Cultural Evolution at the Group Level

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Recap

- Lecture 1. Models of cultural diversity
  - Human communities vary greatly in social organization, behaviors, and knowledge
  - Many theories to explain diversity
    - Darwinian processes
    - Neutral theory
- Lecture 2. Simple models of social learning
  - Use of mathematical models to hone intuitions
  - Comparing predictions of models against real observational data
  - Experimental evidence for how people learn from others

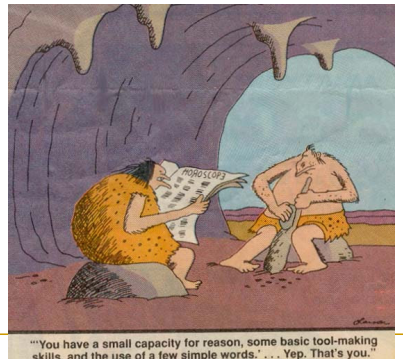
Questions

- How does social demography influence the spread and maintenance of cultural traits?
- Are extant patterns of cultural diversity a result of branching with isolation or long-term mixing between groups?
- Is the cultural history of human groups adequately represented by trees?

Overview

- **Part 1.** How does social demography and community structure influence the spread and maintenance of cultural traits?
- **Part 2.** How can we test competing theories of linguistic and/or cultural history?

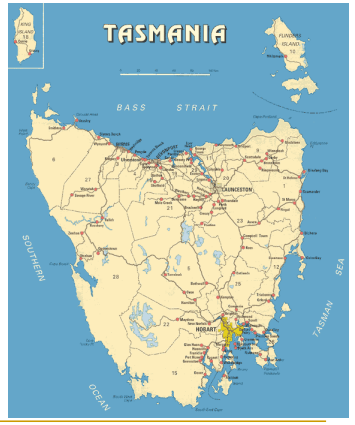
Part 1. Does social demography influence the creation, maintenance and spread of skills, behaviors, ideas?



"'You have a small capacity for reason, some basic tool-making skills, and the use of a few simple words.' . . . Yep. That's you."

The Tasmanian Puzzle

- Europeans arrived 1642:
  - 4000 Tasmanians on island 2/3 the size of Ireland
  - Simplest technology of any people ever encountered
    - Simple stone tools
    - Clubs and one-piece spears.
    - No bone tools
    - No fishing technology
    - Clothing--1-piece wallaby skill
    - Some groups could not make fire
  - Stark contrast to Victorian Aboriginals 150km north



Henrich (2004). American Antiquity.

Archaeology: The Puzzle deepens

- In last 10,000 years, Tasmanians *lost a series* of skills and technologies. These likely include bone tools, cold-weather clothing, hafted tools, nets, fishing spears, barbed spears, spear-thrower, boomerangs and the ability to make fire (?).
- In all, the entire Tasmanian toolkit comprised about 24 items
- Contrast this with aboriginal Australians across the Bass Strait who possessed almost the entire Tasmanian toolkit plus hundreds of additional specialized tools including…
- multi-pronged fishing spears, spear throwers, boomerangs, mounted adzes, composite tools, a variety of nets for birds, fish and wallabies, sewn bark canoes, string bags, ground edge axes and wooden bowls for drinking

Sudden Separation

- 10,000 years ago was the end of the last glacial epoch.
- The ice melted, glaciers retreated, and the oceans rose.
- The "Bass Bridge" become "Bass Straight"
- Tasmanians were suddenly cut off mainland Australia, for at least 8000 years.

Why lose something when its useful?

