MODELLING THE EMERGENCE OF VOCAL GROOMING

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The so-called Gossip and Grooming hypothesis (Dunbar, 1998, 2017), posits that spoken language arose as an alternative to allogrooming as a means of maintaining social bonds in growing group sizes among early humans. Though aspects of Dunbar's theoretical framework have been criticised (e.g. Lindenfors, Wartel, and Lind (2021)), the role of language in social bonding is more widely supported (Tomasello, Carpenter, Call, Behne, & Moll, 2005), and is a key component of the musical protolanguage hypothesis (Fitch, 2017). Here we present a multi-agent model based on work by Slingerland, Mulder, Vaart, and Verbrugge (2009), who showed that greater group sizes can stimulate the use of language within a grooming vs gossip paradigm. We update this model by simulating inter-group contact and subjecting agents to selection pressures acting on tolerance for out-group members, drawing on evidence for increased social connectivity in archaeology (Belfer-Cohen & Hovers, 2020) and selection against reactive aggression in early humans (Benítez-Burraco & Progovac, 2020).

The model

Slingerland et al. (2009) simulated a single group of agents who interact for a number of rounds. Whether this interaction takes the form of one-to-one grooming or one-to-many gossiping is a function of the agents' heritable *gossip probability*. Agents maintain a memory (M) of social interactions that are acquired by participating in, observing, or gossiping about an event. Selection is based on an equal combination of social fitness ($f_{social} = 5 \times \sum_{x=0}^{E_{groom}} \frac{1}{p_x - 1} + 4 \times \sum_{x=0}^{E_{gossip}} \frac{1}{p_x - 1}$, where p_x is the number of agents in a social event x out of all events E) and information fitness ($f_{info} = M^2$) determines which agents reproduce offspring who inherit mutated preferences from their parents.

Our first addition involves investigating group dynamics by dividing the population into multiple groups. The likelihood that an agent interacts with an in- or out-group individual is a function of its heritable *tolerance* preference. Secondly, a recalculation of data (Nakamura, 2000, 2003) and new observations of bonobos and chimpanzees in the wild (Girard-Buttoz et al., 2020) reveal that, contrary to what was originally thought, social grooming is not strictly dyadic and one-way

but is often polyadic and mutual. In line with these findings, gossip and grooming are both one-to-many in the updated model. We investigate if, under these circumstances, gossip still becomes dominant and what the interaction between group dynamics and tolerance is.

Figure 1 shows that a preference for gossip still evolves, in addition to clearly distinct patterns for differently evolved group sizes: agents of large groups develop a preference for gossip with in-group members (low tolerance), while agents of smaller groups rely on both high tolerance and gossip probability.

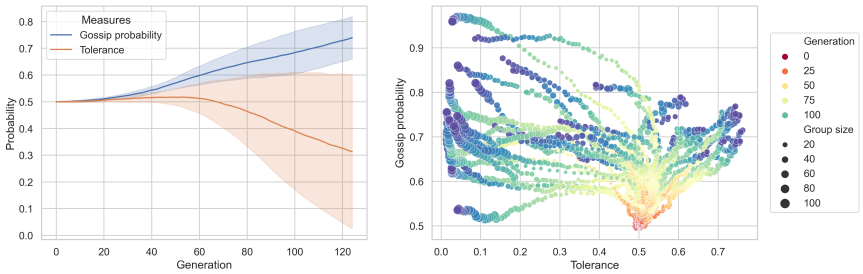

Figure 1. The evolution of tolerance and gossip probability over generations (left). The dynamic between average group size, generation, tolerance, and gossip probability on population level (right). Shaded regions are SD over 40 simulations of 125 generations initialised with 100 agents in 20 groups.

Discussion

We show that vocal grooming (gossip) can emerge as the dominant bonding strategy even when the assumption that clique sizes are different for gossip and grooming are relaxed. While Dunbar (2017) emphasises the role of time constraints in restricting the number of social bonds that can be maintained through one-to-one grooming, as a constraint of group size, our model suggests that the benefit of having information about social events mainly drives the emergence of gossip. Moreover, the results show that the evolution of tolerance is influenced by group structure in the community. Similarly, such ecological factors have been suggested to play a role in inter-group tolerance for primates (Lucchesi et al., 2020). For humans, however, the evolution of inter-group tolerance was likely affected by many other factors including mating patterns and food availability (Spikins, French, John-Wood, & Dytham, 2021). Notably, the Human Self-Domestication hypothesis (Hare, 2017) posits that direct selection against reactive aggression increased tolerance in humans, which may have facilitated more inter-group encounters (Benítez-Burraco & Progovac, 2020). The precise interactions between different factors affecting inter-group tolerance, population dynamics and how these shape the evolution of language is what we propose to investigate further.

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