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The first modern East Asians ?: another look at Upper Cave 101, Liujiang and Minatogawa 1

Peter Brown

Department of Archaeology and Palaeoanthropology
University of New England
Armidale, NSW 2351, Australia

INTRODUCTION

An essential part of being human appears to be a concern with our own origins. Whether it is Aboriginal Dreamtime creation myths of the Rainbow Serpent, or the objects of scientific enquiry, people strive to find out where they have come from. Over the last decade, in particular, interest in the origins of our species has heightened with a protracted and often heated discussion over the origins of anatomically modern humans (Frayer *et al.* 1994; Stringer and Andrews 1988; Stringer and Bräuer 1994; Thorne and Wolpoff 1981). Research into the evolution and dispersion of regionally distinct groups of humans is a crucial element in this ongoing debate (Brown 1992; Howells 1973; Howells 1989; Kaminga and Wright 1988; Wolpoff *et al.* 1984). Within East Asia interest in the biological association between *Homo erectus* and *H. sapiens*, and the origins, evolution and dispersion of recent populations has resulted in a diverse body of publications (Aigner 1976; Chen 1989; Hanihara 1992; Kaminga and Wright 1988; Mizoguchi 1986; Omoto 1995; Pope 1988; Wang 1986; Wu and Dong 1985; Wu and Wu 1985; Wu and Zhang 1985). Many of these focus on relationships between living East Asian populations and extending these relationships back into the past.

When Klaatsch (1908) and Weidenreich (1939a, 1939b, 1943) were first discussing the evolution of regionally distinct groups of humans their arguments were based on the identification of regional morphological patterns.They realised that on average human skeletons from East Asia looked different to those from Europe and Africa. The development of these differences, they thought, could be traced back to differentiated groups of *Homo erectus*. For Weidenreich the ancestors of modern East Asians could be identified in the hominid remains from Locality 1 at Zhoukoudian. This conclusion, considerably elaborated, has received support from the multiregional school of human evolution

(Wolpoff *et al.* 1984; Wolpoff 1991) and is a key element in Chinese Palaeoanthropological research. Others have disputed the significance of these regional features, especially their occurrence in Middle Pleistocene hominids, and see their evolution as a relatively recent phenomenon (Brown 1992; Groves 1989; Habgood 1989; Lahr 1994; Stringer and Andrews 1988; Stringer and Bräuer 1994). While Howells (1973, 1989, 1995) has documented regional variation at a local and global level the difficulty comes in extending late Holocene morphological patterns into the Pleistocene.

In East Asia there are specific problems associated with the search for the origins of the Asian regional group, the "Mongoloids". These include the chronological and geographic distribution of the existing hominid fossils and definitions of "Mongoloid" morphology which fail to consider diachronic, regional and clinal change in morphology. It may be that if ancestral East Asians are present that they remain unidentifiable. At a more specific level while there is considerable evidence for the widespread distribution of East Asian morphology by the mid-Holocene there is debate over the status of the "earliest" modern humans from the Upper Cave (Weidenreich 1939a; Wu 1960, 1961), Liujiang (Wu 1959) and Minatogawa (Suzuki 1982; Suzuki and Hanihara 1982). Is there anything particularly East Asian in the morphology of these fossils, and if not, does it necessarily follow that East Asian skeletal morphology has evolved only recently?

DATING

In a thoughtful review of the chronology of Chinese Palaeolithic sites Chen and Zhang (1991) discuss the reliability of dating procedures and apparent discontinuities in the distribution of *Homo erectus* and early *H. sapiens* sites. They note two clusters within the age distribution of sites, one around 190 kyr and the other 110 kyr, with few sites in the 130-160 kyr and 50-90 kyr range (Figure 1). Chen and Zhang argue that the discontinuities are not simply the chance products of preservation. More likely they reflect the movement of hominids to warmer areas during periods of glacial maximum. An additional problem is that many of the sites which are beyond the range of radiocarbon dating can not be dated with a great deal of precision. Variation within the published dates is often extreme, for instance Yunxian has a geomagnetic date of 830-870 kyr and an electron spin resonance date on stratigraphically associated tooth enamel of 581 ±93 kyr (Chen *et al.* 1996). This is not problem peculiar to China but occurs wherever researchers are forced to deal with complex cave stratigraphy, or sediments which can not be dated using the K/Ar method.

The discontinuities described by Chen and Zhang occur at crucial time periods for discussion of the origins of modern humans in East Asia. Sometime after Xujiayao (Chen *et al.* 1982; Wu and Wu 1985)

