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The Poor Brain of *Homo sapiens neanderthalensis*: See What You Please . . .

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ABSTRACT Neandertals have always been viewed as primitive, and they are currently viewed by some as large-brained but without language (or having a highly restricted one), and retaining primitive features in their brain endocasts. Their large size most probably relates to allometric and metabolic adaptations related to muscularity and living within a periglacial and/or tundra-like habitat, and not behavioral complexity. Their endocasts do not show "primitive" features if size, convolutional patterns, and asymmetries are considered together. Were modern living human hunters and gatherers to be judged on the basis of stone tool technology alone, they would probably be considered less advanced, "brain-wise," than Neandertals.

INTRODUCTION

Poor *Homo sapiens neanderthalensis*.[1] Surely no other ethnic group has had so many nasty slurs and insults thrown at itself than our distant cousins of some 40,000 to 50,000 years ago. All manner of pathological (*à la* Virchow), teratological (rickets, vitamin-D deficiency, e.g., Ivanhoe, 1970), imbecilia (whether from Italy, Ireland, Russia, etc., etc.), and evolutionary insults have been leveled at this early representative of a lineage whose brain was somewhat larger than our own. The final blow is the somewhat prevalent attitude that, based on computer decisions and a lack of art work, poor Neandertals were also mute, or at least babbling away with a highly restricted set of phonemes (Lieberman, 1975, 1976; Lieberman et al., 1972; Lieberman and Crelin, 1971; Marshack, 1976; Jaynes, 1976; cf. Falk, 1975; Wind, 1976; DuBrul, 1976). The movie "Quest for Fire," unless it was all in my imagination, even had them taking their women from behind, until finally some copulatory finesse was given them by the gracile folks, a gift surely good as fire.

The prominent brow ridges, the largish and broad nasal aperture, the large teeth, the lack of a mental process on the chin, the occipital bun, etc., etc., have produced many a bestial portrait, and indeed the very museum in which this symposium was held (through the efforts of McGregor) produced some beautiful reconstructions. Several generations of introductory anthropology students have been forced to imagine them as wearing three-piece suits, carrying attaché cases, and strap-hanging from our local IRT subways, with the vexing problem of trying to assess whether or not such a beast would fall in the range of modern human normal variation. Usually, I take the position, at least for my students, that yes, *I* would notice them, and regard them (the Neandertal "business men") as unusual in appearance. But for this gathering, and the setting, I will confine my remarks to the Neandertal brain, and what we know about it. This is an easy

[1]I am using *neanderthalensis* as a subspecific designation, meaning that I regard these *people* as fully *Homo sapiens*, differing from modern populations in a way analogous to the differences between, for example, Australian aborigines and Eskimos. In other words, I regard them as yet one more ethnic variation of *Homo sapiens*, being unable to digest or find palatable the hubris of a designation such as *H. s. sapiens*; a designation too wise for the realities . . . .

TABLE 1. Cranial Capacities in Different Samples of Neandertals and "Neandertaloids"[1]

Run 1	Vol. (ml)	Run 2	Run 3	Vol. (ml)
1. Skhūl IV	1,555		Skhūl IV	1,555
2. Skhūl V	1,520		Skhūl V	1,520
3. Skhūl VI	1,585		Skhūl VI	1,585
4. Amud	1,740		Amud	1,740
5. Shanidar I	1,600		Shanidar	1,600
6. Djebel Irhoud I	1,305		Djebel Irhoud I	1,305
7. Qafzeh VI	1,570		Djedel Irhoud II	1,450
8. Neandertal	1,525	Neandertal	Qafzeh VI	1,570
9. Le Moustier	1,565	Le Moustier	Neandertal	1,525
10. La Ferrassie I	1,640	La Ferrassie I	Le Moustier	1,565
11. La Chapelle	1,625	La Chapelle	La Ferrassie I	1,640
12. Spy I	1,553	Spy I	La Chapelle	1,625
13.			Spy I	1,553
14.			Spy II	1,305
15.			Tabūn I	1,270
16.			La Quina	1,350
17.			Krapina B	1,450
18.			Saccopastore I	1,245
19.			Saccopastore II	1,300
20.			Monte Circeo I	1,550
$\overline{X}$ = 1565, S.D. = 101, N = 12		$\overline{X}$ = 1582, S.D. = 49, N = 5	$\overline{X}$ = 1485, S.D. = 142.4, N = 20	

