

in a group of burial grounds than can be explained in terms of the natural decay of these teeth. These intravital losses could have been caused either by injury or by periodontosis; the probability of injury can be virtually rejected because of the number of cases. The fact that these losses are observed in such an amount in only some of the burial grounds studied and the fact that they are confined to women are evidence against periodontosis. I consider these intravital losses of front teeth in women to be connected with the long-term load on the teeth of some special activity—and this even in the Middle Ages. I consider it quite natural that Palaeolithic man should have used his teeth as a sort of tool. The finding of fine scratches on the rounded incisal surface does not contradict this; such scratches could arise either from abrasives in the diet or from “tool-use.” It is another question, however, how great the load on the teeth was in different sorts of activity and to what extent it influenced the form of the face.

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Wallace appropriately calls attention to the fact that the hypothesis of the use of the anterior teeth as tools in the Neandertals has never been adequately tested. However, it doesn't seem to me that he has advanced our knowledge much, since he does not actually test the hypothesis himself. The suggestion that Neandertals (and others) were under specific selection to maintain large anterior teeth and roots as the result of their use for other purposes than the direct mastication of food is not solely supported by their wear. There is also the presence of very large roots, labial-lingual expansion of tooth thickness, a high frequency of shoveling (all adding to the structural soundness of the teeth), and the maxillary expansion and thickening (resulting in the loss of the canine fossa) that might be expected to occur in response to stress from incisor loading at a significant angle to the incisor long axis. An alternative hypothesis should be able to explain these additional observations coherently.

Furthermore, I know of no observations suggesting that modern people with an open bite attempt to cut a piece of meat “by manually pulling it over the incisor stumps, or alternately fixing it in the hand whilst the stump-like incisors were raked side-to-side and fore-and-aft like shredders.”

The fine cutting edges that can be found in any Mousterian assemblage, not the worn stumps shown in figure 1, were surely used for cutting.

Finally, the presence of rounded incisors in nonhuman primates is no test of Wallace's hypothesis. It might just as well be interpreted to show that these primates also use their teeth for gripping, holding, and pulling to a significant extent, as is postulated for Neandertals.

In sum, Wallace's hypothesis cannot be accepted for two reasons. First, it does not explain the total morphological complex showing structural adaptation in the Neandertals for anterior tooth loading not related to mastication: that is, loading at an angle to the long axis to the tooth rather than along it. Second, it has no basis in ethnological observation, and in fact posits a rather low degree of intelligence in the Neandertals by suggesting that they used their teeth for cutting instead of the tools that they made.

Curiously, the hypothesis would have no bearing on Brace's statements even if it were correct. Brace suggested that the anterior teeth reduced in size because technological innovations and increased efficiency replaced their use. If Neandertal incisors were large for the reasons Wallace

suggests (cutting, shredding, and tearing), their significant size reduction could still be accounted for by the same mechanism.

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The use of the term “rounded teeth” for what is in reality the result of wear due to mastication does not seem to me appropriate; I think that “abrasion” or “attrition” would be more precise. The data in the literature on tooth wear are rather copious, and the references cited by Wallace give an incomplete idea of their wealth. Unfortunately, they are mostly dispersed in publications dealing with other problems, so that it is difficult to retrieve them. A brief outline of tooth abrasion is given, e.g., by Schumacher and Schmidt (1972). It is well known that in recent man tooth wear is common and that its degree depends chiefly on the cultural level on which food is prepared. In some cases, the use of teeth as tools produces considerable abrasion as well (e.g., the Eskimos). In fossil *sapiens* and the Neandertals (classic as well as progressive), the abrasion of teeth is also common. It is likewise the consequence of dietary influences and, by analogy with recent man, is very probably produced by the use of teeth as tools as well. In my opinion there is no difference in this respect among the various representatives of the Hominidae, fossil or recent. Since the custom of using the teeth as tools has survived through the sapientization of Neandertal man to recent times, the surmise of Brace has no logical foundation, and I agree completely with Wallace.

Reply

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Many people use their teeth as a tool. Seamstresses hold needles, carpenters hold nails, Eskimo women grip hides, and Eskimo men clench bow drills between their teeth (Schour and Sarnat 1942, Lous 1970). Here the incisors are used as a vise, freeing the hands for sewing, hammering, scraping, and drilling. Man's incisors have been employed also as nippers for castrating reindeer (Lous 1970), as pliers for prying off covers of gasoline drums (de Poncins 1941, cited by Turner and Cadien 1969), as jack-hammers for softening hides (Waugh 1933), as scissors for cutting thread (Schour and Sarnat 1942), as scrapers for thinning sinews (Pedersen 1947), as strippers for making rope (Van Reenen 1964), and as rippers for husking coconuts (Sutton 1961). Truly, man's incisors are a multi-purpose tool!

