sub thalamic nucleus (STN) contrast by two-sample t-test between STN and its neighbouring structure (prelemniscal radiations), revealing best contrast in 7T R<sub>2</sub>\* and LFS (phase) maps

## DOWNLOAD

3T and 7T images and annotations available at: <https://www.nitrc.org/projects/colin3t7t/>

Diffusion tensor imaging and more annotations to be added soon!

## REFERENCES

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## ACKNOWLEDGEMENTS

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