

Cognition and Semiotics

MA Cognitive Semiotics, Fall 2020

Lecture 8
Monday Oct 26th

Overview

- Today's lecture: Semiotics in the lab II
 - Factors that shape semiotics, meaning and communication (e.g. language)
 - Iterative learning model/paradigm
 - Transmission structures
 - Summary
 - Assignment for next week

Concepts and notions ahead:

- **Evolutionary causality**
- Schemata
- Selective distortions
- **Learnability**
- Compression (vs. complexity)
- Cognitive bottleneck
- Compositionality
- Expressive pressure
- **Iterative learning model**
- Non-interactive copying
- Latent cognitive biases
- Emergent structure (Emergence)
- Diffusion chain drawing task
- Compression and conventionality
- Alien language learning
- Non-intentional learning
- Filtering rule
- Expressivity
- **Transmission structures**
- Horizontal transmission
- Vertical transmission
- Diffusion chains
- Community design
- Closed group design
- Replacement chains

ES Essentials

Three main experimental designs

- Referential semiotic games

Set of communication forms: **Open**
Set of referents: **Closed**
Suited for studying emergence and evolution of simple systems

- Coordination semiotic games

Set of communication forms: **Open**
Set of referents: **Open**
Suited for studying emergence and evolution of simple systems

- Referential linguistic games

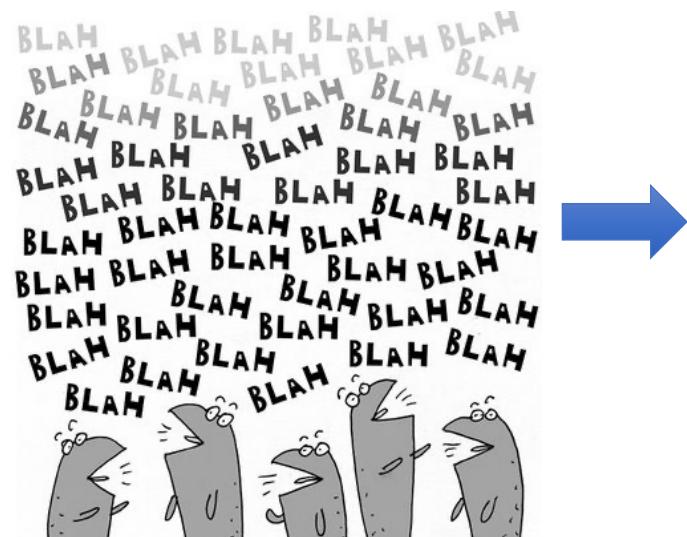
Set of communication forms : **Closed**
Set of referents: **Closed**
Suited for studying more complex language-like structures

1. Linguistic properties as the consequence of communication

- Do key properties of natural language require explanations specific to natural language, or can they be explained in terms of general principles of human communication or cultural transmission? (e.g. combinatoriality)

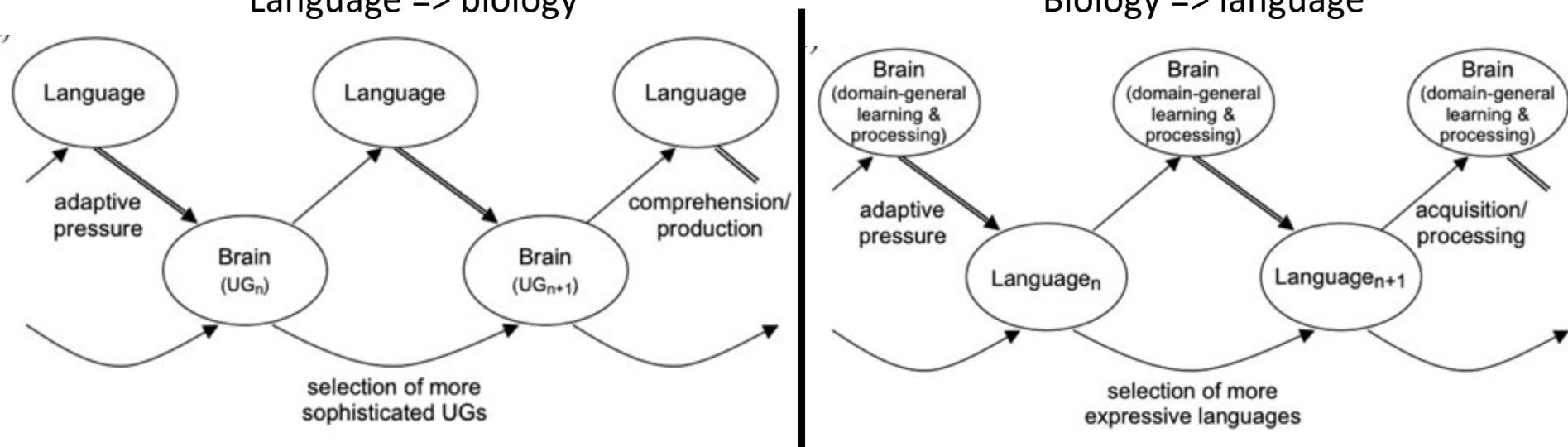
Factors that shape semiotics, meaning and communication

Cognitive constraints



Factors that shape semiotics, meaning and communication

- Language as shaped by the brain (Christiansen & Chater, 2008:489):
 - “We conclude that a biologically determined UG [Universal Grammar] is not evolutionarily viable. Instead, the original motivation for UG – the mesh between learners and languages – arises because language has been shaped to fit the human brain, rather than vice versa. Following Darwin, we view language itself as a complex and interdependent “organism,” which evolves under selectional pressures from human learning and processing mechanisms.”
- Evolutionary Causality:
 - Language => biology
 - Biology => language



Frederic Bartlett (1932): the reconstructive nature of human memory

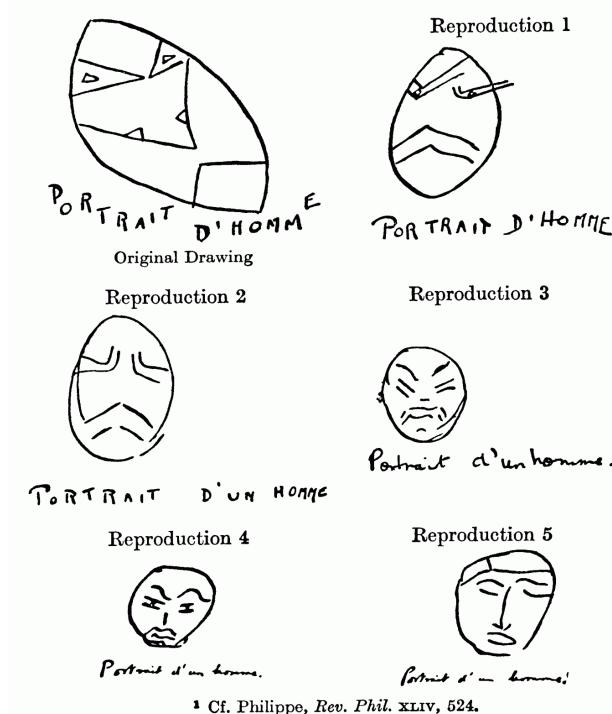
- The war of the ghosts (Bartlett 1932):

"One night two young men from Egulac went down to the river to hunt seals, and while they were there it became foggy and calm. Then they heard war-cries, and they thought: "Maybe this is a war-party". They escaped to the shore, and hid behind a log."

