Origins and Evolution of Language
Week 8: The cultural evolution of language

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Plan for today

- Finish off social cognition
- 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

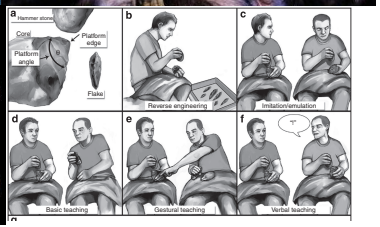
Finishing off social cognition

WILD HD
Other apes sometimes just don’t seem to understand how communication works

So why are we so good at it?

What selective pressures drove the evolution of mind reading and Mitteilungsbedürfnis (mind sharing) in humans?

- We occupy a uniquely social niche?
- We occupy a uniquely technological niche?
- …



Cultural evolution of language

The human package

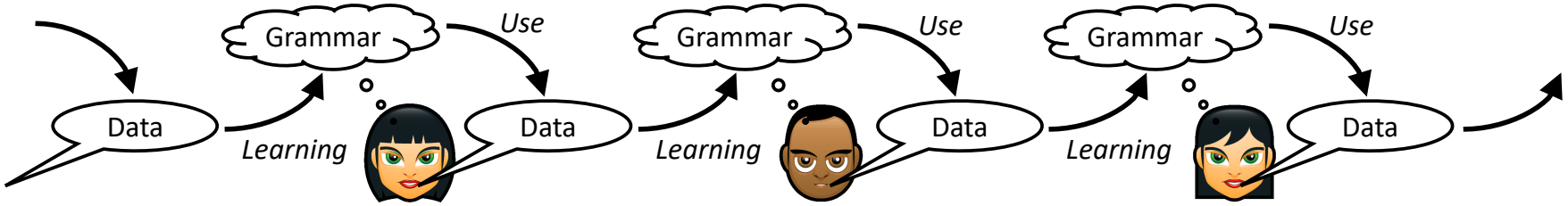
Somehow, we ended up with

- 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**

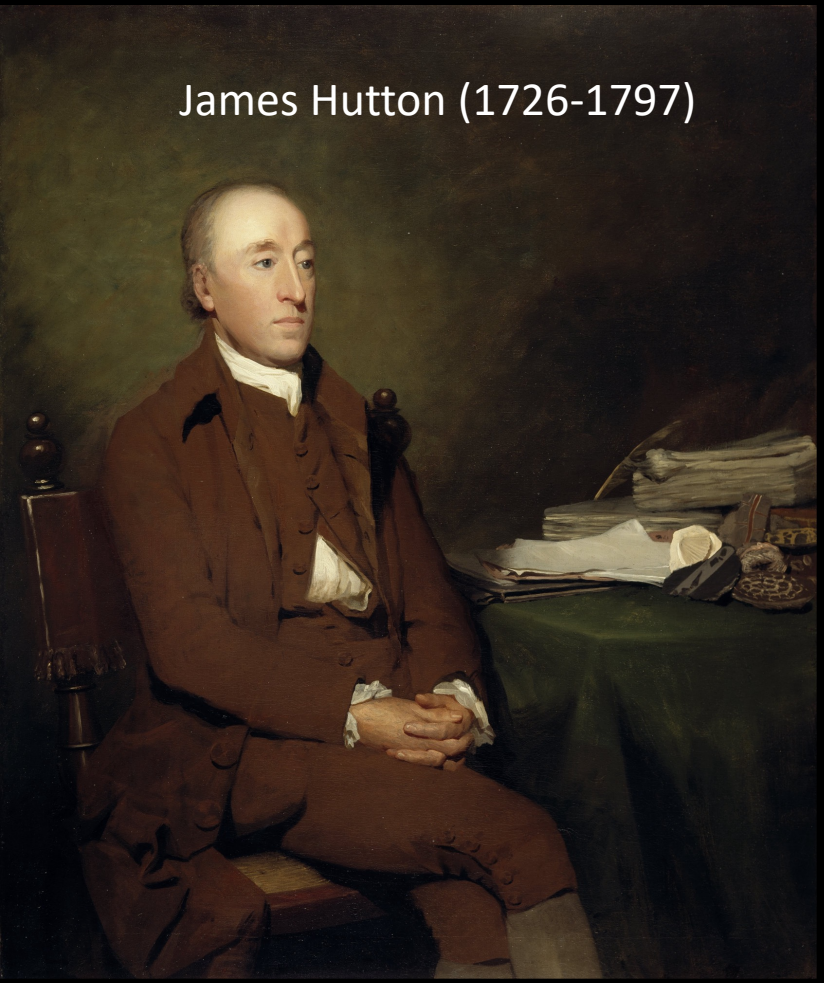
- Once that's in place, exciting stuff happens

The cultural evolution of language



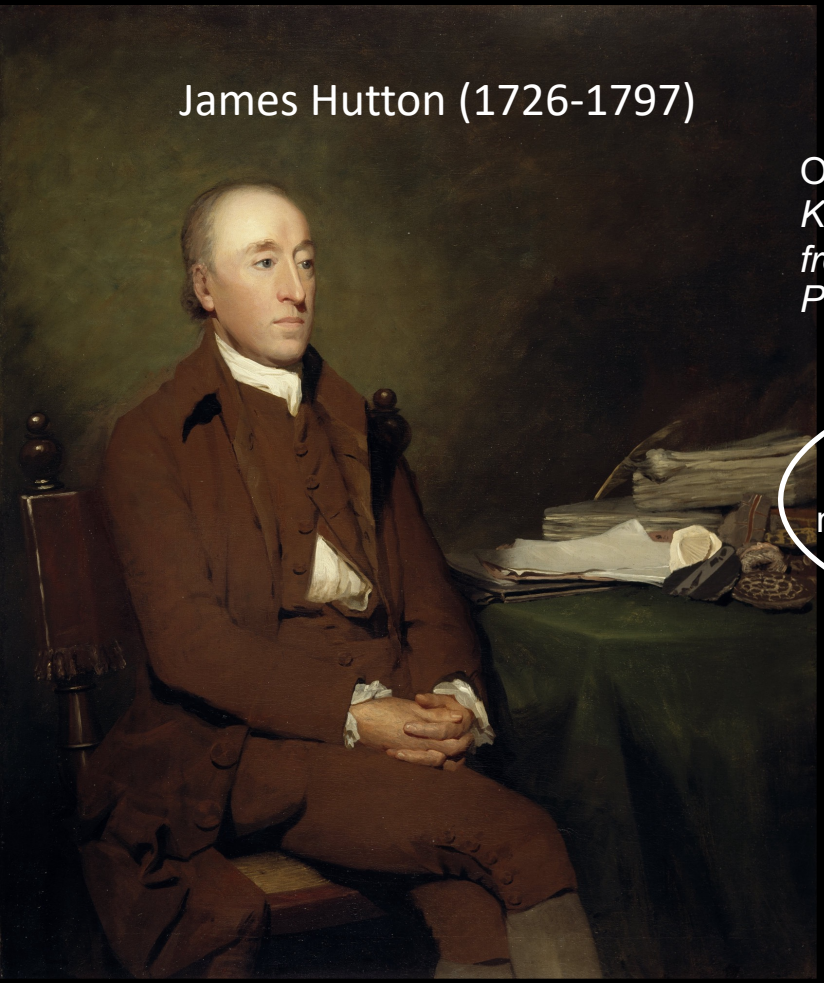
- Language is passed from person to person by **learning**
- People learn from language as it is **used in communication**
- Language **evolves** in response to its learning and use

Uniformitarianism (in geology)



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

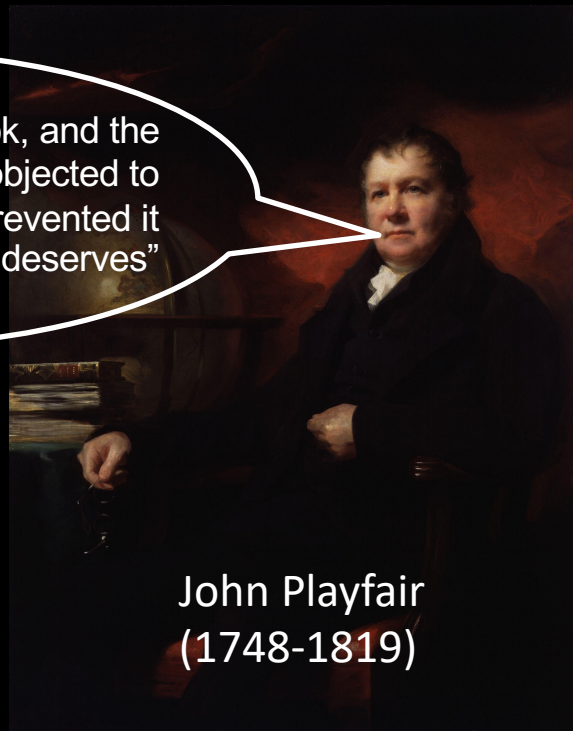
"from what has actually been, we have data for concluding with regard to that which is to happen thereafter."