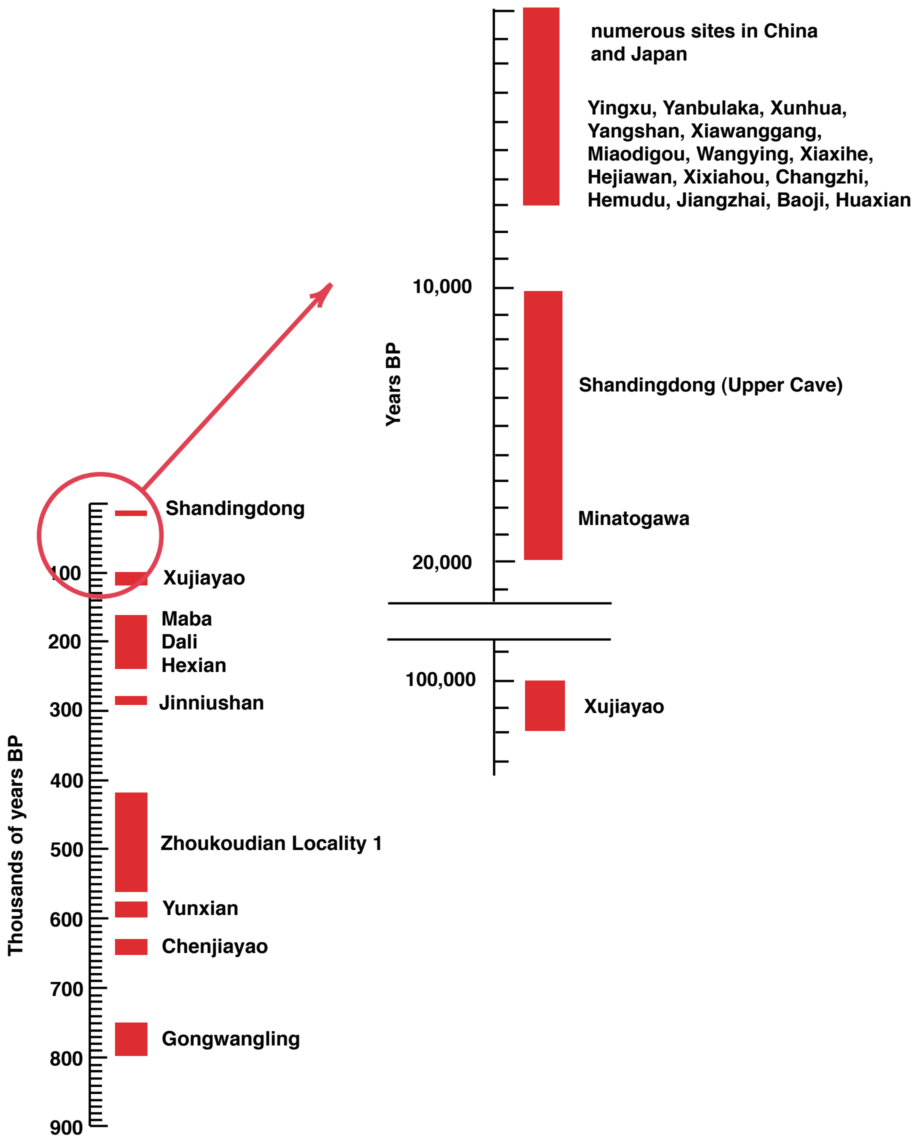

Fig. 1 Approximate dates for the major East Asian hominid localities. Discussion of majority of the mid-Pleistocene and Late Pleistocene dates can be found in Chen and Zhang (1991). The Institute of Archaeology, CASS (1991) provides a comprehensive list of radiocarbon dates covering most of the Chinese Neolithic sites.

modern people appear in China, with the earlier hominid fossils from Maba (Wu and Pang 1959) and Dali (Wu 1981) anatomically intermediate between *H. erectus* and *H. sapiens*. However, an additional gap between the early Neolithic sites of Baoji (Yan *et al.* 1960) and

Huaxian (Yan 1962), in the 5500 to 7000 years BP range (The Institute of Archaeology 1991), and the Upper Cave at Zhoukoudian is of equal importance. While the East Asian morphology of the skeletons recovered from these Neolithic sites has not been contested, most observers have trouble identifying East Asian features in the Upper Cave remains (Howells 1989; Kaminga and Wright 1988; Weidenreich 1939a). The colonisation of the Americas by 11 kyr indicates an earlier date for the appearance of distinctively East Asian features, however, the earliest unequivocal evidence for anatomically East Asian people on the Asian mainland remains at 7000 years BP.

UPPER CAVE 101

The Upper Cave (Shandingdong) skeletons were excavated in 1933 and 1934, with the archaeological assemblage discussed by Pei (1935, 1939) and the human skeletal materials briefly described by Weidenreich (1939) and in more detail by Wu (1960, 1961). The fauna recovered from the lower chamber of the cave suggested to Pei that the deposits were of late Pleistocene age and this was confirmed by conventional radiocarbon dates on non-human bone (Wu and Wang 1985), as well as more recent AMS dates (Chen *et al.* 1989; Hedges *et al.* 1992; Hedges *et al.* 1988) . Dates now extend from 10,175 ± 360 BP (ZK-136-0-4) for the upper part of the cave to 33,200 ±2000 BP (OXA-190) for the basal layers. Unfortunately, as I have discussed previously (Brown 1992), the published accounts of the excavation contain insufficient information to be certain of the stratigraphic relationship between the human remains and the dated animal bones. Both Weidenreich (1939) and Pei (1935, 1939) argue that the human remains were part of intentional burials, with the skeletons subsequently disturbed and disarticulated by animal activity or erosion. It remains unclear whether the burials are contemporaneous with layer 4 or had been interred from a higher layer. Wu and Wang (1985) argue that the older dates from the Upper Cave are well below the areas of human occupation, which they place at around 10,000 BP, while (Chen *et al.* 1989; Hedges *et al.* 1992; Hedges *et al.* 1988) suggest 29-24 kyr BP for the cultural layers.

Weidenreich (1939) believed that the Upper Cave skeletons provided the earliest evidence for the presence of modern humans in the East Asian region. What perplexed Weidenreich, however, was the variation between the three crania, 101, 102 and 103, and the absence of clearly defined East Asian skeletal morphology. When discussing the racial affinity of these crania 101 was considered to be a primitive Mongoloid, 102 a Melanesian and 103 an Eskimo. These conclusions, at best poorly supported, have been discussed in some detail by a number of authors, particularly in relation to the evolutionary history of East Asia (Coon 1962; Kaminga and Wright 1988; Wolpoff et al. 1984; Wu 1960, 1961). Unfortunately, the original specimens, along with the Locality 1 *Homo* *erectus* materials, were lost in 1941 (Shapiro 1976) and can now only be studied through casts.

Of the three crania Upper Cave 101, the "old man", has been studied in more detail primarily due to its better preservation and clearly adult status. In comparison to modern East Asians the cranial vault is extremely long and low, with a receding frontal squama and marked angulation in the occipital region. The forehead is broad and the superciliary region well developed (Figure 2). The nasal bones are pinched, with a high bridge, and the nose must have been more prominent than is common amongst living East Asians. The orbits are relatively low and rectangular, which is a common feature in terminal Pleistocene and Neolithic crania from many parts of the world. The lower border of the nasal aperture is gutted, which is customary amongst East Asians, Australian Aborigines and sub-Saharan Africans. There is moderate sub-nasal prognathism and the mandible has a prominent chin, slight gonial eversion, trace of a mandibular torus and a broad ramus. Weidenreich (1939) did not record dental dimensions and the moderately worn teeth have not been described in detail. All teeth are present and the arch is well spaced, without malocclusion. Comparison of tooth wear rates with known age hunter gatherers suggest that Upper Cave 101 was probably in his late 30's when he died and not an "old man" by today's standards.

To what extent the oro-facial skeleton and cranial vault of Upper Cave 101 contains either "proto-Mongoloid" or East Asian anatomical characteristics has been the subject of some debate (Kaminga and Wright 1988; Wolpoff *et al.* 1984) . Living East Asians and Native Americans have a facial skeleton characterised by great facial height, a tall nasal aperture, high orbits, limited overall prognathism but often marked subnasal prognathism, only moderate bi-frontal breadth but a relatively broad mid-facial region. The nasal bones are generally flattened rather than pinched, the anterolateral surface of the frontal processes of the malars are rotated forwards and the inferior half of the external surface of the malars tend to be orientated upwards, rather than perpendicular. This suite of features are also found in the early Neolithic sites of Baoji (Yan *et al.* 1960) and Huaxian (Yan 1962) but they are not a feature of Upper Cave 101.Turner (1992) has argued that his Sinodont pattern was "probably present in the late Pleistocene north China Upper cave crania" (:145), however, it is unlikely that the majority of his dental traits can be reliably scored on the Upper Cave casts.

