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A theoretical framework for studying culture as a complex adaptive system

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Extended Abstract

Cultural evolution and computational social science are closely interrelated. They both study change in social systems through a highly interdisciplinary approach. Cultural evolution theory provides a framework for understanding the mechanisms that drive cultural change. This knowledge can inform the development of complex computational models that simulate these processes and what kind of patterns to look for in large social datasets. Computational social science provides tools to analyse large datasets of cultural information, which allows testing of hypotheses from cultural evolution theory, even in real-time, and identifies patterns and trends that might not be apparent from smaller datasets. Also, we would argue, modelling approaches in computational social science, with a focus on complex systems and emergent patterns, can be inspirational for developing models of cultural transmission.

Culture is a complex adaptive system but has rarely been studied as such in theoretical work in the field of cultural evolution. Instead, the focus is often on the dispersal of a single trait, or two competing ones, or some one-dimensional trait along a continuum, and how traits will propagate is typically assumed to depend on inborn transmission biases (e.g. Richerson and Boyd, 2005) or cultural attractors (e.g. Claidière and Sperber, 2007). However, many cultural phenomena cannot be understood by studying traits in isolation. Instead, they are embedded in webs of relations, layered with rich social meaning, and sequentially acquired and evaluated, filtered, in light of previously acquired traits. Incorporating multiple traits and their relations is needed to understand the organisation, dynamics, and emergent products of cultural evolution. Such a complex systems approach can offer a more robust theoretical connection between cultural evolution and computational social science, and explain emergent societal patterns.

We have designed a general modelling framework for cultural systems, in which a system consists of a set of traits and a set of relationships between them. These relationships can be weighted on a continuous scale and represent strength of relations and degrees of (in)compatibility between traits. Cultural systems exist both at the level of a population and the level of an individual. When agents are exposed to a new trait, whether they will add it to their repertoire depends on how it fits with their present traits. Added to this, which traits agents will expose to others can also depend on how they fit with their present traits. Traits that are added to agents' repertoires become part of the expanding cultural system, and increase the toolset with which agents evaluate new traits – that is, information filters are emergent and cultural. An illustration of this process is given in Figure 1.

An example where this process is potentially quantifiable is in social media networks: your openness to a post depends on how it (or the sender) fits with your present traits, such as values, current knowledge and tools for reasoning (e.g. you may reject it based on scientific reasoning), and whether you choose to share it depends on similar factors, such as how it fits with your identity.

Through analysis and simulations, we have studied how trait relations and filters can lead to the emergence of complex cultural systems. Some of the results that we will present are the following.

Trait compatibilities can modulate the rate of cultural change. For example, mutual support can maintain system configurations over a long time. Asymmetric relations (one trait promotes another, but the other does not promote the first) can generate cyclic patterns (like fashion fads).

This has consequences for the diversity between groups and polarisation. If a social group is split into two at some point, then the average compatibility between traits in the domain of the group (e.g. groups on social media can be based on certain interests whose components are strongly restricted or where they are more or less arbitrarily connected) has a vast effect on whether these two groups will remain similar over time. If most traits are incompatible, then groups will remain similar until they change by a sudden shift due to threshold effects. If, on the other hand, traits are generally compatible, then the groups will quickly drift apart. Some illustrative simulations are presented in Figure 2.

We also find that ideas that are not essentially connected can easily become connected and form clusters where believing in a certain proposition P correlates strongly with believing in the unrelated proposition Q, such that, eventually, the population is split not only into two clusters, but two clusters with completely opposing ideas. This is based on the assumption that you are more likely to copy someone that shares some ideas with you. A typical example simulation of this model is presented in Figure 3. A prediction from the model is that social media and assortative algorithms will increase polarisation in the strong sense of the word, with polar opposition.

Finally, we find that it is more important for the spread of a trait how it influences the sender of the trait than the receiver (e.g. if a post triggers you to share it has more effect that if it triggers you to click on it).

Overall, this theoretical framework has given demonstrations of several emergent properties that can be found in cultural systems. It has provided several predictions and hypotheses that we believe could be tested using large-scale data on social behaviour and tools from computational social science.

