Chimpanzees organize their social relationships like humans

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Numerous studies reveal that the way humans organize their social relationships exhibits distinctive organizational patterns, which are related to each person's cognitive capacity. As this capacity is not infinite but limited, there is a restriction on the number of relationships an individual can maintain at the same time (famously called Dunbar's number and estimated to be of the order of 150). Additionally, personal networks show a layered structure where each layer corresponds to relationships of different emotional closeness. The size of the layers (typically 5, 15, 50 and 150) exhibits scaling and the intensity of its associated links decreases outwards.

To formalize mathematically the connection between the layered structure of personal networks and the variable effort required for each relationship, a simple resource allocation model was proposed [1]. This model is based on two widely accepted assumptions: the capacity that an individual can invest in social relationships is finite, and different intensities of relationships carry a different cost. A maximum entropy approach including these two constraints yields a one-parameter probability distribution describing the expectation that a given relationship lies in a specific layer, which is in very good agreement with real life observations. In fact, the theory even predicted that when the cognitive capability is very large or the possible friends are only a few, all of them should be in the first layer of very good friends (so called inverted regime), and this was empirically verified *a posteriori*, providing much support for the model.

In spite of this success, this model in [1] treats relationships as discrete categories, and some features that may be used to determine the strength of a relationship, such as time spent together, do not fit this description. For this reason, the original model has been recently extended [2] to study the structure of social relationships when the resources invested in them take continuous values. The probability distribution of this new approach is governed only by one parameter, called η, which is the equivalent in the continuous case to the scaling ratio between consecutive layers in the discrete one. This parameter presents a typical value of $\eta \sim 6$ for several real-life datasets [2], indicating a characteristic feature on how humans organize their social relationships.

By means of this continuous formalism, here we show for the first time evidence that a similar organization of relationships arises in non-human primates, namely in chimpanzees. We use grooming data extracted from over four years of observations of four groups of chimpanzees living in the Chimfunshi Wildlife Orphanage in Zambia, taking grooming as a proxy of the effort devoted to pairwise relationships. Our results confirm that the time chimpanzees devote to grooming other individuals is generally well described by the continuous probability distribution predicted by the model. Thus, every chimpanzee is characterized by a value of the η parameter, and much as in the case of human relationships, typical values of η are close to 6. Furthermore, our results show that the group size influences the organization of their social relationships. In groups consisting of about 10 chimpanzees, the parameter η has a value closer to 0 for most individuals. This indicates an excess of strong relationships compared to the standard situation described by Dunbar's circles—the kind of behavior identified in [1] as the inverted regime, and arising in the same circumstances. In contrast, for larger groups of tenths of individuals, the normal hierarchical structure of the personal network emerges again, and the mean value of the parameter is comparable to the result obtained for humans at the population level.

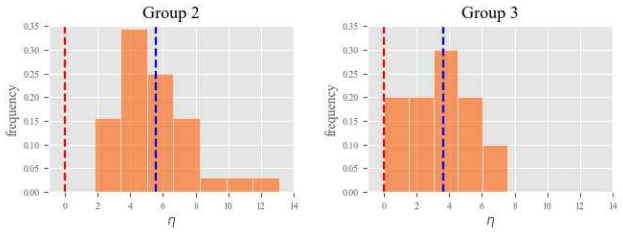

Fig. 1. Histograms of values of η found in a large group (left, $N = 32$) and in a small group (right, $N = 10$) of Chimfunshi chimpanzees. The red dashed line represents the value $\eta = 0$ and the blue one the mean value for each group.

The conclusions of our analysis are twofold: On the one hand, the results provide an indirect confirmation that grooming is indeed indicative of the closeness of a relationship, i.e., it is akin to a measurement of "friendship" among chimpanzees. On the other hand, our analyses confirm the existence of similar social signatures for both humans and chimpanzees, and reveal that they both arise as a consequence of allocating a limited amount of some resource (cognitive capacity) into items (social relationships) with different costs. Therefore, these results should be fairly general and verifiable with data from many other animal species.

[1] I. Tamarit, J.A. Cuesta, R.I.M. Dunbar, and A. Snchez. Cognitive resource allocation determines the organization of personal networks. Proc. Nat'l. Acad. Sci. USA **115**, 8316-8321 (2018).

[2] I. Tamarit, A. Snchez, and J.A. Cuesta. Beyond Dunbar circles: a continuous description of social relationships and resource allocation. Sci. Rep. **12**, 2287 (2022).