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Cultural Transmission of Structured Knowledge and Technological Complexity:

The Axelrod Model Extended

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Behavioral Modernity

"Middle to Upper Paleolithic Transition"
"Upper Paleolithic Revolution"

Slowly changing technology	▶	Rapid and cumulative change
Continental scale traditions	▶	Strong regional differentiation
Low toolkit complexity	▶	Complex, multipart tools

Explaining Behavioral Modernity

~~Major biological differences?~~

Complex tools with moderns and Neanderthals

~~Sharp revolution in space and time~~

Long history in Africa, Near East, and Europe

~~One-way change from ancestral to modern~~

Plenty of early appearances that don't persist

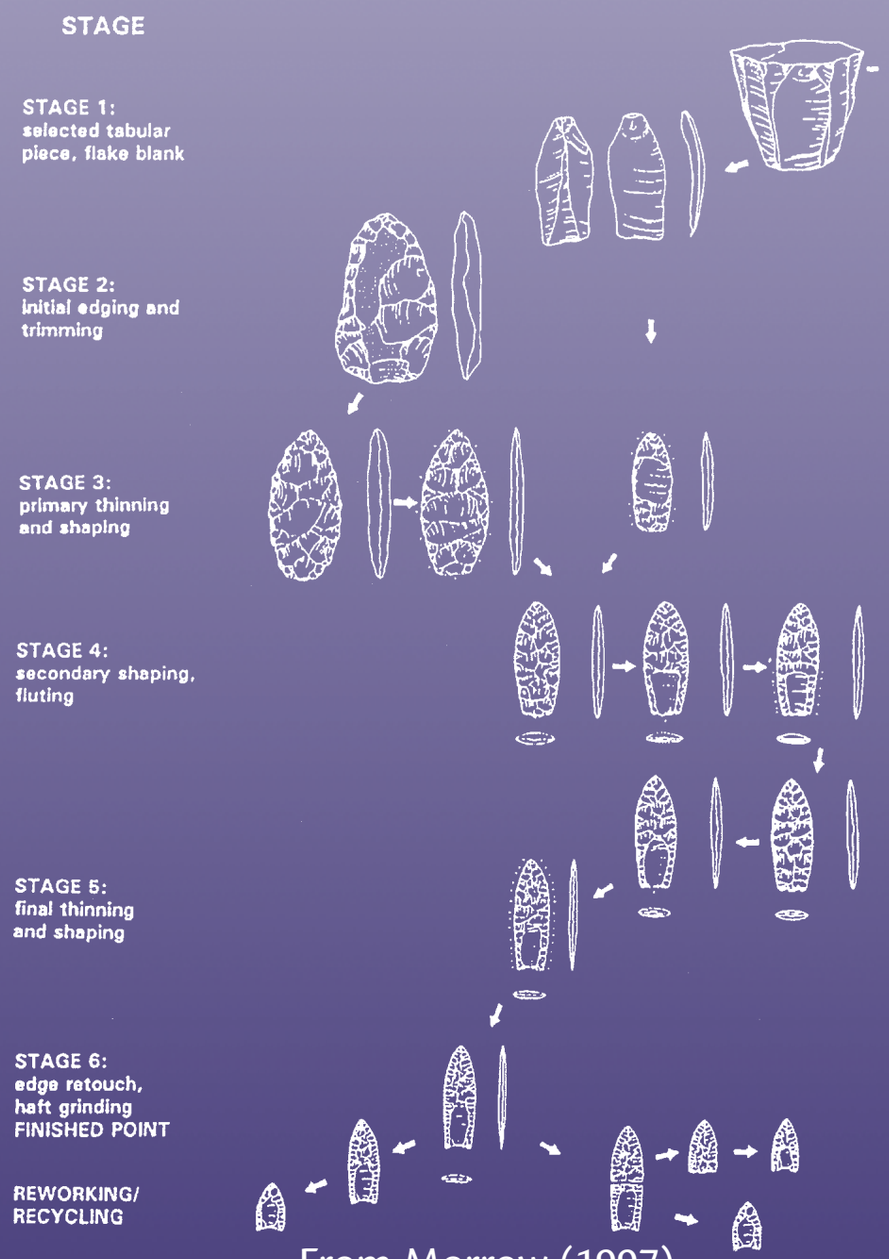
Behavioral Modernity and Cultural Transmission

- Richness and complexity increase with population…or do they?
- Metapopulation dynamics can promote diversity and differentiation (L. Premo)
- Possible changes in learning modes: declining conformism?
- *Possible changes in the structure of socially learned information itself — hierarchy, prerequisites, dependencies (Mesoudi and O'Brien, this paper)*

