Linking Language Development and Language Transmission

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Overview

1. Studying Language Evolution in the Lab:
   Overview and Demonstration

   Iterated learning: What's different in children?

2. Negotiating Meaning:
   Communicative Constraints in Children and Adults

   Can children invent a novel communication system?

3. Transmitting Symbolic Signals:
   Learnability Constraints in Children and Adults

   Who are the agents of language change?

4. Accommodating the Learner:
   The Role of Teaching in Language Transmission

   How do experts transmit linguistic knowledge?

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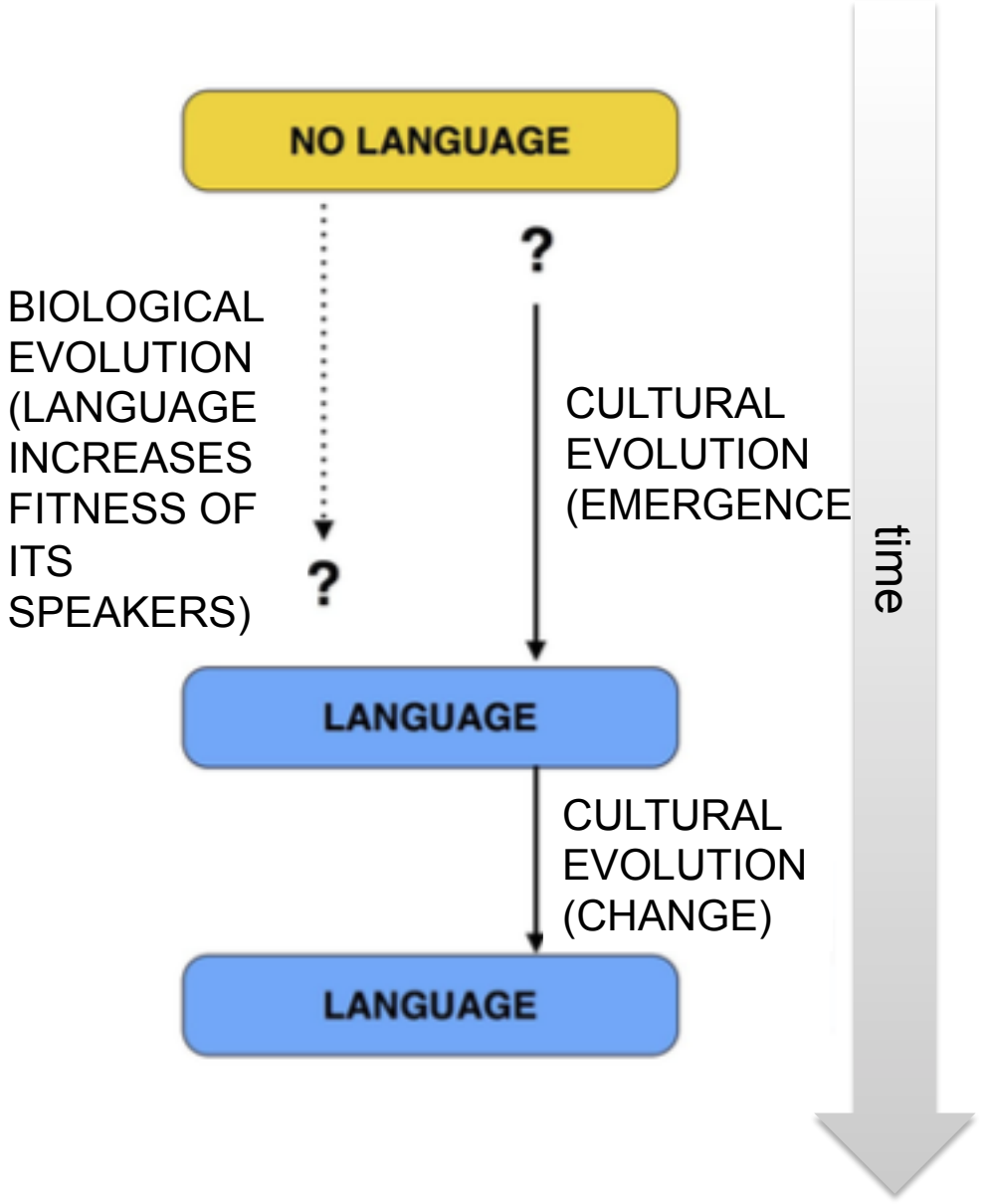
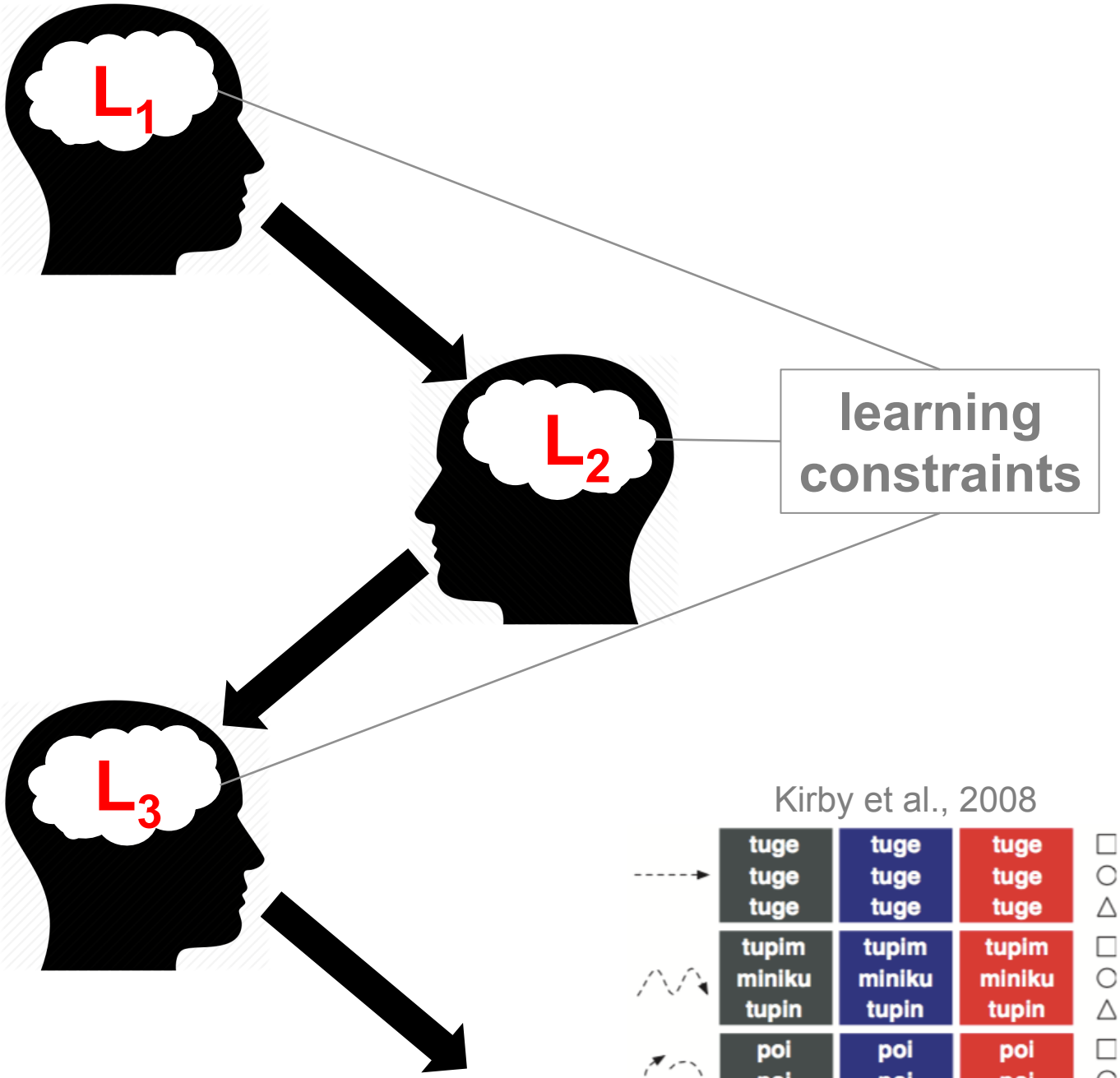
Language = product of cultural evolution.

