Anterior sphenoid in modern humans

Lieberman has proposed\(^1\) that reduced midfacial projection (MFP), in which most of the face lies beneath the neurocranium, is a major unique, derived character of anatomically modern Homo sapiens, and that this reduction is largely a consequence of reduced anterior sphenoid length (ASL). Lieberman's conclusions were based on comparisons of a small sample of archaic Homo crania with those of Holocene and Pleistocene anatomically modern H. sapiens. We have made new measurements of ASL and MFP, and find that ASL was incorrectly estimated in those archaic fossil crania in which these landmarks are unambiguously preserved. It turns out that the anterior sphenoid in modern humans is no shorter than in archaic Homo.

The new measurements were taken from better-quality radiographs and computed tomography scans\(^2\) and from the original specimens of Gibraltar 1 and Broken Hill (courtesy of C. Stringer, T. M. Osborne and F. Zonneveld). ASL values in Holocene and Pleistocene modern humans are 19.9 mm (s.d. 2.0) and 20.0 mm (s.d. 1.8), respectively, not significantly different (P > 0.05, Scheffé's F) from those of archaic Homo (Gibraltar 1, 17.2 mm; Monte Circeo, 16.9 mm; Broken Hill, 17.2 mm). Figure 1a confirms that reduced MFP in anatomically modern humans is not associated with a shorter ASL.

To assess the spatial relationships of ASL and MFP in relative terms, we did a geometric morphometric analysis comparing Holocene modern human crania with the three archaic Homo fossils (Fig. 1b,c). The transformation grid indicates that, relative to the size of the landmark configuration, MFP is shortened and ASL is lengthened in Holocene H. sapiens. The factors underlying these changes may include facial reduction, increased basicranial flexion, and expansion of the temporal lobes in the middle cranial fossa. The comparison also suggests that the pyrhygial area between the palate and the foramen magnum is anteroposteriorly constricted in Holocene modern humans, as was inferred by Lieberman\(^3\), but that this is unrelated to ASL.

We conclude that, although ASL is intraspecifically correlated with MFP in modern humans and chimpanzees\(^4\), it does not account for the unique form of the modern human cranium. Our analysis highlights the need for research that integrates comparative morphometric analyses with developmental studies of cranial growth in human and non-human primates.

Fred Spoor*, Paul O’Higgins*, Christopher Dean*, Daniel E. Lieberman†
*Department of Anatomy and Developmental Biology, University College London, 21 University Street, London WC1E 6JJ, UK
e-mail: fsיפור@ucl.ac.uk
†Department of Anthropology, George Washington University, Washington, DC 20052, USA
e-mail: danlieb@gwu.edu
HALOTROP/ACSOE field campaign at the atmospheric research station in Mace Head from 21 April to 30 May 1997. DOAS identifies and quantifies trace gases by their specific narrow-band (less than 5 nm) optical absorption structure in the open atmosphere, separating trace gas absorptions from broad-band molecule and aerosol extinction processes. A measured atmospheric spectrum after analysis is compared with a reference spectrum of IO in Fig. 1. The characteristic absorption bands of IO at 427.6 nm and 436.4 nm are both visible.

During 5–8 May 1997, IO concentrations increased above the detection limit of 0.9 p.p.t. The diurnal variation of IO follows solar radiation (Fig. 2). The ozone concentration during this period was about 30 ± 10 parts per million (p.p.m.). The wind speed (Fig. 2) was higher than during the rest of the campaign. The wind was from the north, resulting in very clean air from the ocean. The correlation of IO concentrations with solar radiation indicates that iodine is produced by the photolysis of precursor species. Wind direction and preliminary trajectory analysis indicate that these species come from the ocean or the nearby shore. As there were increased concentrations of the short-lived iodinated hydrocarbons CH₂I₂ and CH₂BrI (ref. 11), they were the most likely precursors.

We used a photochemical box model (see Supplementary Information) to estimate the magnitude of the different ozone-loss processes for 6 p.p.t. IO at noon. A loss of 0.06 p.p.b. ozone per hour is calculated for the IO self-reaction cycle. Assuming an upper limit to the mixing ratio of 1 p.p.t. for BrO and ClO, the cross-reactions with IO would destroy less than 0.03 and 0.01 p.p.b. per hour, respectively. From the model, we calculated that there was about 6 p.p.t. of HO₂, leading to an effective ozone destruction of 0.07 p.p.b. per hour by the HOI cycle. In the presence of IO, the modelled HO₂ concentration decreases from roughly 8 to 6 p.p.t. owing to the reaction HO₂ + IO. The ratio of [NO₂]/[NO] increases by about 30% as a result of the reaction NO + IO. At constant NO₃ (comprising NO and NO₂) levels of 70 p.p.t., both effects slow down photolytic ozone production by 0.06 p.p.b. per hour. A larger reduction of O₃ production is expected for higher NO concentration, up to a maximum of 0.15 p.p.b. per hour at 0.5 p.p.b. NO₂ (see Supplementary Information).

The estimated total ozone loss of 0.39 p.p.b. per hour is less than the observed variability of the O₃ concentrations of about 10 p.p.b. but has to be compared with the removal rate by dry deposition of around 0.1 p.p.b. per hour over the ocean and 1 p.p.b. per hour over land. Gas-phase reactions, such as photolysis to form OH radicals, destroy about 0.2 p.p.b. per hour of O₃ at noon. A mixing ratio of 6 p.p.t. IO can therefore increase the removal rate of ozone by about 70% over the ocean and 10% over land.

Our measurements show that IO, although recorded only over four days, exceeds the predicted tropospheric concentrations5–9. At levels of 6 p.p.t., IO can have a substantial influence on boundary-layer photochemistry. From our results and other data10, we predict that IO should be present in clean air on coasts populated by macroalgae. Further investigation should establish the conditions that give rise to IO and the frequency of concentration increases.

**Björn Aliche, Kai Hebestreit, Jochen Stutz, Ulrich Platt**

Institut für Umweltphysik, University of Heidelberg, INF 366, D-69120 Heidelberg, Germany
e-mail: stu@uphys1.uphys.uni-heidelberg.de

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