The power of deciduous teeth in diagnosing taxa:
Case study of a late surviving Neandertal in the Caucasus

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Introduction

The Mousterian cave of Barakaevskaya (Barakai) is one of several caves and rockshelters along the Gubs River, located in Borisovskoe Gorge, northern Caucasus (Figure 1) . A single Mousterian layer from this cave yielded thousands of flint artifacts, retouched bones, faunal remains and a child's mandible. Based on its robust size, taurodont molars and morphologically complex teeth, Faerman et al (1994) concluded that the mandible belonged to a Neanderthal.

Figure 1: Location of Barakai cave

Recent dating of the layer in which the mandible was found places it within the range of 38,950-36,420 cal BP (OxA-23002), roughly contemporaneous with Mesmaiskaya (Skinner et al 2005). This new date, together with the somewhat ambiguous dental morphology (e.g. a divided middle trigonid crest), has prompted us to apply relatively new geometric morphometric techniques to confirm the taxonomic status of the individual. In the process ,we examine whether or not the lower deciduous first molar is taxonomically diagnostic. Benazzi et al (2011) have confirmed shape differences (e.g., more ovoid outline) between Neandertals and *H. sapiens* noted in the lower deciduous second molar (Tattersall and Schwartz, 1999; Souday and Bailey, 2011), but the shape of the lower first deciduous molar has not yet been assessed in this way. This study examines variation in the lower deciduous molar shapes of Neandertals, fossil and recent *H. sapiens* and seeks to place the Barakai individual within that context.

Methods

Occlusal images were taken with a Canon Rebel XT and Nikon D80 digital camera or extracted from three-dimensional models based on mCT scans processed at the Max Planck Institute for Evolutionary Anthropology. All teeth were oriented using standard procedures (Bailey 2004). Images were imported into and edited in Adobe Photoshop®. Where the left tooth was not available, the right tooth was photographed and mirror imaged. Backgrounds were removed to ensure maximum contrast and each image was scaled to approximately the same size and resolution (300 dpi).

Outlines were automatically extracted using scripts developed by RI for ImageJ and R (Iovita and McPherron 2011*, Figure 2). Elliptical Fourier analysis (EFA, Kuhl and Giardina, 1982; Ferson et al., 1985) was used to describe the outlines of the dm1 and dm2. Normalized Fourier coefficients were used in order to remove the effects of size, position, and rotation. The elliptic Fourier coefficients for each specimen (from the 2nd to the 8th harmonic) were treated as variables in discriminant function analyses. The d1 coefficient from the first harmonic was retained (the other coefficients, a1-c1 are respectively 1 and 0), as it represents the elongation of the best-fitting ellipse and may contain important shape information. Following Bailey and Lynch (2005), Wilks Lambda was first calculated for MANOVA, then subjected to a permutation test with 10000 iterations. Finally, Barakai was treated as an unknown and reclassified using the LDA, calculating the posterior probabilities of assignation to a particular group.
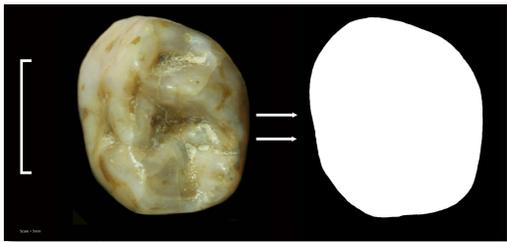

Figure 2: Outline acquisition of lower deciduous first molar

Materials

Our analysis included the deciduous lower first and second molars of 24 Neandertal, 19 Upper Paleolithic *H. sapiens*, 4 early *H. sapiens*, and 131 recent *H. sapiens* individuals from Africa, Asia, Europe, Australia and the Americas (Table 1).

Table 1		
Group	dm₁	dm₂
***H. neanderthalensis* (n=24)** Archi, Arcy sur Cure, Barakai, Cova Negra, Engis, Krapina, Kebara, La Chaise, La Ferrassie, Fontéchevade, Mezmaiskaya, Molare, Peche de l'Azé, Roc de Marsal, Scladina, Valgadoba	n=13	n=18
Upper Paleolithic *H. sapiens* (n=19) Aveline, Balla Barlang, Combe Capelle, Combe Grenal, Estelas, Figuier, Isturitz, Kostenki, Lagar Velho, Madeleine, Miesslingtal, Shukbah, Solutre, St. Germain, Sunghir	n=10	n=15
Early *H. sapiens* (n=4) Qafzeh, Die Kelders, Equus Cave	n=3	n=2
Recent *H. sapiens* (n=131)		
Africa (East, South, West, Egypt)	n=62	n=61
India	n=9	n=10
Europe (West, South)	n=38	n=42
South America	n=16	n=16
Australia	n=2	n=2

Results

Figures 3 and 4 plot the individual lower dm1s and dm2s, respectively. For the lower dm1, Neandertals are clearly separated from Upper Paleolithic *H. sapiens* along LD1, showing no overlap between the groups. Adding early *H. sapiens* and recent *H. sapiens* muddies the picture somewhat. EHS are not separated from Neandertals along LD 1but LD2distinguishes them quite well. Recent *H. sapiens* are somewhat scattered and overlap the Neandertal distribution. They tend to fall in the upper right corner of the plot (positive scores for LD1 and LD2) whereas the Neandertals fall on the lower left corner (negative scores for LD1 and LD2). The outline of the lower dm2 shows a similar pattern, with clear distinction between Upper Paleolithic *H. sapiens* and Neandertals and some recent *H. sapiens* overlapping with the Neandertal distribution. Once again the EHS overlap with Neandertals along LD1 and are better discriminated along LD2.

LD1 accounts for 58.8% of the trace and LD for 31.6% (dm1) and 75.2% and 16.8% (dm2). These linear discriminants are robust at the 0.05 level according to the permutation tests on Wilks Lamda. The Barakai individual classifies as a Neandertal with a posterior probability of 92% based on ldm1 and 87.5% based on ldm2. Not surprisingly, the Barakai individual lies comfortably within the Neandertal distribution for both dm1 and dm2 shapes in Figures 3 and 4.
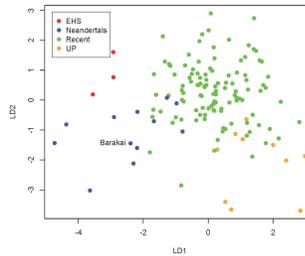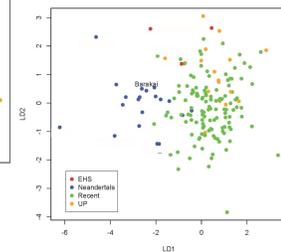

Figure 3: Plot of lower dm1 outlines

Figure 4: Plot of lower dm2 outlines

Conclusions

Until very recently the deciduous teeth of Middle-Late Pleistocene hominins were given little attention. This study of the lower dm1 and dm2 provides further evidence of shape differences in the postcanine teeth of Neandertals and *H. sapiens* and demonstrates the utility of deciduous teeth for taxonomic assessment. The Barakai individual is clearly affiliated with Neandertals, confirming its previous taxonomic designation (Faerman et al, 1994). The recent date places it with other late surviving Neandertals in the Caucasus. We are currently investigating meristic variation and the affect of allometry on the shapes of lower dm1, dm2 and M1 (Bailey et al in prep).

Acknowledgements

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*also available from https://raduiovita.wordpress.com/software/

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