Online Experiments for Language Scientists

Lecture 8: Iterated learning

Kenny Smith

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Beckner et al (2017)

Beckner, C., Pierrehumbert, J., & Hay, J. (2017). The emergence of linguistic structure in an online iterated learning task. *Journal of Language Evolution, 2*, 160–176.

An iterated artificial language learning experiment

- Does compositional structure emerge 'for free' from person-to-person transmission?

Clay Beckner
(now at Warwick)

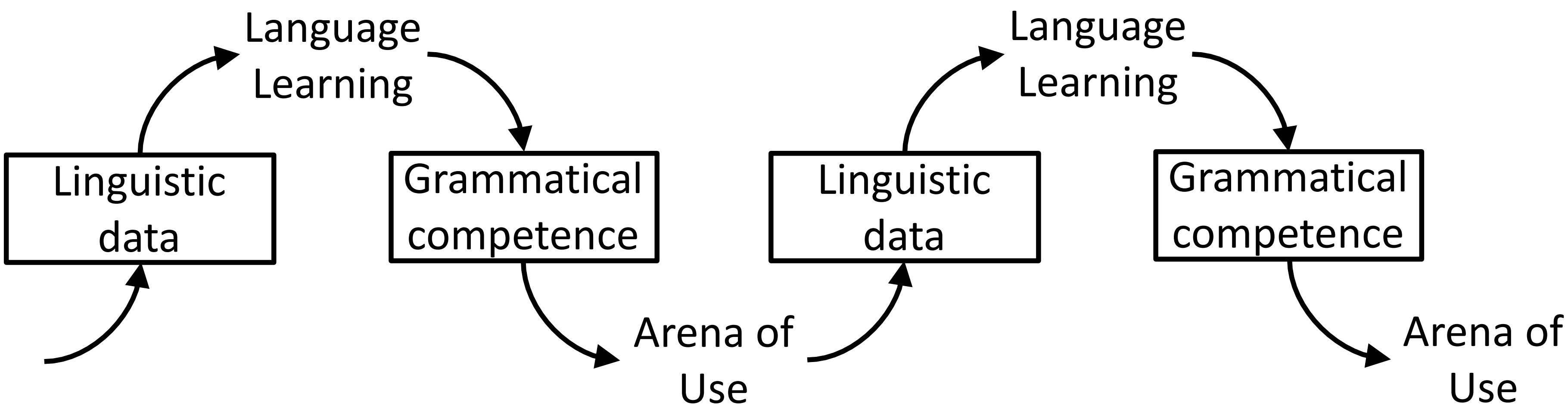
Janet Pierrehumbert
(Oxford)

Jen Hay
(Canterbury, NZ)

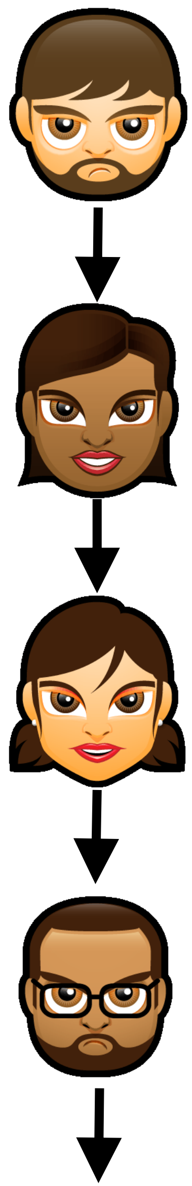
Language is transmitted via repeated **learning** and **use**

