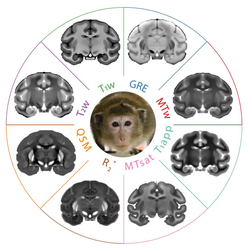

Multi-contrast MRI Atlas of the Cynomolgus Macaque Brain

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INTRODUCTION

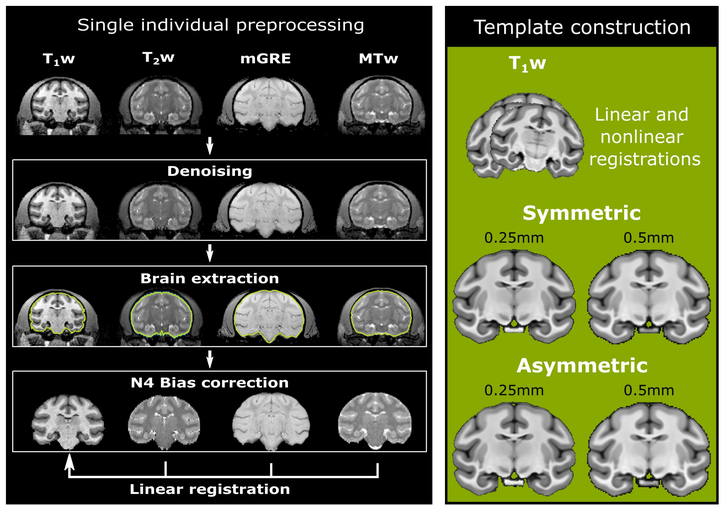
- Species-specific anatomical brain templates are required for accurate spatial normalization of single-subject MRI, automated brain tissue segmentation, and surface generation. Templates facilitate the comparison across subjects, studies, and laboratories.
- Multiple templates are available for rhesus macaques, but only a few for cynomolgus macaques, which differ in brain morphology and endocranial volume[3,10].
- Most templates are based on T1-weighted images, but other MRI-contrasts may provide essential additional information.
- ***In this work, we present high-quality multi-contrast symmetric and asymmetric cynomolgus macaque brain templates along with whole-brain parcellations and surface reconstruction.***

METHODS

- 14 healthy female **cynomolgus macaques** (*Macaca fascicularis*) within an age range of 8 to 20 years (mean = 15 years) were included.

	T_1w	T_2w	GRE	MTw	PDw	T_1w
sequence	3D MPRAGE	FSE	3D ME-GRE	3D FLASH	3D FLASH	3D FLASH
resolution (mm)	0.5x0.5x0.5	0.4x0.4x0.9	0.31x0.31x0.31	0.5x0.5x0.5	0.5x0.5x0.5	0.5x0.5x0.5
repetition time (ms)	2700	8000	57	30	25	10
echo time (ms)	2.7	17	3.7/4.9/48	3.2	3.2	3.2
flip angle (deg)	8	180	20	5	5	15
acquisition time (ms)	14.3	5.2	24	15.3	6.3	5.1

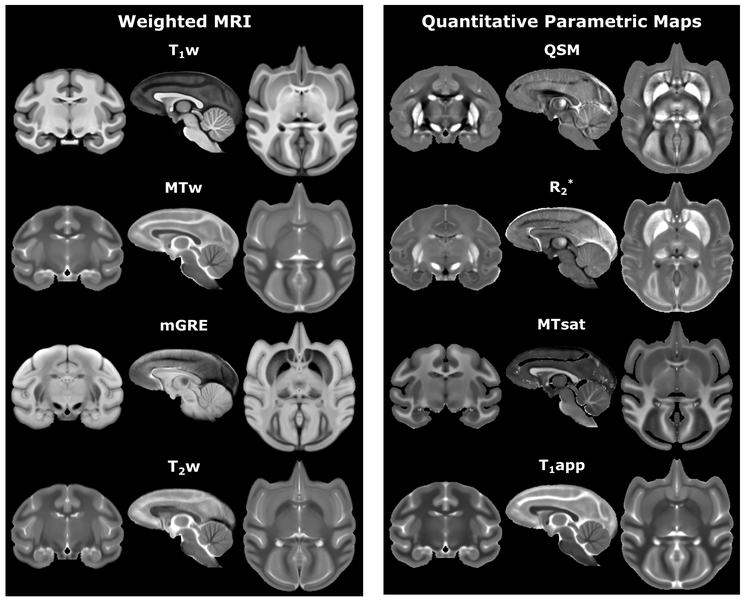
3T Siemens MAGNETOM Prisma; 7 cm single loop coil



- T1-weighted (**T1w**) template was generated using ANTs, and the produced warps were further used to transform weighted contrasts and quantitative parametric maps into the same space[2,11].
- **QSM** reconstruction was carried out using a multi-scale dipole inversion approach1. R2* maps were estimated by fitting the magnitude of signal decay over ten echoes.
- Maps of magnetization transfer saturation (**MTsat**) and apparent T1 relaxation time (**T1app**) were calculated using the method described by Helms et al., 2008.
- Multi-contrast symmetric and asymmetric templates were generated with an isotropic resolution of 0.25 mm and 0.5 mm, respectively.