Language evolution is shaped by constraints on

- **learnability**




L1
L2
L3
learning constraints
Kirby et al., 2008
tuge tuge tuge
tuge tuge tuge
tuge tuge tuge
tupim miniku tupin
tupim miniku tupin
tupim miniku tupin
poi poi poi
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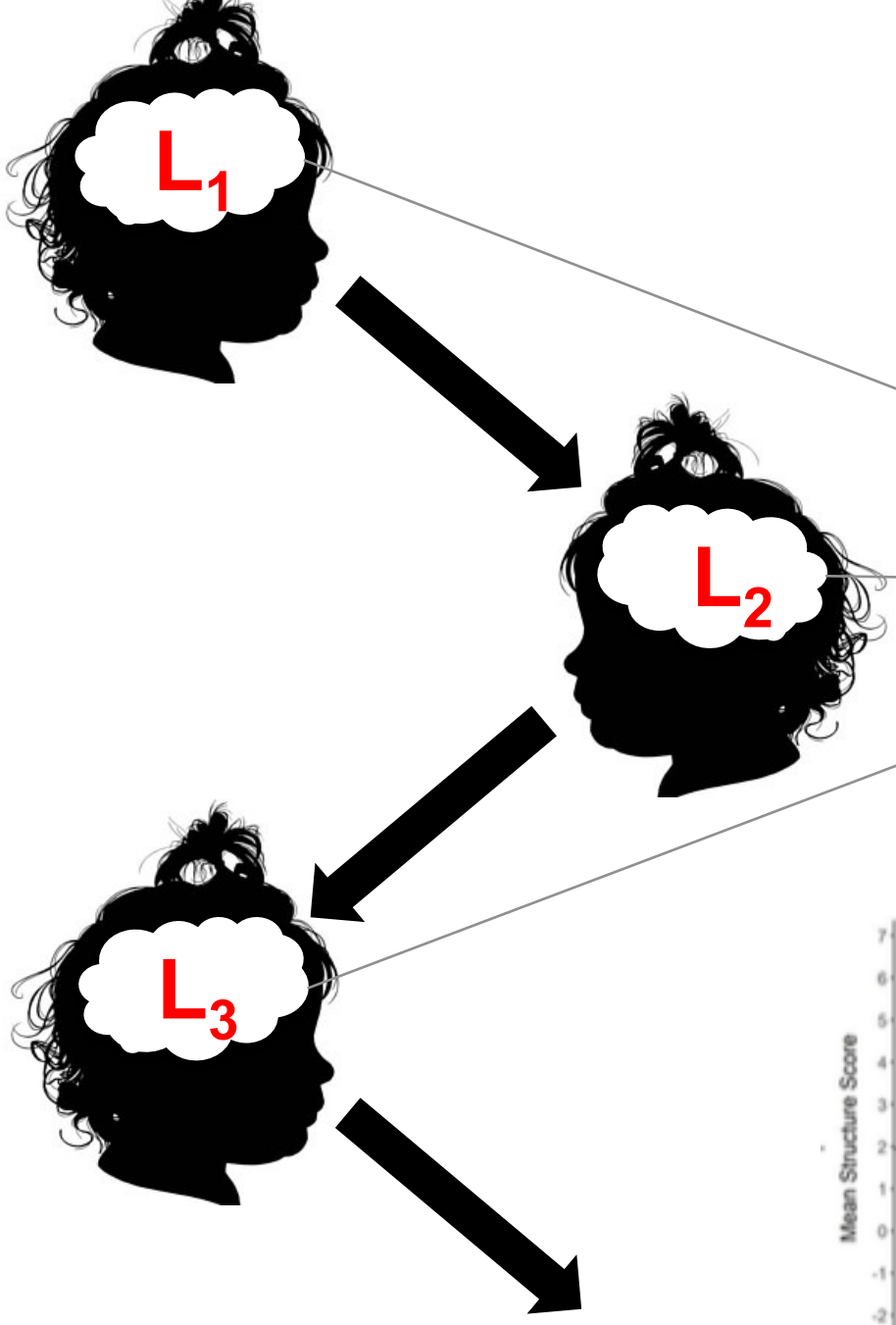
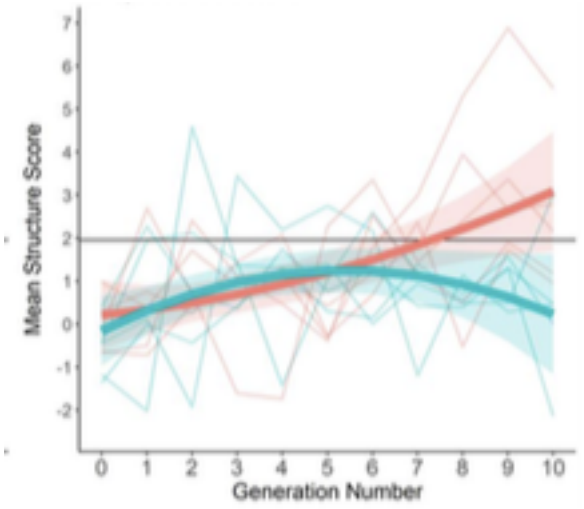


