Portland State UNIVERSITY

Archaeology First Thursday Series

What Can We Know About Past Cultural Transmission?

Extending Behavioral Models to Archaeological Time

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Agenda

1. CT modeling in archaeology
2. Enriching our models of CT
3. Coarse graining of CT models for archaeological use


"The future is already here –
it's just not evenly distributed."
William Gibson
カラオケ
BIG ECHO
ORIENTAL
PASSAGE
PACHINKO & SLOT
TSUTAYA

Cultural transmission models
describe the possible outcomes
that occur when we combine:

- *social learning processes*
- *social networks and institutions*
- *innovation and sources of error*
- *social and ecological niches*

Where "outcomes" include:

- *spatiotemporal patterns*
- *frequency histories*
- *richness and evenness patterns*

Apprenticeship

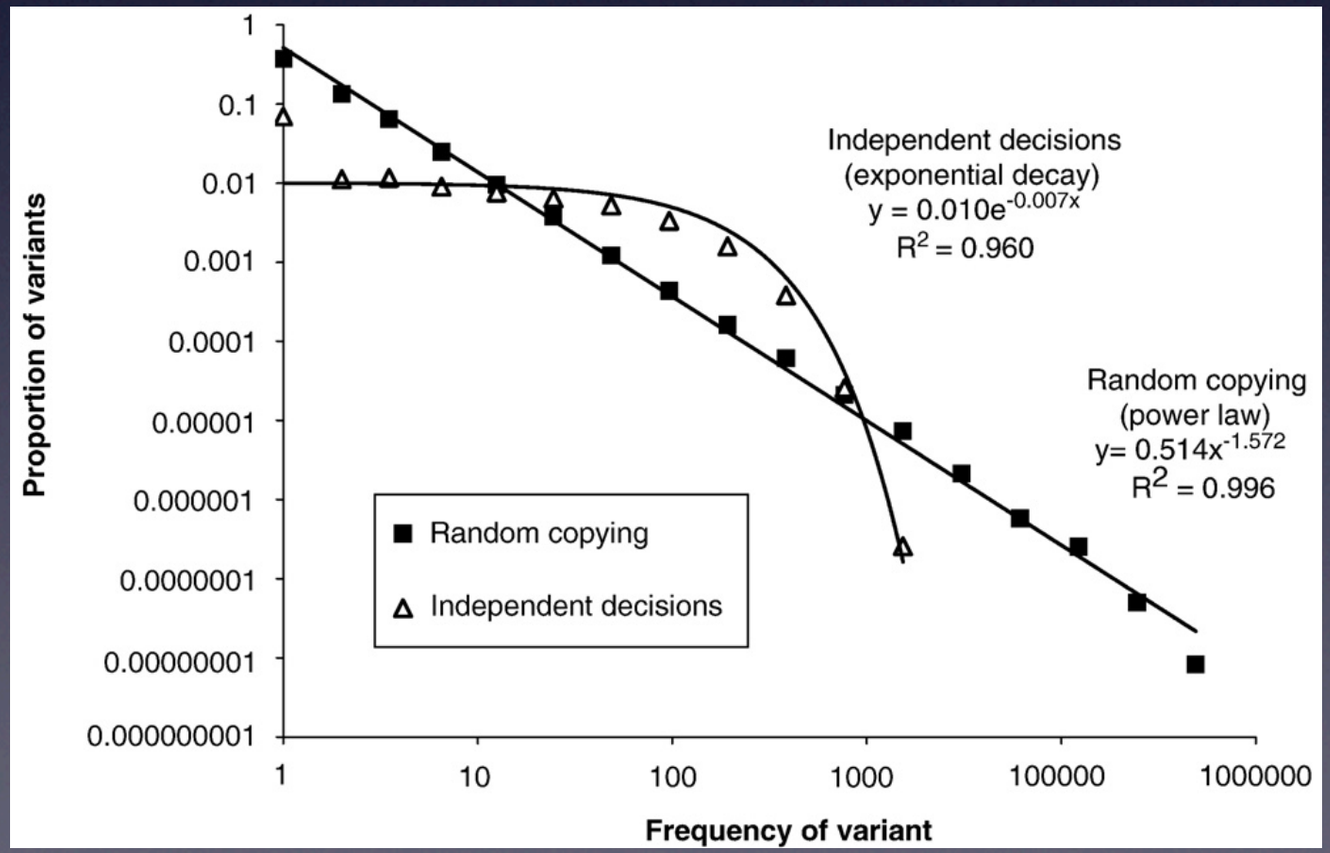
Individual learning
(trial and error)

Formal instruction

Imitation of relatives or peers

Spatiotemporal patterns: diffusion, migration, exchange

Equilibrium frequency distributions



Frameworks for creating formal CT models

- Wright-Fisher infinite-alleles neutral model
- Boyd and Richerson's dual inheritance/bias models
- Cavalli-Sforza and Feldman's dual inheritance models
- Replicator dynamics
- Epidemiological models (e.g., SIS, SIR)

Thick Description

Ecological Time

Evolutionary Time

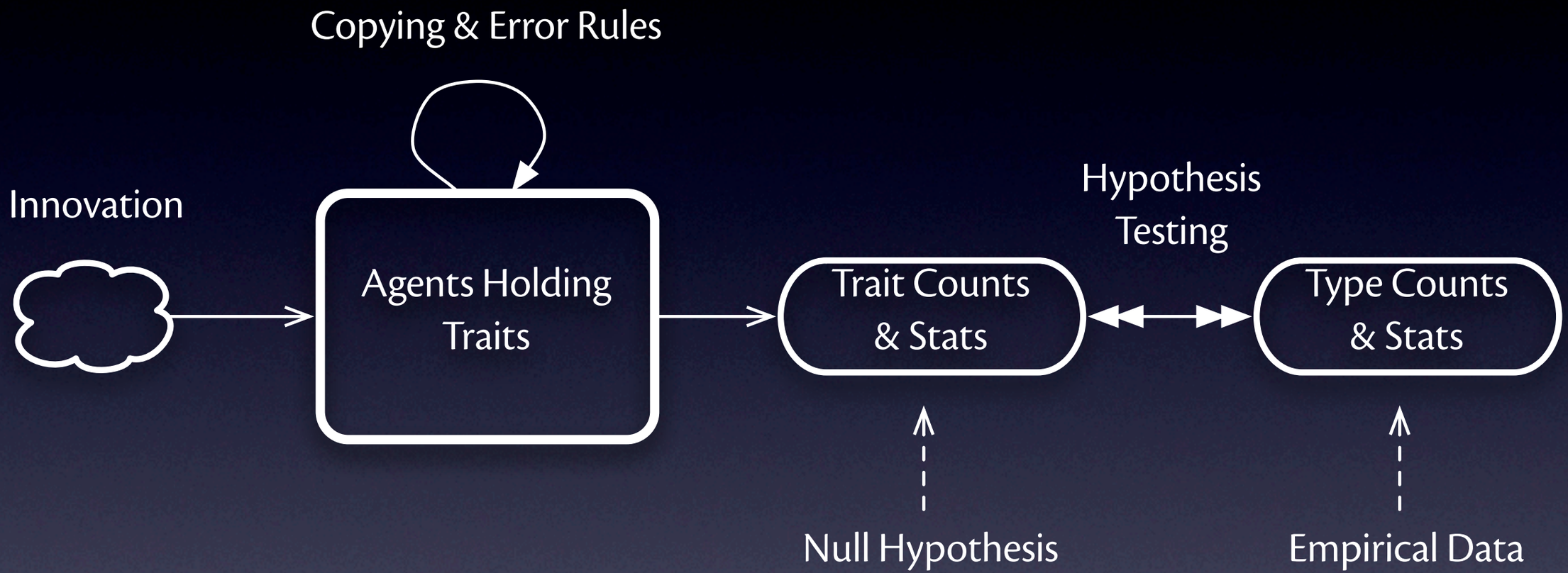
Dual Inheritance Theory

Neutral Theory

Memetics

Thin Description

Diachronic Models



Schematic of CT models in the B&R or neutrality framework

Unbiased transmission rule:
For each agent, select an agent at random, adopt a random trait from the set of traits they hold. With some probability, a newly invented trait is adopted instead.

