Origins and Evolution of Language
Week 9: The cultural evolution of language

Kenny Smith

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Plan for today

- Cultural evolution of language
  - Questions from the reading quiz
  - Uniformitarianism
  - Learning, use, and language change
  - Cultural transmission and the evolution of symbols
  - Cultural transmission and the evolution of structure

What you've seen so far (1/2)

Human linguistic communication has unusual properties (see week 4)

- Evidence for 2nd order intentionality in communication is rare in other animals
- Lots of structured communication out there, but structure is simpler and typically not meaning-related

Human capacity to sustain complex non-linguistic cultures (e.g. tools) is also unusual (see week 6-7)

- Animal cultures exist but are simpler
- Language implicated in maintenance of stone tool technology?
- Complex technologies a possible selection pressure driving human brain expansion?

What you've seen so far (2/2)

Human capacity for learning complex meaning-bearing communicative signals is unusual (see weeks 7-8)

- Vocal learning seen in other animals, but limited in our closest relatives?
- Other animals can learn sequencing constraints, but only simple ones have been tested
- Other animals can learn rules of meaningful combination, but few systematic studies

Human motivation to share mental states and aptitude to reason about the mental states of others is unusual (weeks 4 and 8)

- Mitteilungsbedürfnis is weird!
- Evidence for 2nd order intentionality in communication is rare in other animals
- Some evidence of capacity to reason about knowledge, ignorance and false belief in other apes, but only in competitive contexts
- Complex social living a possible selection pressure driving human brain expansion?

The human package

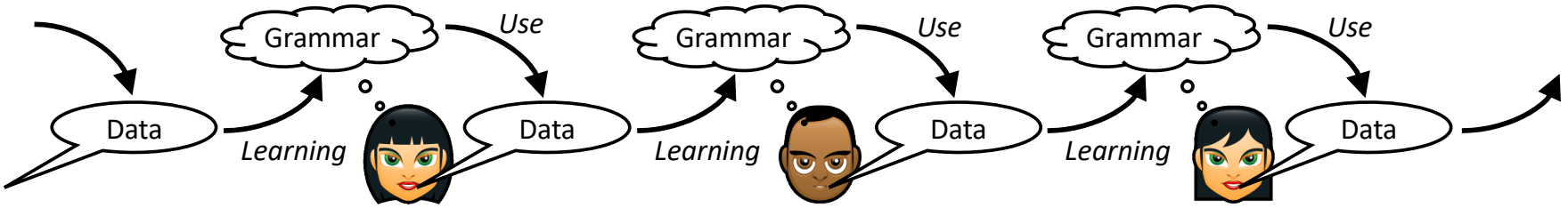
Somehow, we ended up with

- The ability to learn complex grammars
  - capacity for complex vocal imitation
  - ability to learn complex sequencing constraints
  - ability to learn compositional meaning-form mappings
- The ability and motivation to mindread and mindshare

This sets up the preconditions for the **cultural transmission of learned, meaning-bearing communication**

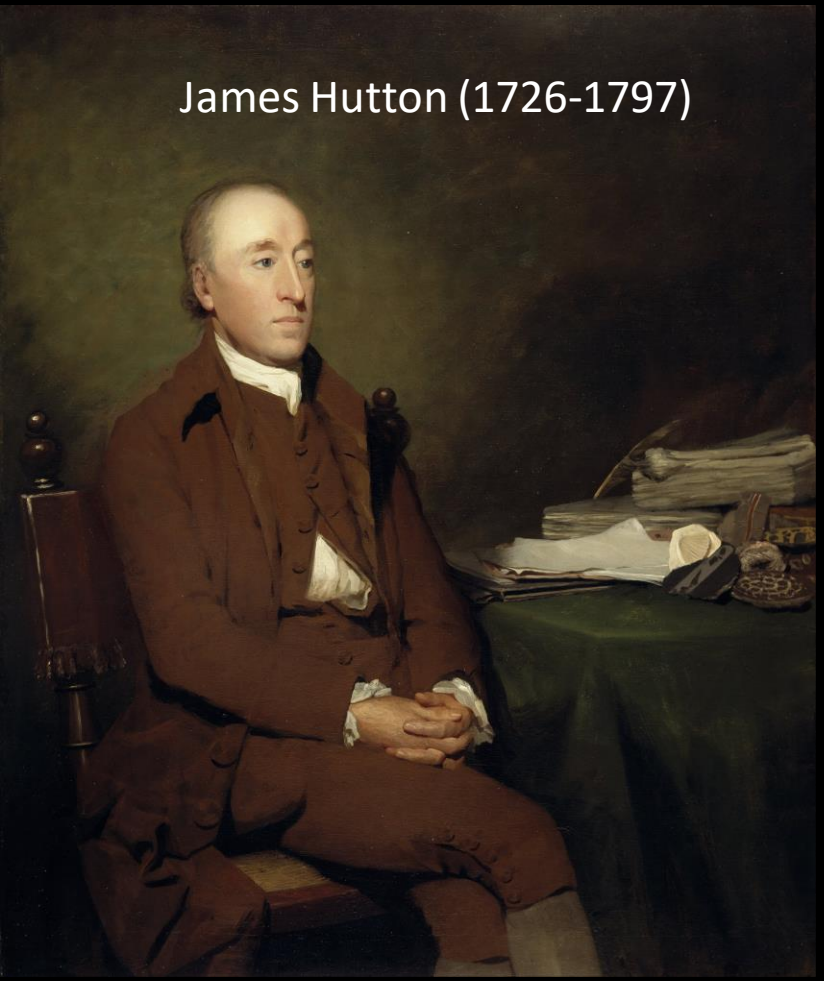
- Once that's in place, exciting stuff happens

The cultural evolution of language



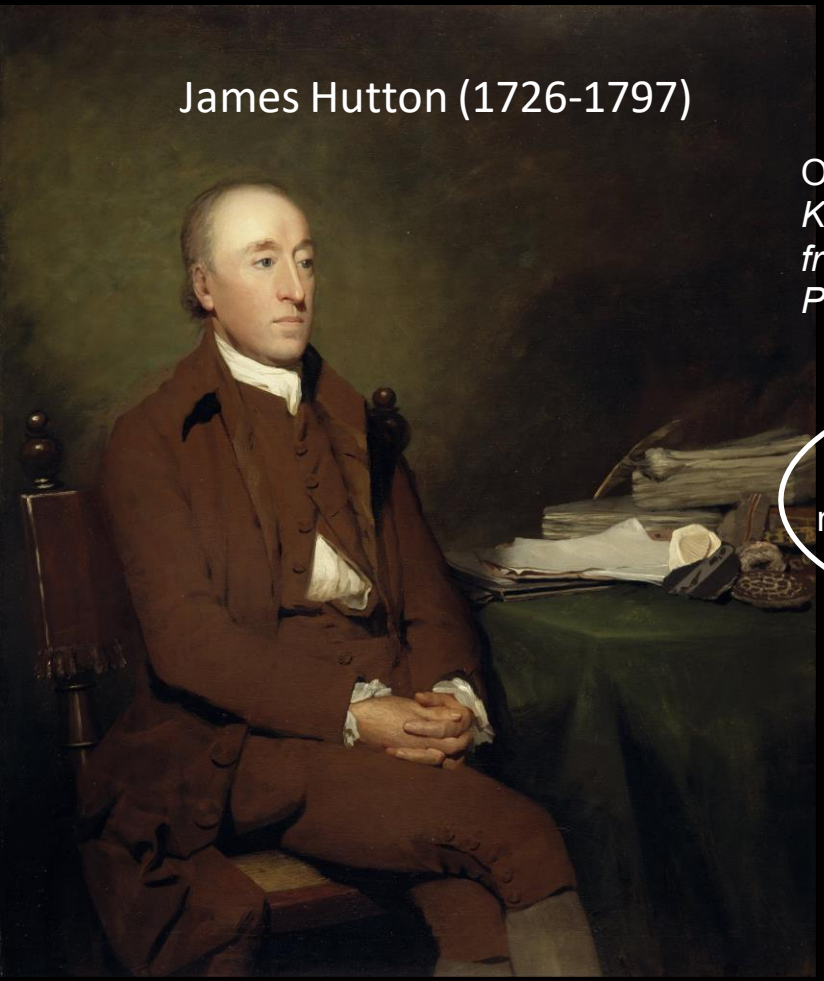
- Language is passed from person to person by **learning**
- People learn from language as it is **used in communication**
- Language **evolves** in response to its learning and use

Uniformitarianism (in geology)



Uniformitarianism: **the present is the key to the past**

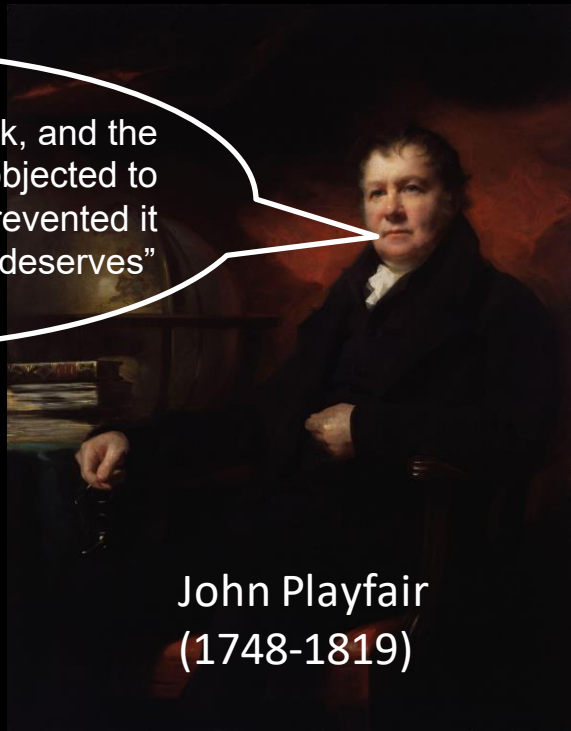
"from what has actually been, we have data for concluding with regard to that which is to happen thereafter."



James Hutton (1726-1797)

On *An Investigation of the Principles of Knowledge and of the Progress of Reason, from Sense to Science and Philosophy* (2000+ pages)

"The great size of the book, and the obscurity which may justly be objected to many parts of it, have probably prevented it from being received as it deserves"



John Playfair (1748-1819)

Lyell on **catastrophism**

Charles Lyell (1797-1875)

“Never was there a doctrine more calculated to foster indolence, and to blunt the keen edge of curiosity, than this assumption of the discordance between the former and the existing causes of change... The student was taught to despond from the first. Geology, it was affirmed, could never arise to the rank of an exact science... [With catastrophism] we see the ancient spirit of speculation revived, and a desire manifestly shown to cut, rather than patiently untie, the Gordian Knot”

Lyell, C. (1854). *Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth's Surface, by Reference to Causes Now in Operation*

Uniformitarianism in evolutionary linguistics

The present is the key to the past

The more we can explain in terms of processes we can observe in the present day, the happier we should be

- Learning and use explain language change visible in the present and the recent historical record
- Can we explain (some of) language origins in terms of the same processes?
- Rather than catastrophism, e.g. language evolved in a single dramatic step due to some single magical event or macromutation

Importantly, uniformity of **process**, not of state: we don't have to say languages have always looked as they do now! (see e.g. Heine & Kuteva, 2002)

Heine, B., & Kuteva, T. (2002). On the Evolution of Grammatical Forms. In. A. Wray (Ed.) The Transition to Language (pp. 376-397). Oxford: Oxford University Press.

Language change

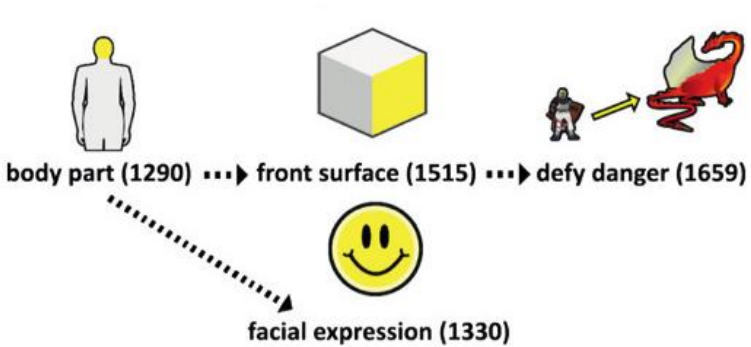
Language change (as attested in the historical record / inferable from synchronic data) is a consequence of:

- Speakers trying to convey meaning efficiently
- Hearers trying to infer speaker meaning
- Language learners (and everyone else) seeking regularities in the linguistic data they encounter

These processes are inherent to the transmission of language via learning and (ostensive-inferential) use

Ad-hoc extension to meet communicative needs

“A reef of dead metaphors” (Deutscher, 2005)



From Ramiro, C., Srinivasan, M., Malt, B. C., & Yu, X. (2018). Algorithms in the historical emergence of word senses. *Proceedings of the National Academy of Sciences, USA, 115,* 2323-2328.

“She was *thrilled* to *discover* that the *assessment board* had *decided* to make her *rival redundant*”

thrill: from thirl, “to pierce”

discover: remove the cover from

assessment: from *assidere,* “to sit by” (in judgment)

board: plank

decided: from *de-caedere, “cut off”*

rival: from *rivalis*, someone who shares the same river

redundant: from redundantem, “overflow”

From p. 125 of Deutscher, G. (2005). *The Unfolding of Language*. New York, NY: Picador.

Grammaticalization

E.g.: development of future tense markers from verbs of motion

I am going to Toronto	MOTION
I am going to stay at home	INTENTION
It is going to rain	FUTURE

Grammaticalization

E.g.: development of future tense markers from verbs of motion

I am going to Toronto	MOTION (+ INTENTION)
I am going to stay at home	INTENTION
It is going to rain	FUTURE

Grammaticalization

E.g.: development of future tense markers from verbs of motion

I am going to Toronto	MOTION (+ INTENTION)
I am going to buy you a gift!	MOTION + INTENTION
I am going to stay at home	INTENTION
It is going to rain	FUTURE

Grammaticalization

E.g.: development of future tense markers from verbs of motion

I am going to Toronto	MOTION (+ INTENTION)
I am going to buy you a gift!	MOTION + INTENTION
I am going to stay at home	INTENTION (+ FUTURE)
It is going to rain	FUTURE

Grammaticalization

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I am going to stay at home	INTENTION (+ FUTURE)
I am going to stay at home tomorrow	INTENTION + FUTURE
It is going to rain	FUTURE

Grammaticalization

E.g.: development of future tense markers from verbs of motion

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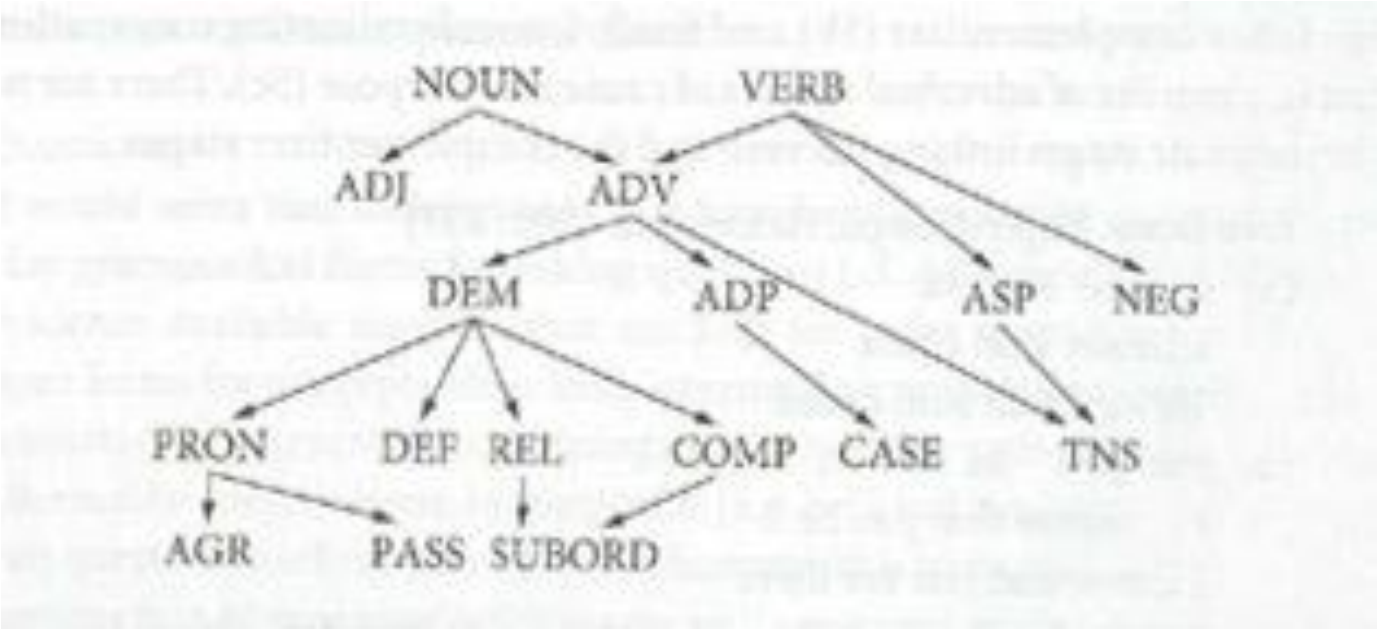
It's gonna to rain	FUTURE



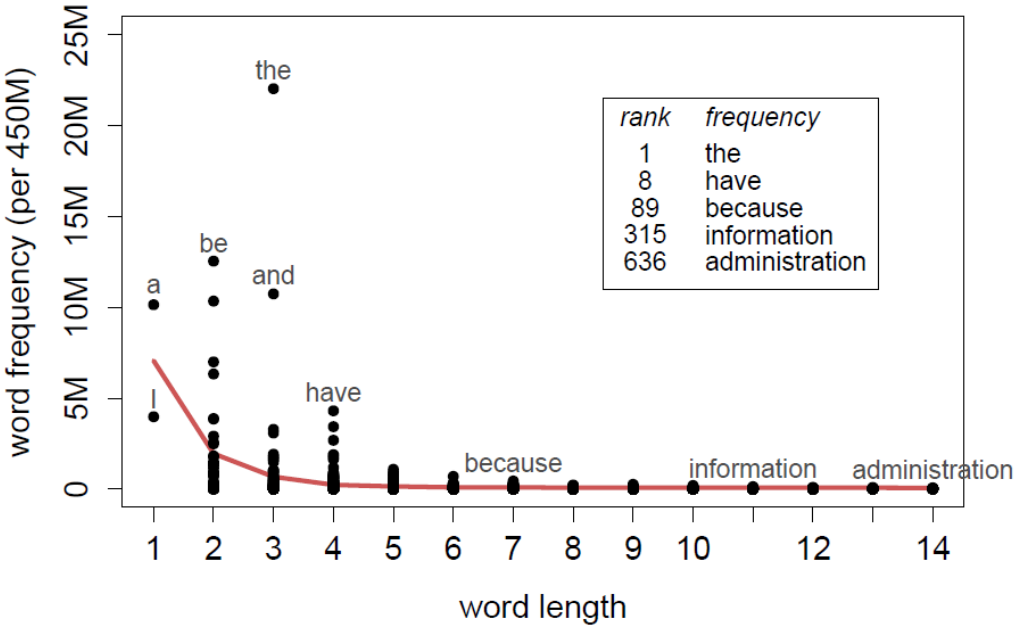
From Heine, B., & Kuteva, T. (2002). On the Evolution of Grammatical Forms. In. A. Wray (Ed.) The Transition to Language (pp. 376-397). Oxford: Oxford University Press.

