Endocast of Taung compared to that of Hobbit; AAPA, Albuquerque, 2010

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1. title page

2. In 2005, my colleagues and I described the virtual endocast of LB1 (seen here) and identified 3 areas in which we observed derived features—parietal association cortex, prefrontal cortex, and posterior temporal lobe. Remember these!

3. We expanded our observations to 7 derived features in these same 3 regions in 2009, within an historical context and by determining polarities in comparison to great apes, *Australopithecus*, *Paranthropus*, and modern *Homo*. We noted that some of the features that we and others had identified as derived, such as a caudally-projected occipital pole relative to the cerebellum (#1), occurred sometimes in great apes. Similarly, expanded convolutions at the frontal poles (#6) were noted to appear, albeit less dramatically, in some chimpanzees, and the No 2 australopithecine endocast from Sterkfontein.

Although some of these 7 features may sometimes be found in other taxa, taken together, they form a Gestalt of derived features that distinguishes Hobbit's endocast from those of any other hominins that we have seen**.** Ralph Holloway used similar reasoning when he argued that the shapes of certain parts of australopithecine endocasts were humanlike rather than apelike in the 1975 publication of his James Arthur lecture and since. For example, quoting Holloway, "***Although there can be considerable variation in endocasts of living pongids, none shows the <u>combination</u> of features seen on hominid endocasts."***

4. Another quick example from our work on microcephalics. Typically, their cerebella project further caudally than their occipital poles, but there are a few exceptions as this slide shows. Nevertheless, the combination of a few shape features (including this one) permitted my team to derive a classification function that completely sorted these microcephalics (below) from normal humans (blue endocasts above, the red one is LB1). It is the gestalt that is important.

5. As you know, Dart's 1925 announcement of Taung was controversial because it contradicted the paleoanthropological beliefs of that time.

6. Dart identified only two sulci, the superior temporal (parallel) and what he thought was a lunate sulcus. His analysis of Taung depended heavily on the latter, which in his opinion was located much further back than was typical for apes (right), resulting in a greater distance between the two sulci in Taung.

7. From this, Dart concluded that, despite its small size, Taung's endocast showed a humanlike expansion of the parieto-occipito-temporal association cortex (shaded).

8. In 1980, I identified the feature that Dart thought was the lunate sulcus as the lambdoid suture and suggested further that the <u>entire</u> sulcal pattern of all of the then-

known australopith endocasts were completely apelike. (In 2007, the temporal pole was restored by Ron Clarke—right.)

9. I also argued that the australopithecine endocasts did not support the hypothesis that some parts of the cerebral cortex evolved before others – so-called "mosaic brain evolution." I did not know at the time that I was re-inventing the wheel.

10. I learned that in 2008 when I visited the WITS archives, where I studied the personal papers, unpublished manuscripts, and unpublished correspondence of Raymond Arthur Dart.

11. The collection contained a 269-page unpublished manuscript (*Australopithecus africanus*: *And his place in human origins*) that Dart wrote between 1925 and 1929. In 1930, the Royal Society in London declined to publish it.

12. I suspect because of some of these people (the Piltdown gang), who were fellows of the Royal Society.

13. Dart's manuscript was revealing and surprising. From it, we learn what Dart *really* thought about the Taung endocast. Here are two illustrations from the archives, which were published for the first time in the last issue of the *Yearbook of Physical Anthropology*. The one on the right was preliminary as Dart worked out Taung's entire sulcal pattern. The one on the left was included in his monograph. In addition to the 2 sulci that Dart identified in 1925, this figure includes 14 others.

14. In particular, note the fronto-orbital sulcus, which Dart identified and discussed, although he seemed unaware that this is found in apes but not humans. Significantly, Dart dashed in sutures in this figure, one of which was a fragment of the lambdoid suture, which he placed just behind the actual lambdoid suture, which he had identified as the lunate sulcus in his 1925 *Nature* article. In his manuscript he stated that the two coincided for most of their lengths, and said that the lunate sulcus measured 25 mm (I measure the lambdoid suture as 37 mm). From his writings, it is clear that Dart knew he had a lunate sulcus problem (and was terribly bothered by it), long before Arthur Keith's published criticism of his identification.

15. Arthur Keith thought Dart placed the lunate sulcus (L? here) behind the lambdoid suture, rather than in front of it (as Dart did). For his part, Keith thought the lunate was in an apelike position in front of lb (LK here).