Conformist transmission rule:
For each agent, select the most common trait in the population with probability *C*, otherwise use unbiased copying or innovation as above.

"When you first get a theory, you don't know how it works! You've got to spend time playing with it....[there is] a *learning curve* for how the hypothesis works: *after* you understand it, you can falsify."

William Wimsatt

People are conformists....sometimes, and in certain contexts.

People are also novelty seekers, especially at certain ages and in specific contexts.

Cultural "Evo-Devo"

Thick Description

Ecological Time

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Diachronic Models

Thin Description

What's missing is a formal way of describing how the use life of cultural information affects its spread and distribution.

In other words, the evolutionary effects of development

cultural "evo-devo"

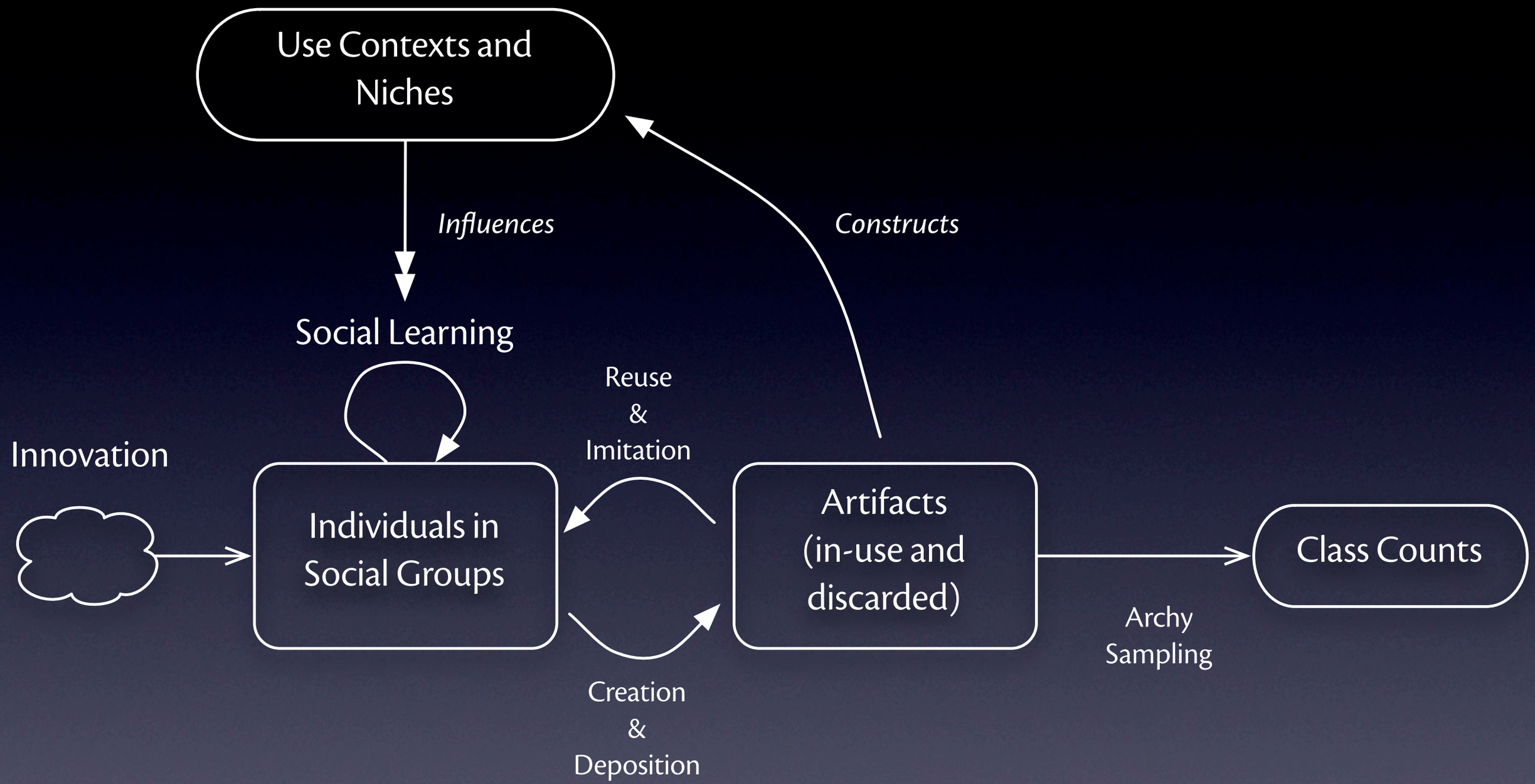
Most real skills and cultural phenomena involve more than just imitation or "copying"

- Imitation
- Formal instruction
- Individual learning

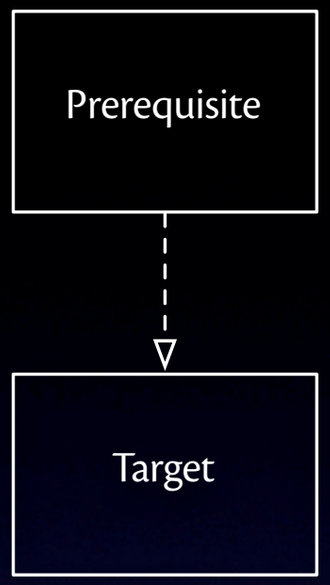
Often acquired over long spans of time with real expertise taking years

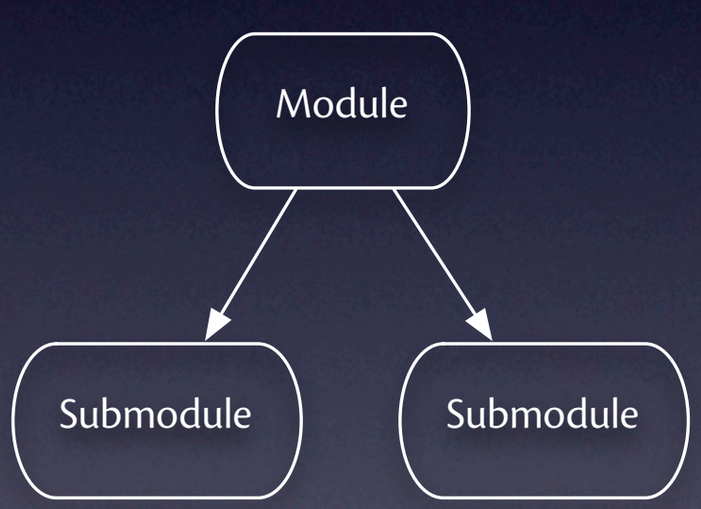
"...the upstream generation structures the learning environment of the downstream generation, so that trial-and-error learning combined with observational learning and (sometimes) explicit instruction results in the reliable reacquisition of expertise."

