Networks, Extinction and Cultural Evolution

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The limits to the standard model

- **Vernon Smith**: 'I urge students to read narrowly within economics, but widely in science. Within economics there is essentially only one model to be adapted to every application: optimization subject to constraints due to resource limitations, institutional rules and /or the behaviour of others, as in Cournot-Nash equilibria. The economic literature is not the best place to find new inspiration beyond these traditional technical methods of modelling'
- **Friedrich Hayek**: ' An economist who is only an economist cannot be a good economist'
- The standard model has probably already been applied almost anywhere it might be useful

An alternative rationality: 'copying' across networks

- Standard theory remains applicable where the assumption of fixed tastes and preferences is reasonable
- Network theory can help extend the concept of bounded rationality
- But in many contexts, copying/imitation across networks forms a more realistic view of agent behaviour
- This is a different model of rationality which gives different results to 'economic' rationality

Networks (1)

- One way of thinking about networks is that they make explicit the agents from which/to which any given agent receives sends information
- In this sense they help formalise bounded rationality

Networks (2)

- **The fundamental feature of networks is that they offer the basis for a different model of rational agent behaviour**
- 'Humans reason poorly and act intuitively': Daniel Kahneman, Nobel lecture, *American Economic Review*, 2003
- In this approach, agents do not process information and choose rationally in standard economic terms. They copy what others have done
- Obviously, in practice there may be a mixture of the two types of rationality
- Copying implies tastes and preferences are **not** fixed

Why Copy? (1)

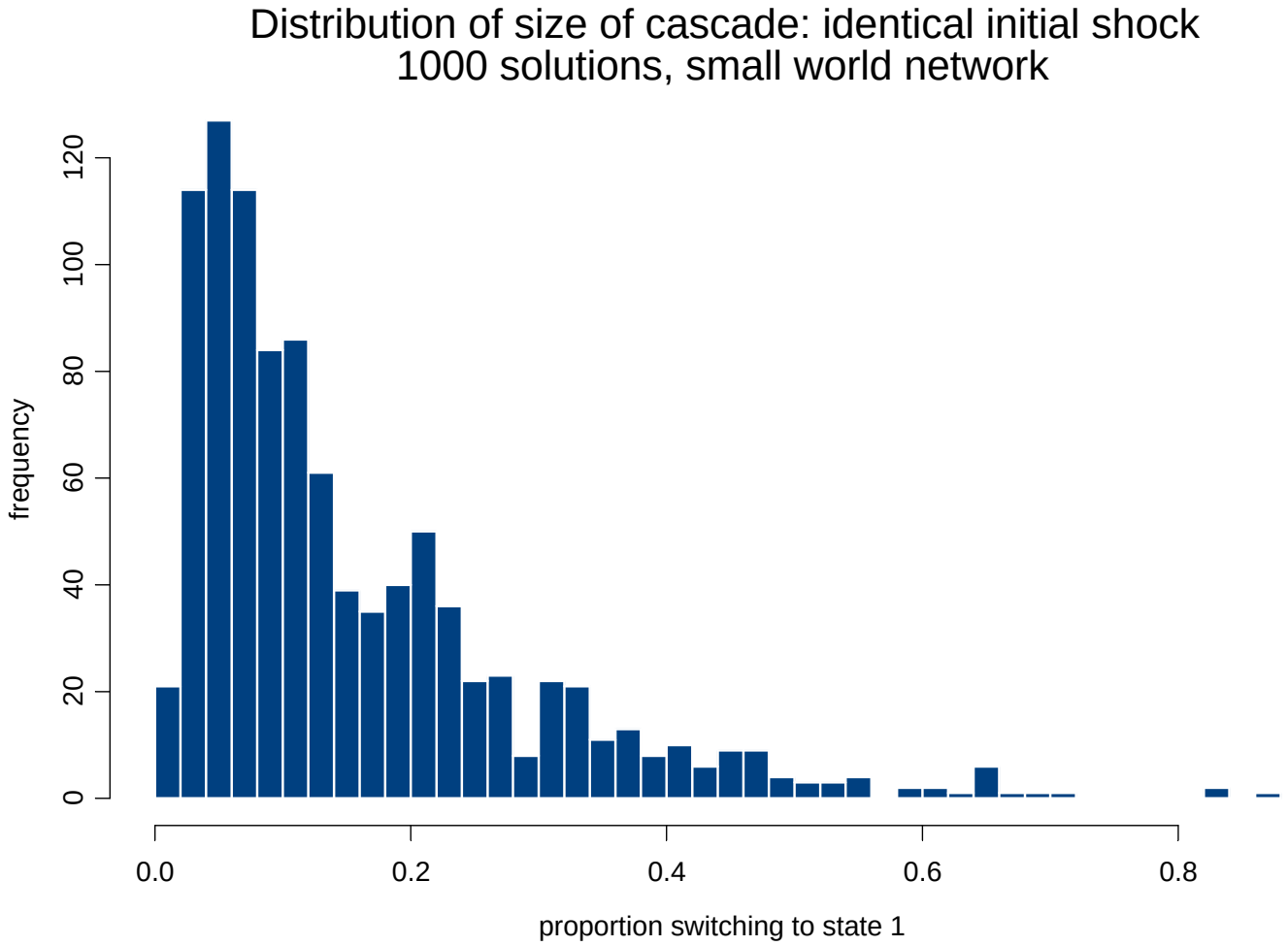
- Asch (1953 and 1955): *conformity*
- the behavior of an agent tends to become more similar to that of the group of which he or she is a member
- either because the agent believes the group to have better information than he or she does, or from a desire to conform to group norms
- *Peer acceptance*: 'it is ok to..... be obese, binge drink'
- Fowler and Christiakis, 'The spread of obesity in a large social network' , *New England Journal of Medicine*', 2007
- Ormerod and Wiltshire, 'Binge drinking in the UK: a social network phenomenon', *Mind and Society*, 2009

