Design and Application of a Chimpanzee Template for SPM/CAT

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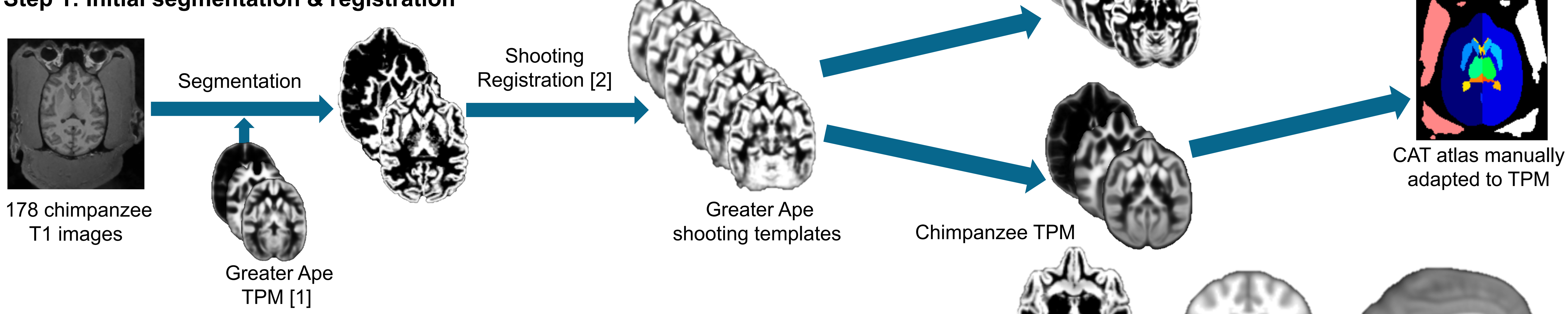
Introduction

- Chimpanzees are our closest extant primate relatives, therefore perfect for understanding the evolutionary development of the human brain
- But Human brains are significantly larger and with increased gyrification [1]
- Therefore, accurate image registration requires chimpanzee specific spatial normalization templates and tissue probability map (TPM).
- Chimpanzee specific templates and TPM are essential for reproducible group analysis
- A high contrast template makes macroanatomical annotations possible
- There is no publicly available chimpanzee atlas nor template so we provide an initial version of a chimpanzee template with macroscopic annotations and TPM for the Computation Anatomy Toolbox (CAT) (http://dbm.neuro.uni-jena.de/cat)

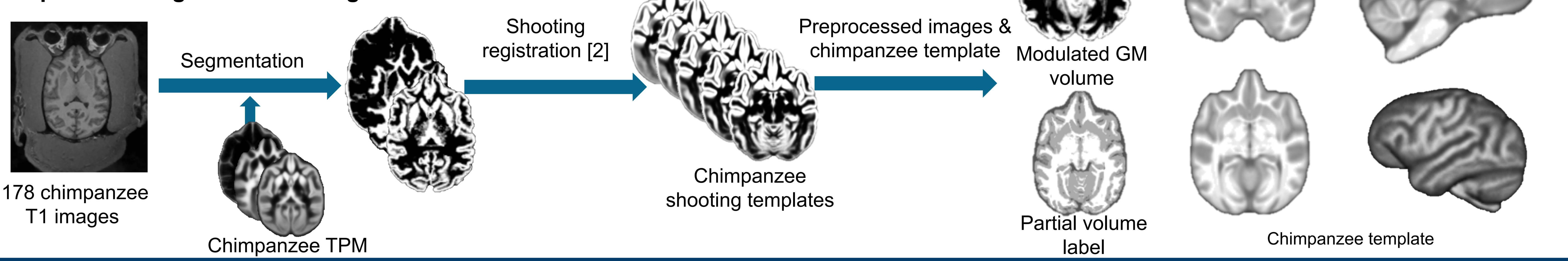
Methods

- 178 chimpanzees, 115 ♀, 63 ♂. (9 -54 y/o, 26.4±10.5) (http://www.chimpanzeebrain.org)
- Housed at Yerkes Primate Research Centre (YPRC) and the University of Texas M.D Cancer Centre (UTMDACC).

