

Volumetric and Asymmetry Determinations on Recent Hominid Endocasts: Spy I and II, Djebel Ihroud I, and the Salé *Homo erectus* Specimens, With Some Notes on Neandertal Brain Size

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ABSTRACT Full brain endocast reconstructions of the Neandertals, Spy I and II, Djebel Ihroud I, and the *Homo erectus* specimen from Salé, Morocco have yielded accurate volumes. Spy I = 1,305 ml; Spy II = 1,553 ml; Djebel Ihroud I = 1,305 ml; Salé = 880 ml. While there are no remarkable gyral and sulcal patterns one can delineate, the brain endocasts do show evidence of left-occipital, right-frontal petalias, suggesting right-handedness, and possibly human cognitive specialization, involving symbol processing and visuospatial integration. Some speculations regarding Neandertal brain size are also offered, in which it is suggested that their possibly larger brain sizes were related to greater muscularity than in modern *Homo sapiens*.

The number of reliable and undistorted brain endocasts for Neandertal hominids is very few. Nevertheless, these hominids have always intrigued the paleoanthropological community on the question of whether Neandertals possessed brain sizes greater than our own modern species. Most would agree that this question cannot be solidly answered without more adequate samples of these hominids, both in Western Europe and the Middle East. The return of some neuroanatomists to the level of gross morphological description in combination with a growing appreciation of the significance of hemispheric asymmetries, has led to renewed interest in the "phrenological" evidence for Neandertal cognitive abilities (e.g., LeMay 1976, 1977; Galaburda et al., 1978; and their references).

This author recently had the opportunity, through the kindness and courtesy of Dr. A. Leguebe, to endocast the Spy I and II crania, discovered almost a century ago in 1886 (Fraipont and Lohest, 1886). To my knowledge, these crania had not been previously endocast.¹ Such an opportunity adds two more "classic" Western European Neandertal en-

docasts to the sample previously composed of La Chapelle-aux-Saints, La Ferrassie, La Quina, and the original Neandertal calotte. Both Spy I and II crania are reasonably free of distortions and complete enough to effect accurate reconstruction in both volumetric and morphological observations.

In addition, through the courtesy of Professor Roger Saban, this author received copies of the Djebel Ihroud I and the recent Moroccan Salé endocasts. While volumetric estimates of these have been published (Djebel Ihroud: Anthony, 1966; Ennouchi, 1962; Salé: Jaeger, 1975), they have not been reconstructed with regard to their missing portions. As I have explained elsewhere (Holloway, 1975, 1978), such reconstruction adds more accuracy to volumetric determinations.

This paper is an initial report on the four endocasts, the principal purpose being to make

¹In fact, someone has tried to endocast these specimens, for in preparing the originals I did discover some tiny silicone fragments in the crevices of the internal table of cranial bone.

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the new volumes available to those interested. Morphological description and morphometric studies (e.g., Holloway, in press) are still in progress and will not be fully reported here, except with regard to observations such as size, overall convolutional detail, asymmetries (petalias), and some indices reflective of their shapes. While it is tempting to treat the question of Neandertal brain size and our own, the sample sizes are simply too small and geographically and temporally diverse, to provide anything but a speculatively based argument. In the Discussion section, I will briefly speculate about this question, if only to satisfy the reviewers' curiosity as to what I think Neandertal brain size signifies.²

MATERIALS AND METHODS

Spy I and II

Both of these cranial portions are relatively complete and undistorted, except for the left parieto-frontal-temporal area on Spy I. As described elsewhere (Holloway, 1978), cracks, pits, and fissures were filled with plasticene, and since the crania were relatively complete, plasticene caps were built over the basal portions of the crania so that the liquid latex could be poured into the cavities, leaving an opening approximate in size and location to the foramen magnum. This technique permits a more complete, and thus more rigid, cured latex shell to be extracted once the plasticene is removed. Some eight to ten layers of liquid latex were allowed to individually dry before the introduction of the succeeding pouring.