Analogical extension & "system pressure"

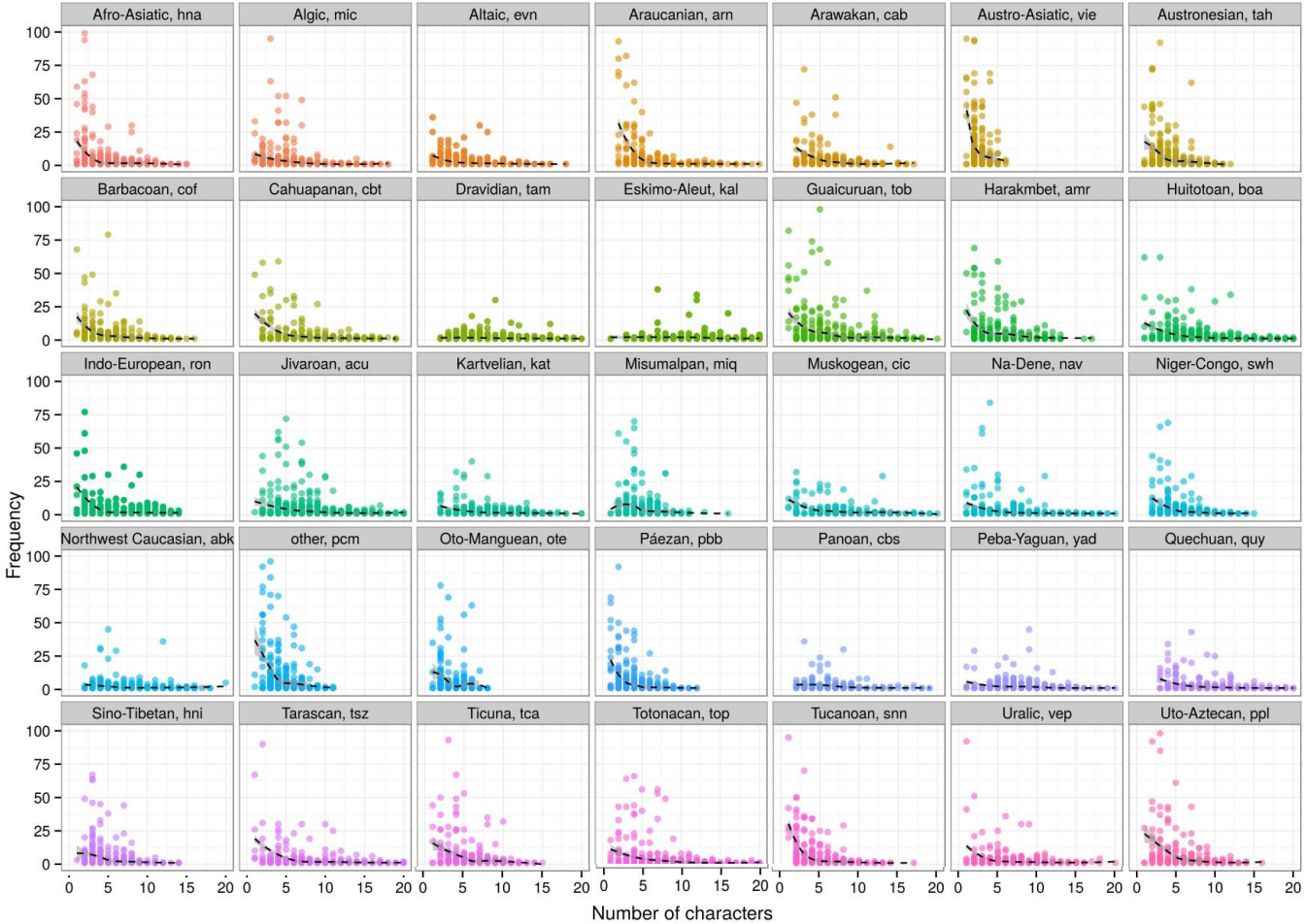
Cover of issue featuring Lieberman, E., Michel, J. B., Jackson, J., Tang, T., & Nowak, M. A. (2007). Quantifying the evolutionary dynamics of language. *Nature, 449,* 713-716.

Analogical extension & “system pressure”

Frequent words tend to be short (Zipf’s Law of Abbreviation)



From Kanwal, J., Smith, K., Culbertson, J., & Kirby, S. (2017). Zipf’s Law of Abbreviation and the Principle of Least Effort: Language users optimise a miniature lexicon for efficient communication. *Cognition, 165*, 45-52.



From Bentz, C., & Ferrer-i-Cancho, R. (2016). Zipf's law of abbreviation as a language universal. In Bentz, C., Jäger, G., & Yanovich, I. (Eds.) *Proceedings of the Leiden Workshop on capturing phylogenetic algorithms for linguistics*.

Analogical extension & "system pressure"

Frequent words tend to be short (Zipf's Law of Abbreviation)

But system-level pressures favor **regularity**

Table 12.9. An unattested system

English	SG	PL	Percentage of singular	Hypothetical language
house	49295	9840	83	*house-Ø/house-ssss*
hare	488	136	78	*hare-Ø/hare-sss*
bear	1182	611	66	*bear-Ø/bear-ss*
window	9936	8506	54	*window-Ø/window-s*
feather	487	810	38	*feather-one/feather-Ø*
parent	3706	15956	19	*parent-oneone/parent-Ø*

From Haspelmath, M. (2014). On system pressure competing with economic motivation. In MacWhinney, B., Malchukov, A., & Moravcsik, E. (Eds) *Competing Motivations in Grammar and Usage* (pp. 197-208). Oxford: Oxford University Press.

Language change

Language change (as attested in the historical record / inferable from synchronic data) is a consequence of:

- Speakers trying to convey meaning efficiently
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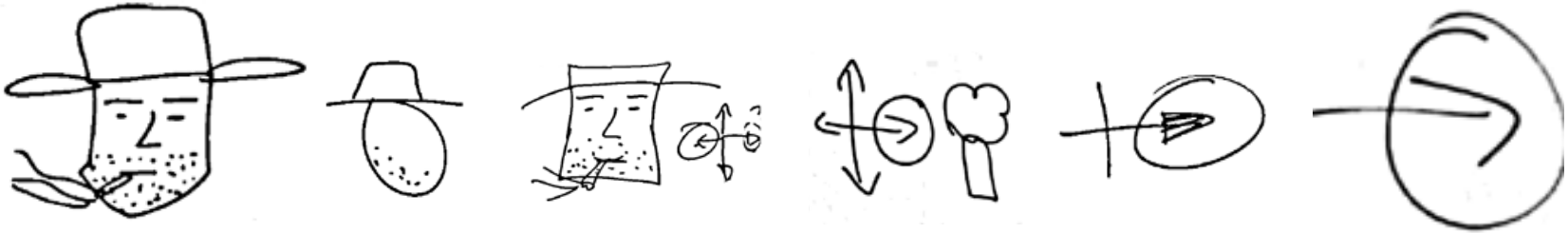
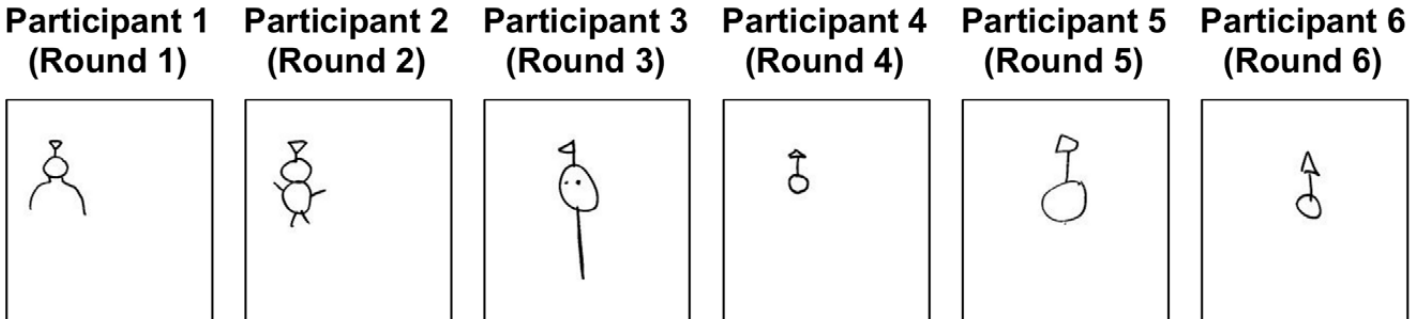
These processes are inherent to the transmission of language via learning and (ostensive-inferential) use

To what extent can these same processes explain the origins of fundamental properties of linguistic systems?

Example: the evolution of signals

The evolution of arbitrary symbols in the lab (from week 1)





Garrod, S. et al. (2007). Foundations of Representation: Where Might Graphical Symbol Systems Come From? *Cognitive Science, 31*, 961-987

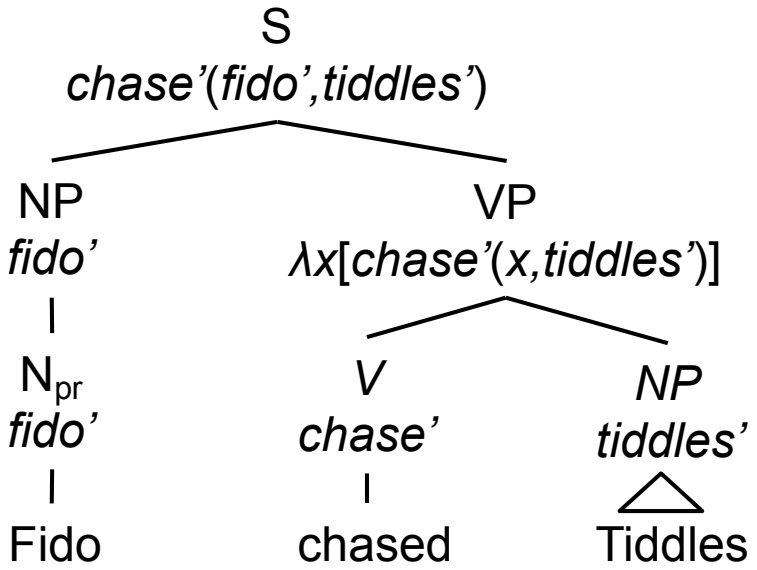
Caldwell, C. A., & Smith, K. (2012). Cultural evolution and the perpetuation of arbitrary communicative conventions in experimental microsocieties. *PLoS ONE, 7,* e43807.

Example: the evolution of structure

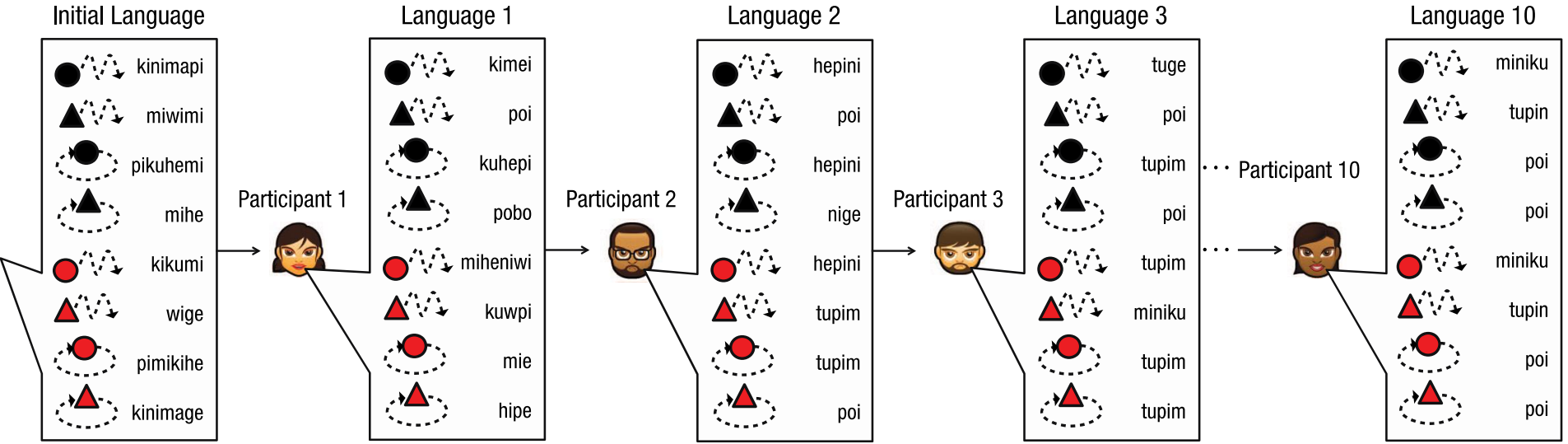
Reminder: Language's communicative power comes from its **structure**

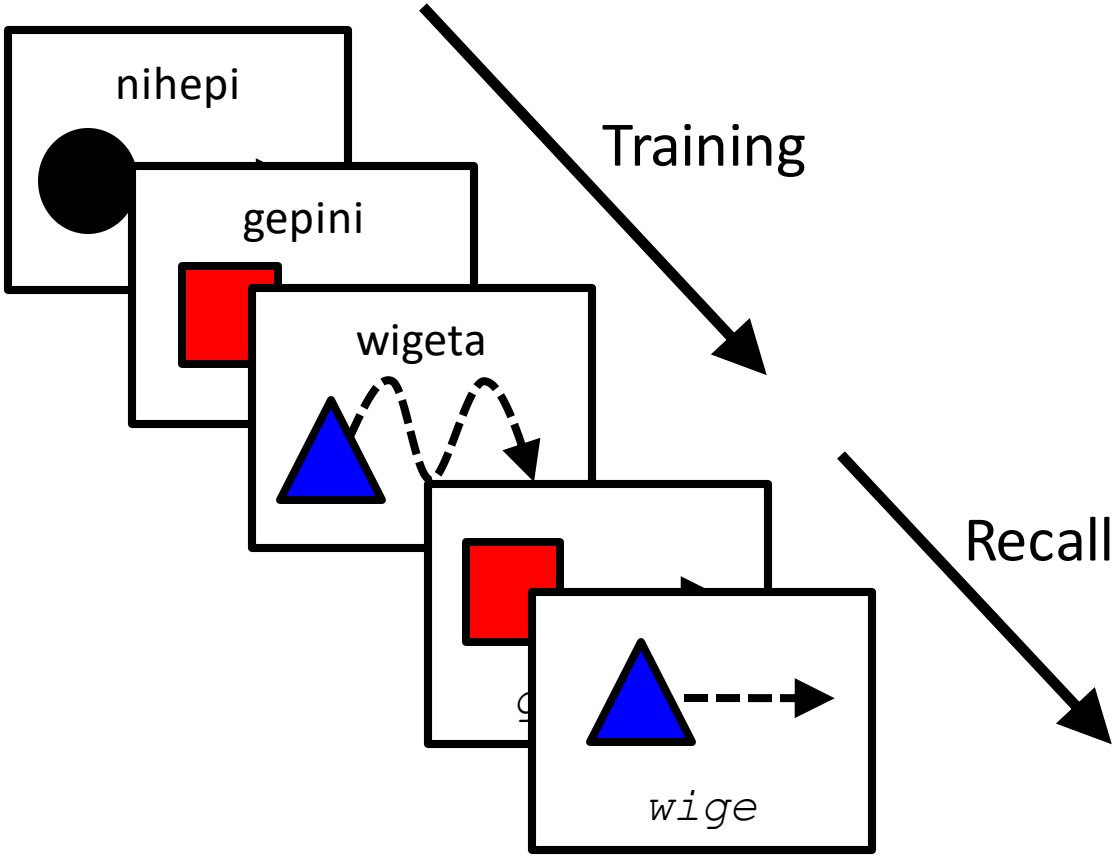
Compositionality: the meaning of an expression is a function of the meaning of its parts and the way in which they are combined

S → NP VP *VP'*(*NP'*)
NP → N_{pr} N'_{pr}
N_{pr} → Fido *fido'*
N_{pr} → Tiddles *tiddles'*
VP → V NP *V'*(*NP'*)
V → chased $\lambda x\,[\lambda y\,[(chase'(x,y)]]$



Iterated Learning



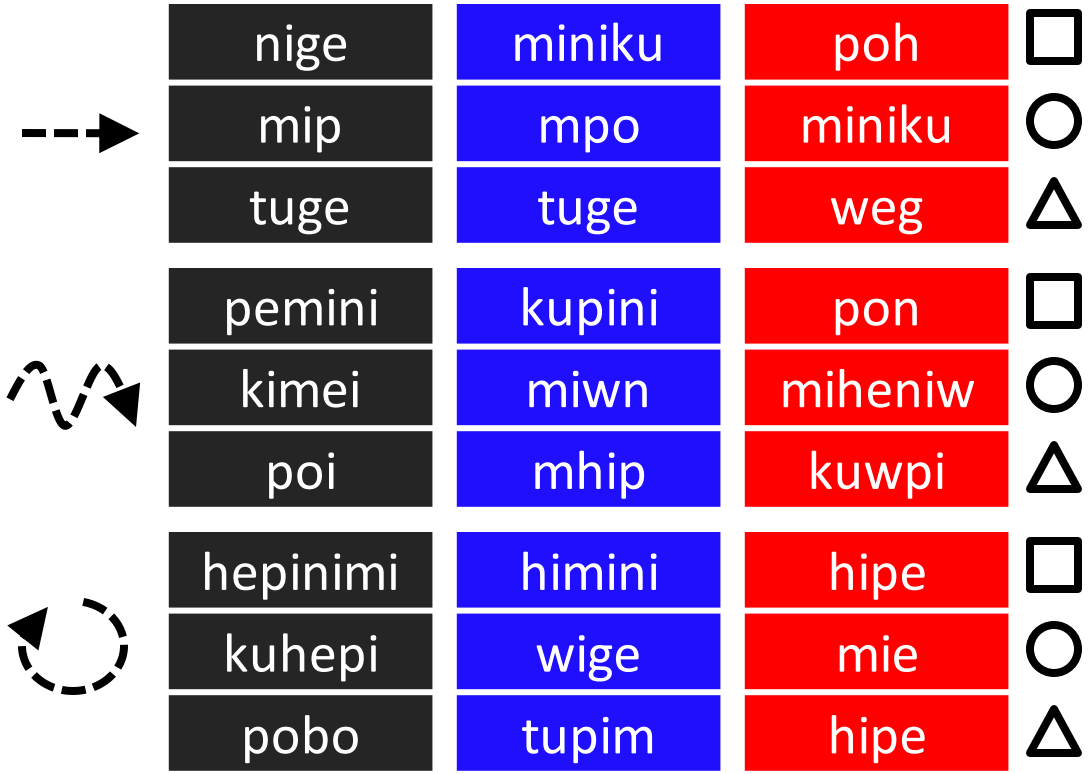


Kirby, S., Cornish, H., & Smith, K. (2008). Cumulative cultural evolution in the laboratory: An experimental approach to the origins of structure in human language. *PNAS, 105,* 10681-10686.

