Supplementary Information for *Copying is not required for ape cultures*

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Additional model information

This document provides additional information on the individual-based model desribed in the paper *Copying is not required for ape cultures*. The code to run the model and to reproduce the results can be found in https://github.com/albertoacerbi/oranzees, together with a detailed documentation of the model development.

The oranzees world

The oranzees model is an individual-based model, fully written in R, that reproduces a world where six populations of "oranzees" (an hypothetical ape species) live. The model is spatially-explicit: the six populations are located at relative positions analogous to the six populations of chimpanzees in Whiten et al. (1999), see Figure 1. For modelling convenience, we put these locations approximately in the centre of a 1000 x 1000 squared environment in order to be able to process their relative distances, that we use to calculate genetic propensity and ecological availability of the behaviours (see below).

The population sizes are also taken from the real chimpanzees populations considered in the study above. Following Lind and Lindenfors (2010), we use data from R. W. Wrangham (2000):

Group	Population size
Uossob	20
Elabik	42
Ognodub	49
Iat Forest	76
Ebmog	50
Elaham	95

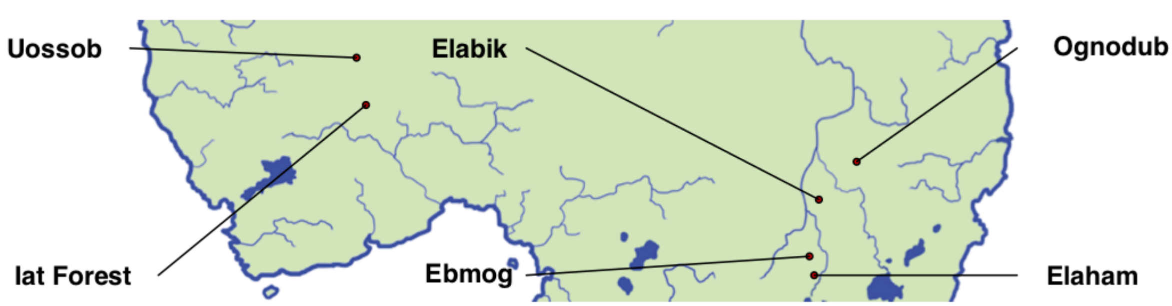

Figure 1: Location of the six populations of oranzees.

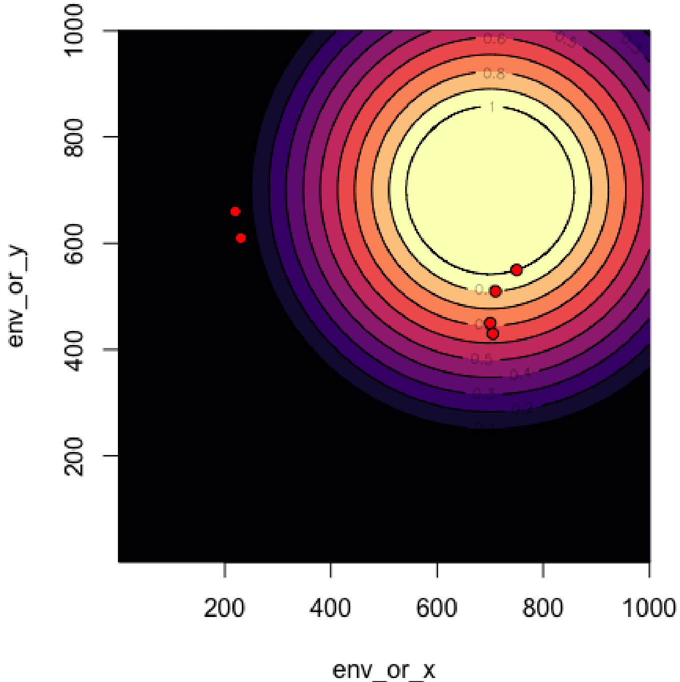

Figure 2: Example of calcualtion of p_g (or p_e). The red points represent the oranzee populations.