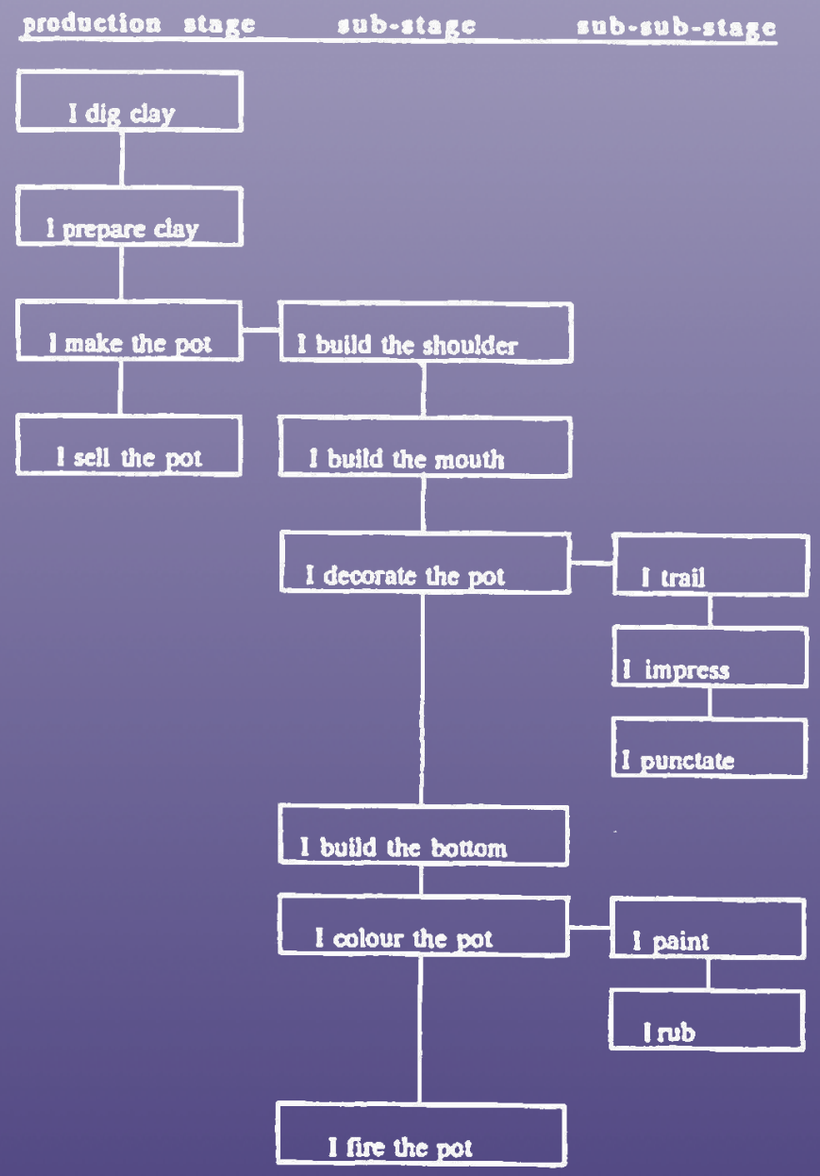
Social Learning of Structured Knowledge

- Knowledge and skills are structured with dependencies
- Which become *prerequisite relations* during learning and skill acquisition
- Complex technologies require dependencies to be passed on intact

Dependencies in skill *execution*…



From Morrow (1997)



From Krause (1990)

imply structure to the order of *learning* and mastery

Hypothesis

Increasing learning fidelity across knowledge prerequisites may directly lead to:

- *More diverse cultural repertoires*
- *Differentiation between individuals and groups*

...and in combination with population structure and other factors, lead directly to behavioral modernity