Step 1: Initial segmentation & registration

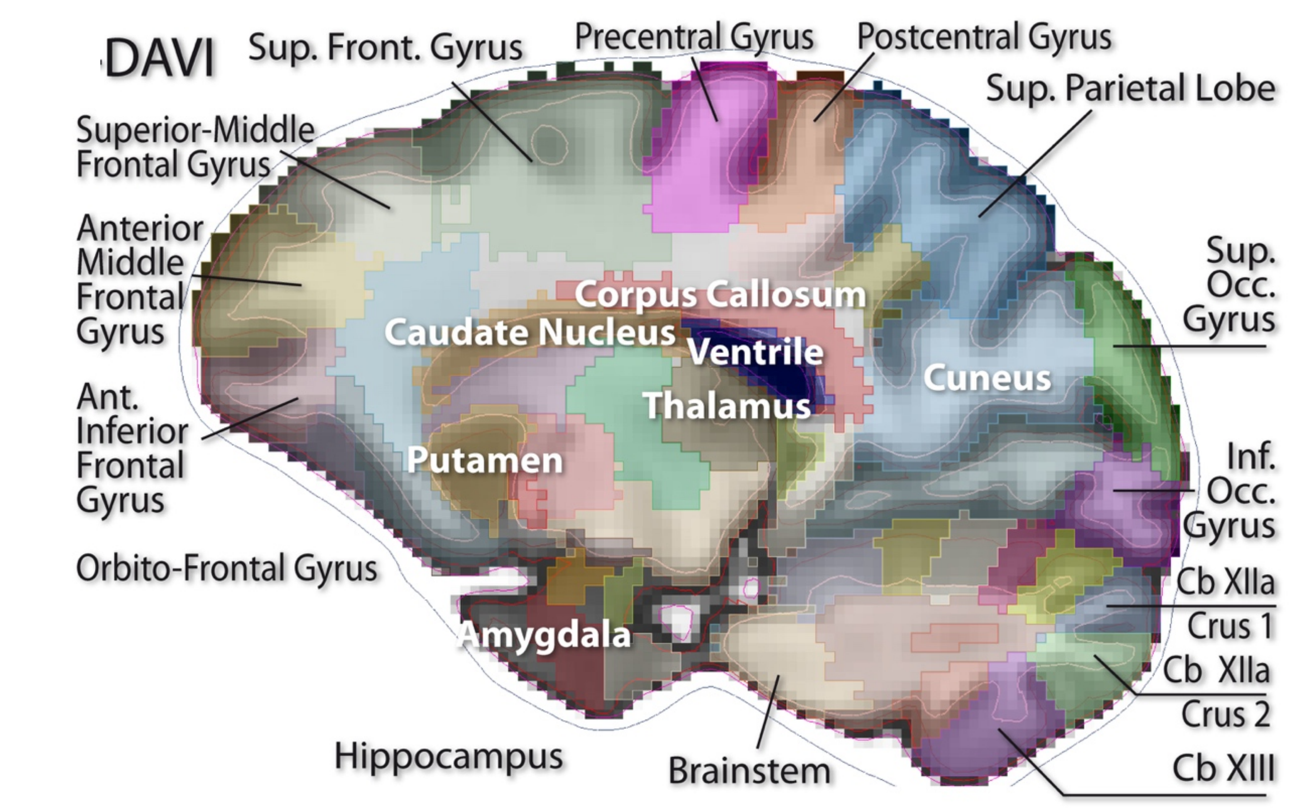


