Simple Models of Social Learning

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Recap from Lecture 1

- Human communities show a great deal of variation in social organization, behaviors, and knowledge
- Several theories attempt to explain why such variation exists
  - Biological differences
  - Rational behavior in context
  - Darwinian processes
  - Neutral theory

Social Learning

- Social learning plays a key role in the last two theories, which depend on the transmission of ideas and behaviors
- *Backtracking:* I'm going to focus on social learning—that is reproduction of behaviors and ideas from "mind to mind" or "body to body"

Questions

- When does it make sense to learn from others?
- When are cultural variants under selection? And how can we detect this?
- How do different learning rules affect the distribution of behaviors and ideas in a population?
- How do people choose individuals to learn from?
- What can explain the human capacity for cumulative social learning?

Tools

- *Population genetics models*—but two kinds of transmission
- *Model comparison*—Predicting distributions of cultural variants under different kinds of imitation
- *Experiments*—how do people choose when to learn socially? And from whom?

5

Overview of Lecture 2

- Introducing Social Learning
- Simple models to assess claims about social learning
- Comparing the predictions of learning models to distributions of cultural variants
- Experiments in social learning

6

Part 1: Introduction to Social Learning

- *Definition:* Change in ideas or behaviors as a result of monitoring other's behaviors
- This often involves an imitation of others' behaviors, but can also involve strategic deviation.
  - If you see someone die after eating a strange mushroom, you choose not to eat such mushrooms
- Contrast with individual trial-and-error learning

7

Context biases in social learning

Problem: You enter a room and must decide whether to sit down or stay standing

- *Just do something*
- *Random learning*: pick someone at random and imitate her
- *Conformist learning*: choose the majority behavior
- *Contrarian learning:* choose the minority behavior
- *Success-biased learning*: choose a successful individual and imitate
- *Similarity-biased learning:* choose someone like you and imitate

8

Social learning in non-human animals

- Choosing prey in novel contexts
- Choosing mates
- Flee-response
- *For a good review:* Danchin et al. (2004). From Nosy Neighbors to Cultural Evolution. Science

9

Part 2: Using simple models to assess claims about social learning

- By 20,000 years ago humans occupied a much wider geographical and ecological range than any other vertebrate species
- Dramatic range of subsistence systems and social arrangements
- Social learning commonly cited as reason for this success in expansion

10

Proposed explanation

- Individual trial-and-error learning is costly, and social learning permits one to avoid this cost (Boyd and Richerson 1985)
- Sometimes no explanation is given

11

Assessing the premises of this claim

- One simple model:
  - Varying environment
  - Fitness consequences of behavior depend on environment
  - Individual learning is costly
  - Social learning costs less, but if the environment changes the information may be wrong

12

"Snerdwumps" Model

- "Snerdwumps" live in variable environment (w/ many states)
- Each environmental state has an optimal behavior with associated fitness increase of *b*
- Fitness increase for other behaviors is 0
- The probability that environments change is *u*
- After environment changes, no existing behaviors are optimal

McElreath and Boyd (2006), based on Rogers (1988)

There are two kinds of learners

- Two genotypes with the following behavioral phenotypes:
  - *Individual learners:* discover locally optimal behavior but pay cost=*c*
  - *Social learners:* imitate a randomly chosen individual from previous generation

Fitness

- Individual Learner: $W(I) = w + b - c$
- Social Learner: $W(S) = w + b(1-u)((1-p) + pq)$

q = freq. of optimal behavior among social learners in prior generation
p = freq. of social learners
u = probability of environmental change