[1]Both Run 1 and Run 2 are for purported males, with Run 2 strictly confined to those "Classic" Western European Neandertals regarded as "cold-adapted." Run 3 includes both males and females, restricted to North Africa, Europe, and the Middle East. Except for Spy I, Spy II, and Djebel Irhoud I, cranial capacities are from Olivier and Tissier (1975). I have only worked on those three endocasts. Run 1 includes Skhūl and Qafzeh fossils which, although not strictly "classic," may nevertheless be associated with more acceptable Near Eastern Neandertals.

task, given that we have never seen one: our cherished hopes of a fully preserved Neandertal corpse imbedded in a block of Siberian ice have not come to light, as yet . . . .

Previous attempts to characterize Neandertal brains as "primitive" have been based on phrenological endocast examinations, which in the "Zeitgeist" of that period (1890–1920) enabled workers to "see" what they believed, or what they wished to believe, particularly with regard to the lunate sulcus or "affenspalte," and the frontal lobes. I will state my conclusions first. I believe the Neandertal brain was fully *Homo*, with no essential differences in its organization compared to our own. It was simply large, and for at least two reasons: 1) it was metabolically efficient within periglacial and/or cold tundra habitats, and 2) it was related to a larger amount of lean body mass than our own, and thus the larger size was, in the main, an allometric scaling effect. Two additional speculations are: 1) Neandertals did have language, and 2) they were highly competent, visuospatially.

BRAIN SIZE AND SAMPLING

It is a vexing problem to decide which discoveries to include in this paper, given the wide geographic distribution of what we commonly recognize as "Neandertal" and the problems of grades and clades, sex determination, and partial crania (e.g., Trinkaus, 1980, 1983; Smith, 1980; Stringer, 1974; Stringer and Trinkaus, 1981; Wolpoff, 1980).

For the purpose of this presentation, I am confining my analysis to the so-called "classic" western European Neandertals, very much along earlier criteria as discussed in Holloway (1981a). There are many statistical analyses that could be performed, depending on one's chosen data base. For example, Table 1 shows three statistical runs; two of these are for purported *males* showing "classic features." Run 1 includes Skhūl IV, V, VI, Djebel Irhoud I, Shanidar I, and Qafzeh II, all from the Middle East or North Africa, showing a considerable range of morphological variations. The Krapina materials, Saccopastore, and Monte Circeo have been deleted, as secure cranial capacities have not been provided and problems of sexing remain (see discussion in Holloway 1981a). In this run, the mean cranial capacity is 1,565 ml, with a standard deviation of 101 ml. If Djebel Irhoud I (1,305 ml) were removed (on the basis of being female), and Amud were also removed on the basis of difficulty of endocast reconstruction, the mean would be 1,574 ml, S.D. = 39 ml, the latter rather low. In run 2, *only* Western European specimens of reasonably certain male identity were used, yielding a mean of 1,582 ml and an S.D. of 49 ml, which is again a low value. Run 3, a "hodge-podge" of males, females, cold-, and supposedly warm-adapted Neandertals (N = 20) still provides a high $\overline{X}$ = 1,485, which is above most averages for northern European populations.

There are, I believe, many weaknesses in these three approaches, and the S.D.s show this. Nevertheless, one must begin somewhere, and I have made the choice fully understanding the vexatious criteria.

A major reason for such constriction really revolves about the choice of modern peoples with possible similar ecological habitats and adaptations, i.e., cold-adapted peoples. Hrdlička's (1942) data on Northern and Eastern Eskimo and on Greenland Eskimo provide male cranial capacities averaging roughly 1,555 ml and these were peoples with high lean body mass compositions, i.e., heavily muscled. Hrdlička's (1942, p. 396) abstract does not provide summary cranial capacities for Northern and Eastern Eskimo females. However, p. 424 shows, for "General Eskimos," male $\bar{x}$ = 1,485 (N = 468) and female $\overline{X}$ = 1,320 (N = 426). The average is thus roughly, 1,402 cm^3. As Hrdlička pointed out, all of these people were of shorter stature than Europeans.