References

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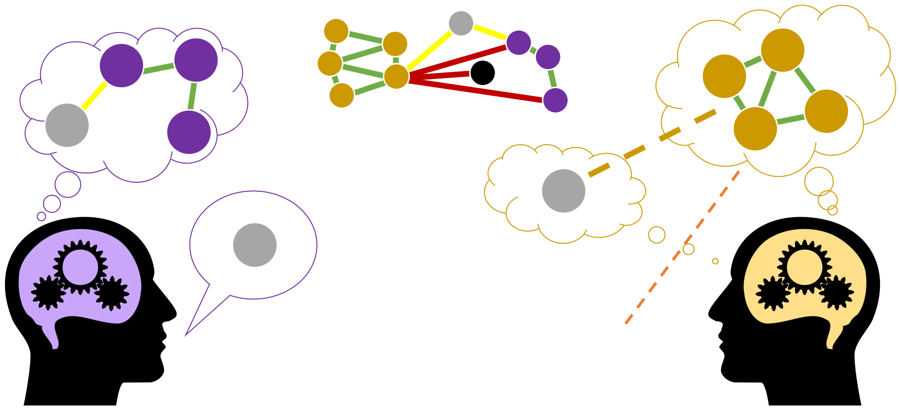

Figure 1: The receiver to the right will interpret the sender's trait in view of their own internal cultural system, and will accept the trait if it fits sufficiently into their system. The relations between cultural traits are represented in the middle by greed edges if they are compatible, red if they are incompatible, and yellow if they are neutral.

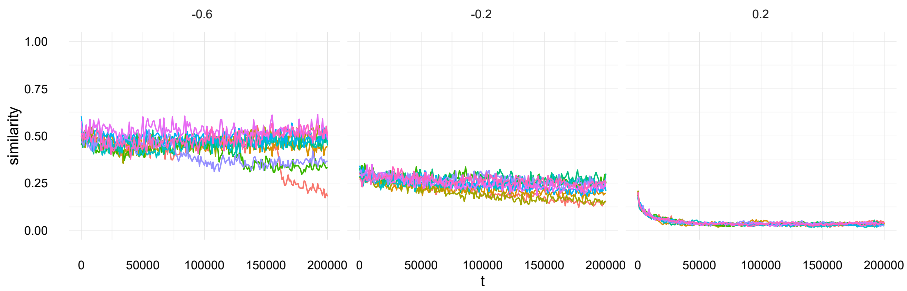

Figure 2: Average similarity over time, for ten simulation runs, between agents compared pairwise between two populations that were initially identical, for different average compatibilities (-0.6, -0.2 and 0.2) in the cultural domain.

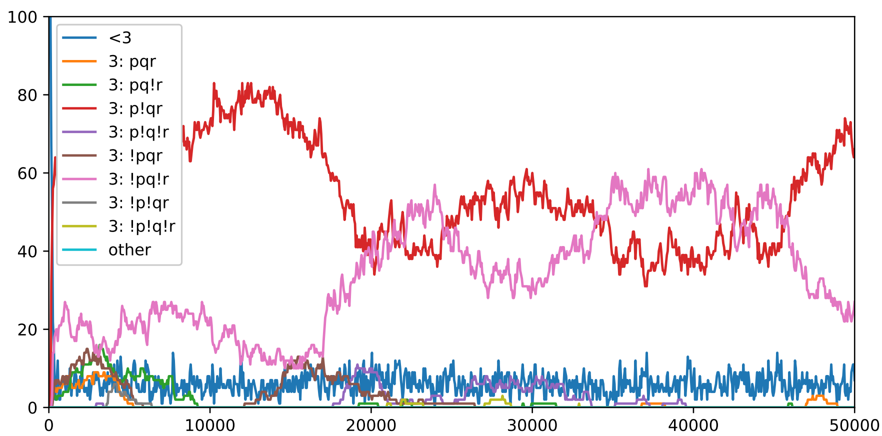

Figure 3: Agents learn traits P, $\neg P$, Q, $\neg Q$, R and $\neg R$ from other agents that do not possess a contradicting trait.