LIUJIANG

The Liujiang skeleton, consisting of a well preserved cranium and limited postcranial material, was discovered in a small cave at Tongtianyan in the Guangxi Zhuang Autonomous Region in 1958 by

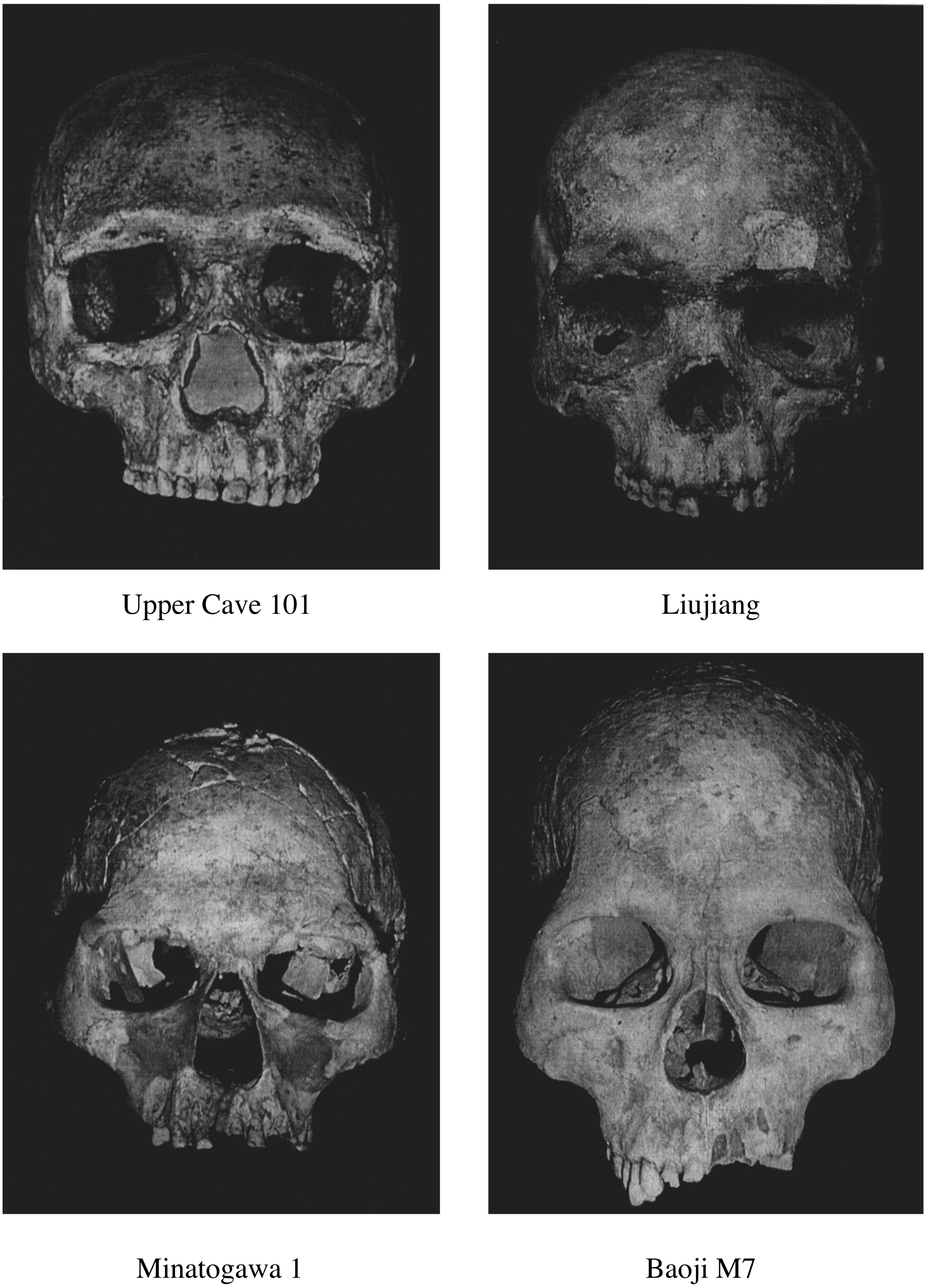

Fig. 2 Facial skeletons of Upper Cave 101, Liujiang, Minatogawa 1 and Baoji M7, all to the same scale. Note width of mid-face, orientation of malars, shape of nasal bones (not preserved in Minatogawa 1), height of face and height of nasal aperture.

people collecting fertilizer (Wu 1959). Liujiang was initially described by Wu (1959), with Wu and Zhang (1985) providing additional comparative anatomical information. The *Ailuropoda-Stegodon* fauna found in association with Liujiang were interpreted as being of Middle Pleistocene age but the contemporaneity of the fauna and human skeletal remains have not been established. Wu (1959) did not support a Middle Pleistocene age for the human skeletal materials arguing that the morphology of the cranium suggested a more recent date. This is supported by morphological and metrical comparison with other East Asian crania, for instance Minatogawa 1 (Suzuki, 1982; Wu, 1992; Hanihara, 1994). More recently a Uranium series date of 67,000 +6000 -5000 was reported for Liujiang (Wu 1988, 1990, 1992) which would make it the earliest example of modern *Homo sapiens* from the East Asian region. However, the stratigraphic relationship of the dated stalactite layer and the human skeletal materials can not be confirmed (Chen and Zhang 1991). At present it must be said that the Liujiang skeleton remains undated.

By both modern and Neolithic standards Liujiang has a long and low cranial vault, with an occipital bun, little obelionic flattening and no sagittal keel. The facial skeleton is short but relatively broad for its height (Figure 2). The superciliary ridges are moderately developed, with some depression of the root of the nose and low, rectangular orbits. Facial prognathism is greater than the average amongst modern and late Neolithic Chinese but is similar to the early Neolithic male average. The mastoid processes are extremely small, and along with the pelvic morphology discussed later, make me uncertain as to the male sex of Liujiang. Both teeth and palate are moderate in size, with congenitally absent third molars, a small odontome in the center of the palate and a shovel shaped right lateral incisor.

There is nothing particularly East Asian about the facial skeleton of Liujiang. While the nasal bones are flattened, the nasal aperture is not very tall and the anterolateral surfaces of the malars are not rotated forwards like in Chinese Neolithic facial skeletons. Low, rectangular orbits are common in the Late Pleistocene and early Holocene throughout the world and this should be disregarded when determining East Asian affinity. Unlike Upper Cave 101 only limited statistical comparisons have been conducted with Liujiang. Both Suzuki (1982) and Wu (1992) place Liujiang closer to Minatogawa 1 than Upper Cave 101, with the former study also distinguishing Liujiang from modern East Asians.

MINATOGAWA 1

The Minatogawa 1 male skeleton was found in 1970 at the Minatogawa limestone quarry on Okinawa (Suzuki and Hanihara 1982).

Three female skeletons, in varying states of preservation, and assorted other fragments were also recovered. The Minatogawa skeletons have been described in detail in Suzuki and Hanihara (1982), with Suzuki (1982) describing the crania. Additional comparative information can be found in Baba and Nerasaki (1991). The Minatogawa 1 cranium is not as complete as Liujiang and Upper Cave 101, particularly in the basi-cranium, facial skeleton and temporal regions. Several of the dimensions used in the analysis to follow had to be estimated.