Why Copy? (2)

- ‘Social learning (learning through observation or interaction with other individuals) is widespread in nature and is central to the remarkable success of humans’; Rendell et.al. ‘Insights from the Social Learning Strategies Tournament’, *Science*, 9 April 2010
- ‘The most important outcome of the tournament is the remarkable success of strategies that rely heavily on copying... This outcome was not anticipated either by the organisers nor by the committee of experts established to oversee the tournament’
- Simple copying worked very well!

Binary choice with externality

- Much of the agent based/network literature which focuses on the spread of ideas/behaviour, essentially involves 'binary choice with externalities' (Schelling 1973, Watts 2002)
- Heterogeneous agents are connected on a network and can be in one of two states of the world
- Agents switch depending upon their individual threshold (propensity to switch) and the states of the world of their neighbours
- With this model, the process of 'adoption' of new norms or shared conceptions is essentially one of copying (imitation)


Distribution of size of cascade: identical initial shock
1000 solutions, small world network
frequency
0
20
40
60
80
100
120
0.0
0.2
0.4
0.6
0.8
proportion switching to state 1

3 key implications

- Most innovations fail
- There is not necessarily a connection between 'quality' and success
- Big changes do not necessarily imply big causes

Preferential attachment

- The process of preferential attachment (Yule 1925, Simon 1955, Barabasi and Albert 1999) involves agents choosing amongst a fixed number (which may be large) of alternatives
- Agents choose probabilistically in proportion to the number of times each alternative has already been chosen by other agents
- We can think of this as corresponding to agents having complete information about the choices made by all other agents
- A drawback of preferential attachment in its basic form is that as the process of selection unfolds and more and more agents make choices, the relative rankings amongst the alternatives becomes fixed.
- attempts to get round this are rather artificial

Cultural evolution (1)

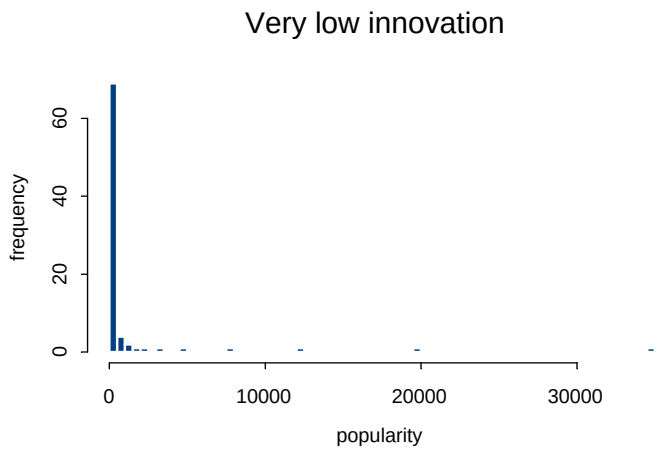
- Cultural evolutionary theory retains preferential attachment as the basis for individual decisions amongst alternatives
- But it allows agents to innovate and select something which no agent has previously done before (Shennan and Wilkinson 2001 Lieberman et al. 2005, Bentley and Shennan 2007)
- Agents select amongst existing alternatives using preferential attachment with probability $(1 - \mu)$ and make an entirely new choice with probability μ
- There is a substantial amount of evidence from a variety of contexts that μ is small, not greater than 0.1 (for example, Eerkens 2000, Larsen 1961, Rogers 1962)

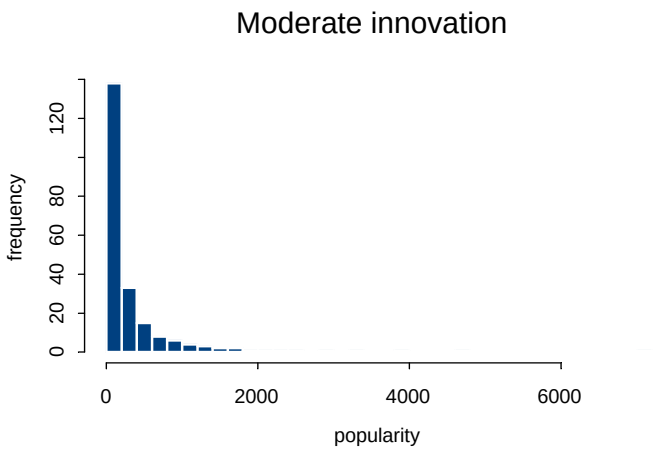
Cultural evolution (2)