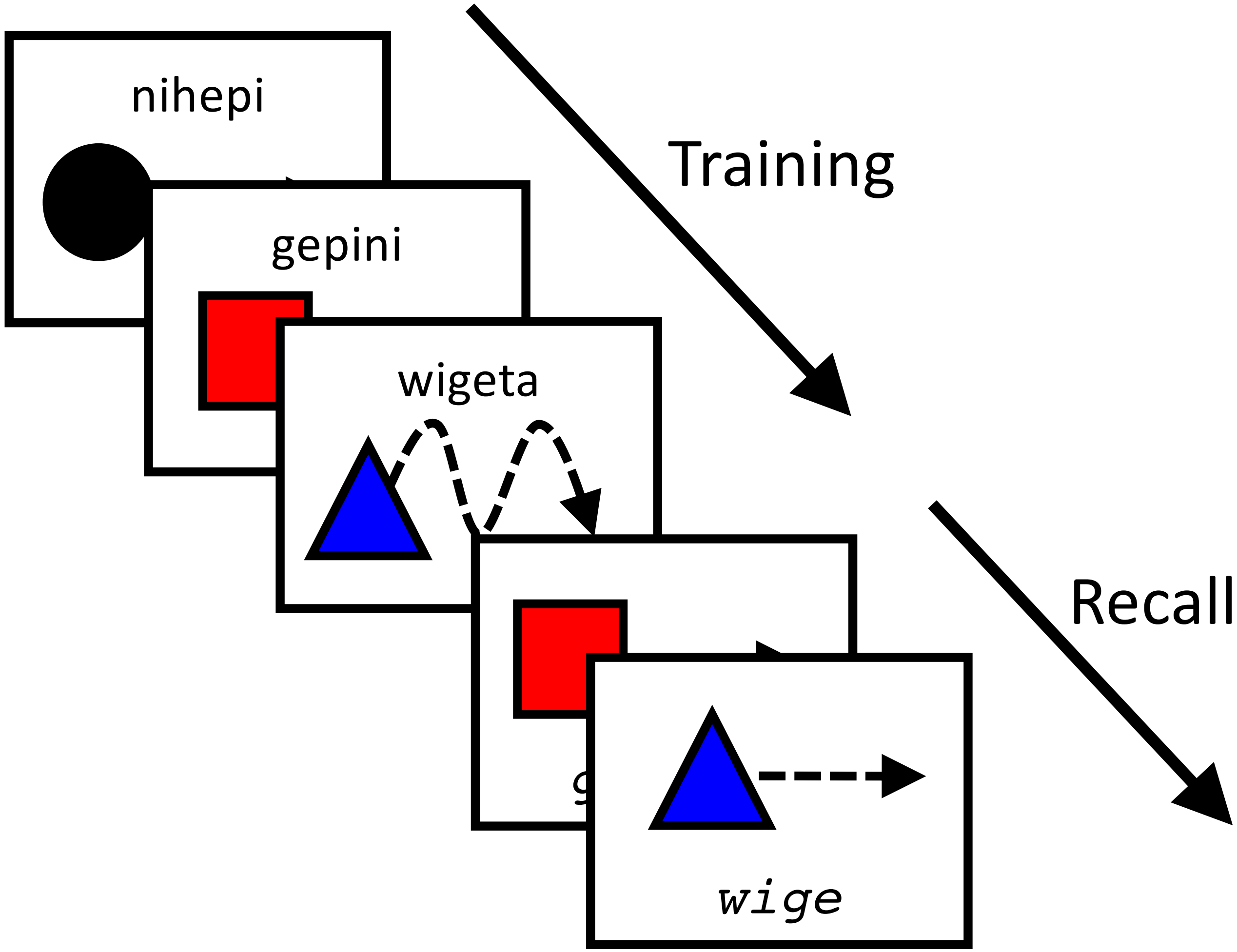
Language is shaped by these processes

The cycle of learning and use produces structure



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.

Demo using this week's practical code

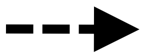
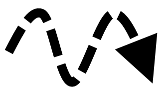
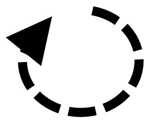
An initial **holistic** (random) language

wimaku	miniki	gepinini	□
nihepi	wigemi	mahekuki	○
wikima	nipikuge	hema	△
miwiniku	pinipi	kihemiwi	□
kinimapi	wikuki	kikumi	○
miwimi	nipi	wige	△
gepihemi	kunige	miki	□
pikuhemi	kimaki	pimikihe	○
mihe	winige	kinimage	△

Initial language from chain 4

	wimaku	miniki	gepinini	□
	nihepi	wigemi	mahekuki	○
	wikima	nipikuge	hema	△
	miwiniku	pinipi	kihemiwi	□
	kinimapi	wikuki	kikumi	○
	miwimi	nipi	wige	△
	gepihemi	kunige	miki	□
	pikuhemi	kimaki	pimikihe	○
	mihe	winige	kinimage	△

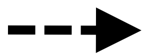
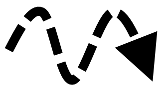
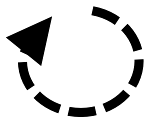
Generation 1 language from chain 4

	nige	miniku	poh	□
	mip	mpo	miniku	○
	tuge	tuge	weg	△
	pemini	kupini	pon	□
	kimei	miwn	miheniw	○
	poi	mhip	kuwpi	△
	hepinimi	himini	hipe	□
	kuhepi	wige	mie	○
	pobo	tupim	hipe	△

