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58. A Plea for a Substitute for the Frankfort Base-Line: With an Account of a New Method of Drawing Skull Contours

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Source: *Man*, Vol. 15 (1915), pp. 101-106

Published by: Royal Anthropological Institute of Great Britain and Ireland

Stable URL: <http://www.jstor.org/stable/2787784>

Accessed: 27-06-2016 09:09 UTC

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been found further inland than Kwera, with one exception—that being the specimen figured as No. 10 in the photograph—which was picked up by Mr. R. L. Reid at M'pera, some five miles higher up stream.

The absence of quartz, or other stone, implements in the hinterland cannot be without significance, and although negative evidence is not always to be trusted, especially in so little known a territory as this, one cannot help thinking that the abundance of easily smelted iron-ores may have a good deal to do with the absence of stone-age relics in the interior of the Mozambique Province.

CONCLUSION.

It would be dangerous, not to say premature, to conclude from so small a collection of implements as that described in these notes that they fairly represent a primitive series—primitive, that is, in workmanship—were it not for the fact that a precisely similar, but numerically much larger, series has been discovered in Rhodesia. The crudeness of the implements suggests considerable antiquity, but no evidence is forthcoming at present from the Mozambique region which justifies one in assigning them to any period older than the early palæolithic, whereas they may be much younger.

E. J. WAYLAND.

Anthropology.

Pycraft.

A Plea for a Substitute for the Frankfort Base-line: With an Account of a New Method of Drawing Skull Contours. By W. P. Pycraft, Zoological Department, British Museum. **58**

While engaged in preparing a report on a collection of Papuan skulls I found it necessary to examine, somewhat critically, the standards of comparison now universally accepted among Anthropologists. Some of these, at least, leave so much to be desired that I venture to think they must be abandoned.

The first of them coming under this condemnation is the “Frankfort base-line.” This offers but doubtful advantages over Camper’s base-line, which it superseded. In the first place, the use of this standard makes a comparison between complete skulls and such as have lost the facial portion (as fossil skulls) impossible. In the second place, complete skulls, in other things equal, but differing in the height and form of the orbits, are made to appear very dissimilar, since the frontal area of the skull will be raised in the one case and depressed in the other, while a similar falsification of the occipital region of necessity follows.

The extreme inefficiency of the Frankfort base-line and the angles obtained therefrom have long been recognised. Just ten years ago Professor Arthur Thomson* endeavoured to provide a substitute in a base-line passing from the nasion backwards to the basion, and set at an angle of 27° from the horizontal—“the average angle formed by the basion with the horizontal.” But, while this line was an undoubted improvement on that of the Frankfort plane, it fails no less completely to yield trustworthy results. And this because it was founded in part upon the basion, which, as I shall presently show, is an absolutely impossible base, whether used as a means of determining the facial angle or the gnathic index.

I propose, then, in the place of these lines to substitute another, passing from the nasion backwards through the centre of the auditory meatus, for it will be found, in practice, to furnish an infinitely better, because more trustworthy and more convenient, means of measurement.

The only semblance of a reason so far advanced for the use of the “Frankfort line” has been that the skull thus placed is in the same position as it is held during life. Wherein lies the advantage of this in studying the skull? It is also urged that this line can be used in measuring the living subject. But as much may be claimed for the line I now propose. This, as has just been pointed out, draws a sharp

* Thomson and Randall MacIver, *The Ancient Races of the Thebiad*, 1915, p. 37.