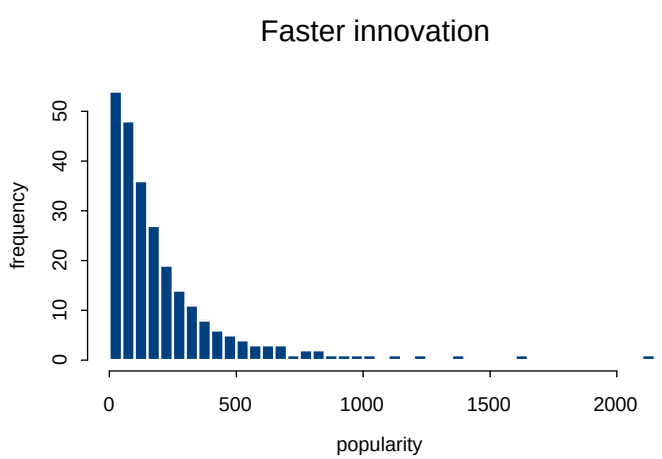
- Turnover in rankings is a natural feature of this model
- The model is known for *m* = 1 and for *m* = 'all', where *m* is the number of previous steps back an agents looks at i.e. how many previous decisions of other agents?
- Bentley, Ormerod and Batty (*Behavioral Ecology and Sociobiology*, 2011) generalize this model
- The 'memory' parameter is allowed to take *any* value – seems natural

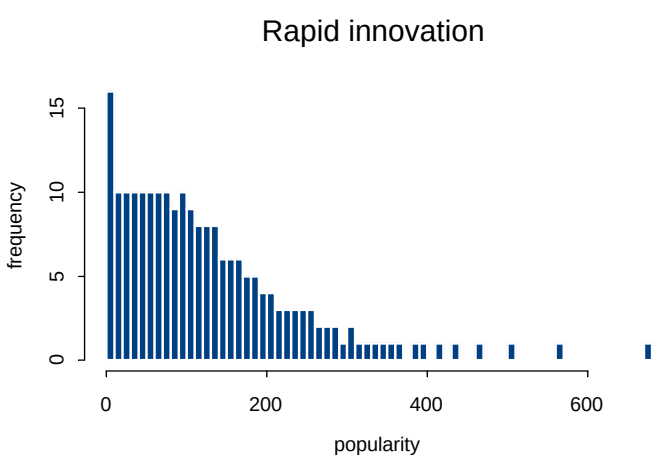
Cultural evolution (3)

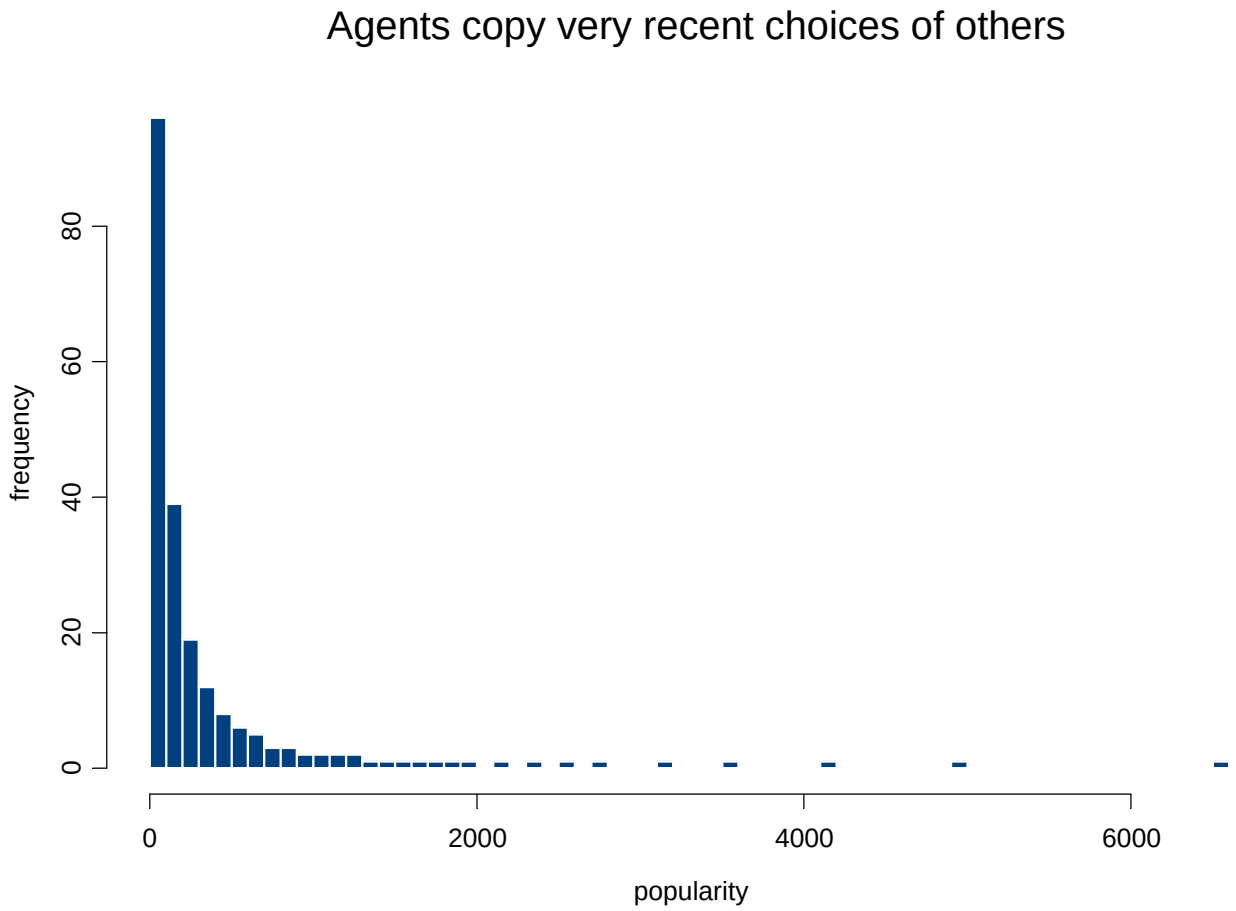
- This model can be calibrated to almost any kind of non-Gaussian right-skewed distribution of the sort we observe in the social sciences
- It gives rise to turnover in rankings
- It is very parsimonious: there are only 2 parameters
- Varying *m* can generate both ‘R’ and ‘S’ curves for replacement
- 'extinction' and equality of outcome vary with innovation and memory