learning constraints

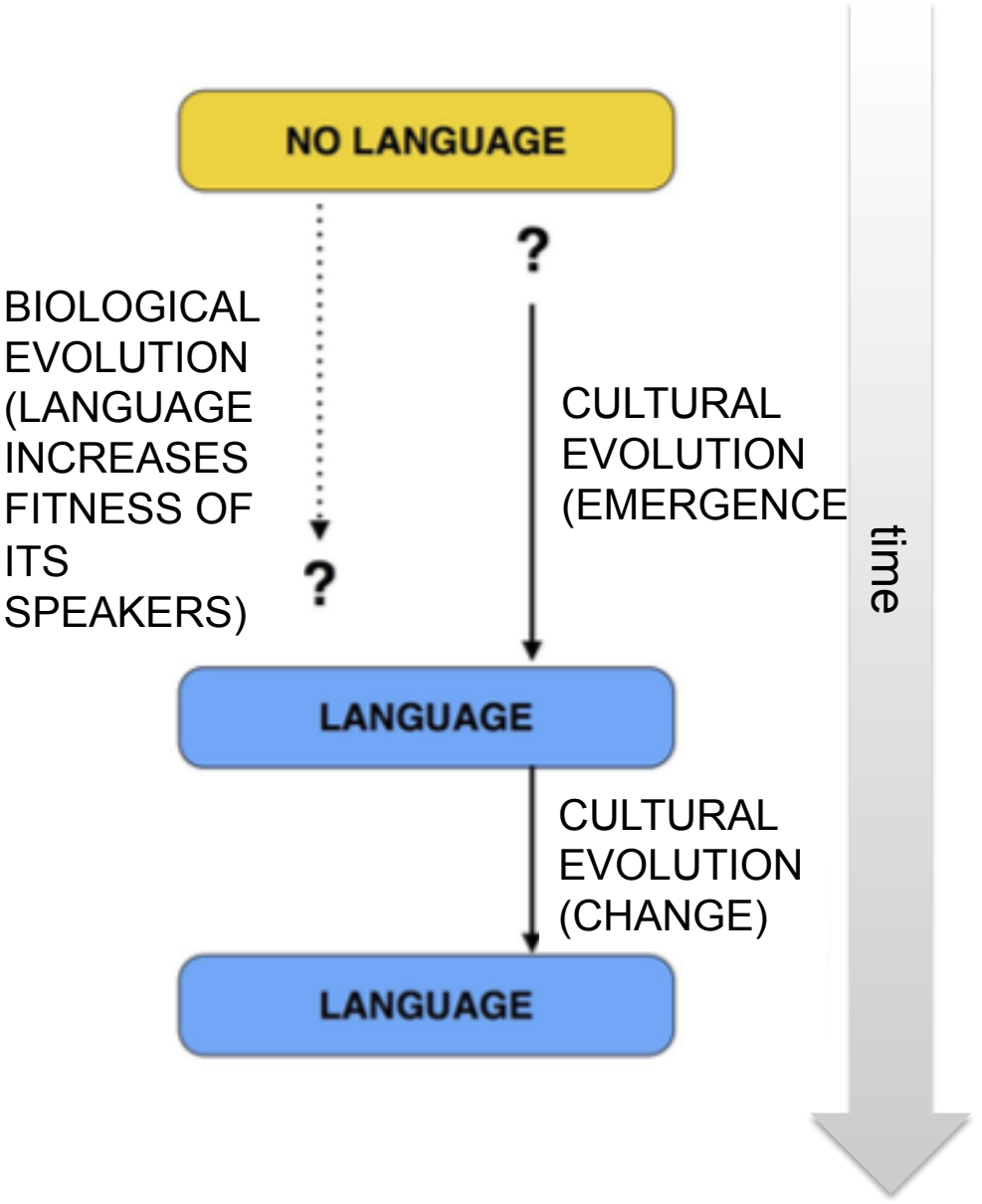
Raviv & Arnon (in press)