- Recollection 20 hours later:

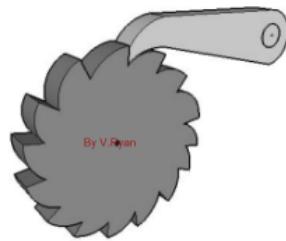
"Two men from Edulac **went fishing**. While thus occupied by the river they heard a noise in the distance. "It sounds like a cry ", said one, ... "

- Systematic distortions: cultural **schemata (priors)** **shape our memories** in non-random ways **to assimilate them to cultural expectation**



* Cf. Philippe, *Rev. Phil.* XLIV, 524.

Communication as an example of cumulative cultural evolution



- Recall cumulative culture: each new generation build on the knowledge and skills of the previous (also referred to as the ratchet effect)



- Communication can be conceived as a tool that is continuously adapting to become more fit, i.e.
 - More expressive - or unambiguous (for communication)
 - More learnable - or memorable (for cognition)

Learnability



- What makes a language easier to learn, remember and produce?

- **Compression:** Smaller repertoire of forms (vs. larger repertoires)

tuge	tuge	tuge
tuge	tuge	tuge
tuge	tuge	tuge

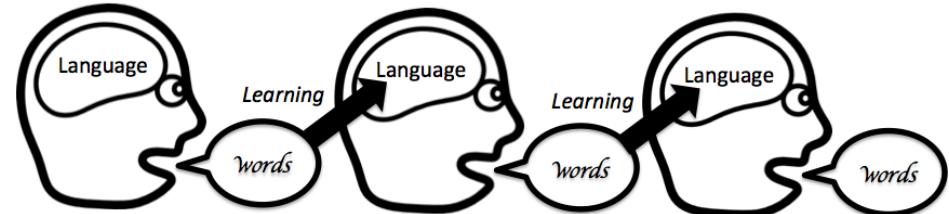
- **Compositionality:** Systematic and regular (vs. idiosyncratic and irregular)

none	●	+
R	RM	RZ
S	SM	SZ

- The “**cognitive bottleneck**”: There are limits on our computational powers. Cognitive constraints might work to **reduce complexity** (size and structure) and introduce **systematicity**

The “iterated learning” paradigm

- Kirby et al (2008): “Iterated learning is a process in which an individual acquires a behavior by observing a similar behavior in another individual who acquired it in the same way”



- Vertical (inter-generational) transmission in contrast to horizontal (online interaction)
 - NB: individual, observational learning (no interaction)
- Cumulative evolution: Through iterations even subtle, latent cognitive biases can be amplified to create emergent structure (“The invisible hand”), i.e. no one is intentionally trying to improve language (cmp. Pictionary games)
- The language is the “participant” and subject matter in the experiment, and the participants are the “equipment”

We will
return to this

Emergence

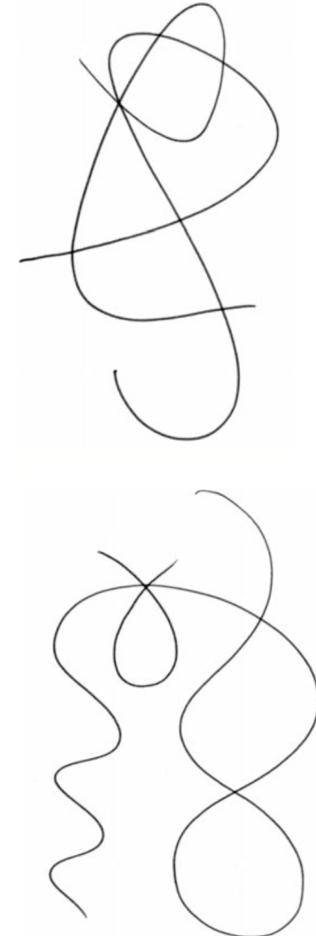


Zoom room example exercise

- Emergent structure and the impact of memory (cognition-internal biases): A diffusion chain drawing task (in zoom!)
 - 6 volunteers
 - Don't look at the screen, just listen, until you are instructed otherwise
 - Participant 1 gets 10 sec exposure, a pause, and then draws from memory
 - Participant 2 gets the output drawing from participant 1. Exposure for 10 sec, a pause, and then drawing from memory
 - Participant 3 gets the output drawing from participant 2, etc. etc.

Tamariz & Kirby (2015): Copying, Compression, and Conventionality

- Two conditions:
 - Drawing while having access to the target
 - Drawing from memory
- Measurements:
 - Complexity (inverse of compressibility)
 - Conventionality (how much they resemble conventional forms)