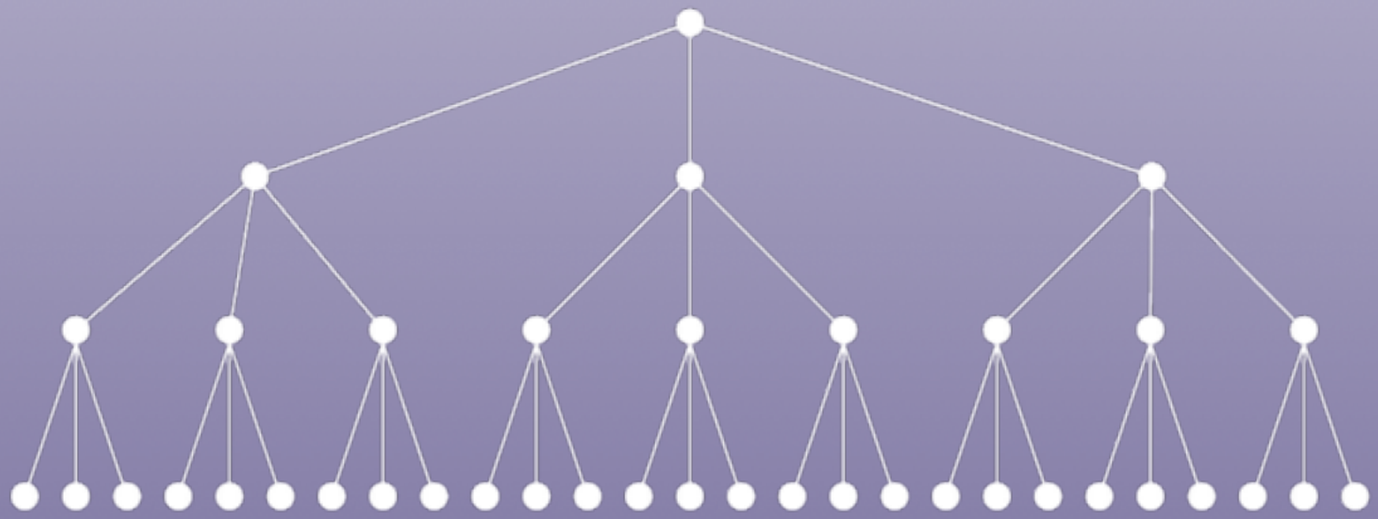
"Semantic" Axelrod Model

Social learning model incorporating:

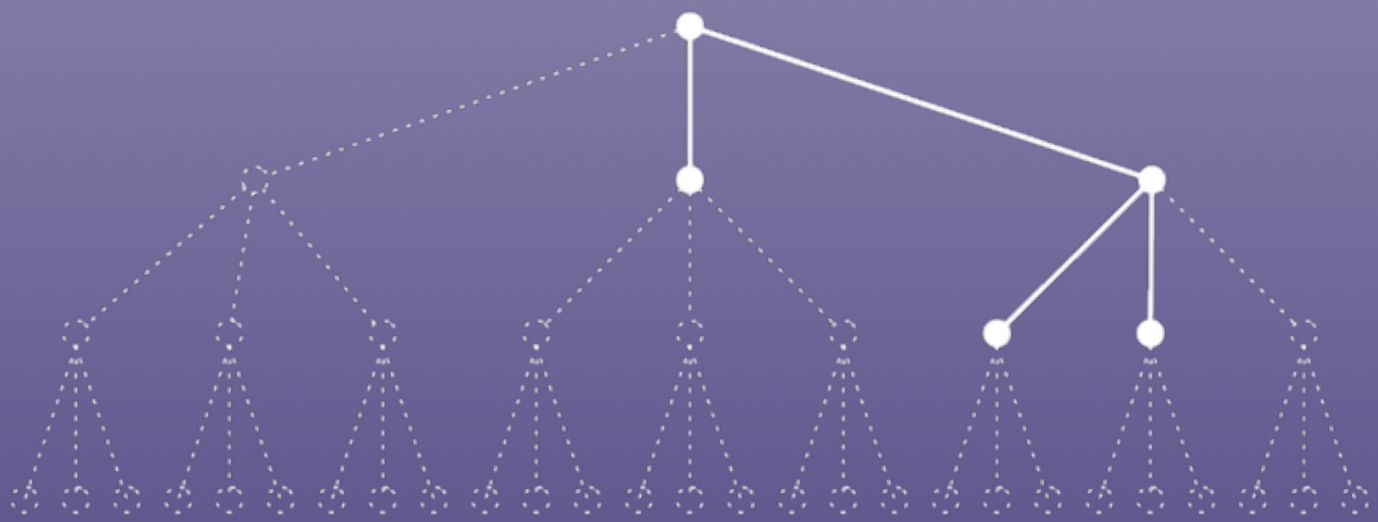
- Design space mapping trait prerequisites
- Copying based upon homophily (Axelrod model)
- Probabilistic learning of prerequisites
- Individual innovations

Parameters: learning rate, innovation rate, design space size

CT model adapted from Robert Axelrod (1997)
Hierarchical trait space from Mesoudi and O'Brien (2008)