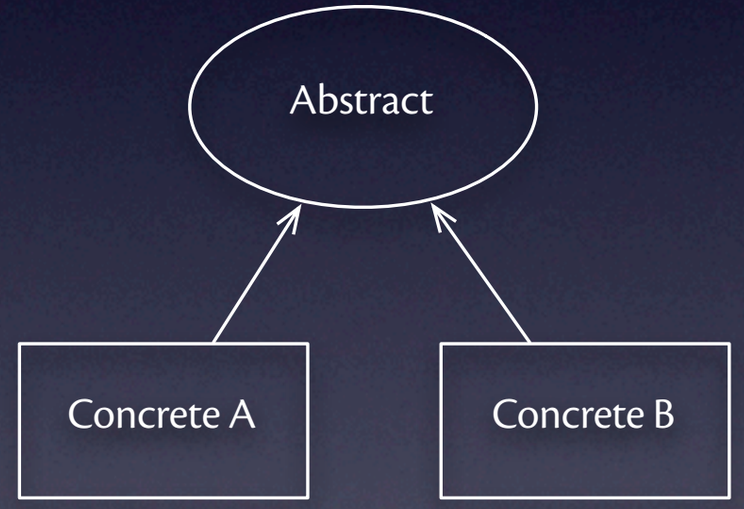
Kim Sterelny, *The Evolved Apprentice*



Schematic of CT models with embodiment and niche construction







Important ways that cultural information is structured

Generative Entrenchment:
Early developmental events structure and constrain later events, becoming "prerequisites"

Genetics and development is rife with GE'd elements

Culture has many GE'd elements as well, and mechanisms for creating stability if not stasis

Amish "*Ordnung*" -- Craig Palmer

- Culture provides tools for “loosening” GE
  - Behavior is changeable with new learning
    - Prototype and test before switching
    - Early/mainstream/late adopter cycle

Cultural "Evo-Devo"

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Thin Description

Diachronic Models

Contents lists available at SciVerse ScienceDirect

Journal of Theoretical Biology

journal homepage: www.elsevier.com/locate/yjtbi

A non-equilibrium neutral model for analysing cultural change

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JTB 330: 18-25

Synchronic ⇒ Diachronic version of unbiased CT

Statistic: expected number of variants at T, till present at T+n

Perfect for archaeological use...?

Cultural "Evo-Devo"

Thick Description

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Thin Description

Coarse Grained Models

Diachronic Models

Coarse graining: fine details are "averaged over" to produce a less detailed model

Types of Scientific Theories

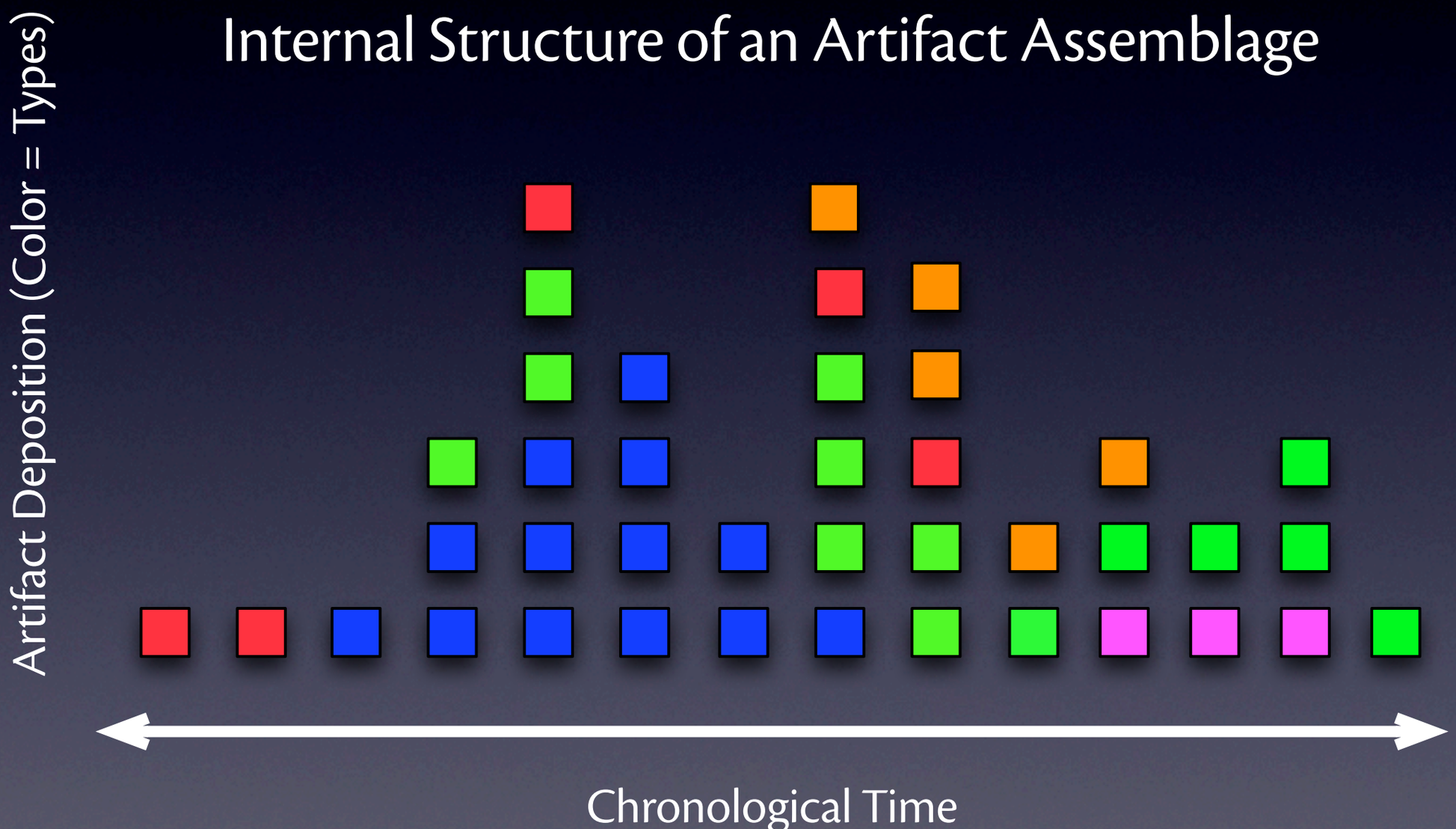
- Fundamental theory
- Effective theory

accurate description of phenomena at a particular scale, without claiming completeness or full realism