Generations

Memory

0 1 4 7 10 13 16 19 22



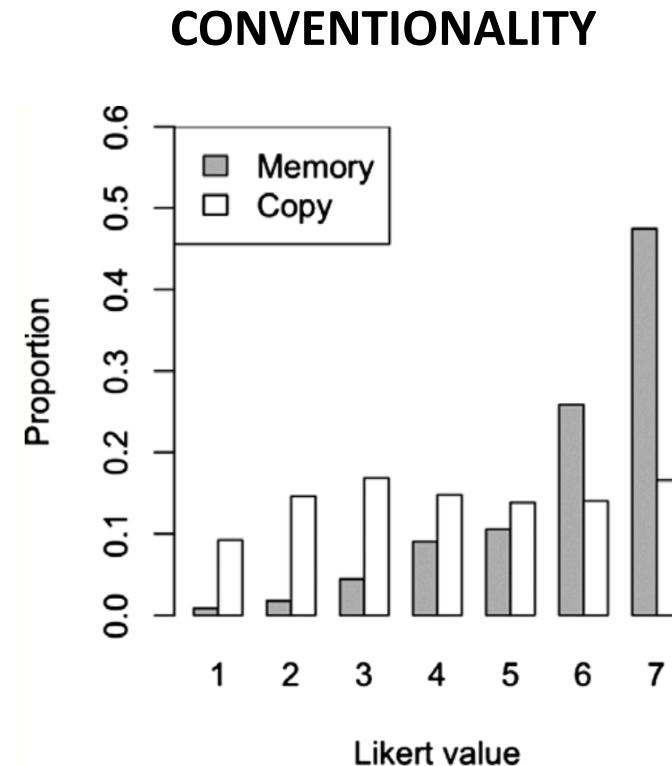
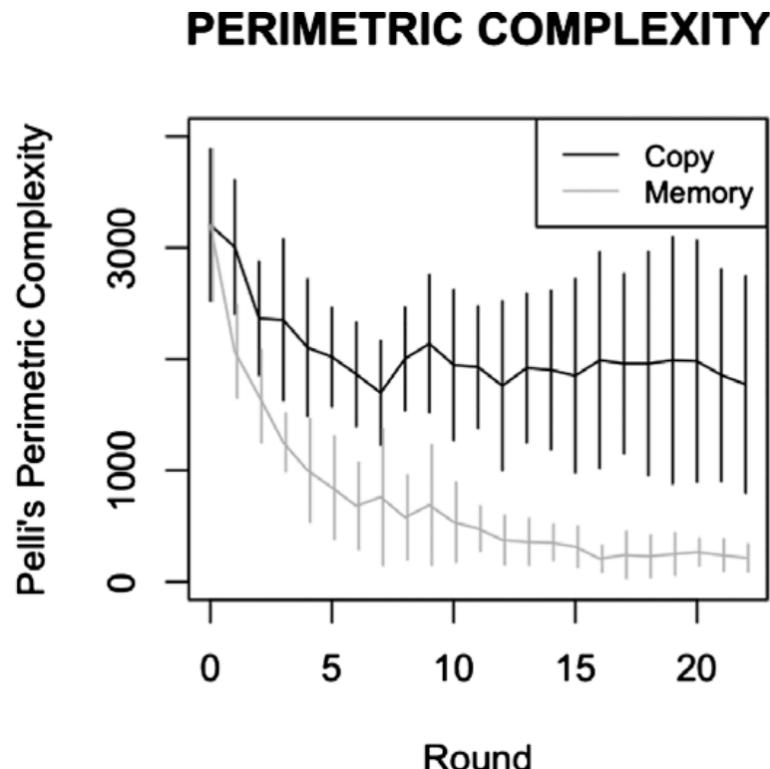
Copy



What happened here?

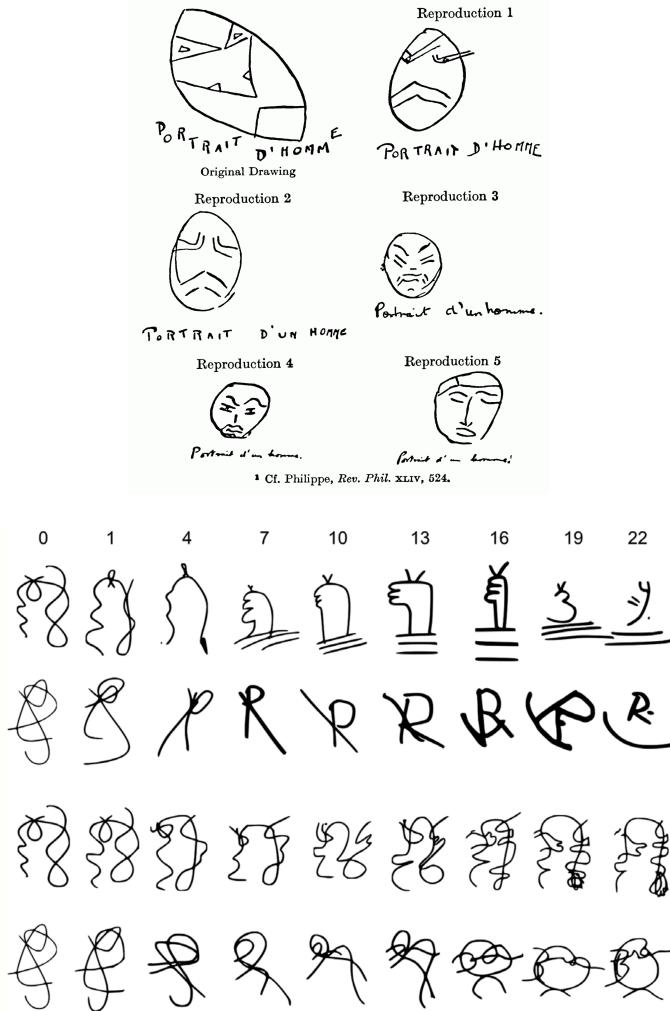
Tamariz & Kirby (2015)

Copying, Compression, and Conventionality



- “We find that learning seems to be the causal factor behind the increase in compressibility observed in the transmitted information, while reproducing is a source of random heritable innovations.” (2015:171)

Recall: the reconstructive nature of human memory



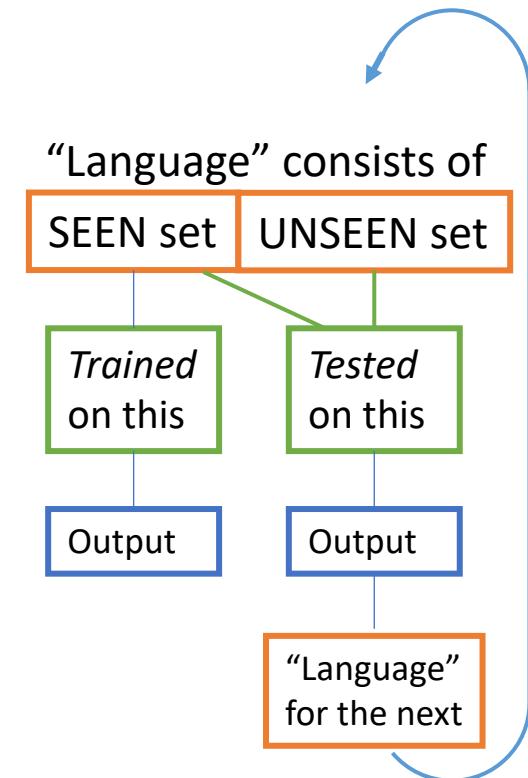
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- Recollection 20 hours later:

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- Systematic distortions: cultural schemata shape our memories in non-random ways to assimilate them to cultural expectation

Kirby et al (2008) Cumulative cultural evolution in the laboratory

- Participants are trained on **form-meaning mappings** of an “alien” language and is then asked to name a set of “meanings” (some of which were not part of the training set)
- The output mappings of the first participant becomes the training set of the second through 10 generations (diffusion chain).
- Participants are **not aware** of the origin of stimuli or that transmission was the purpose (in fact, none of the experimental design or theory)
 - Just trying to reproduce, no intention of improving!