Unlike Liujiang and Upper Cave there does not appear to have been any concern over the reliability of the dating of Minatogawa. Radiocarbon dates of 18,250 ±650 to 16,600 ±300 years BP were obtained from charcoal inside the fissure (Kobayashi *et al.* 1974). Fluorine content of human and non-human bones within the site suggested that they were contemporaneous (Matsu'ura 1982). Assuming that the site was well stratified, that the carbon dates do bracket the skeletons and that the skeletons were not intrusive, then Minatogawa remains do have a strong claim to being the earliest modern human skeletons in East Asia.

The Minatogawa 1 skeleton is that of a relatively short person, approximately 153 cm tall (Baba and Nerasaki 1991), and the cranium is correspondingly small but robust for its size. Minatogawa's vault is both higher and broader relative to cranial length than Liujiang and Upper Cave 101. Maximum cranial breadth is located in a relatively inferior position, just above the squamous suture, and there is marked postorbital constriction. The glabella region is inflated and the nasal root depressed, with nasal bones that appear to be pinched (Figure 2). Facial breadth, both bi-frontal and bimaxillary (estimates) exceeds Liujiang and Upper Cave 101, but the face is extremely short for its breadth. The orbits are low and rectangular in shape. To some degree overall facial morphology is similar to Liujiang, however, the malars in Minatogawa have a more antero-lateral orientation. Areas of masticatory and neck muscle attachment are quite rugose and the chin region of the mandible is not prominent. It is unfortunate that the maxillae, nasal and sub-nasal regions are damaged in Minatogawa 1. Apart from the orientation of the malars there is little in the remaining cranio-facial morphology of Minatogawa 1 that is shared with Neolithic and modern East Asians.

MATERIALS AND METHODS

Regional and diachronic variation in East Asian cranial morphology was examined by combining data from W.W. Howells (1989) with information on recent and Neolithic Chinese populations collected by the author. The Howells data set included a number of groups which can be described as East Asian in the broadest sense, for instance Native Americans. These were included to gain additional information on morphological variation and rates of divergence from a probable common East Asian foundation. Two Australian Aboriginal series, a recent sample from southeastern Australia and a combined terminal Pleistocene group from Coobool Creek, Nacurrie and Kow Swamp (Brown 1987, 1989, 1994), provide outgroups and information on post-Pleistocene evolution.To some degree the inclusion of these Aboriginal groups also provide a test for the claimed Australoid affinities of Liujiang (Coon 1962) .

As the three "Palaeolithic" skeletons, Upper Cave 101 (Weidenreich 1939, Wu 1960, 1961, Wright and Kaminga 1988), Liujiang (Wu 1959) and Minatogawa 1 (Suzuki 1982), have all been described as male this analysis was restricted to male crania. However, it is possible that Liujiang is actually a heavily built female. While the cranial vault is relatively large and robust, at least in comparison with modern Chinese male crania, the morphology of the remaining innominate and sacrum is somewhat feminine. The greater sciatic notch is broad and open and the post-auricular space on the sacroiliac joint is relatively large. Unfortunately the more definitive pubic region is not fully preserved.While Liujiang will be considered a male for the purposes of this analysis this remains a potential source of error. Sex determination of the more recent comparative samples are discussed in the references in Table 1. Where the osteological collections were not of known sex, with sex determined primarily from cranial morphology, an accuracy of no greater than 85-90% would be expected (Krogman and Iscan 1986).

Osteological dimensions (Table 2) were recorded using the procedures outlined in Howells (1973). Variable selection was influenced by their availability in W.W. Howells's raw data file (1973, 1989), preservation, the wish to maximise the number of individuals included in the analysis and the availability of comparative data from the other samples listed in Table 1. To what extent the chosen variables form an optimum variable set is difficult to determine within the limitations of the present analysis. A persistent criticism of the use of multivariate procedures in anthropology is the reproduceability of results, both with different data sets and between the sexes (see Howells 1989, Wolpoff 1976 and van Vark 1994). Surely, the ultimate test of any statistical procedure is whether the results make sense and are supported by the majority of previous studies. In this instance the results of multivariate statistical and graphical procedures can be compared with the earlier work of Howells (1989) and Kaminga and Wright (1988) who used different methods.

Geographic variation in cranio-facial size and shape, presence of outliers, distance between group means and group allocation were examined using direct discriminant function analysis (Tabachnick and Fidell 1989), cluster analysis (Everitt 1981) and Chernoff's multivariate icons (Bookstein *et al.* 1985; Chernoff 1973; Chernoff and Rizvi 1975). A variety of different cluster algorithms were applied, with fairly similar results. The final choice was the between groups hierarchical procedure using squared euclidian distance and standardised data. The underlying assumptions of distributional normality, and homogeneity of variance and covariance, inherent in discriminant function analysis (Eisenbeis and Avery 1972; Gilbert 1969; Huberty 1984) were tested using the procedures outlined in Brown (1989). The inclusion of bi-zygomatic breadth reduced the size of the Neolithic Chinese and terminal Pleistocene Australian samples so that there were too few cases to be non-singular, so this dimension was excluded from the analysis. Upper Cave 101, Liujiang and Minatogawa 1 were included in the analysis as unclassified cases.

An inherent difficulty in the use of multivariate statistical procedures in Archaeological and Palaeoanthropological publications is in the communication of results to a non-specialist audience. A conceptually related group of graphical procedures, which aid in the interpretation of multidimensional data, are multivariate symbols, or icons. These include Chernoff faces (Chernoff 1973), asymmetrical faces (Flury and Riedwyl 1981), star, profile and histogram symbols (Chernoff 1973; Friedman *et al.* 1972; Wilkinson 1989a), Kleiner-Hartigan trees and castles (Kleiner and Hartigan 1981) and Andrews (1972) Fourier wave forms plotted in polar co-ordinates to form Fourier blobs (Wilkinson 1989a). The advantage these symbols have over bar charts and two-dimensional and three-dimensional plots of discriminant function and factor scores is that the contribution of specific variables to the distance between individuals, or groups, is apparent. Symbols also form an important mnemonic device and, to varying degrees, are interpretable without special training or expertise (Andrews 1972; Chambers *et al.* 1983; Chernoff 1973) .

Criticisms of the use of symbols have centered on the difficulties of perception where large numbers of variables are involved and readers are forced to integrate a lot of information (Bertin 1967; Cleveland and McGill 1984) . However, one symbol, the human facial caricatures used by Chernoff (Chernoff 1973; Chernoff and Rizvi 1975), attempts to counteract this problem by relying on the human ability to discriminate between the features comprising the symbol at a detailed level. Data used to generate the final symbols consisted of 20 standardised mean cranial dimensions for each of the groups in Table 1, as well as individual data for Upper Cave 101, Liujiang and Minatogawa 1. Variables were assigned to the various features comprising the Chernoff faces in the order indicated by the loading matrix correlations for the first discriminant function in Table 3. For instance, the highest correlation for Function 1 in Table 3 is for bi-frontal breadth and this was allocated to curvature of mouth, the first of the icon features to be generated (Figure 4). Greater bi-frontal breadth is indicated by an upwardly curved mouth and minimum bi-frontal breadth by a downwardly curved mouth. The full list of icon features, as well as the order in which they were assigned, are provided in Figure 4. Statistical calculations were performed using SPSS 6.1 (SPSS 1990), SYSTAT 5.1 (Wilkinson 1989b) and hand calculation.