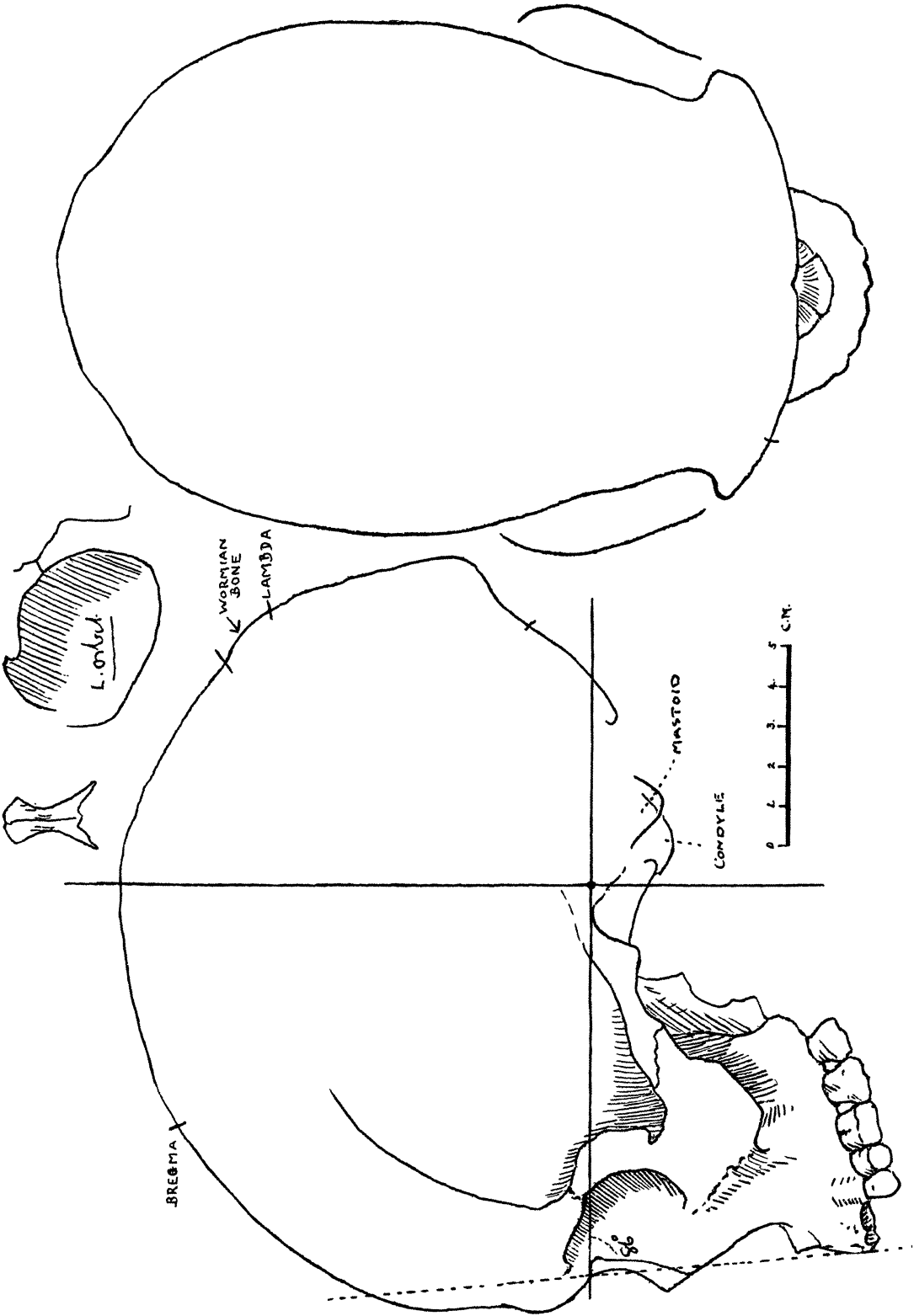
distinction between the face and the cranium, the former lying entirely below and the latter entirely above, or almost entirely above, the line. Where the Frankfort line is used, half the face appears above, and a large portion of the occipital region below, the line, with a consequent confusion of issues.

The advantages of such a base-line become even more apparent when the matter of the gnathic, or alveolar index, and the facial angle are concerned. The value of the former, calculated from the respective distances of the prosthion and nasion from the basion, has frequently been called in question, so much so that some have advocated the substitution of a "sub-nasal index," which is worse than useless. The contradictions and discrepancies of the gnathic index, as commonly taken, are due to the hitherto unsuspected range in the length of the basi-nasal line, and the equally shifting character of the position of the basion below the base-line. The curiously variable character of the depth of the basi-occipital region of the skull is strikingly demonstrated by the use of the base-line now proposed. In some skulls the distance between this line and the basion may be as little as 9 mm., while in others it may be as much as 25 mm. Thus it comes about that of two skulls, in all else equal, the gnathic index, obtained by calculations of the relative lengths of the nasio-prosthionic lines, may in the one case indicate meso-, and in the other prognathism, and this though the facial angle may be the same in both.