Cumulative cultural evolution in the laboratory: An experimental approach to the origins of structure in human language

Simon Kirby*,†, Hannah Cornish*, and Kenny Smith‡

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Edited by Dale Purves, Duke University Medical Center, Durham, NC, and approved June 6, 2008 (received for review August 20, 2007)

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Experiment 1: Results

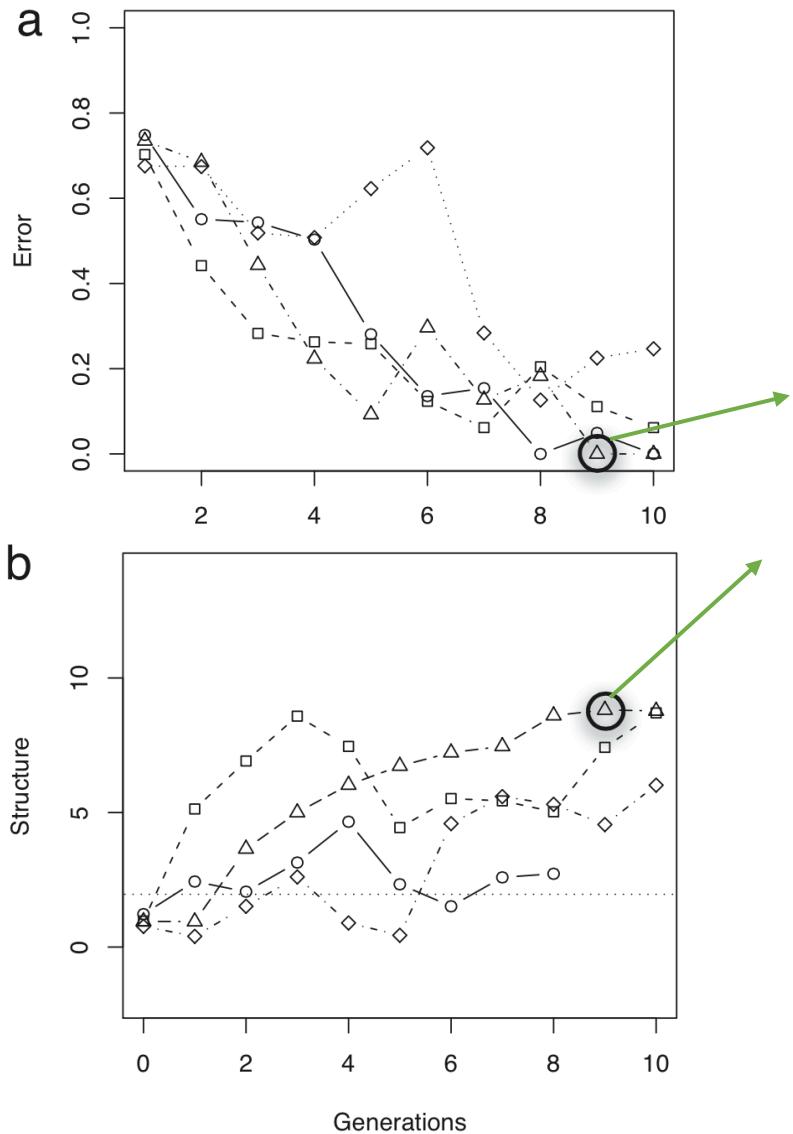
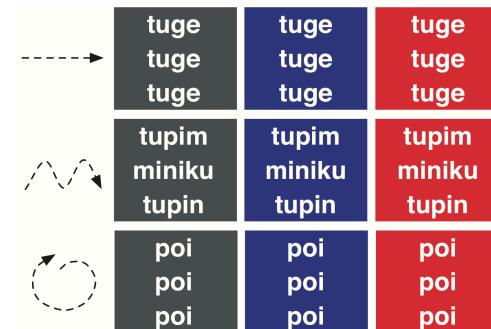


Table 1. Number of distinct words by generation in the first experiment

Generation	0	1	2	3	4	5	6	7	8	9	10
○ Chain 1	27	17	9	6	5	4	4	2	2	2	2
□ Chain 2	27	17	15	8	7	6	6	6	5	5	4
△ Chain 3	27	24	8	6	6	5	6	5	5	5	5
◊ Chain 4	27	23	9	10	9	11	7	5	5	4	4

Experiment 1: In summary

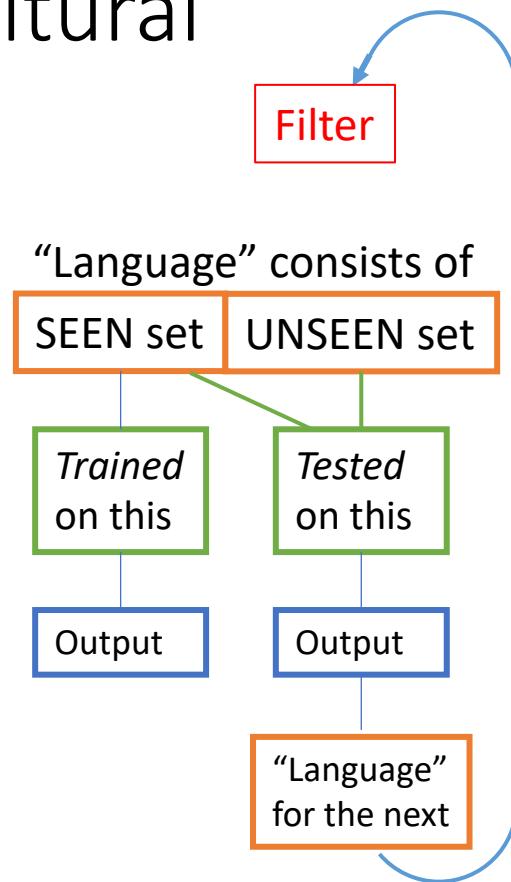
1. The language is adapting to become **increasingly transmissible or learnable**
2. Meanwhile, the languages **gradually introduce underspecification** of meanings (or ambiguity)
3. However, this underspecification is not random – it is **systematic!**



- Thus, a simple set of emergent generalizations facilitates learnability (even of pictures they have never seen) and directly ensure stable cultural transmission of the language
- But the end-language is not unambiguously expressive - How to reduce systematic underspecification?

