

## CULTURAL TRANSMISSION OF MELODIC AND RHYTHMIC UNIVERSALS: 4 EXPERIMENTS AND A MODEL

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Humans are well-versed at processing sequences. In the lab, when confronted with language or other culturally-transmitted systems, humans introduce and amplify structural regularities making the systems easier to learn (Kirby, Griffiths, & Smith, 2014; Kirby, 2017). Is the cultural emergence of fine-grained regularities a prerogative of language alone? Can cultural transmission explain universals in musical structure (Savage et al., 2015; Trehub, 2015) as it explains ‘linguistic universals’ (in the Greenbergian sense)? We tackled these questions in the lab and in-silico by adopting an iterated learning paradigm. Two experiments addressed the evolution of *rhythmic* structure (Ravignani et al., 2016; Ravignani et al., 2017), and two the evolution of *melodic* structure (using, among others, data from Verhoef, 2012; Verhoef et al., 2014). Depending on the experiment, participants were given a slide whistle or an electronic drum kit, and were asked to imitate a sound sequence to the best of their abilities. The output of one generation of participants became the input of the next generation.

Across experiments we varied conditions known to affect transmission chains, such as immediate vs. delayed recall, within-participant vs. between-participant transmission, etc. We also introduce a probabilistic model for the latent structures underpinning rhythmic sequences, alongside a psychologically plausible posterior sampling algorithm (Ravignani et al., 2017). This allows us to obtain approximate structural descriptions of rhythmic patterns across conditions and generations. The initially random experimental stimuli became more musical. In particular, most regularities emerging from our transmission chains are statistical universals of world music (Savage et al., 2015; Fitch, 2017). Both whistles and drumming patterns became more compressible, measured in terms of decreasing entropy, and easier to learn. We found reuse of a small set of basic building blocks in the emerging systems, resulting in more predictable sequences of sounds (Ravignani, 2017). This corresponds with a musical universal, namely the repetition of melodic and rhythmic phrases in music. This reuse of elements is accompanied by a transition from continuous to discrete use of pitch contours (showing convergence to another universal; Ravignani & Verhoef, 2017). Participants produced sequences containing melodic and rhythmic patterns, i.e. musical motifs. We also see a gradual increase in mirrored elements, which suggests that the emerging melodies contain arched contours (a common musical universal). In addition, drumming sequences became more isochronous (Ravignani & Madison, 2017), and composed of few (categorically distributed) alternating inter-beat intervals, related by small integer ratios. Patterns transformed by between-participants transmission show similar properties to those emerging from within-participant transmission (i.e. self learning; Ravignani et al., 2017). Other melodic universals, such as the length of phrases, frequency intervals of melody contours, and organization of scales can also be measured in this data set and are currently being tested. Analysis of the probabilistic model supports these insights, suggesting that later generations show increased re-use of prototypical building blocks both within and across individual sequences (Ravignani et al., 2017). The emergence of musical structure via cultural transmission: (a) does not require semantics or learning language-like behaviours; (b) operates similarly across domains of human cognition; (c) explains characteristics of music appearing as statistical universals around the world (Savage et al., 2015).

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