Cultural changes of baetican olive oil amphorae from an evolutionary perspective

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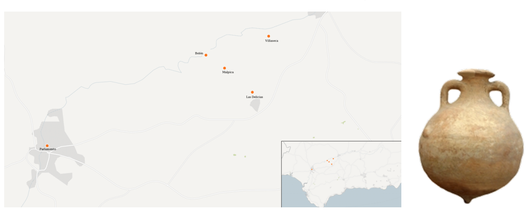
Introduction

Archaeological indicators of variability in material culture can explain how cultural processes evolve over time and space [1]. In particular, our study aims to analyse the changes in the amphorae production patterns during the Roman Empire. This study explores the question of transmission on the learning techniques processes. Specifically, we are interested in understanding if pottery-making techniques were transmitted through vertical or horizontal social learning. If vertical transmission predominates in this process then amphorae made in nearby workshops may share more similar traits than amphorae from farthest workshops [2]. We also analysed the correlation between spatial distance and morphometric variation by exploring test. In this work we have explored the social learning processes associated with amphorae production through a combination of empirical analysis and theoretical exploration.

Materials

We have analyzed 470 amphorae (fig.1 (b)) from 5 different workshops located in *Baetica* (fig.1 (a)). This province supplied a massive quantity of olive oil to the rest of the Empire from the Ist to the IIIrd centuries, and for this reason a large-scale infrastructure of amphorae production was developed here. The same amphoric type (Dressel 20) was produced in several workshops located along the course of the Guadalquivir river. A sample of 90 amphorae was chosen for each of the four analysed workshops. Eight different measures were taken for each amphorae, most of them focused on the rim as an indicator of more variability.



(a)

(b)

Figure 1: a) More than 80 pottery workshops were distributed along the Guadalquivir river and its tributary the Genil. Red points correspond to the workshops analyzed. b) Dressel 20 amphora

Empirical Analysis

Methods

Principal Component Analysis (PCA) was used to capture most of the variance of the 8 measurements into 2 variables.

Results

The pattern observed in the firsts 2 Principal Components suggests that amphorae from closer workshops tend to be more similar (see Figure 2). In this case, the four closest workshops show variation on PC1 (i.e. Belén, Delicias, Villaseca and Malpica) while Parlamento displays a distinctive pattern than the rest of workshops on PC2 values.

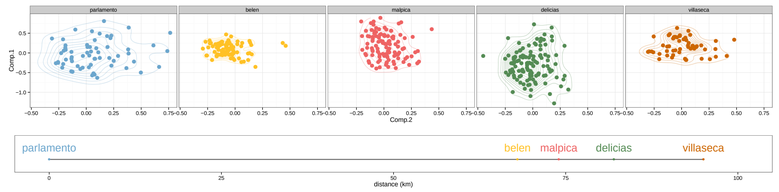


Figure 2: First and Second Principal Components for amphorae measured from the 5 analysed workshops

Theoretical Exploration

Model

We developed a model based on classical random drift [3] mimicking our original dataset. In this model, we define 5 workshops all sharing the same production techniques T^0. Each workshop produces amphorae and changes their production techniques by: modifying their own techniques (Vertical Transmission, VT) or by copying one from another workshop (Horizontal Transmission, HT). We used the more significant measurements (External Diameter & Protruding Rim) taken from the original dataset as the amphora's representation in the model.

To test the influence of HT and VT on the patterns observed we designed three setups:

1. **VT**: probability of random copy between workshop is set to 0. Changes only come from vertical transmission.
2. **VT+HT(d)**: probability of random copy *proportional to distance* between workshops.
3. **VT+HT**: probability of random copy *equal* between all workshops.

Result

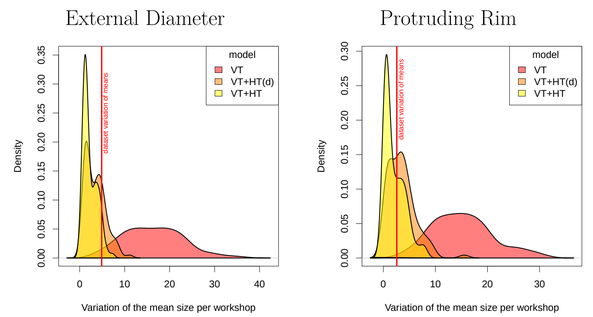


Figure 3: Inter-workshop variation of the mean of the trait after 10 000 timestep for both model (100 simulations per model). The red line correspond to the variation measured on the real data

Fig. 3 shows that when vertical transmission is only acting (**VT**), the variation is higher than the observed variation: the techniques diverge more and more due to random drift. On the other hand, when horizontal transmission is not correlated to spatial distance (**VT+HT**), variation is too low: all workshops tend to use the same techniques and produce similar amphorae. Finally it is when the horizontal transmission is biased toward the distance between workshops (**VT+HT(d)**), that the variation gets closer to the one observed in the dataset.

Discussion

Empirical studies have identified variation on the learning processes among pottery workshops. We observe that this variability is correlated with spatial distance: the analysed morphometric traits show that the similarity between amphorae decrease with the spatial distance between the workshops they were produced.

The combination between empirical data with theoretical model suggests that the similarity on the morphological traits are produced by a continuous contact between closest workshops, as in the case of **VT+HT(d)**. By contrast, when we use the model where **HT** is not correlated to spatial distance the variation is lower than the empirical data. However, this variability in traits is higher than the real data when **VT** is the only one mechanism of transmission without contact between workshops.

This could be interpreted by the fact that pottery techniques were learned from master to disciple at the beginning and these potters exchanged the learning techniques with the nearest workshops.

References

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Acknowledgements

The Funding for this work was provided by the ERC Advanced Grant EPNet (340828).

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