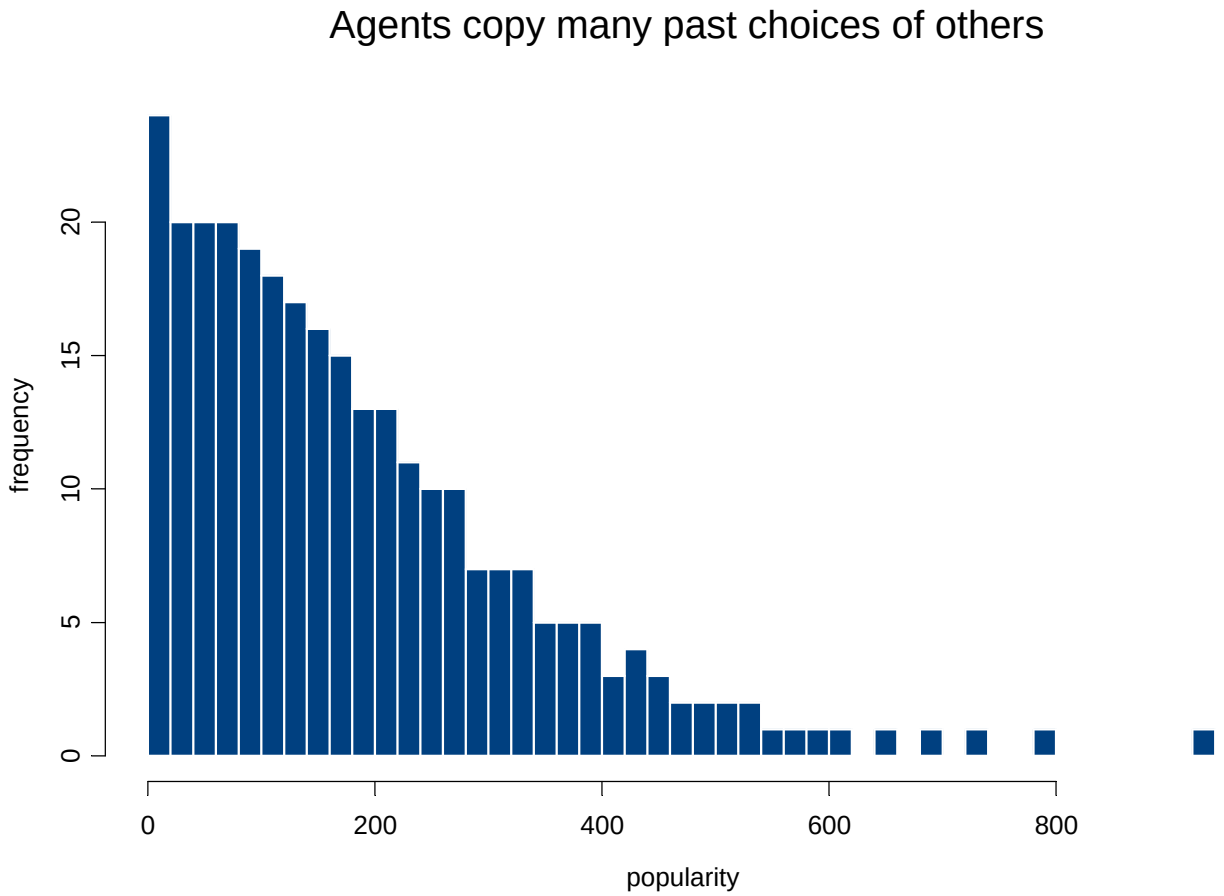

Very low innovation
frequency
0
20
40
60
0
10000
20000
30000
popularity

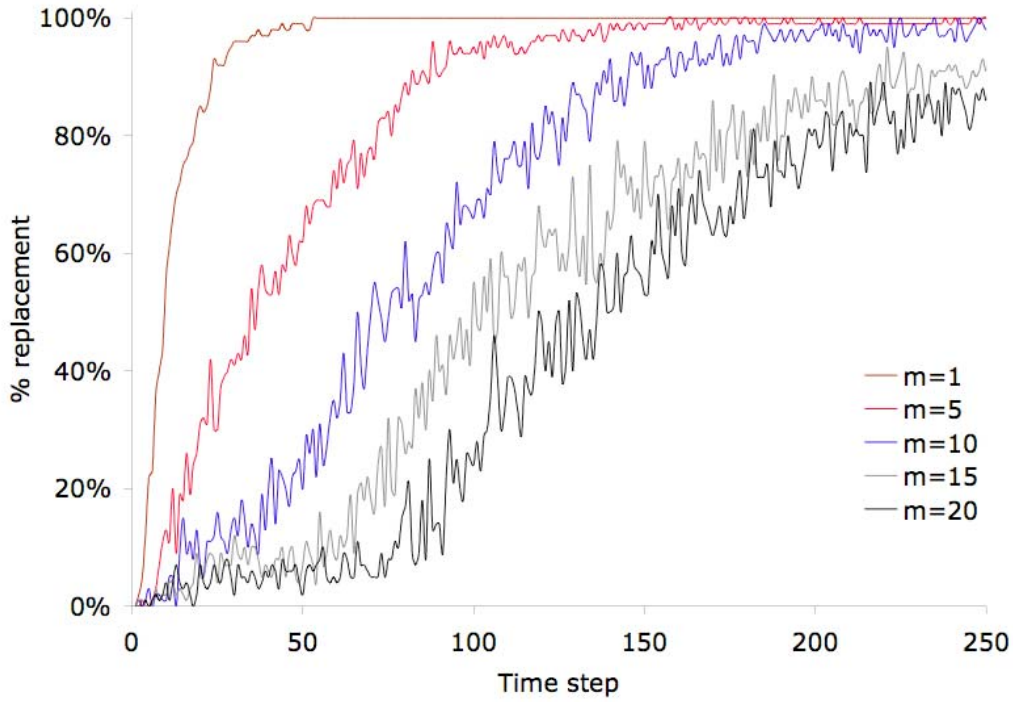

Moderate innovation
frequency
0
20
40
60
80
120
0
2000
4000
6000
popularity


Faster innovation
frequency
0
10
20
30
40
50
0
500
1000
1500
2000
popularity


Rapid innovation
frequency
0
5
10
15
0
200