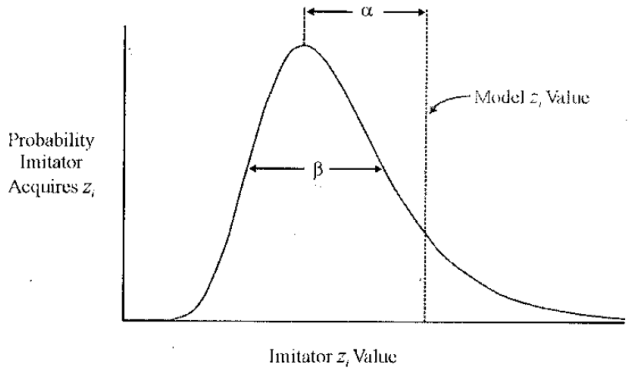
Test the logic of an idea by constructing a mathematical model

a) Everyone attempts to acquire skills/knowledge from the individual with highest *z* value (z_h)

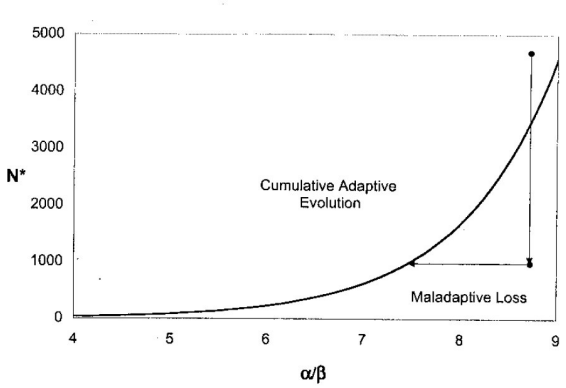
b) Inferential process is fraught with mistakes & errors, because observations supply only a fraction of underlying information.

c) On-average, copiers will fall far short of most skill individual (z_h), but some errors or individual learning will (statistically) make some individuals more proficient or knowledgeable.

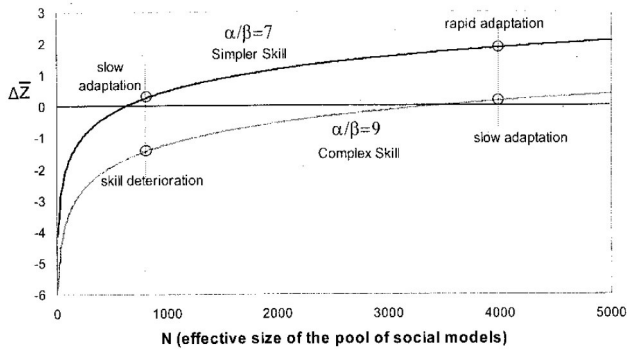
Imperfect Inferential Process



Maintenance of skills depends on N*

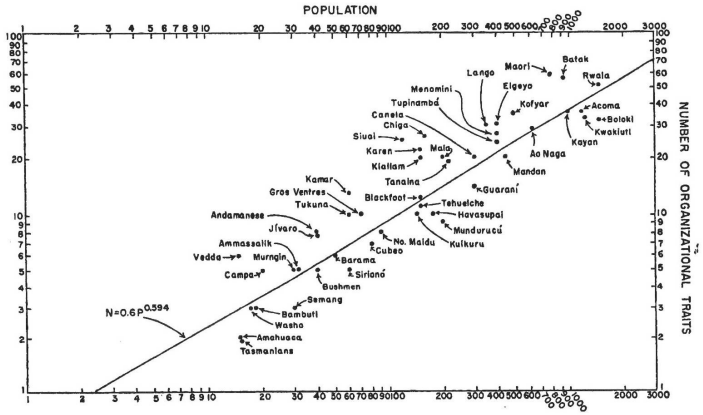


Maintenance of skills depends on N



Tasmanian Puzzle

- Rising seas cut Tasmania off
- This drastically reduced the effective size of the social network for cultural learning
- Gradually, over 1000's of years, useful technologies and knowledge was lost.
- This did not happen in Victoria, as they were connect with larger networks of Australia.
- Point: cultural evolution is a social process that depends on the demographic and network details.



•Both population size and density are related to number of organizational traits
•Traits that are primarily "organizational" in that they involve the coordinated action of at least two people.

Carneiro (1967). Southwestern Journal of Anthropology.

Points

- Human psychological capacity is not enough to support large cultural complexes.
- Rather it must be united with sufficient population or social density.
- Sometimes cultures become less complex

Encyclopedia Britannica

- *Definition of "Cultural Evolution":* the development of a culture from simpler to more complex forms, by a continuous process. The subject may be viewed unilinearly, tracing the evolution of humankind as a whole; or it may be viewed multilinearly, treating the evolution of each culture or society (or of given parts of a culture or society) individually…

Further Reading

- Van Schaik et al. (2003). Science.
- Shennan (2001). Cambridge Archeological Journal.

