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BIOMETRIKA

ON THE NEED FOR STANDARDISATION IN MEASUREMENTS ON THE LIVING.

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I. INTRODUCTION.

1. LACK of agreement between different observers about fundamental definitions and technique of measurement constitutes an almost insurmountable obstacle to comparative studies in Anthropometry of the living. In an attempt to discover how far the measurements provided by different workers can be used for purposes of inter-racial comparisons I selected the following material:

(i) Y. Koganei (1893). "Beiträge zur physischen Anthropologie der Aino."

(ii) Aleš Hrdlička (1912). "The Natives of Kharga Oasis, Egypt."

(iii) F. von Luschan (1913). "Beiträge zur Anthropologie von Kreta."

(iv) T. Kubo (1913). "Beiträge zur phys. Anthropologie der Koreaner."

(v) Fritz Sarasin (1916—1922). "Anthropologie der Neu-Caledonier und Loyalty Insulaner."

(vi) L. H. Dudley-Buxton (1922). "Ethnology of Malta and Gozo."

(vii) S. M. Shirokogoroff (1923). "Anthropology of Northern Asia."

(viii) S. M. Shirokogoroff (1925). "Anthropology of Eastern China, etc."

(ix) Aleš Hrdlička (1925). "Old Americans."

(x) H. Lundborg and F. J. Linders (1926). "Anthropologica Succica."

2. All the above-mentioned authors are well-known workers in anthropology. Koganei was the Professor of Anatomy in the Imperial University of Tokio, and Kubo the Professor of Anatomy in Taihan Hospital, Seoul, Korea, at the time they took their measurements on the Aino (8)* and Koreans (10) respectively. Hrdlička was the Curator (Division of Physical Anthropology) at the United States National Museum, when he collected the materials for his monograph on the Egyptians of Kharga Oasis (4). F. von Luschan and Fritz Sarasin were trained as anthropologists and have published numerous important papers and books on anthropology. H. Lundborg and F. J. Linders are the Director and Vice-Director respectively of

A list of bibliographical references is given in Appendix II. Numbers within brackets refer to that list.

the Swedish State Institute for Race Biology in Upsala. Dudley-Buxton was a member of the staff of the Department of Human Anatomy in the University of Oxford when he collected the material for his paper on the Maltese (3), and is at present, I believe, the Head of the Department of Anthropology in the same University. Shirokogoroff has published several papers on the comparative anthropology of the Far East, and appears to be an acknowledged authority in this subject.

3. One would naturally expect that the works of such trained scientists would be free from ambiguities, and would be comparable with one another, especially when almost all the investigations (with one exception, that of Koganei) were conducted several years later than the date of the International Agreement of Monaco on Anthropometric Measurements in 1906 (20). To my great surprise and consternation I found that this was far from the actual fact. Fresh discrepancies in definitions or in technique continually cropped up, and I was forced to make a systematic comparison of the different definitions of the measurements on the flesh. In the present paper I have given the results of such a comparison, restricting myself to measurements on the living head, and to the following standard lists cited in one or other of the publications mentioned above.

(i) "Notes and Queries on Anthropology" (1st edition, 1874).

(ii) Paul Broca (1879). "Instructions générales pour les recherches anthropologiques à faire sur les vivants."

(iii) Paul Topinard (1885). "Éléments d'Anthropologie générales."

(iv) Paul Topinard (English translation, 1890). "Anthropology."

(v) R. Virchow (1885). List on pp. 99—102 of "Zeitschrift für Ethnologie, Verhandlungen," Bd. XVII.

(vi) E. Schmidt (1888). "Anthropologische Methoden."

(vii) "Notes and Queries" (2nd edition, 1892).

(viii) "Schedule of Measurements in Anthropology" (British Association, 1895).

(ix) "Notes and Queries" (3rd edition, 1899).

(x) F. von Luschan (1906). Article on physical anthropometry in Neumayer's "Anleitung zu wissen. Beobachtungen auf Reisen," Bd. II.

(xi) Report of the Anthropometric Commission appointed by the XIIIth International Congress of Prehistoric Anthropology and Archaeology at Monaco, 1906.

(xii) Report of the Anthropometric Committee of the British Association (1908).

(xiii) "Notes and Queries" (4th edition, 1912).

(xiv) Rudolf Martin (1914). "Lehrbuch der Anthropologie."

(xv) Aleš Hrdlička (1920). "Anthropometry."

4. Koganei gives very short definitions, which are usually insufficient, and refers to Virchow's paper (31). Unfortunately this paper gives merely a list of measurements without any definitions and descriptive notes. Koganei however also mentions Schmidt's book (25), and it is probable that he actually followed it as his standard.

Kubo, in his work on the Koreans (10), constantly refers to Schmidt (25) and occasionally to von Luschan (11). Kubo was a pupil of Koganei's (Kubo mentions this fact in dedicating his book to Koganei), it therefore appears probable that he had been introduced to Schmidt's list by Koganei himself.

Hrdlička in his work on the Egyptians (4) does not give any systematic definitions, neither does he refer to any standard list. The system of measurements described in his book on Anthropometry (5) was published several years later, in 1920, but in this latter book he mentions that "the procedures, instruments, etc., to be here described, are those in regular use at the Division of Physical Anthropology, U.S.A. National Museum and in the field-work for the same" ((5), p. 33). As Hrdlička had gone out to Egypt while holding the post of Curator of the same department it may be presumed that his measurements were taken in accordance with the specifications described in his book on Anthropometry (5). The work on "Old Americans" (6), published in 1925, may also be presumed to be based on the same standards.

F. von Luschan, in his paper on the Cretans, distinctly mentions that "his technique was the same as that which he had originally learnt from Broca and which he himself, with slight modifications, has taught for three decades in practical courses" (translated from S. 354, *Zeitschrift für Ethnologie*, 1913). Broca's instructions (1) and von Luschan's own instructions in (11) have been consulted for elucidating his definitions.

Sarasin does not give any systematic definitions, but in view of his numerous references to Martin (14), I have assumed that Sarasin has followed Martin's scheme, except in points where Sarasin definitely states otherwise.

Dudley-Buxton mentioned in his paper ((3), p. 175) that his "measurements were taken in accordance with Martin's definitions," referring no doubt to (14). As I felt doubtful about certain points, Dr G. M. Morant of the Biometric Laboratory, London, at my request very kindly wrote to Mr Buxton and received the following reply in a letter dated Oxford, 5th February, 1927:

"You will find most conveniently my technique summarized in the British Association Anthropometric Investigations in the British Isles, reprinted from the B.A. Report 1908. My measurements are, following their numbering:

A. 1. G.O.L., 2. G.B., 4. M.F.D.
B. 1. U.F.H., 2. T.F.H., 3. Biz.B., 5. E.O.B., 8. Big.B.
C. 1. N.H., 4. N.B.
E. 1. Stature."

Shirokogoroff mentions ((27), p. 1) "the list of measurements elaborated by the

International Commission in Geneva in 1912," and refers to the *Revue anthropologique*, Nos. 7—8, Juillet—Août, 1913. The Geneva Commission (7) does not however give any measurements on the head as its work was restricted to measurements on the body. But as the Geneva Commission was a continuation of the earlier Monaco Commission of 1906 (20) I have assumed that Shirokogoroff really intended to refer to this latter list. According to Shirokogoroff this list "is generally used in Russia," and "the list elaborated by the Commission in England does not differ from this except in the measurements of the physiognomical length of the head." From the fact that names used by Shirokogoroff are usually those of the B.A. Report (21), and that the physiognomical face length does not occur in the latter, I have identified his "list elaborated by the Commission in England" with the B.A. Report (21) and have used it in conjunction with the Monaco standard (20) in connection with Shirokogoroff's measurements.

Systematic definitions of measurements on the head are not given in *Anthropologica Suecica* (13) but notes are given here and there from which it is possible in many cases to reconstruct the definitions fairly satisfactorily.

II. Definitions of Measurements of the Head (Flesh).

(1) *Head Length.*

5. Buxton and Shirokogoroff follow the B.A. Report (21): "No. A 1 Maximum Length. From the most prominent point of the glabella to the most distant point on the back of the head, known as the occipital point." *Notes and Queries* (1874, 1892, 1899, and 1912) and the British Association Schedule (1895) all give the same definition which is in conformity with the corresponding measurement on the skull. Attention is drawn to the necessity of taking the measurements in the median vertical plane. It corresponds to the International Commission No. 1 "Longueur maxima de la tête ou diamètre antéro-postérieur maximum. Même technique que pour le crâne; ne pas presser" ((20), p. 569). The technique on the skull is described as follows: "C'est le plus grand diamètre dans le plan sagittal et médian du crâne."

"Points anatomiques: en avant: le point le plus saillant de la protubérance intersourcilière (glabelle de Broca); en arrière: le point le plus saillant du susoccipital donné par le maximum d'écartement des branches du compas" ((20), p. 563).

Sarasin presumably follows Martin's definition ((14), p. 157): "No. 1 Grösste Kopflänge (diamètre antéro-postérieur maximum ou glabellaire; maximum glabello-occipital length): Geradlinige Entfernung der Glabella von Opisthokranion, d. h. von dem am meisten hervorragenden Punkte des Hinterhauptes in der Median-sagittalebene."

Koganei also states definitely ((8), p. 254) that it is the greatest glabello-occipital distance, "die grösste Entfernung zwischen dem Stirnnasenwulst und Hinterhaupt."

Hrdlička defines it as the "maximum glabello-occipital diameter of the vault" ((5), p. 68). The procedure described by him is a little different from the B.A. Report

and Martin, but it does not appear likely to make any appreciable difference in the measurements.

Von Luschan follows Broca's instructions ((1), pp. 105—106): "C'est le plus grand écartement qu'on puisse donner au compas sur la ligne médiane du crâne. L'une des branches est appliquée sans pression au-dessus de la racine du nez, sur le point culminant de la glabella ou bosse nasale; on l'y fixe avec la main gauche pendant que la main droite promène l'autre extrémité du compas sur le derrière de la tête...."