400
600
popularity


Agents copy very recent choices of others
frequency
0
20
40
60
80
0
2000
4000
6000
popularity


Agents copy many past choices of others
frequency
0
5
10
15
20
0
200
400
600
800
popularity


100%
80%
60%
40%
20%
0%
% replacement
0
50
100
150
200
250
Time step
m=1
m=5
m=10
m=15
m=20

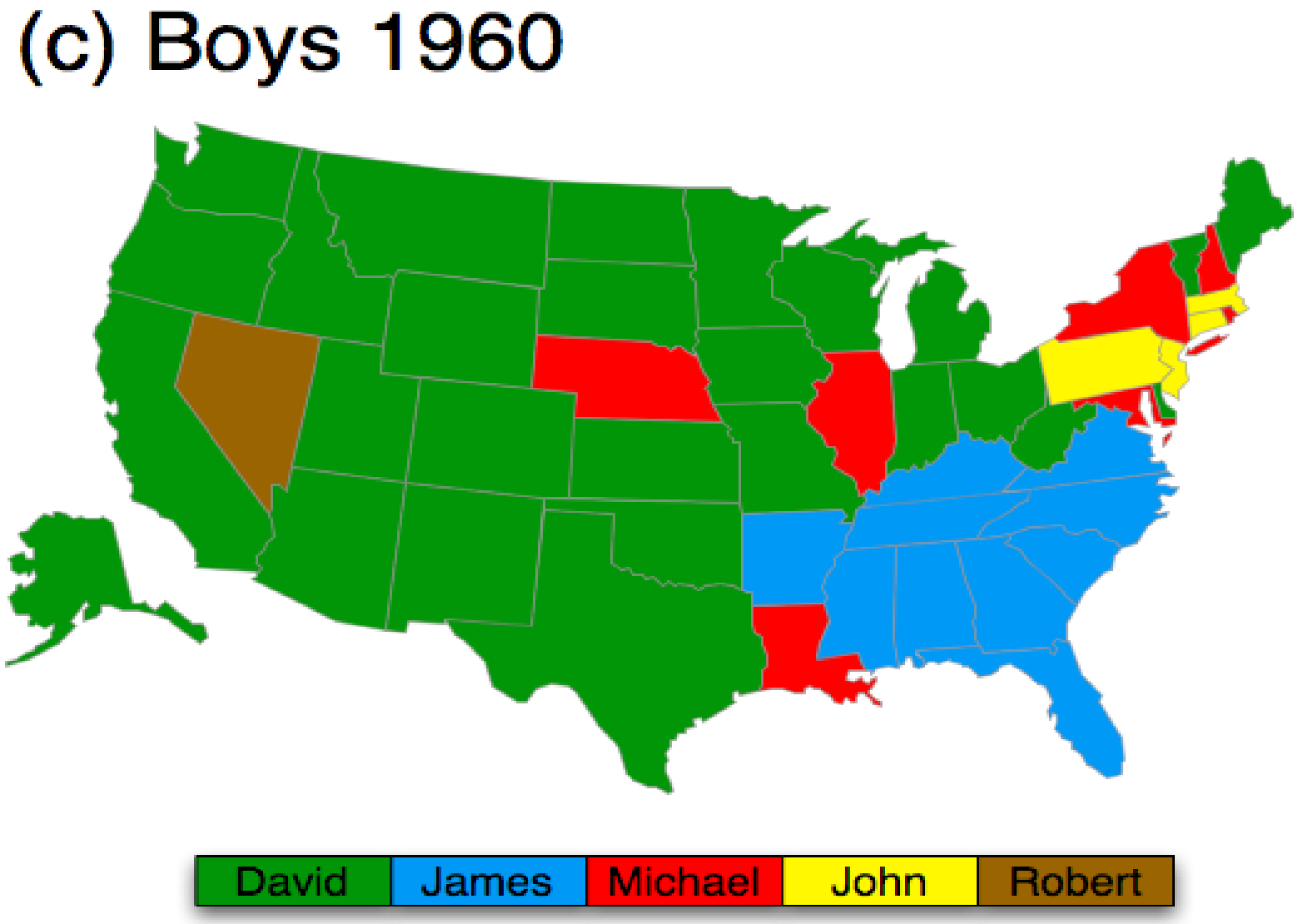
Baby names (1)

