

79th Annual Meeting of the Society for American Archaeology, Austin TX

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
Constrained economic base	▶	Greater diversity in food sources

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

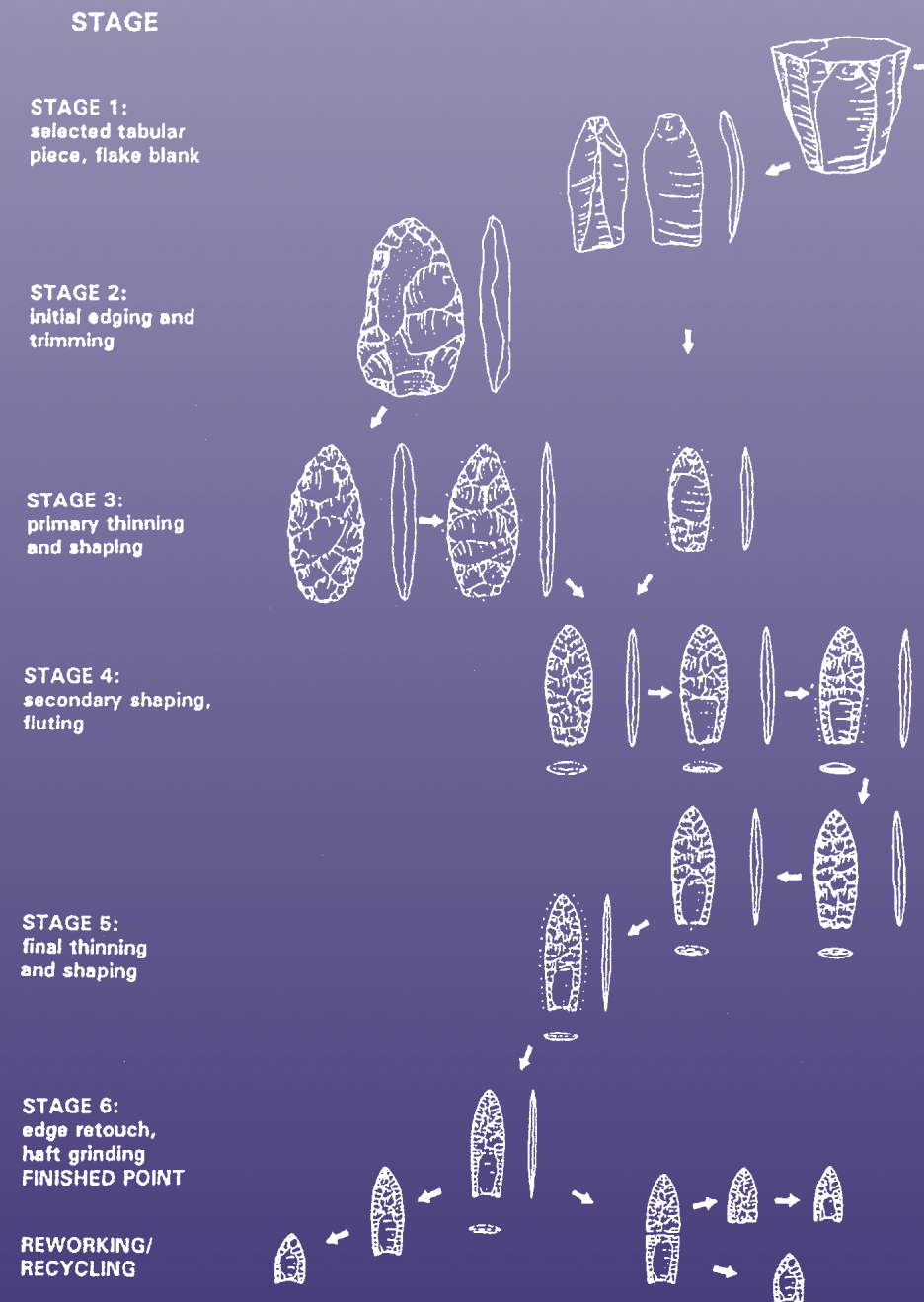
Behavioral Modernity and Cultural Transmission

- Richness and complexity increase with population... or do they?
- Colonization/extinction promotes diversity and differentiation (Premo)
- Possible changes in mode: declining conformism?