Kirby et al (2008) Cumulative cultural evolution in the laboratory

- Experiment 2: Same task, but...
- If any strings were assigned more than 1 meaning, all but 1 meanings (chosen at random) was removed from the SEEN set
- The filtering effect removes the possibility of introducing underspecification
 - Analogous of a “pressure” to be **expressive** that would come from real-language communicative needs



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Experiment 2

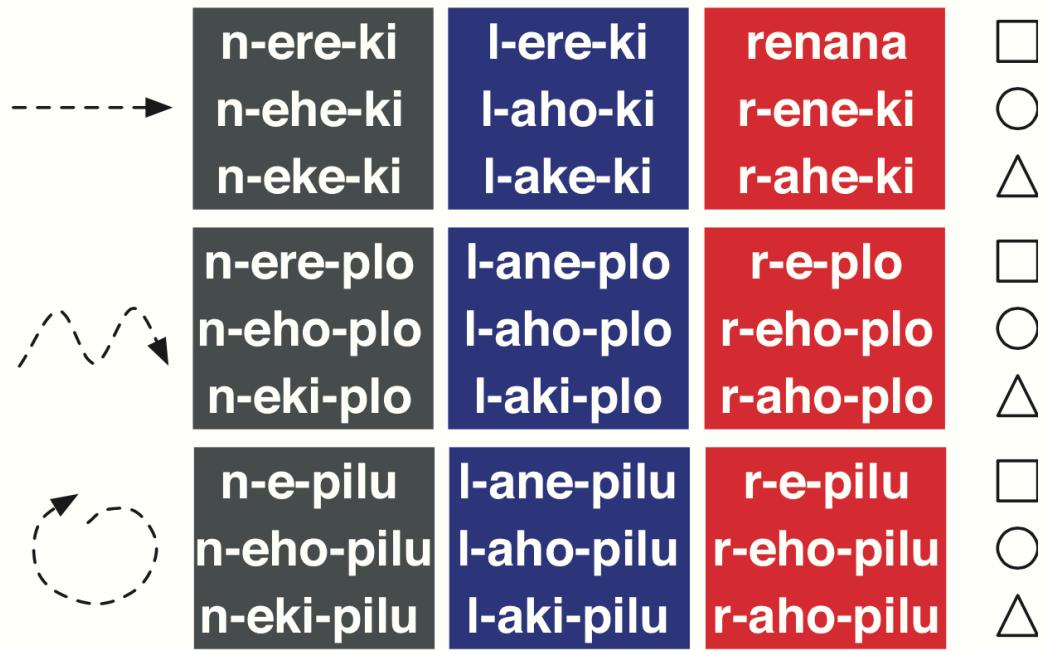
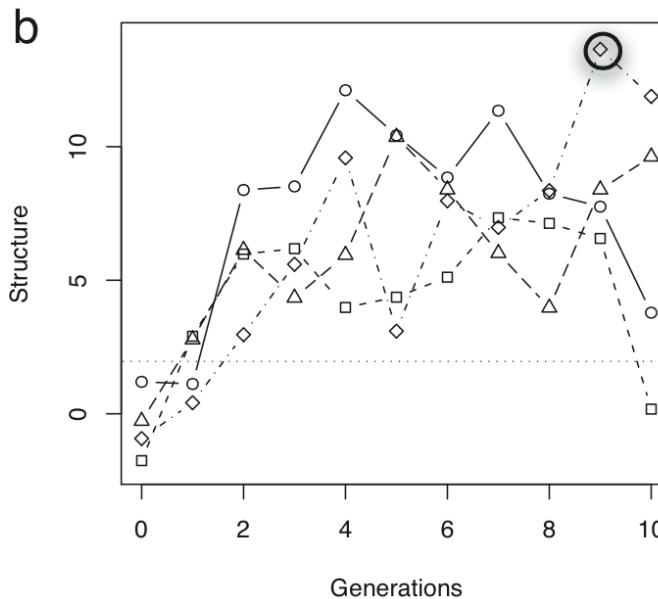
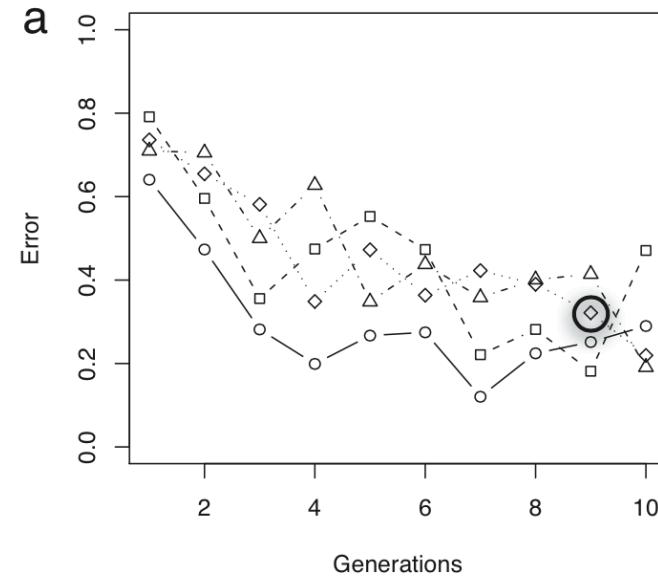


Table 2. Number of distinct words by generation in the second experiment

Generation	0	1	2	3	4	5	6	7	8	9	10
○ Chain 1	27	23	22	17	21	21	17	21	25	13	16
□ Chain 2	27	26	13	10	10	16	16	12	12	13	12
△ Chain 3	27	11	16	14	12	17	14	16	20	19	12
◊ Chain 4	27	19	19	17	19	17	22	23	21	27	23

1. What happened?
2. Characterize the languages that evolved
3. How do they reflect the hypotheses?

Experiment 2: In summary

1. Again, the language is adapting to become increasingly transmissible or learnable
2. And are also becoming more structured
3. However, now the overall number of output words remains comparatively high

- Because *filtering* rules out the generalizations that emerged in the previous experiment, a different kind of structure that does not rely on underspecification must be emerging
- To be transmitted successfully, the language must be both learnable and expressive (unambiguous): Systematic compositional structure emerged (**compositionality**)!

n-ere-ki	I-ere-ki	renana
n-ehe-ki	I-aho-ki	r-ene-ki
n-eki-ki	I-ake-ki	r-ahe-ki
n-ere-plo	I-anne-plo	r-e-plo
n-eho-plo	I-aho-plo	r-eho-plo
n-eki-plo	I-aki-plo	r-aho-plo
n-e-pilu	I-anne-pilu	r-e-pilu
n-eho-pilu	I-aho-pilu	r-eho-pilu
n-eki-pilu	I-aki-pilu	r-aho-pilu

Learning and Expressivity

- “What we have observed here under laboratory conditions is cumulative cultural adaptation **without intentional design** (...) Note that this adaptation is cumulative with respect to learnability and structure, but not with respect to expressivity: cumulative adaptation does not suggest that the languages necessarily become more functional with respect to communication.” (Kirby et al 2008:10684)
- “It is important to reiterate that participants in the experiment **did not intentionally design this solution**; indeed, they were not even aware of the problem. Participants believed they were reproducing as best they could the language to which they were exposed.” (Kirby et al 2008:10685)



Compare to our other semiotic experiments?

Does cognition-internal biases provide a full account of communication systems (and their factors) evolving in the lab?

Any critiques more generally?

