

shape corresponding very nearly to its normal projection ('normal' in the geometrical sense). If the screen is rotated around its vertical axis while the shadow-casting object remains stationary, the shadow appears to enlarge horizontally. Although the shadow on the screen changes shape, the retinal image is unaltered. The shape perceived is nearly that of the shadow viewed normally.

The magnitude of this effect can be measured, again using a null method, by arranging for a compensatory change of shape of the retinal image. This may be done by rotating the (flat) object. The screen and object may be linked to provide simultaneous rotations, their relative angles of rotation being adjustable. The magnitude of the effect may again be stated in terms of the Thouless ratio, which is given by :

$$\frac{\log P - \log S}{\log R - \log S}$$

where  $R$  is the ratio of the width of the shadow on the screen to its height,  $P$  the ratio of perceived width to perceived height (arranged to be constant and measured when the screen is normal to the observer), and  $S$  the ratio of the retinal width of the shadow to the retinal width when the screen is normal. If the angles subtended at the eye are small, the Thouless

ratio is given by  $\frac{\log \cos p}{\log \cos q}$ , where  $p$  is an angle turned

through by the object and  $q$  the corresponding angle turned through by the screen (Fig. 2), the relative angles of rotation being such that no change of shape is observed.

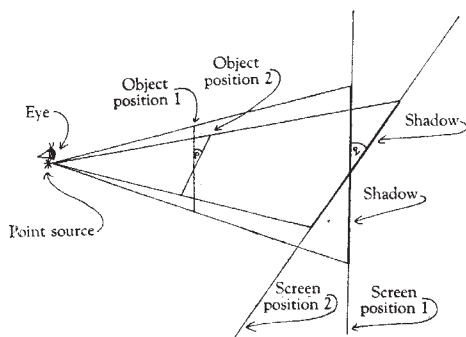


Fig. 2. With eye as close as possible to source, relative angles of rotation are adjusted until no change in shape observed

We are using this shadow method to investigate constancy during movement, which should be important in considering perceptual judgments involved in flying or driving. In particular we have tried to discover whether apparent movement due to constancy can be adapted. It is known that continuous presentation of real movement gives rise to an after-effect of apparent movement in the opposite direction<sup>3</sup>. The question here is: Can apparent expansion or contraction of the shadow produce an after-effect? By projecting the shadow on a series of screens which move continuously away from the observer and are stopped after 1 min., we find that an after-effect does take place, though the retinal image of the shadow remains unchanged during the movement of the screens. During the movement the shadow appears to expand; in the after-effect, it appears to contract. An after-effect of movement can thus be produced without shift of the image across the retina. Observation of the moving screens without the shadow does not produce the same after-effect of

contraction of the shadow thrown on the screen now stationary, so the after-effect is not merely an induced movement, as described by Duncker<sup>4</sup>.

One of us (S. M. A.) is in receipt of a Department of Scientific and Industrial Research studentship, and another (C. D. S.) of a grant from the Medical Research Council, which also provided support for apparatus.

S. M. ANSTIS  
C. D. SHOPLAND  
R. L. GREGORY

Psychological Laboratory,  
University of Cambridge.

<sup>1</sup> Thouless, R. H., *Brit. J. Psychol.*, **21**, 339 (1931); **22**, 1 (1931); **22**, 216 (1932).

<sup>2</sup> Vernon, M. D., *A Further Study of Visual Perception* (Cambridge Univ. Press, 1954).

<sup>3</sup> Wohlgenuth, A., "On the After-Effect of Seen Movement," *Brit. J. Psychol. Monograph Supplement* (Cambridge Univ. Press, 1911).

<sup>4</sup> Duncker, K., "Induced Motion", in *A Source Book of Gestalt Psychology*, edit. by Ellis, W. (Routledge and Kegan Paul, London, 1938).