Generation 2 language from chain 4

nige	tuge	tuge	□
nige	nige	tuge	○
nige	tuge	mpo	△
nige	tuge	mihenu	□
hepini	miniku	hepini	○
poi	mpo	tupim	△
hepini	miniku	tupim	□
hepini	tupim	tupim	○
nige	tupim	poi	△

Generation 3 language from chain 4

	mihenu	tuge	tuge	□
	tuge	tuge	tuge	○
	nige	tuge	tuge	△
	miniku	tuge	minihu	□
	tuge	tupim	tupim	○
	poi	tuge	miniku	△
	mihenu	tupim	tupim	□
	tupim	tupim	tupim	○
	poi	tupim	tupim	△

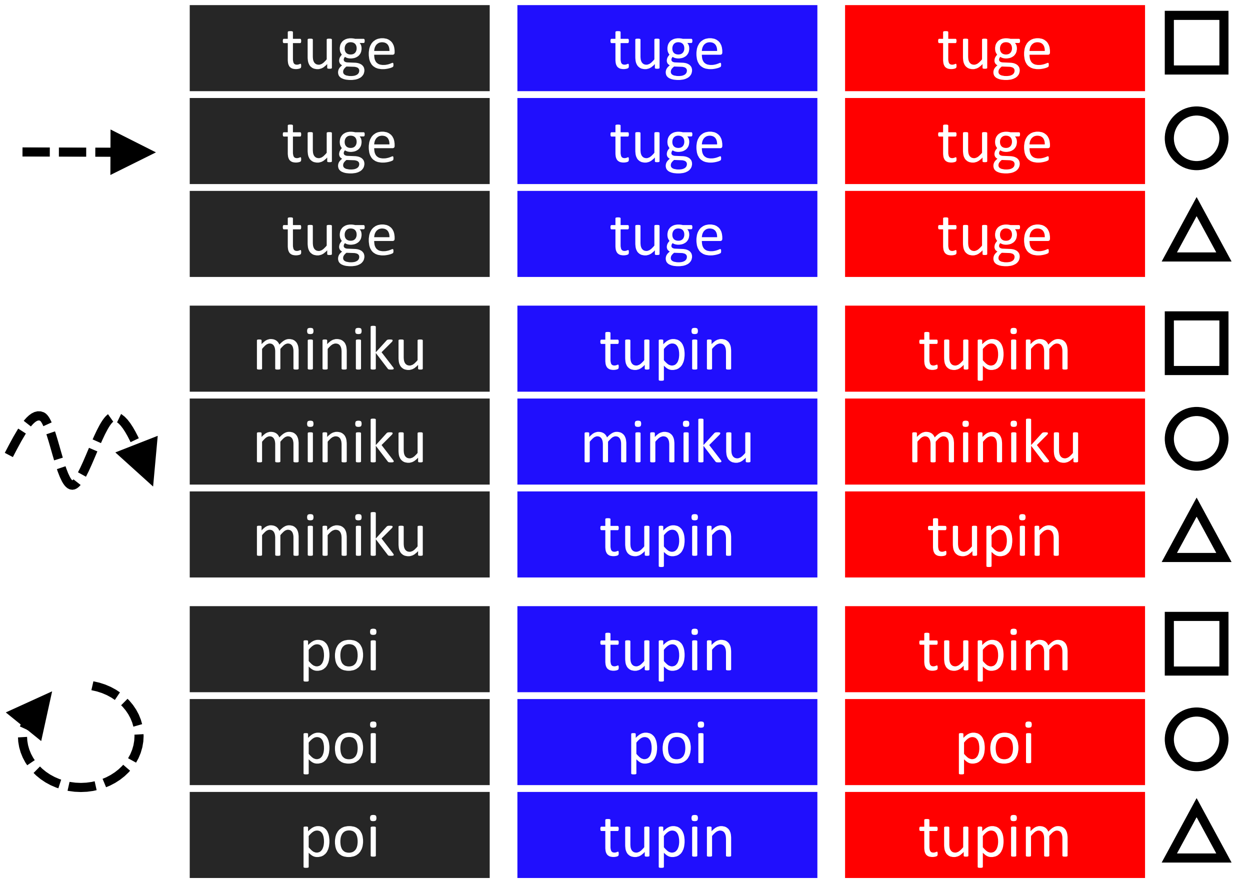
Generation 4 language from chain 4

tuge	tuge	tuge	□
tuge	tuge	tuge	○
	tuge	tuge	△
mihunu	tupim	miniku	□
tupim	tupim	tupim	○
poi	miniku	miniku	△
tupim	tupim	tupim	□
tupim	tupim	tupim	○
poi	tupim	tupim	△