RESULTS

Seventeen discriminant functions were calculated, with a combined $\chi^2 = 4083.4$, $P < .000$, The first 13 functions had a significant association between groups and predictors, with a significant value for χ^2. The first four discriminant functions accounted for 27.15%, 20.27%, 15.06% and 11.8%, respectively, of the between-group variability. Figure

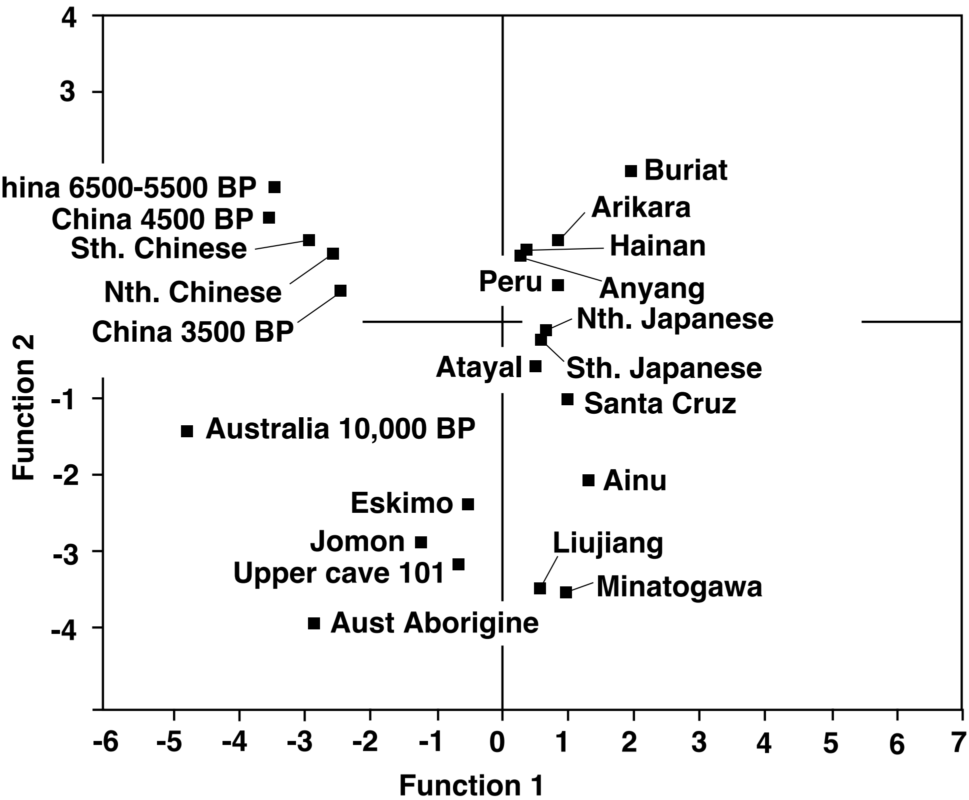

Fig. 3 Location of group centroids for the bivariate plot of the discriminant function 1 and 2 scores. Individual fossils, Upper Cave 101, Liujiang and Minatogawa 1 were entered into the analysis as unclassified cases. Principal discriminating variable on Function 1 id bi-frontal breadth and on Function 2 maximum cranial breadth and glabella-opisthocranion.

3 demonstrates how the first discriminant function maximally separates the sample into two major clusters, with some intermediate groups like the Eskimo and individuals like Upper Cave 101. The loading matrice correlations between predictors and discriminant functions (Table 3) indicating that this is primarily due to bi-frontal breadth, maximum cranial breadth and occipital curvature (lambda-subtense fraction). The second discriminate function discriminates the modern and Neolithic Mongoloid populations from the Australian Aborigines, Eskimo, Ainu and individual fossil crania (Upper Cave 101, Liujiang and Minatogawa 1). Discrimination on this function resulting primarily from maximum cranial breadth, maximum cranial length (glabella-opisthocranion) and facial prognathism (basion-prosthion) (Table 3 and Figure 3). Overall, the scatter plot of Functions 1 and 2 indicate the relative morphological similarity of the modern and Neolithic Chinese groups, while the modern Japanese are closer to a wider range of East Asian and Native American populations. Plots of the total group dispersions associated with Figure 3 revealed the large degree of overlap between the Neolithic and modern Chinese and between the modern Japanese, Anyang, Hainan and Native American groups. The Eskimo and Ainu were more distinct, as were both of the Australian Aboriginal groups.

Function three was more complex and had the largest number of variables providing a significant contribution to the function (>r.30), Table 3. The most important dimensions with this function are bi-frontal breadth, orbital breadth, maximum cranial breadth, bi-auricular breadth, bi-asterionic breadth and basion-bregma. When plotted against Function 1, Function 3 increases the distinction between the Neolithic and modern Chinese groups, as well as between Howell's northern and southern modern Japanese. The southern Japanese clustering closely with Bronze Age Anyang, Hainan and Atayal. The long and narrow headed (dolichocephalic) Australian Aborigines are, as you would expect, distinct from the East Asian and North American groups.

The morphological and metrical associations of Upper Cave 101, Liujiang and Minatogawa 1 were assessed by inserting them into the discriminant function analysis as ungrouped cases (Figure 3). Liujiang and Minatogawa 1 have a great deal of morphological similarity, at least as defined by the selected variables. Of the modern comparative samples they are closest to the Ainu and Eskimo. Although Upper Cave 101 is somewhat more Australoid in appearance, due to its elongated vault, it falls closest to the modern Eskimo. There is little that could be described as distinctly East Asian in the appearance of Upper Cave 101, Liujiang and Minatogawa 1, with all three distinct from modern and Neolithic populations in China and Japan.

Plots of the individual function scores, and summary statistics for the group Mahalanobis distances, indicated that the Hainan, Southern Chinese, China 6500-5500 and Buriat males displayed the highest levels of variation, with greater dispersion around the group centroid than in the other groups. Group classification results allocated 76.2% of cases to their correct group. All but two of the groups had a moderate percentage of their cases consigned to at least two of the other samples. All of the recent Australian Aborigines were correctly allocated to their group, and only 1 of the terminal Pleistocene Aborigines was allocated to the recent Aboriginal group. Group means in the two main clusters tended to be equidistant from each other, with Mahalanobis D^2 indicating that the most distant pair were the Australian Aborigine and Buriat males and the closest pair northern and southern Japanese males.

The Chernoff faces in Figure 4 were arranged on the basis of a hierarchical cluster analysis of 20 mean dimensions. As only 20 variables can be used to generate the Chernoff icons the 20 highest correlations in Table 3, Function 1, were selected. The icons provide a visual means of detecting overall levels of similarity between the different groups in the analysis. Northern and southern modern Japanese are the closest pair, and they are both close to Howell's Bronze Age Anyang series. Modern Southern Chinese crania are closer in their cranial shape to Neolithic Chinese than they are to modern Northern Chinese. There is a greater amount of variation within the three Native American groups than there is between the combined East Asians. Recent and terminal Pleistocene Australian Aborigines can be clearly distinguished from each other, but not to the same extent that Upper Cave 101 is separated from modern and Neolithic Mongoloids. For the majority of the dimensions used to generate the icons Minatogawa 1 is closest to the Jomon. Neither Liujiang or Upper Cave 101 are Australoid in appearance.

