TRANSMISSION CHAINS AND INDIVIDUALS PLACE DIFFERENT CONSTRAINTS ON THE EVOLUTION OF CATEGORY SYSTEMS

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Evolution and learning are both processes that allow organisms to extract and store information about their environment. But when and how do the exploratory dynamics of these processes differ? We present the results of an iterated category learning experiment, where the number and placement of participants' category boundaries are free to evolve over time. We contrast two evolutionary regimes: one where category systems are transmitted over multiple learners and one where they are developed within a single learner, for the same amount of time. We find that there are more constraints on the exploratory process when systems are culturally transmitted among multiple learners. Single learners explore a wider range of category systems and converge on more complex systems, whereas transmission chains explore a more restricted set of systems and nearly always converge on a simple, but easily learnable, one-boundary category system.

297 adults participated in an iterated category learning experiment, where they were trained and tested on a mapping between 2 labels and 10 stimuli. The stimuli had identical shape (a seashell) and varied on a continuous dimension (shade of grey). Participants were divided into two transmission conditions: *cultural* and *individual*, and two frequency conditions: *uniform* and *skewed*. In the *cultural* condition, each participant was trained on a mapping generated directly from the test trials of the previous participant. These participants were organized into 45 linear transmission chains. The first participant in each chain was trained on a random mapping of labels to stimuli. Chains ended when two consecutive participants produced identical mappings in their testing phase (chain length ranged from 3-11 rounds or "generations"). In the *individual* condition, each participant was trained on their own previous test mapping for multiple rounds. Rounds ended when they produced the same mapping twice in a row (or until they completed 8 rounds). In the *uniform* condition, each stimulus was presented an equal number of times (3 times each per training round). In the *skewed* condition, the stimuli were presented with the following frequencies: 10,5,4,3,2,2,1,1,1,1. This condition was counterbalanced between participants so half saw the darker stimuli more frequently and half saw the lighter stimuli more frequently.

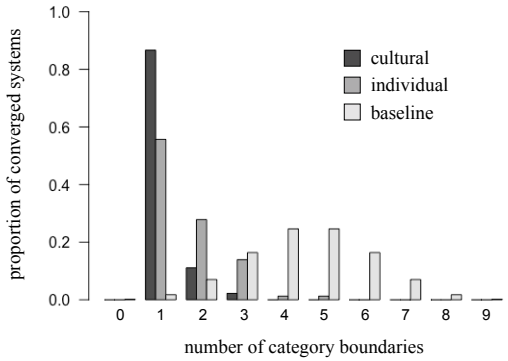

Figure 1.

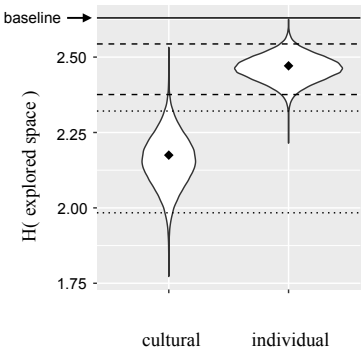

Figure 2.

We found that participants in the cultural condition were significantly more likely to converge on a simple category system with only one boundary, than participants in the individual condition (Figure 1). The baseline in Figure 1 shows the distribution of boundaries that would be produced if participants were randomly clicking on category labels in the testing phase. Figure 2 visualizes the difference in exploratory behavior between conditions using Shannon's 1948 framing of relative entropy. The entropy of the baseline distribution in Figure 1 is 2.6 bits; any distribution with lower entropy has more structure and covers less of the total space of possible category systems. The entropy of the systems that participants explored is significantly lower, at 2.47 bits in the individual condition and 2.17 bits in the cultural condition.[1] The dashed lines show the 95% confidence intervals[2] around the entropy estimate: their lack of overlap indicates that participants in the cultural condition explored a significantly smaller region of all possible category systems than participants in the individual condition.

As for the frequency manipulation, we predicted that it would constrain evolutionary search by affecting the location of category boundaries, but these analyses were confounded by a significant difference in the counterbalance condition: participants were more likely to place boundaries in the lighter region of the greyscale, regardless of skew condition. Future research will focus on unpacking the observed limits on evolutionary search into identifiable constraints that differed between conditions (e.g. the differing demands on memory and attention).

[1]Exploratory breadth was obtained by estimating the Shannon entropy of the distribution of category systems obtained in all testing phases, up to an evolutionary depth of 8 rounds/generations. (Systems in the cultural condition were allowed to evolve for more than 8 generations, so this cutoff aids comparability between conditions). All entropy calculations were corrected with minimax estimation (Hausser & Strimmer, 2014).

[2]Computed with the bootstrap percentile method (Efron, 1979).

References

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