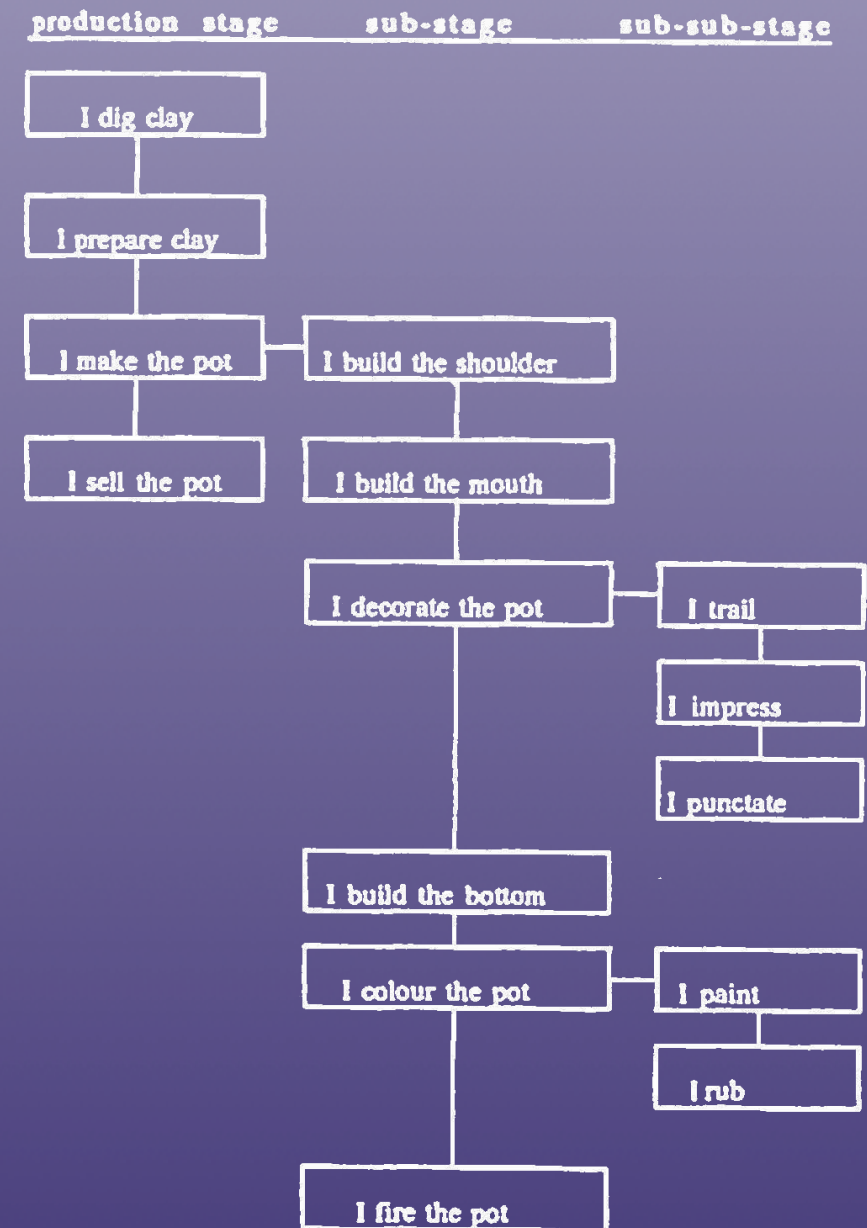
Social Learning of Structured Knowledge

- 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

Structured models of skill *execution*



From Morrow (1997)



From Krause (1990)