The results of the between groups hierarchical cluster analysis, using squared euclidian distance and standardised data, are displayed as a dendrogram in Figure 5. The first split is between Upper Cave 101 and all of the other samples. Liujiang, followed by the terminal Pleistocene Australian Aboriginal group are the next to split and they are separated from the next branch containing Minatogawa 1 and the Jomon. The Buriat and recent Australian Aborigines are followed by two branches, each containing two main subclusters. Native Americans form one subcluster and they are most closely linked to the subcluster containing Hainan, Atayal and modern Northern Chinese. The final branch contains the majority of the Neolithic and modern East Asian groups. Neolithic and modern Southern Chinese form one subcluster, with the moderns most closely linked to the most recent of the Neolithic samples. The Eskimo occupy an intermediate position between these Chinese groups and the final subcluster containing the Ainu, followed by Bronze Age Anyang and both of the modern Japanese groups.

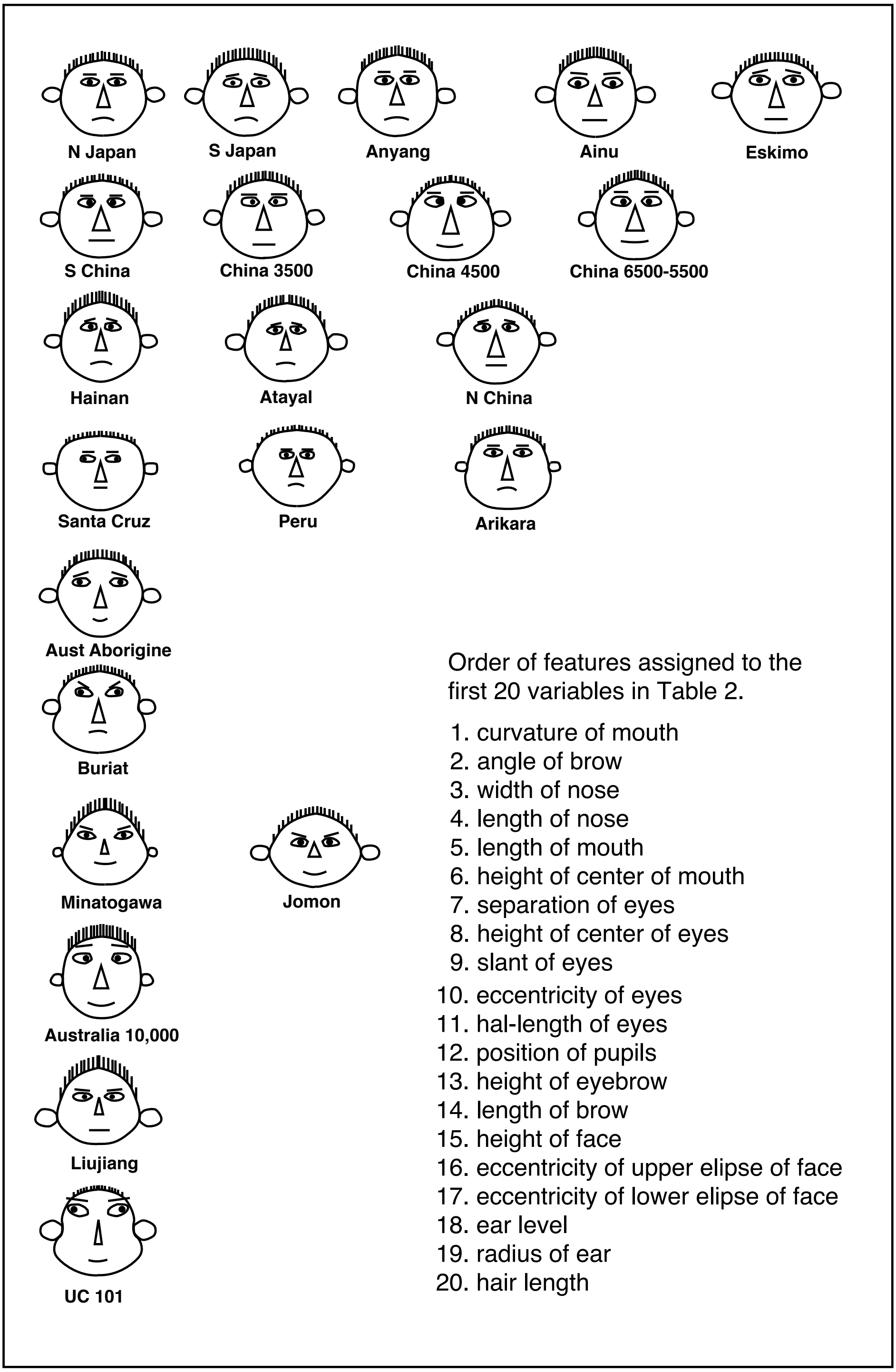

Fig. 4 Chernoff's multivariate facial icons generated from standardised mean dimensions for each of the groups and standardised individual dimensions for Upper Cave 101, Liujiang and Minatogawa 1. Faces arranged in the order indicated by a separate hierarchical cluster analysis. The closest pairs in this figure are the northern and southern Japanese.