Kubo states that his measurement is the one called "Langsdurchmesser des Schädels" by Schmidt ((25), p. 105): "Der vordere Messpunkt liegt in der Mittellinie der Stirn, dicht über dem Glabellawulst, wo dieser wenig oder gar nicht entwickelt ist, einen kleinen Querfingerbreit über dem Niveau der Augenbrauenbogen." This of course is quite different from the glabello-occipital length, and is really the distance from a point ranging from Glabella to Ophryon and the occipital point. It is, however, very curious that Kubo appears to think that the Glabella and the Ophryon are one and the same point. He says in one place ((10), p. 179), "ich habe...die Entfernung zwischen Ophryon (Glabella) der Stirn und dem äussersten Punkte des Hinterhauptes gemessen." Apart from the use of the Glabella within brackets, evidently as a synonym for Ophryon, he goes on to explain in the very next sentence: "Meine Kopflänge ist nicht die Projektions-, sondern die direkte Kopflänge von der *Glabella* (italics our own) bis zum hervorragendsten Punkte des Hinterhauptes, der durchaus nicht immer die Protuberanz ist" ((10), pp. 179—180). It scarcely needs pointing out how careful one must be in making comparisons.

6. One point requires notice. The B.A. Report explicitly states ((21), p. 8) that "the pressure of the points of the callipers on the head should be as much as can be comfortably borne by the person under examination*." Schmidt too recommends the application of fairly strong pressure: "Die beiden Stangenzirkelarme sind ziemlich stark an das Haupt anzupressen" ((25), p. 105).

On the other hand Broca (1) lays down that the measurement should be taken without pressure ("sans pression"), and von Luschan following Broca definitely states that his measurements were taken without pressure: "ich bei der Bestimmung von Länge und Breite des Kopfes gar nicht drücke" ((12), p. 334). Martin is also definitely of the same opinion: "Werden die Spitzen des Instrumentes unter so starkem Druck, als es das Individuum aushalten kann (Vorschrift der British Association), an die Kopfhaut angepresst, dann wird das Mass zu klein. Eine derartige Messung ist aber nicht nur schmerzhaft, sondern auch ungenau und daher zu verwerfen" ((14), p. 157). He adds in a footnote on the same page: "Ein Vergleich der Kopfmasse mit den Schädelmassen ist natürlich nur dann möglich, wenn nach absolut gleicher Technik gemessen und das Instrument nicht in die Kopfhaut eingepresst wird."

* *Notes and Queries* (4th edition, 1912) practically follows the B.A. Report and says "the pressure between the points of the callipers should be firm, but not uncomfortable" (p. 6). Earlier British authorities are silent on this point.

The Monaco Commission distinctly says: "ne pas presser" ((20), p. 57). Hrdlička translates it as "do not press" ((5), p. 21), but curiously enough adds the following note, "a moderate amount of pressure is of course necessary; the instruction is directed against hard pressure." I do not understand the force of "of course," nor what authority Hrdlička has for interpreting the International Instructions in the way he does. It is however clear that Hrdlička's measurements were taken with a moderate degree of pressure.

Shirokogoroff does not appear to be aware of the direct opposition between the two authorities cited by him: the B.A. Report (21) and the Monaco Agreement (20), and it is uncertain what procedure he followed. The fact that he relegates the B.A. Report to a footnote, while he refers to the International Commission in his text, may be interpreted as implying that he attached greater importance to the latter. If this interpretation be correct then his measurements would be "without pressure." This is supported by the fact that he gives the Korean Head Length and the Head Breadth as 183·9 mm. and 153·7 mm. respectively against 181·4 mm. and 150·9 mm. given by Kubo. This amounts to an excess of 2·5 mm. and 2·8 mm. respectively for measurements taken without pressure*.

7. The Maltese (Buxton), the Korean (Kubo), the Egyptian and the Old American (Hrdlička) and very likely the Aino (Koganei) measurements were taken with the application of a certain amount of pressure and are not strictly speaking comparable with the measurements on the Cretans (von Luschan), the New Caledonians (Sarasin) and the Mongolian people of the far east (Shirokogoroff) which were taken without pressure. Definite information is not available about the Swedish data, but assuming that no pressure was employed they would belong to the second group.

Thus we find that Maltese, Aino, Egyptians and Old Americans are comparable with one another, as also Cretans, New Caledonians and the Mongolian and possibly the Swedish samples, but members of one group are not comparable with those belonging to the other group. The Korean Head Length stands apart and is not comparable with any other.

(2) *Head Breadth.*

8. B.A. Report ((21), p. 8): "Maximum Breadth. Measured wherever it can be found above the plane of the ear-holes. The callipers should be held in a vertical transverse plane and moved about until the maximum diameter is ascertained, the observer being careful to keep the points of the callipers exactly opposite to one another." B.A. Schedule ((24), p. 3) states that the maximum breadth is to be found "usually about the top of the ears," but does not otherwise restrict the location. *Notes and Queries* ((17), 2nd edition, 1892) states that it is to be taken "wherever it may be except low down behind the ears."

Martin ((14), No. 3, p. 159): "Grösste Kopfbreite (diamètre transversal maximum). Geradlinige Entfernung der beiden Eurya voneinander, d. h. grösste Breite

* With a mean standard deviation of about 7·0 mm. a difference of 3 mm. in one of the Head Lengths (due to difference of technique) will make a difference in $(M - M')^2$ of nearly 9 times the variance for samples of 100, and will be definitely appreciable.

senkrecht zur Median-sagittal-Ebene, wo sie sich findet....Die Messpunkte müssen in einer Horizontal- und Frontal-Ebene liegen."

Broca ((1), p. 166) mentions "Les extrémités de ce diamètre sont en général situées à deux ou trois travers de doigt en arrière et au-dessus du bord supérieur de l'oreille; mais cela est loin d'être constant, et il faut toujours tâtonner un peu pour trouver le véritable maximum du diamètre transversal." Topinard ((30), p. 36) too mentions "above the ears," but does not otherwise restrict the location.

The International Commission No. 3: "Largeur maxima de la tête ou diamètre transverse maximum" ((20), p. 569). The technique is the same as on the crania: "C'est le plus grand diamètre horizontal et transversal qu'on puisse trouver avec le compas d'épaisseur sur la boîte cranienne. Point anatomique, déterminé seulement par le maximum, mais si ce dernier tombait sur les crêtes sous-temporales, il faudrait éviter leur saillie, en plaçant le compas au-dessus" ((20), p. 563).

Schmidt ((25), No. 31, "Breite des Schädels," p. 105) lays emphasis on the need for both arms of the instrument lying in the same horizontal plane, but does not otherwise discuss the question of the position where the measurement is to be taken.

Hrdlička ((5), p. 96) describes it as the "maximum breadth of the skull above the supramastoid and zygomatic crests."

As regards the location of the end-points there is substantial agreement, although all the definitions are not rigidly identical. In particular cases, especially for deformed individuals, differences may arise owing to the slight ambiguity in the description of the region where this measurement is to be taken.

9. As regards pressure, B.A. Report ((21), p. 8) makes the same remarks as in the case of Head Length: "the pressure on the points of the head should be as much as can be comfortably borne by the person under examination." Other authorities do not mention anything explicitly on this point; but it may be presumed that they would adopt respectively the same procedure as in the case of Head Length. On this assumption, Maltese, Korean, Egyptian, Old American, and very likely Aino data would form one group, and Cretan, New Caledonian, and Mongolian a second one, comparison being possible within either group. It is probable that the Swedish measurements also belong to the second group*.

(3) *Cephalic Index.*

10. Maltese, Aino, Egyptians, and Old Americans may be compared with one another, so also Cretans, New Caledonians and Mongolians and possibly the Swedish. The Korean index is not comparable with any other, even apart from considerations of "pressure"†.

* With a mean S.D. of 5·72 mm. approximately, a difference of 3 mm. in Head-Breadth (which may easily arise owing to the application of pressure) will make a difference of about 14 times the variance in $(M - M')^2$ in samples of 100.

† If the same observer uses the same amount of pressure in taking both the length and breadth measurements of the head, then the error in the cephalic index will be partly compensated, and will not generally be appreciable in samples of small or moderate size, but may become significant for large samples.

(4) *Height of the Head.*

11. Koganei defines this measurement ((8), p. 254) as "die senkrechte Höhe vom oberen Rande der äusseren Gehöröffnung bis zum Scheitel." Kubo gives an identical definition ((10), p. 223), and his measurements are therefore comparable with those of Koganei's. This is also* the definition accepted by the Monaco Commission, No. 3: "Hauteur de la tête (placée bien d'aplomb sur ses condyles).... Points anatomiques: en haut: vertex; en bas: bord supérieur du trou auditif, dont le point de repère (toujours à vérifier) est ordinairement le fond de l'échancrure comprise entre le tragus et l'hélix" ((20), p. 570).

Shirokogoroff adopts a different procedure. He explains that he measured the total stature as well as the height of the ear-hole from the ground. "It was thus possible to work out the height of the head by subtraction of the height of the ear-hole from the stature" ((27), p. 2). It is not clear which portion of the ear-hole (the upper border, or the centre, or the lower border) he took as his end-point. The usual definition of "height to ear-hole" extends to the *middle* of the ear-hole (e.g. *Notes and Queries*, 4th edition, 1912, p. 4). Assuming that Shirokogoroff also measured to the middle of the ear-hole, his measurements of the Height of the Head would not be comparable with those of Kubo and Koganei.

Hrdlička in his monograph on the Egyptians ((4), p. 48) mentioned that he took the measurement "by a spreading and sliding compass. The branches...are introduced well into the auditory meati and allowed to rest on the floor. The expansion of the instrument is noted, with the scale held over the bregma region; the distance from the bregma region to the lower edge of the scale is measured by the rod of the 'compas glissière,' and a simple arithmetical process gives the biauricular line-bregma height." He explains that this gives the distance between "the line connecting the floor of the auditory canals to the scalp over the head."

In his *Anthropometry* ((5), p. 21), in a footnote to his translation of the definition given by the Monaco Commission, Hrdlička says "the height from the middle of the line connecting the floor of the external auditory canals to bregma is now more in vogue," and on p. 70 states that this method "has been practised by the author since 1898." His measurements are therefore not comparable with those of either Koganei and Kubo, or Shirokogoroff.