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

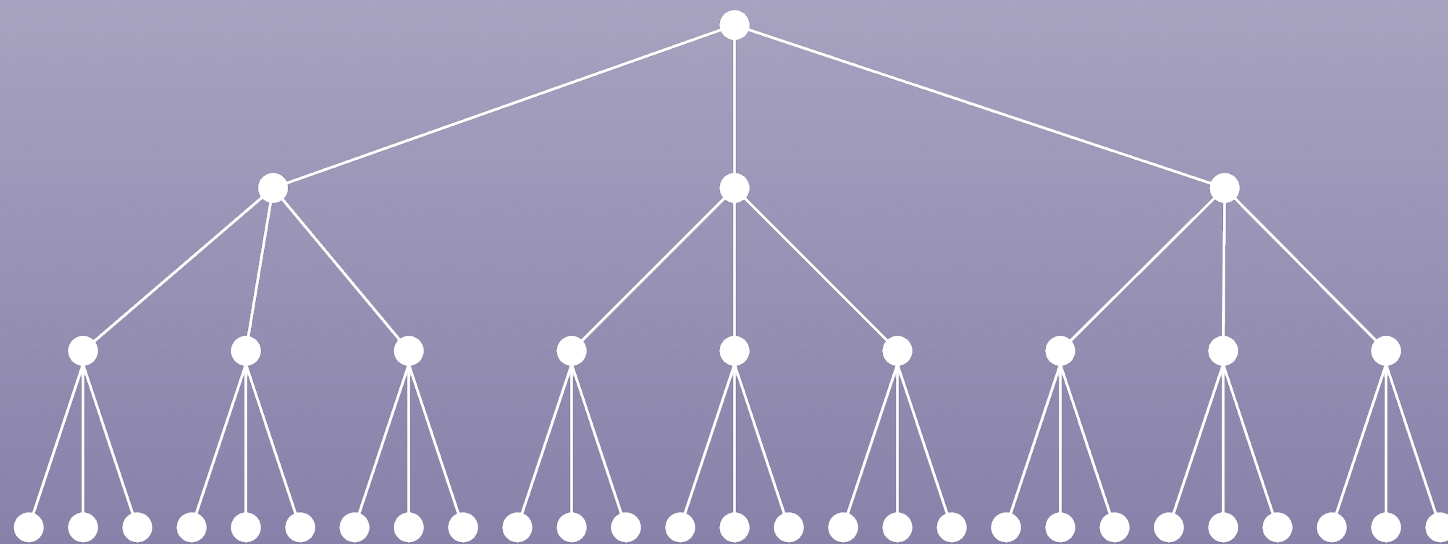
Social learning model incorporating:

- Hierarchical, structured traits
- Skill/knowledge prerequisites
- Copying based upon homophily
- Probabilistic learning of prerequisites
- Rarer individual innovations

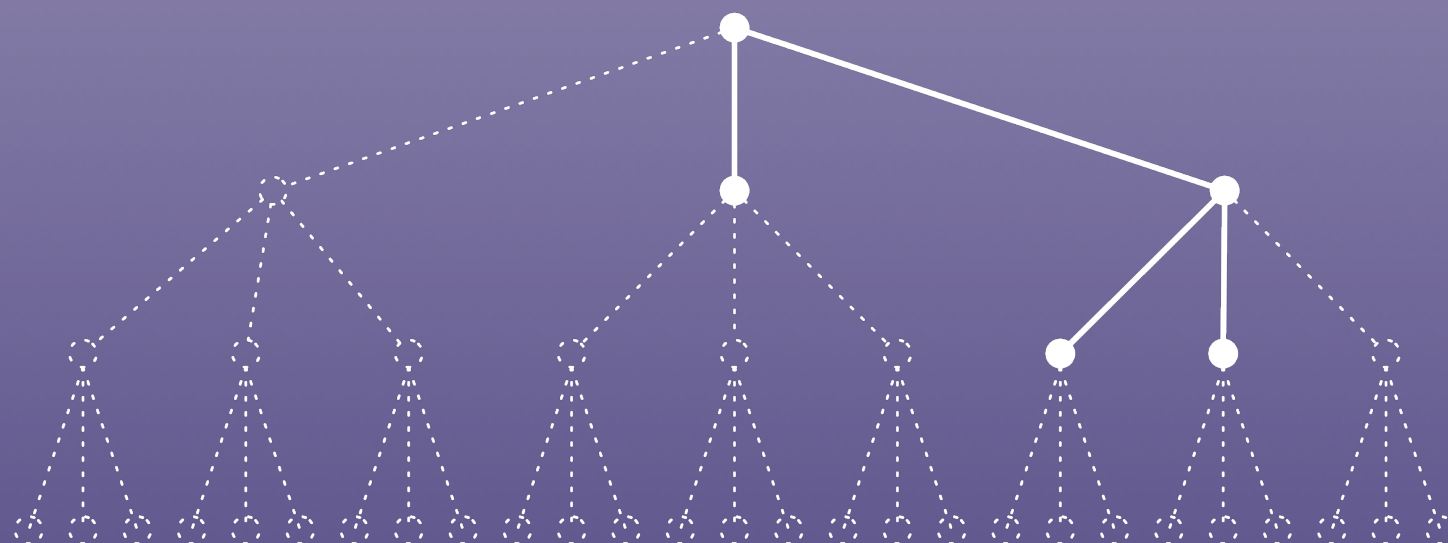
Simulated across: learning rates, design space sizes

