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From skull to brain

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From skull to brain: 3D density maps of cortical sulci as a powerful tool for paleoneurology

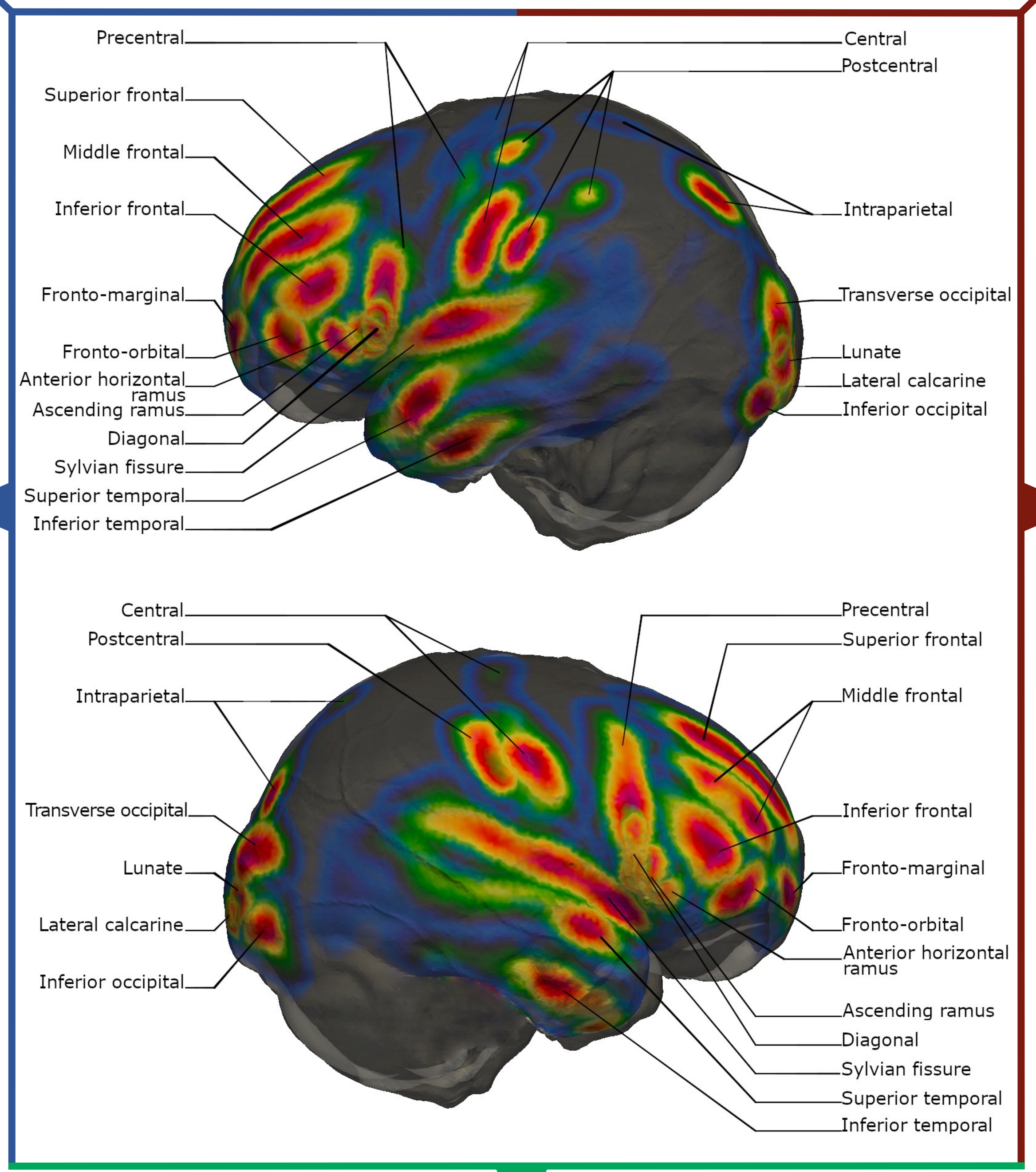
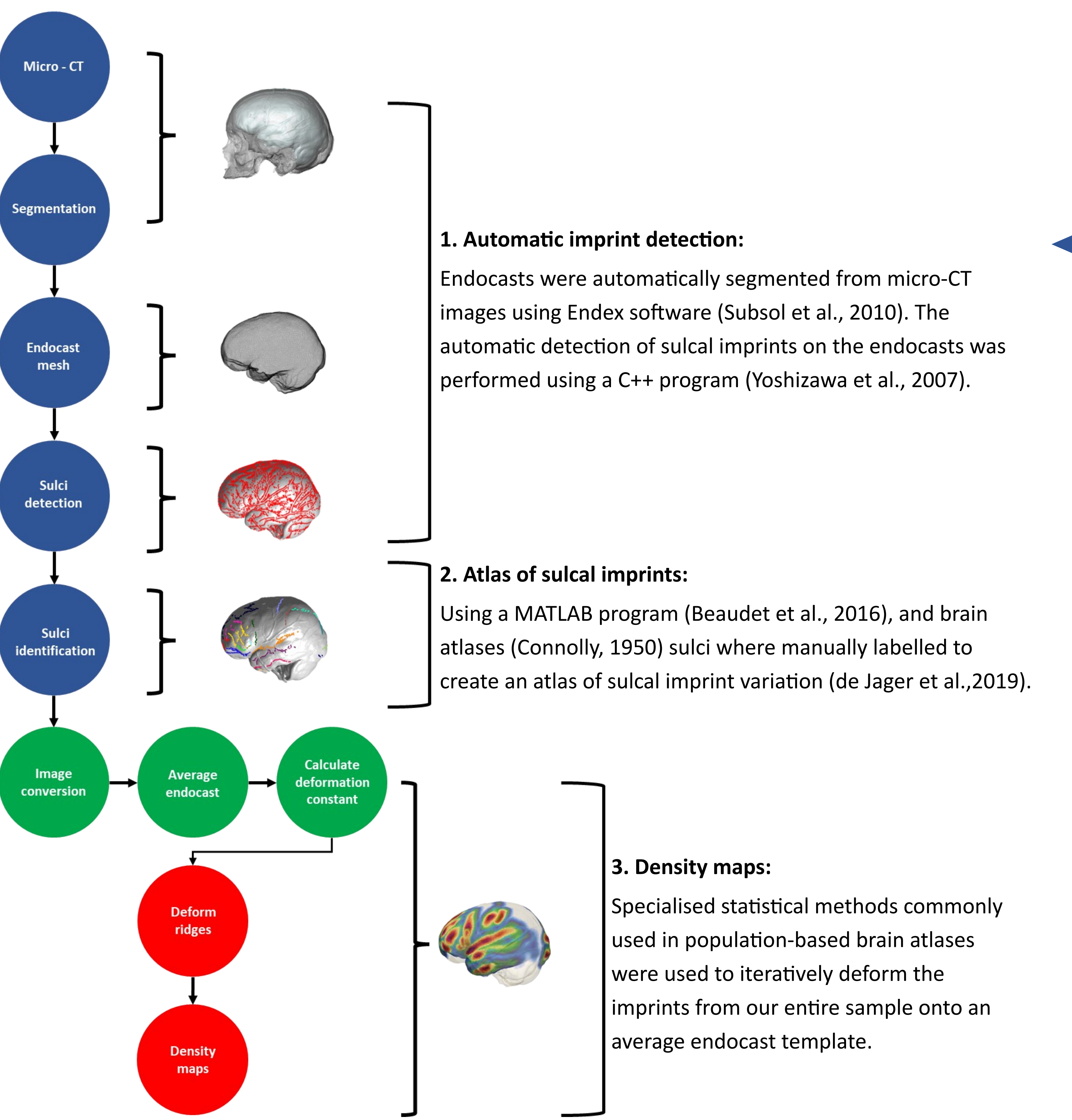
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Key questions in palaeoscience concern the timing and mode of emergence of derived cerebral features of modern human brains. Endocasts, a replica of the internal table of the bony brain case, constitute a proxy for reconstructing a timeline and process of cerebral changes within the human lineage (Holloway et al., 2004). Accurate identification of sulcal imprints in endocasts is critical for evaluating the topographic extension and structural organisation of cortical regions in fossil hominins (Alatorre Warren et al., 2019). High sulcal imprint variation on endocasts and the distortion of these imprints (caused by intra-cranial components) renders accurately identifying sulcal imprints a challenging task (Neubauer, 2014), giving rise to historical debates (e.g., Holloway, 1981). High-resolution imaging techniques combined with established methods used in population-specific brain atlases offer new opportunities for tracking evolutionary changes in endocranial characteristics (Beaudet et al., 2016). We aim to provide a population-level reference from which to guide future analysis of fossil endocasts, with the vision of reducing bias in future sulcal imprint identification endeavours.

