Identification of *Homo*-like features in virtually rendered South African australopith endocasts.

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Tracking the early appearance and full establishment of the derived features characterizing the genus *Homo* in the hominin fossil record should contribute to the assessment and understanding of the inter-species evolutionary relationships within the human lineage (Falk et al. 2000; Falk 2014). Nowadays, key-features in neuroanatomical structures are better revealed from advanced methods of high-resolution 3D imaging and computing (Bruner 2014).

Here we propose an exploratory analytical protocol to investigate three main features suggested to efficiently discriminate humans from non-human taxa: the endocranial morphostructural organization, the sulcal topographic distribution and the petalial patterns.

Materials & Methods

Fig. 1. Sts 5, Taung and Sts 60 (from the left to the right; Sts specimens derive from Member 4 at Sterkfontein).*

		Morphostructural organization	Sulcal pattern	Petalial pattern
Extant taxa	EH	10	2	1
	Pp	10	1	1
	Pt	10	1	1
Fossil specimens	Sts 5	✓	✓	✓
	Taung	✗	✓	✗
	Sts 60	✓	✓	✓

Tab. 1. List of specimens investigated and virtually detailed by various equipments. EH: extant human; *Pt*: *Pan troglodytes*; *Pp*: *Pan paniscus*. In red: medical scanner; in green: micro-CT scanner; in blue: surface scanner. Data for Taung were collected from digital@rchive.

[Morphostructural organization] We highlight the structural differences between the morphostructural organization of extant taxa and two fossil specimens; Sts 5 and Sts 60. The morphological deformations were computed between templates representing each modern taxon (generated from samples of 3D endocrania), Sts 5 and Sts 60 (Dumoncel et al. 2014; Durrleman et al. 2014).

[Sulcal pattern] Based on a method for detecting crest lines on surfaces (Subsol et al. 2005), the sulcal lines are automatically assessed and manually corrected by removing non-anatomical structures. The frontal pole of Taung was virtually reconstructed and registered with the endocranium.

[Petalia pattern] We define a sagittal plane for symmetry as the best-fit plane passing through the landmarks placed along the inter-hemispheric ridge. Each hemisphere was mirrored along this plane and distances between the opposite points were determined (Combès et al. 2011).