Finally, there is yet another problem with these samples, in that the so-called "archaic" *Homo sapiens sapiens* (e.g., Cro-Magnon, Combe-Capelle, Predmost, Chancelade, etc.) could well have had equal or higher cranial capacities *if* we had accurate volume estimates. Of course, these too were "cold-adapted" populations of the late Pleistocene. The point of these comments and statistical manipulations is the relative certitude that indeed, Neandertals did have large brains, and that for their stature, they were probably somewhat larger than our own.

SULCAL CONFIGURATIONS

In 1911, Boule and Anthony published their detailed study of the endocast of La Chapelle-aux-saints. This was later followed with studies by Kappers (1929) and Anthony (1928), who also published a detailed endocast mapping for the La Quina specimen (Anthony, 1913). Critical commentaries by Symington (1916) provoked a response from Boule and Anthony in 1917, regarding the latter's interpretations that the Sylvian fissure was best compared to a position to be found in a fetal human brain of seven months of age. (The most useful commentary on these publications can be found in Connolly, 1950, pp. 342–348).

In general, Boule and Anthony (1911) "found" several reasons for considering these early Neandertal specimens as primitive, such as a lunate sulcus (left side) in a somewhat anterior position, a parieto-occipital fissure well anterior of lambda, and an overall "simplicity" of convolutional pattern. Their frontal lobes were deficient as well.

On the basis of Boule and Anthony's (1911) drawings, LeMay (1975, 1976) concluded that the left hemisphere showed a lower posterior ramus of the Sylvian fissure than the right (LeMay, 1976, p. 361; 1977). This was accepted as a partial bit of evidence for cerebral asymmetry and thus a possible handedness, which in the case of La Chapelle-aux-Saints would have been *left*.

This author has examined the Neandertal cap, La Quina, La Ferrassie, Spy I and II, La Chapelle-aux-Saints, Djebel Irhoud I, and an endocast of the Amud specimen. I can only say that I have *no* confidence in *unambiguously* identifying *any* convolutional patterns that are suggestive of a "primitive" condition. As I have pointed out elsewhere (Holloway, 1976a,b, 1978, 1981a,b, 1983a,b, 1984), newer methodologies must be developed to increase the probabilities of accurate location of key cerebral landmarks if continuing controversies (e.g., Falk, 1980, 1983; Holloway, 1984) are to be avoided. Until this is done, there is good reason to consider much of hominid paleoneurology as a sort of "paleophrenology," as characterized by Jerison (1975).

Unfortunately, we are presently confined to making "educated" judgments, and in that sense, I can find no reason to assert that Neandertals had smaller or more "primitive" Broca's areas than did modern *Homo*. Moreover, there is no evidence for any critical weakness of organization or mass in what would be the so-called Wernicke's area of superior but caudal temporal lobe, and anterior inferior parietal zones.

ASYMMETRIES

Cerebral asymmetries are clearly present in the Neandertals mentioned above. Except for La Chapelle-aux-Saints, they appear to follow a classic modern *Homo* petalial pattern (left-occipital, right-frontal) as described and elaborated by LeMay (see 1976, 1977; and Trinkaus and LeMay, 1982, for complete references). These observations were published by Holloway (1981a) for Neandertals in particular, and by Holloway and de La Coste-Larymondie (1982) for all of the available hominoid endocasts (see also LeMay et al., 1982), and its significance was speculatively argued in Holloway (1976a,b, 1983a,b) with regard to language behavior and visuospatial integration.

Stereoplotting methods (as per Holloway, 1981b) are still nascent. Neandertal-*sapiens* comparisons are simply very suspect given the small sample sizes for Neandertals (4–6), which reduce the effectiveness of multivariate techniques enormously.

