

## HUMAN LANGUAGE LAWS IN CHIMPANZEE SEXUAL SOLICITATION GESTURES

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### 1. Introduction

Two language laws have been identified as manifestations of universal principles of animal behaviour (Semple et al., 2021). Zipf's law of brevity describes a negative relationship between the length of a behaviour and the frequency of its use (Zipf, 1949). Menzerath's law describes a negative correlation between the number of behaviours in a sequence and the average length of behaviours composing it (Menzerath, 1954). Following Torre et al., 2019's physical hypothesis on the emergence of language laws and given the key role gestural communication played in human language evolution (*review*: Rodrigues et al., 2021), chimpanzee gestural communication represents a powerful model in which to explore compression and language laws (Ferrer-i-Cancho et al., 2022), with repertoires of over 70 distinct gesture types (Byrne et al., 2017). Menzerath's law appears to hold in play gesture sequences, but the play repertoire represents a rare failure of Zipf's law, perhaps due to the nature of that specific context (Heesen et al., 2019). Here, we test Zipf's law of brevity and Menzerath's law in male chimpanzee sexual solicitation gestures, which, in contrast to play, are subject to strong selection pressures for success (Hobaiter & Byrne, 2012).

### 2. Methods

We measured 560 male-to-female sexual solicitation gestures from 173 videos of 16 wild, habituated East African chimpanzees (*Pan troglodytes schweinfurthii*) from the Sonso community, Budongo Forest Reserve, Uganda. We calculated

gesture duration following Heesen et al. (2019). Gestures were grouped into *types*, with each instance being an individual *token* (see supp mat). Tokens performed with less than 1s between them formed a sequence of  $n$  tokens. Single gestures formed sequences of length 1. Following Heesen et al. (2019), we computed correlations and compression values related to the respective laws. We also performed subset analysis, grouping gesture types into manual and whole-body gestures.

### 3. Results

Zipf's law of brevity did not hold. A tendency towards an opposite pattern was detected (Spearman correlation - all data:  $r_s=0.30$ ,  $n=26$ ,  $p=0.066$ ; manual subset:  $r_s=0.42$ ,  $n=21$ ,  $p=0.031$ ; supp mat Figure 1) and was corroborated by the permutation analysis. The expected mean code length  $L$  of the data tended to be significantly big, rather than small, compared to the distribution of  $L$  calculated via  $10^5$  permutations (all data:  $L=0.239$ s,  $p_{right}=0.05$ ; manual subset:  $L=2.26$ s,  $p_{right}=0.058$ ). For whole-body gestures no pattern was detected.

While Spearman's test revealed only a trend towards correlation between average gesture duration within sequence  $t$  and sequence size  $n$  (Spearman correlation:  $r_s=-0.08$   $n=359$ ,  $p=0.076$ ; supp mat Figure 2), the total sum of the duration of each sequence  $M$  was significantly small ( $M=1300.67$ ,  $n=359$ ,  $p=0.003$ ) suggesting a linear association between  $n$  and  $t$  following Menzerath's law.

### 4. Discussion

Our results challenge the view that compression is a universal principle in animal communication (Ferrer-i-Cancho et al., 2013; Börstell et al., 2016) as it does not act on a communicative system uniformly. Although 77% of gesture types described here matched those in play sequences (Heesen et al., 2019), and data belonged to the same individuals, collected over the same period, the two different contexts produced conflicting results: in sexual solicitations we detected an opposite pattern to Zipf's law of brevity and no clear evidence for Menzerath's law. In chimpanzee solicitation the benefits of successful communication to individual fitness appear to outweigh the energetic costs associated with the production of prolonged signals in such a highly competitive environment, fitting with theories on sexual selection of traits (Zahavi, 1975). Although an apparent absence of a pattern may depend on the unit of analysis (Demartsev et al., 2019), there is scope for investigating different parts of gesture structure other than duration, which may shed light on the physical or environmental mechanisms that led to the emergence of these patterns in modern human languages.

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