## ANTHROPOLOGY

### The Juvenile Mandible from Olduvai

FURTHER to my report in *Nature* on February 25, p. 649, about the new discoveries of hominid remains in Bed I and Bed II at Olduvai Gorge, additional information can be given on the mandible of the juvenile from the site *FLK.NN.I*, at a horizon older than that of *Zinjanthropus*.

The third lower premolar (often called the first lower premolar by anatomists) is, in all the published Australopithecines, markedly shorter mesio-distally than wide bucco-lingually. The published figures for fully erupted lower third premolars of Australopithecines in South Africa include 14 from Swartkrans with indices  $(100 \times L)/B$  ranging from 76.00 to 91.9 and a mean of 83.2. Kromdraai has only one reasonably preserved third lower premolar with an index of 83.2. Sterkfontein has only two good measurable examples published, which give indices of 77.8 and 76.8 respectively. Makapan has two measurable teeth, and the indices are said to be identical, at 88.4.

It is thus clear that, on the basis of the available published data (which are confirmed by my own observations on the original material at Pretoria and Johannesburg, which Prof. R. A. Dart, Prof. P. V. Tobias and Dr. J. T. Robinson kindly allowed me to examine), the third lower premolars of all known Australopithecine specimens are broader bucco-lingually than they are long mesio-distally. The index  $(100 \times L)/B$  gives a range of 76.00-91.9.

In the juvenile hominid from the level below *Zinjanthropus* of site *FLK.NN.I* the measurements of the third lower premolars are as follows:

	Length	Breadth	Index
Left	11.00	9.5	115.8
Right	11.00	9.5	115.8

Thus, while all the published length-breadth indices of fully erupted lower third premolars of all *Australopithecus* and *Paranthropus* specimens are much less than 100 (that is, broader than long) and have a range of 76.00-91.9, the indices of the tooth in the juvenile hominid from the pre-*Zinjanthropus* level are greater than 100, being in fact 115.8.

Quite apart from this very clear measurable difference which puts the third lower premolar completely out of the known range of measurable

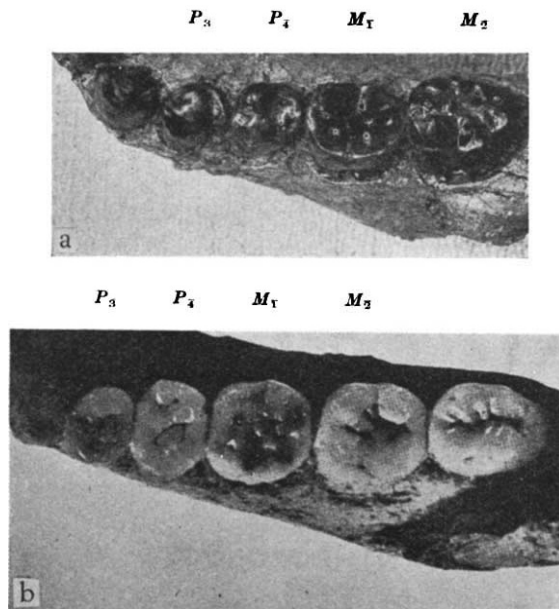


Fig. 1. Comparison between the teeth of the left side of the (a) pre-*Zinjanthropus* juvenile mandible with those of (b) an adult *Paranthropus* to show the morphological differences. In the Olduvai specimen the third molar is not present. (Not to the same scale, but reduced so that the length  $P_3 - M_2$  inclusive is approximately the same so as to show relative proportions)

variation in the Australopithecines, the morphological picture is also completely different from that of any Australopithecine that I have been able to examine, or of which there are published photographs available to me (Fig. 1).

Turning next to the published data of lower fourth premolars (second premolars of some anatomists) of known Australopithecines, we find that there are 13 measurable specimens from Swartkrans, all of which are much wider bucco-lingually than they are mesio-distally. The index  $(100 \times L)/B$  ranges from 61.1 to 91.1 with a mean of 82.3 (very close to the mean for the third lower premolars). Only two specimens from Kromdrai are known and they fall well within the range with indices of 84.4 and 84.7. Only two Sterkfontein lower fourth premolars appear to have been described in the literature, and these give indices of 87.0 and 82.9. I know of no measurable fully erupted fourth lower premolars from Makapan that have been recorded; the known specimens are either not fully erupted or very worn and damaged.