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

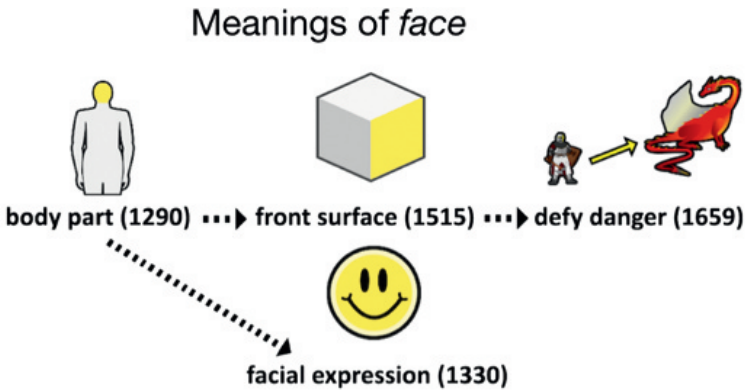
Language change (as attested in the historical record / inferable from synchronic data) is a consequence of:

- 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)
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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

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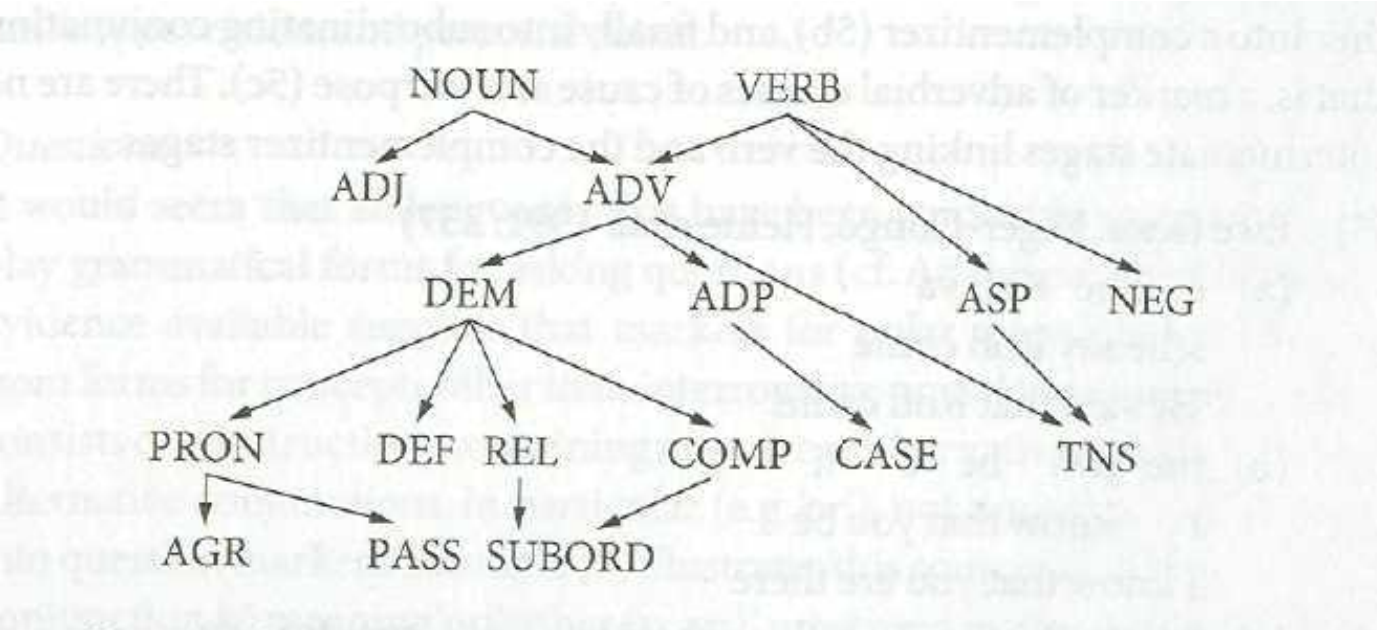

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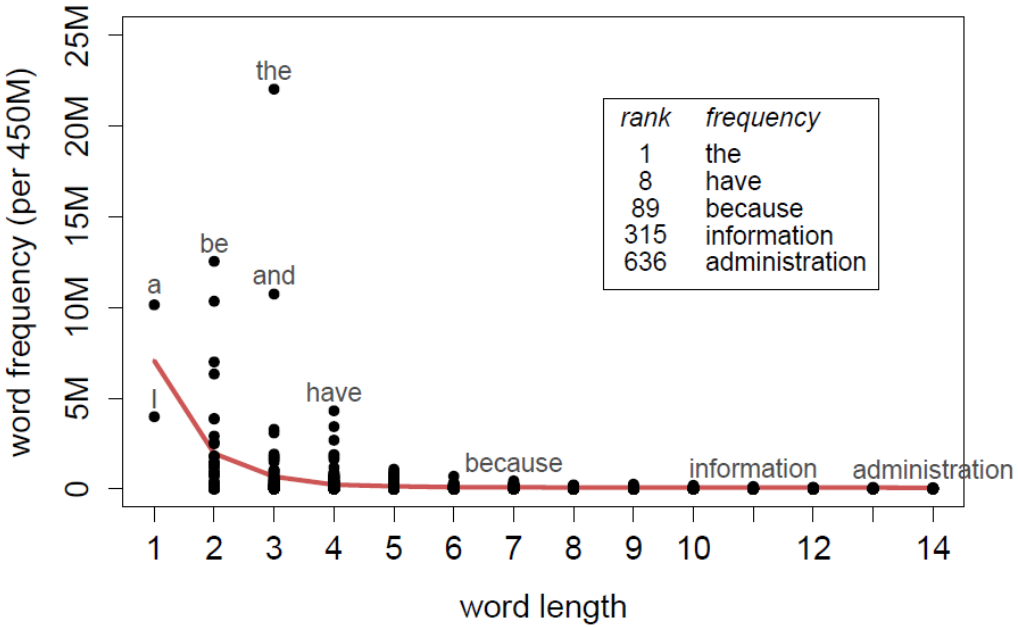
Analogical extension & "system pressure"

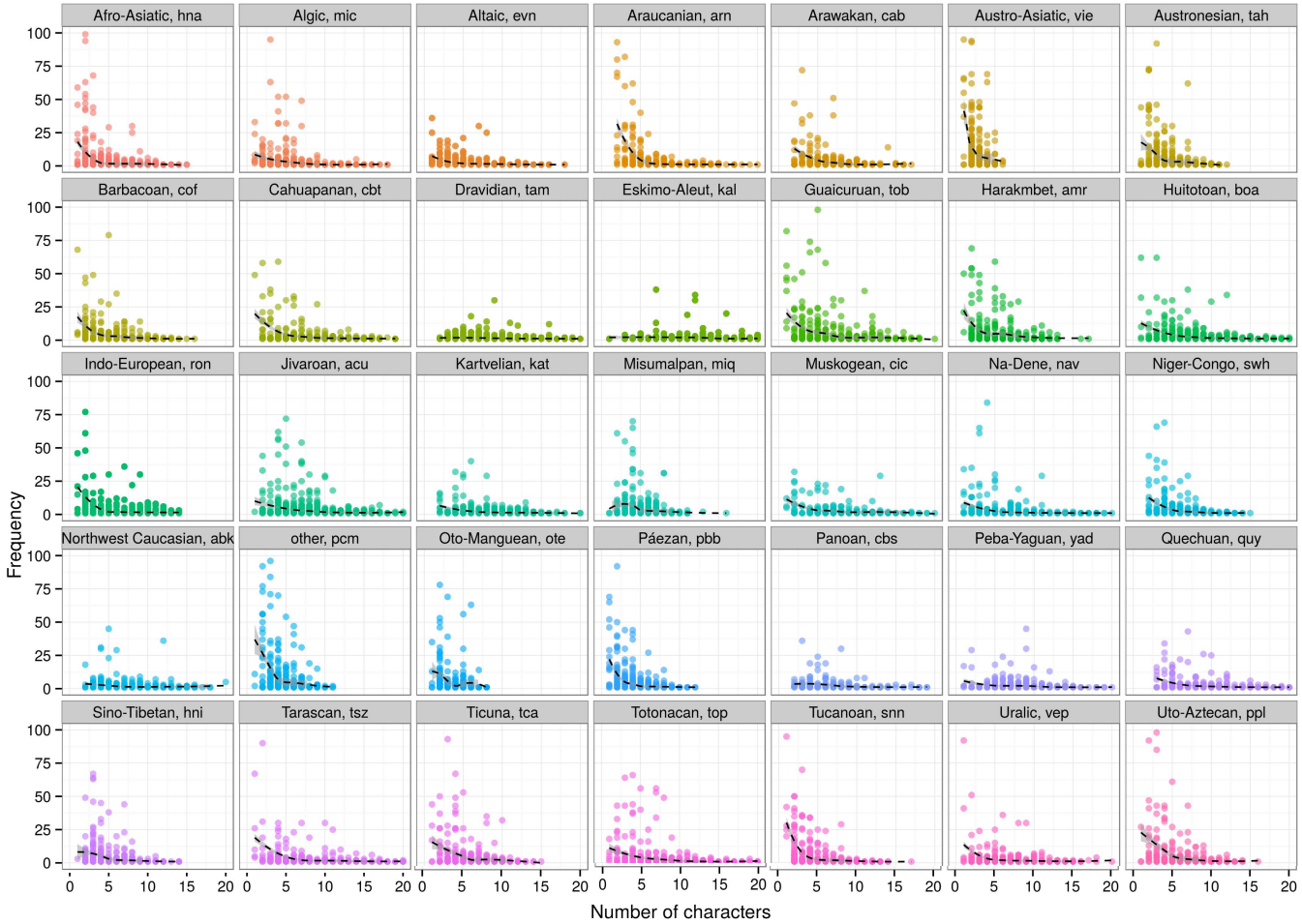
Cover of issue featuring Lieberman, E., Michel, J. B., Jackson, J., Tang, T., & Nowak, M. A. (2007). Quantifying the evolutionary dynamics of language. *Nature, 449,* 713-716.

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

Language change

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Example: the evolution of signals

Krebs, J., & Dawkins, R. (1984). Animal signals: mind-reading and manipulation. In Krebs, J., & Davies, N. (Eds.) *Behavioural Ecology: an evolutionary approach*, 2nd edition (pp. 380-402). Sinauer.