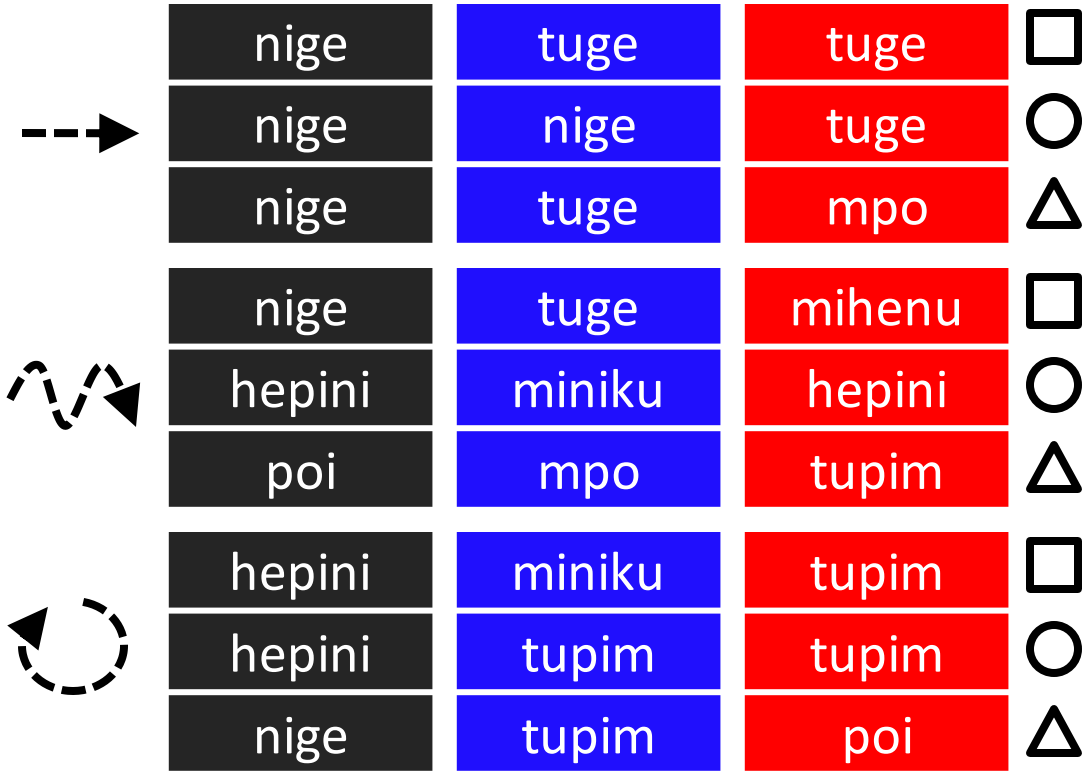
An initial **holistic** language from chain 4