Generation 5 language from chain 4

tuge	tuge	tuge	□
tuge	tuge	tuge	○
tuge	tuge	tuge	△
minuhu	tupim	tupim	□
tupim	tupim	tupim	○
miniku	tupim	miniku	△
tupim	tupim	tupim	□
tupim	tupim	tupim	○
poi	tupim	tupim	△

Generation 6 language from chain 4



Generation 7 language from chain 4

tuge	tuge	tuge	□
tuge	tuge	tuge	○
tuge	tuge	tuge	△
miniku	miniku	tupim	□
miniku	miniku	miniku	○
miniku	tupin	miniku	△
poi	poi	tupim	□
poi	poi	poi	○
poi	tupin	poi	△

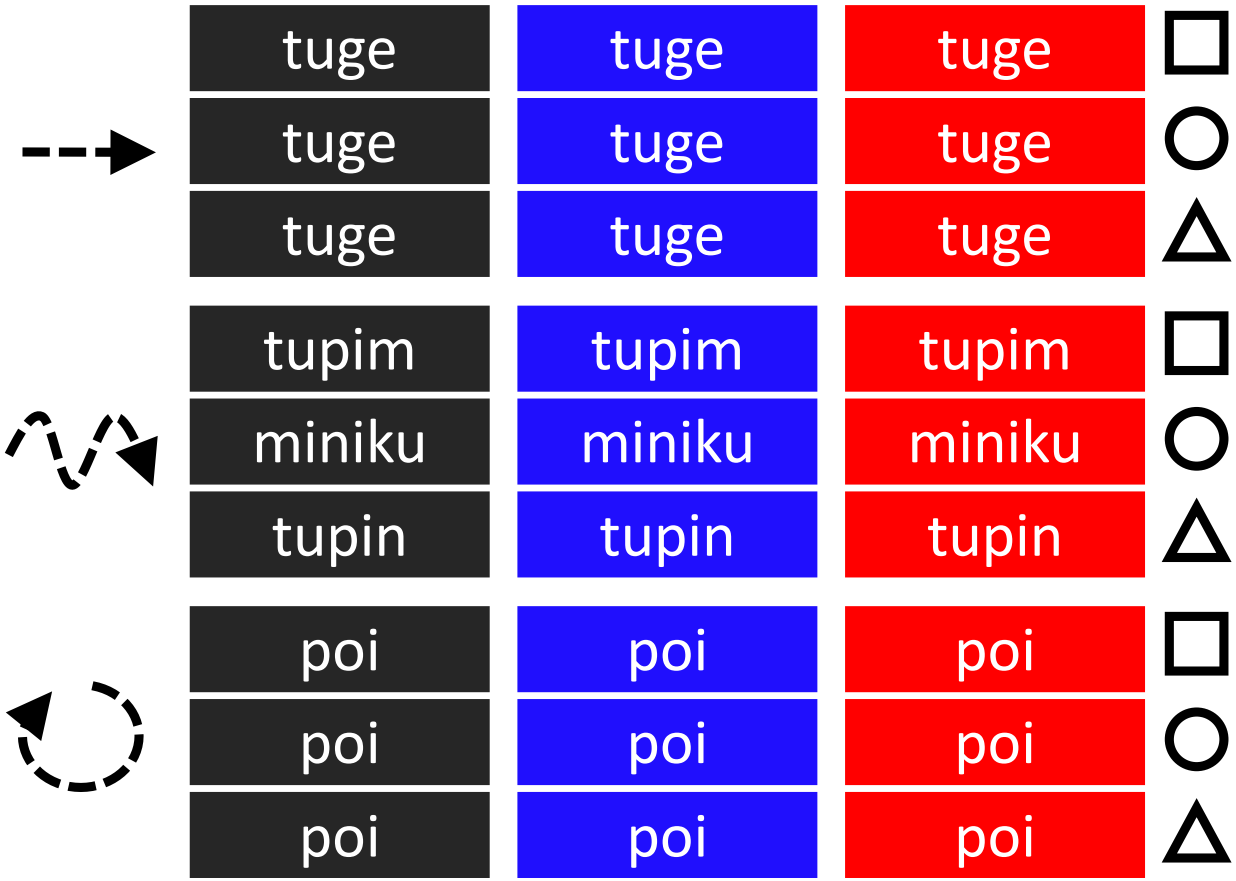
Generation 8 language from chain 4

tuge	tuge	tuge	□
tuge	tuge	tuge	○
tuge	tuge	tuge	△
tupim	tupim	tupim	□
miniku	miniku	miniku	○
tupin	tupin	tupin	△
poi	poi	poi	□
poi	poi	poi	○
poi	poi	poi	△

Generation 9 language from chain 4

tuge	tuge	tuge	□
tuge	tuge	tuge	○
tuge	tuge	tuge	△
tupim	tupim	tupim	□
miniku	miniku	miniku	○
tupin	tupin	tupin	△
poi	poi	poi	□
poi	poi	poi	○
poi	poi	poi	△

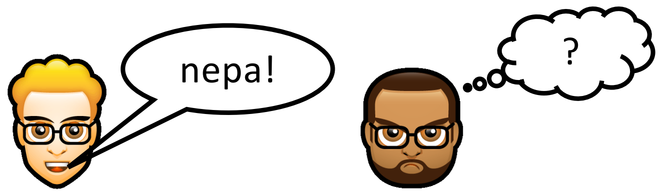
Generation 10 language from chain 4



Final language from chain 1 (!)

nepa	nepa	nepa	□
nepa	nepa	nepa	○
nepa	nepa	nepa	△
nepa	nepa	nepa	□
nepa	nepa	nepa	○
nepa	nepa	nepa	△
nepa	nemene	nepa	□