Cultural "evodevo" ⇒ fundamental theory

Coarse Grained CT models ⇒ effective theory

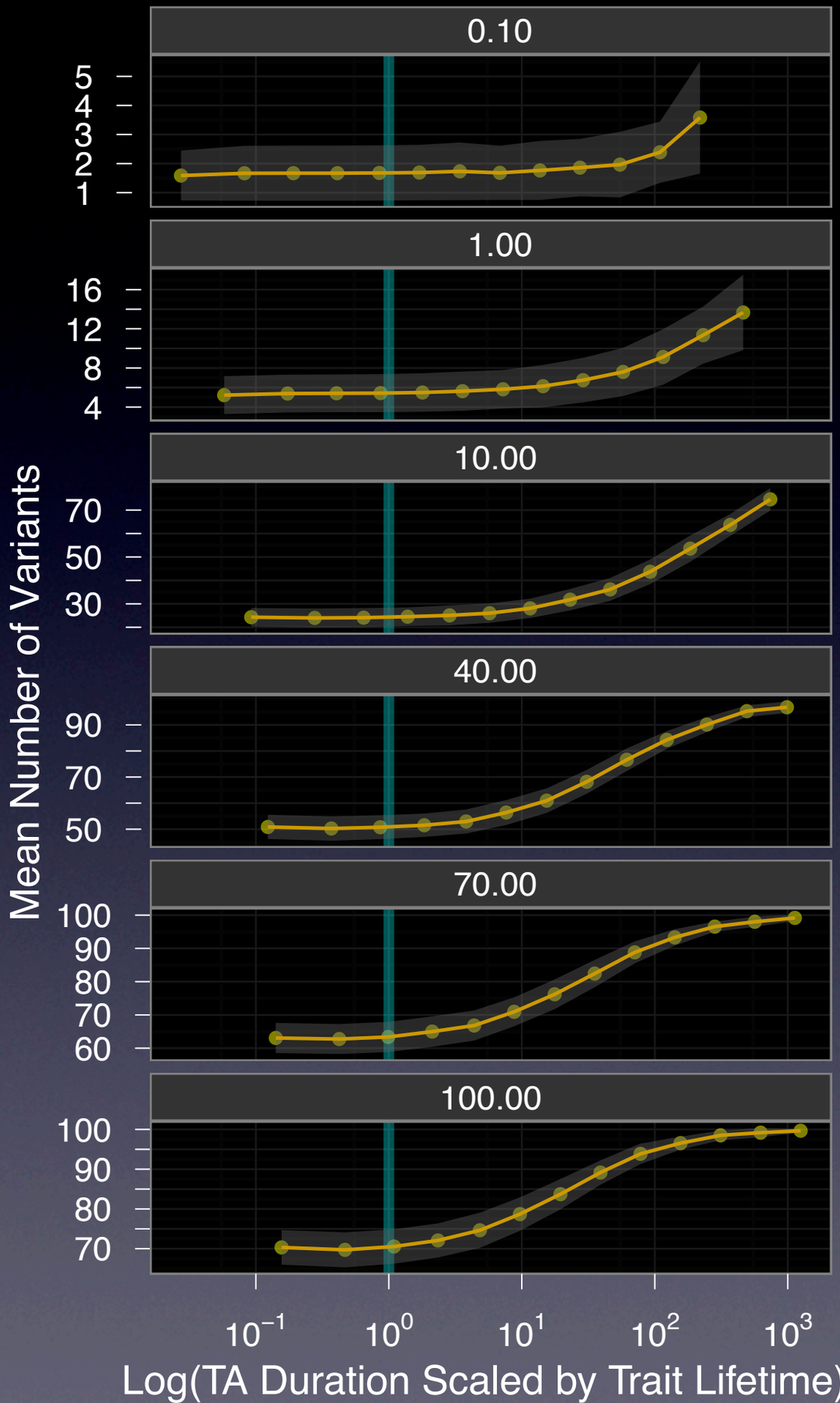
Temporal Coarse Graining (*Time Averaging*)



Numerical simulation experiments

- Simulated unbiased and conformist CT
- Range of innovation & conformism rates
- Each historical trajectory sampled raw, and 11 levels of temporal aggregation
- Measured richness, neutrality tests, evenness, estimation of "theta"

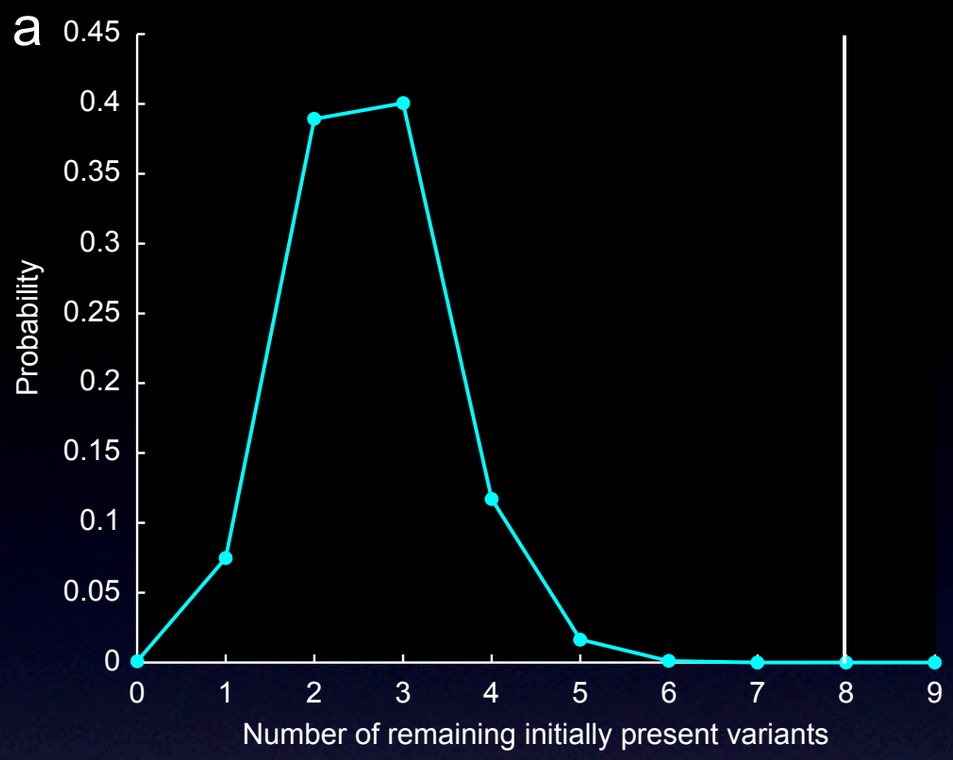
Full results: http://arxiv.org/abs/1204.2043

