

Ontogeny of Facial Fluctuating Asymmetry in African Great Apes

Ashly N. Romero¹, Amy J. Spies², Amandine Eriksen³, Kate McGrath^{4,5}, Jason S. Massey⁶, Halszka Glowacka¹

¹Department of Basic Medical Sciences, University of Arizona College of Medicine – Phoenix, ²Department of Interdisciplinary Health Sciences, Arizona School of Health Sciences, A.T. Still University, ³Department of Biology, University of Indianapolis, ⁴Center for the Advanced Study of Human Paleobiology, The George Washington University, ⁵CENIEH, o Nacional de Investigación sobre la Evolución Humana (Spain), ⁶Department of Anatomy and Developmental Biology, Centre for Human Anatomy Education, Biomedicine Discovery Institute, Monash University

Introduction

Fluctuating asymmetry (FA), defined as random deviations from perfect bilateral symmetry, is thought to reflect developmental instability experienced during ontogeny¹; however, how ontogeny affects FA accumulation remains unclear. Growth for longer durations and/or at slower rates may accrue disruptions that manifest as increased FA². Alternatively, shorter growth durations and/or faster rates may require a trade-off with symmetric growth and result in more FA³.

This study is a preliminary investigation into how growth rate and duration relate to accumulation of FA across ontogeny by comparing both inter- and intraspecific ontogenetic patterns of FA in gorillas and chimpanzees.



Fig. 1: Western lowland gorilla



Fig. 2: Chimpanzee

Materials and Methods

Using 3D geometric morphometrics, we quantified facial FA using 30 fixed landmarks in gorillas (*Gorilla gorilla gorilla*) and chimpanzees (*Pan troglodytes troglodytes*) across sexes and three age categories.

Materials:

- 229 3D scanned ape crania across stages of development categorized by dental eruption (*Gorilla* = 120, *Pan* = 109)

Table 1: Project sample				
Taxon ->	Gorilla		Pan	
Age category	Female	Male	Female	Male
dp4 + M1	20	20	25	16
M2	20	20	17	11
M3	20	20	20	20

Methods:

- Placed 30 3D landmarks in 3D Slicer⁴ across crania (twice) to quantify FA (Fig. 3)
- Procrustes ANOVA, which calculates FA by summing the squared distances between bilateral landmark pairs for each individual (Fig. 4), was performed in MorphoJ⁵
- Sum of squares output was used to calculate the percent variation that FA contributes to the overall variation of each group in the sample

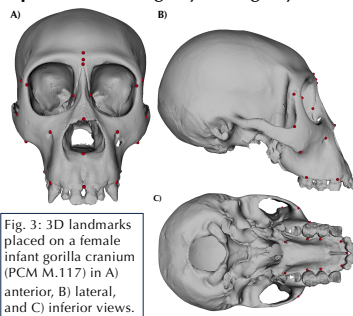
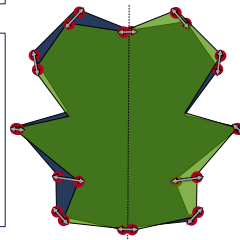


Fig. 3: 3D landmarks placed on a female infant gorilla cranium (PCM M.117) in A) anterior, B) lateral, and C) inferior views.

Fig. 4: Hypothetical shapes represent the original (dark blue) and reflected (green) copy of an organism, while the arrows (gray) represent distances measured and summed to calculate FA level for each individual.



Results

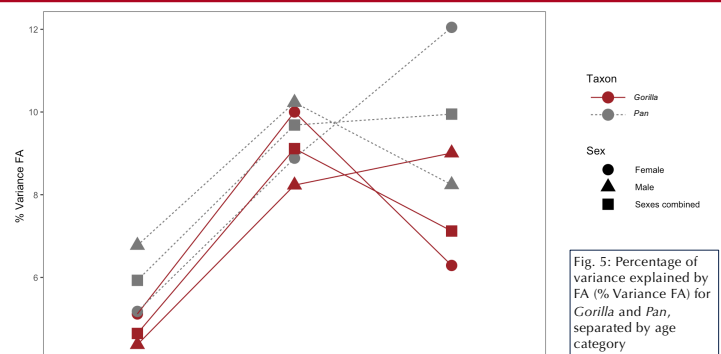


Fig. 5: Percentage of variance explained by FA (% Variance FA) for Gorilla and Pan, separated by age category

- When sexes are combined, chimpanzees exhibit higher percentages of shape variation attributed to FA (% variance FA) than gorillas throughout ontogeny.
- In both species, % variance FA is higher in older age categories (M2 and M3) and in several instances, the M2 category exhibits the highest % variance FA.
- In adult gorillas, males exhibit a higher % variance FA than females and this pattern is reversed in adult chimpanzees.
- Error in the sample is minimal (0.73% to 2.53%), and the ratio of FA to error ranges from 6.19 to 24.45, signifying FA is ~6-24 times greater than the error in the groups.

Discussion and Conclusion

- Preliminary results confirm that facial FA accumulates during ontogeny²; however, body mass growth rate and duration differences between species and sexes (Table 2) do not map neatly onto facial FA results, suggesting that other factors, such as species-specific stress, may be a more important in determining the magnitude of FA accumulation.

Table 2: Comparisons of rate and duration of body mass growth for the species examined in this study based on Leigh and Shea⁶

Comparison	Rate	Duration
Pan vs. Gorilla	Gorilla = Faster	Pan = Shorter
Pan Female vs. Male	Male = Faster	Similar
Gorilla Female vs. Male	Similar	Female = Shorter

- Data from both species indicate an increase in facial FA in the M2 age category, which corresponds to periods of peak growth velocity occurring around this time in chimpanzees (9 yrs) and gorillas (8 yrs)⁶, suggesting that increases in growth rate during ontogeny can influence the accumulation of facial FA.
- Results here indicate a different pattern of adult gorilla and chimpanzee facial FA from Romero et al.³, who found higher craniofacial FA in adult gorillas and suggested that faster growth rates in gorillas account for high FA. This may be due to differences in sample composition, landmarks, or analysis of differing cranial regions.

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College of Medicine
Phoenix
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WEBSITE WITH POSTER PDF
ashlyromero@arizona.edu

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