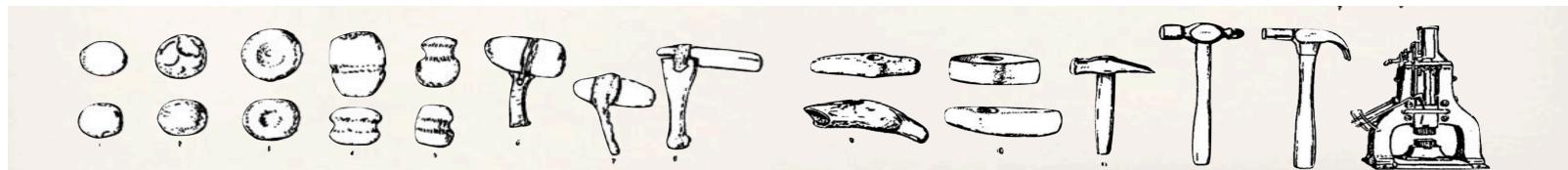
A critique of iterated learning:

- One of the recurring critiques of iterated learning model:
 - “Individualistic models, such as the iterated learning model (Kirby, 2002; Kirby & Hurford, 1997, 2002), assume that as language is transmitted from generation to generation it is incrementally influenced by agents’ learning biases until the language reaches an equilibrium that reflects these prior linguistic biases.”
 - “This account predicts that separate communities and separate isolated pairs will eventually converge on a set of shared priors.”
- i.e. since the iterated learning model assume language to be shaped by subtle innate cognitive biases amplified through transmission, it should predict that all languages eventually converge?
- Also, we may see very different outcomes of contexts that involve a very different interactive structure of the transmissions, e.g. that better resemble societies

We will
return to this

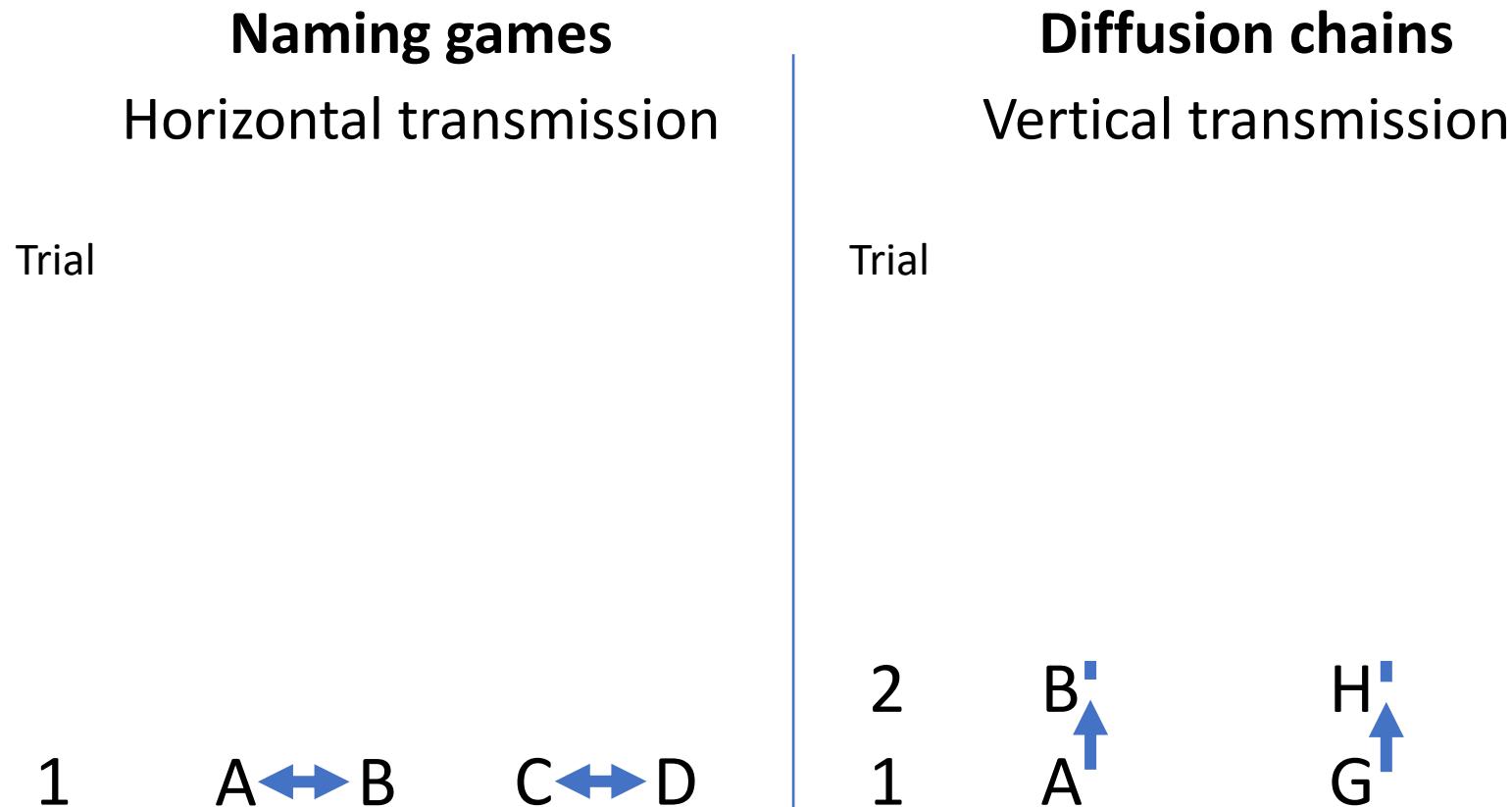
Take-aways so far:

- Human language likely evolved in response to numerous adaptive pressures – some biological, some cognitive, and some environmental and cultural
 - Experiments simulating aspects of cultural transmission can inform discussions on the underlying mechanisms



- Cognitive constraints might work to reduce complexity (increase compressibility) and introduce systematicity (e.g. compositionality, conventionality)
- The Iterative learning paradigm assumes latent cognitive biases that can be amplified to create emergent structure – even without intention!
- Language in these contexts seems to be adapting to become more fit, i.e. both more expressive (for communication) and more learnable (for cognition)

Getting the terminology straight - and structure of transmission overview



Getting the terminology straight - and structure of transmission overview

Naming games		Diffusion chains	
Horizontal transmission		Vertical transmission	
Trial		Trial	
6	A ↔ B C ↔ D	6	F ↑
5	A ↔ B C ↔ D	5	E ↑
4	A ↔ B C ↔ D	4	D ↑
3	A ↔ B C ↔ D	3	C ↑
2	A ↔ B C ↔ D	2	B ↑
1	A ↔ B C ↔ D	1	A ↑