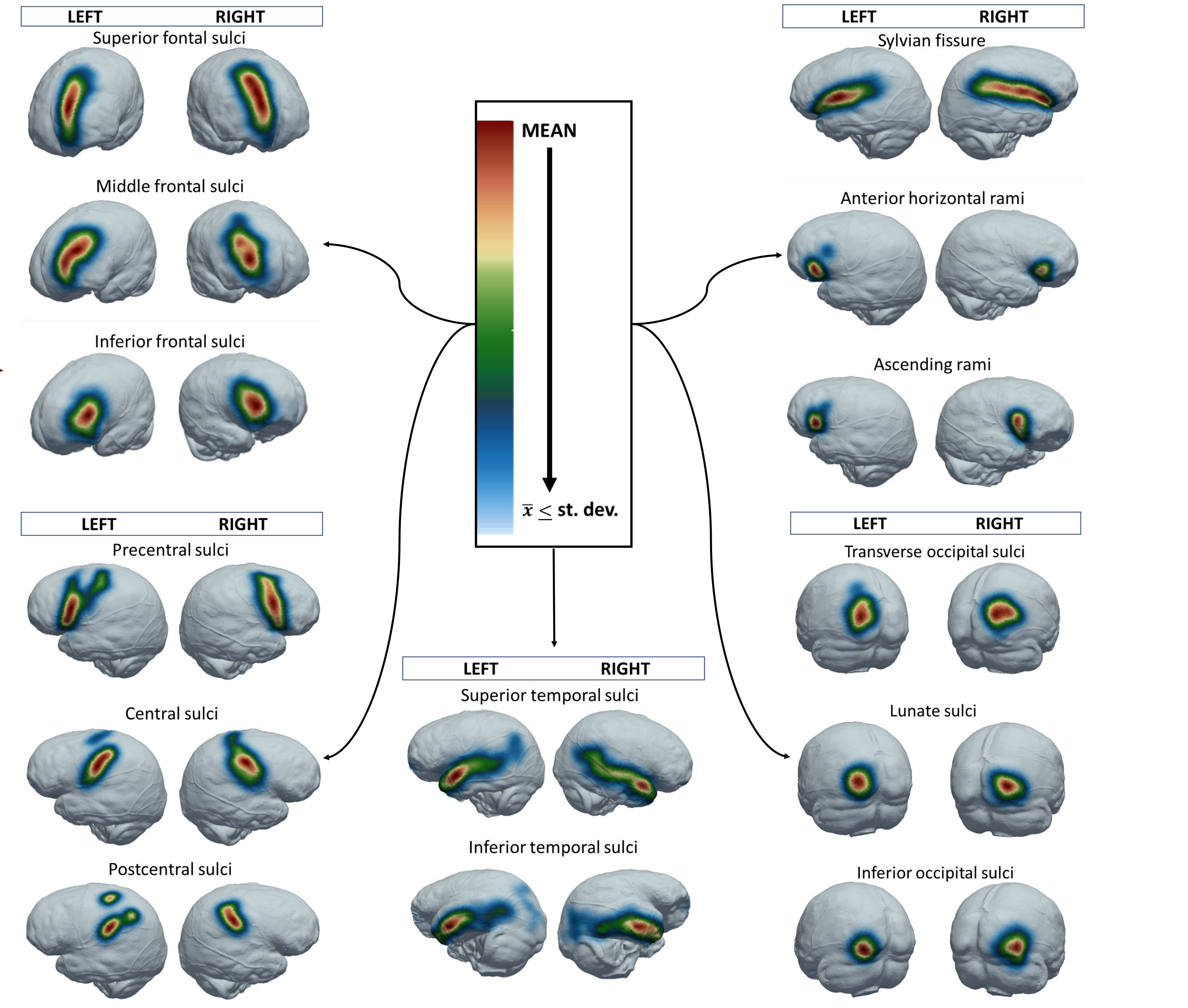
Materials and Methods

We selected 20 modern human crania from Pretoria Bone Collection (South Africa; L'Abbé et al., 2005), and scanned them using Microfocus X-ray Computed Tomography (micro-CT). These specimens were