Results

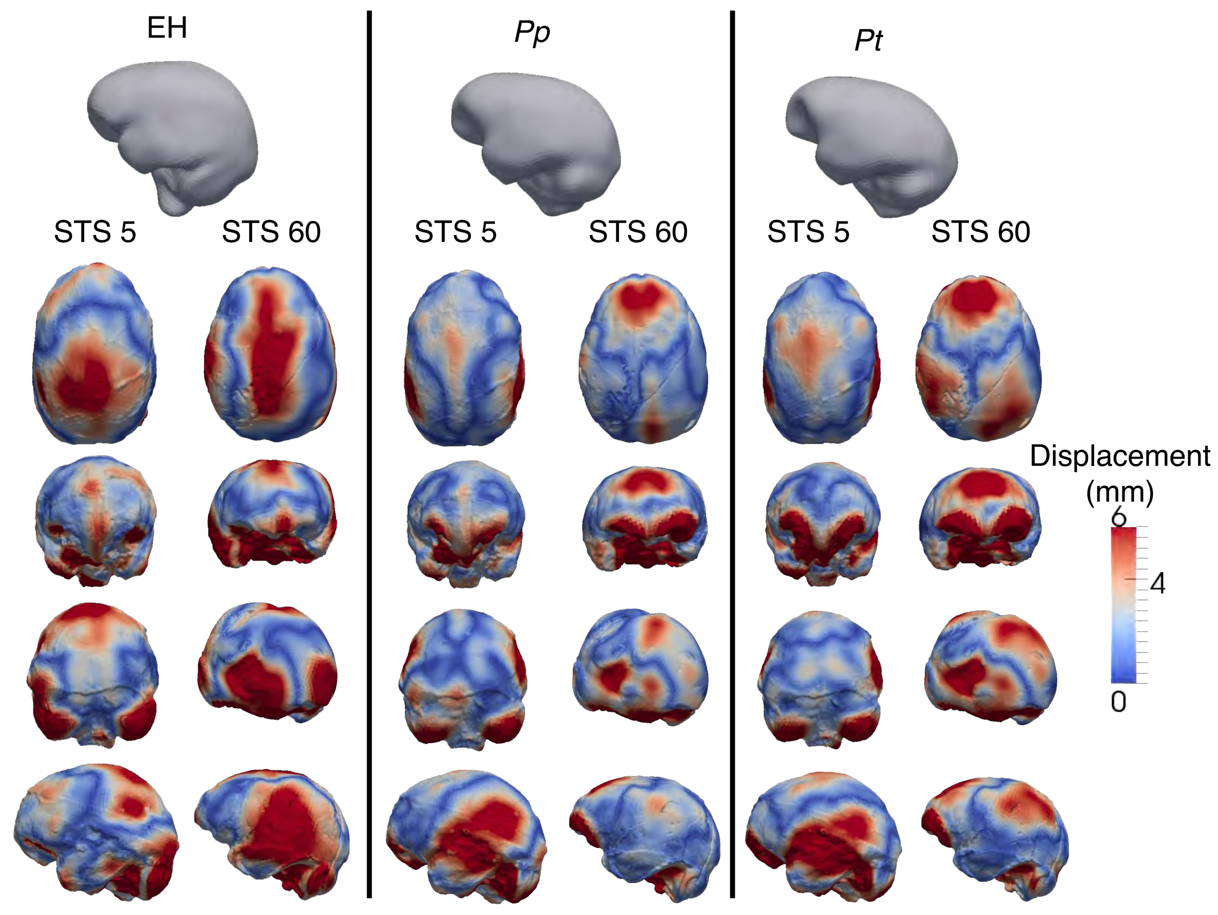

Fig. 2. Morphological deformations from the mean template (top) of EH, *Pt* and *Pp* to Sts 5 and Sts 60. For visualization purposes, deformations have been rendered by a color-scale and projected onto the original surfaces.*

From EH to the fossil specimens:
- higher amount of displacement than with *Pt* and *Pp*,
- deformations localized in the parietal area and the frontal pole.

From *Pp* to the fossil specimens:
- deformations mainly localized in the temporal region for Sts 5,
- overall distance related to the deformation slightly lower in Sts 60,
- differences restricted topographically, located close to the frontal pole and along the inter-hemispheric ridge for both fossils.

Classification based on deformation:
- both Sts 5 and Sts 60 endocrania fit well into the non-human primate variability.

Frontal sulcal pattern:
- a fronto-orbital sulcus is found in Taung, *Pp* and likely in Sts 5,
- superior and middle frontal sulci similar in Taung and Sts 60.

Occipital sulcal pattern:
- one line (1) is nearly systematically detected over an occipital bulging lying beneath the lambdoid suture,
- a second line (2) placed more anteriorly in the occipital lobe is present in *Pt*, in *Pp* and Taung.

Compared to the extant sample:
- the frontal sulcal organization in Taung is closer to the human observed pattern,
- the position of line (1) in Taung is intermediate between extant humans and *Pan*.