Structure of transmission overview

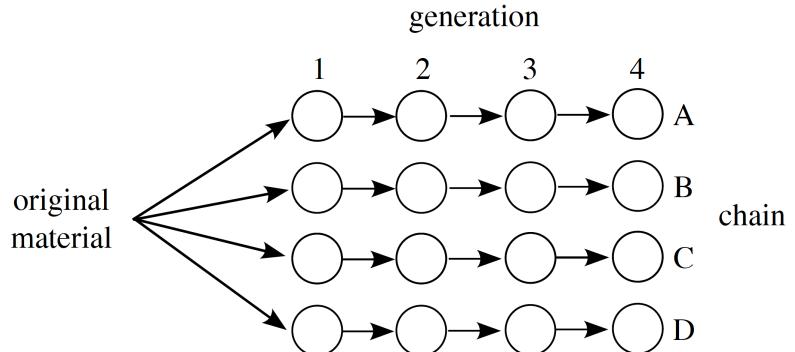
Naming games

Horizontal transmission



Diffusion chains

Vertical transmission

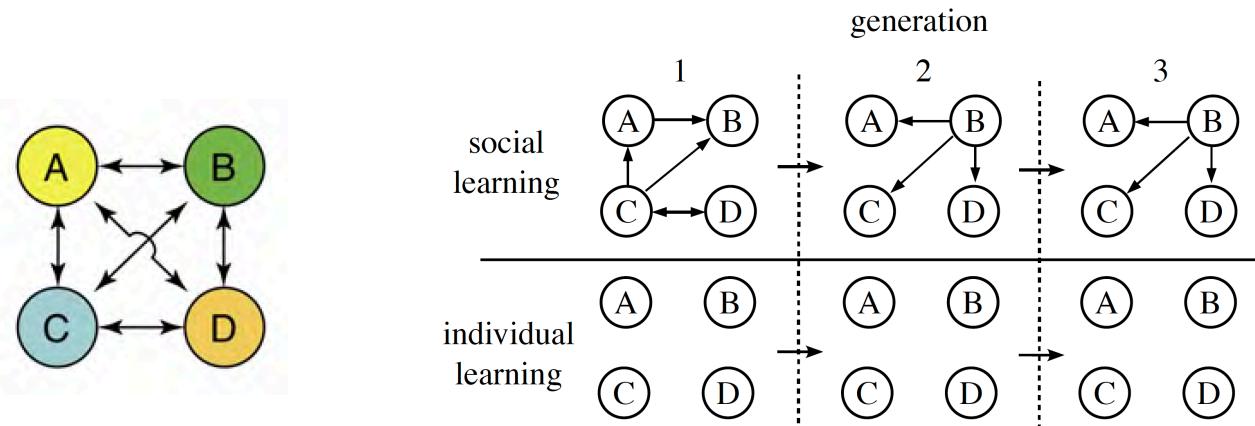


Comparison

- Isolated pair naming games (**horizontal transmission**):
 - Simulate online, iterated communications
 - Focus on collective processes of grounding/bootstrapping
 - Individual factors are less important
- Diffusion chain studies (**vertical transmission**):
 - Simulate inter-generational (cultural) transmission
 - Focus on individual learning and cognition
 - Communication/functionality plays a minor role
- Limitations?

Community design (or closed group design)

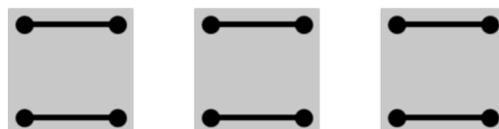
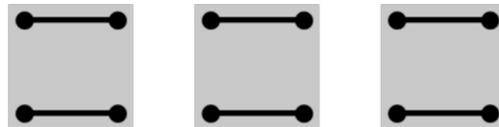
- Mainly vertical but can combine both to different extents:



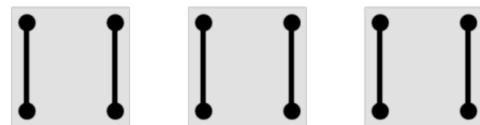
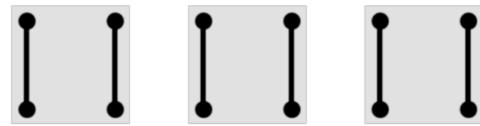
- These microsocieties can investigate, for instance, convergence dynamics – the spread and conventionalization of communicative practices

Simple example of a community design:

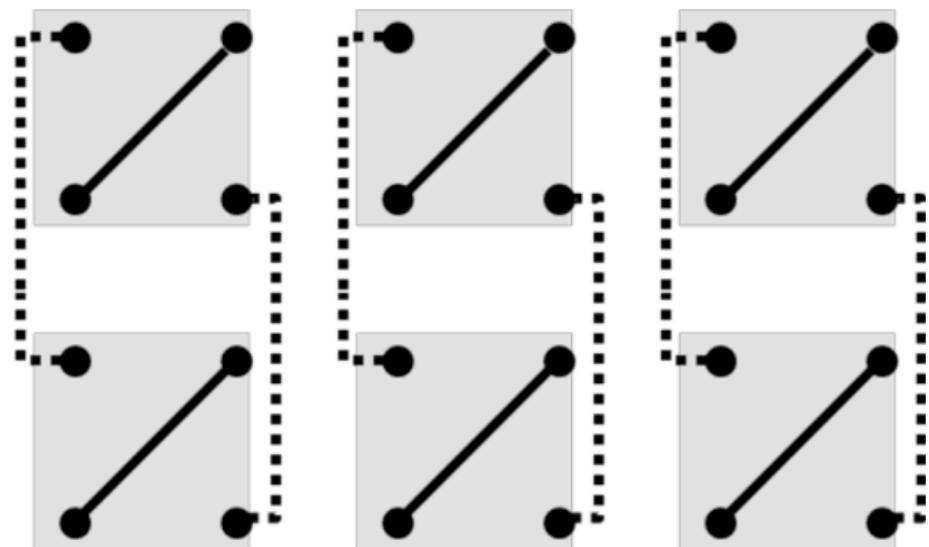
- Mills (2011): on the emergence of community specific procedural conventions (taking turns to list items)



Trial 1, 3, 5: In dialogue



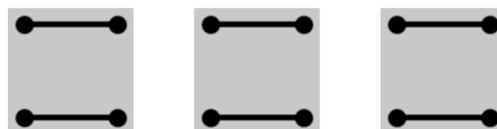
Trial 2, 4, 6: In dialogue



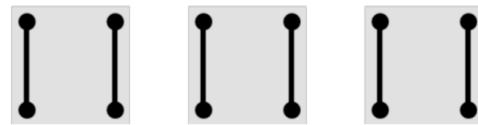
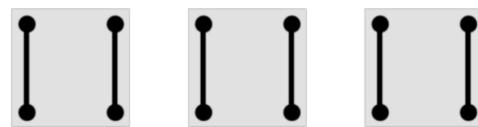
Last trial 7: All got a new partner, but half got a novel partner from the same community and half got a novel partner from a different community

Within and across “speech communities”