selected based on strict systematic exclusion of known pathology or defects that affects the inner table of the cranium.



Results

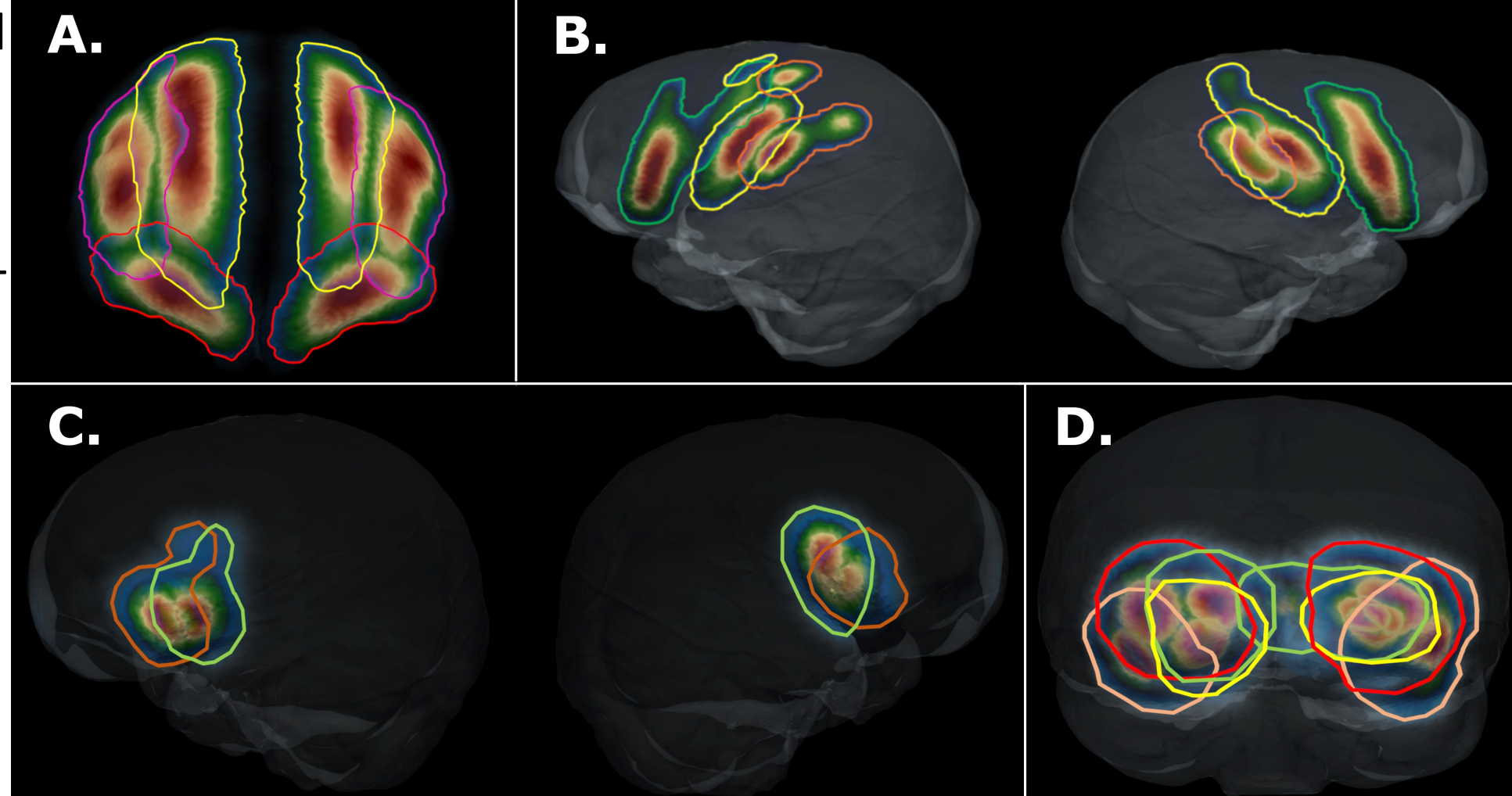
Notable results: **Red** = mean distribution, **Blue** = +2 standard deviations.