Most likely, La Ferrassie I (and the other Neandertals) used their teeth as a tool, from time to time, like these modern peoples; but this, contrary to most of the commentators, is not the hypothesis under test. The hypothesis examined is that Neandertals *habitually* (or, as Brace says, “regularly”) used their teeth as tools, that this is evidenced by rounded incisor wear, and that non-nutritive use of teeth is a selective factor. The problem is important, not only because the Neandertals are our relatives, but also because it raises the question as to how paleoanthropologists, as historians, are to re-create the life of fossil hominids. The dispute between Brace and me revolves around the kinds of observations that are to be regarded as evidence for and against an hypothesis of human evolution. In this

reply, I will examine the purported evidence for Brace's hypothesis and conclude by suggesting an approach to falsify mine.

Support for Brace's hypothesis, in my opinion, would be (1) evidence that people today habitually use their teeth as tools, (2) evidence that those who do enjoy a selective advantage, and (3) evidence from the morphology of the fossils that the teeth were used regularly as tools. Neither here nor elsewhere known to me does Brace or Wolpoff provide evidence that (1) any living person or any extant population of modern man, civilized or primitive, uses the teeth more for non-nutritive activities than for mastication, or that (2) use of the teeth as a tool—even occasionally—is selected for in modern man (Brace 1962, 1964; Wolpoff 1971; Brose and Wolpoff 1971). Would not the hypothesis be strengthened immeasurably by this evidence, rather than *assuming* habitual use and differential reproduction?

Brace's expatiation on the ciné films he has seen and the dental casts he has studied is entertaining but uninformative. The teeth of the Yuendumu today, Brace reveals, are less worn than the teeth of those that lived 20 years ago. This he supposes owes to a presumed reduction of "strain" on the teeth attendant upon a switch from stone to metal knives. Might not the wear difference be due to less sand and soil in the diet of the present-day Yuendumu? Do the Yuendumu today eat more abrasive-free, commercially prepared, European foods than did the Yuendumu of the 1950s? Is the wear abrasion or attrition?

Brace and Wolpoff ask for ethnographic evidence for the so-called raking and stripping mode of incision. Without this evidence Wolpoff is unable to accept my hypothesis. Although Brace examined the dental casts of the Yuendumu, he did not apparently view the ciné film, made by M. J. Barrett, showing the Yuendumu chewing. Had he, he might have hesitated before declaring dogmatically: "Food is cut, not with the teeth, but with a knife." Barrett (personal communication, 1974) has directed my attention to the Yuendumu's use of their hands to pull a piece of meat over their incisors. No knife, either of stone or of metal, can be seen. "The tearing action," Barrett writes, "is similar to the description you give in your article."¹

With little or no ethnographic evidence to call upon, Brace, we might expect, would turn to the fossils for support. Disappointingly, he offers yet another assertion. Without evidence, we are asked to believe that Ternifine, Ochos, and Krapina specimens have "similar wear patterns" to that of La Ferrassie I. Presumably, Brace refers to Ternifine I and Ternifine III, since the anterior teeth of Ternifine II are missing. Presumably, by "similar" he means rounded wear. On that assumption, I examined photographs of the original teeth of Ternifine II and III and plaster teeth in a cast of Ternifine III, without seeing a rounded-wear pattern. Presumably, Brace studied the originals: I ask him therefore to set down the morphological observations which led him to the conclusion that Ternifine and La Ferrassie I have similar wear patterns and to explain why he thinks those observations are evidence that the individuals used their teeth as tools.

Reading between and beyond the lines, I sense that Brace and Wolpoff are reluctant to accept my tentative suggestion on the etiology of the rounded incisor wear of La Ferrassie I because their attitudes and values about Neandertals might have to be rethought. Acceptance would mean for Brace being "forced to conclude that some other selective force must have been present," for Wolpoff thinking of Neandertals as having a "rather low degree of intelligence." First, let me hurry to reassure Wolpoff: whilst paleoanato-

mists may claim to tell much about a fossil's life from teeth, they don't pretend to find among the bumps and grooves IQ scores. As for Brace, I would no more force him to consider another way of looking at Neandertals than I would compel him to read an account of evolutionary biology (e.g., Mayr 1963, Dobzhansky 1970), where he would learn that natural selection is not the only evolutionary mechanism that sorts genetic variation. Might not genetic drift, as Howell (1951, 1952) has suggested, be responsible for (some? all?) cranio-facial morphology of classic Neandertals?