RESULTS

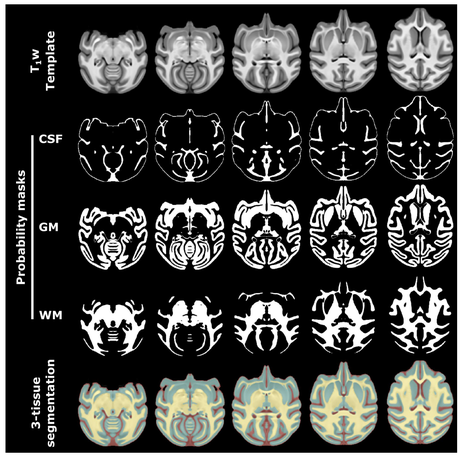
Multi-contrast templates



T1w: T1-weighted; MTw: Magnetization Transfer-weighted; mGRE: mean of multi-echo gradient-echo magnitude across echo times; T2w: T2-weighted; QSM: Quantitative Susceptibility Mapping; R2*: effective transverse relaxation rate; Mtsat: Magnetization Transfer saturation; T1app: apparent T1 relaxation time.

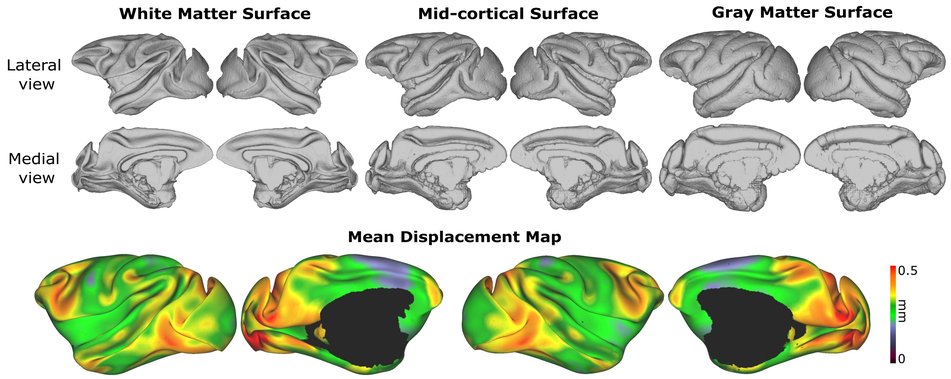
- The T1w template provides an excellent gray and white matter contrast.
- QSM and R2* templates make subcortical gray matter nuclei clearly distinguishable from other parts of the brain.
- MTsat template reveals differences in the degree of myelination.
- In contrast to T1w, the T1app template provides quantitative values of the longitudinal relaxation time.

Tissue segmentation



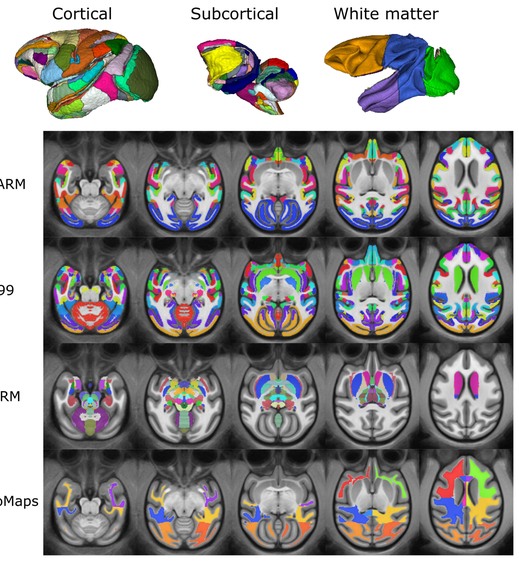
- The T1w template was used for three-class tissue segmentation providing cerebrospinal fluid (CSF), gray matter (GM), and white matter (WM) probability masks.
- The GM segmentation failed in the case of subcortical gray matter nuclei. Only caudate and putamen were classified correctly.
- QSM and R2* templates have been used to overcome this limitation (see talk #1248).

Surfaces



- Brain surfaces were constructed using the '*precon_all*' surface generation pipeline[11].
- The mean displacement map shows average deformation between each subject and the asymmetric cynomolgus macaque template. Inter-subject variability was most pronounced in frontal and occipital brain regions.

Parcellations



- Nonlinear alignment warps to the NMT v2 atlas were used to propagate the Cortical Hierarchy Atlas of the Rhesus Macaque (CHARM) and Subcortical Atlas of the Rhesus Macaque (SARM) labels[4,6].
- Similarly, nonlinear warps to the D99 atlas and INIA19 atlas were used to propagate D99 and NeuroMaps labels into the template space[8,9].

References

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CONCLUSION

- This study presents high-resolution multi-contrast MRI symmetric and asymmetric brain templates of cynomolgus macaque in stereotaxic space.
- Provided templates include both weighted MRI as well as quantitative parametric maps.
- The availability of multiple MRI contrasts allowed for better and more detailed visualization of brain structures and may be used for further anatomical parcellation.
- Transformation to commonly used rhesus macaque templates will support comparative studies across species.

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