USING MACHINE LEARNING TO SHOW CHIMPANZEE (PAN TROGLODYTES SCHWEINFURTHII) LIP-SMACK RHYTHM VARIATION: IMPLICATIONS FOR THE STUDY OF HUMAN SPEECH EVOLUTION.

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1. Introduction

Despite the incredible diversity of sound and structure, all human languages have an open-close mouth rhythm of 2-7Hz (Chandrasekaran et al., 2009) that is essential for speech perception (Shannon et al., 1995; Smith et al., 2002). Chimpanzee lip-smacks are an affiliative signal recently found to match the rhythm of human speech (Pereira et al., 2020) and, unlike other primate signals displaying this rhythm (Ghazanfar et al., 2012; Toyoda et al., 2017; Terleph et al., 2018), show substantial variation between and within populations. Human speech rhythm also varies within the 2-7Hz range between languages (Abercrombie, 1967; Ordin and Polyanskaya, 2015) and within them depending on the addressee (Wynn et al., 2018). The recent evidence that chimpanzee lip-smacks vary within the 2-7Hz band suggests that this important step-change in flexibility occurred before our split from other hominids. Whilst suggesting important similarities to human speech, it remains unclear whether lip-smack rhythm variation described (Periera et al. 2020) in chimpanzees was under individual control, and/or shaped by genetic or environmental factors. Here we further explore variation in chimpanzee lip smacks and assess the impact of features of individual (identity, age, rank), partner (identity, relative rank), and group identity. To increase sample size and improve measurement reliability, we employed a novel machine learning approach using DeepLabCut (Mathis and Mathis, 2020).

2. Methods

We recorded videos of lip-smacking from 2007-2020 in two communities within the Budongo population of East-African chimpanzees. We extracted 161 lip-smacking bouts from 26 individuals (19 males, 7 females, age 9-45 years) We created a bespoke chimpanzee facial tracker, to track 10 key-points using DeepLabCut (Mathis and Mathis, 2020). The effect of an individual's community, identity, age, sex, relative rank to their grooming partner or the sex of their grooming partner on bout rhythm was tested with a GLMM.

3. Results

Lip-smack rhythm varied from 1.52hz-9.49hz, with a mean frequency of 2.9hz (± 1.67Hz). The Waibira community showed a mean of 2.9hz (± 1.67Hz) and Sonso a mean of 2.87hz (±1.57Hz). We found no effect of the test variables or their interactions on rhythm. No two bouts displayed by the same individual showed the same rhythm, even within a grooming event with the same partner.

4. Discussion

We employed novel machine learning techniques to generate substantial sample sizes and reveal a new-found degree of flexibility in chimpanzee lip-smack rhythm. Rhythm falls within the range of speech, averaging towards the lower end of the range. This supports previous findings that primate rhythmic facial signals may be a precursor to speech (Morrill et al. 2012; Periera et al. 2020) rather than being dictated by other rhythmic mouth movements, such as chewing. This is further supported by substantial within-individual variation, which may have presented itself as within- and between-group variation in previous studies with small datasets (see: Periera et al. 2020).

Rhythm varied within a grooming bout, where multiple context factors are unlikely to have changed. Like speech, lip-smack rhythm is not fully explained by an individual's identity, sex, age, community, relative rank, or their partner's sex. Instead, they appear highly flexible, potentially reflecting context specific, rapidly changing features within a grooming bout. Controlling for context changes occurring during a grooming bout may offer further insight into what is driving variation. Within-bout variation in rhythm may suggest high levels of fine motor control, allowing chimpanzees to quickly change the timing of their lip-smacking during its production, as human's can to aid their communication during speech (Wynn et al., 2018).

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