Part 3. Testing models of cultural history

- Given the extant pattern of cultural variation among populations, how can we assess different theories of their history?
- Here, I make no assumptions about whether evolution or change is Darwinian.

Aims

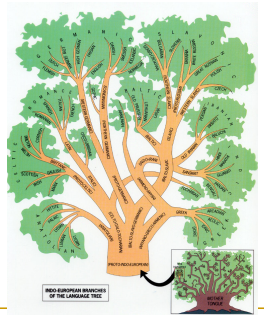
- **Review current models of long-term cultural and linguistic history**
- Introduce East Papuan case
- Describe likelihood framework to compare competing models
- Apply approach to data on syntactic features of East Papuan languages

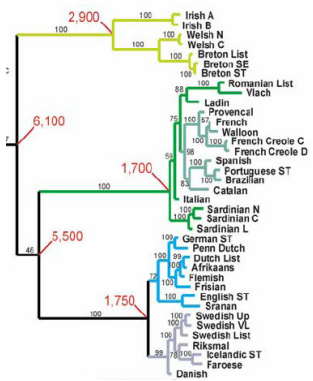
Problem

- What processes have lead to extant patterns of variation in cultural or linguistic features across populations?
- Culture:
  - Practices (i.e. basket-making, tapestry-weaving)
  - Beliefs (i.e. food taboos)
  - Institutions (i.e. kinship and marriage patterns)
- Language:
  - Word lists
  - Syntactic features

Family Trees

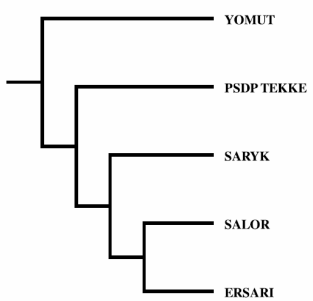
- *Underlying theory:* branching and subsequent isolation

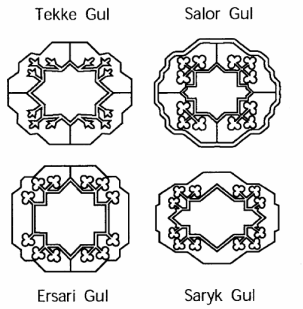




From Gray and Atkinson (2003)

Cultural Variation





Maximum Parsimony Cladogram in Turkmen textile designs, Tehrani & Collard 2002

Reticulation Critique

- Two arguments
  - high degrees of observed hybridization
  - circularity of tree construction
- Often Anthropologists and Linguistic Fieldworkers
- Weaknesses:
  - Largely verbal
  - Particular cases
  - Too many models
  - Processes are there, but how important?

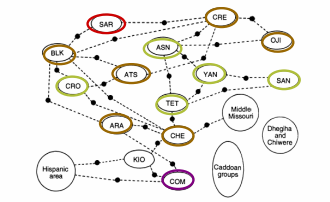


Figure 7
Hybrid bands existing among the tribal nations of the Great Plains. SAR = Sarcee, CRE = Plains Cree, BLK = Blackfeet, ASN = Assiniboin, OJI = Plains Ojibwa, CRO = Crow, ATS = Atsina, YAN = Yankton, SAN = Santee, TET = Teton, ARA = Arapaho, CHE = Cheyenne, KIO = Kiowa, COM = Comanche.