Symap comparisons (unpublished)[2] between Neandertal and *sapiens* endocasts, based on the analysis of *residuals* following allometric correction, do show some significant differences of features in the anterior occipital-posterior parietal zone. Group differences, however, vanish if brain size is used as a covariate to test F-ratios by another method. Perhaps it is a matter of the occipital bun or "chignon" of Neandertal fame, which has recently been reviewed by Trinkaus and LeMay (1982), as an extended growth phase of occipital cortex in Neandertals. This is an interesting possibility, perhaps signaling an increased amount of primary visual striate cortex.[3] Certainly, the frontal lobe is almost indistinguishable from modern *Homo*, and aside from some increased platycephaly in the mid-dorsal region, no significant differences can be found, as the F-ratios are very low between modern *Homo* and Neandertals (see Fig. 1).

CONCLUSIONS AND SPECULATIONS

One cannot help but wonder what modern archaeologists would conclude after studying all Eskimo, Aleut, Australian, Bushman, and tropical rainforest aboriginal material cutlures *if only stone tools remained.* No language? No ritual? No concern for the dead, spirits, etc.? (cf. Solecki, 1971). And if, by chance, *no* archaeological or ethnographic evidence was available, one would have to conclude on the basis of brain size alone (given our obsession with this variable) that Neandertals were more advanced, behaviorally, than living groups whose languages and social customs still defy complete understanding among 20th century anthropologists. Perhaps to someone (or something) from outer space, it would be the brains of the 20th century anthropologists that require study. After all, many of the above aboriginal groups do have rich social culture, and many speak more languages than the average American.

The punch line for all this muted speculation and discussion is that the lean body mass proportion and larger brain size for Neandertals was published before most of us were born. By whom? Eugène Dubois (1921). The suggestion was re-echoed by Trinkaus and Howells (1979), and, using data from Danish brain weights (Pakkenberg and Voigt, 1964), by Holloway (1980, 1981a). Unpublished data from roughly three thousand autopsy cases, multi-ethnic in composition, shows that there is a stronger correlation between brain size and body size (particularly stature) in males than in females, which is particularly strong in age cohorts (by decades) from 30–60 years.[4]

If this relationship is added to the interesting clinical data from Beals et al. (1984), that smaller brain sizes are found in more tropical regions, the large size of Neandertal brains has its explanation in biological interrelationships among size, lean body mass, temperature, and metabolism, and *NOT* complexity (or lack of it) of behavior. One does not have to wait for Neandertal carv-

[2]Unfortunately, prior to 1981, the endocasts of Spy I and II and Debel Irhoud I were not available for inclusion in the pilot study of the dorsal surface, and since that time no further progress has been made in enlarging the sample or replicating the original studies on a more accurate and partially automated stereoplotter device. As no funding support exists for this project, no progress is in sight . . . . As my 1981a paper explains, discriminant analytic techniques must be limited to a number of variables not larger than the sample size of any one relevant group, e.g., Neandertals.

[3]I am aware, through the kindness of Dr. Clive Harper (personal communication) of the Royal Perth Hospital, Western Australia, of work in progress using image-analytic techniques to quantify volumetric distributions of cerebral cortex between Australian aboriginal and Caucasian brains. There appears to be a higher percentage of lateral visual striate cortex among aboriginals, which, if true, would correlate in an interesting way with published cognitive testing of visuospatial abilities between aboriginals and Caucasians, in which the former have higher test scores regardless of cultural training (e.g., Kearins, 1981). As the Symap Figure 1 shows, there are high F-ratios between modern human and Neandertal endocasts in a portion of anterior occipital and posterior parietal cortical zones. These *prove* nothing at present, and thus my suggestion of spatiovisual competency being heightened in Neandertals is purely speculative.

[4]These data, currently being analyzed, are from autopsy cases for Australian aborigines and Caucasians, and Black, Hispanic, and Caucasian samples from New York.

difficulty of endocast reconstruction, the mean would be 1,574 ml, S.D. = 39 ml, the latter rather low. In run 2, *only* Western European specimens of reasonably certain male identity were used, yielding a mean of 1,582 ml and an S.D. of 49 ml, which is again a low value. Run 3, a "hodge-podge" of males, females, cold-, and supposedly warm-adapted Neandertals (N = 20) still provides a high $\overline{X}$ = 1,485, which is above most averages for northern European populations.