Seen vs unseen

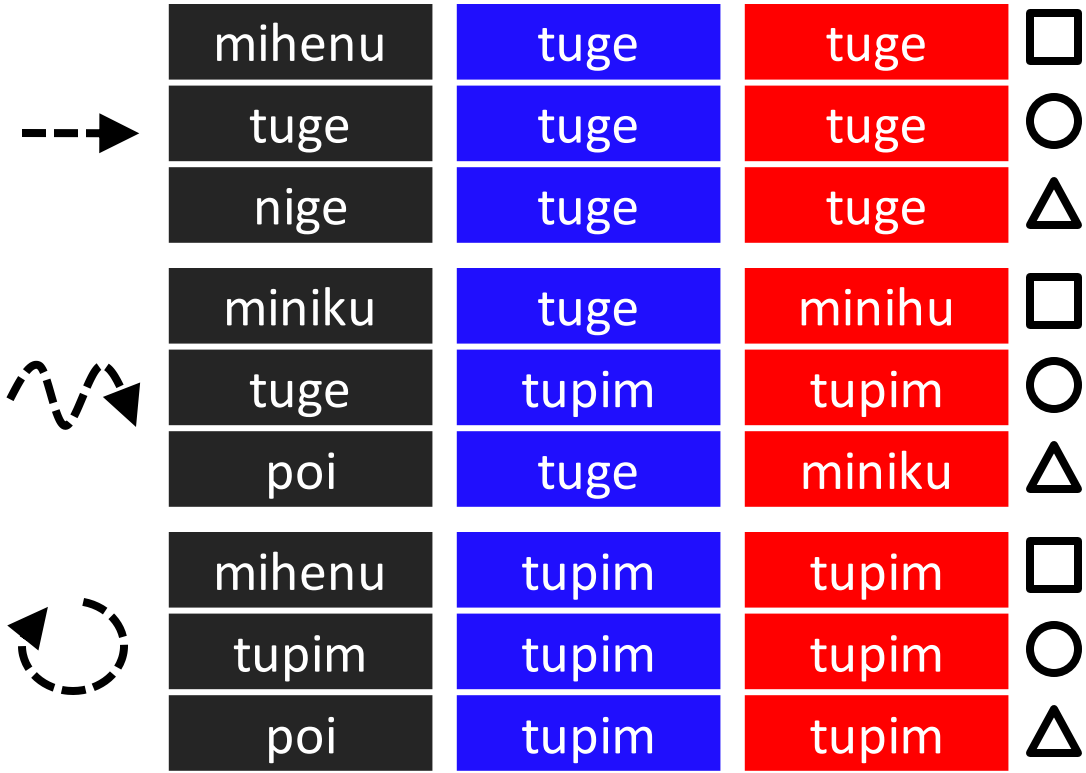
Generation 1 language from chain 4



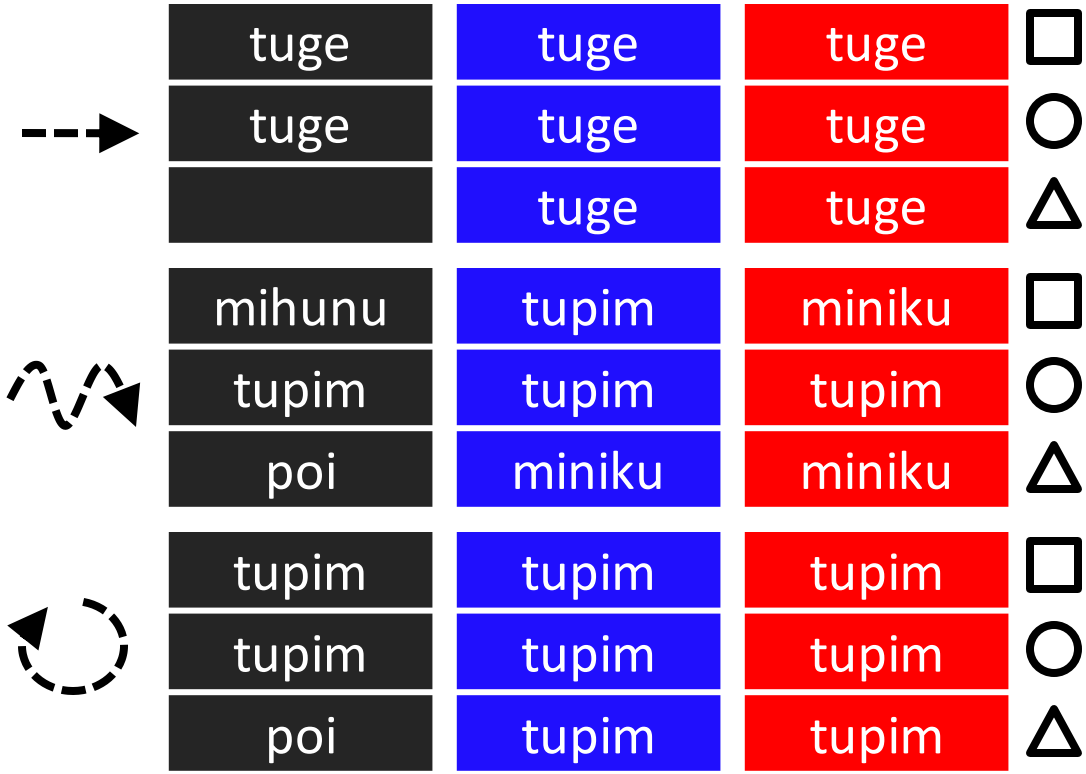
Generation 2 language from chain 4



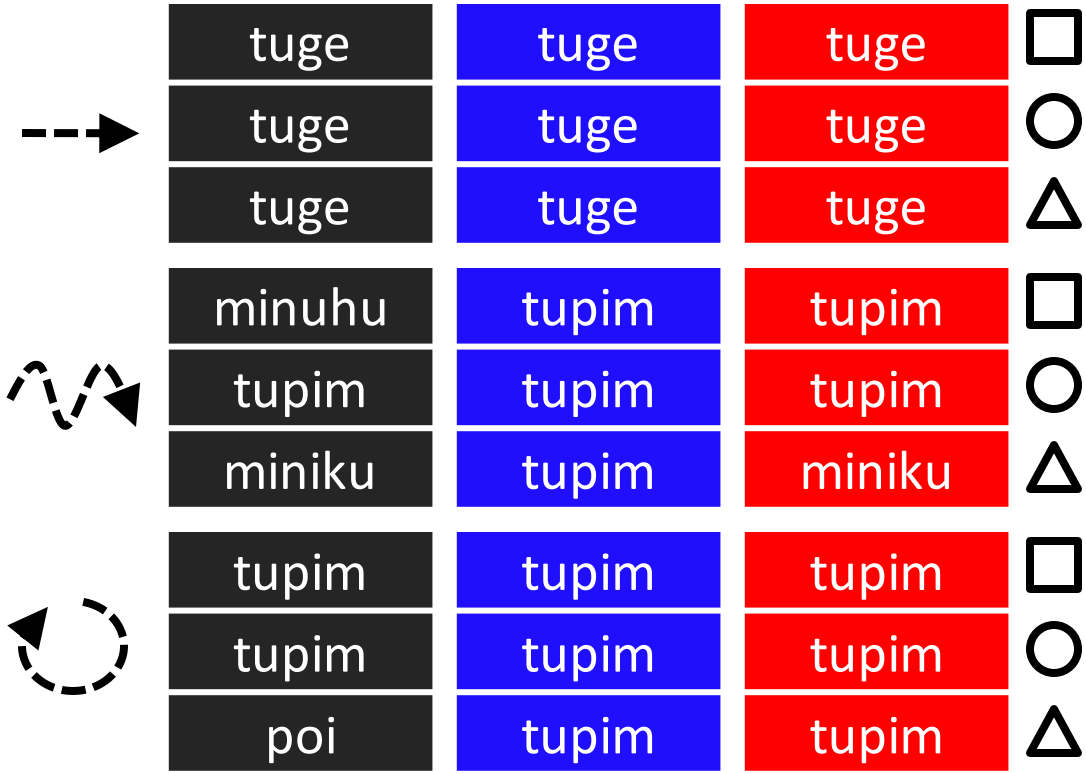
Generation 3 language from chain 4



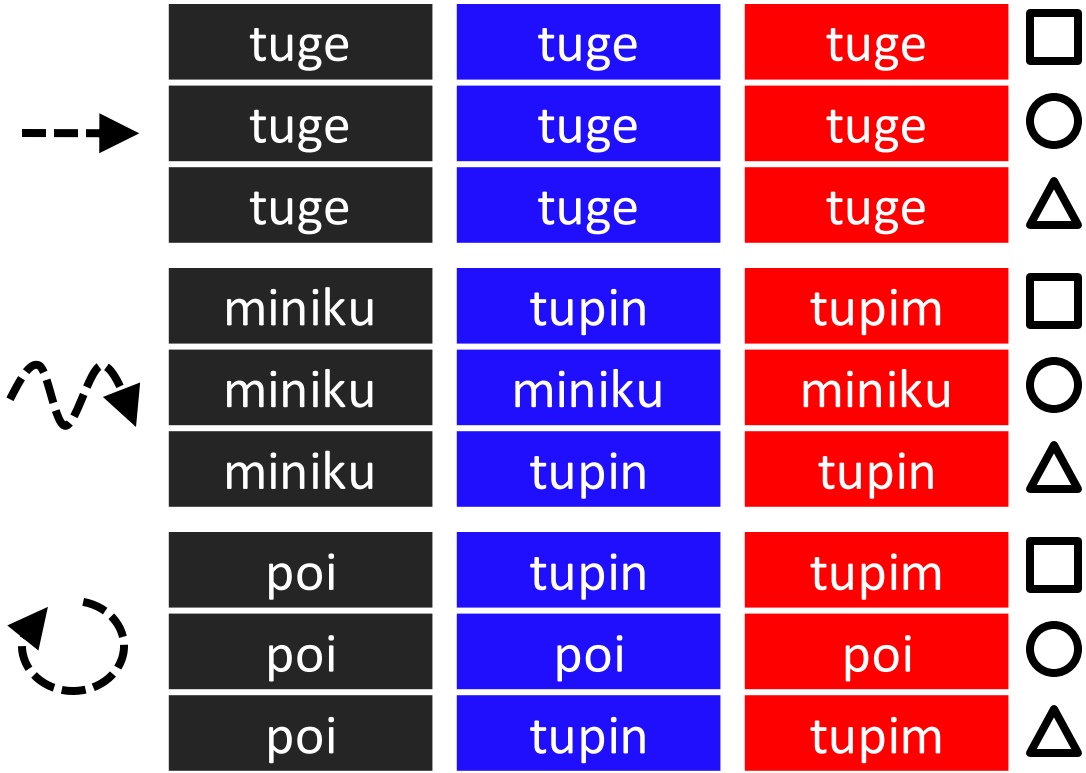
Generation 4 language from chain 4



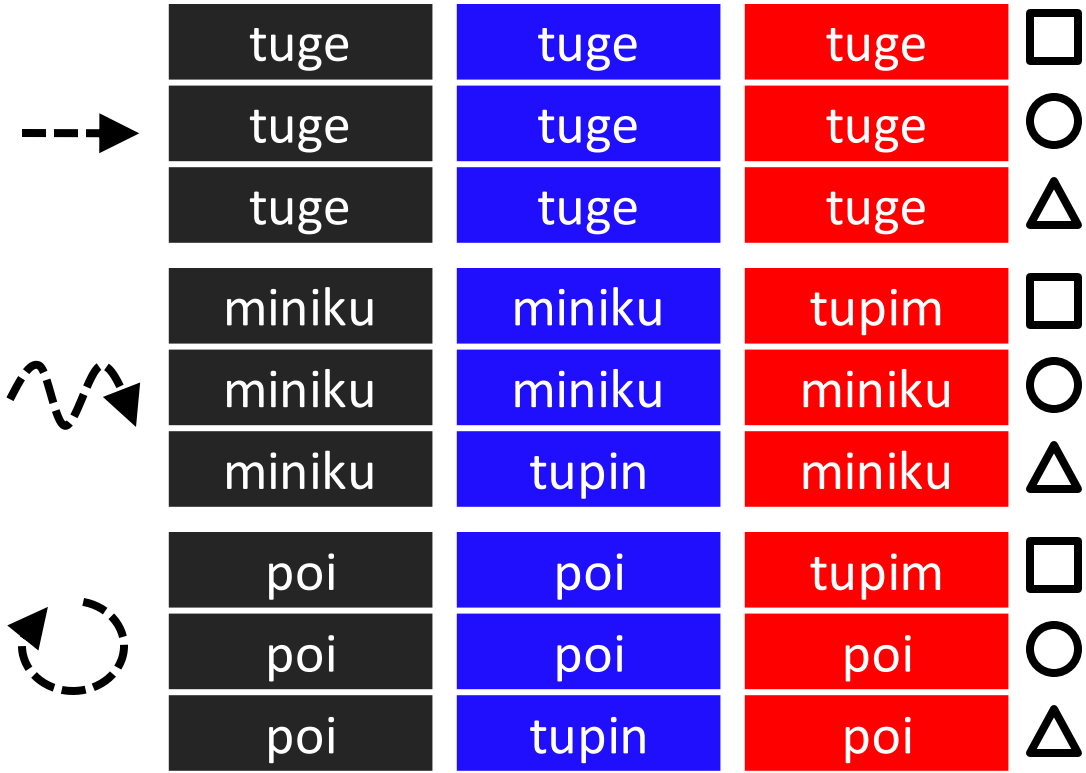
Generation 5 language from chain 4



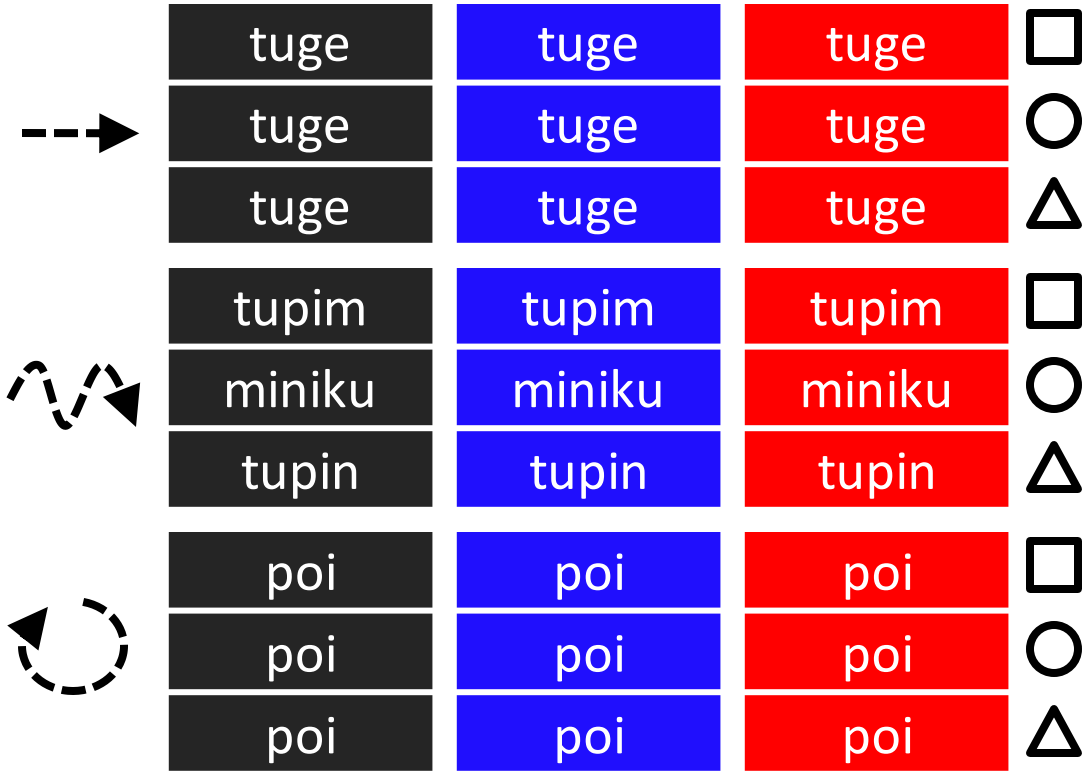
Generation 6 language from chain 4



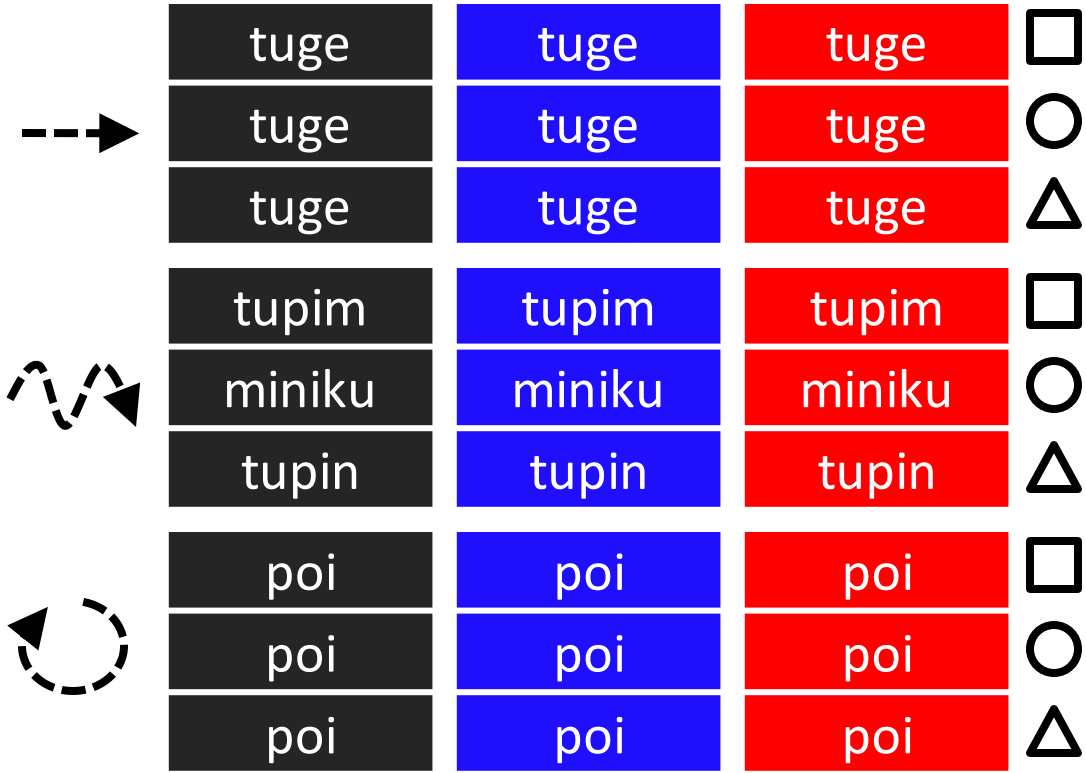
Generation 7 language from chain 4



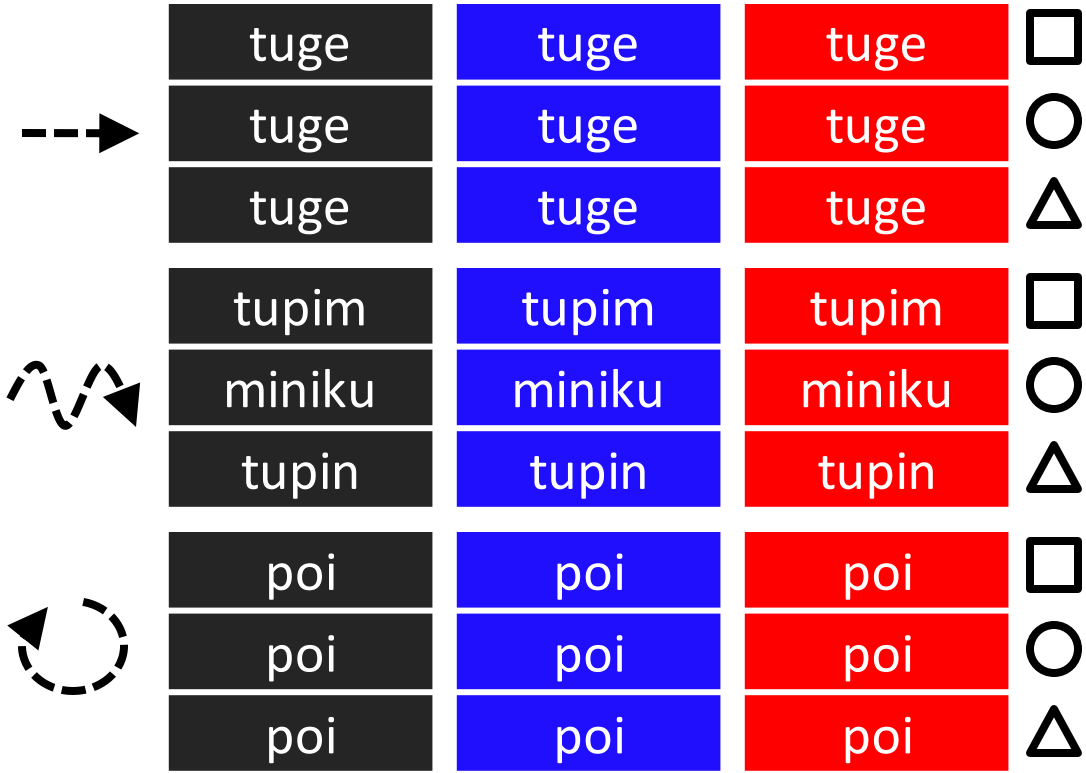
Generation 8 language from chain 4



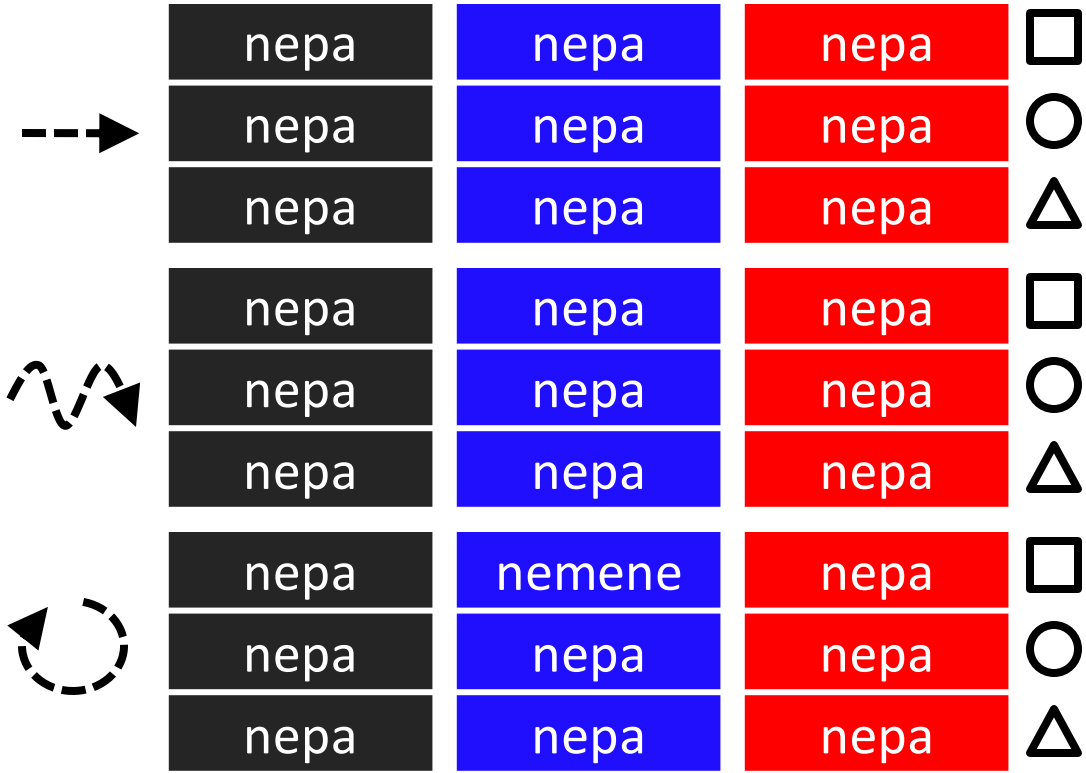
Generation 9 language from chain 4



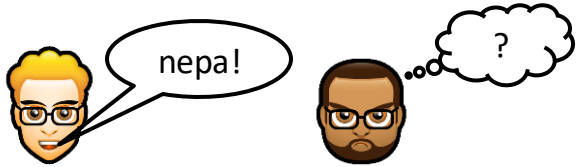
Generation 10 language from chain 4



Final language from chain 1 (!)



The languages become **degenerate**



Learnability and degeneracy

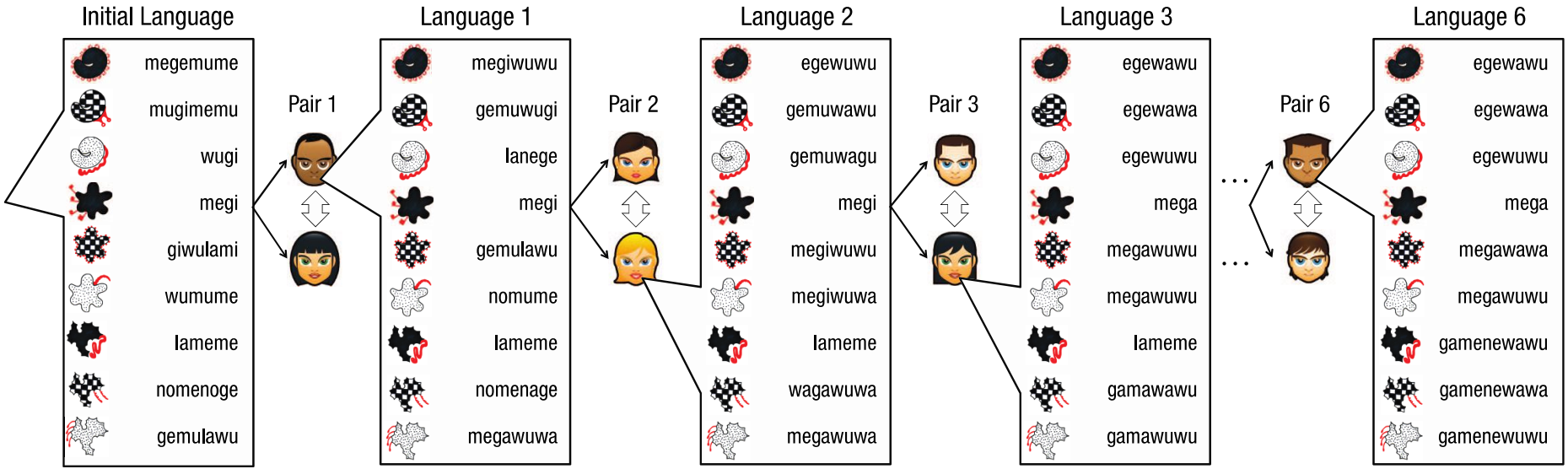
Learners prefer simpler languages

The only pressure in Kirby, Cornish & Smith (2008) Experiment 1 is **learnability**

- The languages don't need to be **expressive**
- They get very simple

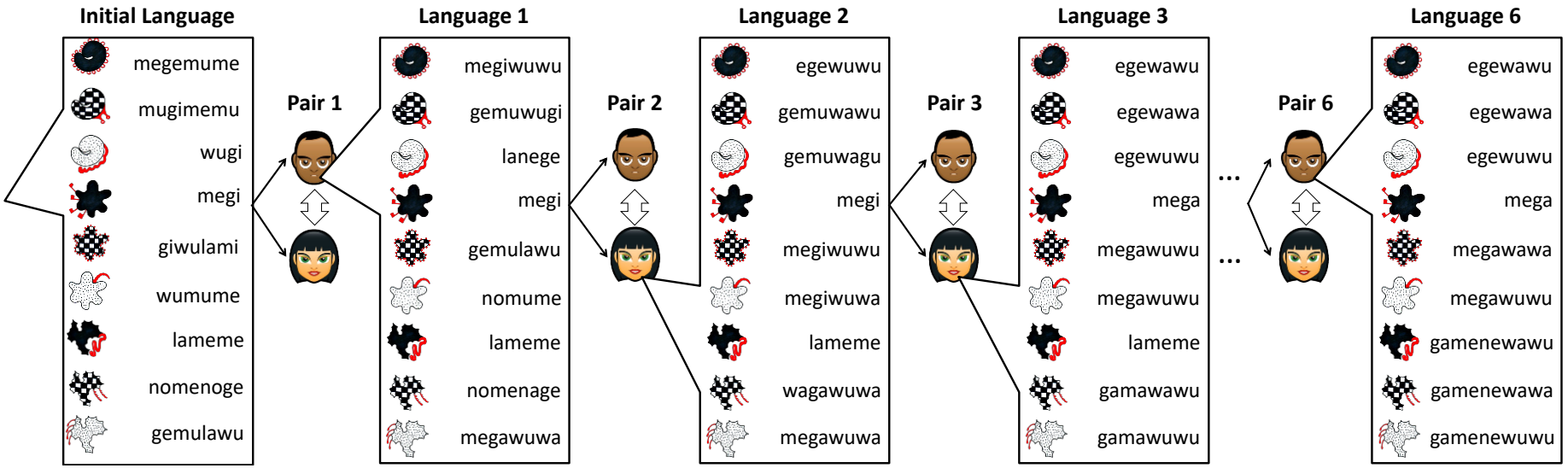
Can we add in a pressure for expressivity?

Kirby, Tamariz, Cornish & Smith (2015): Adding communication



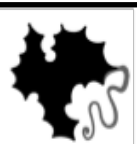
Kirby, S., Tamariz, M., Cornish, H., & Smith, K. (2015). Compression and Communication in the Cultural Evolution of Linguistic Structure. *Cognition, 141*, 87-102.

Kirby, Tamariz, Cornish & Smith (2015): Adding communication, removing learning

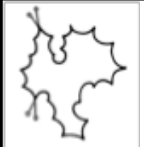


Kirby, S., Tamariz, M., Cornish, H., & Smith, K. (2015). Compression and Communication in the Cultural Evolution of Linguistic Structure. *Cognition, 141*, 87-102.