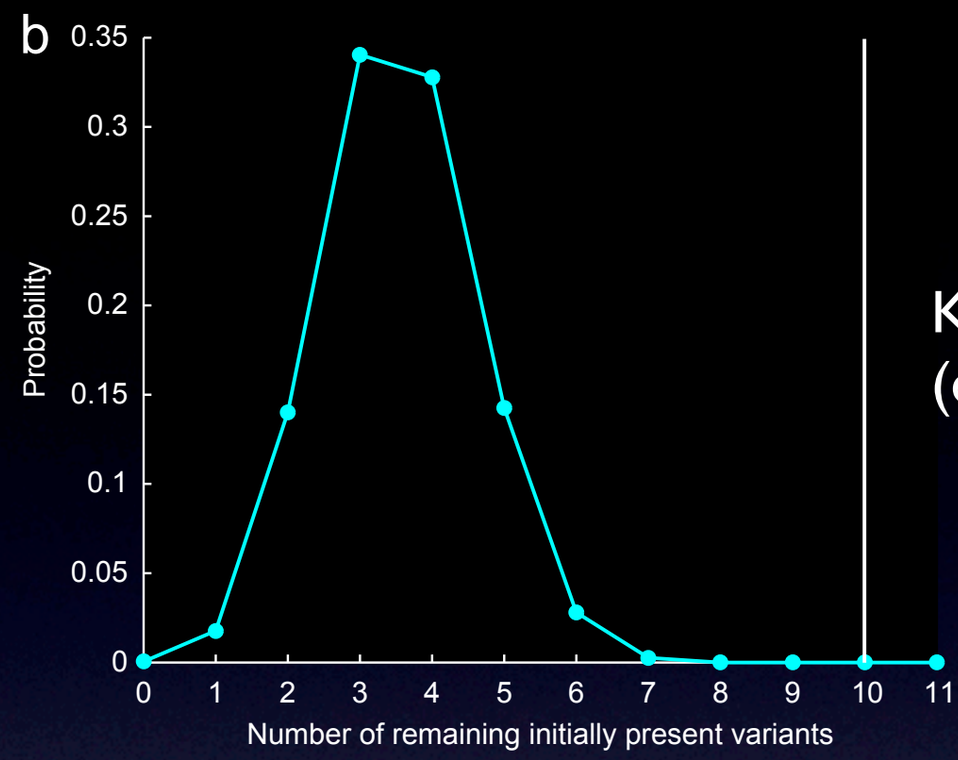


Number of variants is inflated

Effect strong at duration > Average variant lifetime

Effect strong at high innovation rates





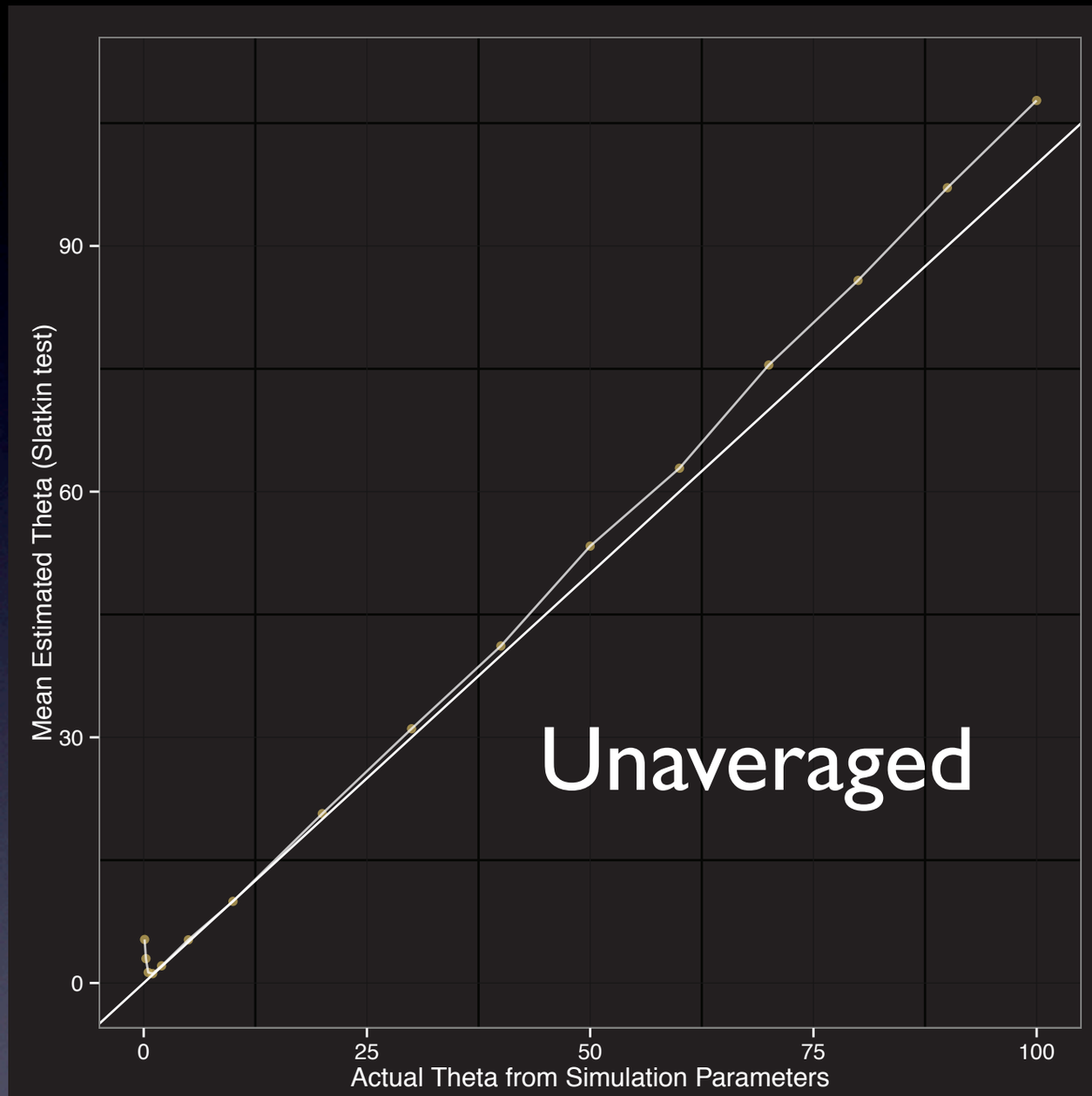
Kandler and Steele 2013
(excerpt Fig. 3)

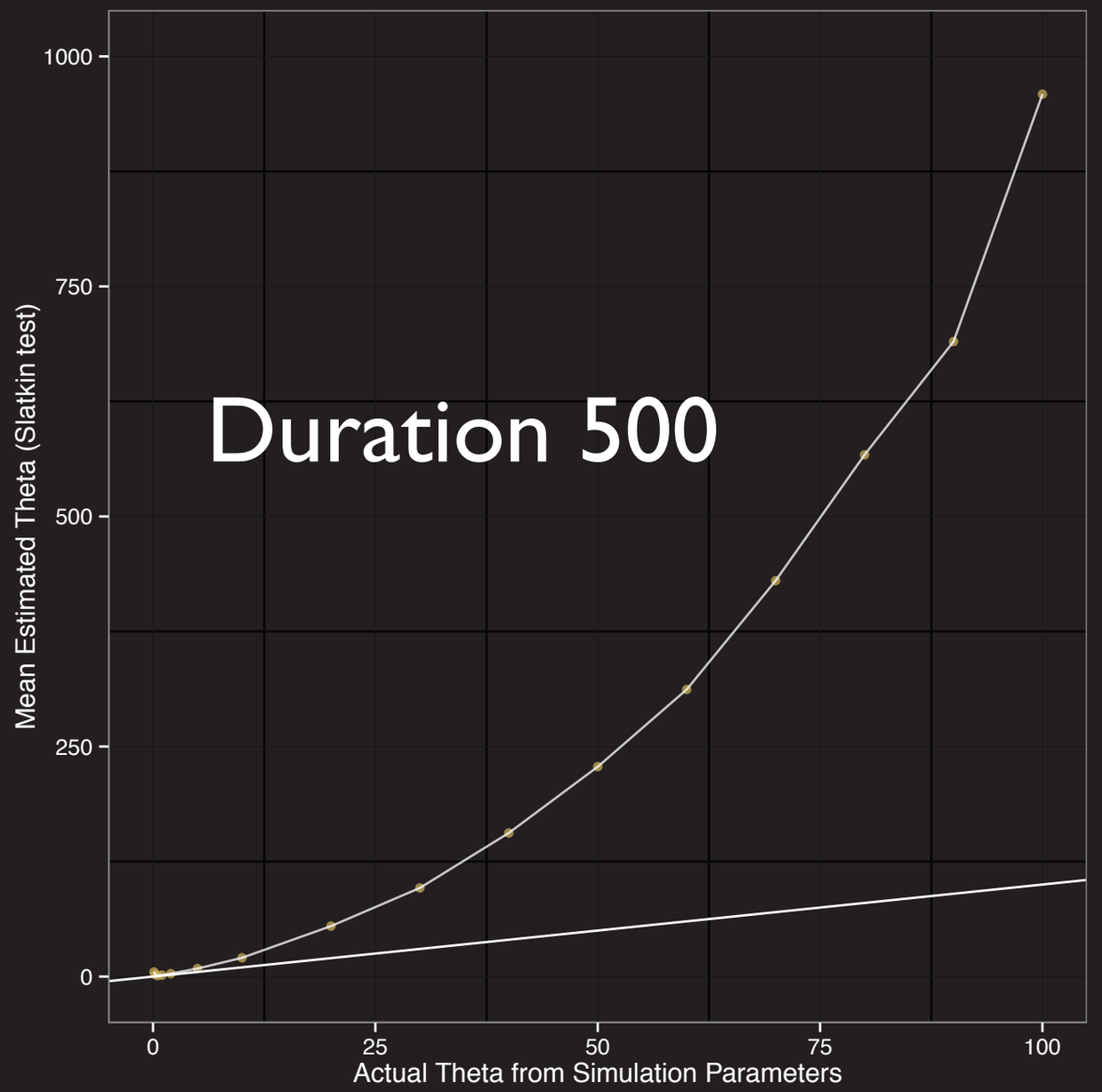
Diachronic model predicts the surviving number of variants in pairs of LBK ceramic phases