- Choices of first names reflect 3 general principles of collective behaviour that apply to fashion/popular culture
- They involve a number of people carrying out the same or similar activity at the same time
- The behaviour exhibited is transient or continually changing
- There is some kind of dependencyamongst individuals, they are not acting independently
- 'the choice of a name ‘connects us to society in a way that encapsulates the great contradiction in human social life: between the desire to fit in and the desire to be unique’ Stephen Pinker

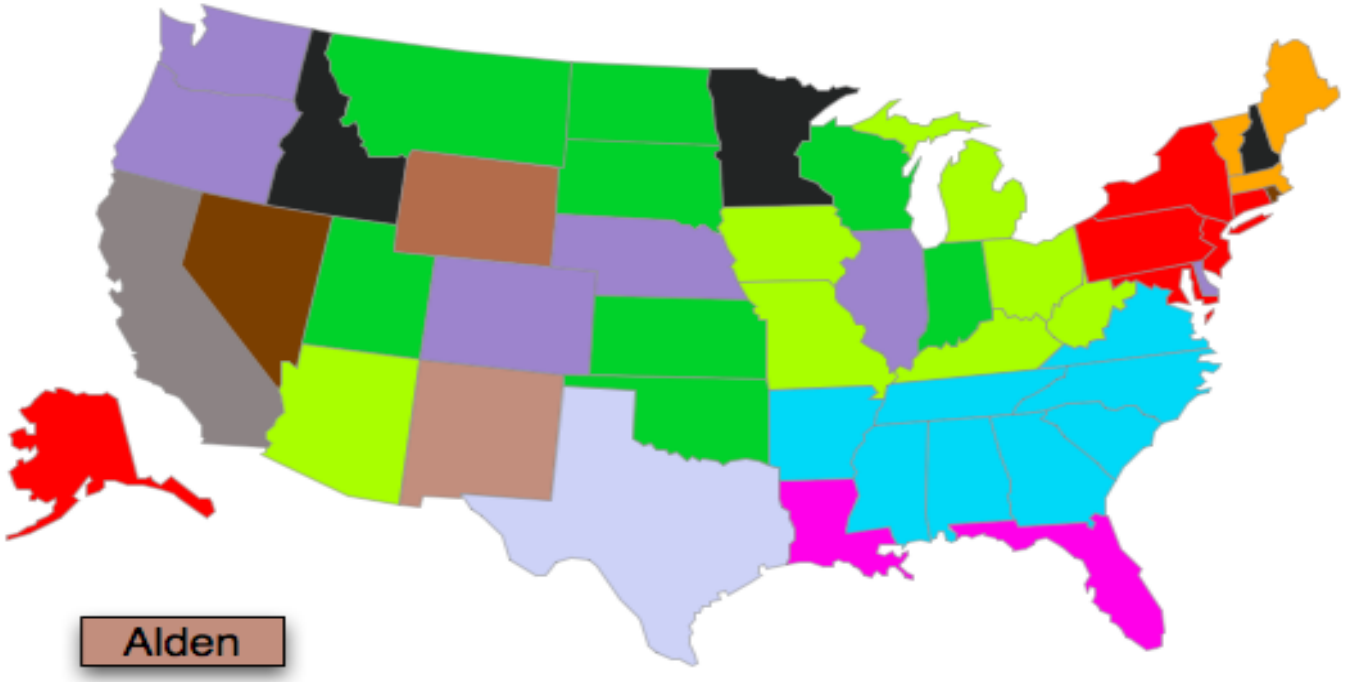
Baby names (2)