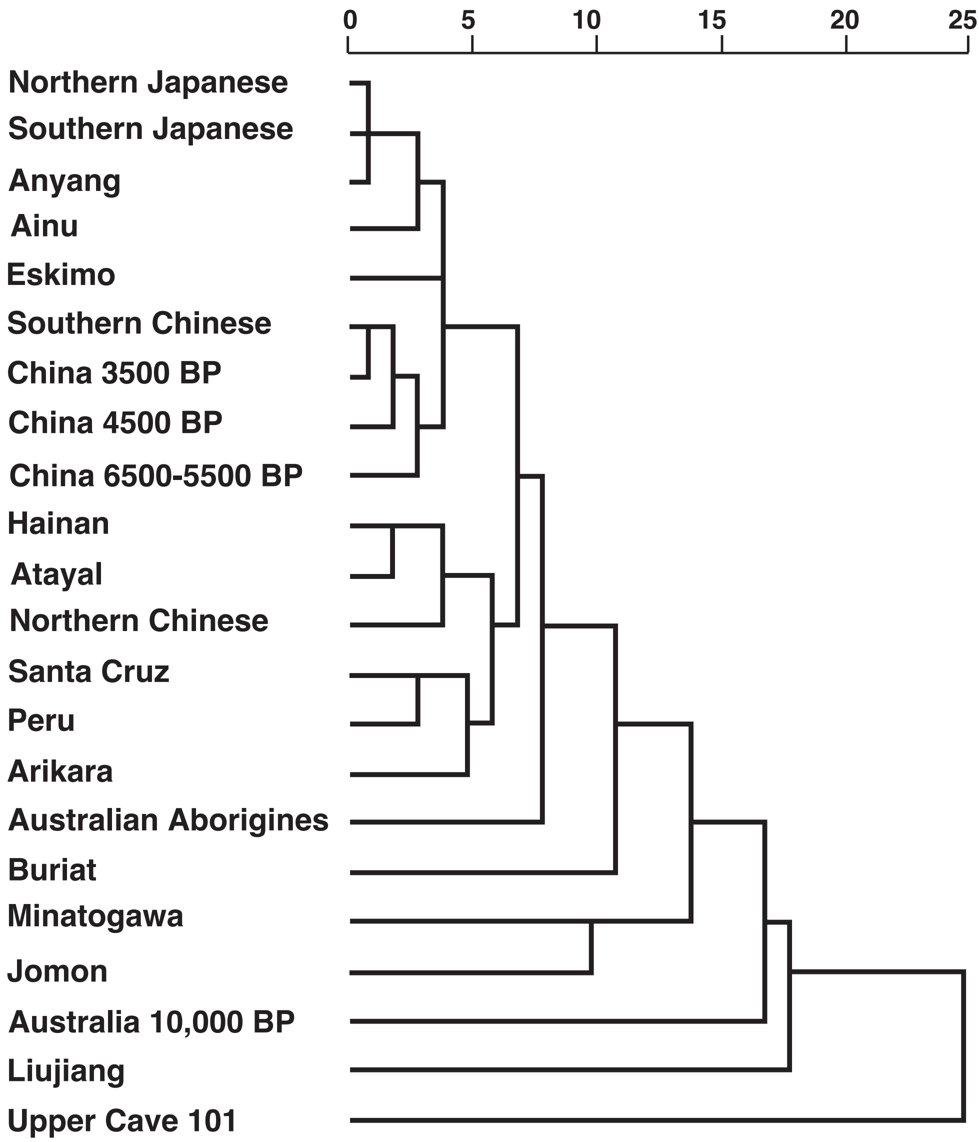

Fig. 5 Between groups hierarchical cluster analysis using squared euclidian distance and data standardised to z scores based on 25 cranial dimensions.

DISCUSSION

Discriminant function analysis of 25 cranio-facial dimensions distinguished two broad sub-groups, primarily Neolithic and recent China from the rest, within the analysis. The Bronze Age Anyang series should have clustered with the Neolithic and Southern Chinese samples but it was always closer to the modern Japanese.The Australian Aborigines, Ainu and Eskimo tended to form separate groups. Native Americans tended to group together and with the modern Japanese. The Ainu were morphologicaly close to the modern Japanese but Howells (1989) was uncertain of the genetic history of his Ainu sample.What this means in terms of the evolution and dispersion of people in the Asian region is unclear. At present the earliest people with a generalised East Asian cranial morphology are probably found in the Americas. Is it a possibility that migration across the Bearing Straits went in two directions and the first morphological Mongoloids evolved in the Americas?

Overall the results of this analysis support the conclusions reached by other researchers (Weidenreich 1939, Kaminga and Wright 1988, Howells 1989, Suzuki 1982, Hanihara 1994, Wu 1992) in that it is clear that Upper Cave 101, Liujiang and Minatogawa 1 are not modern or Neolithic East Asians.The dimensions and morphology of their craniofacial skeletons, at least in as far as they were defined in this analysis, fall outside the broad East Asian range of variation. Facial height, orbit shape, malar morphology and relative vault dimensions exclude them from the East Asians. However, can it be argued that they are in some way "incipient" or "protoMongoloids"? This is a far more difficult issue as no one knows what a "protoMongoloid" would look like.

There is also nothing particularly "Australoid" about the morphology of Upper Cave 101, Liujiang and Minatogawa 1. If by "Australoid" Coon (1962) was suggesting like recent Australian Aborigines, then tooth dimensions and facial prognathism alone make them very unlikely candidates (Brown 1989). Greater supraorbital development, including an inflated glabella, more pronounced superciliary ridges and a depressed nasion, was a common feature in early Holocene and late Pleistocene human crania throughout the world. Similarly, human crania during this time period tended to have low, rectangular orbits, a longer and lower cranial vault and greater curvature in the occipital region. The presence of some of these features in Liujiang, Upper Cave 101 and Minatogawa 1 just reinforce the fact that they are not modern crania from the regions in which they were found.

No one should be surprised that these three fossils fall outside the modern East Asian range of variation, after all terminal Pleistocene Australian Aborigines also fall outside the recent Aboriginal range in cranio-facial size and, to a lesser degree, shape (Brown 1989, 1992). One of the best recorded events in the evolution of our species is the global change in body size and robusticty during the first 4000 years of the Holocene. On average people became shorter and less heavily muscled, tooth size and associated facial prognathism decreased, areas of cranial buttressing decreased and cranial vaults became shorter and higher (Brown 1992). To a slight degree this diachronic change is evident in the comparison between the Neolithic and southern Chinese groups. The modern Southern Chinese are closest in their craniofacial size and shape to the 3500 years BP group, then the 4500 years BP group and finally the 6500-5500 years BP group. There is a gradual change, primarily in tooth size, prognathism and facial breadth dimensions, as you move from 6500-5500 years BP towards the present. Perhaps this diachronic change could be used to help predict what earlier East Asians, or "proto-Mongoloids", may have looked like.

In other parts of the world, however, where there is evidence of diachronic change, for instance Nubia (Calcagno 1986; Carlson 1976; Carlson and Van Gervan 1977) and Australia (Brown 1989, 1992) you invariably find that the terminal Pleistocene residents are still recognisable as ancestors of contemporary populations. Late Pleistocene Aborigines are still clearly recognisable as Aborigines, just bigger and skeletally more robust. However, Upper Cave 101, Liujiang and Minatogawa are not readily recognisable as East Asians or as being ancestors of any modern East Asian population. Given the distinctive mid-facial morphology at Baoji (Yan *et al.* 1960) and Huaxian (Yan 1962) at 7000 years BP you should expect to find something similar at the Upper Cave at Zhoukoudian, perhaps only 3000 years earlier. The fact that you do not provides an obstacle for those who argue for evolutionary continuity between mid-Pleistocene Chinese hominids and modern people in the same region (Wolpoff *et al.* 1984).