Ritualization: conflicting interest

fight for something of value

Territorial animal	Intruder
Prepare to attack	Predict attack, evade
Obvious preparation of attack reduces need to actually attack	Over-sensitivity to fake signals means I am too easy to scare off
Make preparatory actions more obvious/convincing	Only respond to genuine preparatory actions

→ Escalation of signal, resistance to being **manipulated**

Ritualization: common interest

both want to avoid conflict

Territorial animal	Intruder
Prepare to attack	
	Predict attack, evade
Conflict averted! Obvious preparation of attack reduces need to actually attack	
	Conflict averted! Sensitivity to preparation for attack reduces likelihood of being attacked
Make *preparatory* actions only	
	Be alert for signals of preparation

→ Subtle signals, '**mind-reading'**

Phylogenetic ritualization

- All of this can take place over evolutionary time
  - Individuals who make slightly more obvious movements in preparation for attack get in fewer fights and have more offspring
  - Individuals who are sensitive to such preparations (but not too sensitive) get in fewer fights and have more offspring
- **Evolution by natural selection** does the prediction and tweaks the innate signalling behaviour

Ontogenetic ritualization

Ritualization can also happen within the interaction history of two sufficiently smart organisms

- e.g. ‘nursing poke’ between infant and mother chimp: Infant drags arm away from breast; mother comes to anticipate desire to feed when arm touched; touch of arm comes to signal desire to feed

Halina, M., Rossano, F., & Tomasello, M. (2013). The ontogenetic ritualization of bonobo gestures. *Animal Cognition, 16,* 653-666.

Do ritualized signals spread in chimp populations?

Tomasello et al., 1985-1994, longitudinal study of gestural communication at Yerkes Regional Primate Centre Field Station

- Majority of gestures are:
  - used only by one individual
  - one-way gestures
- Little overlap between mother and offspring repertoires
- No more overlap within groups than between groups

Ritualized signals are a consequence of an idiosyncratic history of pairwise repeated interaction

Will an artificially-introduced symbol spread?

- Train a dominant female on a new begging gesture
  - Arm raise + head touch on fence
  - Multiple hours of reinforcement training
- Release trained female into population
- Observe
  - Does she produce the trained signal?
  - Do other chimps copy it?

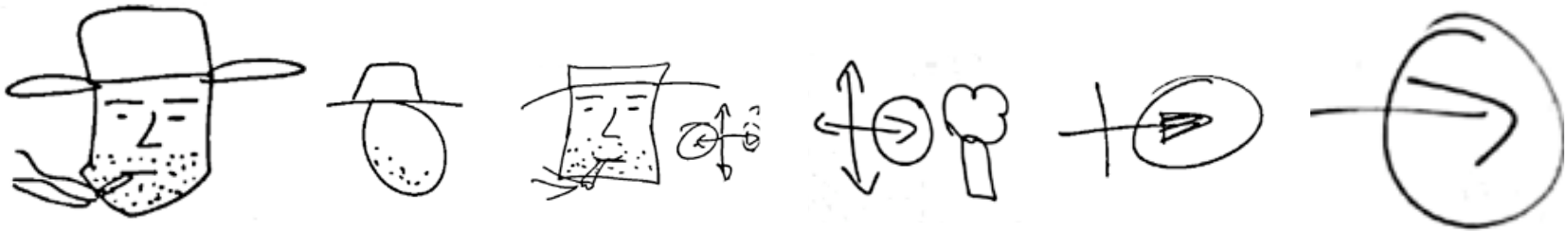
Tomasello, M., Call, J., Warren, J. A., Frost, G. T., Carpenter, M., & Nagell, K. M. (1997). The ontogeny of chimpanzee gestural signals: A comparison across groups and generations. *Evolution of Communication, 1,* 223-259.

Will an artificially-introduced symbol spread?

- Lots of opportunities for other chimps to observe
  - Multiple observations of focal female performing novel gesture
  - Multiple observers per gesture
- No imitation
  - Novel gesture never produced by anyone other than the focal female
  - Including focal female's offspring

Tomasello, M., Call, J., Warren, J. A., Frost, G. T., Carpenter, M., & Nagell, K. M. (1997). The ontogeny of chimpanzee gestural signals: A comparison across groups and generations. *Evolution of Communication, 1,* 223-259.

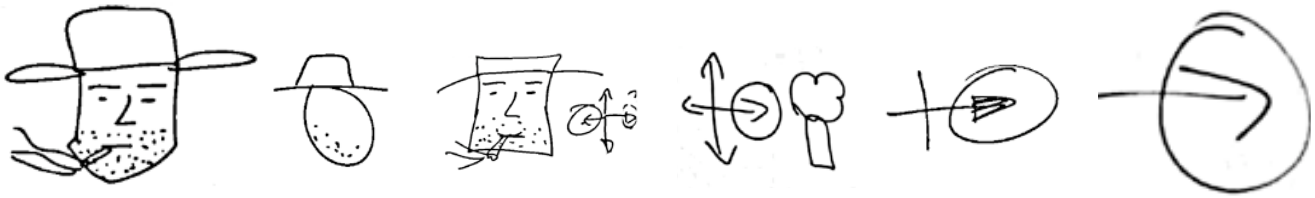
Ritualization in the lab in humans



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

Ontogenetic ritualization and the origin of symbols

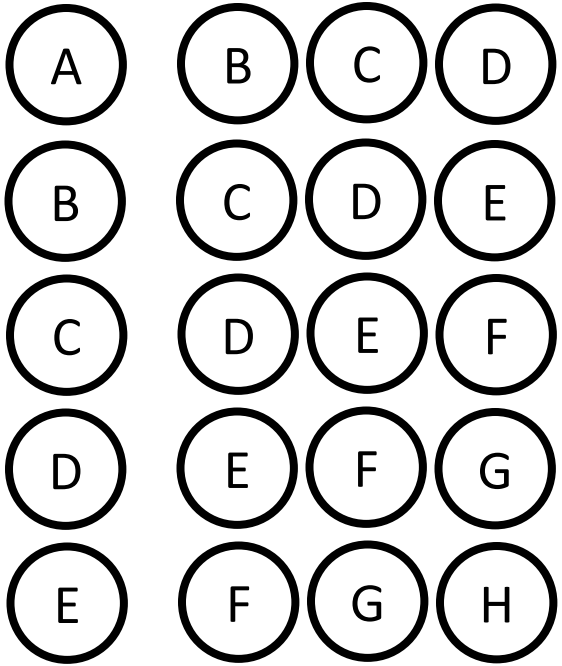
Ontogenetic ritualization: *Non-obvious* relationship between the signal and its 'meaning' (intended outcome)



Symbol: *arbitrary* relationship between signal and meaning

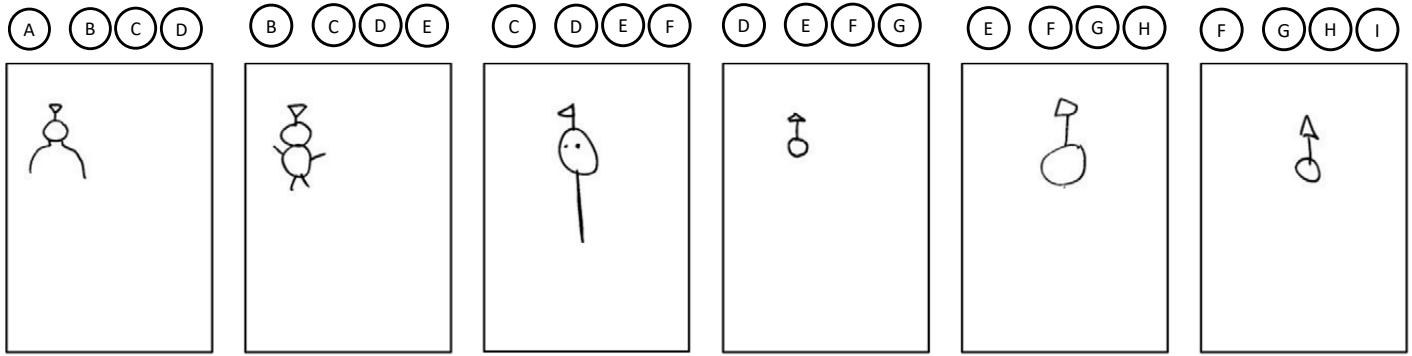
- If you were involved in establishing the ritual, you know the link, so these aren't really symbols.
- But a naïve observer wouldn't…

Transmission and symbol formation



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

Transmission in laboratory ‘societies’



(potentially) truly arbitrary signals

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

Ritualization and symbols: a summary

Ritualization in animal communication

- Phylogenetic
- Ontogenetic

Great apes have what it takes to ritualize, but not to learn and **transmit** arbitrary symbols

- Why?