- The United States Social Administration provides a database on baby names
- the top 100 baby names by US state since 1960
- for the US as a whole, all of names with at least 5 occurrences in each year since 1879

Spatial heterogeneity in popular culture: most popular names for boys



(d) Boys 2009



Alden

Ethan	Jacob	Alexander	Anthony	Daniel	Jayden
William	Michael	Logan	Noah	Jose	Wyatt

Calibrating model to baby name data

– Actual distribution versus average of 500 model solutions for each of 125 parameter combinations ($\mu < 10\%$, $m \leq 10$)

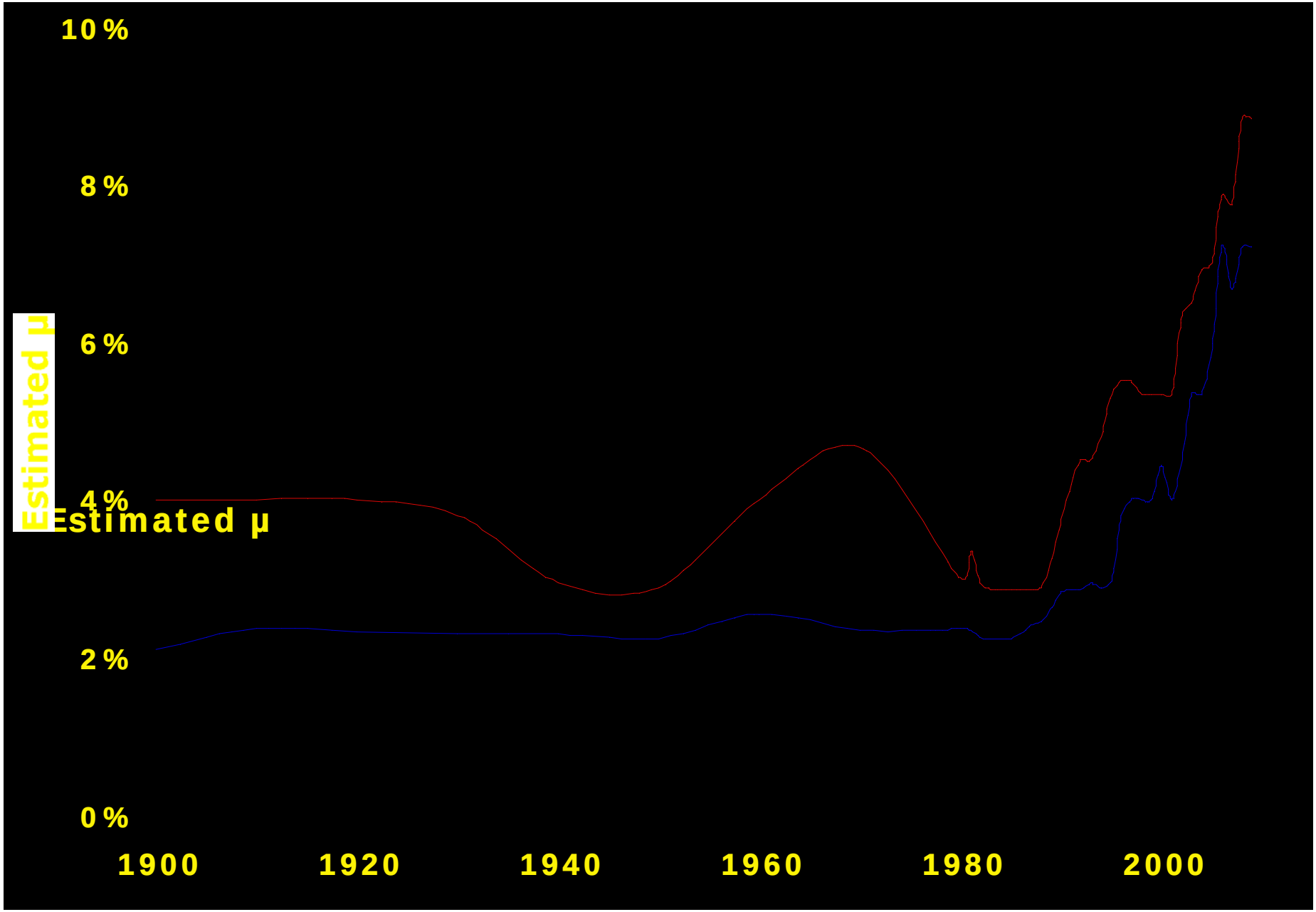
–Test null hypothesis the distributions are the same, using Anderson-Darling test