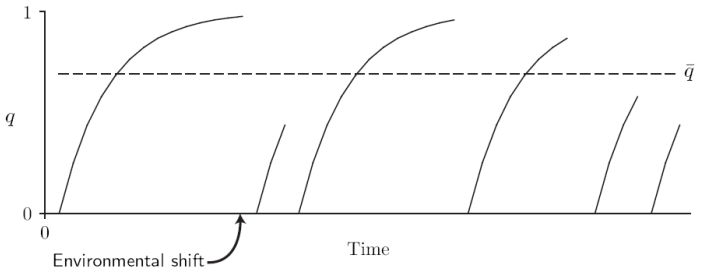
Recursion for q

$$q' = (1-u)((1-p) + pq) + 0 * u$$

Substituting q' into earlier equation for fitness of social learners, we get:

$$W(S) = w + bq'$$

Changes in q over time



Over the long-term we have a *stationary distribution* of *q* with expected value = *q bar*

17

A moving target

- Learning processes govern the frequency of adaptive behavior
- Natural selection acts on frequency of social learners
- And each of these frequencies depends on the other
- We get out of this by assuming that genetic evolution occurs much more slowly than social learning dynamics

18

Assuming gene frequencies are constant What is the expected value of q?

- We find the expected value of the steady state distribution of q

$$\bar{q} = (1-u)E[(1-p+pq]$$
$$= (1-u)(1-p+p\bar{q})$$

$$\bar{q} = \frac{(1-p)(1-u)}{1-p(1-u)}$$

19

Now we can calculate the fitness of social learners in terms of p

$$\hat{W}(S) = w + b\bar{q}$$
$$= w + b\frac{(1-p)(1-u)}{1-p(1-u)}$$

20

When can social learners invade?

$$\hat{W}(S) > W(I)$$

$$b\frac{(1-p)(1-u)}{1-p(1-u)} > b-c$$

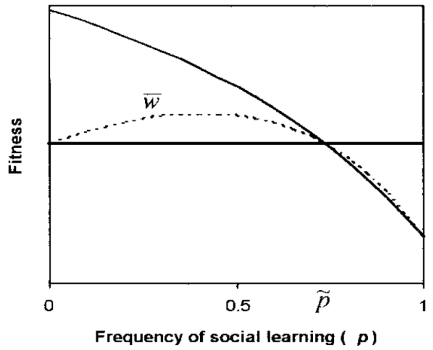
$$b(1-u) > b-c$$

$$\frac{c}{b} > u$$

When the cost of individual learning divided by the benefit of the optimal behavior is greater than the probability of environmental change

21

But does social learning convey a fitness advantage in the long-run?



22

Conclusions from this Simple Model

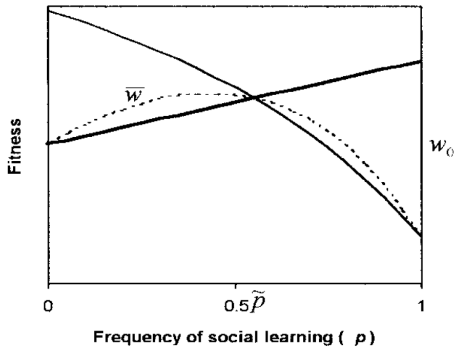
- Under certain conditions, it pays individuals to imitate
- Thus, imitation will increase in a population
- BUT, this may not improve the average fitness of social learners
- Thus we may need more to understand how social learning played a role in the expansion of humans

23

Are any of our assumptions wrong?

24

If more social learners makes individual learning less costly….



25

Changing the Game

- Increase in proportion of social learners increases accuracy of individual learning
- Increase in proportion of social learners decreases the cost of individual learning (Boyd and Richerson 2005)
- Social learners "pay" prestigious individual learners (deference, gifts, labor) for knowledge (Henrich and Gil-White, 2001)
- Critical social learning (Enquist et al. 2007)

26

Broader Lessons

- Explicitly modeling a proposition can lead to count-intuitive implications
- It can also point to assumptions necessary for certain implications

27

Further Reading

- Aoki et al. (2005). The emergence of social learning in a temporally changing environment: a theoretical model. Current Anthropology; 46, 2

28

Part 3. Neutral Model

- N individuals
- Each has a behavioral or cultural variant
- At each time step each person randomly copies from someone from previous time step
- With probability, μ, a variant changes to a novel variant