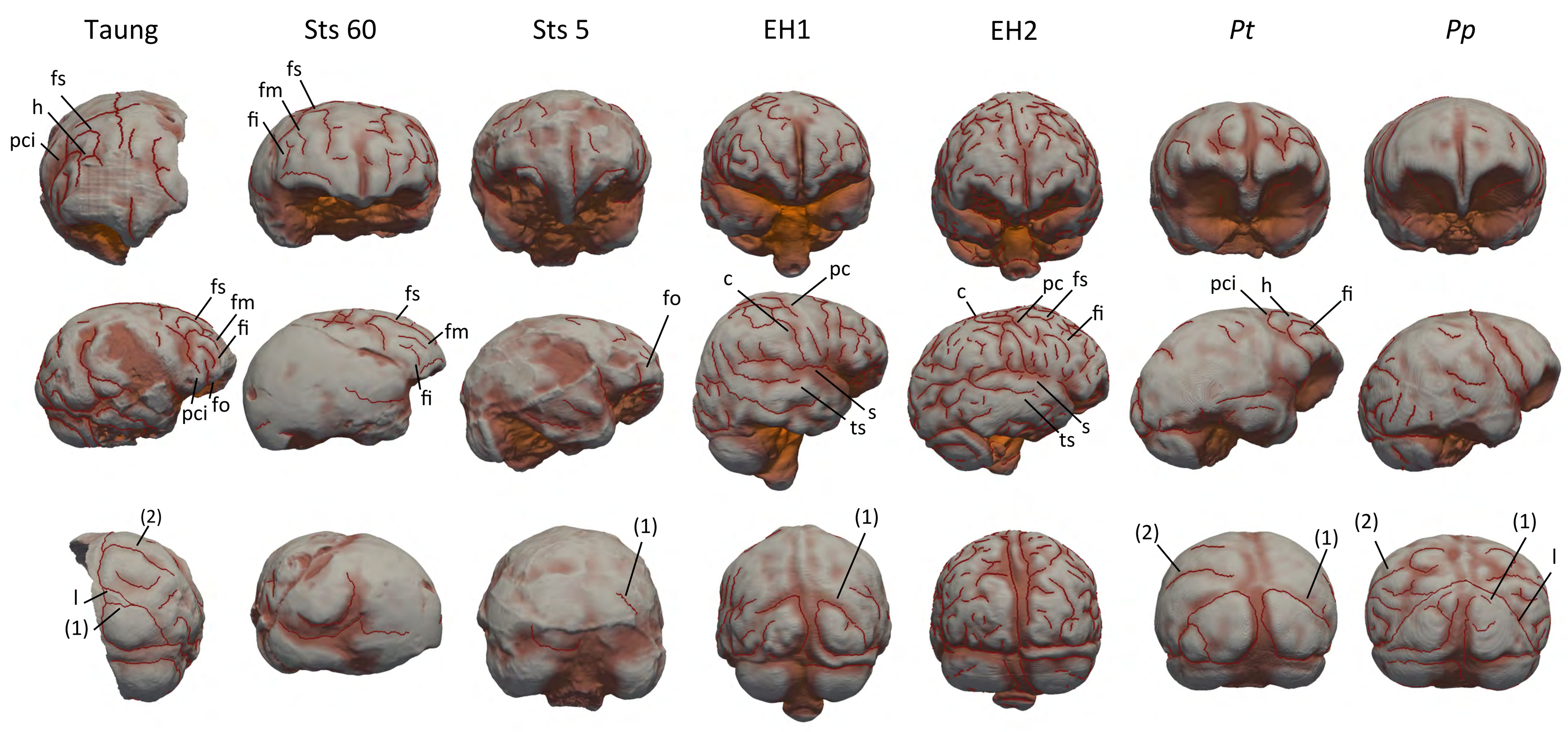

Fig. 3. Semi-automatically detected sulcal pattern. c: central s.; fi: inferior frontal s.; fm: middle frontal s.; fo: fronto-orbital s.; fs: superior frontal s.; h: horizontal ramus of the precentral s.; l: lambdoid suture; pc: precentral s.; pci: precentral inferior s.; r: rectus s.; s: Sylvian fissure; ts: superior frontal s. EH1: adult extant human; EH2: juvenile extant human.*