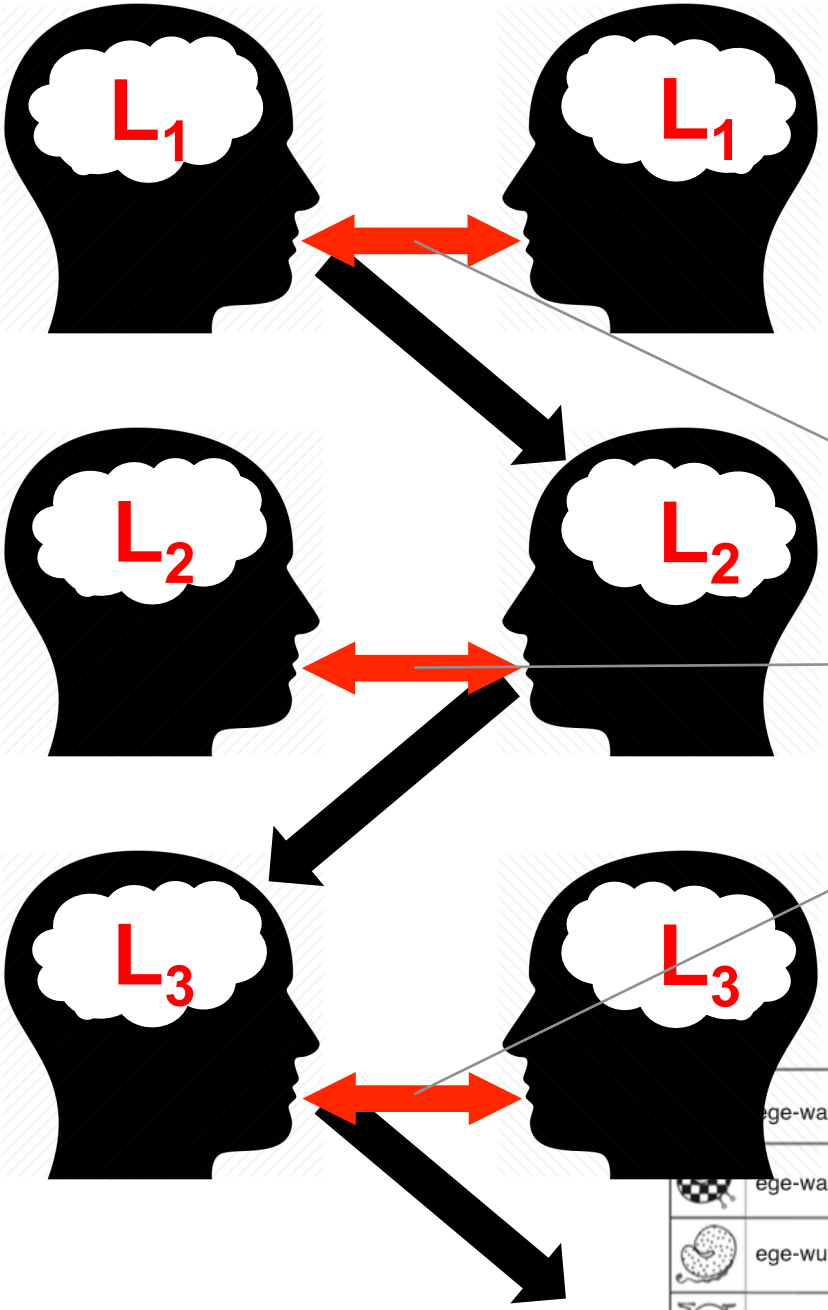


Language = product of cultural evolution.

