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# In-vivo imaging of the human thalamus with multimodal 7T MRI

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## INTRODUCTION

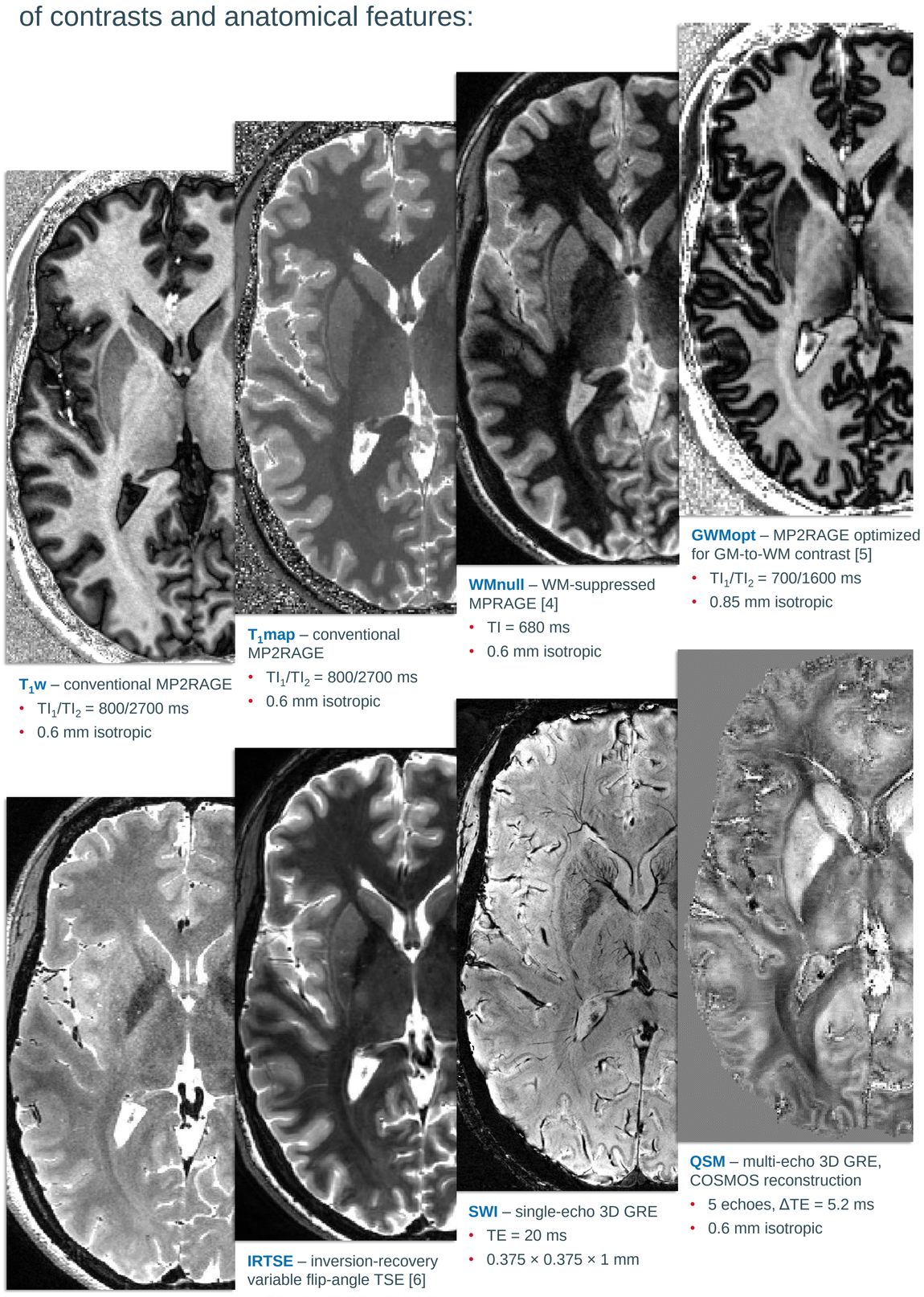
- Imaging the **thalamus** and its different nuclei would be highly valuable to neuroscience and neuroradiology, but has remained challenging;
- Conventional MRI modalities ($T_{1,2}$-weighted) show negligible contrast;
- New modalities at **7T** have shown promising, unprecedented capabilities for thalamic imaging [1];
- **In this work**, we initiated a comprehensive practical review of 7T thalamic imaging approaches, all acquired in the same brain, at sub-mm resolution.

## METHODS

- **Data acquisition:** A healthy participant underwent several scans at 7T (Siemens Terra) – total TA~2.3h; see Results for sequence details;
- **Data processing:** Registration for alignment with two thalamic atlases:
  - Simplified Morel (THOMAS approach [2]);
  - Schaltenbrand [3] (MNI space, slice z = 3.5 mm);
- **Anatomical analysis:** The aligned images were separately evaluated by two imaging experts, by visual inspection, and compared to the atlases.