Experimental studies in humans:

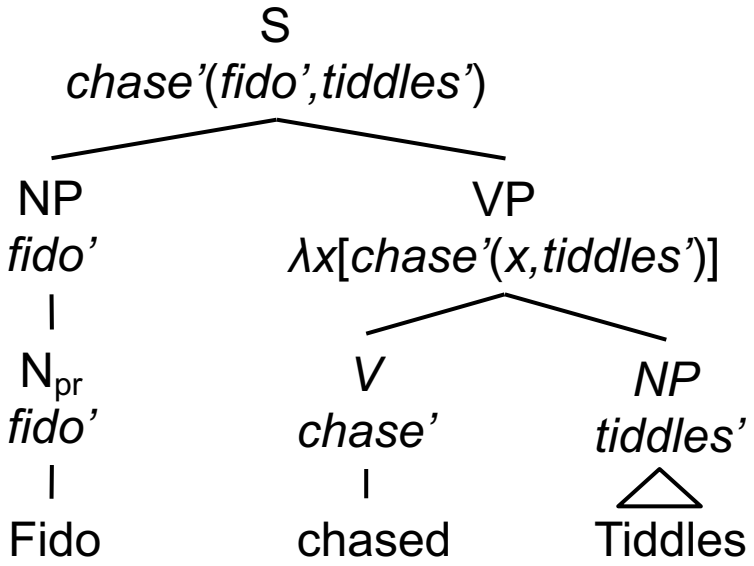
- Interaction in dyads: Ritualization of iconic signals
- **Cultural transmission: Arbitrary symbols**

Example: the evolution of structure

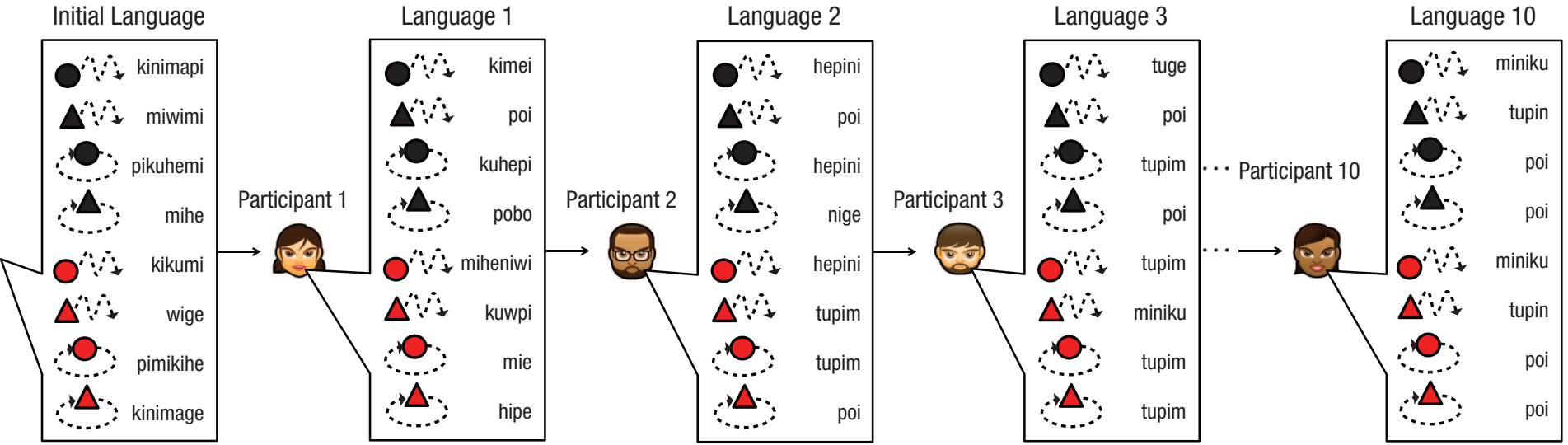
Reminder: Language's communicative power comes from its **structure**

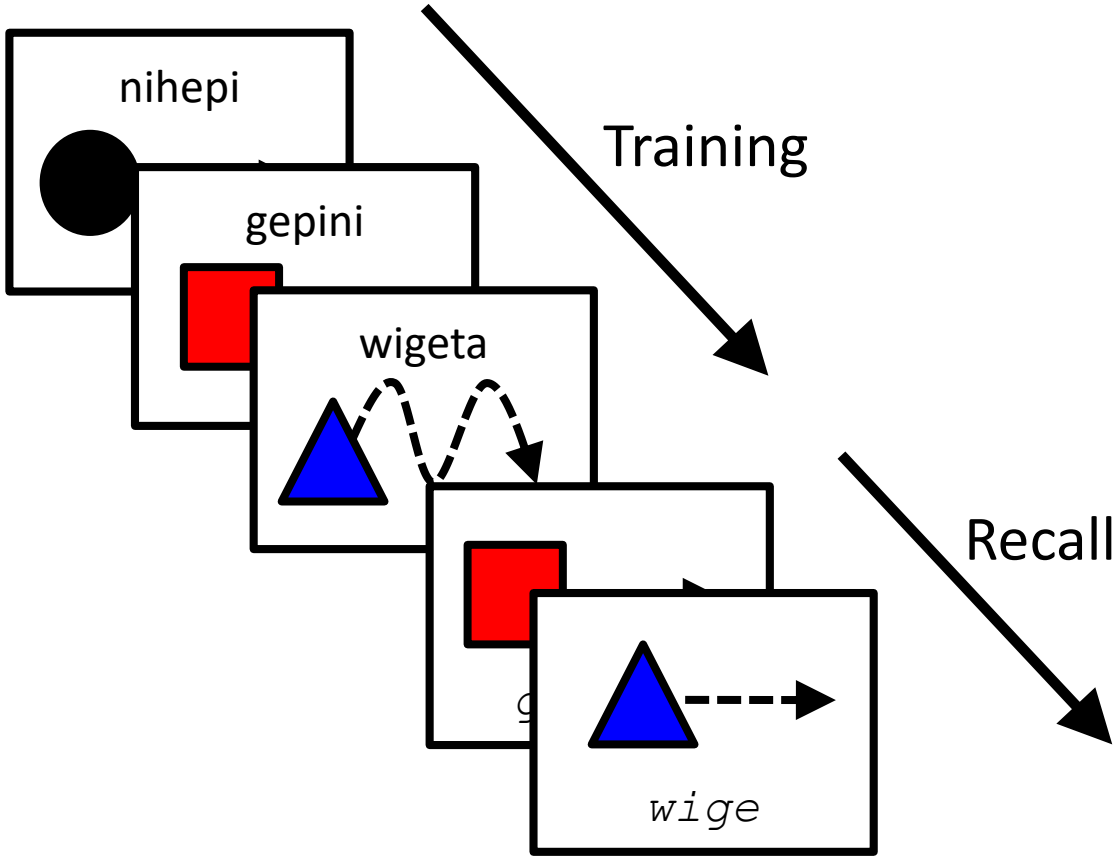
Compositionality: the meaning of an expression is a function of the meaning of its parts and the way in which they are combined

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 $\lambda x\,[\lambda y\,[(chase'(x,y)]]$