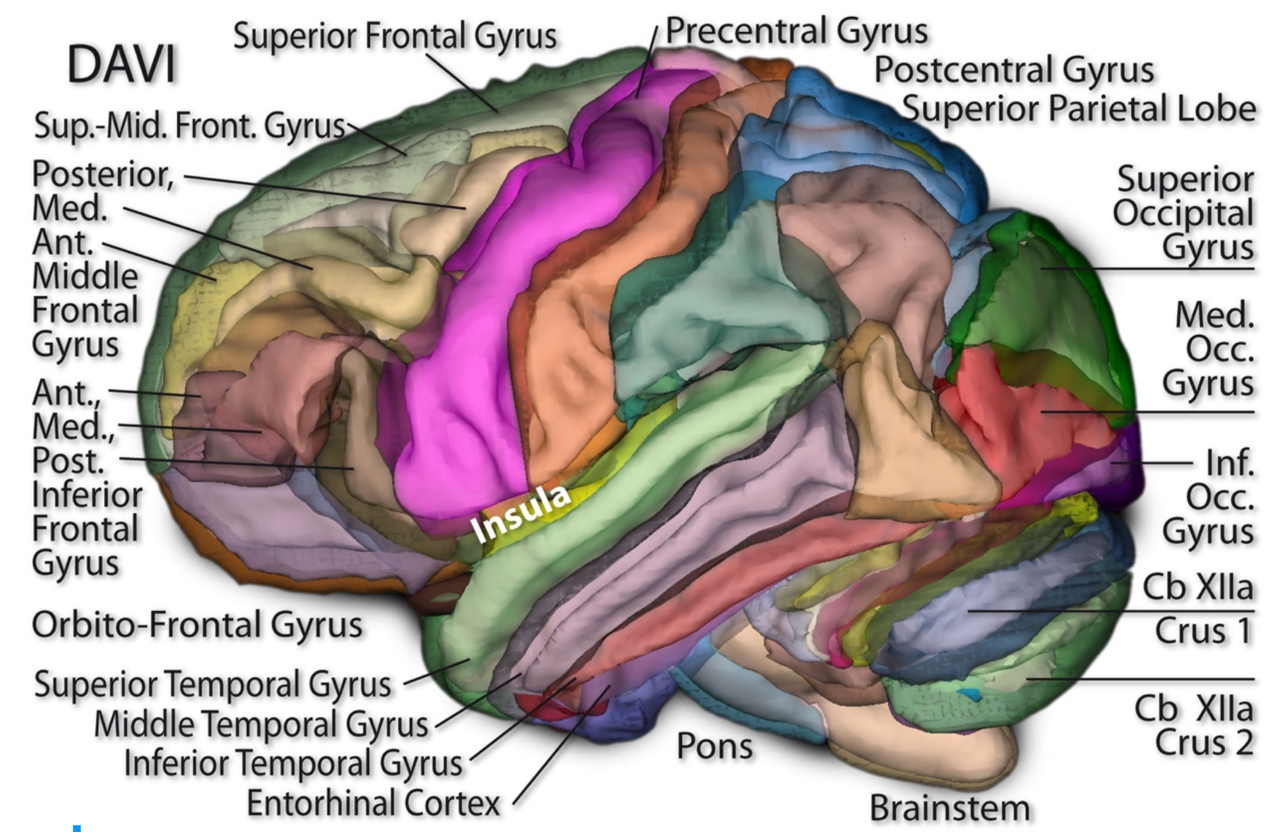
Step 2: Final segmentation & registration