From Moore (1994)

- Athapaskan
- Algonquian
- Siouan
- Uto-Aztecan

Comparison of two approaches

	Trees	Reticulation
Data	N-group comparison, Quantitative	Case studies
Analysis	Search within space of trees, Exclude cases of hybridization	Particular examples of hybridization

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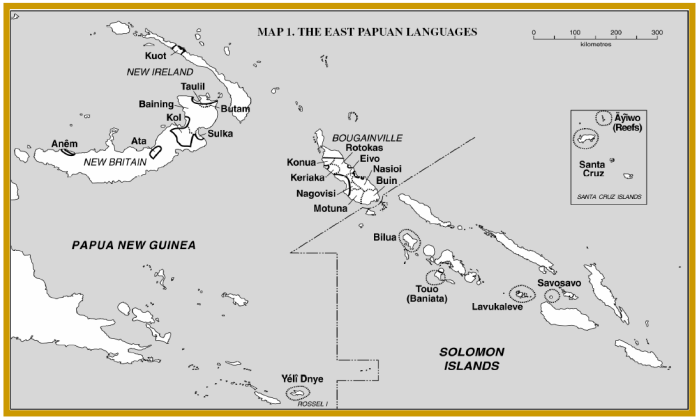
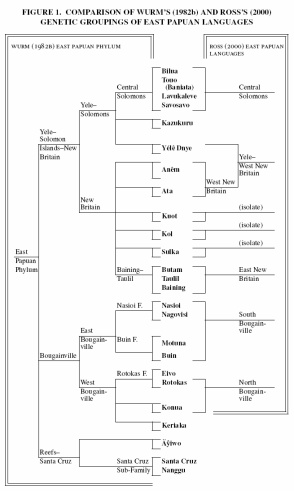
Example from East Papuan



From Dunn et al. 2002

Debated Histories

- Wurm (1975), lexicostatistics and typological classification
- Ross (2005), pronouns
- Dunn et al. (2005), syntactic features, maximum parsimony
- Terrell et al. (1997), process argument



From Dunn et al. 2002

Recent approach to the problem

- Dunn et al. (Science 2005)
- 15 “East Papuan” languages
- 16 “Austronesian” languages
- Problem: very few plausible cognates (< 3%)
- 11 sound system & 114 syntactic features
- Dichotomous (presence/absence)
- Concerns
  - Missing data (141 out of 1875)
  - Non-independence of features?
  - Forms versus features

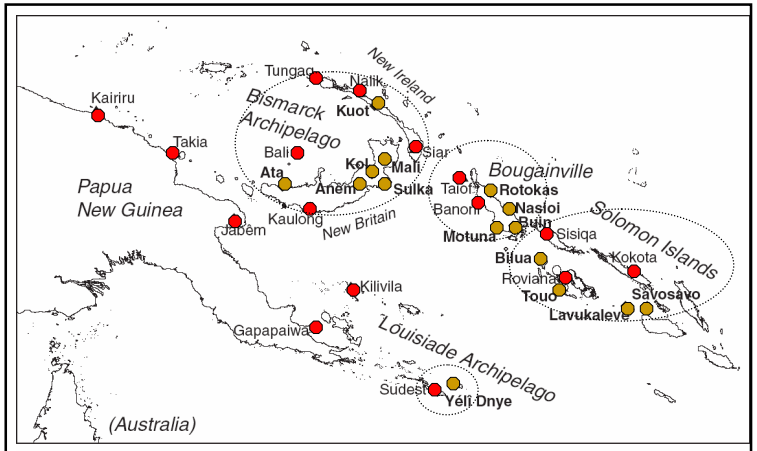


Fig. 1. Island Melanesia, showing the distribution of the Western Oceanic (Austronesian) (triangles) and Papuan (diamonds) languages used in the sample.

East Papuan — Western Oceanic

Modified from Dunn et al. (2005)

What counts as a syntactic feature?

- *Example:* Presence of copula

  "I am a person" vs. "Ya chelovek"

- Others are not so straightforward
- Data: 125-element vector of 0s and 1s

*According to Dunn et al.

Data Layout

	Group	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
	Rotokas	0	1	1	0	1	1	1	0	1	.	0	1
	Buin	1	0	1	1	0							
	Nalik												
	Bilua												
	Kuot												
	Mali												
	Sulka												
	Yeli Dnye												
	….												