Hrdlička mentions that his method "gives results somewhat higher than those obtained by Gray's radiometer" ((4), p. 48). In fact for the same individual, Hrdlička's method would give the greatest, Kubo and Koganei's the lowest readings, while Shirokogoroff's value would lie between the two.

To sum up, Kubo's and Koganei's measurements are comparable with each other but with no other. Nor are the other measurements comparable among themselves†.

* [I am not clear that this is so, the "vertex" is the highest point of the head above the Frankfurt plane, it is not necessarily identical with the "apex," the point in the median plane vertically above the biauricular line. From biauricular line to vertex will usually be greater than the vertical height of the head. K.P.]

† The difference between Kubo and Shirokogoroff for the Korean sample is 7·2 mm. With a mean S.D. of 6·13 mm. this will make a difference of more than 125 times the variance in $(M - M')^2$. Hrdlička mentions in one place ((5), p. 72) that his method "with due care...gives results which may vary within less than 3 mm." Assuming that a difference of even 3 mm. is made by adopting different procedures, a difference of more than 12 times the variance will be made in $(M - M')^2$ for samples of 100.

(5) *Horizontal Circumference of the Head.*

12. Koganei describes it ((8), p. 255) as the circumference measured over the Glabella and the furthest part on the back of the head ("über der Glabella und dem vorspringendsten Punkte des Hinterhauptes gemessen"). This corresponds to No. 45, Horizontalumfang des Kopfes, of Martin ((14), p. 173) which passes over the Glabella and the "vorspringendsten Punkte des Hinterkopfes (Opisthokranion)," and to the B.A. Report No. A 4 Maximum Circumference ((21), p. 8) which is described as the circumference "measured by passing the tape horizontally (*sic*) round the cranium at the level of the glabella in front and the occipital point behind."

Kubo adopts the same definition as Koganei, and says ((10), p. 212): "Ich habe den Umfang desselben über der Glabella und dem vorstehenden Punkte des Hinterhauptes so gemessen, dass das Bandmass genau in einer transversalen Ebene, nicht auf der einen Seite höher als auf der anderen zu liegen kam." But we have already seen that he believes the Glabella and the Ophryon to be identical points. This confusion makes his present definition a little uncertain. If he has actually measured it over the Ophryon then his circumference would correspond to Martin's ((14), p. 173) "No. 45 *a* Horizontalumfang rund um den Kopf, jedoch über das Ophryon (statt über die Glabella)."

13. The qualifying phrase "horizontal" appears to be a little misleading. Broca says ((1), p. 277): "Elle n'est pas horizontale, comme son nom pourrait le faire croire, mais toujours plus ou moins oblique, attendu qu'elle passe plus haut en avant qu'en arrière....On n'oubliera pas que cette courbe est un maximum."

(6) *Nasal Height.*

14. The Nasal Height (which is a constituent of the Nasal Index) is recognised to be one of the most important measurements in cephalometry, and yet the most diverse methods appear to have been used in measuring it. Martin ((14), pp. 166—167) gives us no less than five different definitions under the general name "nasal height" or "nasal length." The upper point of reference has been taken as (i) the Ophryon, (ii) the intersection (in the median-plane) of the tangent line to the two orbital edges, (iii) the nasion (or what is believed to be the point on the flesh corresponding to the naso-frontal suture on the skull), or (iv) the deepest part of the nasal bridge. There is greater agreement about the lower point of reference; it has usually been taken as the sub-nasal point (where the nasal septum joins the upper lip). But in at least one case (Shirokogoroff) this latter point seems to have been confused with the pro-nasal point or tip of the nose. The surprising thing in this connection is the lack of appreciation on the part of eminent anthropometrists of the need for noting a precise description of the definition actually adopted in practice.

B.A. Report ((21), p. 9) gives: "No. C 1 Nasal Height. From the nasion to the sub-nasal point."

Martin ((14), p. 166): "No. 21 Höhe der Nase (fälschlich Länge der Nase, Nasobasallänge, hauteur ou longueur du nez). Geradlinige Entfernung des Nasion vom Sub-nasale."

Broca ((1), p. 182): "No. 4 Longueur du nez. Elle se mesure en appliquant transversalement les deux branches de la glissière sur la racine du nez, et sur le point sous-nasal."

Topinard ((30), p. 357): "The height is taken with the sliding compass, vertically from the root to the base of the nose, as on the skull."

The Monaco Commission ((20), p. 570) gives No. 12 "Hauteur du nez. Points anatomiques: en haut: nasion; en bas: sous-cloison du nez, au niveau de son union avec la lèvre supérieure. Ne pas presser."

Hrdlička himself ((5), p. 74) has a practically identical definition: "Nose: Length.—The length (or 'height') of the nose from the nasal septum where this joins the upper lip, to the nasion."

Koganei ((8), p. 255) calls it "Nasenlänge" and defines it as "die Entfernung der Nasenwurzel vom Ansatze der Nasenschiedewand an der Oberlippe." Kubo calls it ((10), p. 317, No. 34) "Höhe (Länge) der Nase," gives an identical definition and adds "die Nasenlänge ist also nicht auf dem Rücken, sondern an der Basis der Nase, zwischen Nasenwurzel und Nasen-Oberlippen-Winkel, zu messen," which is practically a quotation from Schmidt ((25), p. 108, No. 49). This makes it clear that the sub-nasal point and not the tip of the nose is the lower point of reference.

15. It will be noticed that in the above definitions the upper point of reference is given as the "nasion," the "Nasenwurzel" or the "root of the nose," and in spite of the verbal agreement this is where trouble begins, because there exists a complete lack of agreement about the precise definition of these terms.

B.A. Report ((21), p. 6) defines the "Nasion" as "the bottom or deepest part of the depression between the forehead (Glabella) and the nose, or, in other words the most depressed part at the root of the nose*." Other British authorities are in agreement on this point. *Notes and Queries* ((19), 1912, p. 7, No. 7) gives "Nasal Height—from the nasion or the most depressed point at the root of the nose to the sub-nasal point or angle between the septum of the nose (i.e. the partition between the nostrils) and the upper lip." *Notes and Queries* ((18), 1899, p. 22) gives the following description: "...the upper point at the termination or root of the nose between the eyes....This last point is sometimes a little difficult to determine. There is a small transverse fold of the skin (sometimes two folds) at the root of the nose; it is on this fold, or when there are two folds, between the folds, that the upper point of the instrument should rest, generally about two millimetres above the level of the transverse axis of the eye." This description is a verbatim copy from the second edition (1892) of the same book. The Brit. Assoc. Schedule ((24), 1895) describes the nasal height as the distance "from the furrow at root of nose to the angle between the nose and the upper lip in the middle line."

The British view therefore identifies, and has always identified, the "Nasion" with the root of the nose, defining the latter term as the most depressed part of the nose where the skin has frequently a fold or two.

* It is curious however that the illustration on p. 387 (original report) shows the nasion on the flesh as coinciding with the naso-frontal suture on the skull. This is one example of the lack of preciseness in essential points found in existing standards.

16. Other authorities are however of quite different opinions. Martin is quite explicit on this point ((14), p. 129): "Die Nasenwurzel entspricht nicht der am tiefsten eingesattelten Stelle des Nasenrückens, die meist im oberen Teil der Ossa nasalia gelegen ist, sondern der Sutura naso-frontalis, deren Verlauf nach einiger Uebung trotz des vorhandenen Nahtgewebes und des meist dünnen M. procerus (M. depressor glabellae n. H. Virchow) auch am Lebenden festgestellt werden kann. Man findet den Punkt am besten, wenn man seine rechte Hand ruhig auf den Kopf des zu messenden Individuum legt und mit dem lateralen Rand der Daumenbeere unter leichtem Druck die Haut auf der Nasenwurzel auf und ab schiebt. Man beachte, dass das Nasion in der Regel im Niveau der medialen Enden der härenen Augenbrauen, meist an deren Unterrand, nicht in der Höhe der Lidspalte gelegen ist." He concludes by observing: "Von manchen Autoren wird fälschlich die am tiefsten eingesattelte Stelle der Nase als 'Nasenwurzel' bezeichnet."

The illustration in his book ((14), fig. 38, p. 128) clearly shows that according to Martin the nasion is situated at a considerable distance above the most depressed part of the nasal bridge. In fact Martin had stated at a different place ((15), pp. 393—394): "Allerdings liegt die tiefste Einsattelung der Nase gewöhnlich nicht an der Nasenwurzel, sondern beträchtlich unterhalb derselben; ich habe z. B. bei Senoi von Ulu Gopei eine Entfernung von 7 bis 9 mm. zwischen diesen beiden Punkten feststellen können."

The general tendency among continental authorities seems to be to make the upper point of reference on the flesh correspond to the nasion on the skull, which is defined as the naso-frontal suture. For example, Broca says ((1), p. 139): "La dépression transversale qui la sépare du nez s'appelle la *racine du nez*, ou *point nasal* ou *nasion*; elle correspond sur le squelette à la suture qui unit l'os frontal aux os nasaux." Topinard also had definitely used the words ((30), p. 357) "as on the skull," the implication clearly being some kind of correspondence between the points of reference on the flesh and on the skull.

Hrdlička ((5), p. 72) says: "The nasion should correspond as closely as possible to the anatomical nasion, i.e. the mid point of the naso-frontal suture."

Von Luschan ((11), p. 41) states: "Man fühlt stets eine kleine Vertiefung die genau der Naht zwischen Nasenbein und Stirnbein entspricht." He also notes: "Laien fehlen regelmässig dadurch, dass sie die Nasenwurzel wesentlich tiefer suchen und etwa die Mitte der Linie zwischen den inneren Augenwinkeln zum Ausgangspunkt ihrer Messung machen wollen."