The Frankfort angle is as uncertain, and as unsatisfactory, an index as was Camper's facial angle which it superseded. And this because, owing to the very wide range in the height of the orbit, a diversion of the angle of as much as 5° may be made, which is more than sufficient to make a prognathous skull appear mesognathous, or *vice versa*. The angle thus measured, however, as a matter of fact, is *not* the facial angle, but the amplitude of the rotation of the skull on the meatal axis.

The facial angle can, however, be measured, and accurately measured, by the use of my nasio-meatal base-line. Further, it will be found to work in complete harmony with, and to afford a useful check upon, the figures yielded by the gnathic index as at present used. The avowed purpose of this angle is to record the movement of the facial upon the cranial portion of the skull, and this movement may be regarded as taking place upon the nasio-frontal hinge. This being so, then the nasio-prosthionic line intersecting the base-line may be regarded as a pendulum. We have to measure the swing of that pendulum.

So complete is the harmony between the figures yielded by angle thus taken and the figures obtained by computing the gnathic index, that the latter can always be accurately obtained before computation by adding twenty to the figures given by the angle. Thus, where this is 77° the alveolar index will be 97. Any apparent discrepancy between this relation will invariably be found to be due to eccentricities in regard to the position of the basion. For example, in an English skull which I used when experimenting with this base-line, the facial angle was 65° but the alveolar index was 86 (B.N. 108, B.P. 93, A.I. 86). Here the harmony between the angle and the index was disturbed by an excess in the basi-prosthionic length of 1 mm. Reducing this from 93 to 92 gave the required index of 85. Frequently the discrepancy is greater than this, the alveolar index yielding figures as much as 4 or 5 mm. above or below the required number to establish agreement between the angle and the index. But in every such instance the error can be positively demonstrated to lie with the index, according to which obviously prognathous skulls are made to appear mesognathous, and *vice versa*. I have, for example, among my records, four skulls yielding an alveolar index of 103, that is to say they are, apparently, all on the border-line of mesognathism. But the facial angles of these skulls obtained from the proposed base-line are as follows: 88° , 82° , 79° , and 78° ,



which show that the correct indices are respectively 108, 102, 99, and 98, instead of a uniform 103. The merest glance at the skulls suffices to demonstrate the inaccuracy of the indices obtained by the method now in use. Such indices are worse than useless, they are misleading, and should accordingly be obtained in future from the facial angle after the fashion herein proposed.

Huxley was right in his opinion that "The so-called facial angle . . . does not simply express the development of the jaws in relation to the face, but is the product of two factors, a facial and a cranial, which vary independently." But he was in error when he maintained that "the face remaining the same, prognathism may be indefinitely increased, or diminished, by the rotation of the frontal end of the skull, backwards or forwards, upon the anterior end of the frontal axis." *

In the first place the postulated "rotation of the frontal end of the skull" is an entirely mythical movement, the change in the angle of the "anterior base" of the skull, which he had in mind, is due to the "down-thrust" consequent on the increased size of the brain, which also involves the "middle-base" of the cranium, the vault of which is at the same time thrust upwards. If the postulated movement did actually take place it would have a disastrous effect upon the posterior nares, for it would unduly shorten the distance between the basion and the posterior alveolar border. The controlling factor, in regard to this angle, so far as the cranium is concerned, is the meato-nasionic length, that is to say, the distance from the meatus to the nasion. Where this is short, in regard to the total length of the face, so, in proportion, will the tendency to prognathism be increased, the determining factor in this being the minimum distance possible between the posterior alveolar border and the basion compatible with the requirements of respiration. Thus, then, a no less important contributory factor is the length of the alveolar border. Owing to the requirements of the respiratory area just referred to, where this border is long a forward projection of the jaw is inevitable, and the extent of this projection will depend on the meato-nasionic length. If this is short relatively to the length of the face, then the alveolar index will be high, or rather the angle will be high, for the figures yielded by Flower's index afford a less reliable measure of the gnathism owing to the extremely variable position of the basion.