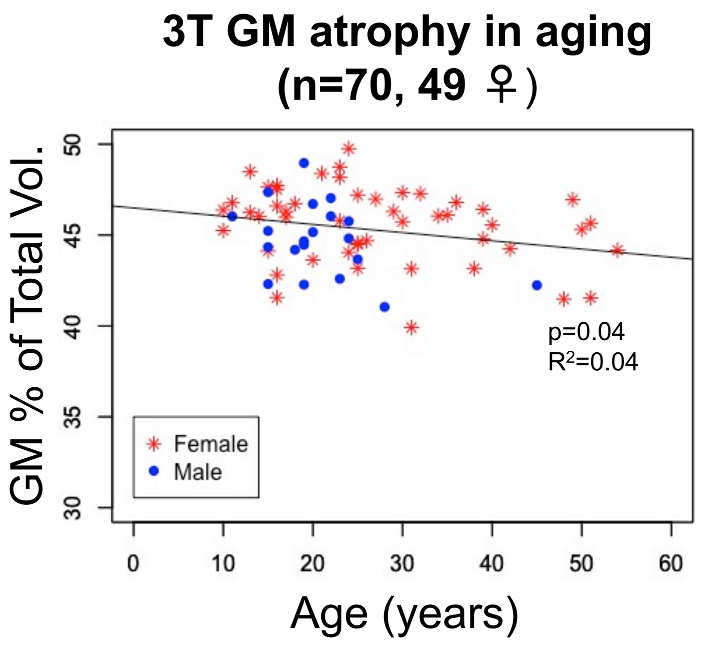
Results

Davi Labelling

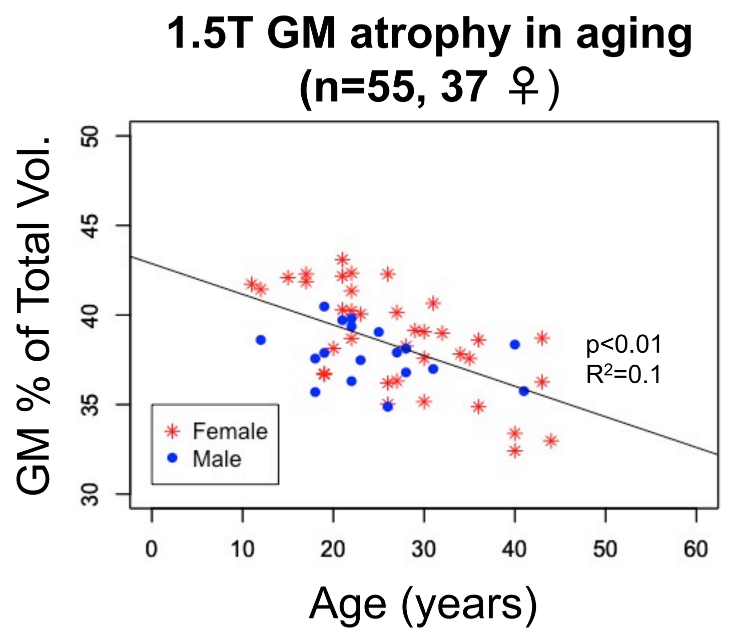




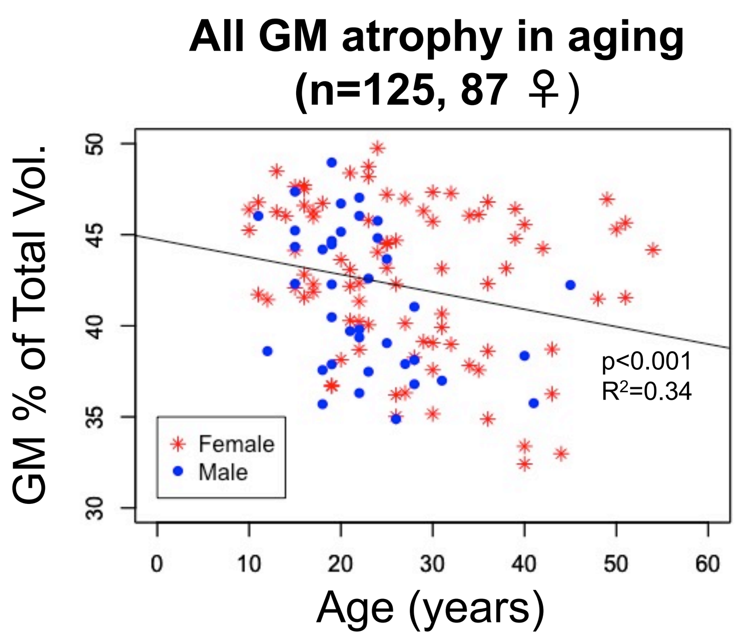
Age Regression



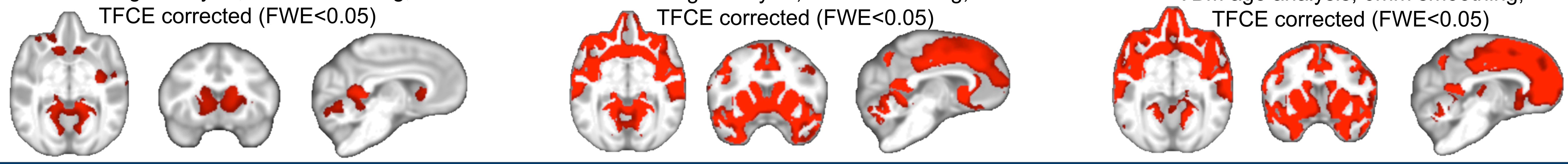
VBM age analysis, 6mm smoothing, TFCE corrected (FWE<0.05)



VBM age analysis, 6mm smoothing, TFCE corrected (FWE<0.05)



VBM age analysis, 6mm smoothing, TFCE corrected (FWE<0.05)