17. We thus find two sharply contrasted views about the location of the nasion, and hence about the upper point of reference in taking measurements of the nasal height. There is general agreement about the fact that the nasion on the skull is usually situated considerably higher up than the most depressed part at the root of nose on the the flesh. We have already seen that Martin found the difference as high as from 7 to 9 mm. in certain individuals. The anatomical work of R. Havelock Charles ((2), 1894) on 54 male and 8 female cadavers shows that the nasal height on the skull is almost certainly longer than the nasal height on the living. But

unfortunately Havelock Charles does not provide us with any statement of how he measured the nasal height on the cadaver. He talks of the visible "root" of the nose, but is the "root" of the nose the most receding point of the nasal bridge, when the head is adjusted to the Frankfurt horizontal, let us say? He does not write as if he had recognised that the height of the nose on the living had been measured in a variety of ways. When we come to Havelock Charles's *lower* point of measurement we do not find that he has stated in the case of either skull or cadaver what he has taken for it. All we are told is that "Having carefully measured with sliding compasses, the nasal diameters of 62 'subjects,' I removed the integuments, etc., and having cleared the naso-frontal suture and anterior nasal aperture, I again took the diameter*." He does not tell us whether, in measurement on the subject, he took the *sub-nasale*, or the lowest point of the fleshy aperture, or whether if the former he applied pressure or not. Nor again are we told whether in measuring the nasal height on the skull he took as his lower point, the lowest point of the pyriform aperture, the base of the nasal spine, or the spine itself†. However, Charles found the nose in the flesh to be less than the nose on the skull in height by -2 to $+16$ mm. It does not follow that this difference is due to the "root of the nose" not being the nasion. A portion of it depends on the depth of the *sub-nasale* being in the flesh below the nasal spine. Thus it seems probable that the difference between the two lengths is only a minimum difference of the distance from the nasion to the "root of the nose," whatever the latter exactly connotes. We have for the 54 Panjabi males, Mean Difference = 4·33 mm. $\pm$ ·32, and for the eight (!) Panjabi females, 3·50 mm. $\pm$ ·26. Thus it seems probable that the distance from nasion to root of nose is at least 4·5 mm. for males and 3·5 mm. for females of this race, and it may vary considerably with other races. As Havelock Charles emphasises nasal indices thus measured on the living and on the skull are not comparable‡.

18. It is a pity that Charles did not make any attempt to find out how accurately a point on the flesh could be located to correspond with the naso-frontal suture. To a layman it certainly appears doubtful whether this point can actually be determined with any degree of reliability. Hrdlička ((5), p. 72) says in this connection: "In a certain portion of subjects this point may be felt by the observer's finger nail or the point of a pencil§." But Hrdlička immediately remarks: "but in a majority we must rely on knowledge of its location derived from extensive observation on skulls and dissecting room material. It is always situated above a horizontal line connecting the two inner canthi." Thus in a *majority of cases* (according to Hrdlička's own admission) the location of the point must be made by what is nothing else but guess-work, and in case of observers without any experience of the dissecting room, by perfectly random guess-work without any basis of previous knowledge. From the

* *loc. cit.* p. 2. Havelock Charles without definition uses the symbol μ, customary for microns, for millimetres.

† He may have taken it again to the sub-nasal point, but this is not usual in measuring the nasal height of the skull.

‡ A difference of 4·0 mm. in the mean will make a difference of more than 56 times the variance in $(M - M')^2$ for samples of 100 (with a mean S.D. of about 3·7 mm.).

§ This is also the course recommended by Martin.

point of view of metrology an external or surface landmark, such as the most depressed part of the root of the nose, would appear to be far more satisfactory.

19. Buxton (Maltese) followed the B.A. Report, and must therefore have adopted "the most depressed part at the root of the nose" as his upper point of reference*.

Sarasin (New Caledonians) also has taken the same definitions. In his own work on *Versuch einer Anthropologie der Insel Celebes* (Wiesbaden, 1906), *Zweiter Teil*, p. 29, he says, referring to this question of the location of the nasion: "Ich befinde mich hier in einem Widerspruch mit Martin, welcher am Lebenden als Ausgangspunkt die Stirn-Nasenbein-Sutur auszutasten sucht; diese liegt aber gewöhnlich beträchtlich oberhalb der tiefsten Einsattelungsstelle der Nase. Ich halte das nicht für richtig, denn das physiognomische Nasenbild des lebenden Menschen wird, wie auch Martin ((15), p. 394) zugibt, die Einsattelungsstelle bedingt und nicht durch die Sutur am Schädel, und dieses Bild der lebenden Nase ist es, was wir durch einen Index ausdrücken wollen. Auch hat es gar keinen Sinn, ein aus der Schädelanatomie gewonnenes Maass mit einem reinen Fleischteilmaass, wie es die Breite der Nasenflügel ist, miteinander in einem Index zu vergleichen." In his work on the New Caledonians ((22), p. 95) he says he has: "als obere Messpunkt für die Nasenhöhe die tiefste Einsattelungsstelle der Nase gewählt, um einen besseren Ausdruck für das Nasenbild des Lebenden zu gewissen."

It is however not clear what procedure Kubo (Koreans) has followed. Kubo constantly refers to Schmidt's book (25) but unfortunately Schmidt is not very explicit on this point. Schmidt ((25), p. 107, No. 43) describes the "Nasenwurzel" as "die tiefste Stelle der Einsattelung zwischen Stirn und Nase," which apparently identifies the root of the nose with the most depressed part of the nose, but continues in the very next sentence to say: "Man fühlt hier bei feiner Haut die Knochensutur durch, welche die Nasenbeine vom Stirnbein trennt." Which renders things quite inconclusive. Kubo also referred with approval to the following note by Baelz ((10), p. 253) about the difficulty of locating the root of the nose in east-Asiatic peoples: "Die Nasenwurzel hat beim Japaner meist eine andere relative Lage, als beim Europäer wir verstehen die tiefste Stelle des Nasensattels. Beim Europäer ist diese Stelle nur wenig unterhalb der Verbindungsstelle beider Augenbrauen gelegen, beim Japaner dagegen ist der Unterschied sehr bedeutend, beim Europäer bildet der Nasensattel eine scharf markierte Stelle, eine Art Winkel, beim Japaner dagegen einen flachen Bogen†." This passage would suggest that Kubo was really seeking for the most depressed part at the root of the nose, and was therefore pointing out the difficulties encountered in locating this point for east-Asiatic peoples. On this interpretation his measurements would be comparable with those of Buxton and Sarasin but the legitimacy of such a comparison cannot be established with certainty.

* Buxton appears to be unaware of or has neglected the divergence between the two authorities cited by him on different occasions, namely in (3) he cites Martin (14), but in the letter to Dr Morant already quoted on p. 3 above he cites the B.A. Report (21).

† For a careful study of the form of the nose see E. von Eickstedt (32).

F. von Luschan (Cretans) and Hrdlička (Egyptians, Old Americans) on the other hand definitely adopted a different definition of the nasion on the living and attempted to locate a point on the flesh which corresponded as closely as possible to the naso-frontal suture on the skull.

It is possible that Koganei (Aino) also did the same thing, for although he does not mention anything explicitly in his paper on the Aino, in a later monograph on the Northern Chinese Soldiers ((9), p. 137) he distinctly states: "Als oberer Messpunkt wurde nicht die tiefste Stelle der Einsattelung zwischen Stirn und Nase, welche wenigstens bei ostasiatischen Völkern gewöhnlich gar nicht der Stirn-Nasennaht entspricht, sondern einige mm. oberhalb derselben genommen, wo eben die Stirn-Nasennaht gelegen ist welche aber nur schwer durchzufühlen ist."

For the Swedish data Lundborg and Linders mention Martin (14) in one place, and it is probable that Martin's definition of the nasion was followed in this case. This hypothesis is supported by the following remarks ((13), p. 11): "...The examiners often cannot locate the nasion (sutura naso-frontalis) with certainty." In footnote 8, on p. 159, commenting on the Morphological Face Height we have: "Hilden measured from the deepest part of the nasal root to the gnathion." Comparing Hilden's mean Morphological Face Height 123·1 (71 individuals) with Lundborg's 126·6 mm. (for 47,387 men) I find a difference of 3·5 mm. in favour of the latter, which supports the conjecture that the latter were trying to identify the nasion on the flesh with the naso-frontal suture on the skull*. There is another footnote, No. 10 on p. 159, "Bryn located the nasion as a point 2 mm. above the deepest part of the nose†." These footnotes suggest that Lundborg and Linders' point of reference was different from those of Hilden and Bryn.

20. We must now consider Shirokogoroff's measurements. He at first uses the term "Height of the Nose" ((27), p. 1), but subsequently adopts "Length of the nose" and continues to use the latter name in most places. He is apparently not aware of the fact that these two names refer to two different entities. The "Nasal Length" is defined by the B.A. Report ((21), No. C. 3, p. 10) and Martin ((14), No. 23, p. 167) as the distance from the nasion to the tip of the nose, and is quite different from the "nasal height" which is measured to the sub-nasal point.

A comparison of Shirokogoroff's means with those of other authors shows that it is improbable that he actually measured the nasal height. For a series of 141 Koreans, Shirokogoroff gives a mean "nasal height" of 40·8 ± ·18 mm., while Kubo's value is 49·0 ± ·09 mm. for 477 individuals. This gives a difference of 8·2 ± ·31, or a difference of about 26·5 times its own probable error.

Again for Northern Chinese we have Koganei's value ((9), p. 144) of 53·0 mm. for 968 individuals against Shirokogoroff's of 41·8 for 391 individuals, giving a difference of 11·2 ± 0·15 mm. or a difference of 80 times the probable error. Such

* I should note however that Hilden's measurements referred to the inhabitants of the island of Rüno, which is *believed* to be populated by Swedes, while Lundborg and Linders' measurements were all taken on persons of authentic Swedish extraction. So that we cannot be absolutely certain that the difference of 3·5 mm. was due to a difference in technique and not to a difference of race.

† This footnote is interesting as giving still another definition of the nasion on the living.

huge differences are, of course, extremely unlikely to occur in different samples of the same population, and they strongly suggest some fundamental differences in the technique. In fact for the two Korean series, for measurements which are known to be comparable, the next biggest difference is 0·81 mm. only for the Bigonial Diameter which is just over 5·2 times the standard deviation; a big difference no doubt, but still of quite another order from the difference in nasal height.