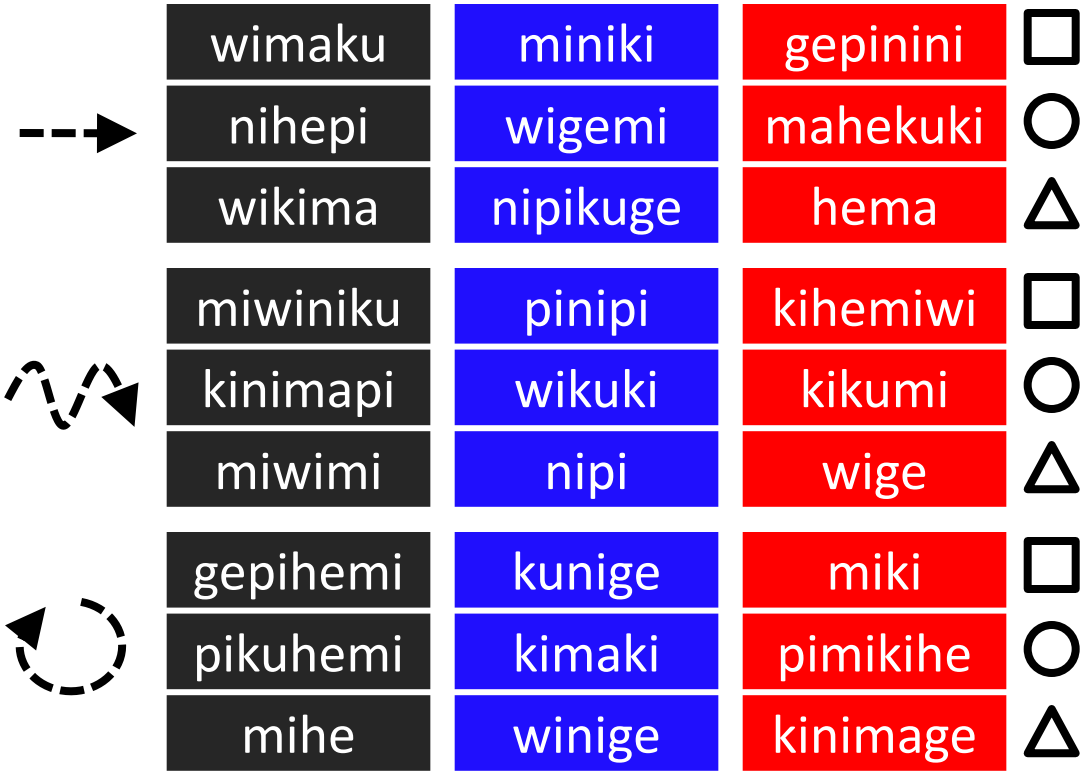
Iterated Learning





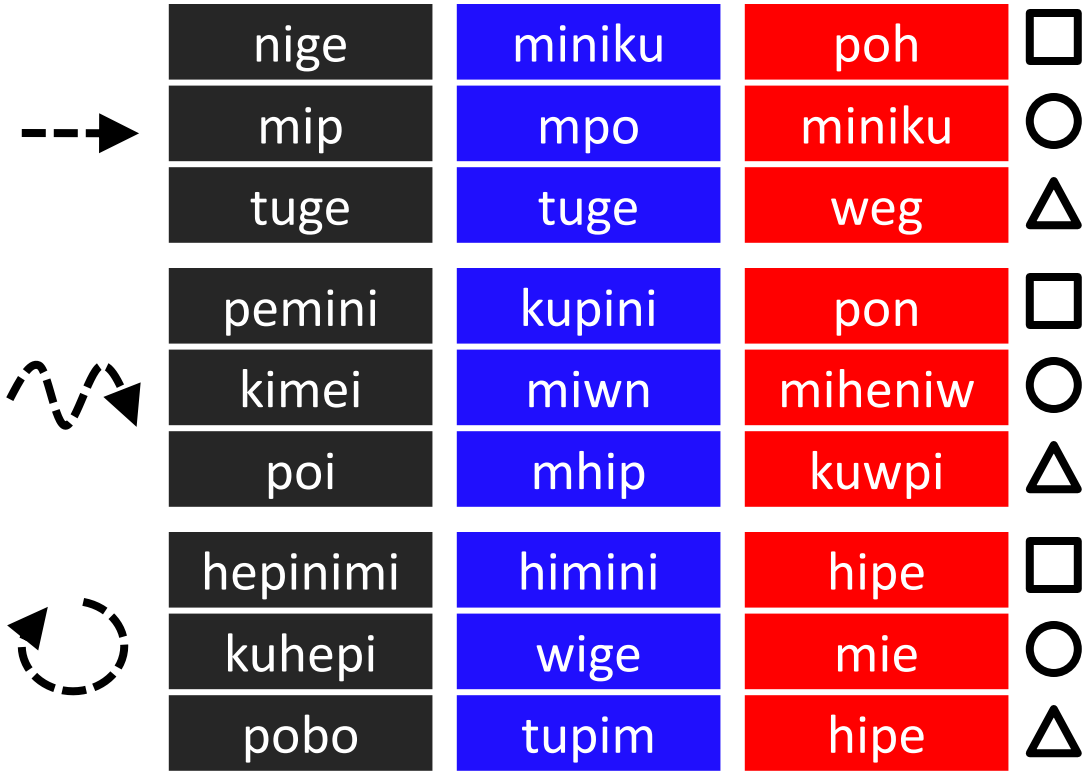
Kirby, S., Cornish, H., & Smith, K. (2008). Cumulative cultural evolution in the laboratory: An experimental approach to the origins of structure in human language. *PNAS, 105,* 10681-10686.