Kimura and Crow 1965, Crow and Kimura 1970

29

Implications under the Neutral Model

- The equilibrium frequency distribution of variants at one point in time is:

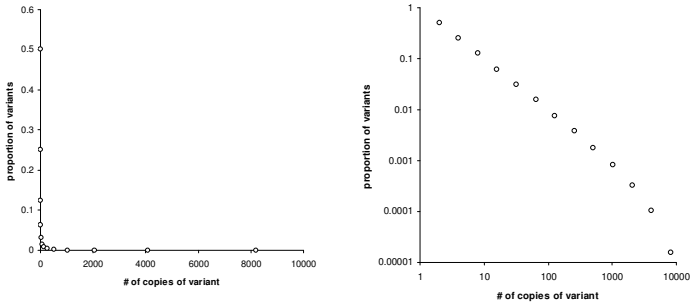
$$P(v) = 2N\mu v^{-1}(1-v)^{2N\mu-1}$$

Where P(v) is the proportion of variants with frequency v.
This is for haploid organisms.

Ask me about the imitation error

30

Graph of Frequency Distribution



31

Using with cultural data

- Cultural and archeological data is rarely available from one point in time
- Bentley, Hahn and Shennan (2004) use simulations to estimate distribution for data accumulated over time.
- They compare with distributions of:
  - First names
  - Pottery motifs
  - Patent Citations

32

First Names

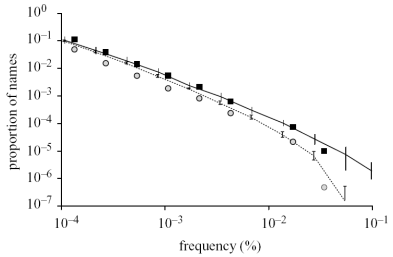
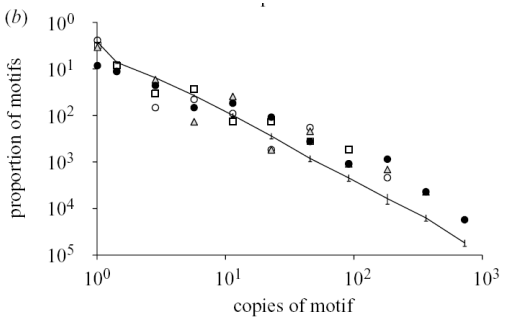


Figure 4. Frequency distribution of first names, from 1990 US Census data. The popularity of a name is measured as a fraction of the US population. The exponent α for male names (squares) is 1.73 ($r^2 = 0.990$) and for female names (circles) is 1.93 ($r^2 = 0.968$). Dotted line, $N\mu = 16$ model (100 time steps); solid line, $N\mu = 8$ model (100 time steps).

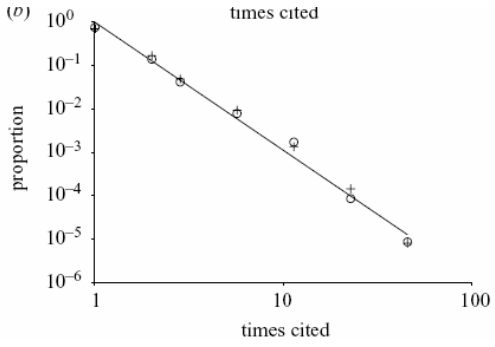
33

Pottery Motifs from Merzbach, Germany



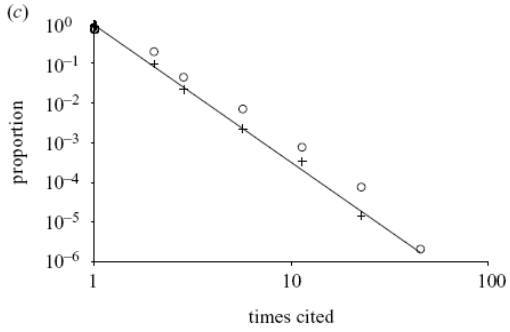
34

Patent Citations for 'CD' patents



35

Patent Citations for 'automobile



36

What's missing?