The crania and their latex interiors were cured at 50°C for 4 hours. After cooling, the plasticene bases were removed, the cured endocasts collapsed, and then were extracted from the interiors. The endocast shells were then filled with liquid plaster of paris in three stages, with the endocasts under water. Once hardened, the now-solid endocasts were measured against the original cranial portions to ascertain distortion.

The original latex endocasts were next molded at the American Museum of Natural History, New York, by Mr. Henig, and solid plaster casts were obtained from these molds. Those regions of the base which were originally plasticene retainers were carved away, and reconstructions of the missing basal portions effected in plasticene (Figs. 1, 2).

Next, the reconstructed endocasts were waterproofed with Krylon spray, and were weighted in air to the nearest 0.1 gm. The endocasts were subsequently weighed in water

and the weight again recorded to the nearest 0.1 gm. This was done on separate, but consecutive days, six times. The difference in weights, by Archimedes' principle, is the volume. The average of six measurements was taken to be the cranial capacity.

Djebel Ihroud I

Through the courtesy of Professor Roger Saban, I received a plaster cast of this specimen, which is undistorted, missing only the basal portions of the posterior part of the rostral olfactory region, medial portions of the temporal lobes, and the lower portions of the cerebellar lobes. These missing portions were reconstructed in plasticene (Fig. 3), and volume determinations were made as described previously.

The Salé specimen

Through the courtesy and cooperation of Professor Saban, I was also able to receive an incomplete plaster endocast of the Salé cranium. Far less reconstruction in plasticene was required, and all excrescences from gaps in the original cranium were carved away. The same methods and procedures described above were used to determine the endocranial capacity of the Salé specimen (Fig. 4).

RESULTS

Table 1 provides the endocranial capacities for these specimens, and those estimations by previous authors from the literature.

With regard to convolutional patterns, none of these endocasts shows any details which can be unambiguously identified. All major sulci, such as the parieto-occipital, lunate, the central or Rolandic, or the Sylvian, are obliterated. *In particular, one cannot trace any of the limbs of the posterior portion of the Sylvian fissure. There are some minor "dimples" in the anterior frontal lobes of Salé, Spy I and II, and none on Djebel Ihroud I.*

The transverse sinus is clearly right on the Salé endocast, Djebel I, Spy II, but left on Spy I. There is no known significance to this

²It would be more accurate to characterize the discussion as a "preliminary speculation," as a manuscript on Neandertal brain size is currently being prepared. In this article, I am excluding all Near Eastern, Eastern and Central European, African, and Chinese candidates for Neandertal identity, because they are either too fragmentary, taxonomically or morphometrically questionable (e.g., see Stringer, 1974; Santa Luca, 1978), or because I have not worked on them directly. I am aware of the pitfalls of small sample sizes, comparing different populations, and the problems of measuring techniques (e.g., Todd, 1923), sex identification, geographic and temporal diversity, evolutionary clades and grades, and so-called early Neandertals such as Swanscombe, Ehrhardsdorf, Steinheim, etc.