CT model adapted from Robert Axelrod (1997)

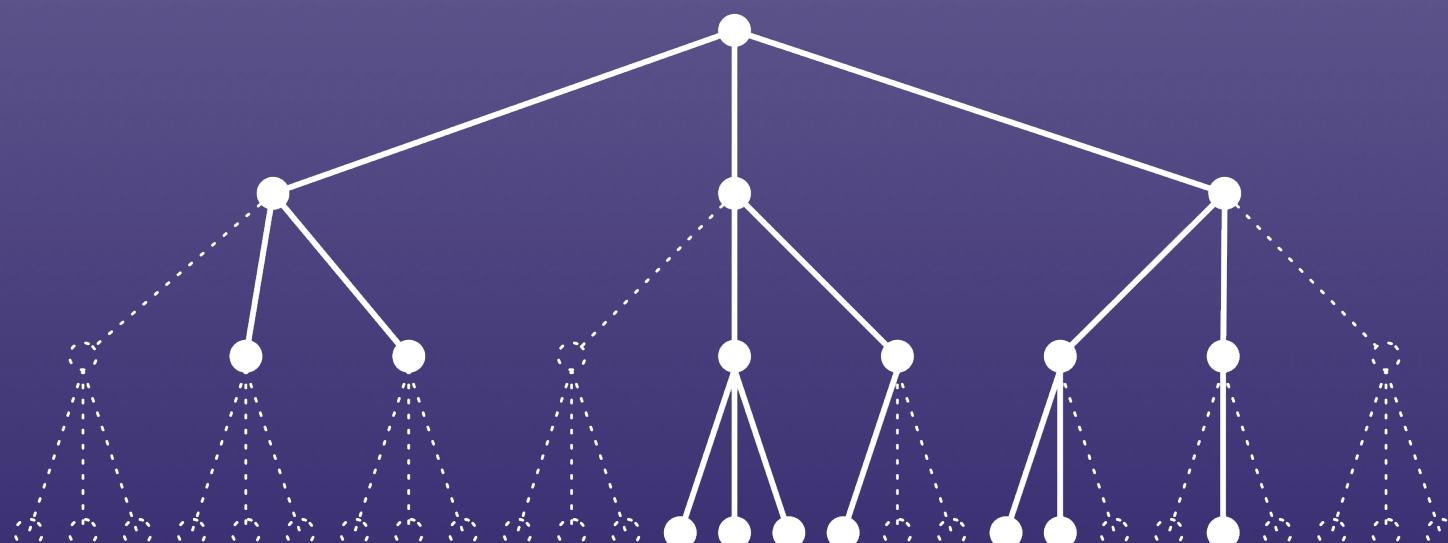
Hierarchical trait space from Mesoudi and O’Brien (2008)