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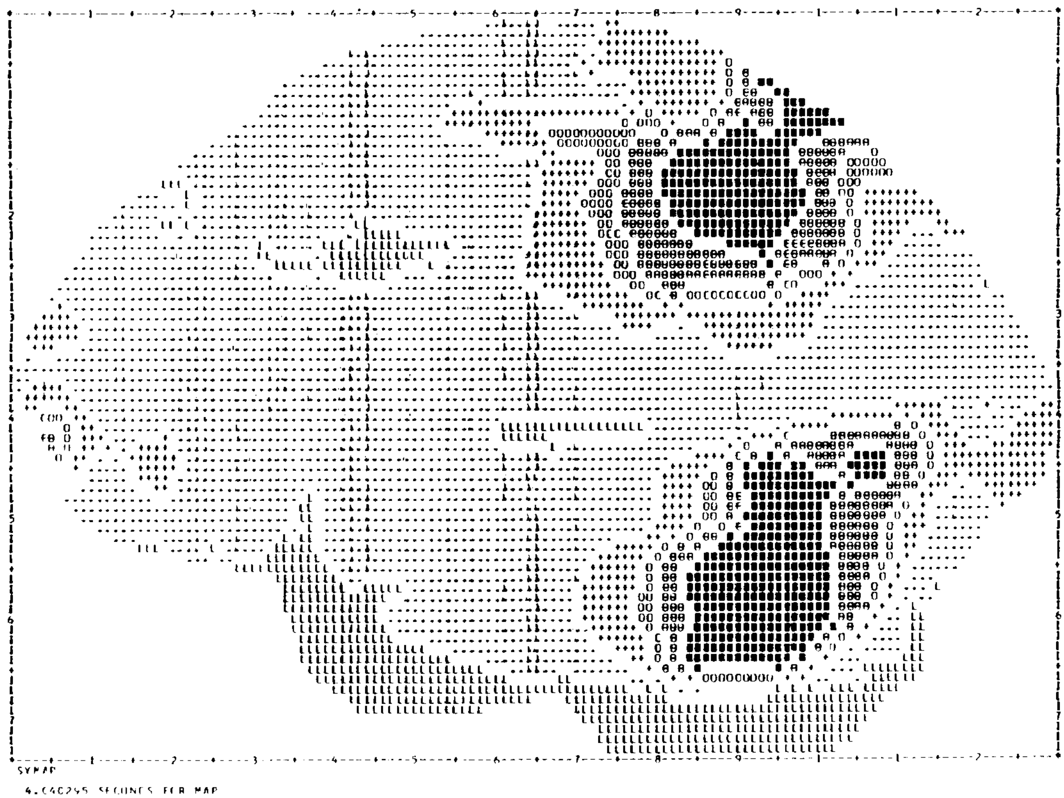

Fig. 1. Symap picture for modern human–Neandertal comparisons of univariate F-ratios and their approximate distribution on the lateral and dorsal endocast surface, *after* allometric corrections have been made (see Holloway, 1981b for details). The "black holes" are those regions with the highest F-ratios for the residuals (after allometric correction), and on this "map" they varied between 16 and 29.6. The two "black holes" are in the following areas (per Brodmann's classification): upper, areas 5 and 7, or superior parietal lobule; lower, areas 22, 37, 40, 39, which are "associative auditory;" and posteriorly, area 19, or "peristriate" cortex. I suspect but cannot demonstrate that the upper "black hole" is an allometric effect produced by a combination of a greater parietal bossing in modern human endocasts and a more pronounced degree of platycephaly in Neandertals. Much more research is needed to clarify the lower "black hole," which may be an artifact of size, or true cerebral organization. In any event, there is no suggestion that this region, so approximate to Wernicke's area, is more primitive in Neandertals.

ings, cave paintings, or sculptures (we anxiously await knowledge about their Venuses . . .) to credit them with communicative skills and complex social behavior. They buried their dead, practiced ritual, and many would be the Upper Paleolithic and Mesolithic populations that could be denied language abilities if we were to rely exclusively on "soft archaeological" remains.