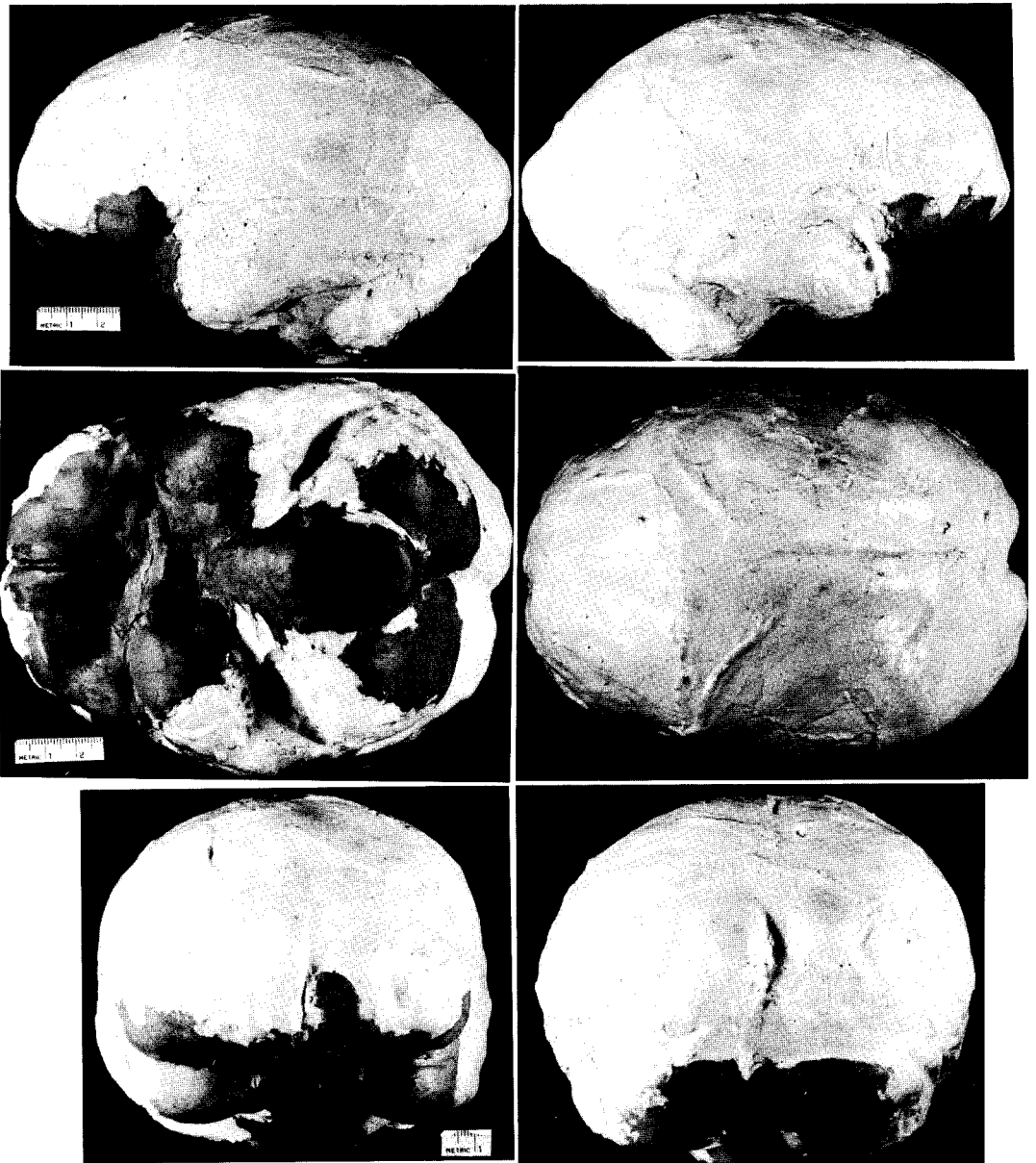


Fig. 1. Photographs of the reconstructed Spy I endocranial. First row, left to right, left and right lateral views; second row, basal and dorsal views; third row, frontal and occipital views. In each view, the endocranial has been oriented in a plane passing approximately through frontal and occipital poles.

feature. All of the endocranials however, do show left-occipital and right-frontal petalia patterns, which include both the anterior-posterior and medial-lateral petalias. This pattern is typical of modern *Homo sapiens* (LeMay 1976, 1977; Galaburda et al., 1978).

The Broca cap region of the third inferior frontal convolution is very protuberant on the left side of the Djebel Ihroud endocranial. This feature cannot be seen as clearly in the others.

The endocranials of Spy I and II and Djebel Ihroud are platycephalic, and clearly Neander-

TABLE 1. Endocranial capacities (measured in ml)

Endocast	This work	Previous estimates	Sources
Spy I	1,305	1,525 (Coon)	Coon, 1962
		1,562	von Koenigswald, 1976
		1,300	Thoma, 1975
Spy II	1,553	1,425	Coon, 1962
		1,504	Thoma, 1975
		1,480	Anthony, 1966
Djebel Throuid I	1,305		Ennouchi, 1962
Sale	880	930-960	Jaeger, 1975