An initial **holistic** language from chain 4

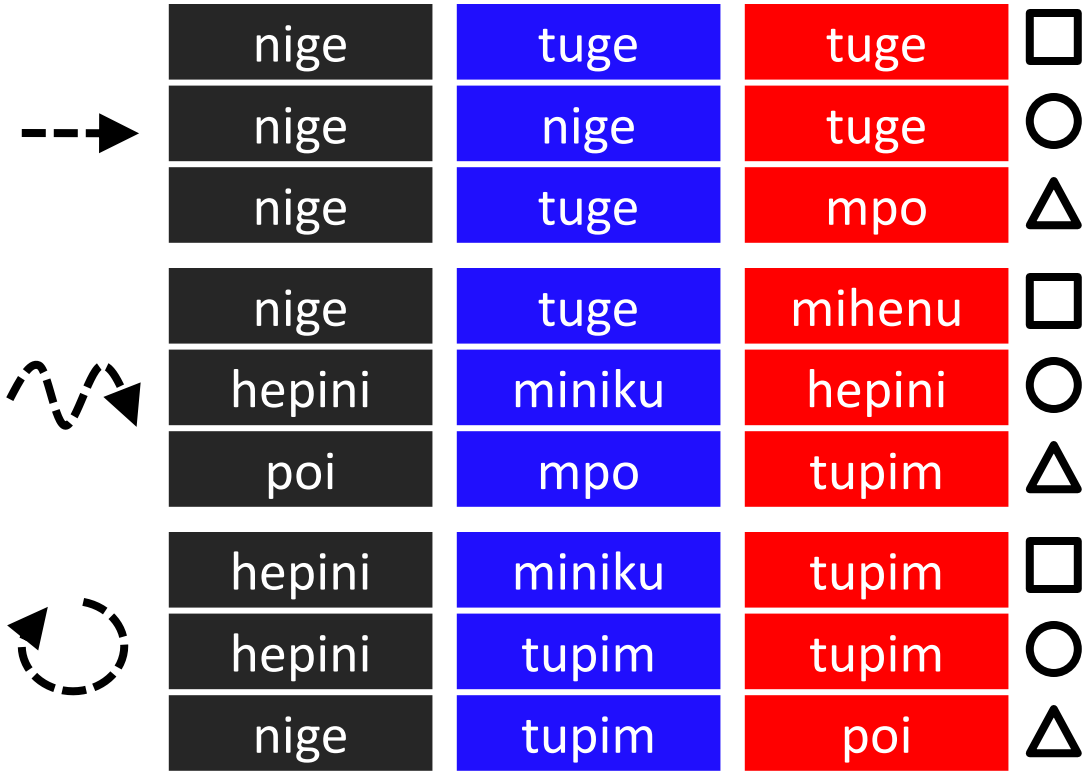


Seen vs unseen

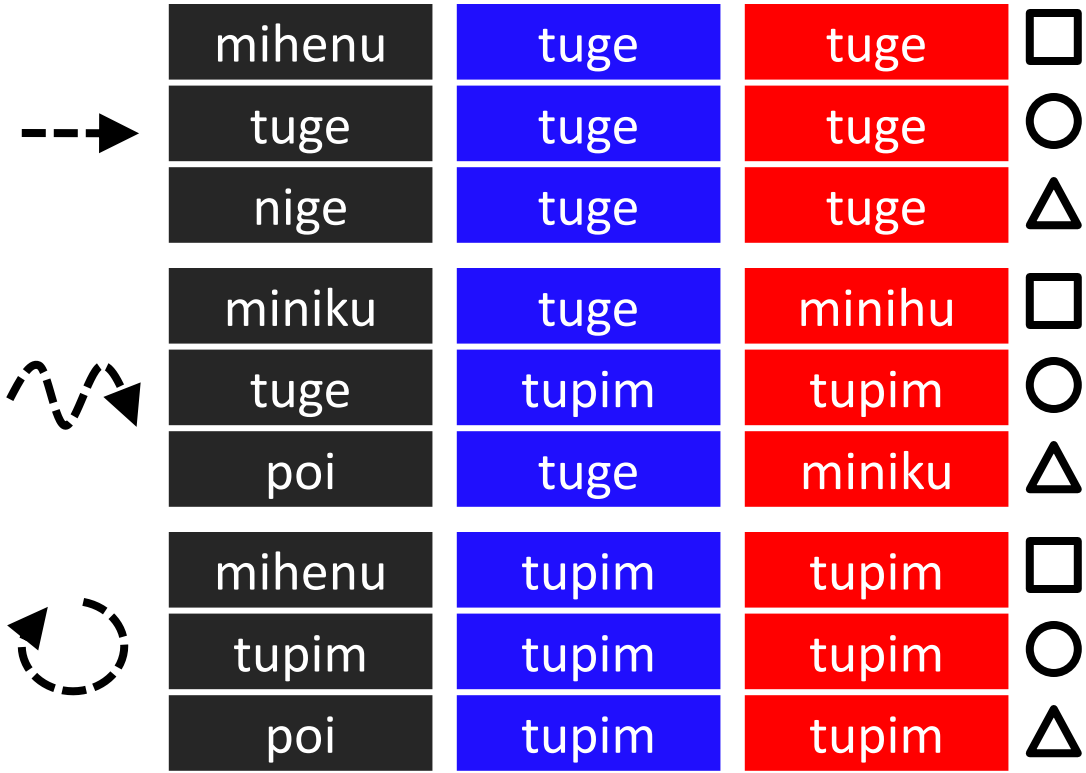
Generation 1 language from chain 4



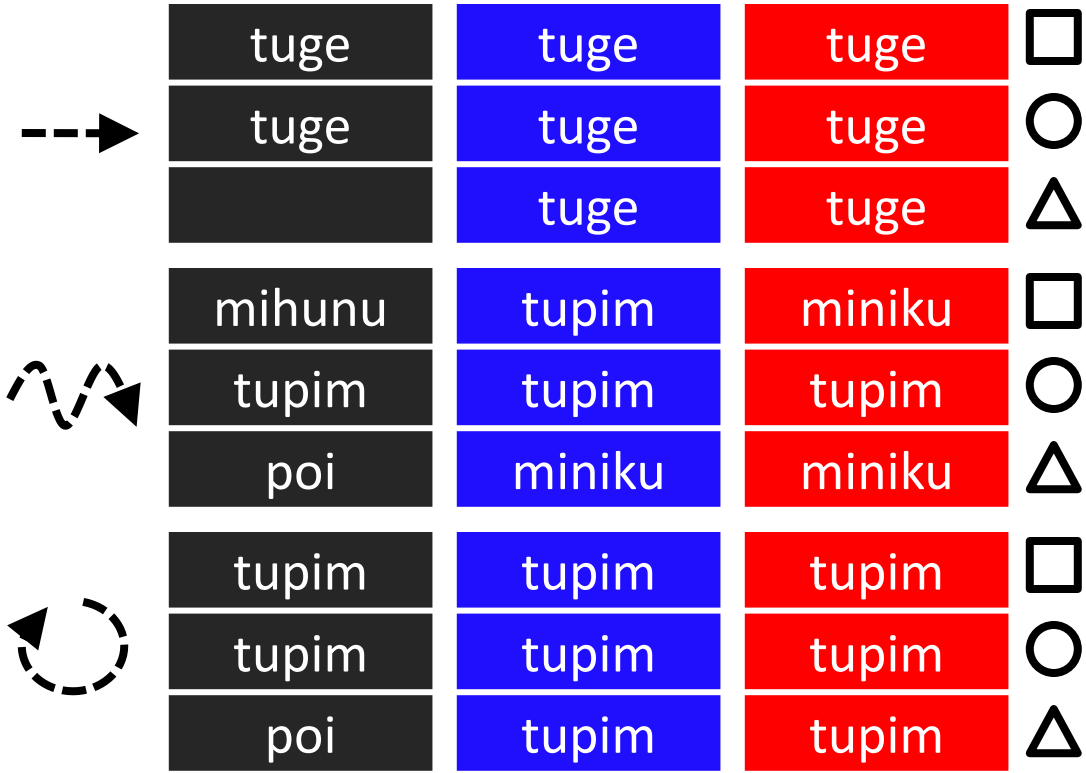
Generation 2 language from chain 4



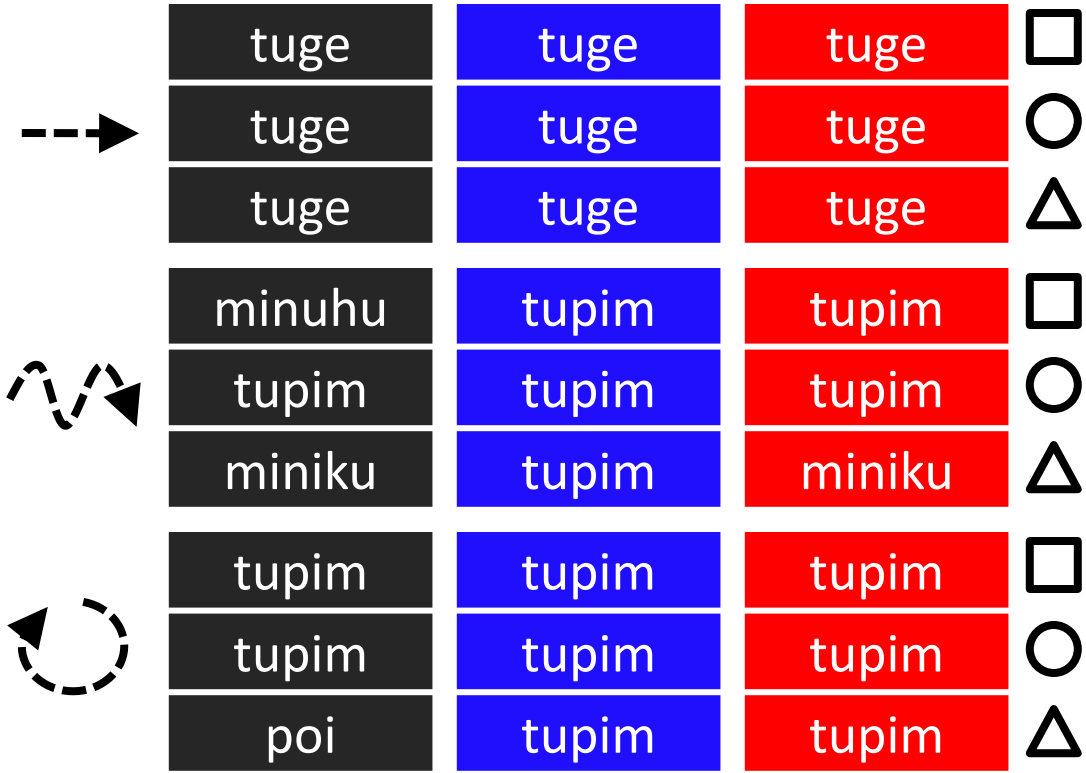
Generation 3 language from chain 4



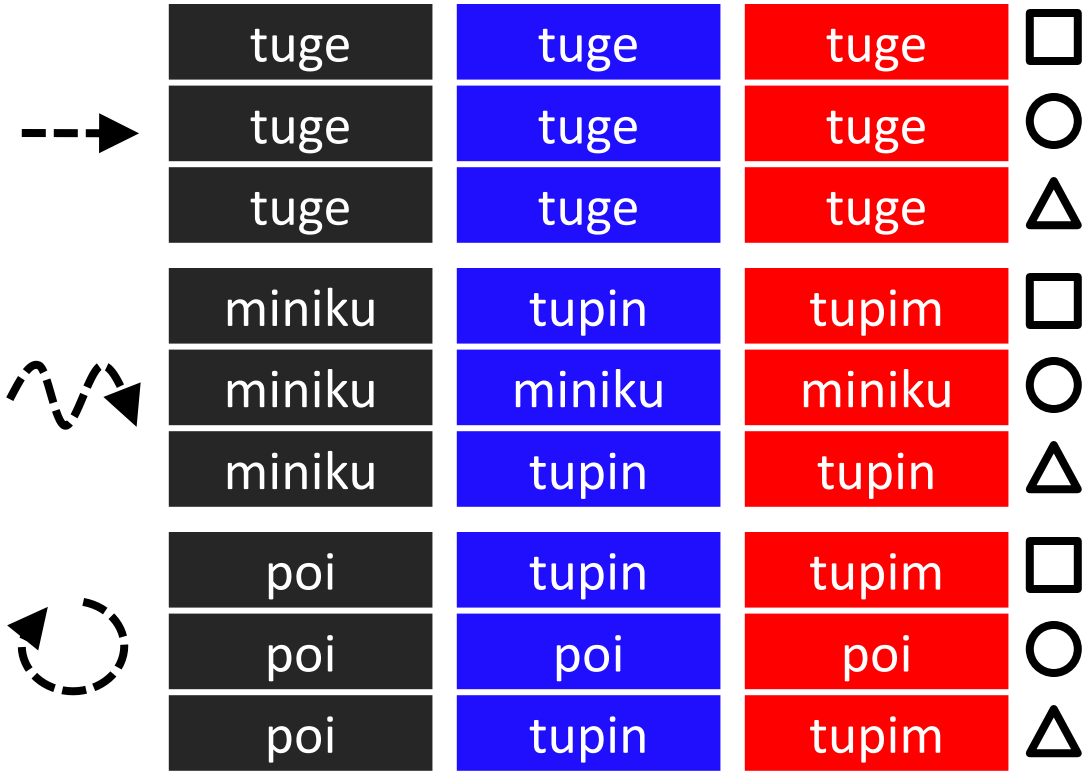
Generation 4 language from chain 4



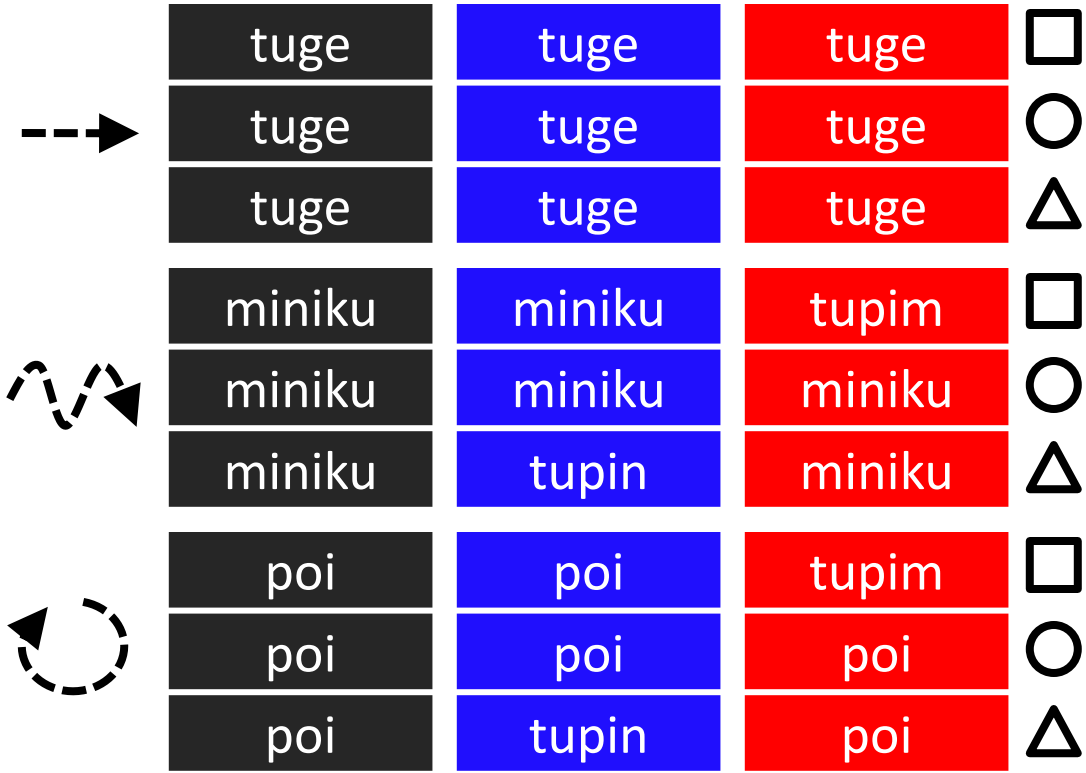