An alternate title for this paper might be "The Tyranny of Brain Size," for its essential message is about this variable, which, when considered alone, is one that is embarrassingly weak when relationships to behavior are to be made, particularly within species. Just as Blacks and Australian aborigines have been the butt of ethnocentric prejudice for their smaller brain sizes, so have Neandertals for "primitive" endocranial features that are simply nonexistent. Logically (in that above sense), Neandertals should be the brightest of all, a proposition I find equally loathesome . . . .

ACKNOWLEDGMENTS

Parts of this research were funded by NSF grant BNS 7911235. I am indebted to Ms. Beverly March for her skill and patience in typing this paper.

LITERATURE CITED

Anthony, R (1913) L'encephale de l'homme fossile de la Quina. Bull. Mem. Soc. Anthrop. Paris. 6e Ser., *4:*117–195.

Anthony, R (1928) Anatomie comparée du cerveau. Paris: Gaston Doin et Cie.

Beals, KL, Smith CL, and Dodd, SM (1984) Brain size, cranial morphology, climate and time machines. Curr. Anthropol. *25:*301–330.

Boule, M, and Anthony, R (1911) L'encephale de l'homme fossile de la Chapelle-aux-Saints. L'Anthropol. *22:*129–196.

Boule, M, and Anthony R (1917) Neopallial morphology of fossil man as studied from endocranial casts. J. Anat. J. Physiol. *51:*95–102.

Connolly, CJ (1950) External Morphology of the Primate Brain. Springfield, Illinois: C.C. Thomas.

Dubois, E (1921) On the significance of the large cranial capacity of *Homo Neanderthalensis*. Proc. Kon. Ned. Akad. Wetenschappen *23:*1271–1288.

Du Brul, EL (1976) Biomechanics of speech sounds. Ann. N.Y. Acad. Sci. *280:*631–642.

Falk, D (1975) Comparative anatomy of the larynx in man and the chimpanzee: Implications for language in Neandertal. Am. J. Phys. Anthropol. *43:*123–132.

Falk, D (1980) A reanalysis of the South African australopithecine natural endocasts. Am. J. Phys. Anthropol. *53:*525–539.

Falk, D (1983) The Taung endocast: A reply to Holloway. Am. J. Phys. Anthropol. *60:*479–490.

Holloway, RL (1976a) Some problems of hominid brain endocast reconstruction, allometry, and neural reorganization. In: Coll. VI, IX Congr. Union Int. Sci. Pre. Protohist., Pretirage. Nice: C.N.R.S., pp. 66–119.

Holloway, RL (1976b) Paleoneurological evidence for language origins. Ann. N.Y. Acad. Sci. *280:*330–348.

Holloway, RL (1978) The relevance of endocasts for studying primate brain evolution. In CR Noback (ed): Sensory Systems in Primates. New York: Plenum, pp. 181–200.

Holloway, RL (1980) Within-species brain-body variability: A re-examination of the Danish data and other primate species. Am. J. Phys. Anthropol. *53:*109–121.

Holloway, RL (1981a) 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. Am. J. Phys. Anthropol. *55:*385–393.

Holloway, RL (1981b) Exploring the dorsal surface of hominid brain endocasts by stereoplotter and discriminant analysis. Phil. Trans. Roy. Soc. (Lond.) *B292:* 155–166.

Holloway, RL (1983a) Human brain evolution: A search for units, models, and synthesis. Canad. J. Anthrop. *3*:215–232.

Holloway, RL (1983b) Human paleontological evidence relevant to language behavior. Human Neurobiol *2*:105–114.

Holloway, RL (1984) The Taung endocast and the lunate sulcus: A rejection of the hypothesis of its anterior position. Am. J. Phys. Anthropol. *64*:285–288.