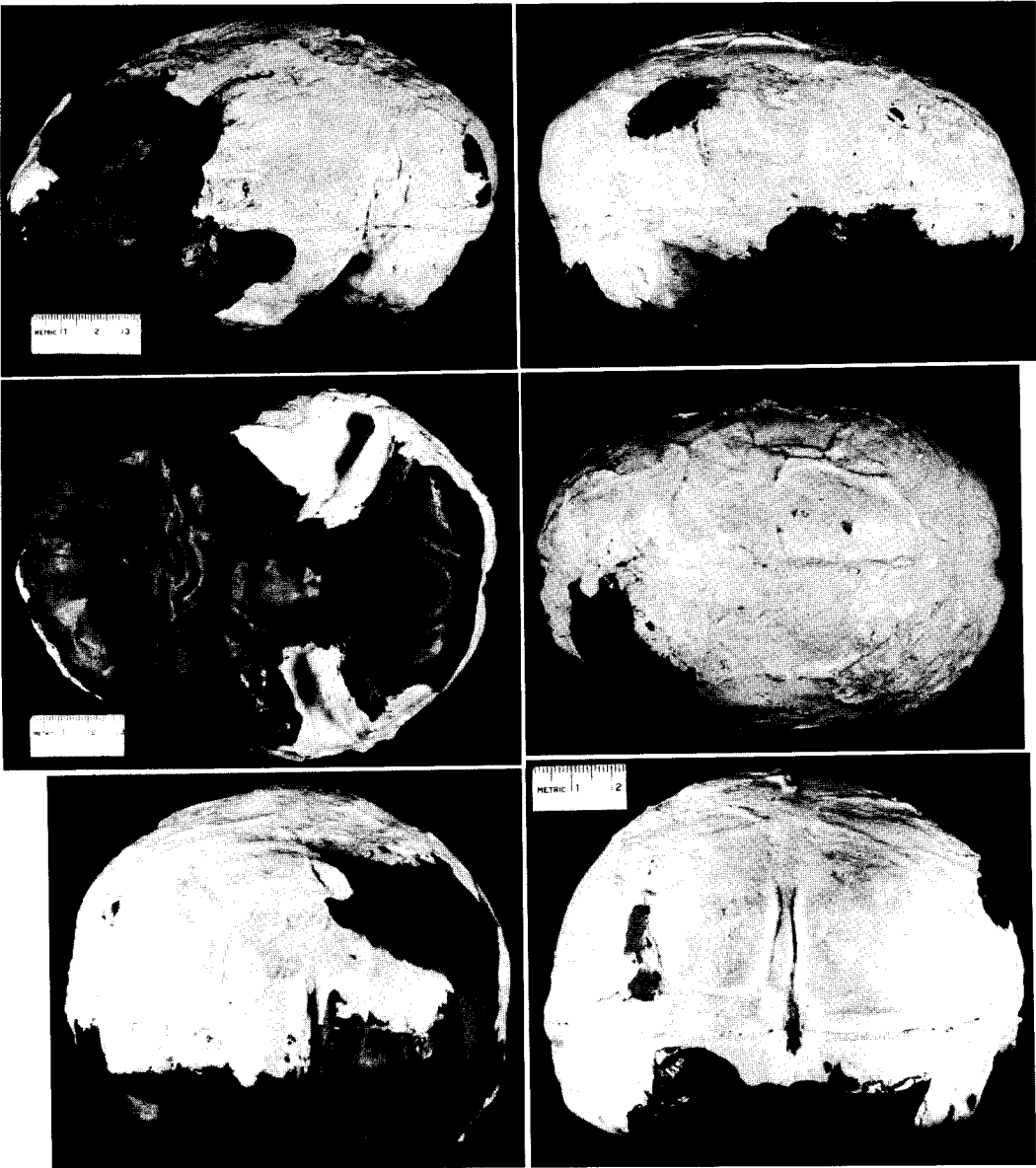


Fig. 2. Reconstructed endocast of Spy II. (Description as in Fig. 1.)

tal in appearance. Anthony (1966) published a brief description of the Djebel Ihroud endocast, stressing its Neandertal qualities, and provided a few metrical values, which are incorporated in Table 2. The Salé specimen, however, while the smallest, has considerable parietal bossing when viewed posteriorly.