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Ainu	South central Hokkaido (Howells 1989)
Anyang	Shang Dynasty Chinese, 42 males (Howells 1989)
Arikara, Native Americans	Sully Village site, south Dakota (Howells 1973,1989).
Atayal	Taiwan Aboriginals, 29 males (Howells 1989)
Australian Aborigines	Central Murray River Valley and Swanport , 75 males (Brown 1989)
Australia 10,000 BP	Nacurrie, Coobool Creek and Keilor, 15 males(Brown 1987, 1989, 1994)
Buriat	Siberia, 55 males (Howells 1973, 1989)
China 5500-6500 BP	Baoji, Huaxian, Hejiawan, Xixiahou, Changzhi, Dawenkou and Jiangzhai, 27 males (Yan 1962;Yan et al. 1960)
China 4500 BP	Miaodigou, Wangying, Xiaxihe, Xiawanggang, 25 males (Han and Pan 1979)
China 3500 BP	Yingxu, Yanbulaka, Xunhua, Yangshan, 57 males
Eskimo	Inugsuk culture, Greenland, 53 males (Howells 1973, 1989).
Hainan	Southern Chinese, 45 males (Howells 1989).
Northern Chinese	Primarily Shanxi and Hebei provinces, 37 males of known sex (Black 1928).
Northern Japanese	Hokkaido, 55 males, known sex (Howells 1989).
Peru, Native Americans	Yauyos district, 55 males (Howells 1973, 1989).
Santa Cruz Island, Native Americans	California, 51 males (Howells 1989)
Southern Chinese	Primarily Guandong Province, 38 males of known sex (Brown 1990)
Southern Japanese	Northern Kyushu, 50 males, known sex (Howells 1989)

Table 1 List of materials and sources of data.

	5500-6500 BP		4500 BP		3500 BP		Sth. China		Nth. China		U.C. 101	Liuj.	Minat. 1
	n. 27		n. 25		n. 57		n. 38		n. 37				
Variable list	$\overline{X}$	s.d.	$\overline{X}$	s.d.	$\overline{X}$	s.d.	$\overline{X}$	s.d.	$\overline{X}$	s.d.			
glabella-opisthocranion	183.4	7.12	181.6	7.5	184.9	5.95	181.7	7.58	175.5	5.72	206	191	181
basion-nasion	105.5	5.66	104.5	4.47	102.4	3.84	102.1	4.85	99.35	3.87	109	105	102
basion-bregma	144.9	11.2	140.4	5.8	137.4	5.64	141.1	5.07	136.2	3.99	133	135	136
max. cranial breadth	141.8	5.13	142.2	5.92	139.4	5.65	140.5	7.08	135.4	5.13	144	143	147
bi-auricular breadth	128.1	4.57	131.4	4.68	129.1	8.7	126.0	5.71	123.9	5.22	137	126	129
bi-asterionic breadth	110.6	5.07	110.9	5.74	110.0	5.32	109.0	5.79	106.4	3.86	122	108	117
basion-prosthion	104.4	5.47	98.4	4.82	99.7	4.72	97.9	5.26	94.9	4.06	107	104	(105)
nasion-prosthion	75.5	3.70	75.6	6.18	73.8	4.23	73.3	4.7	73.8	3.69	76	66	(61)
nasal height	53.8	3.00	55.4	4.78	54.4	3.29	54.0	3.41	55.1	2.79	58	46	(50)
nasal breadth	27.1	1.62	26.3	1.62	26.3	1.88	26.1	2.11	25.2	2.16	33	25	25
palate breadth	67.1	3.47	67.2	2.15	65.2	3.36	65.4	2.99	63.7	3.72	69	64	(65)
mastoid height	30.6	2.94	29.8	4.14	30.1	3.37	28.8	3.11	30.7	3.01	31	22	32
orbit height	33.3	2.43	34.0	1.83	33.7	2.38	33.7	2.14	36.3	1.95	34	27	30
orbit breadth	40.9	3.10	41.2	2.41	40.9	2.14	40.3	1.91	40.3	1.71	45	41	45
bi-maxillary breadth	106.9	5.27	105.2	4.91	101.6	4.74	99.9	4.7	97.3	4.83	104	98	(105)
bi-frontal breadth	107.0	3.68	106.9	4.39	104.2	3.78	104.6	4.02	102.4	3.48	108	106	111
nasion-bregma chord	116.3	4.34	113.9	4.51	113.4	3.75	113.7	4.6	109.5	4.28	116	102	105
nasion-bregma subt.	25.8	2.04	25.6	3.01	25.9	2.53	25.9	2.82	24.7	2.64	29	28	20
nasion-subtense fraction	52.9	4.46	51.8	4.07	50.4	4.52	52.2	4.68	48.1	4.24	64	52	47
bregma-lambda chord	114.7	6.63	115.1	5.02	116.3	5.89	114.1	6.5	111.2	5.01	120	118	111
bregma-lambda subt.	25.4	3.23	26.1	3.31	25.2	3.14	25.7	3.16	24.8	2.69	22	25	24
bregma-subtense fraction	59.9	5.44	57.5	5.95	58.5	4.99	55.9	6.15	56.7	5.41	52	65	61
lambda-opisthion chord	103.4	7.04	98.9	4.10	96.8	4.93	98.4	5.17	96.9	5.3	98	92	(95)
lambda-opisthion subt.	29.4	5.31	27.2	3.78	28.7	3.62	29.1	3.85	27.5	3.45	28	25	(22)
lambda-subtense fraction	61.5	9.27	55.9	7.98	53.4	8.64	57.9	6.83	56.2	9.13	33	37	(32)

Table 2 Summary statistics for the Neolithic and modern Chinese samples and individual dimensions for Upper Cave 101, Liujiang and Minatogawa 1 (mm).

Variable	Funct. 1	Funct. 2	Funct. 3	Funct. 4
bi-frontal breadth	–.47230	–.03952	.49044	.26065
orbit breadth	–.15999	–.24841	.43899	.38463
maximum cranial breadth	.28937	.37719	.42437	.41451
bi-auricular breadth	.07338	.24665	.40792	.29646
bi-asterionic breadth	.12728	–.00232	.38644	.25011
basion-nasion	–.11095	–.17179	.02375	.62480
basion-bregma	–.21657	.03579	–.32613	.45456
glabella-opisthocranion	–.08208	–.35475	.15552	.41235
nasal breadth	.08160	.22091	.03853	.31613
orbit height	.07206	–.04212	.21628	.01913
lambda-subtense fraction	–.27006	.10433	–.03483	.16091
lambda-opisthion chord	–.01664	–.05152	–.14476	.06814
basion-prosthion	–.09248	–.29628	.17005	.35607
nasion-bregma subtense	–.04490	–.10485	–.15496	.38796
nasal height	–.15207	.22833	.27291	.33460
nasion-subtense fraction	–.00466	–.04013	.20127	.17977
nasion-bregma chord	–.12478	–.00173	.09989	.26678
bregma-lambda chord	–.17424	–.11473	–.17335	.35618
mastoid height	–.02072	.09165	–.02497	.04246
bi-maxillary breadth	–.03582	.17608	.23465	.23847
lambda-opisthion subtense	.07518	–.03912	.20049	–.05141
bregma-subtense fraction	–.03973	–.08249	–.27955	.27172
palate breadth	.04659	.00390	.21109	.15889
bregma-lambda subtense	–.15112	.08407	–.16968	.07945
nasion-prosthion	–.24346	.24268	.26584	.24854

Table 3 Loading matrix of correlations between predictors and the first four discriminant functions.