16. Reading Dart's manuscript and re-examining the original Taung endocast at WITS caused me to make two minor revisions to my 1980 identifications. I dashed in a pit in the temporal lobe, and extended the terminal branch of the superior temporal sulcus (**ts**) into a damaged area, which caused me to identify it as the **superior** (**a1**) rather than **angular** branch (**a2)** of **ts**. In so doing, I corrected a mistake that Ralph Holloway had pointed out some years ago.

I was gratified that Dart saw each and every sulcus that I identified, although our names for a few of them differed. He, however, saw a bit more than I did—particularly at the back of the brain, where he struggled to bolster his identification of the lunate sulcus.

17. In that he was mistaken. As detailed in the 2009 *Yrbk of Phys Anthropol*, lunate sulci usually do not reproduce well on ape endocasts, and there is plenty of room between L1? and L2? for one to have existed in an ape-like forward position on Taung. The L2? sulcal pattern, in fact, has been described by Connolly on a bonobo endocast (see 2009 *Yrbk of PA*).

18. Dart extended his analysis to include brain shape, and that is what excited me most. It was as if I were reading my team's 2005 paper on Hobbit's endocast! Following his mentor, Grafton Elliot Smith, Dart described expansions in 3 cortices of Taung's endocast—To quote his unpublished manuscript: "It is important to reiterate that the only type of evidence the cast can yield, which would indicate proximity to Man, is that of expanded association cortices; which by their localisation, have profoundly affected the shape of the brains as compared with those of living Apes. Further the particular regions of the lateral brain surface which are especially expanded in Man and have affected its general contour as compared with Apes, are three in number. They are what Elliot-Smith…has called the "three significant cortical areas"…and are the parietal, the inferior frontal or prefrontal and the inferior temporal."

Further, Dart related the three areas to global shape changes associated with bipedalism and enhanced cognitive skulls such as understanding vocalizations of conspecifics (but without language). To quote him: "The assumption of the erect posture and the ability to display great muscular skill therefore depends upon the orderly expansion of all three of the significant cortices."

19. There are interesting parallels between the discoveries and controversial receptions of Taung and Hobbit.

20. Although both are derived in their shapes in the same three association areas, Taung and Hobbit's endocasts (left and right columns, respectively) differed significantly: Taung's frontal lobe had an ape-like fronto-orbital sulcus, LB1's did not; in dorsal view, Taung's endocast was long & narrow, LB1's was wider, especially at the back). From the back, the height of Taung's endocast is greater compared to its width compared to LB1. There appears to be a greater projection of the occipital pole relative to the cerebellum in LB1, and its lateral profile looks reminiscent of Asian *H. erectus* endocasts.

21. Nevertheless, like other *Australopithecus* endocasts, the shape of Taung's frontal lobes in dorsal view was derived compared to *Paranthropus*. LB1's endocast was also squared off and, further, had two enormous convolutions straddling the midline—similar to, but larger than, those of the No. 2 endocast from Sterkfontein and some chimpanzees.

22. I believe that during primate brain evolution, cortical shape changes may have preceded the appearance or disappearance of sulci, perhaps in conjunction with an overall increase in brain size. This hypothesis is in keeping with revelations from the WITS archives as well as David Van Essen's tension-based theory of sulcal patterns, illustrated here. In other words, dynamic changes in connections within and/or between local regions of the cerebral cortex would have led, initially, to alterations in their shapes. As this process continued, it would have eventually triggered the appearance (or disappearance) of sulci. Van Essen's concept may, thus, explain not only how new sulci appear during evolution, but also how they disappear when two formerly separated regions become highly interconnected. Such interconnections are, of course, what enlarged association cortices are all about.

23. This hypothesis causes me to question the widely-accepted belief proposed over a century ago by Grafton Elliot Smith, and championed in 1925 by Raymond Dart—namely, that the lunate sulcus was displaced posteriorly during the course of hominin brain evolution by expanding parietal association cortex. Rather, I think that expanding parieto-occipito-temporal cortices may have formed more and stronger interconnections as they enlarged, and that, over time, these bridges may have resulted in the loss of the lunate sulcus in bigger-brained hominins.

24. This hypothesis is consistent with the strong possibility that humans do not have true lunate sulci that approximate the rostral border of primary visual cortex, as suggested by the landmark research of Allen et al. in 2006.

25. This is a quotation from Dart's unpublished manuscript. As you can see, he was very passionate about endocasts. I think he would have appreciated this symposium!

26. Acknowledgments.