The meningeal patterns of Djebel Ihroud and Salé have been described by Saban (1977) and will not be repeated here.

DISCUSSION

Given the lack of distortion in the Djebel Ihroud I, Salé, or Spy II crania, this author is

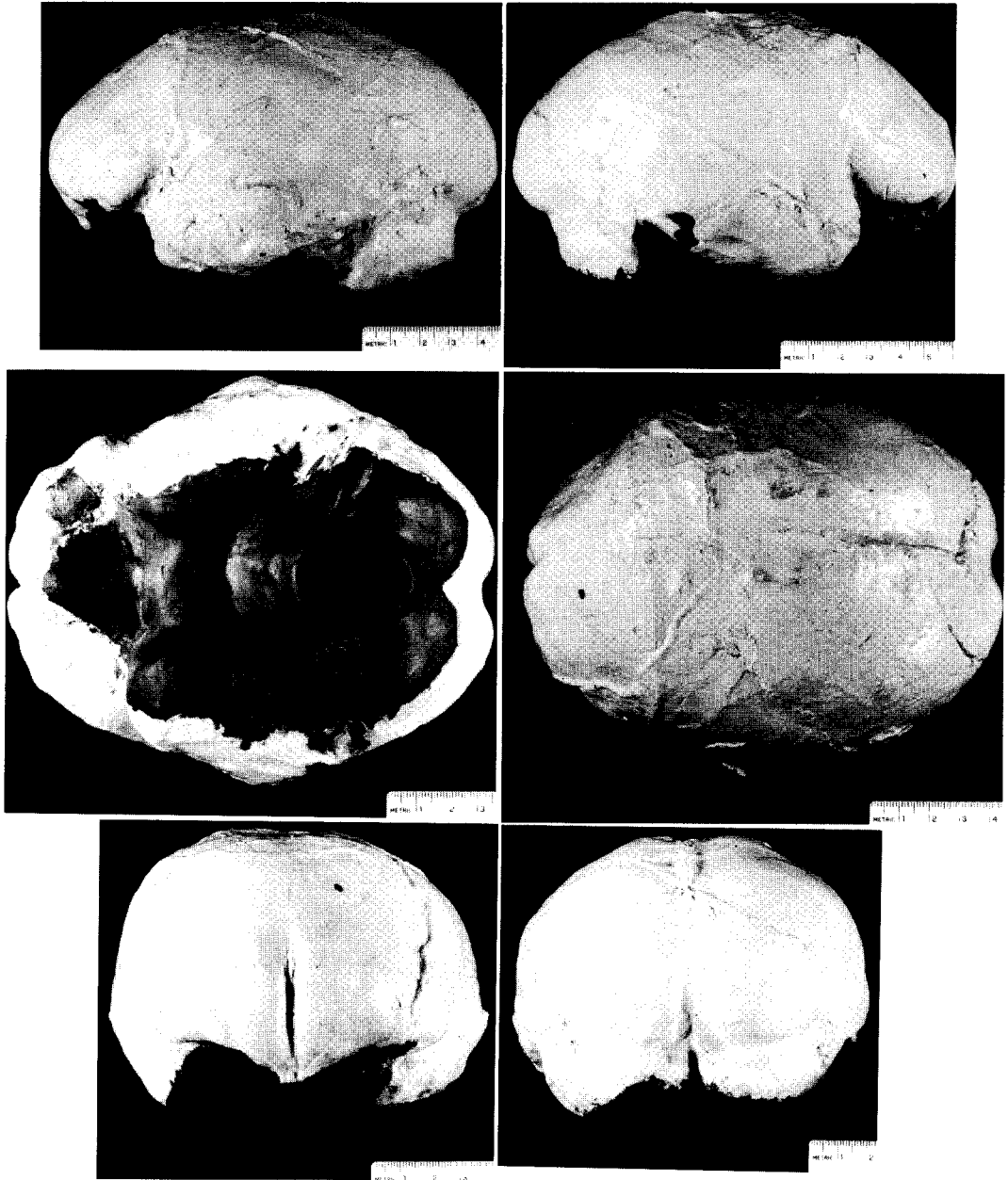


Fig. 3. Reconstruction of endocast of the Salé specimen. (Description as in Fig. 1.)