Davi Labelled ROI Age Regression

ROI	3T	1.5T	Total
Sup. Frontal G.	n.s.	☆☆☆	☆
Mid. Frontal G.	n.s.	☆☆	n.s.
Pars Orbitalis	☆	☆	☆☆
Pars Triangularis	n.s.	☆☆	☆
Pars Opercularis	n.s.	n.s.	n.s.
Orbitofrontal Cortex	☆☆	☆☆☆	☆☆☆
Med. Orbitofrontal G.	☆☆☆	☆☆	☆☆☆
Pre-central G.	n.s.	☆☆	n.s.
Post-central G.	n.s.	☆☆	n.s.
Paracentral Lobule	☆	n.s.	n.s.
Cingulate G.	n.s.	☆☆☆	☆☆
Sup. Temporal G.	☆	☆☆☆	☆☆☆
Mid. Temporal G.	n.s.	☆☆	☆
Inf. Temporal G.	☆☆	☆☆☆	☆☆☆
Entorhinal gyrus	n.s.	☆☆☆	n.s.
Insula	n.s.	☆☆	☆
Parahippocampal G.	n.s.	n.s.	☆☆
Fusifrom G.	☆	☆☆	☆☆☆
Amygdala	n.s.	☆☆☆	☆☆
Hippocampus	n.s.	n.s.	n.s.
Sup. Parietal Lobule	n.s.	☆	n.s.
Supramarginal G.	n.s	☆☆	☆☆
Angular G.	n.s.	☆	☆
Sup. Occipittal G.	n.s.	☆☆	n.s.
Mid. Occipittal G.	n.s.	n.s.	n.s.
Inf. Occipittal G.	n.s.	n.s.	n.s.
Precuneus	n.s.	☆☆	☆☆
Cuneus	n.s.	n.s.	n.s.
Lingual G.	☆☆☆	☆☆	☆☆
Caudate Nucleus	☆☆☆	☆☆	☆☆☆
Putamen	☆	☆☆	☆☆☆
Globus pallidas	☆☆☆	n.s.	☆☆
Thalamus	n.s.	☆☆	n.s.
Hypothalamus	n.s.	n.s.	n.s.

☆- $p \leq 0.05$, ☆☆- $p \leq 0.01$ ☆☆☆- $p \leq 0.001$. n.s. = not significant.

Discussion

- Here we present a chimpanzee specific preprocessing pipeline with required templates for the CAT toolbox that enables automated processing and analysis.
- We validated our template by showing similar age effects as [3,4] and VBM illustrated a widespread GM volume decrease with age, similar to that seen in humans [5]
- We understand that macroscopic parcellation is limited in general [6]. However, our ROI and VBM analysis showed that this pipeline and macroscopic labelling can help to improve our understanding of primate brain development and aging [7].

References: 1. Rilling, J. K., & Insel, T. R. (1999). The primate neocortex in comparative perspective using magnetic resonance imaging. *Journal of Human Evolution*, *37*(2), 191–223. 2. Ashburner, J., & Friston, K. J. (2011). Diffeomorphic registration using geodesic shooting and Gauss-Newton optimisation. *NeuroImage*, *55*(3), 954–967. 3. Chen, X., Errangi, B., Li, L., Glasser, M. F., Westlye, L. T., Fjell, A. M., et al. (2013). Brain aging in humans, chimpanzees (Pan troglodytes), and rhesus macaques (Macaca mulatta): magnetic resonance imaging studies of macro- and microstructural changes. *Neurobiology of Aging*, *34*(10), 2248–2260. 4. Autrey, M. M., Reamer, L., Mareno, M. C., Sherwood, C. C., Herndon, J. G., Preuss, T., Hopkins, W. D. (2014). Age-Related Effects in the Neocortical Organization of Chimpanzees: Gray and White Matter Volume, Cortical Thickness, Gyrification. *NeuroImage*, *101*, 59–67. 5. Ziegler, G., Dahnke, R., Jancke, L., Yotter, R. A., May, A., & Gaser, C. (2012). Brain structural trajectories over the adult lifespan. *Human Brain Mapping*, *33*(10), 2377–2389. 6. Eickhoff, S. B., Stephan, K. E., Mohlberg, H., Grefkes, C., Fink, G. R., Amunts, K., & Zilles, K. (2005). A new SPM toolbox for combining probabilistic cytoarchitectonic maps and functional imaging data. NeuroImage, 25(4), 1325–1335. 7. Hecht, E. E., Mahovetz, L. M., Preuss, T. M., & Hopkins, W. D. (2017). A neuroanatomical predictor of mirror self-recognition in chimpanzees. *Soc Cogn Affect Neurosci*, *12*(1), 37–48.

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