Holloway, RL, and de La Coste-Larymondie, MC (1982) Brain endocast asymmetry in pongids and hominids: Some preliminary findings on the paleontology of cerebral dominance. Am. J. Phys. Anthropol. *58:*101–110.

Hrdlička, A (1942) Catalogue of human crania in the United States National Museum collections: Eskimo in general. Proc. U.S. Nat. Mus. *91:*169–429.

Ivanhoe, F (1970) Was Virchow right about Neandertal? Nature *227:*577–579.

Jaynes, J (1976) The evolution of language in the late Pleistocene. Ann. N.Y. Acad. Sci. *280:*312–325.

Jerison, HJ (1975) Fossil evidence of the evolution of the human brain. Ann. Rev. Anthrop. *4:*27–58.

Kappers, Ariens CU (1929) The Evolution of the Nervous System in Invertebrates, Vertebrates, and Man. Harlem: De Erven F. Bohn.

Kearins, JM (1981) Visual spatial memory in Australian Aboriginal children of desert regions. Cognitive Psychol. *13:*434–460.

LeMay, M (1975) The language capacity of Neandertal Man. Am. J. Phys. Anthropol. *42:*9–14.

LeMay, M (1976) Morphological cerebral asymmetries of modern man, fossil man, and non-human primates. Ann. N.Y. Acad. Sci. *280:*213–215.

LeMay, M (1977) Asymmetries of the skull and handedness. J. Neurol. Sci. *32:*213–225.

LeMay, M, Billig, MS, and Geschwind, N (1982) Asymmetries of the brains and skulls of non-human primates. In E Armstrong and D Falk (eds): Primate Brain Evolution: Methods and Concepts. New York: Plenum, pp. 263–278.

Lieberman, P (1975) On the Origins of Language. New York: MacMillan.

Lieberman, P (1976) Interactive models for evolution: Neural mechanisms, anatomy, and behavior. Ann. N.Y. Acad. Sci. *280:*660–672.

Lieberman, PE, and Crelin, ES (1971) On the speech of Neandertal man. Ling. Inquiry *2:*203–222.

Lieberman, P, Crelin, ES, and Klatt, DH (1972) Phonetic ability and related anatomy of the newborn, adult human, Neandertal man, and the chimpanzee. Am. Anthropol. *74:*287–307.

Marshack, A (1976) Some implications of the Paleolithic symbolic evidence for the origin of language. Ann. N.Y. Acad. Sci. *280:*289–311.

Olivier, G, and Tissier H (1975) Determination of cranial capacity in fossil men. Am. J. Phys. Anthropol. *43:*353–362.

Pakkenberg, H, and Voigt, V (1964) Brain weight of the Danes. Acta. Anat. (Basel) *56:*297–307.

Smith, FH (1980) Sexual differences in European Neanderthal crania with specific reference to the Krapina remains. J. Hum. Evol. *9:*359–375.

Solecki, R (1971) Shanidar: The First Flower People. New York: Knopf.

Stringer, CB (1974) Population relationships of later Pleistocene hominids: A multivariate study of available crania. J. Archaeol. Sci. (London) *1*:317–342.

Stringer, CB, and Trinkaus, E (1981) The Shanidar Neandertal Crania. In Stringer, CB (ed): Aspects of Human Evolution. London: Taylor and Francis Ltd., pp. 129–168.

Symington, F (1916) Endocranial casts and brain form: A criticism of some recent speculations. J. Anat. J. Physiol. *50:*111–130.

Trinkaus, E (1980) Sexual differences in Neandertal limb bones. J. Hum. Evol. *9:*377–397.

Trinkaus, E (1983) The Shanidar Neandertals. New York: Academic Press.

Trinkaus, E and Howells, WW (1979) The neanderthals. Sci. Amer. *241*:118–133.

Trinkaus, E, and LeMay, M (1982) Occipital bunning among later Pleistocene hominids. Am. J. Phys. Anthropol. *57:*27–36.

Wind, J (1976) Phylogeny of the human vocal tract. Ann. N.Y. Acad. Sci. *280:*612–630.

Wolpoff, MH (1980) Paleoanthropology. New York: Knopf.