

Packaged Transmission of Cultural Traits Generates False Signal for Selection

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Cultural traits are often transmitted together during social learning, but the evolutionary consequences of such “packaged transmission” has yet to be studied. At the cognition level, traits may be transmitted together due to overimitation, causal reasoning, categorical perception, etc. At the level of trait architecture, there are complex traits consisting of smaller components, such as institutions and technology. The storage media such as books and films are yet another level that allows traits to be transmitted together. It is well known in biology that genes tend to transmit together when they are located on the same chromosome, known as genetic linkage. Genetic linkage has many profound evolutionary consequences, such as slowing adaptation, increasing mutation load, allowing neutral or deleterious genes to spread by hitchhiking on an adaptive gene, and building supergenes that help complex adaptations to be maintained in the population. Whether the same effects are present in cultural evolution is unclear since the processes behind cultural evolution are not identical to those of genetic evolution. For example, people do not learn two equal halves of all traits from their two parents at birth, but some traits from each of several people at various occasions throughout their lifetime. Furthermore, learned behaviors are not arranged side-by-side on a chromosome. Instead, any two cultural traits can potentially be linked, forming networks of interconnected traits. In this research, we focus on the question of whether links interfere with our ability to distinguish adaptive traits from neutral traits, which is often done by observing the level of variation in the population. We first derive a cultural-evolution equivalent of the Wright-Fisher model to investigate how deviating from bi-parental inheritance might change the dynamics of evolution. Then we build an agent-based simulation that allows formation and breakage of links between cultural traits to explore their effects. The simulation includes 1000 individuals, each with 5 traits (loci), each with 4 variants (alleles). During transmission, one randomly selected trait along with all other traits that are connected to it (directly or through other traits) are learned together in a package, along with the presence or absence of links to these traits. We compare the evolution of neutral traits and adaptive traits in simulations with different rates of link formation and breakage. The results from the analytical model show that bi-parental inheritance is not a crucial component for evolution, but large packages tend to help drift remove variation from the population. The results from the simulation further show that links can indeed interfere with our ability to detect selection by lowering the variation of neutral traits through three mechanisms. First, links lead to larger packages, which help remove variation as showed by the analytical model. Second, similar to genetic linkage, links allow neutral variants to spread by hitchhiking on adaptive variants. Third, even when no trait is under selection, the presence of links alone can lead to different rates of trait transmission, lowering the diversity of neutral traits as if they are under selection. This last effect is an emergent property of the links and does not have an analogue in genetic evolution. Population-level data such as allele frequency and pairwise difference are therefore insufficient for inferring whether selection is or was present. While existing research in cultural evolution tend to treat traits as independent units that can be studied on their own, our results suggest that the practice is inadequate, especially as researchers gain interest in cultural niche construction, cumulative culture, and coevolution. It is therefore important to identify links in empirical systems and to further develop the models.

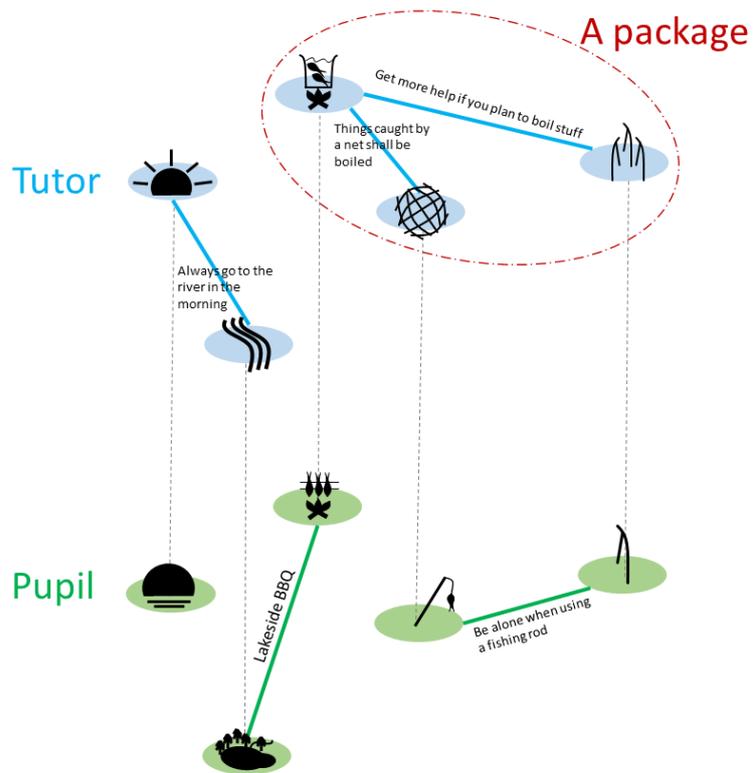


Figure 1: An example of a pupil trying to update its fishing strategy by copying from a tutor. The five traits are (from left to right) time of day, location, cooking method, fishing tool, and the number of participants. The tutor has three links and the pupil two.