Observed survival is much larger than predicted.

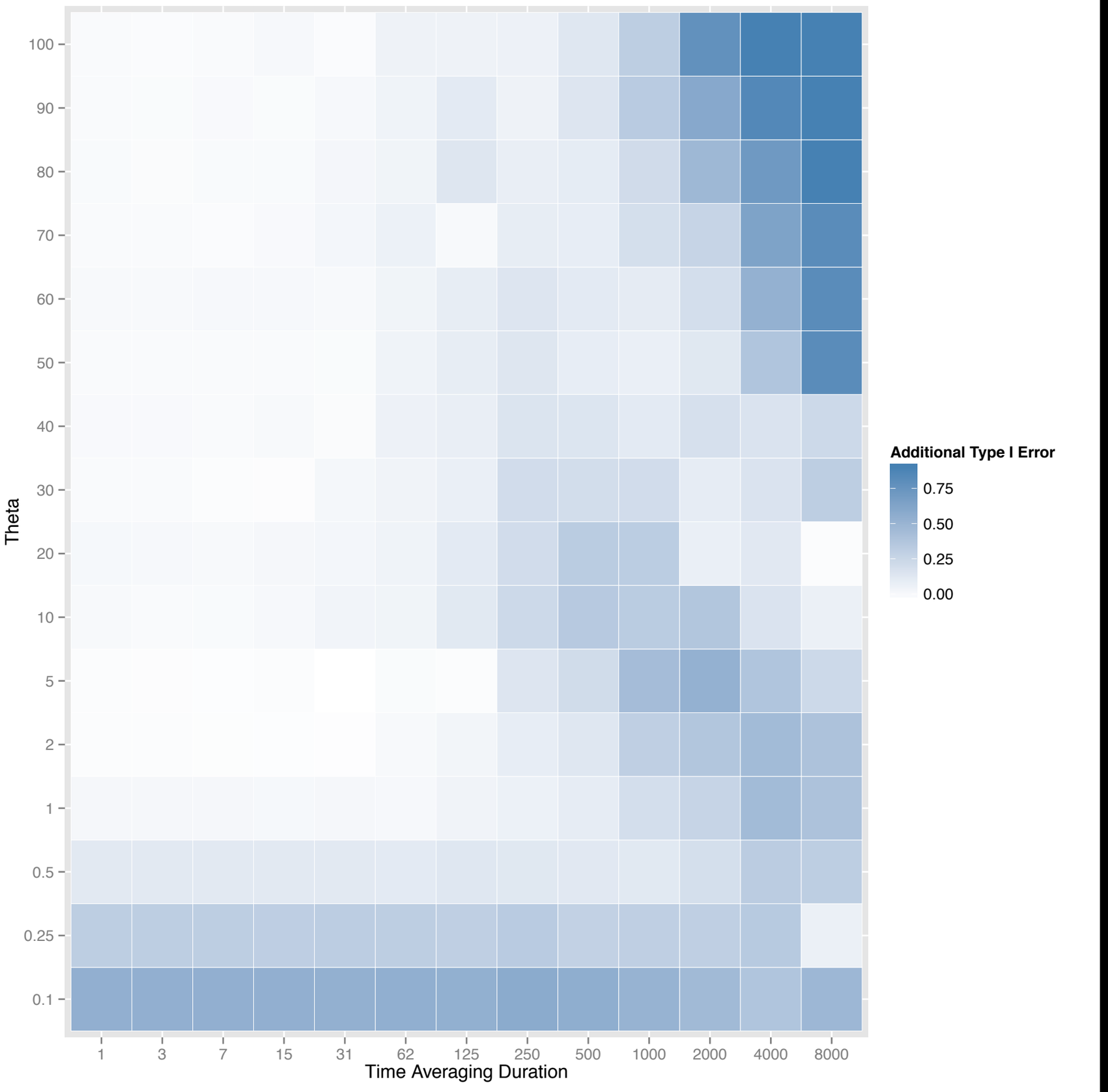
Is this pro-novelty bias or the inflationary effect of time averaging on class richness?