It is unlikely that differences as large as 8·2 and 11·2 mm. are due solely to a difference in the location of the upper point of reference, though that must be admitted as a possible explanation. The mean Panjabi difference found by Havelock Charles is 4·2 mm., but the form of the nasal bridge varies widely from race to race and the corresponding Chinese value may be much greater.

The absolute magnitudes of Shirokogoroff's "nasal height" are suspiciously low. For example for Koreans it is 40·8 mm. For certain other Chinese samples it is still lower, e.g. Kwantung (total) 40·0 mm., Kwantung (non-selected) 39·3 mm. The lowest value of the nasal height which I could find in standard literature was 41·7 mm. for Kachin in Martin ((14), p. 451).

21. The natural explanation suggested by Shirokogoroff's frequent use of the term "length of the nose" would be that he had actually taken his measurements to the tip of the nose (instead of to the sub-nasal point) as his lower point of reference. This explanation is rendered all the more plausible by the peculiar history of the two names.

In both the 2nd and 3rd editions of *Notes and Queries* published in 1892 and 1899 respectively, as also in the B.A. Schedule of 1895, the names "Length of the Nose" and "Nasal Length" (*and not "Nasal Height"*) are used to denote the distance from the nasion to the sub-nasal point. Among British authorities, the name "nasal height" was used in its modern sense for the first time in the British Association Report of 1908. At the same time the name "nasal length" was also defined for the first time to denote the distance to the tip of the nose. Thus among British authorities "nasal length" would have one meaning up to 1908, and an altogether different meaning since that year. The same anomalous position had existed also in continental literature. In fact in earlier years the general tendency everywhere was to call the distance between the nasion and the sub-nasal point (and not the tip of the nose) the "nasal length." For example Broca ((1), p. 182) in 1879 calls it "Longueur du nez," and Schmidt ((25), p. 108) in 1888 calls it "Länge der Nase." On the continent, the International Commission of Monaco of 1906 seems to have been the first authoritative body to introduce the modern name "nasal height" for this particular measurement.

Koganei writing in 1893 naturally uses "Nasenlänge," while Kubo in 1913 calls it "Höhe der Nase," but adds the word "Länge," within brackets after "Höhe," evidently to link it up with the older name. Von Luschan in 1913, Sarasin in 1916, Buxton in 1922, and Lundborg and Linders in 1926 all use the modern name "nasal height." Curiously enough Hrdlička continued to use the older name "length" even in 1920, but he added the word "height" within brackets ((5), p. 74).

22. Summing up we find that the data considered here fall into three distinct groups:

(i) Maltese, New Caledonians, and possibly Koreans, measured according to the British definition of the most depressed part of the nose as the upper point of reference.

(ii) Cretans, Egyptians and Old Americans, and possibly the Aino and the Swedish data, measured according to a definition which makes the upper point on the flesh correspond as closely as possible to the naso-frontal suture on the skull.

(iii) The Mongolian data measured very likely to the tip of the nose instead of to the sub-nasal point.

Members of each group are probably comparable with one another, but not with members of a different group.

(7) *Nasal Breadth.*

23. B.A. Report ((21), p. 10): No. C 2 "Nasal breadth. The greatest diameter, measured without pressure, between the wings of the nose." This may be identified with Martin's ((14), p. 162) No. 13 "Breite der Nase (Untere Nasenbreite, Nasenflügelbreite): Geradlinige Entfernung der beiden Alaria, d. h. der Punkte der grössten seitlichen Ausladung der beiden Nasenflügel voneinander." Martin also mentions that the measurements must be taken without pressure ("ohne den geringsten Druck auf die Nasenflügel"). Topinard had given the definition "the breadth from the widest portions of the alae" ((30), p. 357), and the Monaco Commission of 1906: "No. 13 Largeur du nez. Points anatomiques: face externe des ailes du nez" ((20), p. 571), and Hrdlička ((5), p. 74) agree with the above definition.

Measurements taken by Buxton (Maltese), Hrdlička (Egyptians, Old Americans). Shirokogoroff (Mongolians), Sarasin (New Caledonians), and von Luschan (Cretans) are therefore probably comparable with one another.

Koganei (Aino) and Kubo (Koreans) on the other hand call it "Nasenbreite" ((8), p. 255, No. 15) and "Breite der Nase" ((10), p. 323, No. 35) respectively, and both define it as "der Abstand der Ansätze der Nasenflügel voneinander." The use of the word "Ansatz" (onset, beginning) shows that this measurement is the same as Schmidt's "Breite der Nase" ((25), p. 108, No. 50): "an der Ansatzstelle der Nasenflügel zu messen," which may also be identified with Martin's ((14), p. 163) No. 13*a*: "Grösste Breite am Hinterrand der Nasenflügel, da, wo sie an der Wangenhaut festgewachsen sind." Koganei and Kubo's measurements while comparable with each other are therefore not comparable with the first group*.

(8) *Nasal Index.*

24. Comparing the classification under (6) Nasal Height and (7) Nasal Breadth we get the following distinct groups for the Nasal Index:

(i) Maltese, New Caledonians.

(ii) Koreans.

* A difference of only 5 mm. will make a difference in $(M - M')$ of 12 times the S.D. in samples of 100 (with mean S.D. = 2·9 mm.).

(iii) Cretans, Egyptians, Old Americans.

(iv) Aino.

(v) Mongolians.

Thus for such an important characteristic as the "Nasal Index" valid comparison is not possible for the greater part of the data*.

It has been shown above (Sections 6—8) that the nasal measurements of the living have been determined in a variety of different ways by different schools of anthropologists. The divergences dependent on that fact are evidently large compared with the inter-racial variations of the measurements, and there is no satisfactory method of adjusting the data so that they may be compared directly. The value of these statistics is greatly lessened owing to the deplorable lack of agreement between leading anthropologists of different countries. The nasal index of both the skull and the living head has been recognised as a character which should be of great importance in distinguishing different races of man, and various attempts have been made to assemble the comparative material available. The earliest list of any permanent value appears to be that furnished by Topinard in 1885 ((29), p. 303). No references are given, but all the racial means may have been determined in accordance with the French technique originated by Broca. Two years later Collignon published a more extended list, again without references†. It included means provided by Rudolf Virchow. The best known tables of living nasal indices of more recent date are those of Martin ((14), pp. 447—449), Thomson and Dudley-Buxton‡ and Deniker§. All agree in giving no references whatever. Of the three Deniker¶ the only one who comments on the fact that different methods of technique were used in determining the measurements. Martin's list includes data provided by English (Duckworth, Beddoe, Thurston, Risley‖, Haddon and the Census of India‖), French (Collignon, Deniker, Legendre, Mondière and Chantre), and German (Schmidt, von Luschan, Fischer, K. Ranke and Martin) anthropologists and many others. Of the series compared in detail above Koganei's Aino, Hrdlička's Egyptian and von Luschan's Cretan means are quoted, and it was shown there that no valid comparison can be made between the Aino measurements on the one hand and the Egyptian and Cretan on the other. It would be easy to find other groups which cannot be legitimately compared. Thomson and Dudley-Buxton cite neither

* Differences due to technique will be appreciable even in small samples. For example, with a mean S.D. of 7·97, a difference of 5 units in means will made a difference in $(M - M')$ of 4·4 times the S.D. of the difference in samples of 100.

† R. Collignon: La Nomenclature quinaire de l'Indice nasale du vivant. *Revue d'Anthropologie*, 2ème année, 3ème série, T. 2, 1887, pp. 8—19.

‡ Arthur Thomson and L. H. Dudley-Buxton: Man's Nasal Index in Relation to Certain Climatic Conditions. *Journal of the Royal Anthropological Institute*, Vol. LIII, 1923, pp. 92—122. The living nasal indices are given in Appendix I (pp. 116—119).

§ J. Deniker: *Les Races et les Peuples de la Terre*, 2nd edition, Paris, 1926. The living nasal indices are given in Appendix III (pp. 718—721).

‖ The Census of India data were obtained under Risley's directions and it is probable that the French technique (as defined by Topinard) was used throughout.

references nor authorities for the material which they quote, but they certainly use the means given in the Census of India* and by Deniker, Delisle and Collignon. Possibly all the nasal indices given were found in accordance with the usual French technique, but the omission to supply any information relating to this vital matter is a regrettable one. Deniker (*op. cit.* pp. 98—99) comments on the fact that German and French anthropologists have determined nasal measurements in different ways and he says that all the means given in his list "ont été prises d'après la méthode Broca-Collignon." On turning to his table, however, we find several values given by E. Schmidt, Fischer and Sarasin. Of the series compared in detail above, Sarasin's New Caledonian, Hrdlička's Egyptian and von Luschan's Cretan means are given. It has been shown that the comparison of the first with the last two is quite invalid. We are obliged to conclude that no single one of these lists can be considered to have any statistical value until it has been carefully revised or confirmed. It is extraordinary that the anthropologists who prepared them should have been so oblivious to the demands of empirical science.

(9) *Nasal Depth.*

25. B.A. Report ((21), p. 10): "No. C 2 Nasal depth. From the sub-nasal point to the most projecting point of the tip of the nose." Martin ((14), p. 167) gives practically an identical definition—No. 22 "Länge des Nasenbodens (Tiefe der Nase, falschlich Höhe der Nase, Nasenelevation; saillie de la base du nez; nasal depth): Projektivische Entfernung des Subnasale vom Pronasale." The Monaco Commission, No. 14 "Saillie de la base du nez," also gives the same definition ((20), p. 571): "Points anatomiques en avant: le point le plus saillant du lobule nasal; en arrière: le point où le plan médian est coupé par la ligne transversale joignant le point le plus reculé de chacun des plis naso-labiaux. Prendre la distance en projection de ses deux points avec un instrument approprié."

Both Koganei ((8), p. 255, No. 13) and Kubo ((10), p. 331, No. 36) define it as "die Prominenz der Nase vom Gesicht, gemessen vom Ansatze der Nasenschiedewand an der Oberlippe bis zur Spitze," and their measurements are comparable.

26. We again notice a terminological ambiguity. Koganei calls this measurement "Nasenhöhe," while Kubo calls it "Tiefe der Nase," but adds the word "Höhe" within brackets.