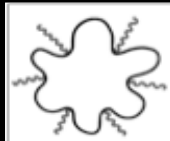
An initial language

 megemume	 megi	 lameme
 mugimemu	 giwulami	 nomenoge
 wugi	 wumume	 gemulawu
 lamege	 wulamugi	 megiwuwa

A final language from a chain

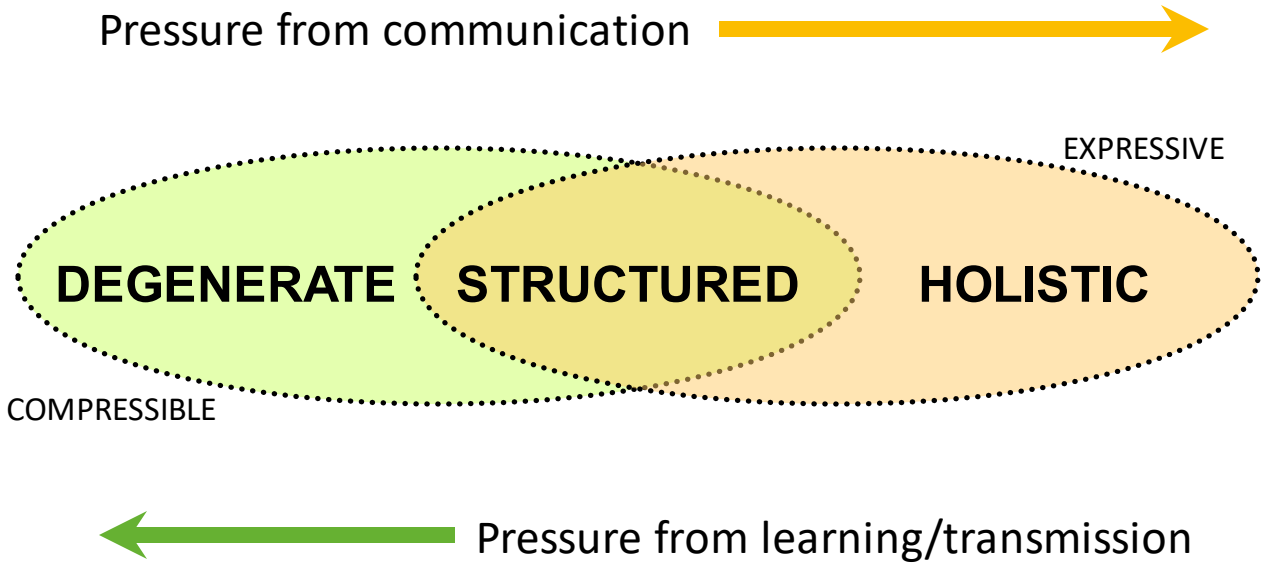
 egewawu	 mega	 gamenewawu
 egewawa	 megawawa	 gamenewawa
 egewuwu	 megawuwu	 gamenewuwu
 ege	 wulagi	 gamane

A final **holistic** language from a dyad

 manununumoko	 moko	 konu
 wekihumanunu	 mokowekihu	 lawa
 makihu	 mahiku	 wekihulawa
 manununumonu	 nomu	 wekihu

Learnability + expressivity = **structure**

Structure as a trade-off between compressibility and expressivity that plays out over cultural transmission



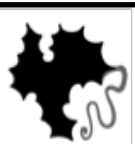
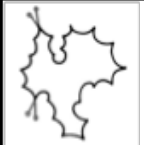
Similar results for duality of patterning: e.g.

Reminder from week 3
Pinker & Bloom (1990)

"All we have argued is that human language, like other specialized biological systems, evolved by natural selection. Our conclusion is based on two facts that we would think would be entirely uncontroversial: Language shows signs of complex design for the communication of propositional structures, and the only explanation for the origin of organs with complex design is the process of natural selection." (p. 726)

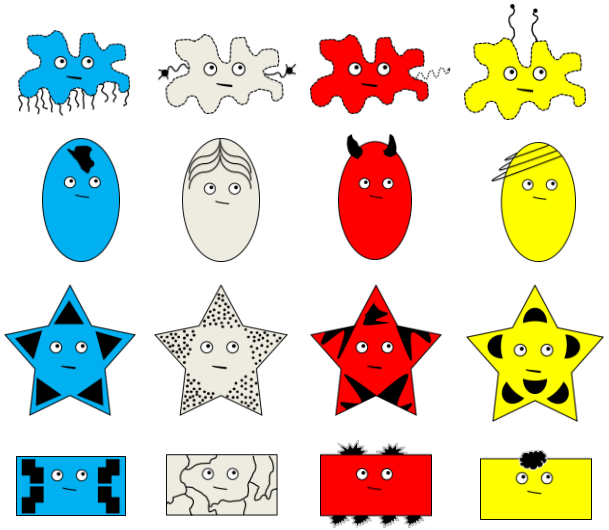
Pinker, S., & Bloom, P. (1990). Natural language and natural selection. *Behavioural and Brain Sciences, 13,* 707-784.

What about the beautiful adaptive fit between the structure of our thoughts and the structure of language?

 egewawu	 mega	 gamenewawu
 egewawa	 megawawa	 gamenewawa
 egewuwu	 megawuwu	 gamenewuwu
 ege	 wulagi	 gamane

The structure of the communicative task affects the kinds of structures that emerge

E.g. Winters, J., Kirby, S., & Smith, K. (2018). Contextual predictability shapes signal autonomy. *Cognition, 176,* 15-30.



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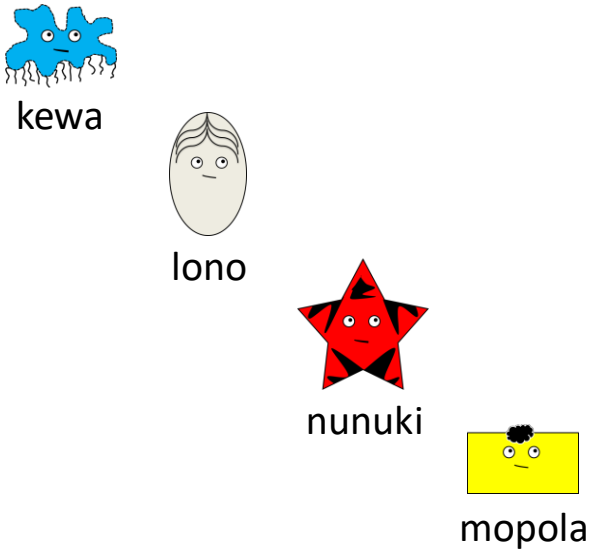
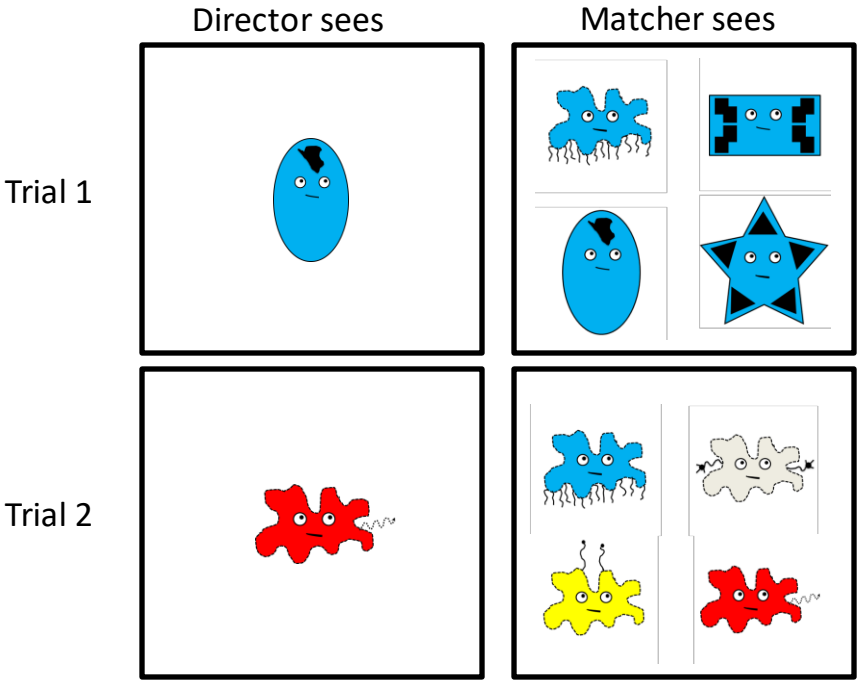
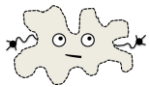



Director sees
Matcher sees
Trial 1
Trial 2
...

mege-ha



mege-hi

mege-hu

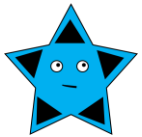
megi-lo

waka-ha

waka-hi

waka-hu

waki-lo

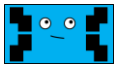


goko-ha

goko-hi

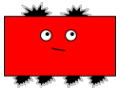
goko-hu

goki-lo



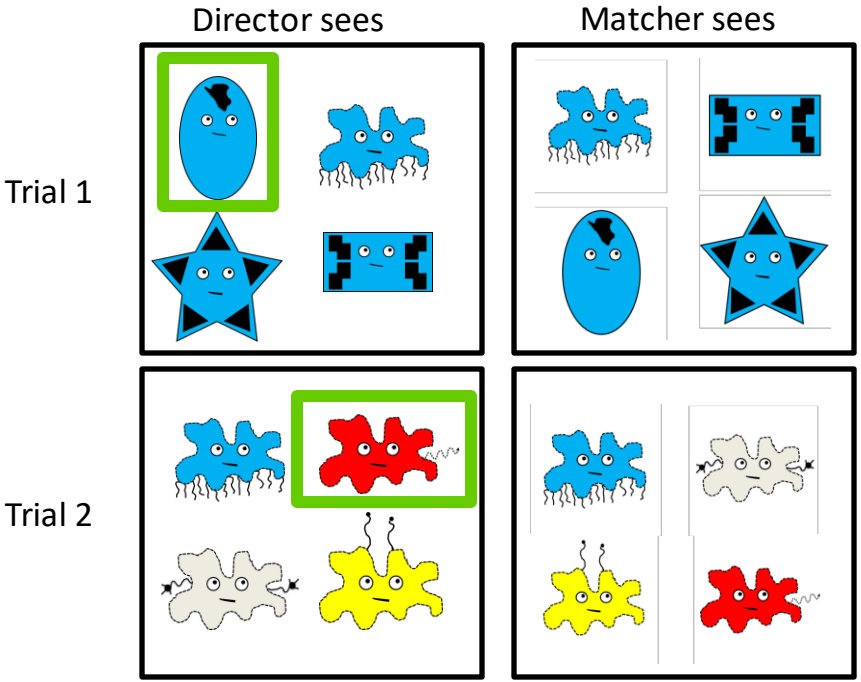
kuki-ha

kuko-hi



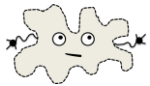
kuko-hu

kuki-lo


Director sees
Matcher sees
Trial 1
Trial 2
...

On shape-relevant trials …


kewu


kewu


kewu

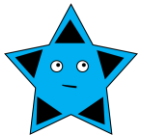

kewu


nunuki


nunuki


nunuki

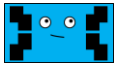

nunuki


lono

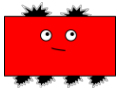

lono


lono


lono


mopola

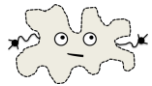

mopola


mopola


mopola

On colour-relevant trials…


kewu mopola


kewu nunuki


kewu lono

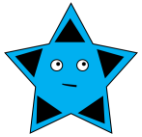

kewu kewu


nunuki mopola


nunuki


nunuki lono

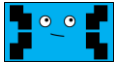

nunuki kewu


lono mopola

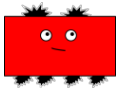

lono nunuki


lono

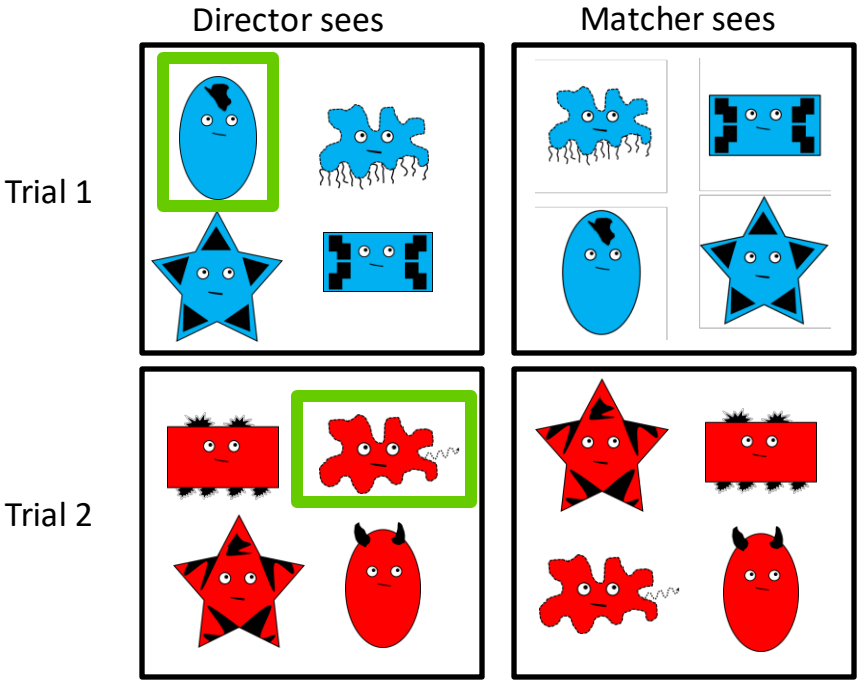

lono kewu


mopola mopola

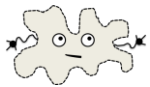

mopola nunuki


mopola lono


mopola kewu


Director sees
Matcher sees
Trial 1
Trial 2
...

hagolo



hagolo

hagolo

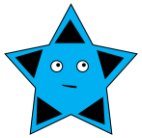
hagolo

nuhumi

nuhumi

nuhumi

nuhumi

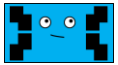


winigo

winigo

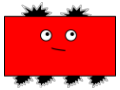
winigo

winigo



kamu

kamu



kamu

kamu

Reminder from week 3
Pinker & Bloom (1990)

"All we have argued is that human language, like other specialized biological systems, evolved by natural selection. Our conclusion is based on two facts that we would think would be entirely uncontroversial: Language shows signs of complex design for the communication of propositional structures, and the only explanation for the origin of organs with complex design is the process of natural selection." (p. 726)

Pinker, S., & Bloom, P. (1990). Natural language and natural selection. *Behavioural and Brain Sciences, 13,* 707-784.

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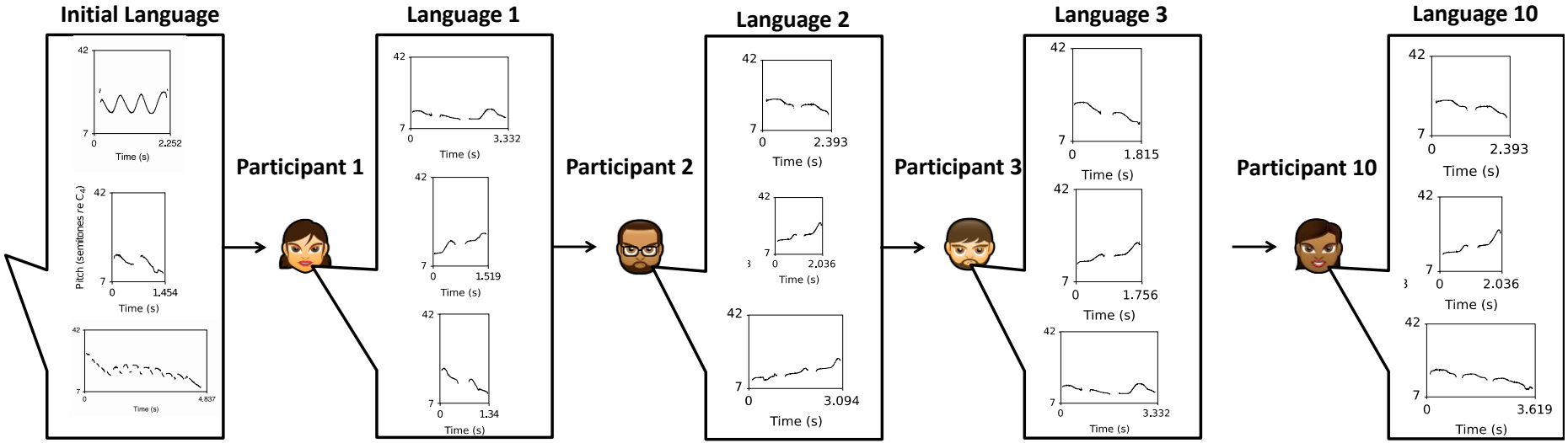
Example: duality of patterning

Language's communicative power comes from its **structure**

Duality of patterning: meaning-bearing units composed of (re)combinations of meaningless differentiating units