Effects of Time Averaging Upon Estimation of Θ





Θ = 2 * population size * innovation rate



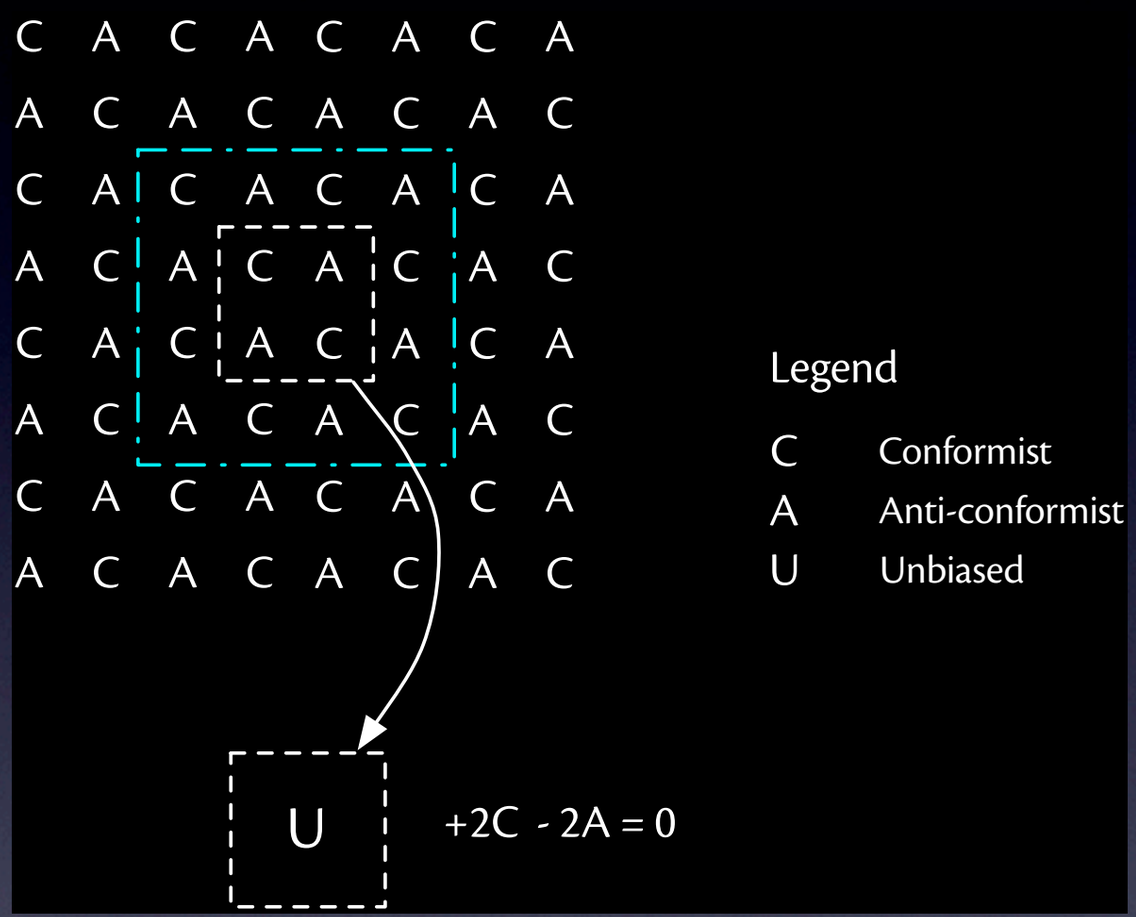
Where do neutrality tests encounter problems under time averaging?

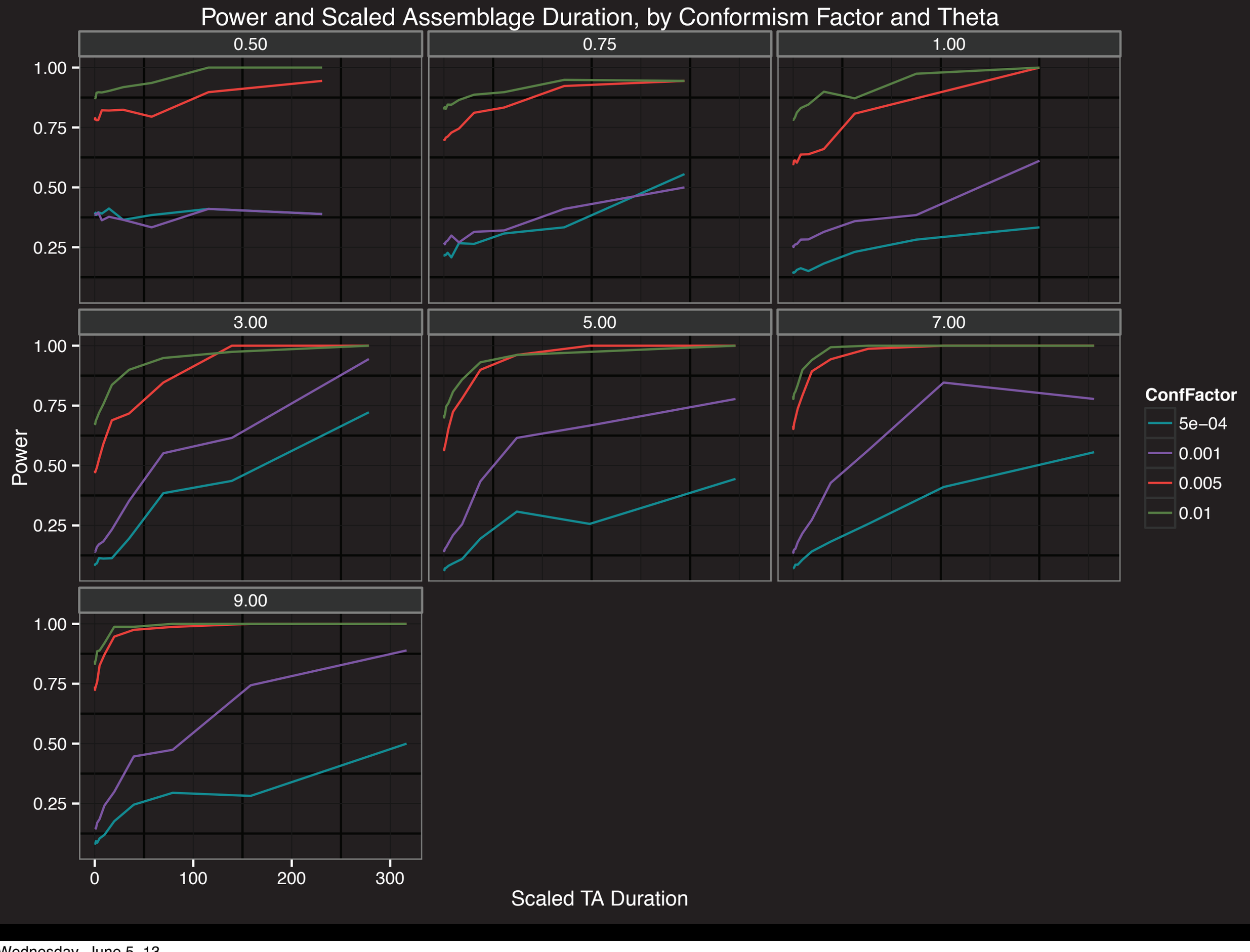
Real populations display diverse modes of social learning