Design Space



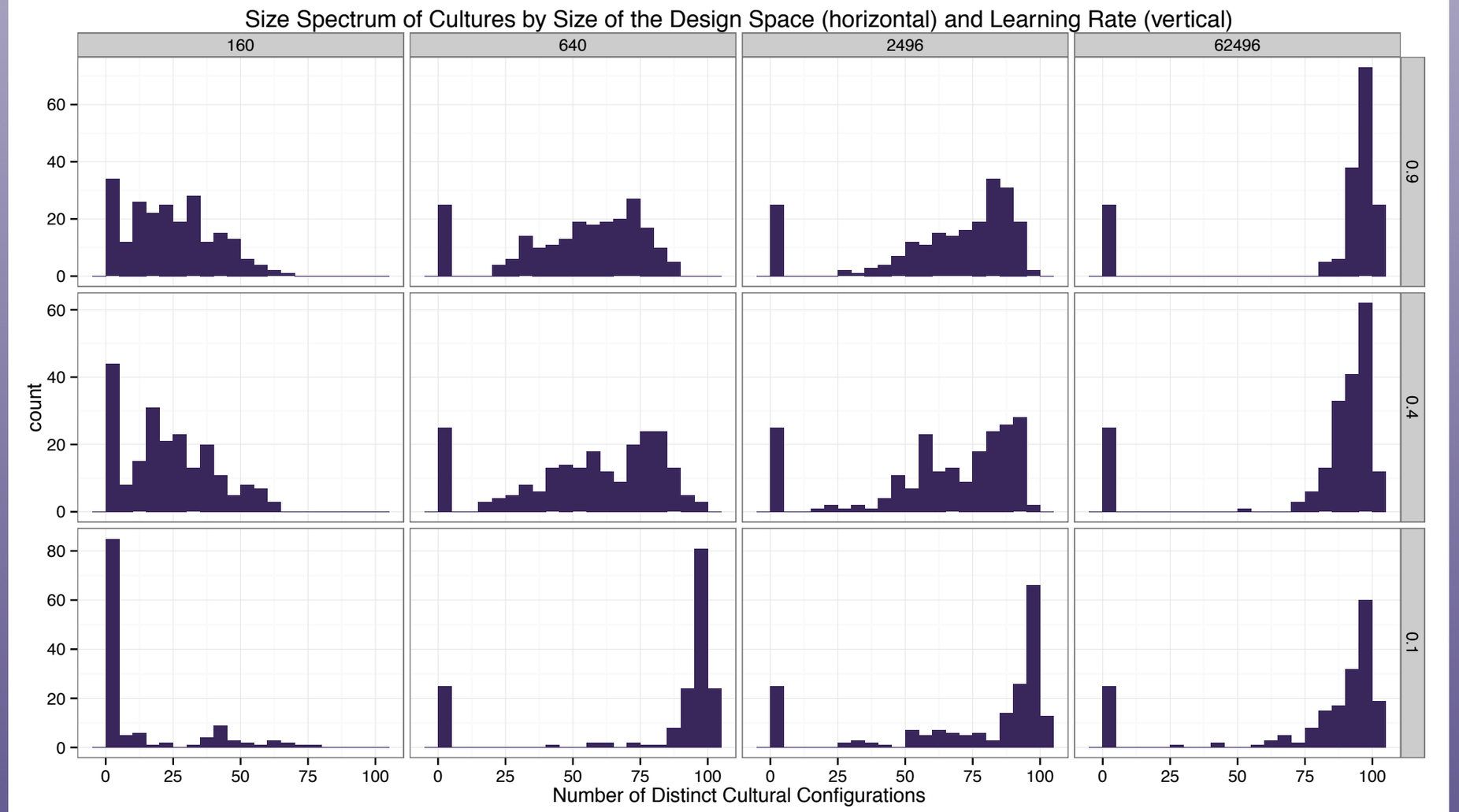
Starting Configuration

Completed Sample

Expectations

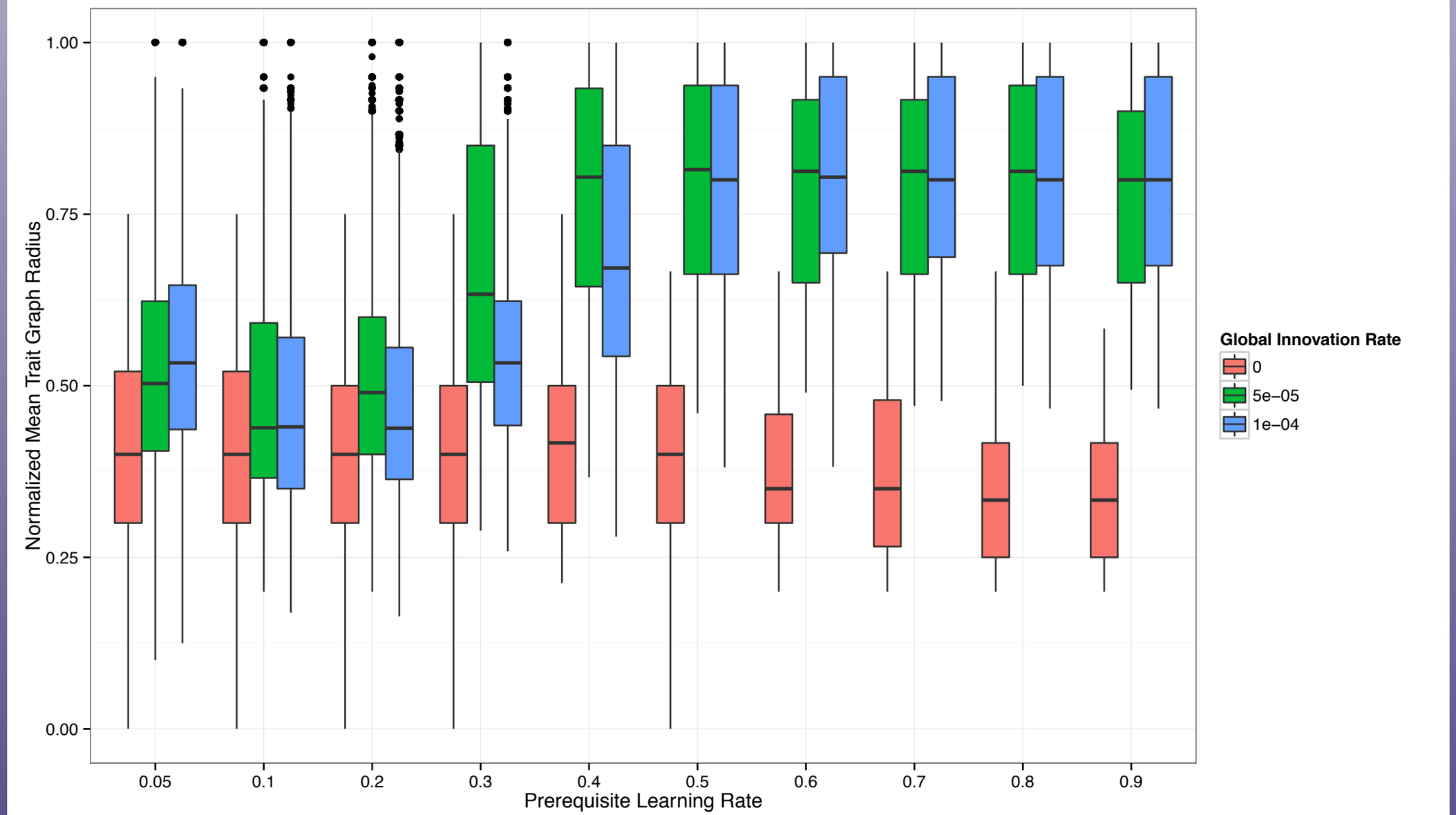
Intrapopulation diversification:
More cultural configurations at high prerequisite learning rates.

Cumulative knowledge:
Depth of trait trees increases with prerequisite learning rate



Low learning/small design space: *Most individuals share traits, little differentiation into separate repertoires.*

High prereq learning or large design space: *Cultural repertoires become differentiated, most individuals hold unique configurations*



Low prerequisite learning: *cultural repertoire fairly static compared to initial conditions*

High prereq learning + global innovation: *growing and deepening cultural repertoire*

Summary

- Differentiation is facilitated by enhancing learning of prerequisites efficiently.
- Richer cultural repertoires require both learning prerequisites and individual innovation.
- Expansion of the overall design space is both a product and a driving force

Structured models like this are a useful platform for examining technological evolution, and questions like behavioral modernity

Tip of the…

- Technology models
- Population structure
- Trait fitness models

For more information

- Notes: http://notebook.madsenlab.org
- Code: https://github.com/mmadsen/axelrod-ct
- Analysis: https://github.com/mmadsen/madsenlipo2014
- Preprint: http://arxiv.org/abs/1404.5704