nepa	nepa	nepa	○
nepa	nepa	nepa	△

The languages become **degenerate**



Generation 9 language from chain 5 (with homonymy filter)

ne-re-ki	la-re-ki	renana	□
ne-he-ki	la-ho-ki	re-ne-ki	○
ne-ke-ki	la-ke-ki	ra-he-ki	△
ne-re-plo	la-ne-plo	re--plo	□
ne-ho-plo	la-ho-plo	re-ho-plo	○
ne-ki-plo	la-ki-plo	ra-ho-plo	△
ne--pilu	la-ne-pilu	re--pilu	□
ne-ho-pilu	la-ho-pilu	re-he-pilu	○
ne-ki-pilu	la-ki-pilu	ra-ho-pilu	△

Beckner et al. (2017)

Reanalysis/gentle roasting of Kirby, Cornish & Smith (2018)

- Our sample size was tiny
- Our statistics were rudimentary
- They find an interesting (?) difference between semantic dimensions

Replication

- Participants recruited from MTurk
- N=240 (2 conditions, 12 chains per condition, 10 participants per chain)
- 22-25 minutes, paid $3

Measuring structure

“the dog chew-ed the bone” – “the dog lick-ed the bone”

Meaning distance = 1 (predicate)

Signal distance = 1 (verb stem)

“the dog chew-ed the bone” - “the dog lick-s the bone”

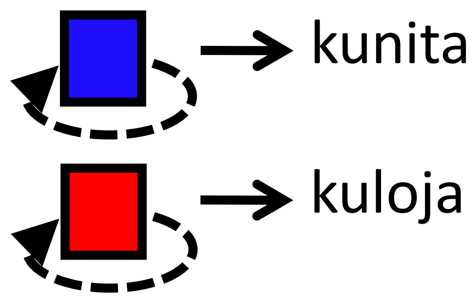
Meaning distance = 2 (predicate, tense)

Signal distance = 2 (verb stem, suffix)