When we turn to the juvenile hominid from the pre-*Zinjanthropus* level at FLK.NN.I, we find that the fourth premolars are markedly longer mesio-distally than they are bucco-lingually. The measurements and indices are as follows:

	Length	Breadth	Index
Left	11.0	10	104
Right	11.0	10.50	104.7

Thus we find that whereas in the known Australopithecines the range in the index  $(100 \times L)/B$  is from 61.1 to 91.1, in the juvenile from the pre-*Zinjanthropus* level at Olduvai, the position is quite different. The mesio-distal length is greater than the bucco-lingual width, so that the indices are more than 100.

Again, apart from measurable differences, the fourth premolars in the new jaw are morphologically different

from those I have seen in the collections of Australopithecines at Johannesburg and Pretoria (Fig. 1).

The published data on the first lower molars of *Australopithecus* shows that the index  $(100 \times L)/B$  varies from 114.6 in one of the Sterkfontein specimens to 100.8, also from Sterkfontein, and the indices from other sites fall within this range, both in respect of *Australopithecus* and *Paranthropus*. The first lower molars in the juvenile jaw from the pre-*Zinjanthropus* level show identical measurements of length 14.25 and breadth 12.00, giving an index of 117.00. This is outside the published range of variation of Australopithecine first lower molars. Morphologically, too, there are differences in the crown pattern, which is much simpler and more like that which can be observed in some modern Australian Aborigine teeth.

The second lower molar of the pre-*Zinjanthropus* juvenile is 16.00 mm. long and 14.00 mm. wide. In this case, the index falls within the range of variation of the known Australopithecines. Some morphological differences seem to me to be present, but need further study. I do not recall (nor have I notes on) any really comparable tooth in the collections in Pretoria or Johannesburg, but I say this with reservations.

There is a single upper molar (which appears to be an unerupted upper molar) in which the roots have not yet formed and in which the crown is completely fresh. It seems likely that it represents the third upper molar of the same juvenile as is represented by the mandible, and in which the lower second molar is erupted but scarcely worn.

If this tooth is correctly interpreted as an unerupted third upper left molar, then it confirms my view that the teeth of the juvenile pre-*Zinjanthropus* differ, in most measurable respects, from the Australopithecines. The tooth has a mesio-distal length of 13.5 and a bucco-lingual width of 12.75, giving an index of  $(100 \times L)/B$  of 106, which seems to be outside the range of variation published for any Australopithecine upper third molar. Even if it is not a third upper molar but a second, it is still outside a published range, while morphologically it does not seem to be of Australopithecine type.

In conclusion, may I say that when I used the word 'child' with reference to the pre-*Zinjanthropus* juvenile in my report in *Nature* of February 25, I was not intending thereby to imply that the father was a 'man' in the sense of the accepted definition of treating him as the 'maker of tools to a set and regular pattern'. I used the word 'child' simply as meaning a juvenile of the family Hominidae.

There are stone tools and a bone tool in direct association with the juvenile, but it is not yet certain whether his family made these tools, any more than it is quite certain that *Zinjanthropus* made the tools which are in direct association with the skull from FLK.I.

If I am right in believing that the juvenile from FLK.NN.I is not an Australopithecine, but a very remote and truly primitive ancestor of *Homo*, then it is possible (and I stress the fact here that I only use the word 'possible' at this stage of the inquiry) that it was this branch of the Hominidae that also made the Oldowan tools at the site FLK.I where *Zinjanthropus boisei* was found. We do not yet know the final truth of this problem.

L. S. B. LEAKEY

The Coryndon Museum,  
Box 658, Nairobi,  
Kenya.