(10) *Morphological (Total) Face Height.*

27. B.A. Report ((21), p. 9): "No. B 2 Total Face Height. From the nasion to the lower edge of the point of the chin. A contact measurement†." Buxton calls it the "total facial height‡." The Monaco Commission, No. 9 "Diamètre naso-

* The Census of India data were obtained under Risley's directions and it is probable that the French technique (as defined by Topinard) was used throughout.

† A contact measurement is one to be taken without pressure.

‡ I may note in passing that this same measurement is called "Length of Face" in *Notes and Queries*, 1874 ((16), p. 4, No. 41), 1892 ((17), p. 24) and 1899 ((18), p. 24). But the name is changed to "total facial height" in the 1912 edition ((19), p. 7).

mentonnier*. Même technique que sur le squelette, en pressant un peu comme pour le précédent. Chercher le nasion en remontant avec l'ongle le dos du nez jusqu'au léger ressaut que fait le bord inférieur du frontal" ((20), p. 570). The anatomical points for the craniological measurements are defined, "en haut: nasion; en bas: bord inférieur de la mandibule, dans le plan médian" ((20), p. 564, No. 11).

Hrdlička calls it the "chin-nasion height" in his work on the Egyptians ((4), p. 61), and describes it as "the distance from the lowest point of the chin in the median line to a point corresponding to the middle of the fronto-nasal articulation." In his later work on Anthropometry ((5), p. 72) he calls it the "Anatomical Face Length" and defines it as "the distance from the menton (the lowest point in the middle of the bony chin) to the nasion."

It may be identified with Martin's ((14), p. 165) No. 18 "Morphologische Gesichtshöhe (Nasomentale Gesichtshöhe; Kieferhöhe; hauteur naso-mentonnière; total face length): Geradlinige Entfernung des Nasion vom Gnathion" and with Schmidt's ((25), p. 107) No. 43 "der Abstand des Kinnes von der Nasenwurzel."

Koganei calls it "Gesichtshöhe B" after Virchow, and describes it as the chin-nasion distance: "die Entfernung der Nasenwurzel (Stirn-Nasennaht) vom unteren Kinnrande" ((8), p. 254). Kubo uses the name "Morphologische Gesichtshöhe" ((10), No. 21) but gives the same definition as Koganei. Von Luschan calls it the "Nasenwurzel-Kinn" distance without giving further details. Sarasin uses the name "Nasomentale Höhe," and as he usually follows Martin, his measurement may be taken to be the same as No. 18 of Martin. Shirokogoroff uses the name "Anatomical Face Length"; I have therefore identified his measurement with this present one which I am calling morphological (or total) face height.

28. It will be noticed that the lower point of reference is spoken of indifferently as the "lower edge of the chin," "the middle of the bony chin," "the gnathion," etc., and while there is general agreement about the region concerned, I have no information to judge whether they all refer in actual practice to the same identical point. As usual the authorities either give no directions at all, or else inadequate directions, regarding the point whether pressure is to be used or not in locating the gnathion and, if so, what degree of pressure. But assuming that there is no ambiguity about the lower point of reference it is clear that the same confusion exists about the upper point as in the case of the nasal height. I believe we may safely assume that each observer will stick to his own particular definition of the "nasion" in taking both measurements (i.e. "the nasal height" and "the morphological (total) face height"). On this assumption and ignoring the important question of pressure we obtain two distinct groups:

(i) Maltese, New Caledonian, Mongolian†, and possibly Korean.

(ii) Cretan, Egyptian, Old American, and possibly Aino and the Swedish data.

* This is of course quite a different measurement from No. 8 "Hauteur totale du visage" which corresponds to the Physiognomic Face Length.

† Shirokogoroff (Mongolian) may now be classed with Buxton and Sarasin.

It will perhaps be moderately safe to compare measurements within the same group, but a comparison between series in different groups would be quite invalid*.

(11) *Bizygomatic Breadth.*

29. B.A. Report ((21), p. 9) calls it No. B 3 "Maximum interzygomatic breadth" and defines it as the "maximum diameter between corresponding points on the opposite zygomatic arches," and notes that "the pressure used is to be as much as can be comfortably borne by the person under examination." Buxton calls it "Bizygomatic Breadth" and Shirokogoroff uses the name "Interzygomatic Breadth."

The Monaco Commission, No. 6 "Diamètre Bizygomatique. Même technique que pour le crâne. Chercher avec soin le maximum qui est souvent plus en arrière qu'on ne le suppose" ((20), p. 570). The craniological definition specifies the anatomical points as "face externe des apophyses zygomatiques" ((20), p. 564, No. 8).

Hrdlička calls it the "maximum bizygomatic diameter" and defines it as the distance between "the most widely separated points on the external surface of the zygomatic arches," which is virtually the same as the definition of the International Commission's No. 6.

This measurement corresponds to Koganei's "Gesichtsbreite *a*" which he defines as "der grösste Abstand der Jochbogen voneinander" ((8), p. 254). Kubo gives an identical definition but uses the name "Jochbogenbreite," which is also the name used by Martin ((14), p. 160), No. 6 "Jochbogenbreite (oft fälschlich Jochbreite genannt, Gesichtsbreite A nach Virchow; largeur totale de la face ou distance bi-zygomatique; maximum interzygomatic breadth): Geradlinige Entfernung der beiden Zygia, d. h. der am meisten seitlich vorstehenden Punkte der Jochbogen voneinander."

Von Luschan and Sarasin both have measurements under the name "Jochbreite." From the above-mentioned remark of Martin that "Jochbogenbreite" is often wrongly called "Jochbreite," and from the fact that both von Luschan and Sarasin use this measurement to calculate the Facial Index, we may conclude that their "Jochbreite" is the same as our "Bizygomatic Breadth."

30. A difficulty remains about the use of pressure in taking measurements. The B.A. Report alone gives instructions on this point, all other authorities remaining silent. In the absence of any information as to pressure we may, perhaps, assume that all the measurements are comparable, but it must not be forgotten that there is a possibility of a statistically significant error being introduced when we make such an assumption.

(12) *Morphological Facial Index.*

31. The Morphological Facial Index is defined as the ratio of the Morphological Face Height to the Bizygomatic Breadth multiplied by 100. The same comparisons

* With a mean S.D. of 6·4 mm. and a difference of 4 mm. (Havelock Charles's value for the difference between the two definitions of the nasion), we get a difference of 22 times the variance in $(M - M')^2$ in samples of 100.

will therefore be possible as in the case of the Morphological Face Height. That is, we have two distinct groups, and this only if we neglect any pressure difference:

(i) Maltese, New Caledonian, Mongolian, and possibly Korean.

(ii) Cretan, Egyptian, Old American, and possibly Aino and the Swedish data.

(13) *Upper Face Length.*

32. B.A. Report ((21), p. 9): No. B 1 "Upper Face Length from the nasion to the edge of the gum between the two upper central incisor teeth. A contact measurement," which may correspond to Martin's ((14), p. 165) No. 20 "Morphologische Obergesichtshöhe (diamètre nasio-alvéolaire, upper face length): Geradlinige Entfernung des Nasion vom Prosthion," and to the International Commission's No. 11 "Diamètre nasio-alvéolaire." Same technique as on crania for which the anatomical points are defined: "en haut: nasion; en bas: le point le plus inférieur du bord alvéolaire, entre les deux incisives médianes et supérieures" ((20), p. 565, No. 12). The "Upper Face Length"* of Buxton (Maltese) and Shirokogoroff (Mongolian) are therefore comparable†.

33. Koganei ((8), p. 254) has one measurement which he calls the "Mittelgesichtshöhe" after Virchow, and defines as "die Entfernung der Nasenwurzel von der Mundspalte (bei geschlossenen Munde)." Kubo ((10), p. 259) gives an identical definition, and his measurements are therefore comparable with Koganei's. This measurement corresponds to Martin's ((14), p. 165) No. 20 "Physiognomische Obergesichtshöhe (Mittelgesichtshöhe nach Virchow, diamètre nasio-buccal): Geradlinige Entfernung des Nasion vom Stomion," and to the International Commission's No. 10 "Diamètre naso-buccal. Points anatomiques dans le plan médian: en haut: nasion; en bas: interligne des lèvres" ((20), p. 570). This measurement is therefore quite different from the "Upper face length" of the B.A. Report. The measurements of Koganei (Aino) and Kubo (Korean) while comparable with each other are not therefore comparable with those of Buxton (Maltese) or Shirokogoroff (Mongolian).

(14) *Minimum Frontal Diameter.*

34. B.A. Report ((21), p. 2): No. A 3 "Minimum Frontal Diameter. From one frontal crest to the other across the narrowest part of the forehead." Buxton, Shirokogoroff and Hrdlička use the same name, and the latter defines it ((5), p. 73) as "the shortest horizontal diameter between the two temporal crests," which is also virtually the same definition as that given for the International Commission's No. 4 "Largeur frontale minima" ((20), p. 570), the technique being the same as

* The use of the word "length" in connection with this measurement is a little inconsistent, for the word "height" is used for an exactly analogous measurement, namely the "morphological (total) face height."

† We have here a good illustration of the confused terminology at present in use. We speak of Morphological Face *Height* and Upper Face *Length*! It would be well to keep the term Height for projected lengths taken in the vertical, i.e. perpendicular to the standard horizontal plane.

on the skull: "C'est le diamètre horizontal le plus court entre les deux crêtes temporales du frontal" ((20), p. 564, No. 5).

It corresponds to Martin's ((14), p. 159) No. 4, "Kleinste Stirnbreite: Geradlinige Entfernung der beiden Frontotemporalia voneinander." Von Luschan uses the same name "Kleinste Stirnbreite," as also Koganei ((8), p. 254, No. 4) and Kubo ((10), p. 240, No. 19), both of whom define it as "der kleinste Abstand der Schläfenlinien am Stirnbein."

I should note here that Martin explicitly states that the instrument should be placed in such a way that no pressure is exerted ("ohne zu drücken"), while all other authorities are silent on this point. I do not know what difference will be made by the application of different degrees of pressure, but if we could neglect such differences then all the measurements would be comparable.