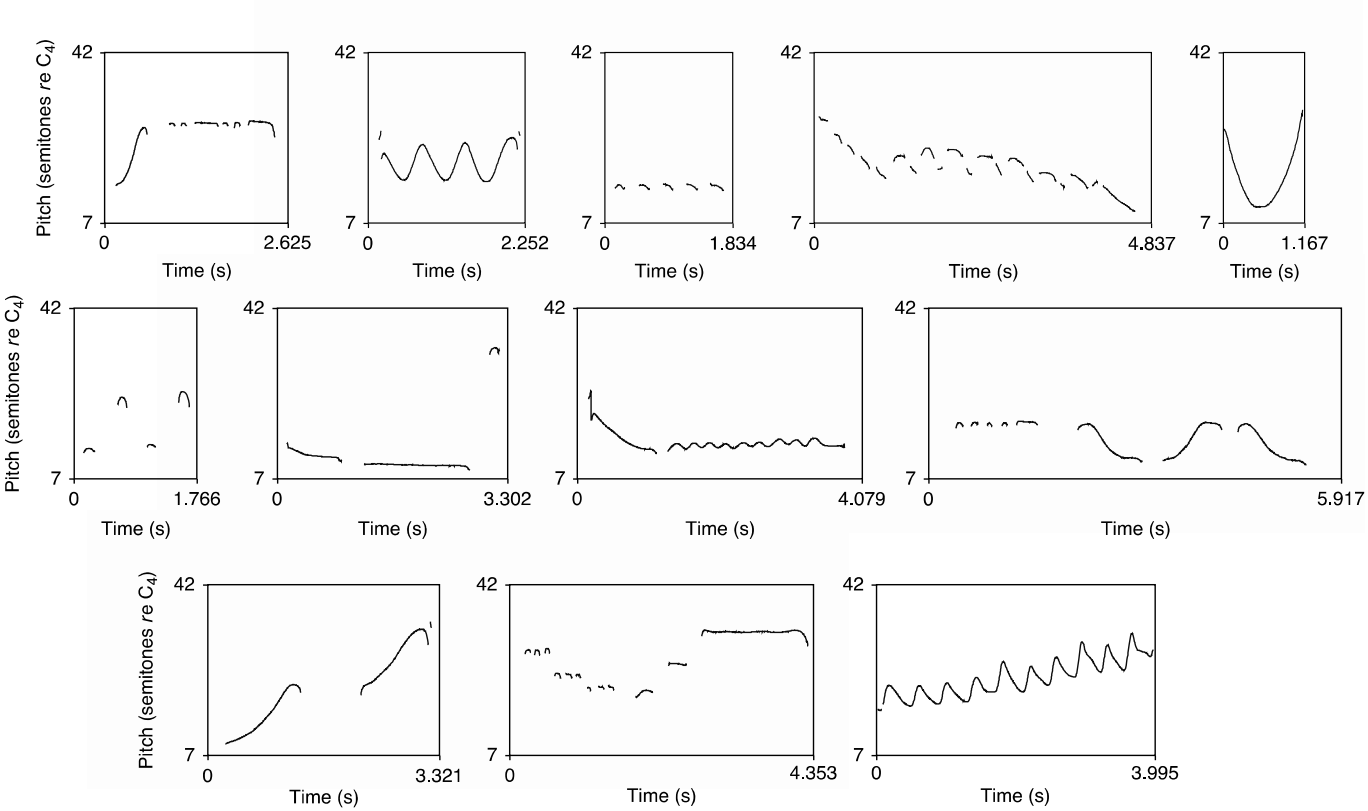
Word	**Meaning**
log	*"Noun; an unhewn portion of a felled tree"*
dog	*"Noun; A domesticated carnivorous mammal"*
dig	*"Verb; To work in making holes or turning the ground"*
dim	*"Adjective; Faintly luminous"*

Iterated Learning of Whistles

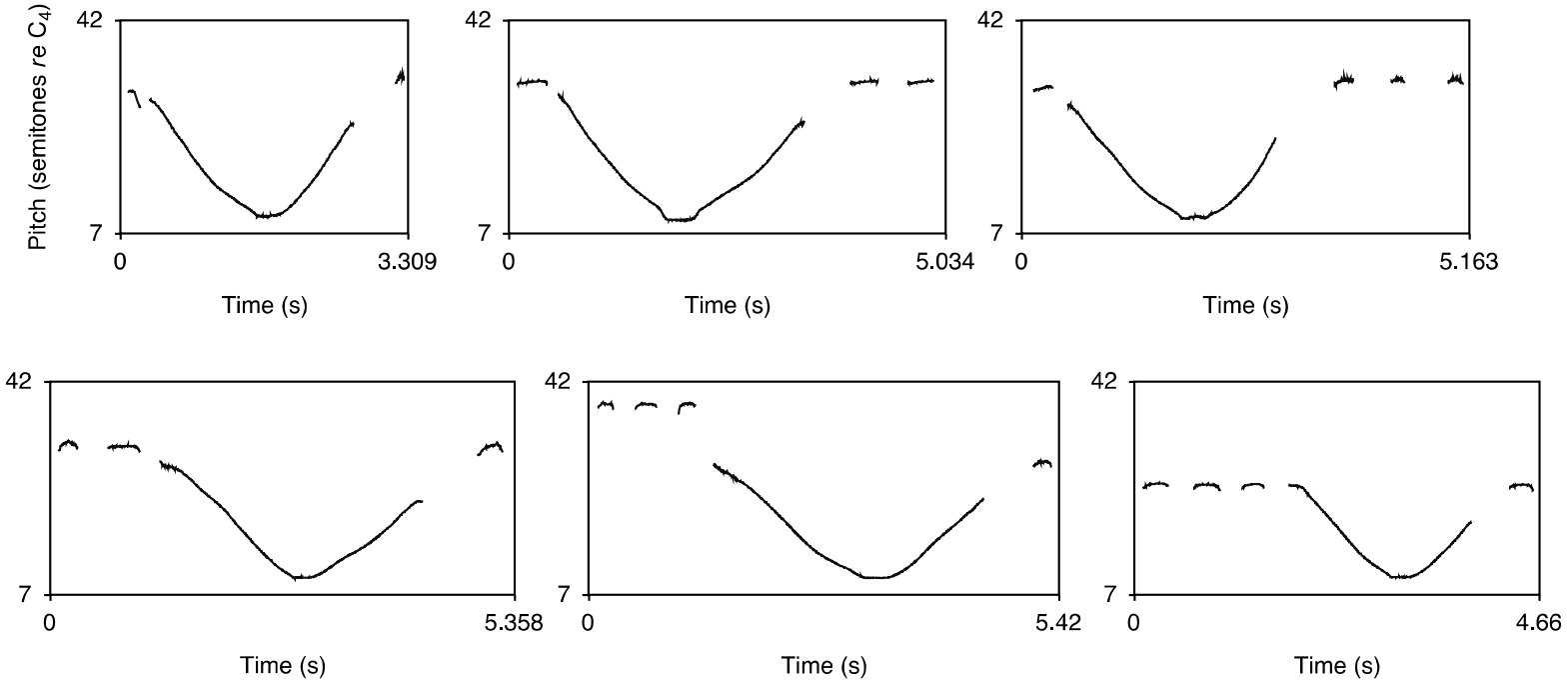


Verhoef, T., Kirby, S., & de Boer, B. (2014). Emergence of combinatorial structure and economy through iterated learning with continuous acoustic signals. *Journal of Phonetics, 43,* 57-68.

The initial whistle set

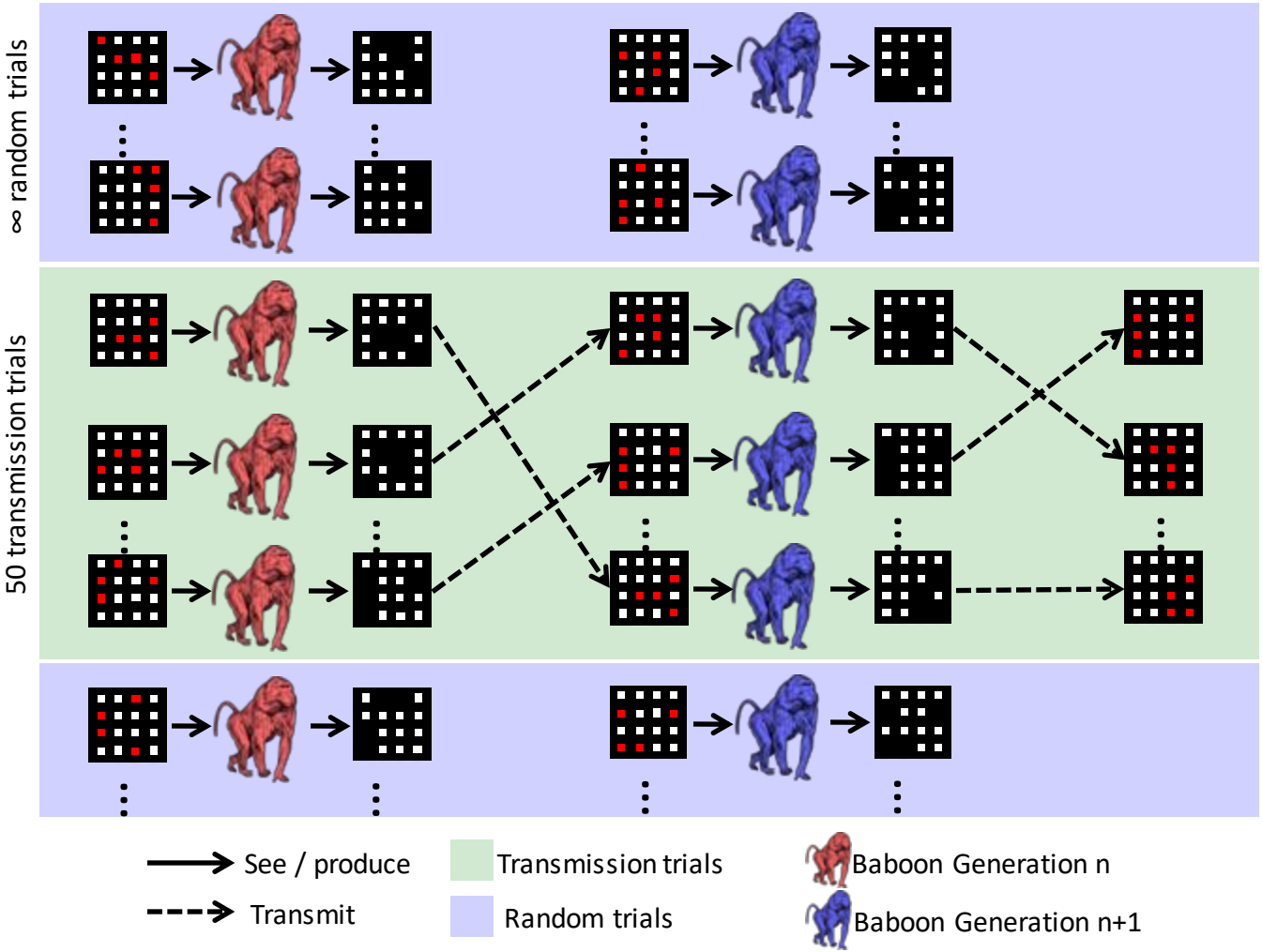


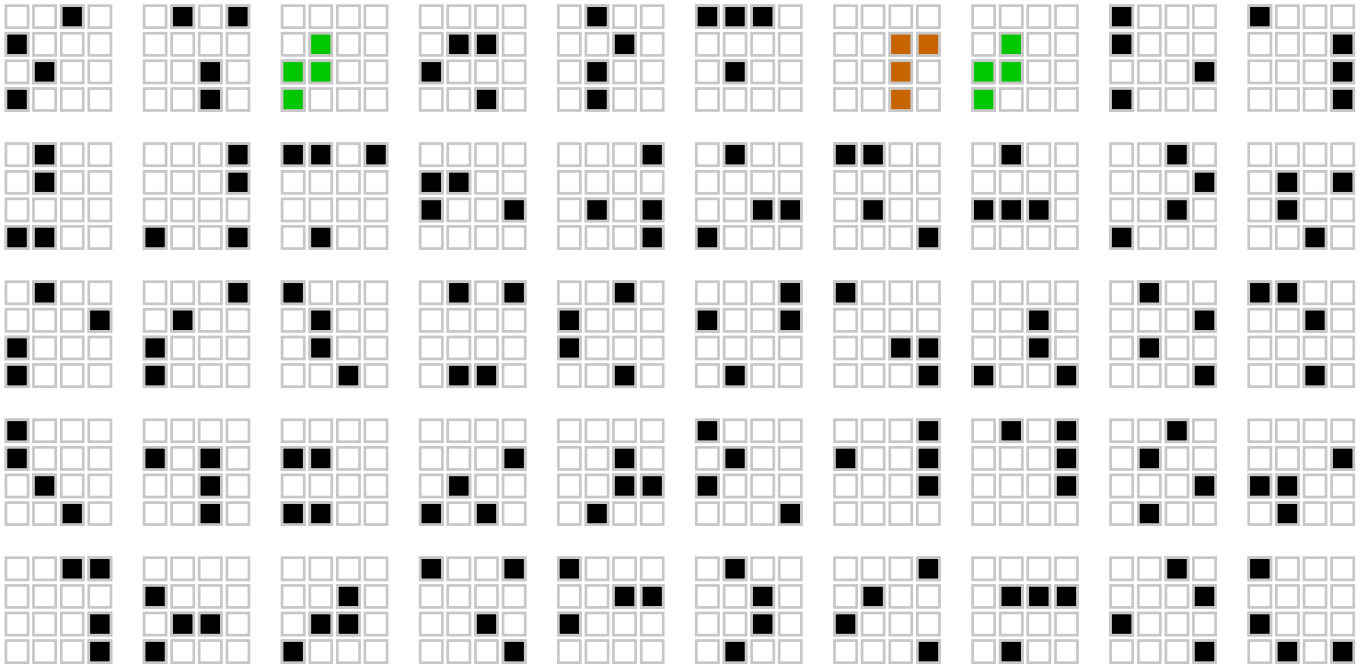
(Part of) A generation 10 whistle set



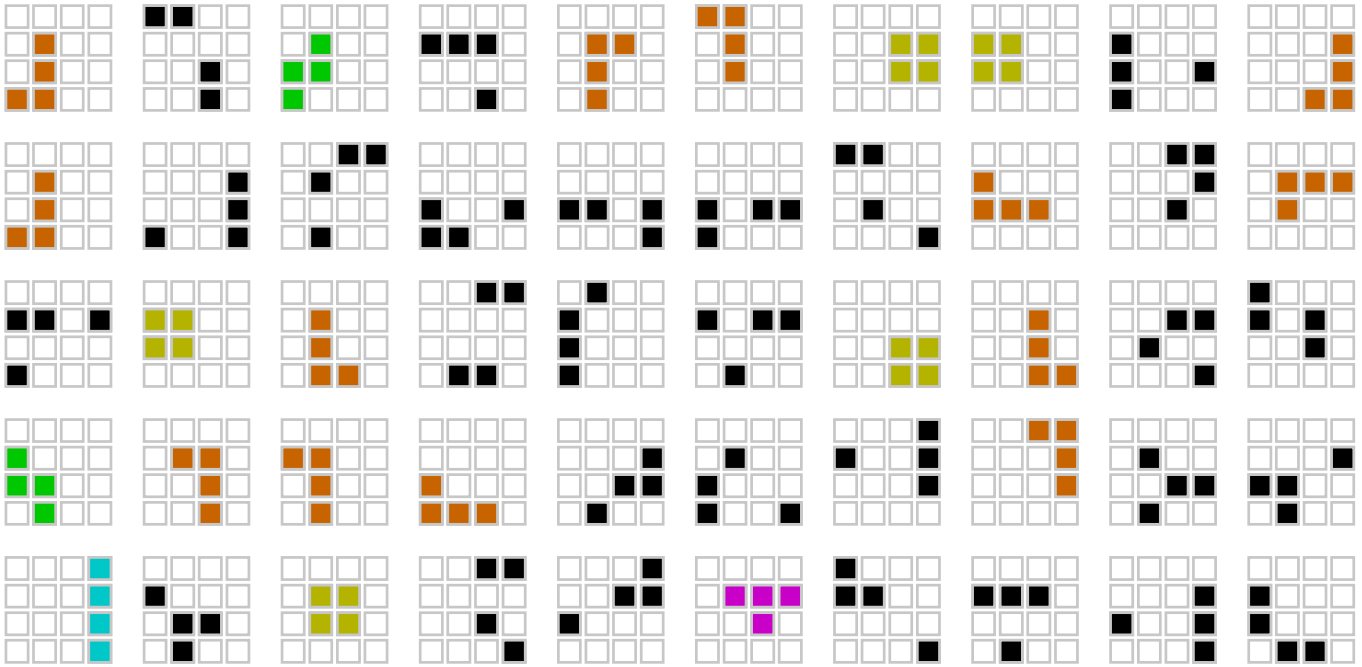
If structure arises from social learning, why isn’t it more common?

Claidière, N., Smith, K., Kirby, S., & Fagot, J. (2014). Cultural evolution of a systematically structured behaviour in a non-human primate. *Proceedings of the Royal Society B, 281,* 20141541.