37

Other models

- Bentley and Shennan (2003, Am. Antiquity) describe the frequency distributions expected for other models:
  - Independent decisions
  - Biased Transmission (Conformist, Anti-conformist, Prestige)

38

Conclusion

- Probably not all cultural phenomenon fit the neutral model, but it is a good null model to test against
- We need more models with explicit predictions AND data for cultural variants that we might expect to be under selection (Not just pop culture and citations)

39

Further readings on testing theories of social learning against observational data

- Herzog et al. (2004). Proc. Of the Royal Society B.
- Bentley et al. (2007). Evolution and Human Behavior
- Peyton Young: Spread of Innovations by Social Learning
- Simkin & Roychowdhury (2005): Stochastic modeling of citation slips. Scientometrics.
- Neiman (1995). American Antiquity. 60, 7

40

Part 4. Experimental Studies

- Intended to identify the context and content effects on social learning
- Salganik et al. (2006). Science.
- Efferson et al. (2007). Evol. & Human Behavior
- McElreath et al. (2005). EHB

Salganik et al. (2006)

- Question: why are music companies unable to predict which songs will become hits?
- Artificial online market of 48 unknown songs and ~14,000 teenagers recruited from teen-interest WWW website

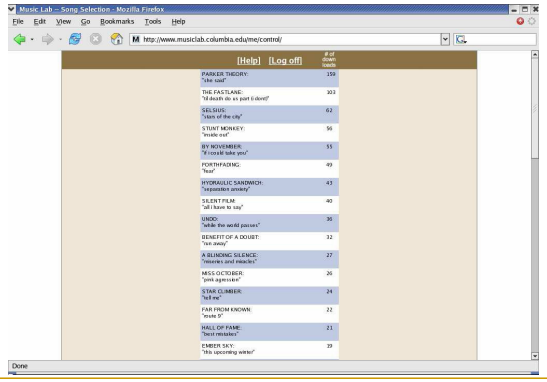
The Songs

Band name	Song name
52metro	Lockdown
A Blinding Silence	Miseries and Miracles
Art of Kanly	Seductive Intro, Melodic Breakdown
Beerbong	Father to Son
Benefit of a Doubt	Run Away
By November	If I Could Take You
Cape Renewal	Baseball Warlock v1
Dante	Life's Mystery
Deep Enough to Die	For the Sky
Drawn in the Sky	Tap the Ride
Ember Sky	This Upcoming Winter
Evan Gold	Robert Downey Jr.
Fading Through	Wish me Luck
Far from Known	Route 9
Forthfading	Fear
Go Mordecai	It Does What Its Told
Hall of Fame	Best Mistakes
Hartsfield	Enough is Enough
Hydraulic Sandwich	Separation Anxiety
Miss October	Pink Aggression
Moral Hazard	Waste of my Life
Nooner at Nine	Walk Away
Not for Scholars	As Seasons Change
Parker Theory	She Said
Post Break Tragedy	Florence
Ryan Essmaker	Detour_(Be Still)
Salute the Dawn	I am Error
Secretary	Keep Your Eyes on the Ballistics
Selsius	Stars of the City
Shipwreck Union	Out of the Woods
Sibrian	Eye Patch
Silent Film	All I have to Say
Silverfox	Gnaw
Simply Waiting	Went with the Count
Star Climber	Tell Me
Stranger	One Drop
Stunt Monkey	Inside Out
Sum Rana	The Bolshevik Boogie
Summerswasted	A Plan Behind Destruction
The Broken Promise	The End in Friend
The Calefaction	Trapped in an Orange Peel
The Fastlane	Til Death do us Part (I don't)
The Thrift Syndicate	2003 a Tragedy
This New Dawn	The Belief Above the Answer
Undo	While the World Passes
Unknown Citizens	Falling Over
Up Falls Down	A Brighter Burning Star
Up for Nothing	In Sight Of

Experiment 1.

