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From the NYCEP Morphometrics Group

Precision in 3-D landmark data collection for geometric morphometrics.

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Geometric morphometrics is an important tool in examining shape variation among and within taxa, and throughout ontogeny. Among the numerous instruments used to collect three-dimensional (3D) data for morphometric analysis are the Microscribe-3DX, a mechanical arm 3D digitizer and the Cyberware 3030 RGB laser surface scanner. While these two instruments accomplish the same goal, inter-device consistency has not yet been carefully tested, nor has inter-observer reliability. Inter-observer and inter-device consistency are required for the sharing and reuse of data. We each collected a series of landmarks (xyz coordinates) on a *Papio ursinus* cranium with both devices and applied multivariate analysis of variance (MANOVA) to examine observer and device effects on the collected data after Procrustes alignment.

Centroid size differed significantly by device, but not by observer. For most landmarks MANOVA indicated significant inter-observer and inter-device differences. Fewer observer-device interac-

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tion differences were indicated. Overall, results suggest that precision (consistency) is comparable in both devices, although for a few landmarks, the laser scanner was significantly less precise. One reason for the inter-device differences in precision may have been the difficulty in visually locating landmark-defining sutures on the laser scan image. However, when landmarks were clearly visible on the laser scan image, the precision between devices was not significantly different. Therefore, while both devices were nearly equivalent in the precision of their measures, it is not possible to say which of these instruments is more accurate ("correct") with this data set.

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3D visualization of inferred intermediates on a phylogenetic tree--applications in paleoanthropology.

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Paleoanthropology has always suffered from an incomplete fossil record and the resulting relative paucity of intermediate forms; the fragmentary nature of many fossils compounds this problem. In a visualization approach, we collect surface data on exemplar specimens with a laser scanner and landmark coordinate data with a Microscribe 3D digitizer on larger samples for each taxon of interest. Generalized Procrustes analysis produces average landmark configurations for each taxon, by sex, which are scaled to the same size and can be compared statistically. Given an a priori cladogram relating these taxa, our program (building from Rohlf's TPS tree) visualizes an intermediate landmark configuration at any point along the cladogram. A thin plate spline is then computed between a chosen taxon and the computed intermediate, and the taxon's exemplar surface is then splined to the inferred intermediate. This 3D image can be rotated to any view and compared visually to known fossils, some of which may be too fragmentary or distorted to have been included in the statistical analysis. We demonstrate this program using data on modern and fossil cercopithecid monkeys and on hominids (great apes and humans). While the resulting visualizations are based solely on the morphometric properties of the chosen landmarks, and do not include character or genetic data, the resulting forms are of value for a more complete understanding of the role of shape in phylogenetics and the proximity of various fossils to theoretical inferred intermediate forms.

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Allometry in the skulls of *Papio* subspecies: Alternative visualization techniques.

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Recent work by Frost et. al. (in prep) has shown that one of the largest components of the shape variation of skulls in Papio is allometry. Landmarks and ridge curves (lines) were digitized on a large sample of baboon skulls using a Microscribe 3D and were subjected to generalized Procrustes alignment. Principal components of this alignment were correlated with scaling as represented by centroid size, and the resultant vector taken to represent allometry. Traditional methods of visualizing the thin-plate spline between forms, as between larger and smaller baboons in this case, either simply show the difference between the positions of the landmarks or use a projection of the thin-plate spline as represented by a deformed regular planar grid, which is movable along any (potentially oblique) axis. These visualizations require user familiarity and may be less suitable to elucidating the deformation of surfaces as versus landmarks, as the surfaces will obscure portions of the projection. As an alternative, we present a method of sectioning the thin-plate spline by a laser-scanned exemplar surface, allowing a much more compact and elegant display of the non-linear transformation of the spline. These visualizations are then assessed by their ability to focus attention on regional features of papionin scaling.

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