(15) *Bigonial Diameter.*

35. B.A. Report ((21), p. 9): No. B 8 "Gonial Breadth. The diameter between the extreme outer points of the angles of the lower jaw. The measurement is to be taken with the maximum comfortable pressure." Martin's definition ((14), p. 161) is: "No. 8 Unterkieferwinkelbreite (Untergesichtsbreite, untere oder mandibuläre Gesichtsbreite; largeur mandibulaire, bigoniaque ou bigonial; bigonial breadth): Geradlinige Entfernung der beiden Gonia voneinander. Die Tasterspitzen sind nicht hinten an die Unterkieferwinkel, sondern vielmehr etwas seitlich unmittelbar oberhalb des Randes aufzusetzen, damit die äussere seitliche Ausladung der Unterkieferwinkel, die sehr stark sein kann, mitgemessen wird." Nothing is said of the degree of pressure to be used in taking the measurement but, otherwise, it appears to be comparable with the B.A. "gonial breadth" and with the "diamètre bigonique" of the International Commission ((20), p. 570, No. 7).

Buxton and Shirokogoroff call it "Bigonial Breadth," while Hrdlička calls it "Bigonial Diameter" and defines it ((5), p. 73) as the distance between "the gonions or points of the angles of the lower jaw."

Koganei ((8), p. 254, No. 10) calls it "Gesichtsbreite C," and defines it as "der Abstand der Kieferwinkel voneinander." Kubo ((10), p. 279, No. 27) uses the name "Unterkieferwinkelbreite" and describes it as Virchow's "Gesichtsbreite C." Von Luschan calls it "Kieferwinkelbreite."

It is by no means clear that all these measurements were taken between the outer points of the angles as Martin directs and, indeed, all the definitions of the gonia of the living face that have been given are lacking in precision and they might be interpreted in different ways by different observers. Another source of uncertainty is introduced by the absence of instructions regarding the question of pressure and for this measurement that is a vital point. No pair of these bigonial diameters can be compared without making assumptions which may be unjustified.

(16) *Internal Ocular Breadth.*

36. B.A. Report ((21), p. 9): No. B 7 "Internal Ocular Breadth. The diameter between the two internal canthi of the eyelids. A contact measurement." It adds

the direction that the measurement is to be taken when the eyes are open. Buxton who uses the same name, and Shirokogoroff who has one measurement called "Internal Interocular Breadth," have probably followed the above definition which is virtually the same as the International Commission's No. 16 "Largeur bipalpébrale interne. Points anatomiques: angle interne de chaque œil, sans s'occuper de la caroncule" ((20), p. 571). Martin ((14), p. 161) gives it as No. 9 "Breite zwischen den inneren Augenwinkeln (Nasenwurzelbreite, obere Nasenbreite; largeur interoculaire, bi-caronculaire, bi-angulaire interne, bi-oculaire interne ou bi-palpébrale; internal ocular or interocular breadth): Geradlinige Entfernung der beiden Entokanthia voneinander bei offener Lidspalte." Koganei ((8), p. 255, No. 11) describes it as "Distanz zwischen den inneren Augenwinkel" which is probably the same as the above described measurement.

37. Kubo on the other hand is a little uncertain. He calls it ((10), p. 295, No. 30) "Breite zwischen den inneren Augenwinkeln (Interocularabstand)" which would apparently identify his measurement with the above-mentioned sets. But in his description he distinctly mentions the "Abstand der inneren Orbitalränder des knöchernen Schädels" which is taken verbatim from Schmidt ((25), p. 106, No. 38). This would imply that he was actually measuring the distance between the two internal edges of the orbital ridge, which distance of course may differ a little from the distance between the two internal canthi. Comparison with other sets is therefore a little doubtful.

(17) *External Ocular Breadth.*

38. B.A. Report ((21), p. 9): No. B 6 "External Ocular Breadth. The diameter between the two external canthi of the eyelids. A contact measurement." Measurement to be taken when the eyes are open.

Shirokogoroff who calls it ((27), p. 1, No. 19) "External interocular breadth" has probably followed the above definition. Koganei describes it ((8), p. 255, No. 12) as "Distanz der äusseren Augenwinkeln," and his measurements are probably comparable with those of Shirokogoroff.

The above measurement corresponds to Schmidt's ((25), p. 106) No. 37 "Breite zwischen den beiden äusseren Augenwinkeln," to the International Commission's No. 15 "Largeur bi-palpébrale externe. Points anatomiques: angle externe de chaque œil, dans sa région profonde, en contact immédiat avec le globe de l'œil. Les yeux du sujet étant bien ouverts, le regard un peu au-dessus de l'horizon, viser ce point avec les branches du compas appuyées sur les joues du sujet" ((20), p. 571), and to Martin's ((14), p. 161) No. 10 "Breite zwischen den äusseren Augenwinkeln (Obergesichtsbreite nach Weisbach; largeur bi-oculaire externe, bi-angulaire, bi-palpébrale externe; external biocular breadth): Geradlinige Entfernung der beiden Ektokanthia voneinander bei offener Lidspalte."

39. Kubo is again doubtful. He calls it ((10), p. 301, No. 31) "Breite zwischen den äusseren Augenwinkeln," but actually defines it as "Breite zwischen den

äusseren knöchernen Augenhöhlenrändern." This of course is a quite different measurement corresponding to the B.A. Report ((21), p. 9) No. B 5 "External Orbital Breadth. Maximum diameter between the outer margins of the orbital openings," to Schmidt's ((25), p. 106) No. 36 "Breite zwischen den äusseren knöchernen Augenhöhlenrändern," and to Martin's ((14), p. 162) No. 10 (1) "Breite zwischen den äusseren Augenhöhlenrändern (diamètre orbitaire; external orbital breadth): Geradlinige Entfernung der beiden äusseren Orbitalränder im Niveau der äusseren Lidkommissar voneinander." Kubo's measurement* cannot therefore be compared with either Shirokogoroff's or Koganei's, but it may be compared with Buxton's who definitely took the "External Orbital Breadth" (B 5 of the B.A. Report) and not the "External Ocular Breadth" (B 6).

(18) *Breadth of the Mouth.*

40. Hrdlička defines it as the "distance between the angles of the mouth at points where the mucous membrane joins the skin, with mouth naturally closed, without tension" ((5), p. 75), which is practically a literal translation of the International Commission's No. 17 "Largeur de la bouche. Points anatomiques: commissures des lèvres, au point où la muqueuse se continue avec la peau; prendre leur distance, la bouche étant dans sa position moyenne" ((20), p. 571).

Koganei ((8), p. 255, No. 16) calls it "Länge des Mundes" but does not give any definition, Kubo calls it ((10), p. 339, No. 37) "Breite (Länge) des Mundes," and notes that it was measured with the mouth closed. The addition of the word "Länge" within brackets shows that it was formerly known by that name. It corresponds to Martin's ((14), p. 163) No. 14 "Breite der Mundspalte (Mundlänge; longueur buccale): Geradlinige Entfernung der beiden Cheilia voneinander. Der Mund muss geschlossen und in Ruhelage sein." All the measurements are therefore comparable.

(19) *Length of the Ear.*

41. B.A. Report ((21), p. 10): D 2 "Greatest length of the ear. From the highest to the lowest point of the auricle." Shirokogoroff uses the same name.

Monaco Commission: No. 19 (*a*) "Oreille—Longueur maxima: Points anatomiques: en haut: le point le plus élevé du bord de l'hélix; en bas: extrémité inférieure du lobule. Placer la tige du compas parallèle au grand axe de l'oreille et ses branches tangentes aux points indiqués, sans presser" ((20), p. 572).

Hrdlička called it "Height of the Ear†" in his paper on the Egyptians ((4), p. 91), and stated that his measurement was the same as that of Topinard ((29), 1885, p. 1004), Weisbach (*Zeit. für Ethnologie*, Bd. IX, supplement, 1878), and

* This is another example of a measurement being called by a name properly belonging to an altogether different measurement.

† It would be well to retain this term for the projection of the maximum length on the vertical, i.e. when the rod of the callipers is *held perpendicular*, with the head adjusted to the standard horizontal plane.

Schwalbe (*Beiträge zur Anthropologie des Ohres*—Virchow's *Festschrift*, 1891, p. 95). Schwalbe himself called it "Grösste Länge des Ohres" ((26), pp. 113—114) and mentioned that "dieses Mass ist identisch mit dem, welches von Weisbach und Virchow als Höhe des Ohres bezeichnet wird. Die grösste Länge des Ohrscheitels bis zum entferntesten Punkt des unteren Ohrrandes." Comparing Schwalbe's diagram ((26), p. 115, Fig. 10, $ab = L$) with that of the B.A. Report (fig. 1, AB), I find that the two definitions are identical.

42. In his later book ((5), p. 76) Hrdlička changed the name to "Maximum Length" and defined the landmarks as follows: "Superiorly the highest point on the border of the helix; inferiorly the lowest point on the lobule. The rod of the compass should be held parallel to the long axis of the ear; use no pressure." This is again practically a translation of the International Commission's No. 19 (*a*).

43. Koganei calls it ((8), p. 255, No. 17) "Länge des Ohres," and defines it: "vom unteren Ende des Ohrläppchens bis zum hochsten Punkte der Ohrmuschel gemessen."

Kubo calls it ((10), p. 349, No. 39) "Physiognomische Länge des Ohres (Höhe des Ohres)" and following von Luschan ((11), p. 40, No. 54) defines it as "dessen wirkliche Höhe zwischen den wagerechten Tangenten an dem oberen und dem unteren Rand." The measurement corresponds to Martin's ((14), p. 168) No. 29 "Physiognomische Länge des Ohres (grösste Länge des ganzen Ohres nach Schwalbe): Geradlinige Entfernung des Ohrscheitels (Superaurale) von dem tiefsten Punkte des Ohrläppchens (Subaurale)." Probably all the measurements are comparable.

III. THE COMPARATIVE VALUE OF THE MATERIAL.

44. It may be presumed that the chief, if not the only, reason for taking anthropometric measurements is to use such measurements for purposes of comparison, that is: for the study of racial or group resemblances and divergences. The real value of any particular collection of material would then be determined by the possibilities of comparison offered by it. Any portion of the material which is not available for comparison may therefore be considered useless for our purposes.