Geographical gradient for genetic propensity and ecological availability

As described in the main manuscript, two parameter of the models, α_g and α_e, determine, independently for each behaviour, the probability that the genetic propensity and ecological availability are equal for all the six populations.

If they are not equal, the value of p_g (or p_e) are assigned using a geographical gradient, by choosing a random point in the oranzees' world, and calculating its distance to each population. Distances are then transformed to p_g (or p_e) by rescaling them between 0 and 1, so that for the farther population $p_g = 0$ i.e. the associated behaviour will be impossible to express (or $p_e = 0$ i.e. the associated behaviour will be absent with an "ecological explanation")

In the example in Figure 2, a particular behavior will have $p_g = 1$ (or $p_e = 1$) in the Ognodub site, $p_g = 0$ (or $p_e = 0$) in Iat Forest and Uossob, and intermediate values in the other sites.

Sub-categories of behaviours

There are 64 behaviours, divided in two main categories: “social” and “food-related”. Each category is further subdivided in sub-categories. Sub-categories, for food-related behaviour, are further assigned to specific “nutrients”. These information are used to calcualte oranzees’ state according to its behaviour (see main manuscript). The names of behaviours and of the sub-categories are only suugestive. They are used to illustrate our results in Figure 2 (main manuscript).

Social

Sub-category	Behaviour
Play	fruit-missile
Play	slap-fight
Play	air-split
Play	leaf-mask
Play	whistle
Play	pebble-tease
Play	tumbling
Play	brick-fall
Display	stone drop
Display	branch pull-release
Display	arm-cross
Display	two-hand-drum
Display	splah
Display	arm-swing
Display	explode-leaf
Display	contorsionist
Groom	tool back-scratcher
Groom	hand back-scratcher
Groom	tongue-bathe
Groom	tooth-pick
Groom	dirt-shower
Groom	ant-shower
Groom	q-tip
Groom	exfoliate-fruit
Courthsip	flower-offer
Courthsip	hand-stand
Courthsip	rope-swing
Courthsip	leaf-fan
Courthsip	wreath-clutch
Courthsip	ear-pull
Courthsip	kissy-hand
Courthsip	hop-dance

Food-related

Sub-category	Behaviour	Nutrient
Fruit-hammer foraging	wood-wood	Y
Fruit-hammer foraging	wood-stone	Y
Fruit-hammer foraging	stone-wood	Y
Fruit-hammer foraging	stone-stone	Y
Fruit-hammer foraging	bone-wood	Y
Fruit-hammer foraging	bone-stone	Y
Fruit-hammer foraging	wood-ground	Y
Fruit-hammer foraging	stone-ground	Y
Stick-based foraging	stick-throw V	Z
Stick-based foraging	stick-throw A	Z
Stick-based foraging	fish-stab	Z
Stick-based foraging	hedgehog-flick	Z
Stick-based foraging	worm-hook	Z
Stick-based foraging	bird-probe	Z
Stick-based foraging	fish-hammer	Z
Stick-based foraging	spin-seed	Z
Anvil smash	anvil-smash S	Y
Anvil smash	anvil-smash W	Y
Anvil smash	smash-ground	Y
Anvil smash	drop-ground	Y
Rolling pin tecniques	rolling-wood	Z
Rolling pin tecniques	rolling-stone	Z
Rolling pin tecniques	rolling-bone	Z
Rolling pin tecniques	rolling-other	Z
Insect swatting	bug-clap	Y
Insect swatting	stick-insect	Y
Fish stunning	fish-stun-stone	Z
Fish stunning	fish-stun-wood	Z
Tortoise-flip	tortoise-drop-on-stone	Y
Potato-mash	tube-mash	Z
Clubbing	mammal-clubbing	Y
Egg cracking	egg-crack	Z

Figure 3: Single run with $\alpha_g = 0.2$, $\alpha_e = 0.8$, and $S = 1$.

Example of single run

Figure 3 shows an example of the entire history of all behaviors in a single run, for a single population (geographical location and population size are based on "Uossob"), with $\alpha_g = 0.2$, $\alpha_e = 0.8$, and $S = 1$, i.e. one of the combination of parameters that produces a number of cultural behaviour similar to Whiten et al. (1999).