My contention that there is an extremely close relationship between the facial angle and the gnathic index, and that these indices are governed, not as Huxley supposed, by movements of the anterior base of the cranium, but by (α) the length of the meato-nasionic line, (β) the alveolar length, and (γ) the basio-alveolar distance, can be demonstrated beyond dispute by the use of the base-line I now propose.

For it will be found that when skulls having the same meato-nasion length are compared, that the differences in their facial angles can be accounted for by comparing the differences between the combined alveolar lengths and the alveolar distances in each skull in the series. The two following examples should make this point clear. I have selected these at random, the better to establish my case. The first two are skulls of a New Caledonian and a Burmese:—

New Caledonia - M.N., 93; 89°; A.L., 60; B.-A.D., 47.

Burmese - M.N., 93; 77°; A.L., 55; B.-A.D., 38.

The meato-nasion lengths (M.N.), it is to be noted, are equal, while the difference in the facial angles are as high as 12. This difference can be accounted for, within 2 mm., by the differences between the alveolar lengths and the basi-alveolar distances (A.L. and B.-A.D.). Thus, in the skull with the lower facial angle the alveolar length has decreased 5 mm. and the basi-alveolar distance 9 mm.

* Huxley, *Journ. Anat. and Physiol.*, Vol. I.

The skulls of a Papuan and a Tasmanian similarly compared show a like relationship :—

Papuan - - M.N., 90 ; 88° ; A.L., 66 ; B.-A.D., 44.

Tasmanian - M.N., 92 ; 82° ; A.L., 58 ; B.-A.D., 45.

The meato-nasion lengths in these two cases, it will be noted, are slightly different ; between the facial angles there is a difference of 6, the lesser angle being due to the shorter alveolar border, which is less than that of the Papuan by 8 mm. If the alveolar distances in the two skulls were equal, then the differences between the combined alveolar lengths, and distances, and the angles would be reduced to two units. This extraordinary correspondence between the length of the jaw, and the basi-alveolar distance, and the facial angle will be found to obtain wherever skulls having the same, or approximately the same, meato-nasial length are compared ; which sufficiently demonstrates my contention that the facial angle is directly dependent on the length of the jaw, and not on movements of the basi-cranial axis.

A further illustration of the soundness of this theory is furnished by the fact that, given the angle and alveolar lengths of one skull, the facial angles of any others can be found by a simple sum in proportion, provided that skulls of the same

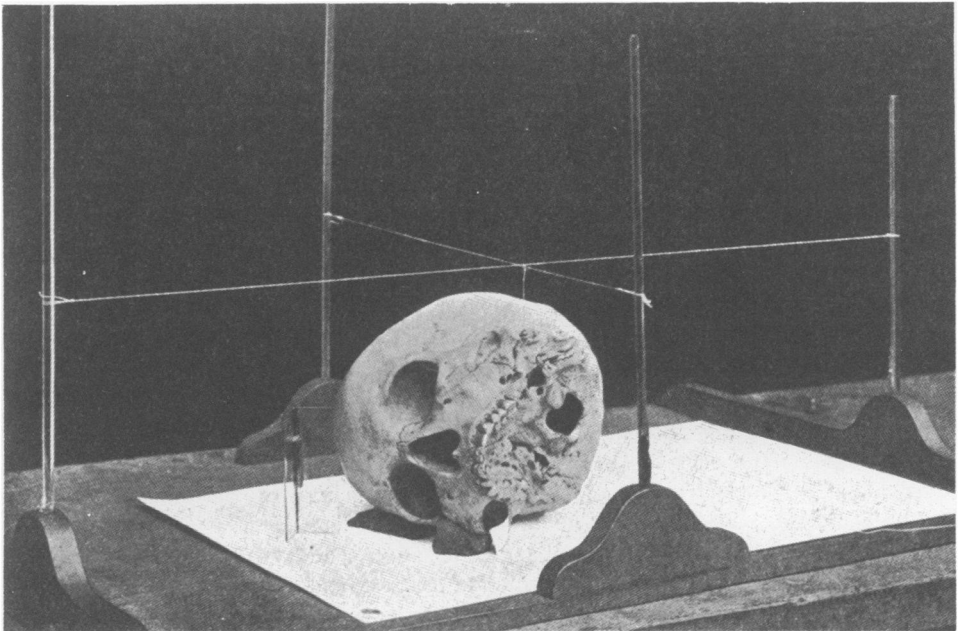


FIG. 1.—METHOD OF DRAWING SKULL CONTOURS.