## RESULTS: imaging contrasts

- The structural modalities covered in this work yielded a rich, diverse range of contrasts and anatomical features:



**$T_1$w** – conventional MP2RAGE
- $TI_1/TI_2$ = 800/2700 ms
- 0.6 mm isotropic

**$T_1$map** – conventional MP2RAGE
- $TI_1/TI_2$ = 800/2700 ms
- 0.6 mm isotropic

**WMnull** – WM-suppressed MPRAGE [4]
- TI = 680 ms
- 0.6 mm isotropic

**GWMopt** – MP2RAGE optimized for GM-to-WM contrast [5]
- $TI_1/TI_2$ = 700/1600 ms
- 0.85 mm isotropic

**$T_2$w** – variable flip-angle TSE
- TF = 96, TE = 146 ms
- 0.5 mm isotropic

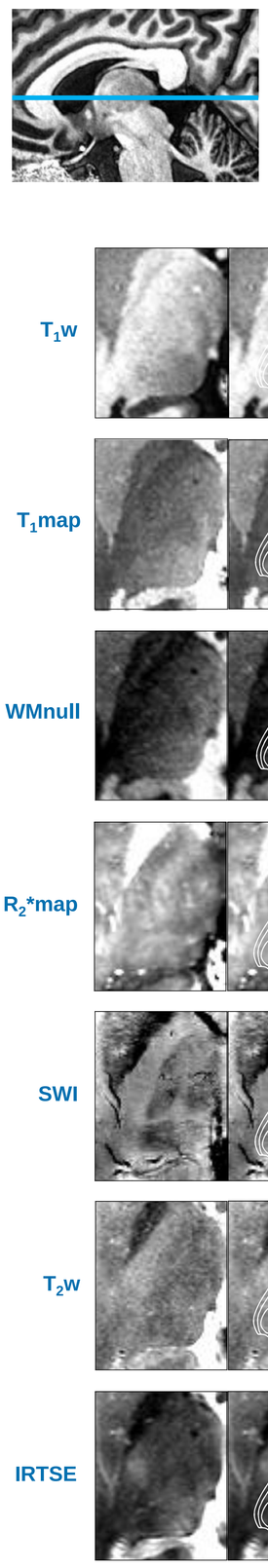
**IRTSE** – inversion-recovery variable flip-angle TSE [6]
- TF = 96, TI/TE = 500/148 ms
- 0.6 × 0.6 × 2 mm

**SWI** – single-echo 3D GRE
- TE = 20 ms
- 0.375 × 0.375 × 1 mm

**QSM** – multi-echo 3D GRE, COSMOS reconstruction
- 5 echoes, ΔTE = 5.2 ms
- 0.6 mm isotropic

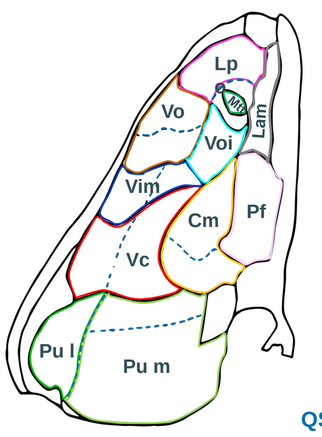
## RESULTS: thalamic anatomy

**Best imaging modalities to differentiate each pair of nuclei**

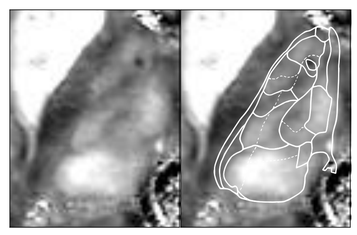


| | Lpo | Vo | Voi | Vim | Vc | Pu m | Pu l | Cm | Pf | Lam | Mtt |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lpo** | | $GWM_{opt}$ QSM | | | | | | | | $GWM_{opt}$ | QSM $GWM_{opt}$ |
| **Vo** | | | QSM | QSM | | | | | | | |
| **Voi** | | QSM $GWM_{opt}$ | | | | | | None | | None | QSM $GWM_{opt}$ |
| **Vim** | | | QSM | | | | | | | | |
| **Vc** | | | | $GWM_{opt}$ QSM | QSM $GWM_{opt}$ | QSM | | | | | |
| **Pu m** | | | None | $GWM_{opt}$ QSM | | | | | | | |
| **Pu l** | | | | | | | | | | | |
| **Cm** | | | | | | | | | $GWM_{opt}$ | | |
| **Pf** | | | | | | | | | | None | |
| **Lam** | | | | | | | | | | | QSM $GWM_{opt}$ |
| **Mtt** | | | | | | | | | | | |

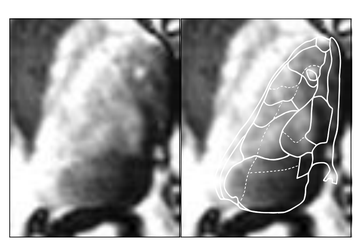



QSM



GWMopt



- Conventional **$T_1$w** and **$T_2$w** confirmed to be of limited value;
- Dedicated modalities (esp. **GWMopt** & **QSM**) can differentiate almost every pair of nuclei

## CONCLUSION

- The results indicate that **QSM** and **GWMopt** are the most valuable modalities currently available to differentiate thalamic nuclei;
- Future work will include additional subjects and more quantitative metrics.

**Refs**: [1] Deistung 2013; [2] Su 2019; [3] Schaltenbrand and Wahren, 1977; [4] Tourdias 2014; [5] Marques 2013; [6] Kanowski 2014

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