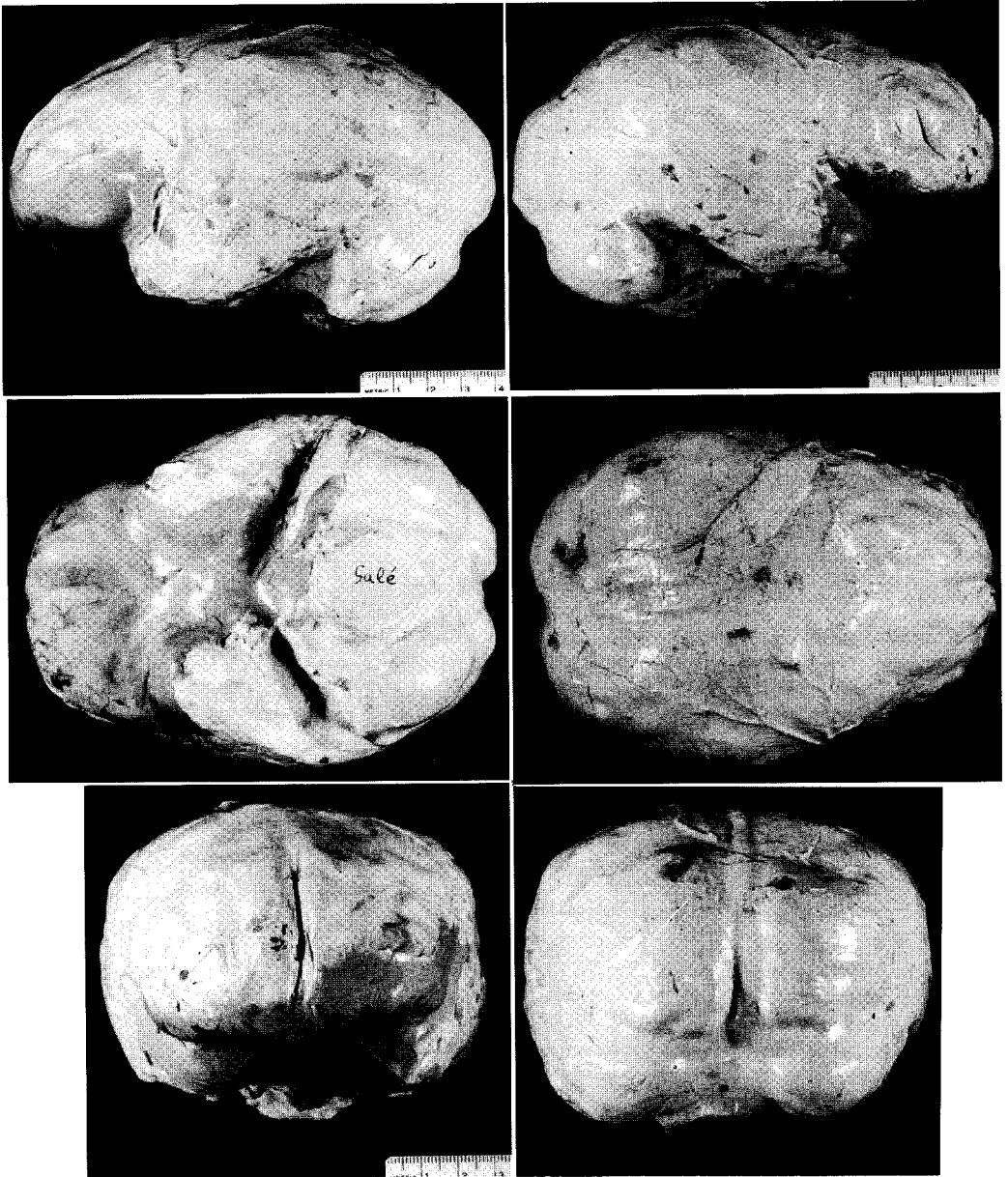


Fig. 4. Reconstruction of Djebel Ihroud I endocrast. (Description as in Fig. 1.) Note that the dorsal view appears distorted: This is due to the bregmatic hump, and the photograph does not fully indicate the lateral extent of the right frontal petalia.