meato-nasial lengths are compared. The skulls of the Papuan and Tasmanian just referred to, treated in this manner, afford an example of this test :—

$$110 : 88 :: 103 : 82.$$

In these two skulls it will be noted there is a difference of 2 mm. in the meato-nasion length. But skulls having a greater difference than this cannot be compared.

It is to be noted that the total length of the skull is not a factor in these calculations.

To return now to the gnathic index. Since the figures yielded by the derivation from the facial angle agree so closely with those obtained from Flower's method of calculating this index, the standard of gnathism need not be changed ; but the continued use of the term prognathous is open to many objections, I propose to

substitute the term megalognathous. The gnathic index may then be formulated as follows :—

Angle less than 78 orthognathous.

„ between 78 and 83 mesognathous.

„ above 83 megalognathous [prognathous].

Finally, I venture to express the opinion that the base-line now proposed affords, for the first time, a really reliable and uniform standard of comparison between the skulls of different races, since it has reduced the sources of error to a minimum.

I pass now to a brief description of the method I have devised for obtaining the facial angle, and at the same time of drawing the complete contour of the skull. That it is in every way better adapted to its purpose than the stereograph can, I venture to think, be established beyond question, for it ensures greater accuracy and detail and is extremely simple to use.

Briefly, the skull is placed upon its side upon a sheet of millimetre ruled paper, laid upon a board provided with four uprights, between which threads are stretched so as to cross one another at right angles. The skull is then adjusted on pads of modelling clay, or soft wax, placed upon small squares of glass to prevent soiling the paper, till the nasion, bregma, lambda, and post-palatine spine are all at the same height from the paper, a height which must be exactly half the maximum width of the skull, *e.g.*, 67 mm. in a skull having a maximum breadth of 134 mm. These details being settled, the nasion is brought exactly under the longitudinal thread, and over the base-line of the paper and the centre of the meatus exactly under the point of intersection of the crossing threads. The centre of the meatus is determined not by the actual shape of the aperture, which is often oval, but by the centre of the axis of the meatal rods of Pearson's head-spanner used for determining the meatal height. To fix upon this centre accurately, a shot suspended from the intersection of the threads is dropped into the upper segment of the meatus. To show that this method of fixing upon the centre of the meatus is accurate I may remark that it is rare indeed that the height recorded by the head spanner and that recorded on the contour made by this method differ by more than 1 mm.

These preliminaries arranged, the work of drawing begins. This is done by means of a guide formed by two glass micro slips fixed at right angles to one another. The edge of the guide is placed against the frontal, for example, and a pencil dot is placed against the edge of the "guide" resting upon the paper; the guide is then moved about a centimetre and another dot is made, and so on till the circuit of the skull is complete. The position of the bregma and lambda are then indicated by lines cutting the contour of the skull at right angles, and finally, the shape of the orbits and the contour of the lower border of the sygoma are dotted in by means of a special guide; when the skull is removed and the isolated dots are converted into a continuous line. As soon as the skull is removed from the paper the drawing is measured and basi-nasion and basi-prosthion lengths to see that the basi-bregma and meatal heights are correct, when the facial angle is taken and the various indices are entered upon the sheet, with any other details which may be desired. I generally include a drawing of the norma verticalis and mandible taken by the same means. But as to these, and other details, I propose to say more in my forthcoming report.

W. P. PYCRAFT.

New Hebrides.

Rivers.

The Boomerang in the New Hebrides. *By W. H. R. Rivers.*

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Through the kindness of the Rev. F. G. Bowie, of the Presbyterian Mission in the New Hebrides, I was able last year to visit the northern part of the west coast of Espiritu Santo (always known locally as Santo). The natives of this