The Approach

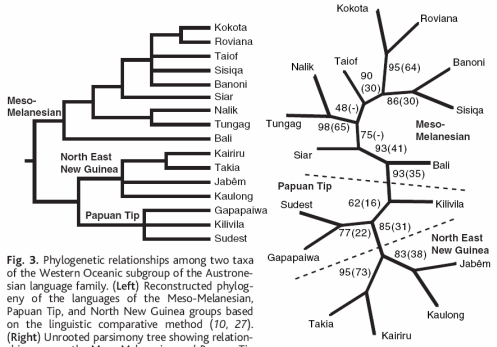
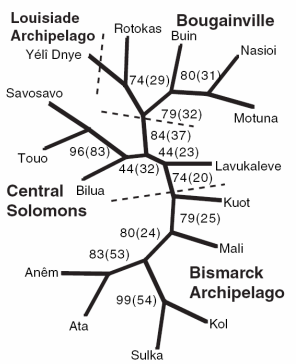


Fig. 3. Phylogenetic relationships among two taxa of the Western Oceanic subgroup of the Austronesian language family. (**Left**) Reconstructed phylogeny of the languages of the Meso-Melanesian, Papuan Tip, and North New Guinea groups based on the linguistic comparative method (*10, 27*). (**Right**) Unrooted parsimony tree showing relationships among the Meso-Melanesian and Papuan Tip groups based on grammatical traits only (that is, discarding abundant lexical evidence) (the figure shows reweighted and raw bootstrap values). The two trees show a high degree of concordance, with monophyly in both major taxa and the similar geographical structuring of within-taxon diversity.

Puzzling Result



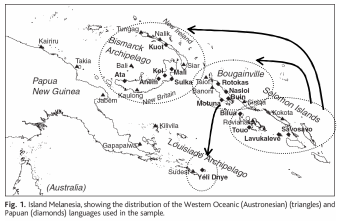


Fig. 1. Island Melanesia, showing the distribution of the Western Oceanic (Austronesian) (triangles) and Papuan (diamonds) languages used in the sample.

Also, Competing Theories

- Long-range divergence (Dunn et al. 2005).
  "Most plausible…divergence of Papuan languages from a common ancestral stock, as part of late Pleistocene dispersals."
- Recent contact (Terrell et al. 1997)
  - Recent West Oceanic dispersal
  - Region of endemic bilingualism (Ross)
  - Between-language transfer of syntactic features (case studies: Sulka, Kuot)
- Within-island group descent (or convergence)

How do we compare these claims?

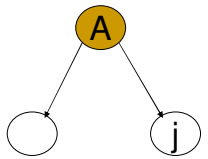
Aims

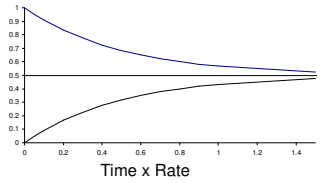
- Review current models of long-term cultural and linguistic evolution
- Introduce East Papuan case
- **Describe likelihood framework to compare competing models**
- Apply approach to data on syntactic features of East Papuan languages

A likelihood framework

- Specify models of process (divergence and convergence)
- Construct related likelihood functions
- Maximize likelihood function for each model
- Compare models using some criteria (e.g., AIC, BIC)

Event 1: Descent



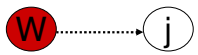


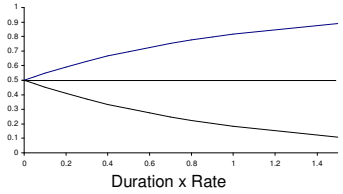
$$p(t_{jk}=1 \mid A_k=1, T_j r_k) = p(t_{ik}=0 \mid A_k=0, T_j r_k) = 0.5(1+e^{-2T_j r_k})$$

$$p(t_{jk}=1 \mid A_k=0, T_j r_k) = p(t_{jk}=0 \mid A_k=1, T_j r_k) = 0.5(1-e^{-2T_j r_k})$$

t_{jk}= value of trait k in group j
A_k= value of trait k in ancestor (perhaps unobserved)
$T_j r_k$=time since j's divergence from A x rate of change in trait k
(Major assumption: 0→1 equally likely as 1→0)