Generation 5 language from chain 4



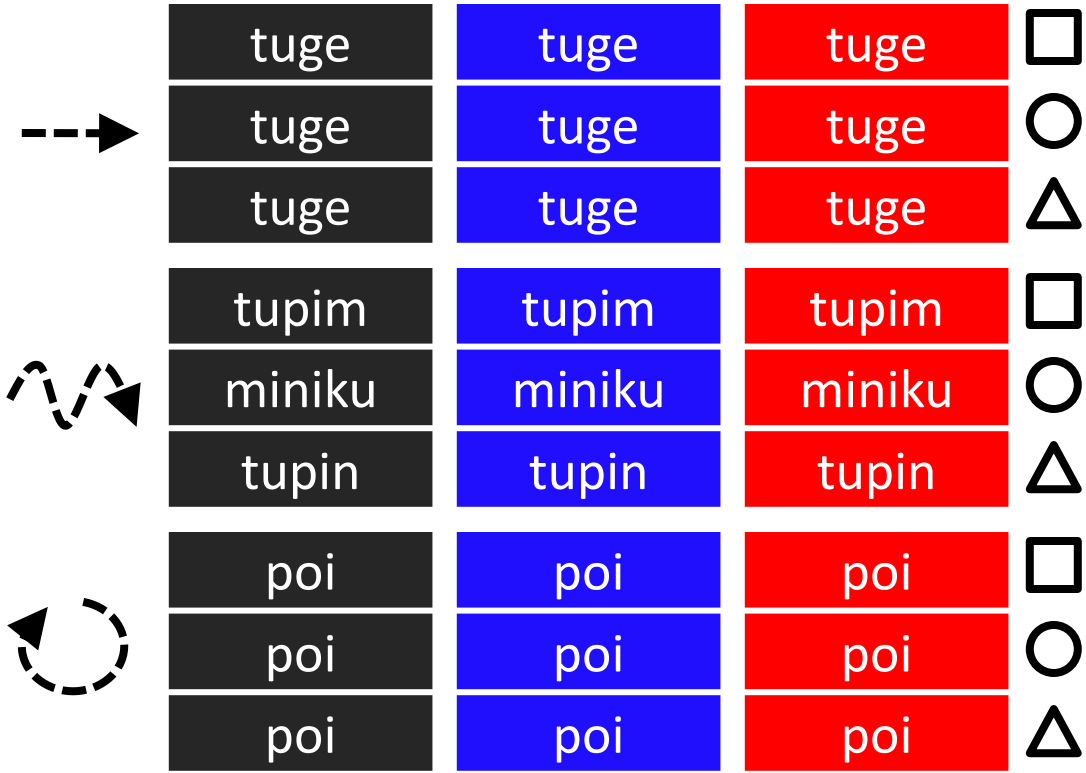
Generation 6 language from chain 4



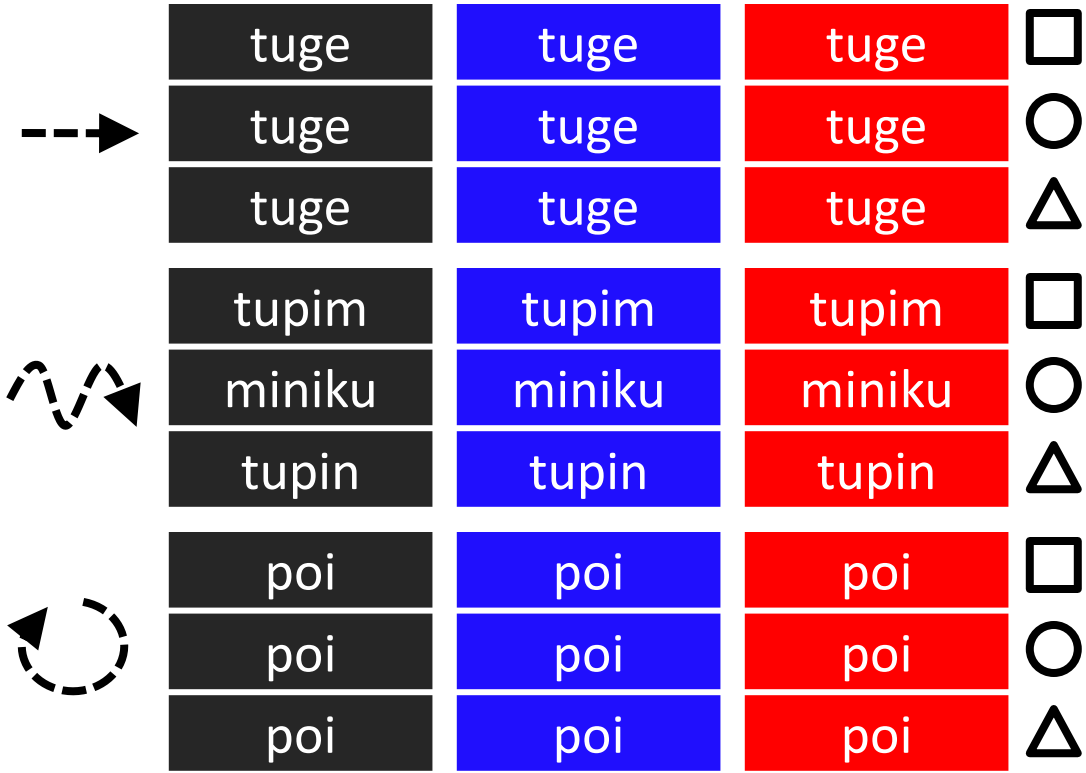
Generation 7 language from chain 4



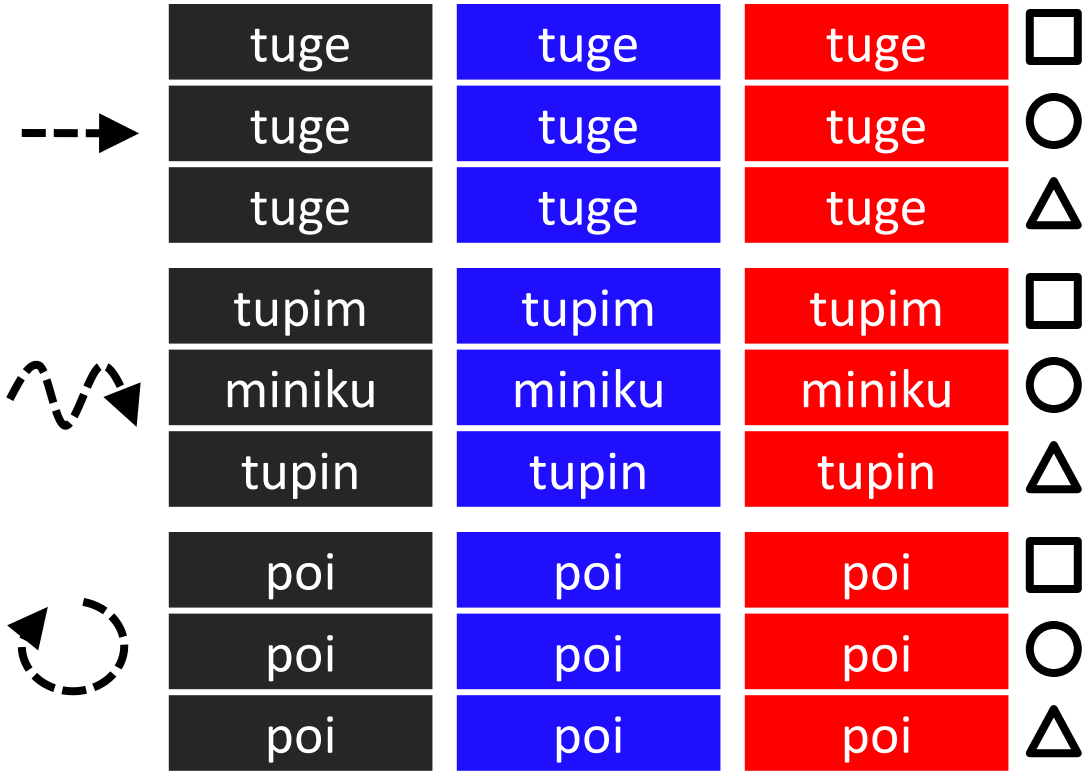
Generation 8 language from chain 4



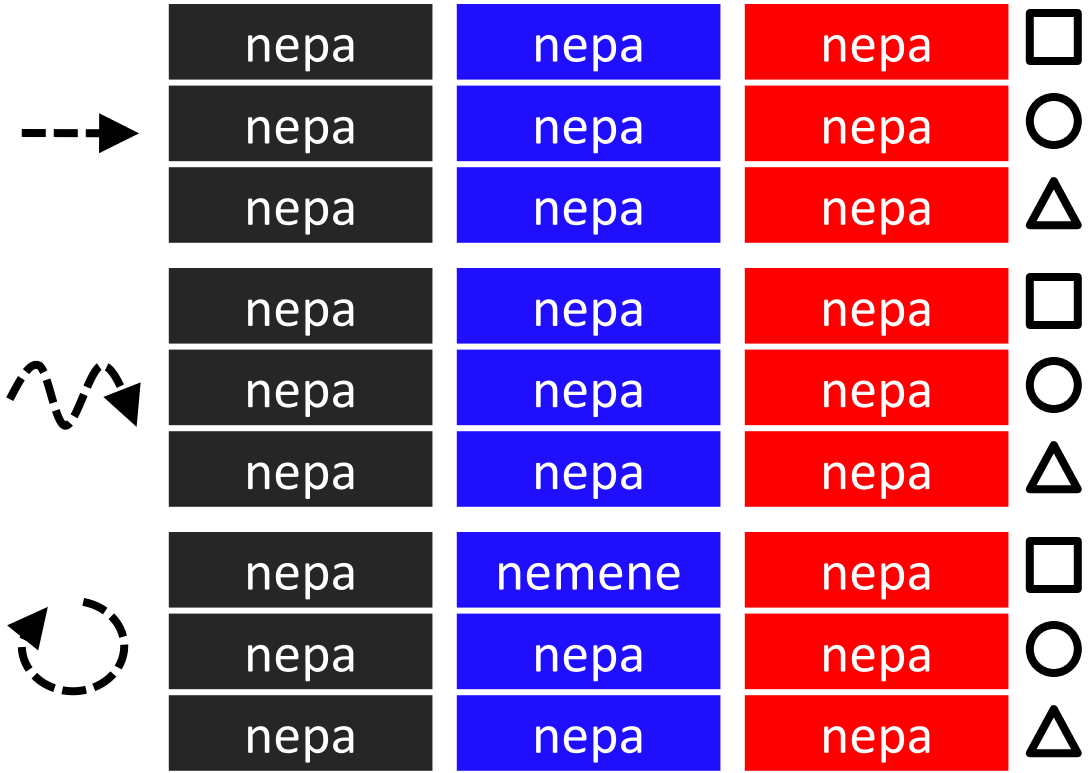
Generation 9 language from chain 4



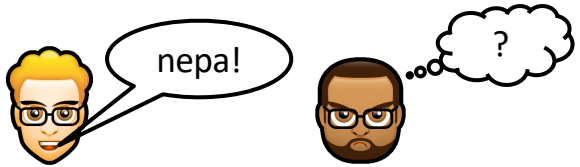
Generation 10 language from chain 4



Final language from chain 1 (!)