45. Let us consider the present material. Counting Shirokogoroff's material as one single unit we have nine distinct sets of observations taken by nine different observers. For any particular character for which comparable measurements are available for every set, $\frac{1}{2}(9 \times 8) = 36$ different comparisons will be theoretically possible. Owing to lack of agreement in definitions or technique all measurements however may not be comparable, in which case the number of comparisons actually possible will be considerably reduced. For example, for the Nasal Index we have the following groups:

(i) Korean (Kubo)
(ii) Aino (Koganei)
(iii) Mongolian (Shirokogoroff)
(iv) Swedish (Lundborg)

} Single sets, no comparison possible.

(v) Maltese (Buxton)
New Caledonian (Sarasin) } Two sets, 1 comparison possible.

(vi) Cretan (von Luschan)
Egyptian (Hrdlička)
Old American (Hrdlička) } Three sets, 3 comparisons possible.

Thus only 4 (out of a possible 36) comparisons are feasible in practice. We may reckon the effective value of the material to be 4/36 or about 11 °/₀ only.

I give below, Table I, such detailed analysis for each character separately. Col. (3) gives the total number of sets for which a particular measurement is available, Col. (4) the number of comparisons which would have been possible if all measurements had been strictly comparable, Col. (5) the number of comparisons which might be reasonably made in practice, though even then they include several—such as those between the bigonial diameters (see Section (15) above)—which could only be justified fully if far more adequate information were available

TABLE I.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
*1	Head Length	9	36	9	25 °/₀	12	33 °/₀
*2	Head Breadth	9	36	9	25	16	44
*3	Cephalic Index	9	36	9	25	12	33
4	Height of Head	5	10	2	20	2	20
5	Horizontal Circumference of Head	2	1	1	100	1	100
*6	Nasal Height	9	36	4	11	13	36
*7	Nasal Breadth	9	36	16	44	22	61
*8	Nasal Index	9	36	4	11	4	11
9	Nasal Depth	2	1	1	100	1	100
*10	Morphological Face Height ...	9	36	6	17	16	44
*11	Bizygomatic Diameter	9	36	36	100	36	100
*12	Morphological Facial Index ...	9	36	6	17	16	44
*13	Upper Face Length	4	6	2	33	2	33
14	Minimum Frontal Diameter ...	8	28	28	100	28	100
15	Bigonial Diameter	7	21	21	100	21	100
16	Internal Ocular Breadth... ...	5	10	6	60	6	60
*17	External Ocular Breadth ...	4	6	2	33	2	33
18	Breadth of Mouth...	5	10	10	100	10	100
19	Length of Ear	5	10	10	100	10	100
	Total		427	182	42·6 °/₀	230	53·8 °/₀

regarding the definitions of points and measurements. Lacking any direct negative evidence, it has been assumed that the different workers used the same degree of pressure in determining a particular measurement. If it were demanded that the comparison should be perfectly rigorous, so that the absence of information on such a point would necessitate the rejection of the observation, then the strictly comparable material would be reduced almost to none. Col. (6) is the percentage effective value (or efficiency) given by the ratio of (5) to (4) expressed as a

percentage, Col. (7) and Col. (8) corresponding numbers if all doubtful cases are included as being available for comparison.

Adding up for all characters we notice that only 182 comparisons can be made with any degree of certainty* out of a possible 427, giving an effective value of 42·6%. If doubtful cases were included the actual number and percentage would be increased to 230 and 53·8% respectively. The above analysis does not however give a fair idea of the real position, for in the above list we have included a number of characters which are rather rare.

46. Let us confine ourselves to the standard list given in *Notes and Queries* (19). It consists of 9 measurements of the head, out of which we have 8 in the above list. Including the three relevant indices we obtain a total of 11 measurements (marked with an asterisk in Table I) for which we now get Table II.

TABLE II.

Number of Comparisons

Theoretically possible	Actually possible	
	Rejecting doubtful cases	Including doubtful cases
336	103	151
Percentage	30·6%	45·0%

If we further omit the two characters Nos. (13) and (17) in Table I, i.e. restrict ourselves to the *characters which are available in every set*, we get the following table.

TABLE III.

Number of Comparisons

Theoretically possible	Actually possible	
	Rejecting doubtful cases	Including doubtful cases
324	99	147
Percentage	30·6%	45·4%

The appalling fact then comes out that only from 30% to 45% of the theoretically possible comparisons can actually be made in practice, i.e. fully from

* Even this assumes that the same amount of pressure has been used by different observers in measuring Morphological Face Height, Bizygomatic Diameter, Minimum Frontal Diameter and Bigonial Diameter. If different degrees of pressure were employed, and such differences cannot be legitimately ignored, then the actual number of possible comparisons is reduced to 85 or to less than 20% of the number theoretically possible. Not neglecting pressure differences the possible comparisons in Table II are 55 or 16·4% and in Table III, 51 or 15·7%!

55°/₀ to 70°/₀ of the usefulness of the material is wasted owing to lack of agreement in definitions and technique. A more exacting critic might be unwilling to make some of the assumptions which we have made in order to obtain these figures. If he demand that comparison should be restricted to measurements *certainly known* to have been found by identical methods then he would find that only 20°/₀ or even 15°/₀ of the possible comparisons could be made legitimately. To put it in a different way *the effective value of the present material might have been increased at least two- or three-fold and possibly five- or six-fold by proper standardisation without any additional expenditure of energy, time or money in collecting the material.*

47. I may note here that the present material was originally collected with a view to obtaining as large a number of comparable characters as possible. In fact I rejected several series of observations where a preliminary examination showed that a sufficient number of comparable characters would not be available. Thus my very generous estimate of a wastage of from 55°/₀ to 70°/₀ is more likely to be an under-estimate than otherwise for measurements in general.

The actual situation is indeed much worse owing to another reason. Ordinarily one gets from 10 to 15 different measurements (on the head) in good sets of observations, and only rarely 20 or more. So that owing to the reduction in number of measurements due to lack of standardisation the number of characters actually available for comparison may be easily reduced to anything from 5 to 8 on an average. But for serious comparative studies it is absolutely essential to have a larger number of characters, preferably 20 or more. Thus the reduction in number of available characters, owing to want of standardisation, will very often render the whole material practically useless for comparative purposes.

We are obliged to conclude that even from the best of the series of head measurements at present available we are quite unable to establish reliable inter-racial comparisons. The labour of estimating how far the measurements may be legitimately compared is not one from which the biometrician is likely to derive much profit, for he will usually be left with insufficient material to serve his needs. The comparisons frequently made between similar measurements taken according to different methods of technique are merely idle.

IV. Conclusions.

48. The present study indicates that the greater part of the existing anthropometric measurements on the living are probably useless for comparative purposes owing to lack of agreement in definitions and technique.

Such lack of standardisation is due to the existence of a multiplicity of "standard lists" each with its own adherents. The International Agreement of 1906 has failed to achieve any appreciable degree of uniformity among anthropometric workers. Out of eight observers considered in this paper (all of whom carried out their present investigations after 1906) only two (Hrdlička and Shirokogoroff) mention the 1906 Agreement, but both of them introduce departures from this Agreement. Several

important standard lists, e.g. the British Association Report (1908), *Notes and Queries* (1912), Martin's list (1914), were drawn up after the International list, but have made substantial departures from it.

The failure of the International Agreement of 1906 may be ascribed to several causes. Specifications are in many places vague and uncertain, detailed descriptions are not often given about the actual procedure to be followed in taking measurements, and the list contains too few characters. Finally it does not appear to have been readily available in a convenient form.

It is hardly necessary to point out that no progress in comparative Anthropometry will be possible until arrangements have been made for securing adequate uniformity of standards among different observers. The only way in which this can be achieved is to convene another International Conference for drawing up a more satisfactory set of standards than the Monaco (1906) Agreement.

The greater part of this paper was written in the Biometric Laboratory, University of London, and I have to thank Prof. Karl Pearson for his active interest and valuable suggestions at every stage of my work. I also acknowledge with gratitude the help I have received from Dr G. M. Morant of the same laboratory.

APPENDIX I.

The following table gives a rough idea of the order of the difference made in $Z = (M - M')/\Sigma_{(M-M')}$ for certain estimated values of the difference in means arising from differences in technique. Col. (3) gives the total number of individual measurements (taken from the data considered in the present paper) on which the average

(1) No.	(2) Name of character	(3) No. of Individuals	(4) $\bar{\sigma}$ Mean Standard deviation	(5) Estimated difference in Means	(6) "Z" for samples of 100
1	Head Length	1863	6·92 mm.	3 mm.	3·0
2	Head Breadth	1864	5·72 mm.	3 mm.	3·7
3	Cephalic Index	1863	4·20	0·4	0·7
4	Height of Head	795	6·13 mm.	3 mm.	3·4
5	Horizontal Circumference of Head	640	13·25 mm.		
6	Nasal Height	1856	3·74 mm.	4 mm.	7·5
7	Nasal Breadth	1852	2·93 mm.	5 mm.	12·1
8	Nasal Index	1850	7·97	5·0	4·4
9	Nasal Depth	440	1·95 mm.		
10	Morphological Face Height ...	1852	6·41 mm.	4 mm.	4·4
11	Bizygomatic Diameter	1855	5·45 mm.		
12	Morphological Facial Index ...	1847	4·72	3·0	5·7
13	Upper Face Length	592	3·81 mm.	5 mm.	9·2
14	Minimum Frontal Diameter ...	1612	4·96 mm.		
15	Bigonial Diameter	1620	6·07 mm.		
16	Internal Ocular Breadth	1510	2·91 mm.	3 mm.	7·2
17	External Ocular Breadth ...	1185	4·87 mm.	3 mm.	4·3
18	Breadth of Mouth	866	3·72		
19	Length of Ear	735	4·66 mm.		

standard deviation ($\bar{\sigma}$) given in Col. (4) is based. Col. (5) gives the estimated difference in means due to differences in technique. I may note that these are on the whole conservative estimates. Col. (6) gives "Z" for samples of 100. It will be seen that except for the Cephalic Index differences in technique will certainly not be negligible in comparison with errors of sampling when the group consists of 100 individuals or more.

Appendix II.

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