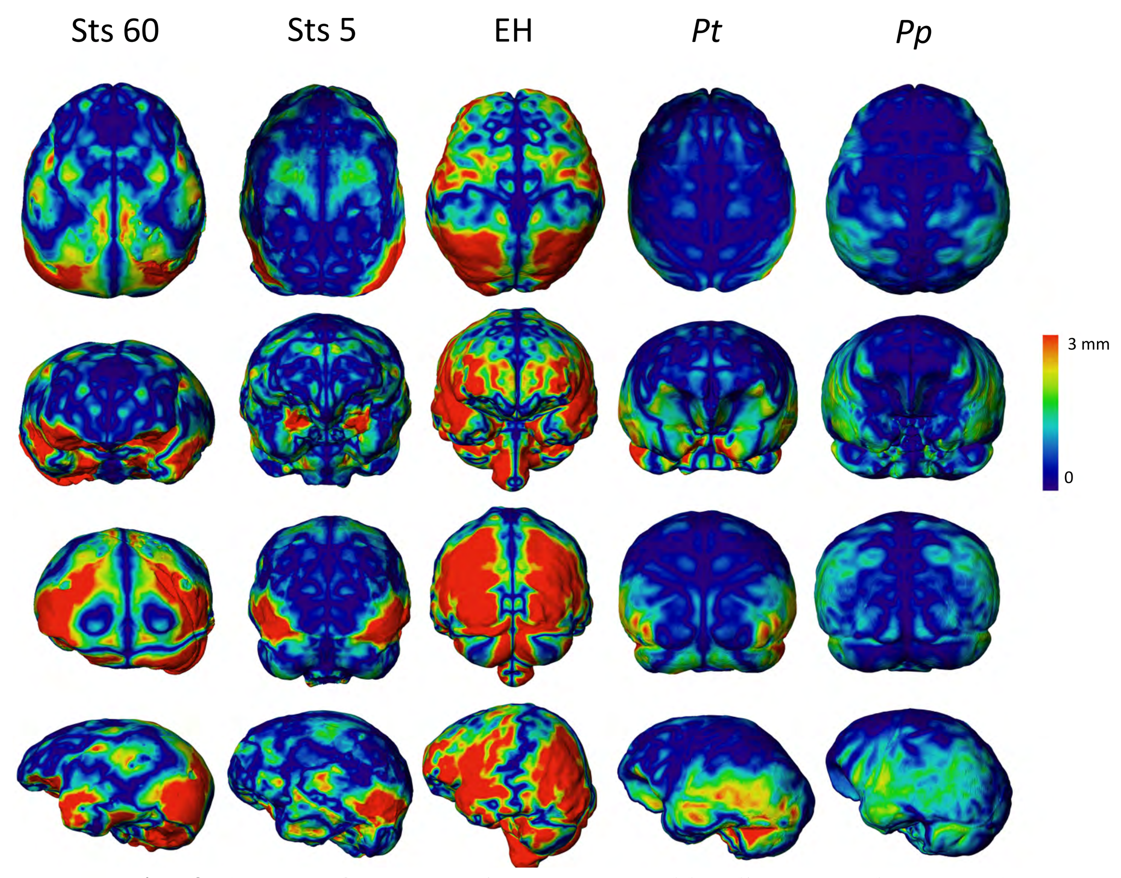

Fig. 4. Pattern of asymmetries represented by distance color maps.*

A general asymmetry pattern was assessed for Sts 5 and Sts 60 (consistent with Holloway et al. 2004a):
- marked asymmetry on the occipital lobes (left>right for Sts 5),
- faint asymmetry for the frontal pole (right>left for Sts 5).

Additional asymmetric areas:
- the frontal region close to the central sulcus,
- a constrained zone above the Sylvian fissure,
- a well-circumscribed region corresponding to Broca's area for Sts 5.

Compared to the extant sample:
- similar pattern between fossil specimens and EH but with a topographically more extended occipital and frontal patelias expressed at a higher degree for EH,
- distinct pattern for *Pan* with a clear asymmetry between the parieto-temporal lobes.

Conclusive remarks

When compared to extant humans, both Sts 5 and Sts 60 main endocranial regions affected by deformation are located in frontal and parietal areas. These areas correspond to those supposed to be derived in the "habiline" brain (Tobias, 1987). We therefore suggest that such a derived conformation was not fully established in Sts 5 and Sts 60.

The frontal sulcal pattern of both Sts 5 and Sts 60 shows some similarities with the extant human one. Regarding the occipital sulcal organization, line (1) detected could correspond to the position of the lunate sulcus according to Holloway et al. (2004a, b), while line (2) more likely corresponds to the position of the lunate sulcus suggested by Falk (2009).

According to the maps of cerebral asymmetries, Sts 5 and Sts 60 petalial pattern appear similar to those of extant humans, even if much less pronounced.

An additional remark concerns the stability of the endocranial pattern in Sts 5, Sts 60 and Taung, whose main features were very similarly expressed in all specimens, independently of their developmental stage.

References: Bruner E. 2014. *Springer*; Combès B. et al. 2011. *A.J.P.A.* 144; Dumoncel J. et al. 2014. *A.J.P.A.* 153; Durrleman S. et al. 2014. *Neuroimage* 101; Falk D. 2009. *Yearb. Phys. Anthropol.* 52; Falk D. 2014. *Front. Hum. Neurosci.* 8; Falk D. et al. 2000. *J.H.E.* 38; Holloway R. et al. 2004a. *Wiley-Liss*; Holloway R. et al. 2004b. *C.R. Palevol* 3; Subsol G. et al. 2009. *Paleoanthropol. Soc.*; Tobias P.V. 1987. *J.H.E.* 16.

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* Images not to scale.