The languages become **degenerate**



Learnability and degeneracy

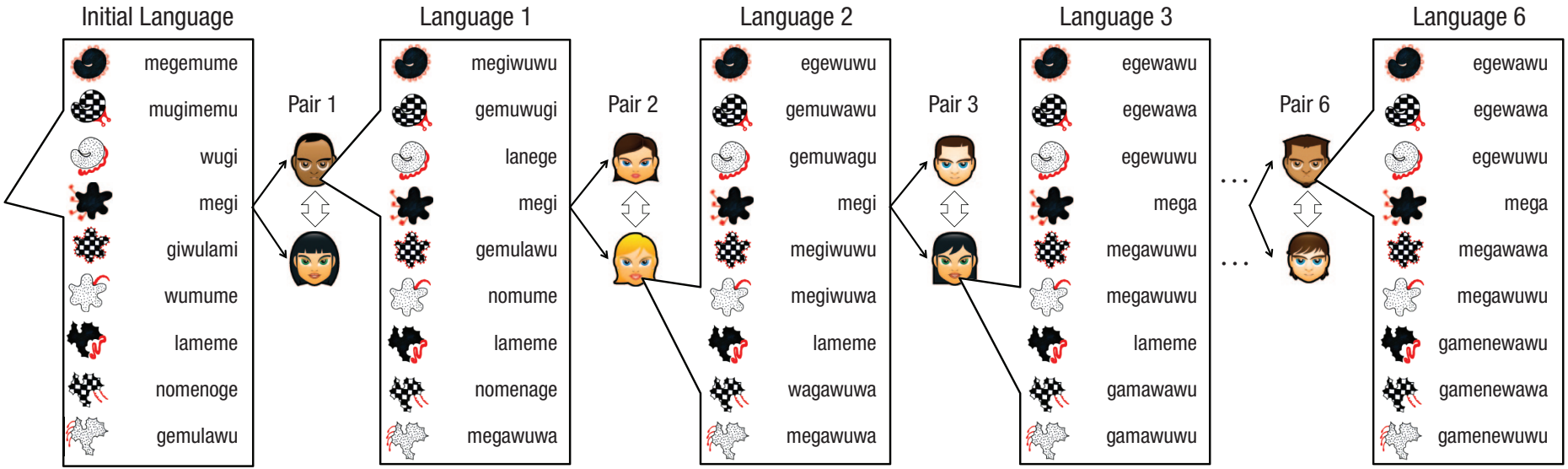
Learners prefer simpler languages

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

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

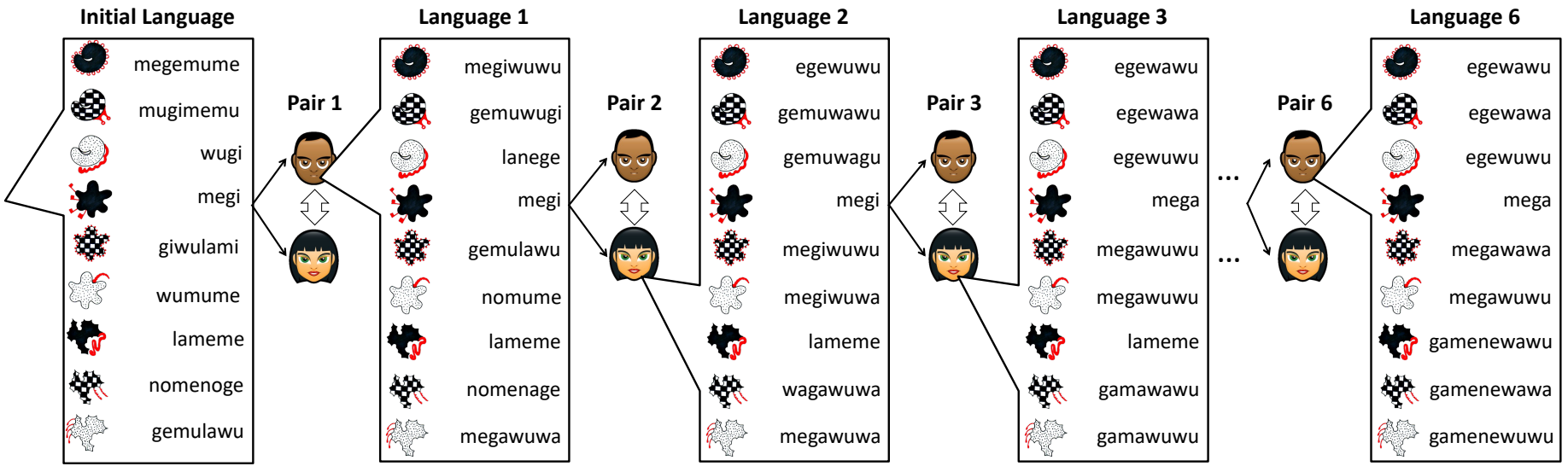
Can we add in a pressure for expressivity?

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



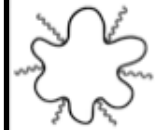
Kirby, S., Tamariz, M., Cornish, H., & Smith, K. (2015). Compression and Communication in the Cultural Evolution of Linguistic Structure. *Cognition, 141*, 87-102.

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

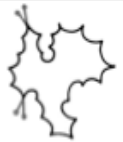


Kirby, S., Tamariz, M., Cornish, H., & Smith, K. (2015). Compression and Communication in the Cultural Evolution of Linguistic Structure. *Cognition, 141*, 87-102.

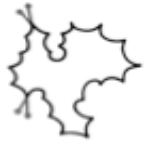
An initial language

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

A final language from a chain

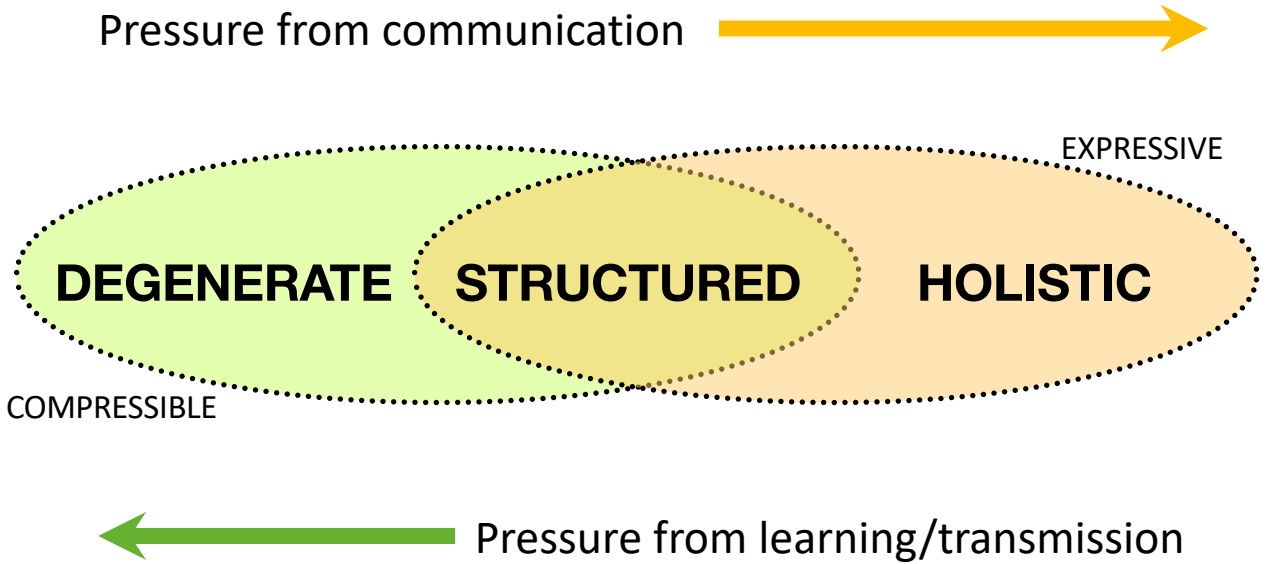
egewawu	mega	gamenewawu
egewawa	megawawa	gamenewawa
egewuwu	megawuwu	gamenewuwu
ege	wulagi	 gamane

A final **holistic** language from a dyad

manunumoko	moko	konu
wekihumanunu	mokowekihu	lawa
makihu	mahiku	wekihulawa
manunumonu	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. 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.

Cultural evolution of language: a summary

A uniformitarian approach

- How far can we get in appealing only to the same processes we see shaping language in the present?

Processes of language change

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

Processes of language evolution

- Same class of processes can explain origins of symbols and structure
- At least in populations capable of the right kind of learning and use

Next up

- Tutorial (Wednesday groups only)
  - Biological and cultural evolution in the evolution of language
- Next and final lecture
  - Monday 27th March (week 10)
  - Topic as agreed!