Design Space



Starting Configuration



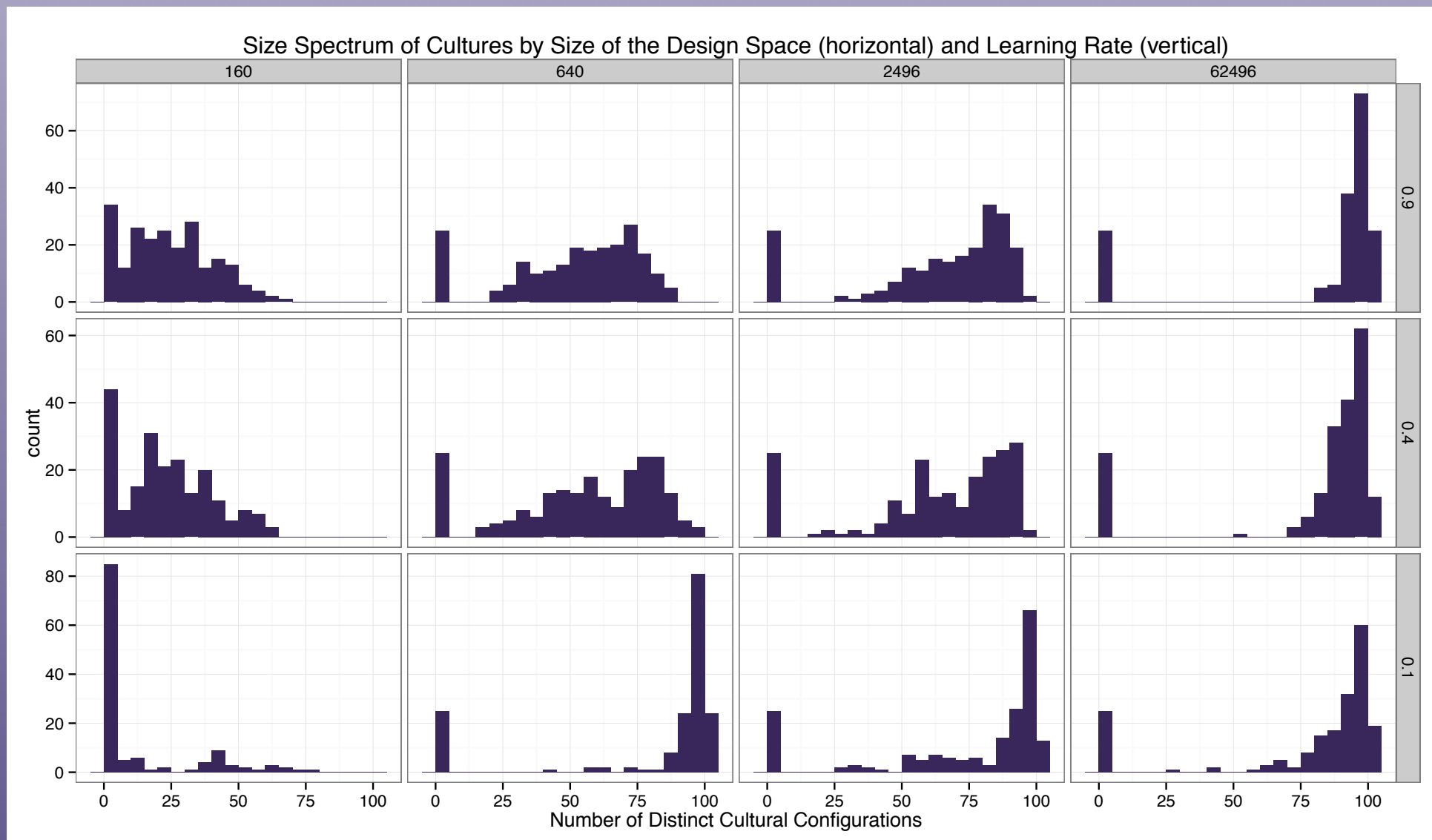
Completed Sample

Intrapopulation diversification:

More cultural configurations at high prerequisite learning rates.