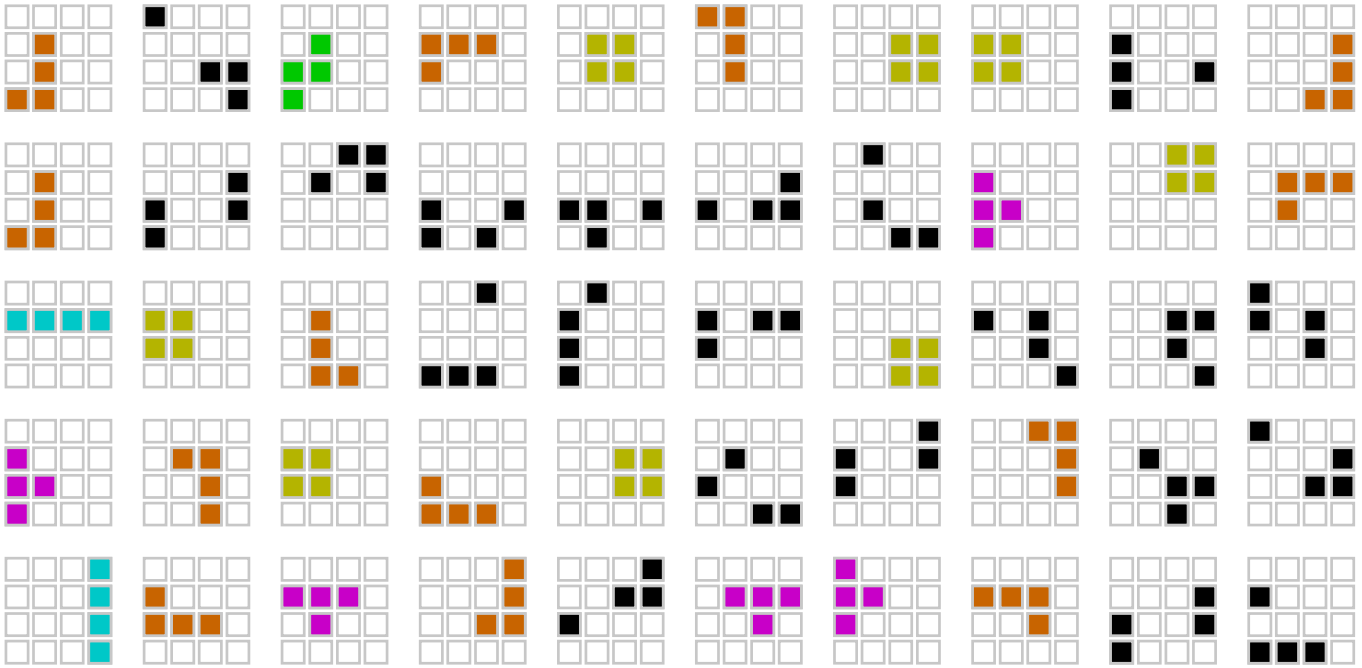

∞ random trials
50 transmission trials
See / produce
Transmit
Transmission trials
Random trials
Baboon Generation n
Baboon Generation n+1