Age classes to calcualte customary behaviours

To determine *customary* behaviours, we need to define age classes for individuals (the definition of customary behaviours, from Whiten et al. (1999) is a behaviour observed in over 50% of individuals in at least one age class). We define three age classes as follows:

- *adults*: individuals that are more that 16-year old.
- *subadults*: individuals between 8 and 16-year old.
- *juveniles*: individuals that are less than 8-year old.

Figure S4

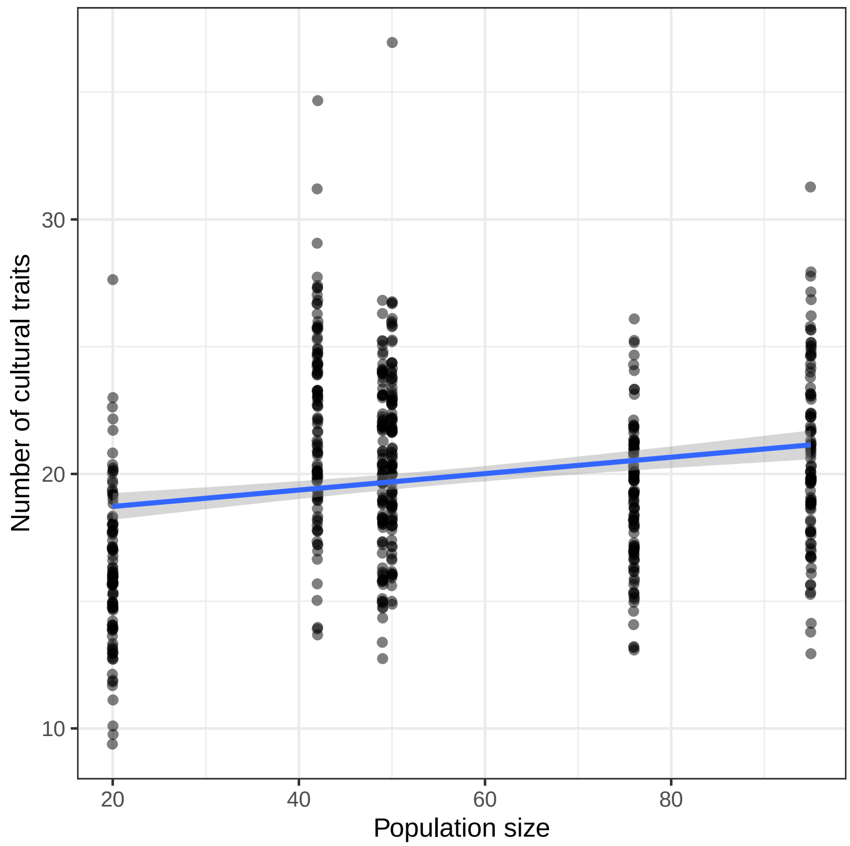

Figure 4: Number of cultural behaviours for each population for the parameters $\alpha_e = 0.8; \alpha_g = 0.2, S = 1$. The blue line is a linear fit of the data. $N = 100$ runs.

References

Lind, Johan, and Patrik Lindenfors. 2010. "The Number of Cultural Traits Is Correlated with Female Group Size but Not with Male Group Size in Chimpanzee Communities." *PLoS ONE* 5 (3). doi:10.1371/journal.pone.0009241.

Whiten, A., J. Goodall, W. C. McGrew, T. Nishida, V. Reynolds, Y. Sugiyama, C. E. G. Tutin, R. W. Wrangham, and C. Boesch. 1999. "Cultures in Chimpanzees." *Nature* 399 (6737): 682–85. doi:10.1038/21415.

Wrangham, Richard W. 2000. "Why Are Male Chimpanzees More Gregarious Than Mothers? A Scramble Competition Hypothesis." In *Primate Males: Causes and Consequences of Variation in Group Composition*, 248–58. Cambridge: Cambridge University Press.