Conclusion and perspectives

This approach provides an innovative, non-invasive, statistically modelled method from which to reliably infer human endocranial sulcal imprint variation, correlating with observations from previous studies and literature (Connolly, 1950; Fillard et al., 2007). For the first time, we could observe topographic overlap in sulci that are critically discussed in palaeoscience such as sulci on the occipital lobe, involving the lunate sulcus (e.g., Holloway, 1981), and sulci bordering the Broca's area. This analytical protocol afforded an objective perspective to contribute towards more refined endocranial research in paleoneurology. Expansion of our specimen database (i.e., primates and hominins) is expected to further improve the statistical power of observed features. This expansion will improve the detection of observable remodelling of these cortical features, and consequently contribute towards a completely observer independent approach; thereby guiding discussions surrounding fossil classifications and the contentious hypotheses on the evolution of cognitive abilities among hominins.

Overlapping of imprints were observed when viewing imprints of the frontal lobe (A), as well as laterally (B) between the precentral, central and post-central sulci with severe overlapping superiorly. Major overlapping was observed in sulci bordering the Broca's cap (C) and the sulci of the occipital lobe (D) involving the lunate sulcus.



References: Alatorre Warren, J. L. et al. (2019) *Proceedings of the National Academy of Sciences*, 116(44), 22115–22121; Beaudet, A. et al. (2016) *Journal of Human Evolution*, 101, 65–78; Connolly, C. J. (1950) *External Morphology of the Primate Brain*; de Jager, E. J. et al. (2019) *Journal of Anatomy*, 235(4), 803–810; Fillard, P. et al. (2007) *NeuroImage*, 34(2), 639–650; Holloway, R. L. (1981) *American Journal of Physical Anthropology*, 56(1), 43–58; Holloway, R. L. et al. (2004) *The Human Fossil Record*; L'Abbé, E. N. et al. (2005) *HOMO*, 56(2), 197–205; Neubauer, S. (2014) *Brain, Behavior and Evolution*, 84(2), 117–134; Subsol, G. et al. (2010) *American Journal of Physical Anthropology*; 79th Annual Meeting of the American Association of Physical Anthropologists, 226–227; Yoshizawa, S. et al. (2007) *15th Pacific Conference on Computer Graphics and Applications (PG'07)*, 231–237.

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