–In general, rejected for around 100 combinations at p-value < 0.05

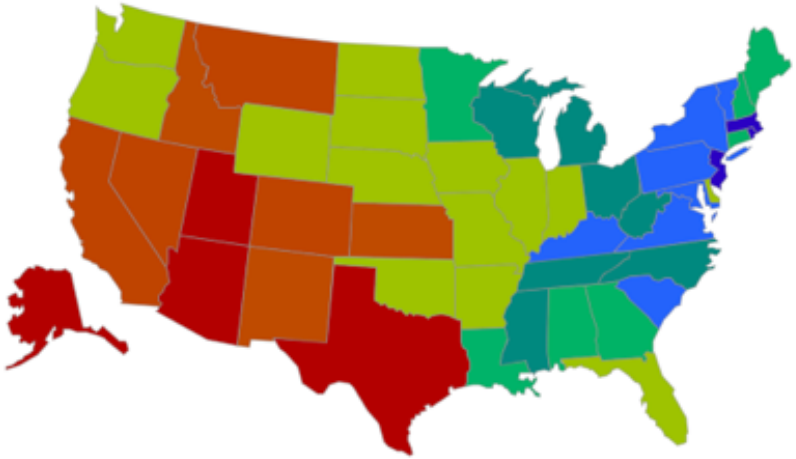
– Accept the small number where rejection is only at $p > 0.2$

–The effect of m was not significant for these preferred combinations, yielding a clear mean for μ

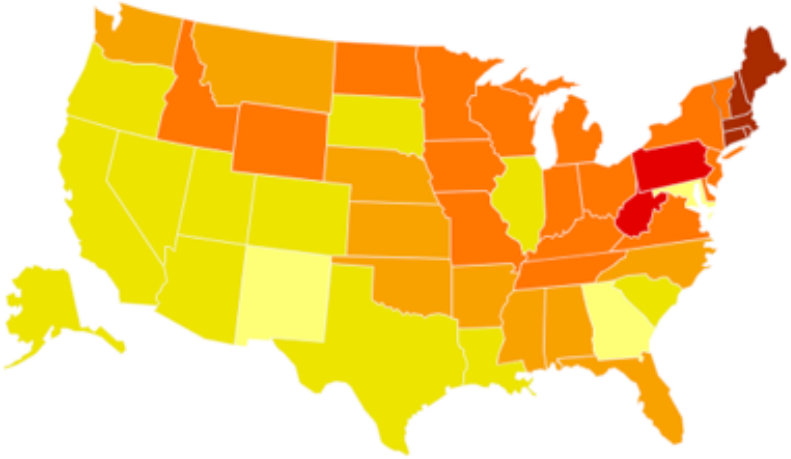
$p > 0.2$


10%
8%
6%
4%
2%
0%
Estimated μ
Estimated μ
1900
1920
1940
1960
1980
2000

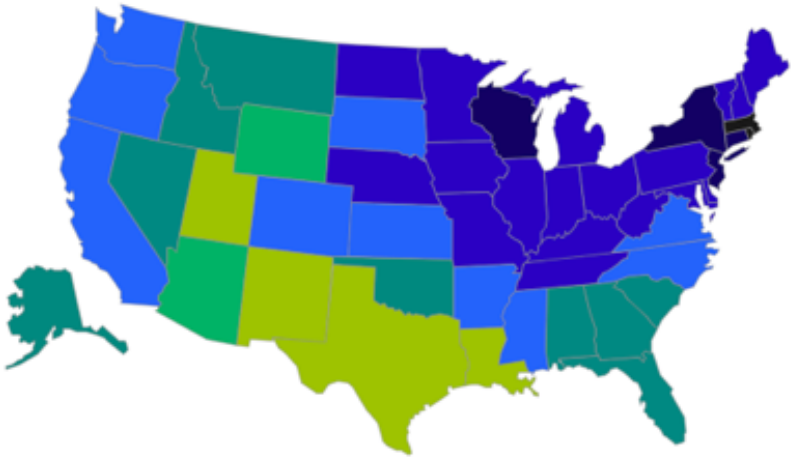
a) Girls 1960



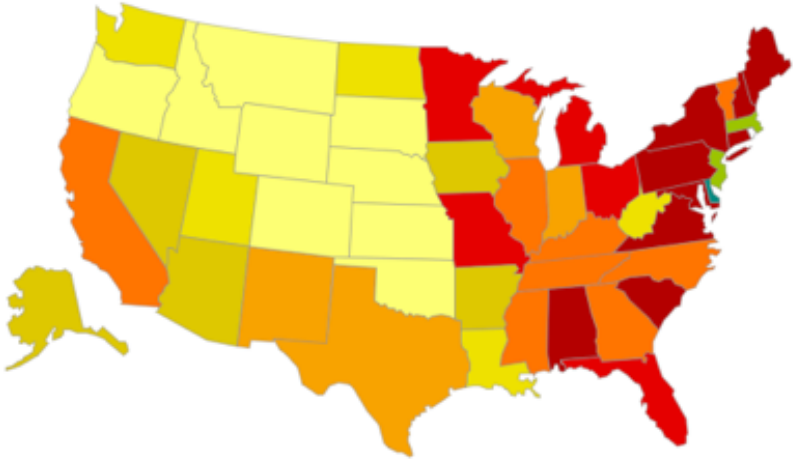
(b) Girls 2009



c) Boys 1960



(d) Boys 2009



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.050-.054	.055-.060	.061-.065	.066-.070	.071-.080	.081-.090	> .090