fully confident of the reconstructed volumes reported herein. The distortion of Spy I is very minimal so that any error due to distortion is unlikely. In all cases, reconstruction was only necessary for small portions of the total endocrast and thus the volumes should be

reasonably accurate on that basis also. Original endocranial measurements on Salé and Djebel Ihroud I are not available, so it is unknown as to whether or to what degree the original plaster portions might have shrunk or expanded in the endocasting and casting pro-

TABLE 2. Some endocranial measurements, chord and arcs, in cm¹

Measurement or index	Endocast							
	Spy I		Spy II		Salé		Djebel Ihroud	
	L	R	L	R	L	R	L	R
1. A-P length (frontal pole to occipital pole) — chord	17.7(E)	17.6	17.4(E)	17.4	15.5	15.5	17.2	17.2
2. Maximal width	14.4 (PT)		13.6 (PT)		12.2 (T)		14.1 (T)	
3. Height (vertex to temporal poles)	11.6		11.3		9.2		10.9	
4. Bregma-Lambda			(Indistinct)		(Indistinct)			
a. chord	10.5		N.A.		N.A.		11.0	
b. arc	11.0		N.A.		N.A.		11.5	
5. Bregma-Asterion								
a. chord	12.9	13.1(E)	N.A.		N.A.		12.4	12.3
b. arc	15.3	16.9(E)	N.A.		N.A.		14.8	15.5
6. Length/height (1/3)	1.52		1.54		1.68		1.58	
7. Width/length (2/1)	0.82		0.78		0.78		0.82	
8. Width/height (2/3)	1.24		1.20		1.31		1.29	

¹Symbols used: (E) = estimate; (T) = temporal lobe; (PT) = posterior temporal or lower parietal; (N.A.) = not available; L = left; R = right.

cess. Usually, such changes in dimensions are extremely slight, rarely over 1% from my experience. In any event, Table 2 indicates a few linear measurements on the reconstructions should anyone wish to pursue the question.

During earlier visits (1971–1972) to examine the Spy I and II crania the crania were filled with water (after closing all cracks and foramina), to get some rough estimates of their volumes. These were: Spy I = 1,280–1,300 ml, and Spy II = 1,575–1,580 ml. Given the radically different methods, these values compare well with the fully reconstructed positives.

One of the more frustrating experiences has been trying to find well-documented estimates of the Spy I and II cranial capacities. Coon's (1962) values from his Table 37 (Appendix, no page number) are not cited as to sources, and are clearly reversed in order. Sergi (1974:14) has an interesting sentence which claims that Fraipont passed on the volumes of 1,562 ml for Spy I and 1,723 ml for Spy II to Boule but the latter did not publish them. The context includes a brief discussion of Manouvrier's methods as Sergi applied them to Monte Circeo I, but the question of such application to the Spy crania remains open. Dubois (1921) claimed that Fraipont provided the 1,562 and 1,723 ml values (also discussed in von Bonin (1934:21), which probably explains Coon's (1962) Table 37 values. More recently, Thoma (1975) suggested values of \pm 1,300 ml for Spy I and 1,504 ml for Spy II, values very close to those reported herein by

this author. As Table 1 reflects, aside from Thoma's (1975) values, there are considerable discrepancies between some of the values reported elsewhere and in this study. This is another reason why this author is hesitant to undertake any in-depth statistical analysis of Neandertal vs. modern *Homo sapiens* brain size.