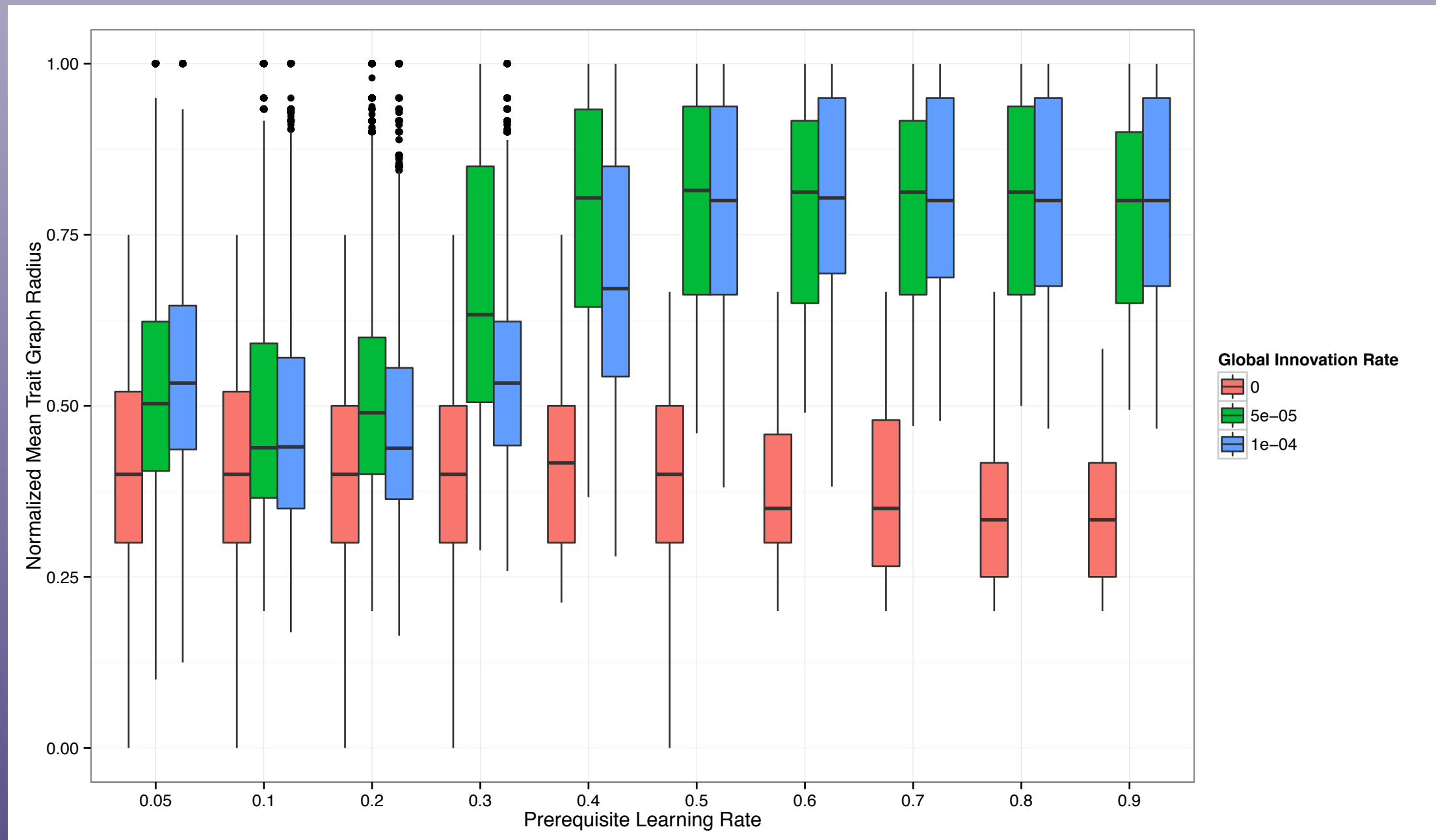
Cumulative knowledge:

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*

- Differentiation is facilitated by enhancing learning of structured skills and information
- Richer cultural repertoires require both learning prerequisites and individual innovation (unsurprisingly?)

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

A photograph of an iceberg floating in the ocean. The tip of the iceberg is visible above the water line, while the much larger, submerged part is visible below. The sky is blue with some clouds, and the water is a deep blue. The text "Tip of the..." is overlaid on the right side of the image.

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>