Language evolution is shaped by constraints on

- **learnability**
- **usage**

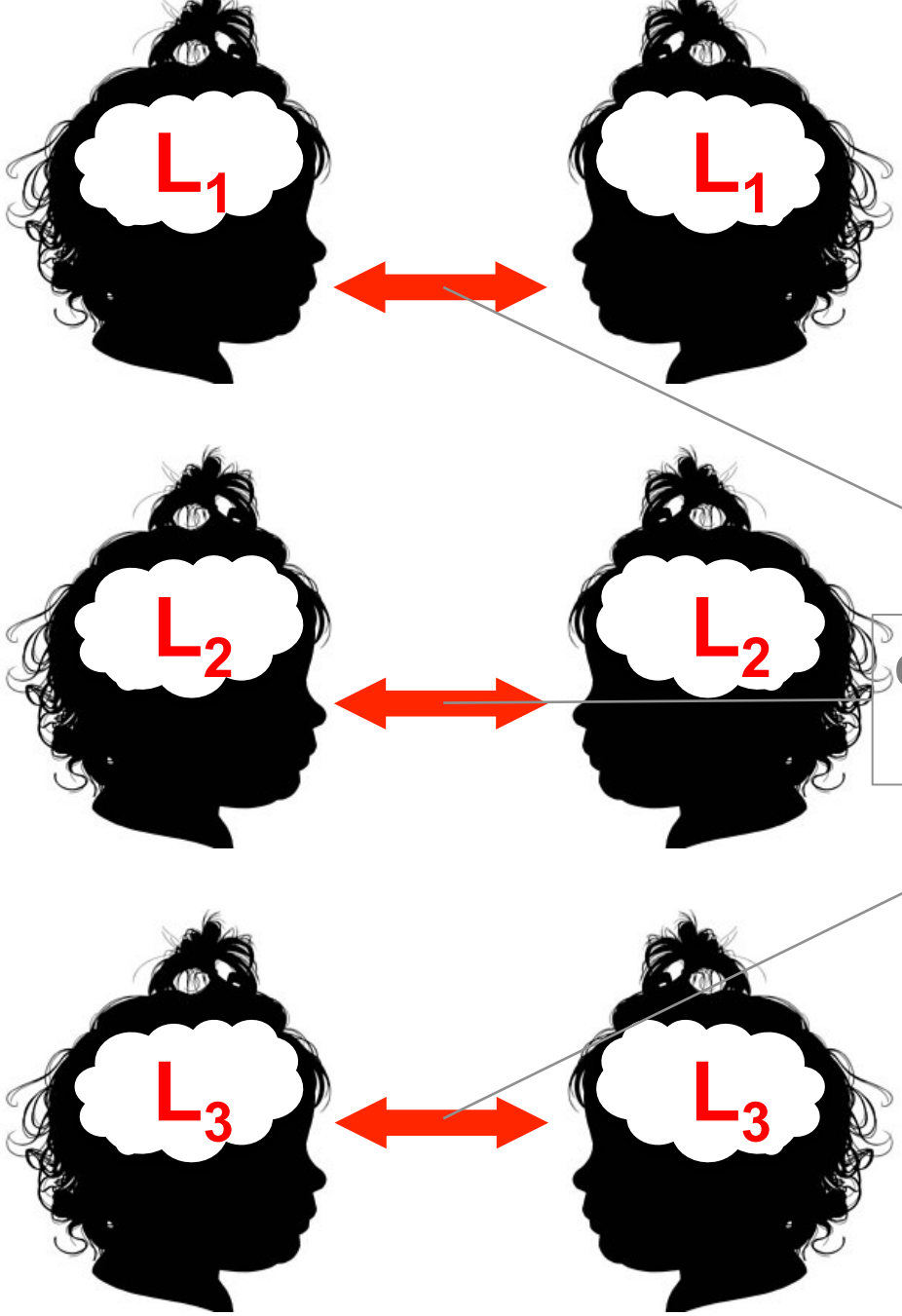




communication constraints

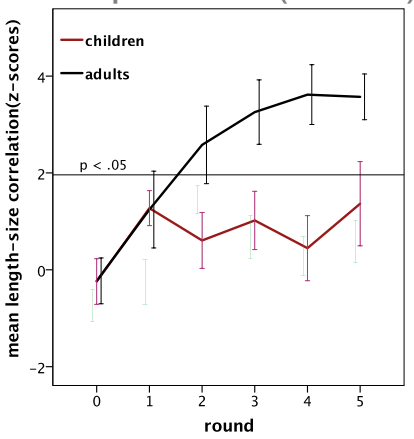
Kirby et al., 2015

ege-wawu	mega	gamene-wawu
ege-wawa	mega-wawa	gamene-wawa
ege-wuwu	mega-wuwu	gamene-wuwu
ege	wulagi	gamane