If Boule's (1909) values of 1,626 ml for La Chapelle, 1,525 ml for Neandertal, and 1,350 ml for La Quina are correct, and the value of 1,641 ml for La Ferraissie is also reliable, the combined sample of six Western Neandertals (including Spy I and II) yields a mean volume of 1,504 ml with an S.D. of 145.8, and a coefficient of variation (C.V.) of 9.69%. If Spy I and La Quina are excluded, on the assumption that they were female Neandertals, the mean male volume is 1,584.7 ml, with an S.D. of 54.7 ml, and a C.V. of 3.45%. Trinkaus (1980:385) regards Spy I as female on the basis of the postcranial bones, but warns us that the postcranials do not necessarily belong with the cranium. Smith (1980) reverses them, but with a similar caveat, and regards the sexing of La Quina as difficult. Smith's male identification for La Quina appears to be based on the mandible and supraorbital region, whereas the mastoid and nuchal plane regions are respectively F/M, M/F, i.e., intermediate. (Monte Circeo and Saccopastore, as well as all Middle Eastern Neandertals have been purposefully excluded since either their values or temporal and geographic relationships are problematic to the concept of a "classic"

Western European Neandertal population.) One can readily find cranial capacities for modern *Homo sapiens* males in excess of 1,585 ml, and in excess of 1,327 ml for females. Population figures, however, are another matter, as any reading of von Bonin's (1934) classic paper will indicate, given the problems with perfectly comparable techniques in assessing cranial capacity with water, various seeds, or shot. The highest "population" figures I have found, where one person ascertained the capacities, are from Hrdlicka's (1942:394, 424) listings for Northern and Eastern Eskimo (1,555 ml, N = 17), Greenland Eskimo (1,527 ml, N = 45), Nelson Island (1,566 ml, N = 8), and Southampton Island (1,555 ml, N = 45).

There are a number of points and caveats which should be made. First of all, how reliable are the older published data, e.g., Hrdlicka (1942)? Secondly, if there are body-size relationships with brain-size as Pakkenberg and Voigt (1964) and myself (Holloway, 1980) indicate (see also Szarski, 1980), any comparisons should be limited to breeding populations or ethnic isolates where stature, body weight, and hopefully, lean-body-mass are known and comparable. How secure would such guesses be for comparable data in Neandertal samples? The impression I receive from Trinkaus's (1980, 1977) studies is that Neandertals were heavily muscled hominids, and probably possessed relatively high ratios of lean-body-mass to other tissues. Indeed, Trinkaus and Howells (1979:125) suggest that Neandertal brains were larger because they were more heavily muscled. This becomes a fascinating connection, briefly argued (in a different context) by Szarski (1980), but fully anticipated some 60 years ago by Dubois (1921), and in direct connection with Neandertals! If I might be permitted some levity, one could call it the "meat-head" view of Neandertal brain size, meaning that given so much striated muscle fiber, their brains were naturally larger on the average than our own. I believe there is much to recommend this view, but I trust it is obvious that much more work needs to be done on the problem, and I suggest it only as a speculation that I currently favor. In other words, I believe that on the average, Neandertals did have larger brains than ourselves, but that the size difference was related to a greater amount of striated muscle fiber, i.e., lean-body-mass. Once this is somehow corrected, the differences might disappear. I certainly do not subscribe to the view that we are less mentally efficient than our Neandertal ancestors.

Finally, some comments about the morphology of these endocasts may be of interest. The convolutional patterns are extremely vague and it is not possible to describe, with any certitude, features such as the lunate sulcus, or more particularly, ascending or descending limbs of the posterior part of the Sylvian fissure. I cannot find them. Their patterns of asymmetry are, however, very interesting in light of Galaburda et al.'s (1978) and LeMay's (1976, 1977) observations.

The petalial pattern for right-handed modern *Homo sapiens* is very distinctly weighted in the direction of left-occipital (both A-P and lateral) and right-frontal (lateral) petalias. This pattern appears on each of the four described endocasts. Current studies at Columbia University with Ms. Christine de L'Coste (unpublished) are showing that this pattern does extend back to the Australopithecines. It is a very different pattern from that seen on approximately 140 pongid endocasts examined thus far. Gorillas and other pongids may occasionally show petalias, but they very seldom show the human combination of petalial patterning described above. To the extent that such petalial variation correlates with handedness, and cognitive specializations such as symbol processing (left) and visuospatial integration (right), these traits appear fully present in *Homo erectus* and Neandertals. This too, is speculative, but the patterns are present in Spy I and II, Djebel Ihroud I, and the Salé specimens described in this paper.

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