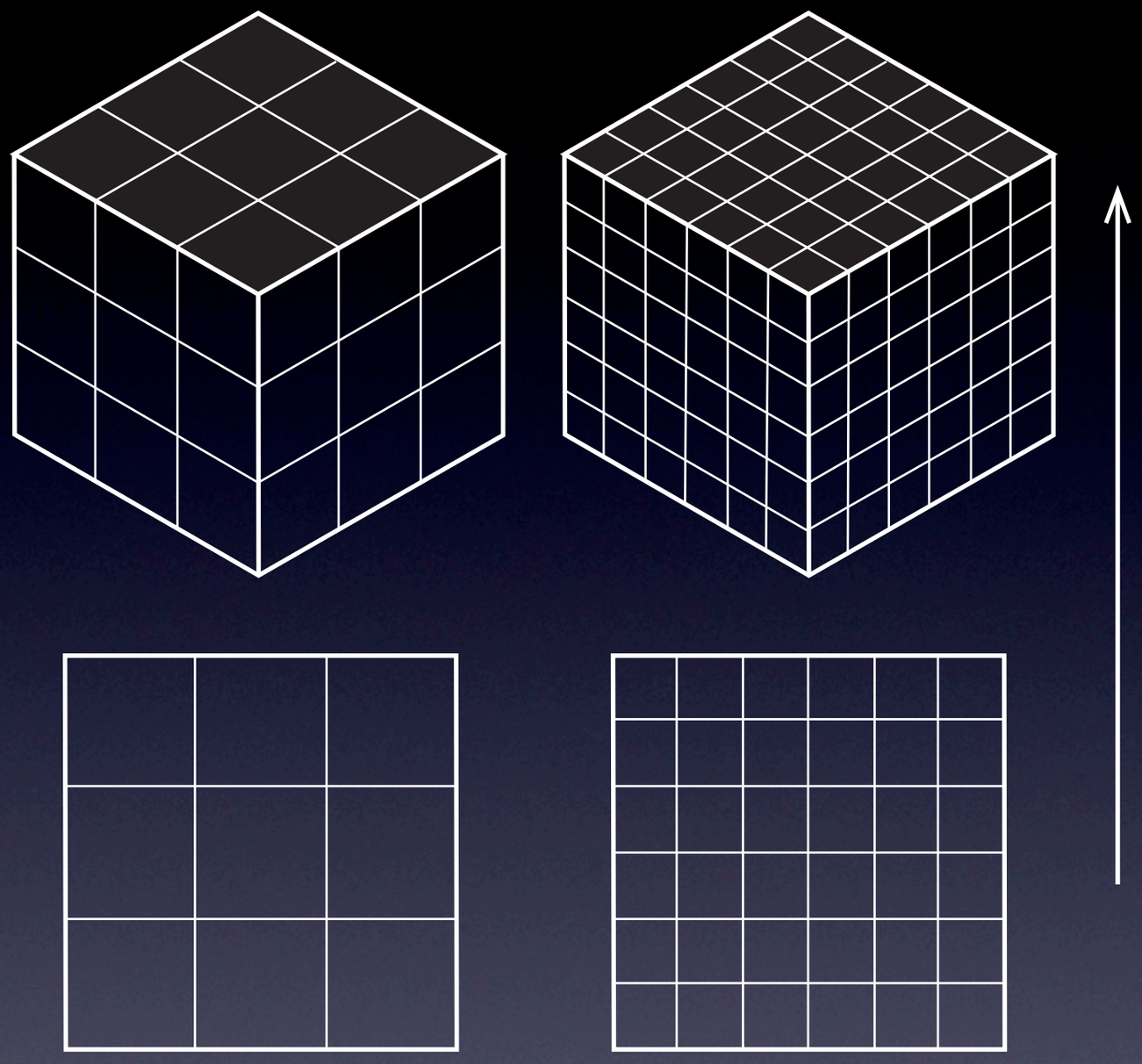
Do all of the biases in CT cancel each other out, at the population level?

What tests are the most powerful discriminators?

How do the answers change with time averaging?



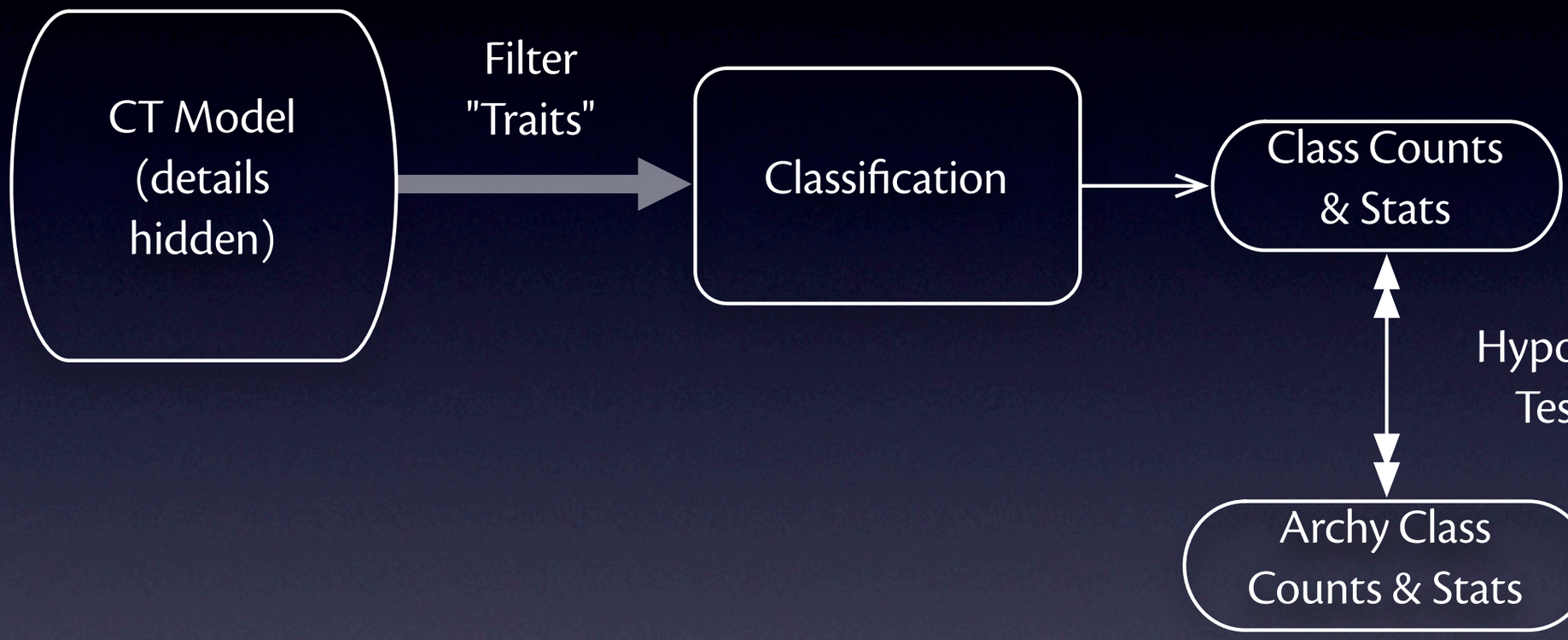

Power and Scaled Assemblage Duration, by Conformism Factor and Theta
0.50
0.75
1.00
3.00
5.00
7.00
9.00
1.00
0.75
0.50
0.25
Power
0
100
200
300
Scaled TA Duration
ConfFactor
5e−04
0.001
0.005
0.01



Classificatory Coarse Graining

How do observables from CT models change when we measure variation using types with:

Different dimensionality
Different granularity



Schematic of CT models coarse grained through classification(s)

Thick Description

Cultural "Evo-Devo"

Rich Models of CT for Archaeological Time

Ecological Time

Evolutionary Time

Dual Inheritance Theory

Neutral Theory

Coarse Grained Models

Diachronic Models

Thin Description

For more information:

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http://notebook.madsenlab.org

Appendix

Objection: cultural behavior and information is too different from genetics to be modeled the same way

Cultural traits are NOT

- Alleles at fixed loci
- "Coded" replicators

Cultural traits ARE

- Networks of actions, facts, and strategies, linked to contexts
- Heritable given social, environmental, and developmental "scaffolding"
- Reconstructed, not transcribed, into products

BUT....Genetics is in the same boat...

- Genes require lots of "scaffolding"
- Gene effects are always reconstructed ("evo-devo")
- Eventual result depends upon epigenetic variation
- The line between "acquired" and "inherited" is blurrier than critics think...

Marmosets: *chimerism*

Born as twins, each sharing sibling's genotype and parental genotypes

Oak: *mosaicism*

Each branch can develop a divergent genotype