communication constraints

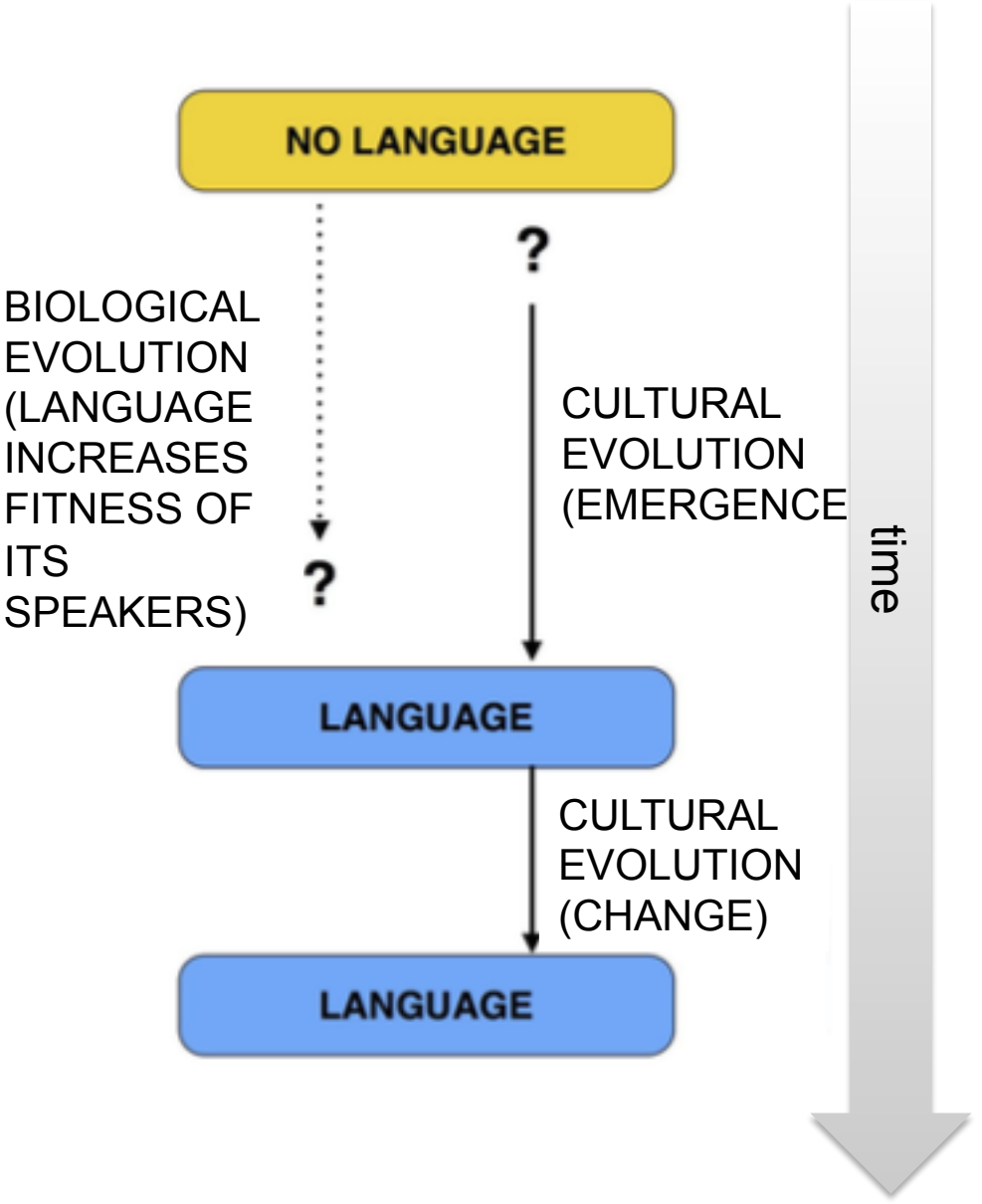
Kempe et al. (subm.)