Event 2: Contact



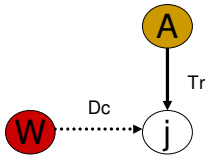


$$p(t_{jk}=1 \mid W_k=1, D_j c_k) = p(t_{jk}=0 \mid W_k=0, D_j c_k) = 1-0.5e^{-D_j c_k}$$

$$p(t_{jk}=1 \mid W_k=0, D_j c_k) = p(t_{jk}=0 \mid W_k=1, D_j c_k) = 0.5e^{-D_j c_k}$$

t_{jk}= value of trait k in group j
W_k= value of trait k in donor (in this case Western Oceanic)
$D_j c_k$=duration of j's contact from W x rate of transmission of trait k
(Major assumption: 0→1 equally likely as 1→0)

Descent & Contact



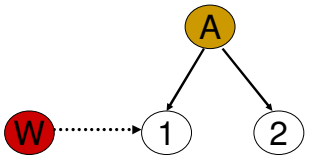
$$p(t_{jk}=1 \mid A_k=1, W_k=1, Tr, Dc) = 1-0.5(1-e^{-2Tr})e^{-Dc}$$

$$p(t_{jk}=1 \mid A_k=0, W_k=1, Tr, Dc) = 1-0.5(1+e^{-2Tr})e^{-Dc}$$

$$p(t_{jk}=1 \mid A_k=1, W_k=0, Tr, Dc) = 0.5(1+e^{-2Tr})e^{-Dc}$$

$$p(t_{jk}=1 \mid A_k=0, W_k=0, Tr, Dc) = 0.5(1-e^{-2Tr})e^{-Dc}$$

Putting it together



$$L(Model|t_{jk}) = \prod_k \left[\begin{array}{l} p(A=0)\left[\left[\begin{array}{l} p(W=1)\left[p(t_{1k}=1|A,W,Tr,Dc)^{t_{1k}}\ p(t_{1k}=0|A,W,Tr,Dc)^{1-t_{1k}}\right]+ \\ p(W=0)\left[p(t_{1k}=1|A,W,Tr,Dc)^{t_{1k}}\ p(t_{1k}=0|A,W,Tr,Dc)^{1-t_{1k}}\right] \end{array}\right]\times \right. \\ \left.\left[p(t_{2k}=1|A,Tr)^{t_{1k}}\ p(t_{2k}=0|A,Tr)^{1-t_{1k}}\right]\right]+ \\ p(A=1)\left[\left[\begin{array}{l} p(W=1)\left[p(t_{1k}=1|A,W,Tr,Dc)^{t_{1k}}\ p(t_{1k}=0|A,W,Tr,Dc)^{1-t_{1k}}\right]+ \\ p(W=0)\left[p(t_{1k}=1|A,W,Tr,Dc)^{t_{1k}}\ p(t_{1k}=0|A,W,Tr,Dc)^{1-t_{1k}}\right] \end{array}\right]\times \right. \\ \left.\left[p(t_{2k}=1|A,Tr)^{t_{1k}}\ p(t_{2k}=0|A,Tr)^{1-t_{1k}}\right]\right] \end{array} \right]$$

Assumptions (for now)

- Rate of change and rate of transmission are the same across all traits
- Traits are statistically independent

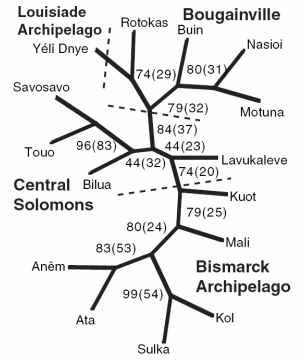
Aims

- Review current models of cultural and linguistic history
- Introduce East Papuan case
- Describe a likelihood framework
- **Apply the approach to compare models of East Papuan linguistic diversity**

Three Models

1. Fully connected tree (Dunn et al. 2005)
2. Within-island group descent
3. Recent Western Oceanic influence

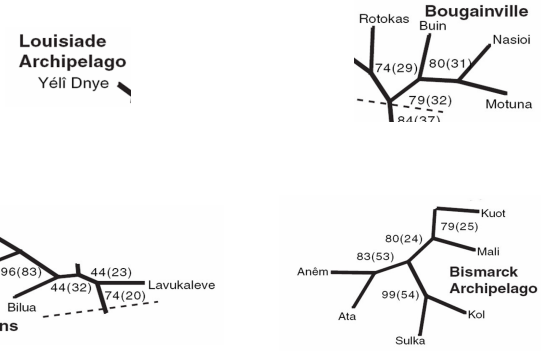
Model 1: Fully Connected Tree (Dunn et al. 2005).