After listening to song one rated song ('I love it' to 'I hate it') and could download

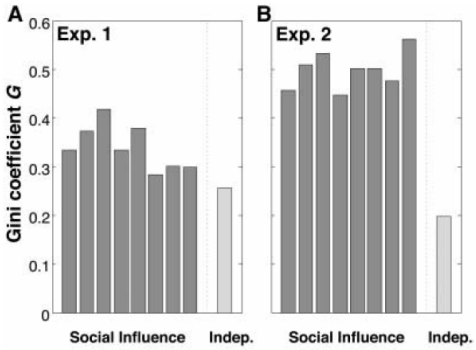
Experiment 2



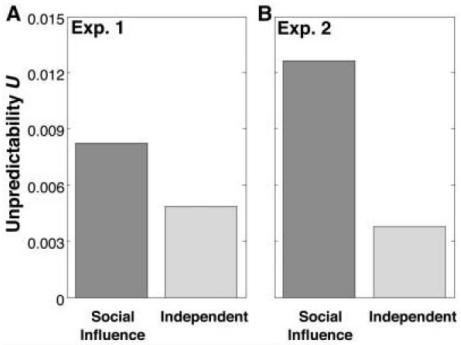
Salganik et al. (2006)

$$m_i = \frac{d_i}{\sum_{k=1}^{S} d_k} \qquad d_i = \text{download count for song } i$$

$$G = \frac{\sum_{i=1}^{S}\sum_{j=1}^{S}|m_i - m_j|}{2S\sum_{k=1}^{S} m_k}$$

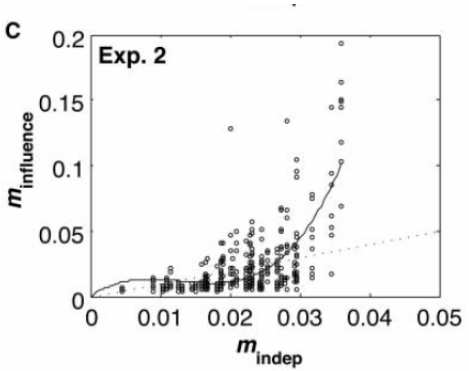


Salganik et al. (2006)



$$u_i = \sum_{j=1}^{W}\sum_{k=j+1}^{W} |m_{i,j} - m_{i,k}| / \binom{W}{2}$$

Influence does increase market share of best songs



Testing theories about differential success of stories

- Heath et al. (2001). The differential success of urban legends is influenced by both their judged plausibility and their emotional evocativeness (principally disgustingness).
- Norenzayan et al. (2006). Comparison of successful and unsuccessful Grimm's fairy tales, widely known fairy tales had 2 or 3 counterintuitive violations.

Heath et al. (2001). Journal of Personality and Social Psychology.

The Value of Good Case Studies

- Ecological Fallacy: Many authors have written about how exotic ants negatively impacted or exterminated native ants in Madiera islands
- In 1850, a botanist and paleontologist, spent several weeks in Madeira's capital recovering from TB

Wetterer (2006). Scientometrics.

Original observation

- *Distribution:* "They are found on the whole south side of the island of Madeira, up to a height of about 1000 feet above the sea, in incalculable numbers, especially in hot sunny places. In the city of Funchal there can scarcely be a house which does not harbour millions of the these creatures, which mount up to the higest stones, issue forth in whole troops out of the chinks of walls and floor, and in orderly regular columns traverse the room in all directions. They creep up the table legs, along their edges, upon the tables themselves, and even into chests of drawers, boxes, etc."
- *Impact:* consumed food around the house and destroyed his dried insect collection. No mention of impact on other ants.

Heer 1856

Overview

- Social Learning
- Neutral models of imitation processes
- Experiments in social learning

Modeling challenges

- Data quantity and quality
- Closer link between known processes of change and mathematical models
- We have still ignored innovations
  - are their general principles that guide cultural innovation?
  - What are the conditions under which cultural innovation arises?

Next Steps

- Lecture 3—Null Models of Language Change