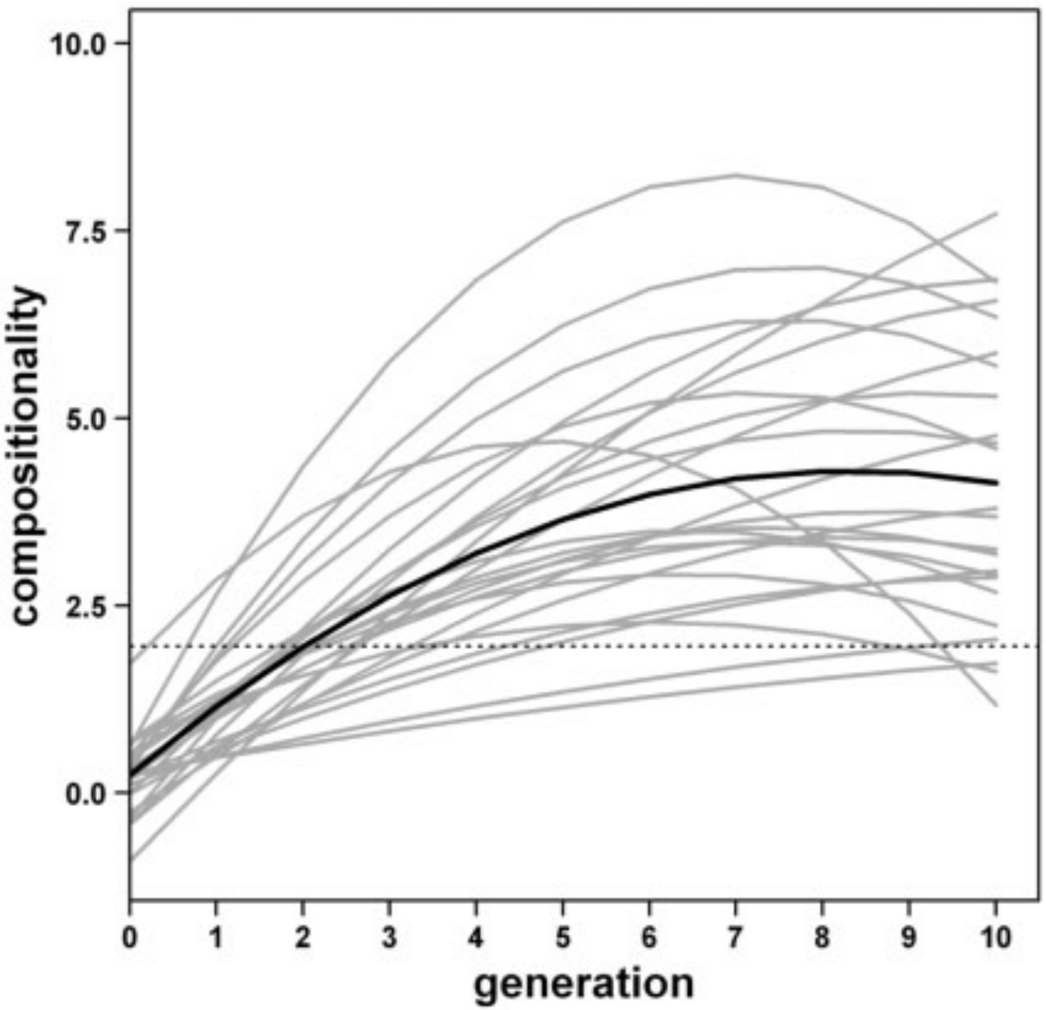
Pairwise meaning and signal distances will be highly correlated in a compositional system: similar meanings map to similar signals (and dissimilar meanings map to dissimilar signals)

Measuring structure

- For every pair of meaning-signal pairs
  - Measure meaning distance (Hamming distance)
  - Measure signal distance (Levenshtein string-edit distance)
  - Correlate these distances
- Evaluate statistical significance of that correlation
  - Randomise label assignments, recalculate measure, repeat 1000 times to give distribution
  - Calculate z-score of veridical correlation



Meaning Distance = 1
Signal distance = 3



	'red'	'green'	'blue'	
'berry'	shen-to	shen-ta	shen-to	'1'
	shen-tra	shen-tro	shen-tra	'2'
	shen-trio	shen-trio	shen-trio	'3'
'key'	div-tro	div-tro	div-tro	'1'
	dev-tro	dev-tro	dev-etrio	'2'
	dev-stra	div-stra	dev-stra	'3'
'phone'	lolni-tro	lolni-tro	lolni-to	'1'
	lolne-stra	lolni-tro	lolne-stro	'2'
	lolni-tra	lolni-stra	lolni-stra	'3'

Beckner et al.'s conclusions

Iterated learning **does** produce structure

- Our 2008 result replicates with a proper sample size
- The method also works online…
- … but for this kind of challenging task, MTurk data is noisier?

Time for Q&A/discussion on this week's reading

Next up

Wednesday, 9am: lab on Gather

- Iterated learning, manipulating CSVs and looping trials

Next week: final lecture and lab 🥲

- Zipf’s Law of Abbreviation, dyadic interaction