27 parameters

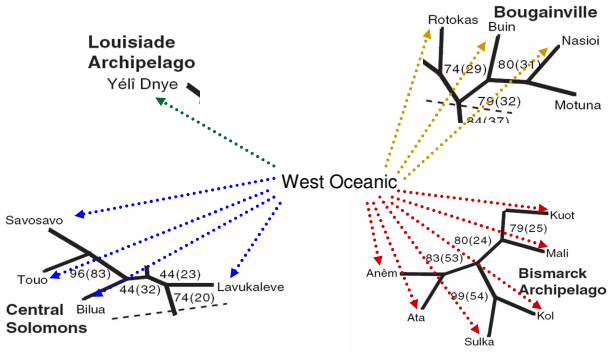
Dunn et al. (2005)

Model 2: Island Group Trees Only (No common ancestor)



19 parameters

Model 3: Island Groups with West Oceanic Influence.



4 parameters

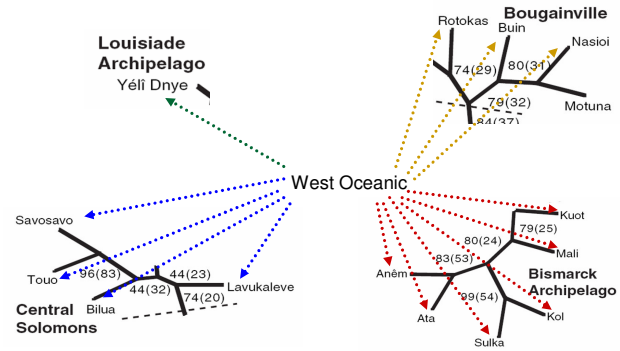
Comparing Models

Model	params	Lnlikelihood	AIC	BIC
Random	*0*	*-1201.22*	2402.4	2402.4
Tree	*27*	*-1046.09*	2148.2	2289.3
4 islands	*3*	*-1097.22*	2200.4	2236.4
4 island + Western Oceanic	*7*	*-1047.38*	2108.8	2145.9

Tentative Conclusions

- Among the proposed models, within-island similarity and West Oceanic influence best account for the data.
- There is little support for ancestral East Papuan (given this data and the models considered)
- A “tree structure” can arise from a combination of processes

Model 3: Island Groups with West Oceanic Influence.



4 parameters

Lessons

- Time depths of the historical processes may be much more shallow than originally expected
- The importance of using external data (historical, archeological, linguistic) to develop testable models.

Recap

- Lecture 1. Models of cultural diversity
  - Human communities vary greatly in social organization, behaviors, and knowledge
  - Many theories to explain diversity (Darwinian processes, Neutral theory, Ecological and Biological determinism)
- Lecture 2. Simple models of social learning
  - Use of mathematical models to hone intuitions
  - Comparing predictions of models against real observational data
  - Experimental evidence for how people learn from others
- Today. Cultural evolution at the group level
  - How social demography effects the maintenance of skills
  - How to compare competing theories of cultural history

Wrapping up

- Diversity in human communities leaves many open questions.
- We have reviewed some tools available to devise and test and compare theories of cultural change and diversity
- Data, data, data
- Careful case studies of change

Data

- Cross-cultural datasets
  - Human Relations Area Files (Yale University)
    - Ethnography
    - Archeology
  - Standard Cross-cultural sample (Murdock and White 1966)
  - Western North American Indians (Jorgensen 1981)
- Linguistic datasets
  - University of Auckland (Austronesian, Bantu languages)
  - Language corpuses (British National Corpus)
- Forager Toolkits (Collard, U. of British Colombia)
- Greek City-States

Data

- Texts
  - Drout's work on monastery texts
  - Pocklington and Best
- Sampling riffs
  - Pacey Foster

THANK YOU