Wolpoff, following Brace, assumes that the large front teeth of Neandertals are a product of selection. Contrary to Wolpoff, I did not explain anterior tooth size in Neandertals as an adaptation for "cutting, shredding, and tearing." I did not interpret—and I think it wrong of Wolpoff to interpret—my observations as evidence for any selection hypothesis. No claim is made to have explained *any* Neandertal anatomy other than the rounded incisors of La Ferrassie I. Wolpoff believes that the large front teeth were selected for "anterior tooth loading not related to mastication," which is no more than what Brace said in 1964: Neandertal teeth were regularly used as tools. If so, might not this regular use wear the teeth? Is the rounded wear seen on the incisors of La Ferrassie I the result of tool use? I think not, for reasons given earlier, but let us examine the wear on the incisors of other Neandertals. No doubt Brace (and Wolpoff) would agree that their hypothesis is testable and that this approach is a test. According to Howells, Skuhl V does not have rounded anterior teeth. This is more evidence against Brace's hypothesis.

Incidentally, Wolpoff, in suggesting that Neandertal front teeth were loaded extraorally by nonaxial (horizontal and oblique) forces, seemingly is unaware of the extensive periodontal and orthodontic literature implicating nonaxial forces in the etiology of periodontal injury, cemental and osseous resorption, traumatic occlusion, bruxism, spastic masticatory muscles, clicking temporomandibular joints, and referred facial pain (e.g., MacPhee and Cowley 1969, Picton 1969, Gorlin and Goldman 1970, Lerman 1973, Shafer, Hine, and Levy 1974). Here we see Wolpoff, who holds to the notion that classic Neandertals evolved into modern man, unwittingly "explaining" evolution on the basis of pathology. If Wolpoff is correct in believing that the classic Neandertals used their teeth regularly as tools, would not this be more consistent with the idea that they became extinct?

Brace introduces us to historiography with his comment "we shall never *really* know what prehistoric people did with their teeth." Historians would agree. They make no claim to "know" the past or write history-as-actuality. At best they attempt to make internally consistent models of the past out of observations of past events interpreted in the light of the present. Now, it is true that there is some debate amongst historians as to what they have been doing and how best to proceed, but they agree most emphatically that they do not re-create the past from preconceived notions of what ought or ought not to have been. This they wisely leave to novelists, propagandists, and mystics. On this view, I invite Brace to disclose how he comes to know that Neandertal front teeth "are so much larger than dietary uses alone would require."

My hypothesis, that the front teeth of La Ferrassie I were worn by sand and soil in the food, is testable, as I suggested, by making observations under magnification of the tooth surfaces. Evidence against the hypothesis, in my opinion, would be matching upper and lower attrition facets on the enamel rims and buccal incisal borders of the incisors, which would indicate that the wear resulted from tooth-to-tooth contact, during either mastication or

¹I am grateful to M. J. Barrett for the gift of the film, entitled *Mastication: A Dynamic Process*.

bruxism. The anterior open bite, which I inferred from manual articulation of the molars, is questioned by Brace and Koritzer. Again, this is testable. The diagnosis would be either controverted by the presence of incisal facets or confirmed by their absence, since by definition the incisors fail to contact in an anterior open bite. My hypothesis is also falsifiable by showing that the wear is post-mortem damage. Can that possibility be excluded?

Scratches on the incisal surface equal in size to those on other surfaces of the same and different teeth would suggest that the abrasive was ingested grit, the width of the scratches delimiting the particle size of the abrasive. In addition to the location, position, width, and length of the scratches, questions arise as to their pattern. Are they oriented in a preferred direction, or do they criss-cross one another randomly? The questions are almost limitless (e.g., Wallace 1972), but to continue is unprofitable. The question I, and presumably others, are interested in is not what might be, but what *is*, seen on the tooth surfaces of La Ferrassie I. The answer to this question, like the solution to the Neanderthal Problem, will be found, not in the armchair, but at the workbench with the fossils in hand.

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