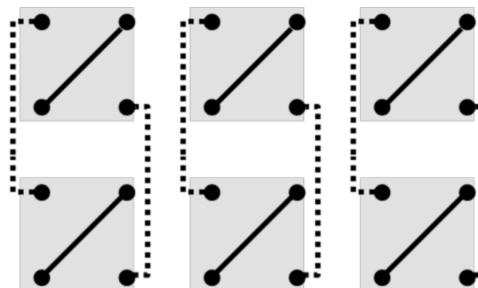
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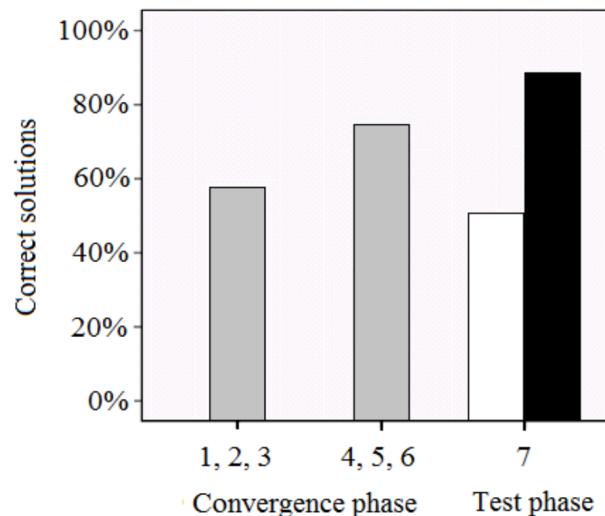
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Trial 2, 4, 6: In dialogue

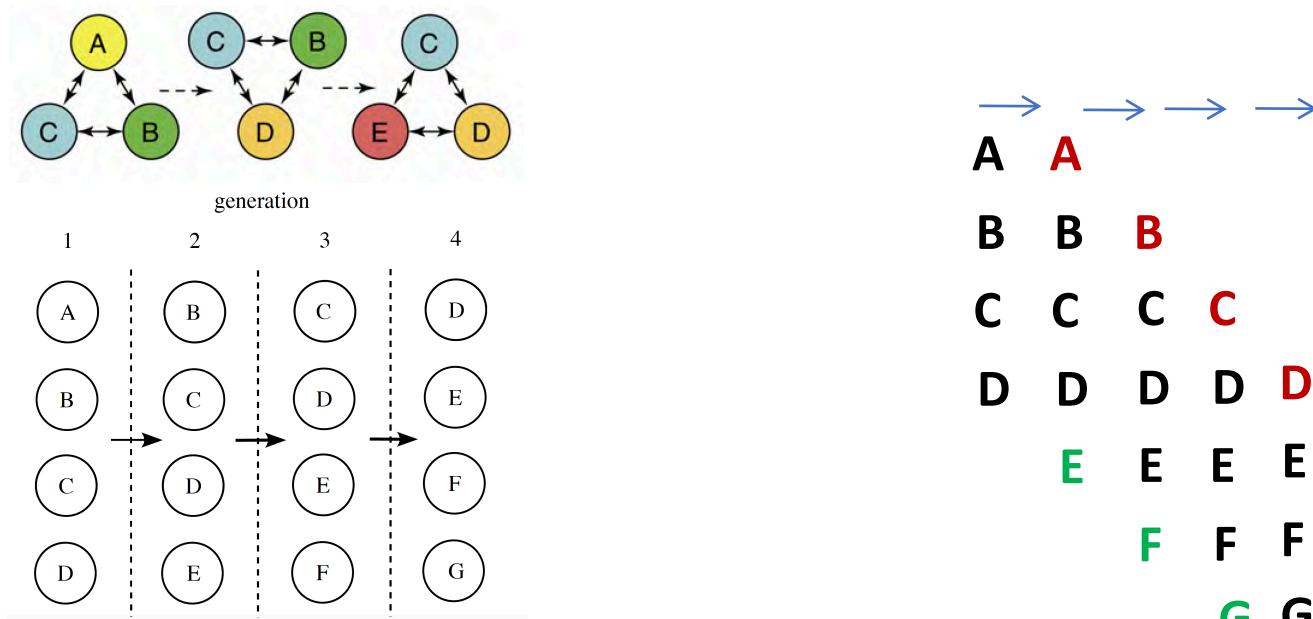


Trial 7



Replacement chain

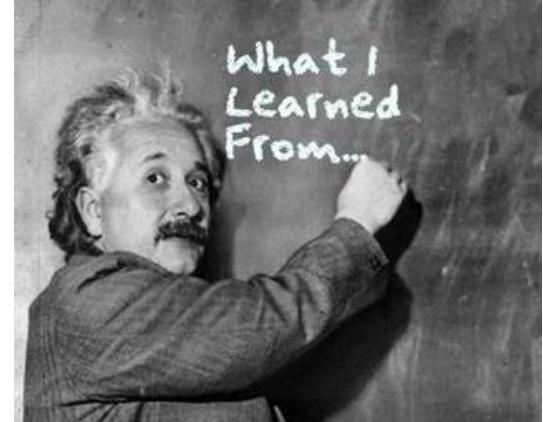
- Mainly horizontal but combines both: Through generations group members are gradually replaced



- Implications?

See also Lecture 6

Discussion



- Which structure or paradigm works best, in your opinion?
- Always depends on the specific (more narrow) questions (regardless of the high-reaching titles and terminology!)
- For any given structure or paradigm used, we can always come up with important factors or unanswered question that would be better answered by other paradigms
 - So, do that in your exam papers ;)



For next time

- Check out the following papers – and read **one in detail**:
 - Derex et al (2019) *Causal understanding is not necessary for the improvement of culturally evolving technology*
 - Fay et al (2008). *The fitness and functionality of culturally evolved communication systems*
 - Nölle et al (2018). *The emergence of systematicity: How environmental and communicative factors shape a novel communication system*

Transmis. chain
on Technology

Communication:
Internal factors

Communication:
External factors

- Choose 1, and **make a note** of the following:

1. What is the paper investigating?
2. How are they investigating this?
3. Why is this a good way? Why not?
4. What did they find out (results)?
5. What does it tell us (discussion)?

- And put your notes in a draft document for next time

For next time

- Next week, we'll do a writing assignment – which will be graded (everyone must submit this assignment; it's **500-1000 words max**, excl. references)
 - To go over topics from the last two lectures
 - To tick off exam preparation and feedback
 - Guide you on how written exams work well
- We'll first **go over the exam regulations** and then have an in-class **writing bootcamp** – so do show up!
 - You are encouraged to already start on your notes/draft version
- Following submission, we'll do an anonymous peer-review round, where we review each other's papers and give feedback

Deadline will be 8/11

Bring your charged-up laptop

Recap – concepts and notions

- **Evolutionary causality**
- Schemata
- Selective distortions
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- **Iterative learning model**
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See you next week