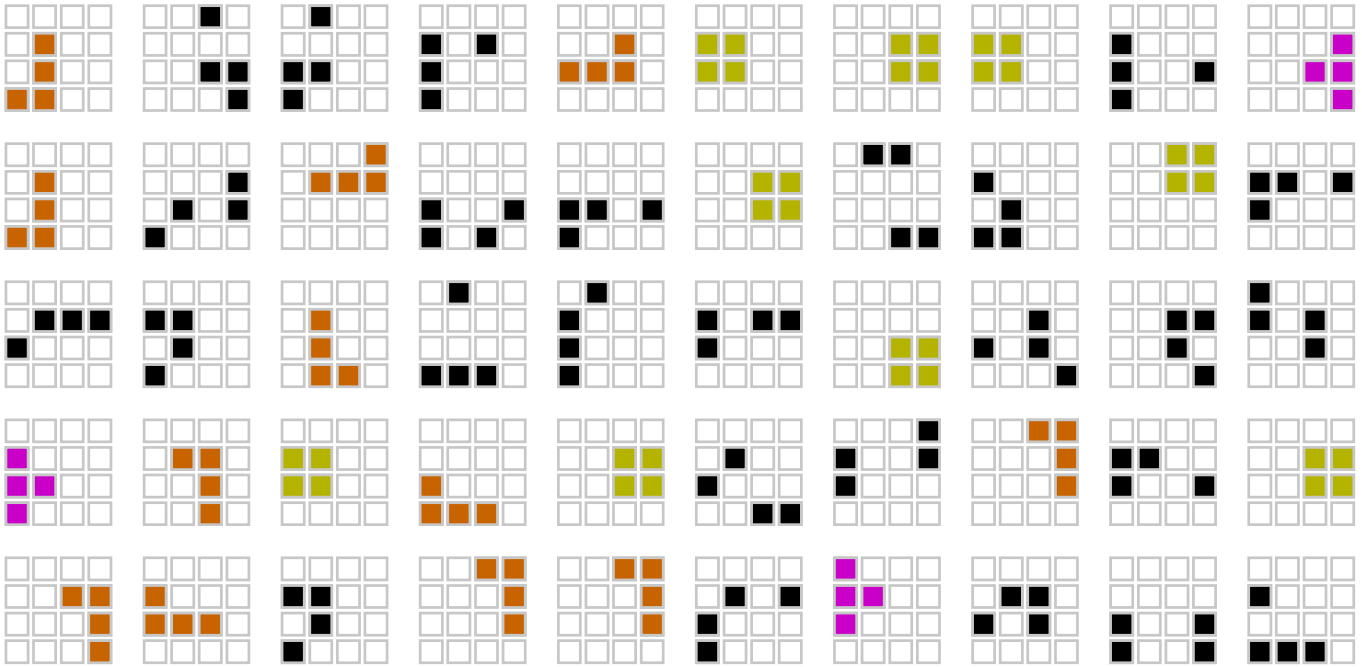
Random grids



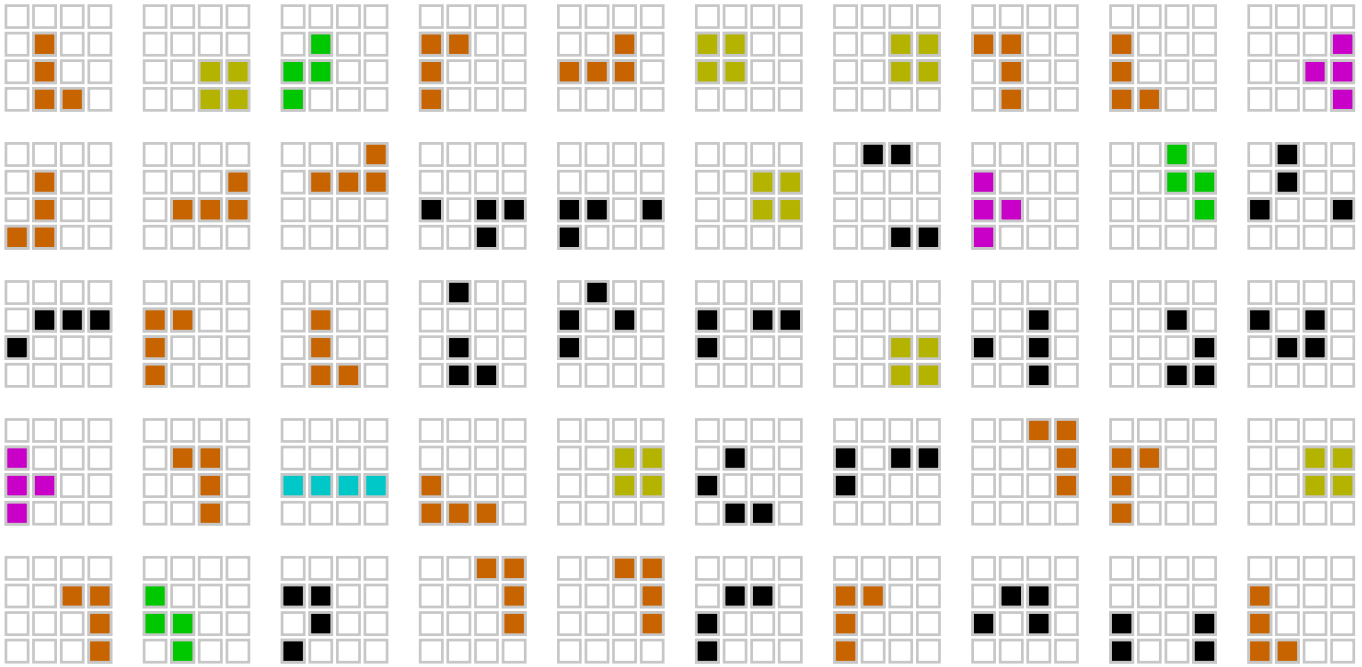
Generation 1



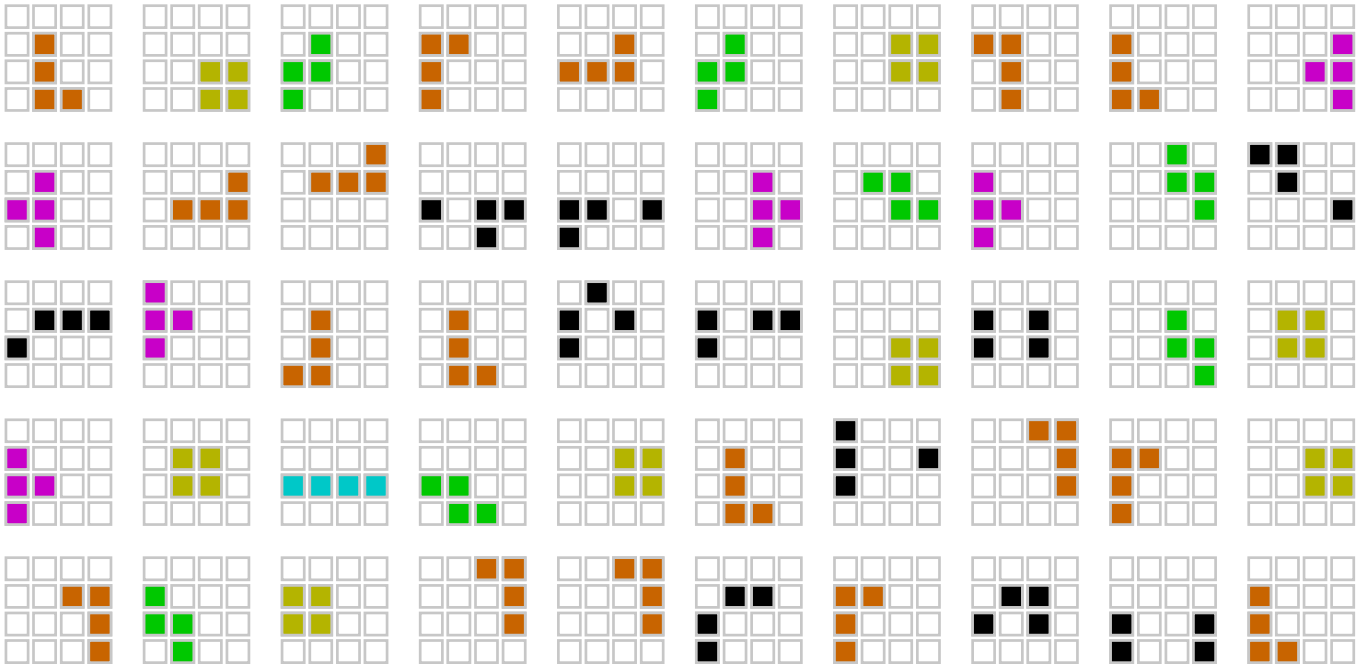
Generation 2



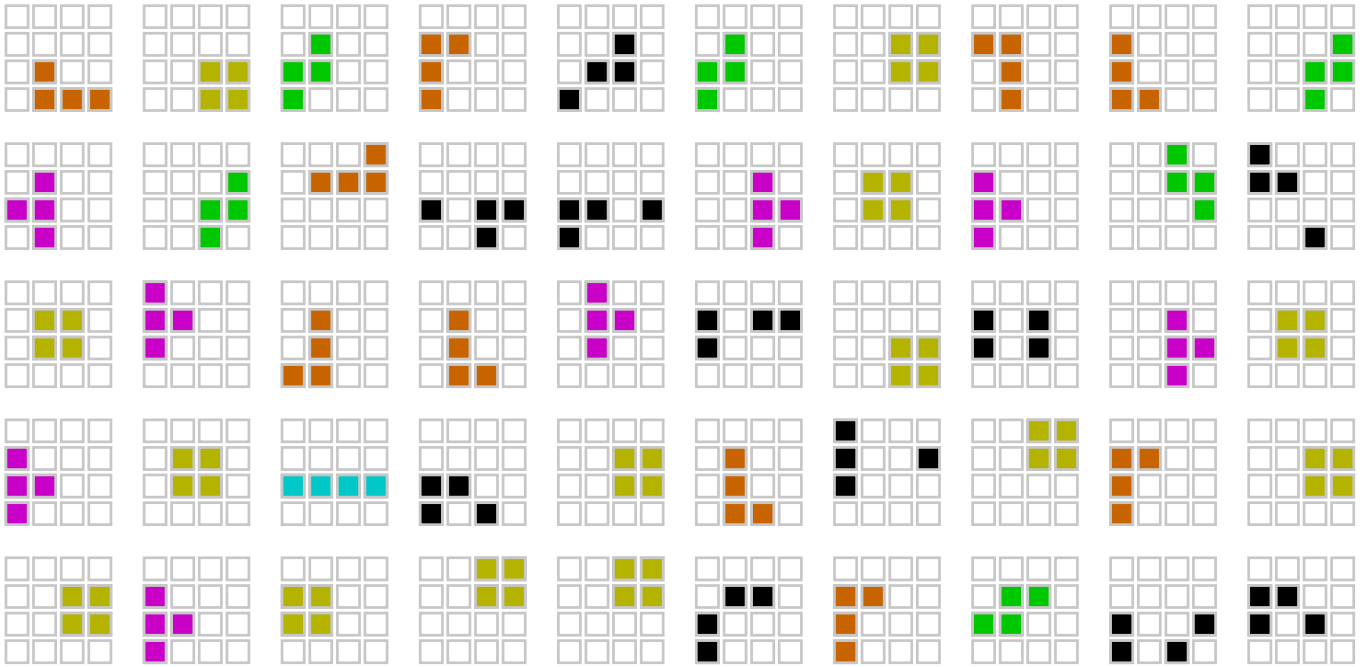
Generation 3



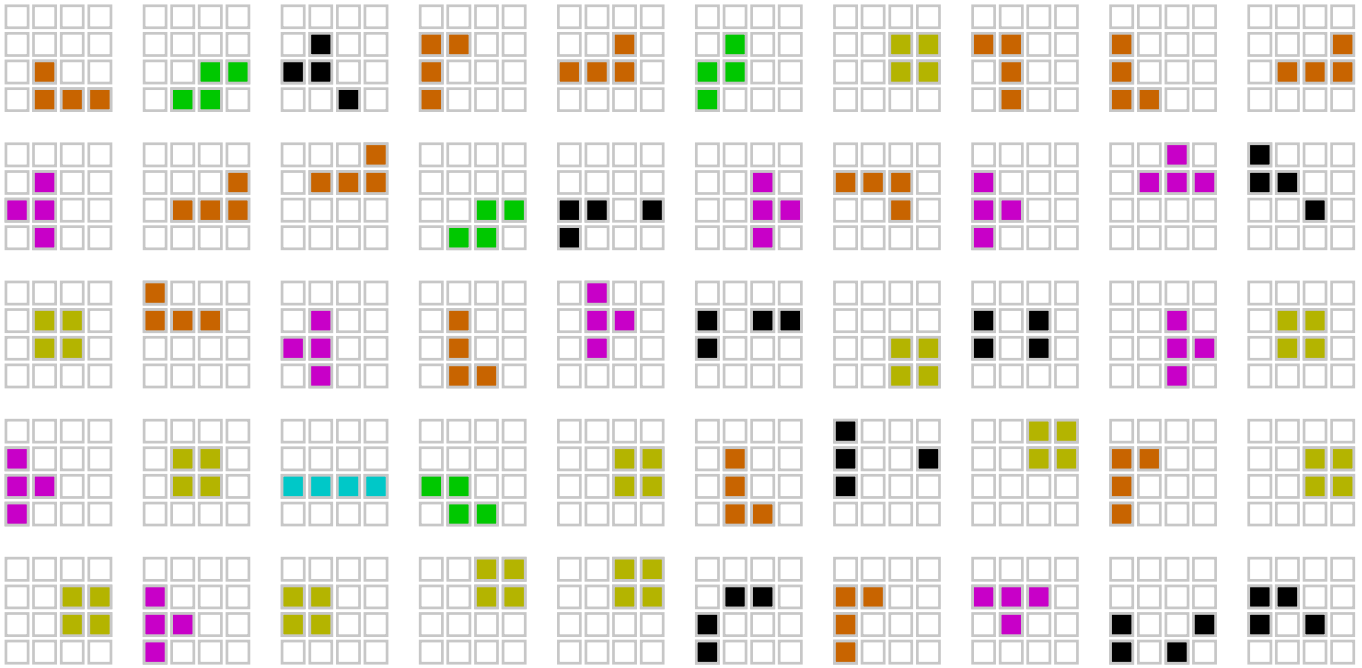
Generation 4



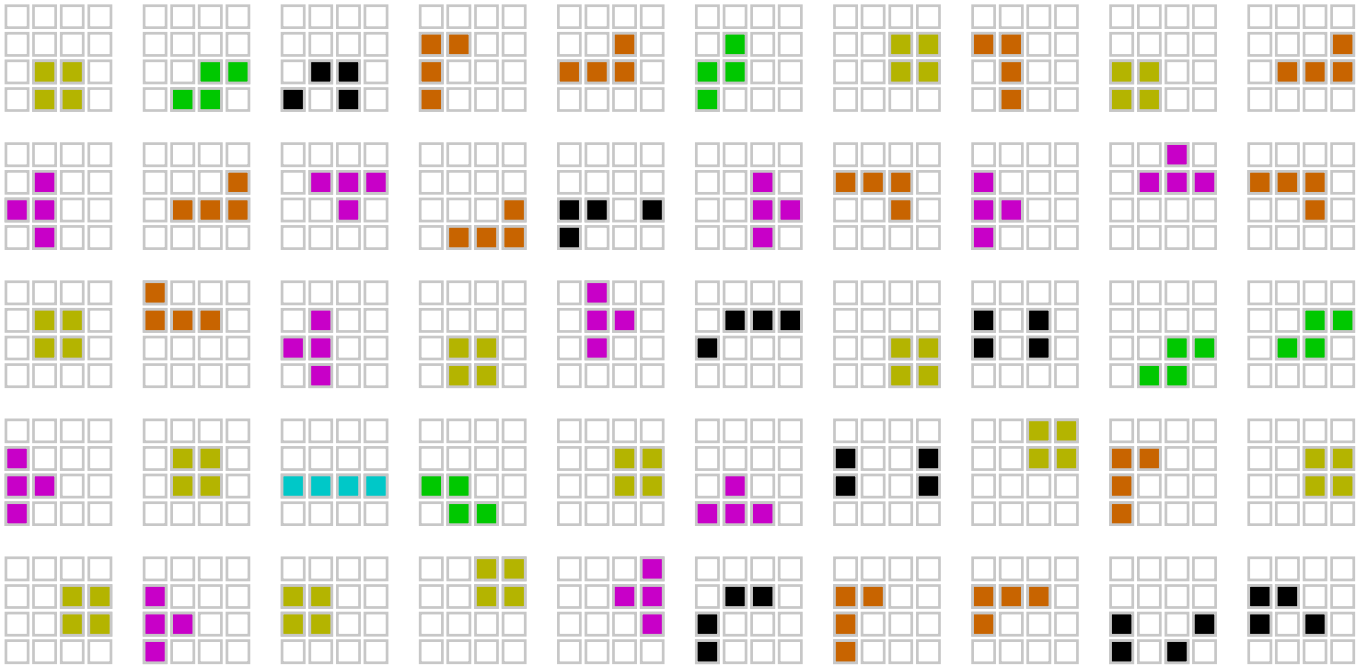
Generation 5



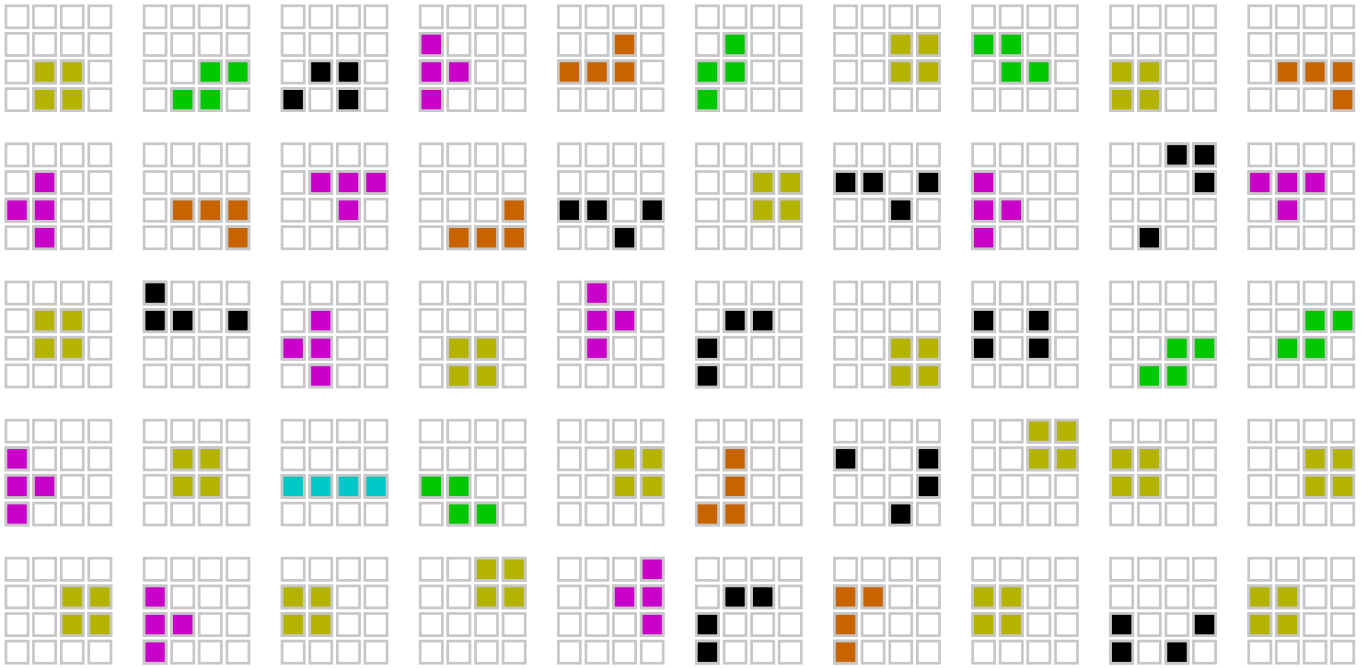
Generation 6



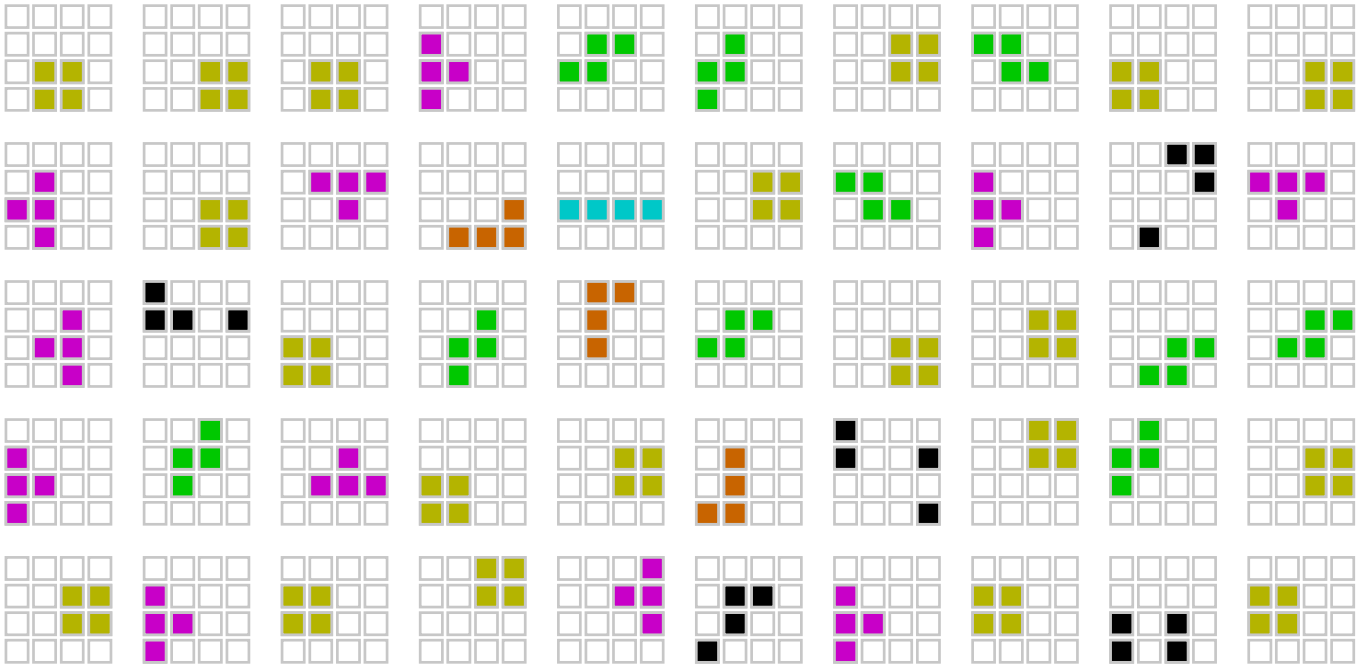
Generation 7



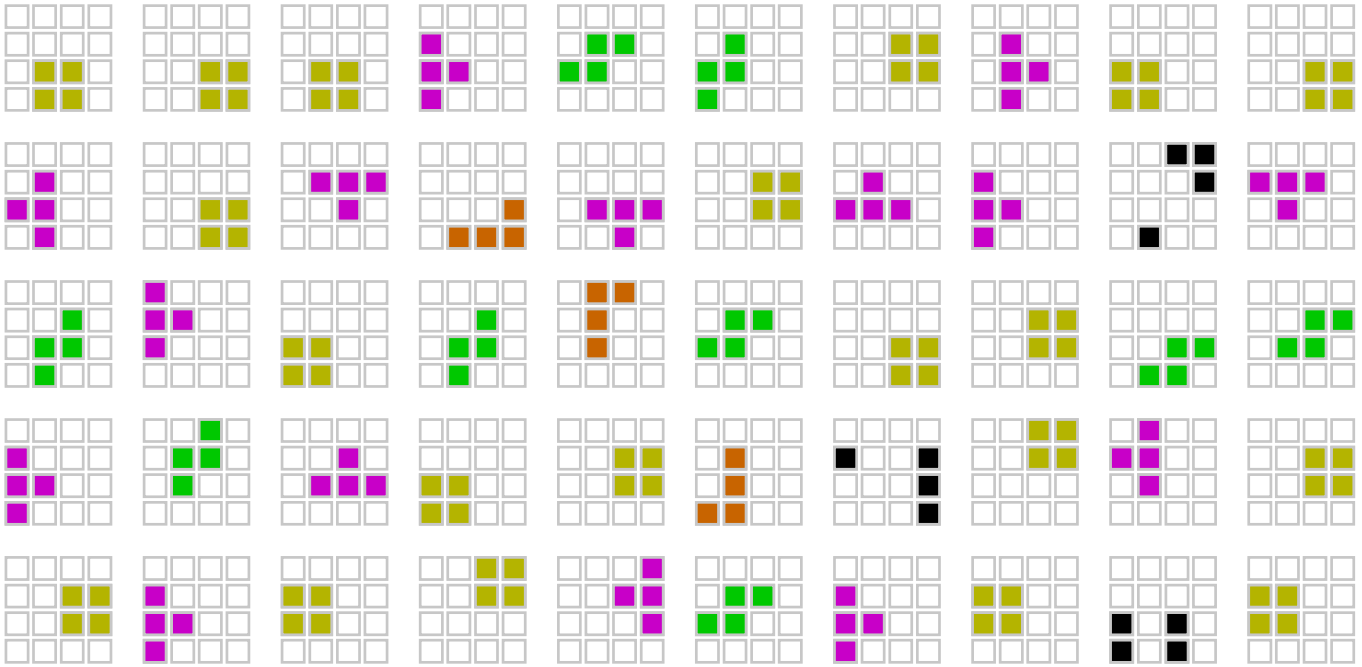
Generation 8



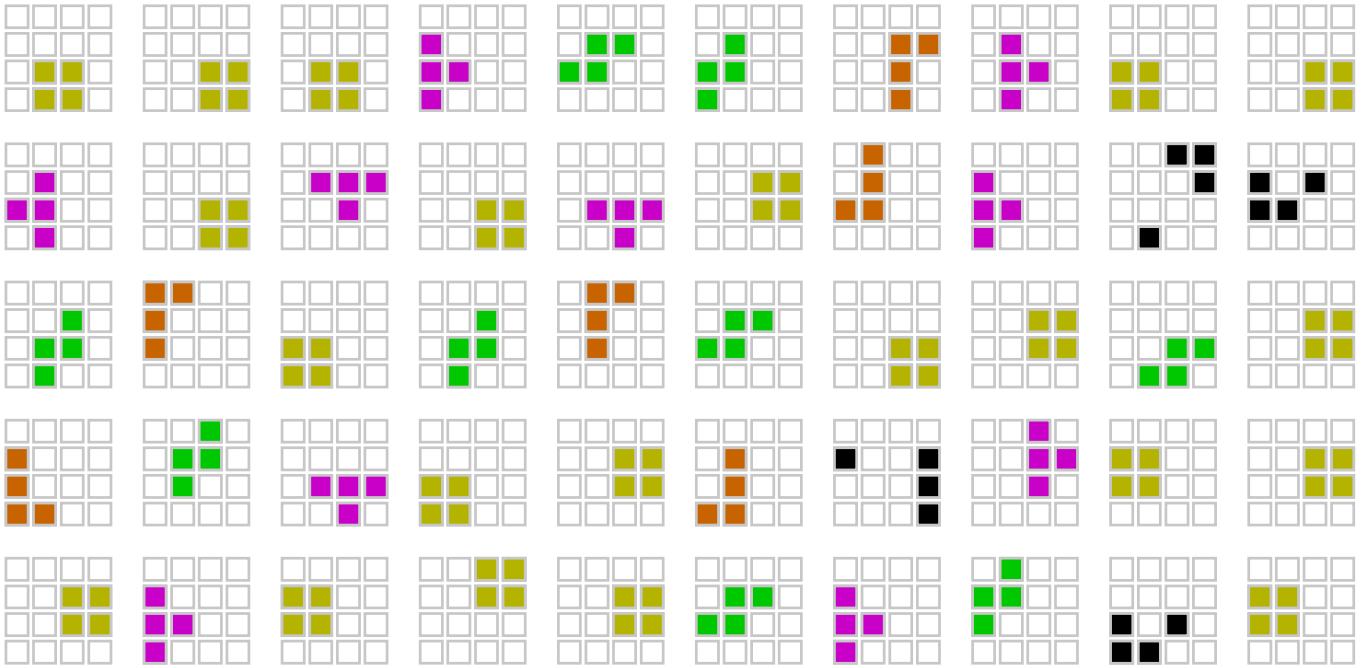
Generation 9



Generation 10

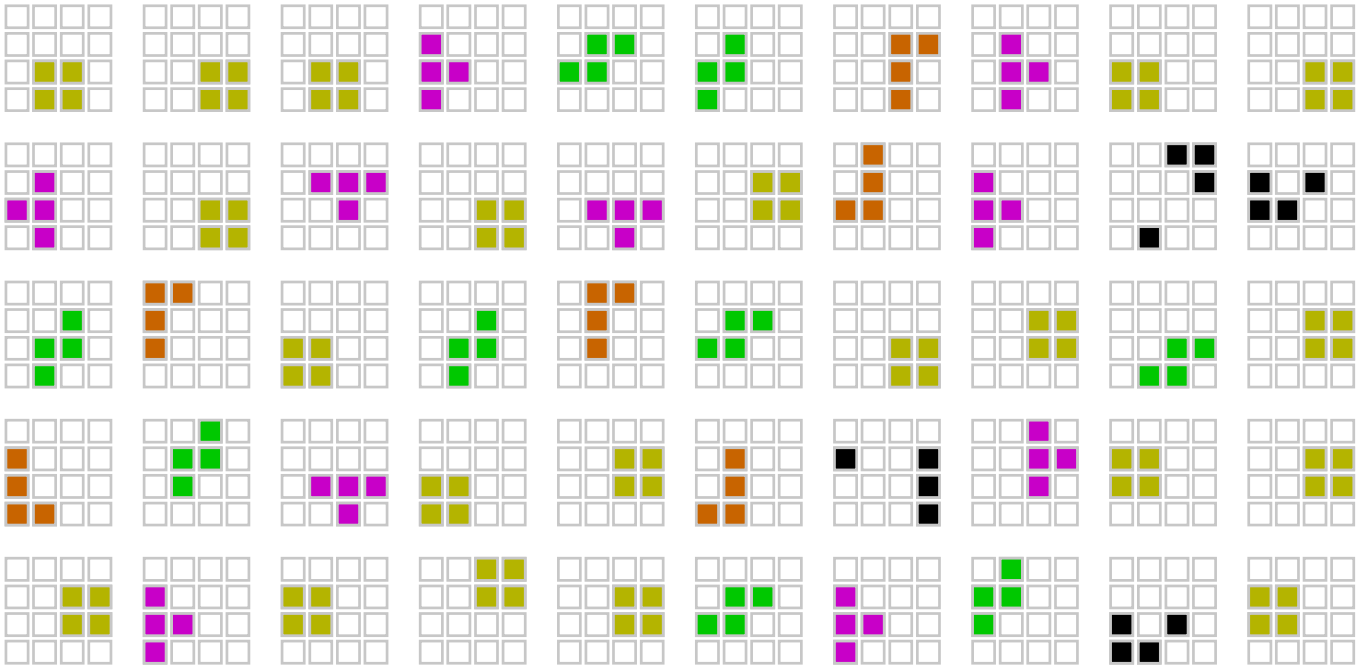


Generation 11



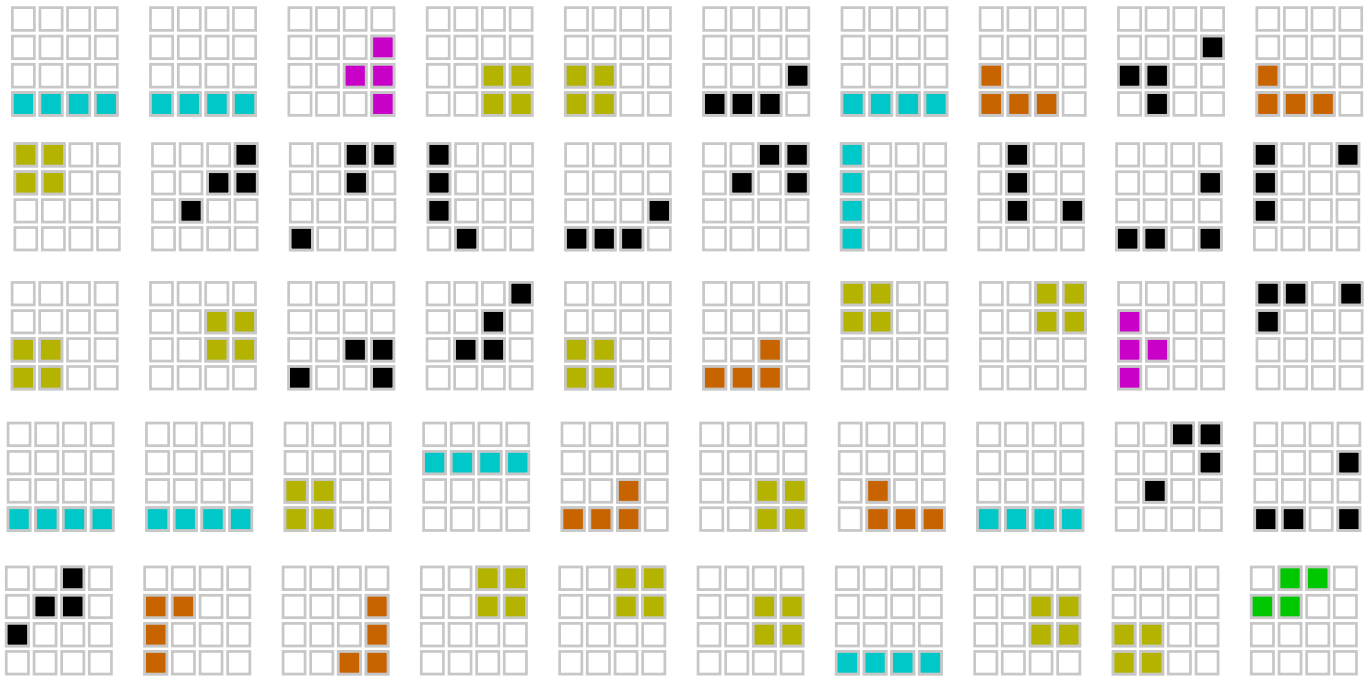
Generation 12

Emergence of a **system**



Chain 4, Generation 12

Emergence of a **system**



Chain 1, Generation 12

Systematic structure develops even in baboons (if you scaffold their environment in the right way)

Cultural evolution of language: a summary

A uniformitarian approach

- We should attempt to explain the (hidden) past in terms of processes we can see operating in the present
- How far can we get in appealing only to the same processes we see shaping language in the present?

Language change

- (analogy-based) learning and (ostensive-inferential) use are important mechanisms

Language evolution

- Same processes can explain origins of symbols, compositionality, and duality of patterning
- At least in populations capable of the right kind of learning and use

Next up

- Tutorial
  - Do natural languages in different communities (transmitted under different constraints, with different communitive needs) show different adaptations to those different niches?
- Next and final lecture
  - Sign language as a window into language origins