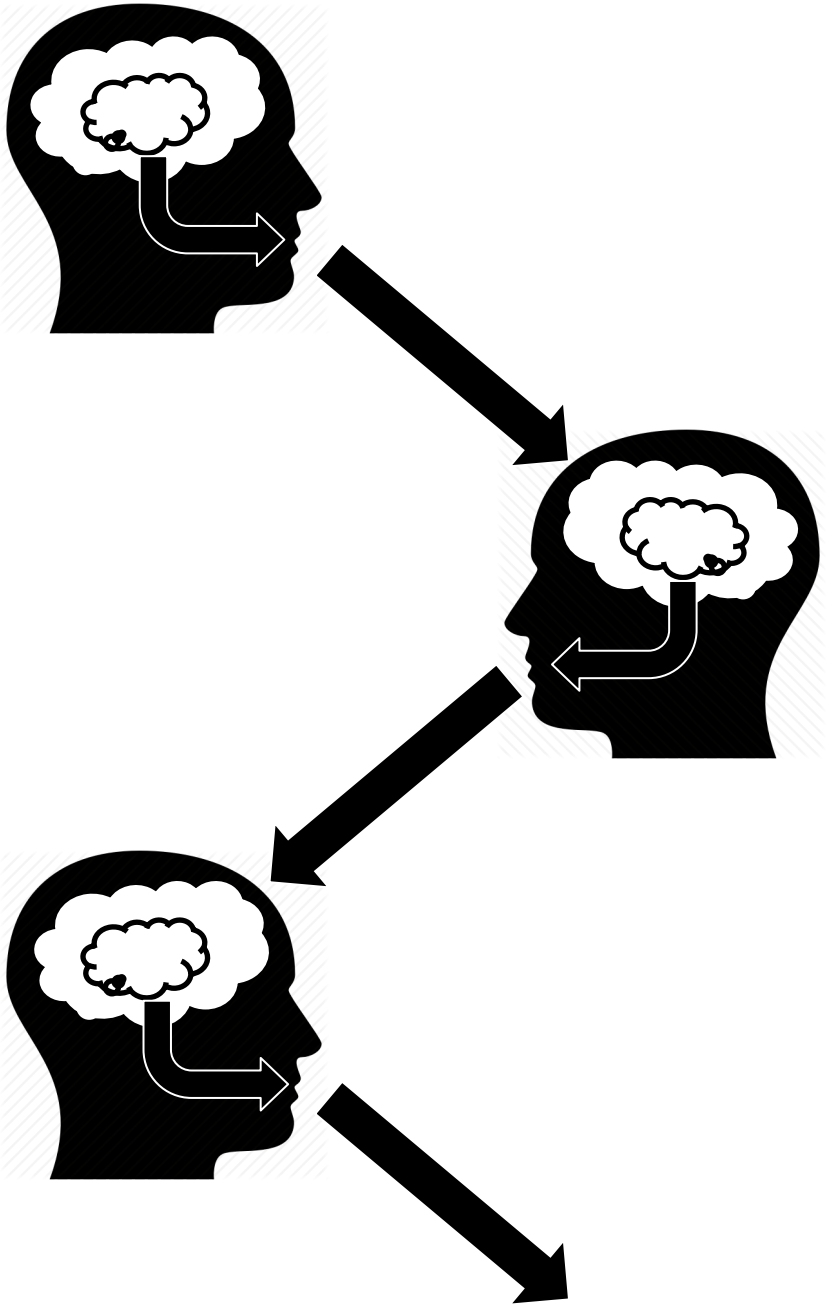


Language = product of cultural evolution.

Language evolution is shaped by constraints on

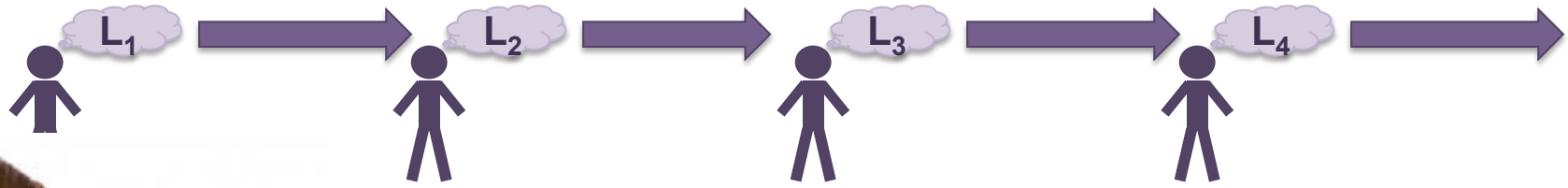
- **learnability**
- **usage**
- **transmission**

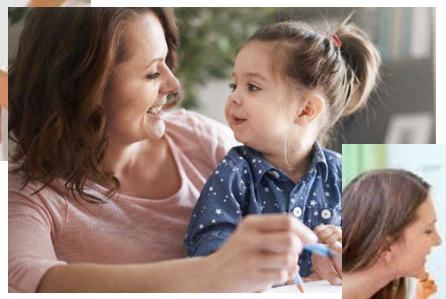


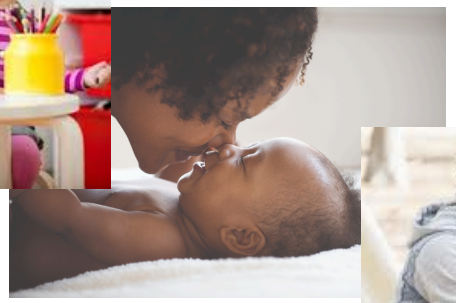


CDS

Studying Language Evolution in the Lab



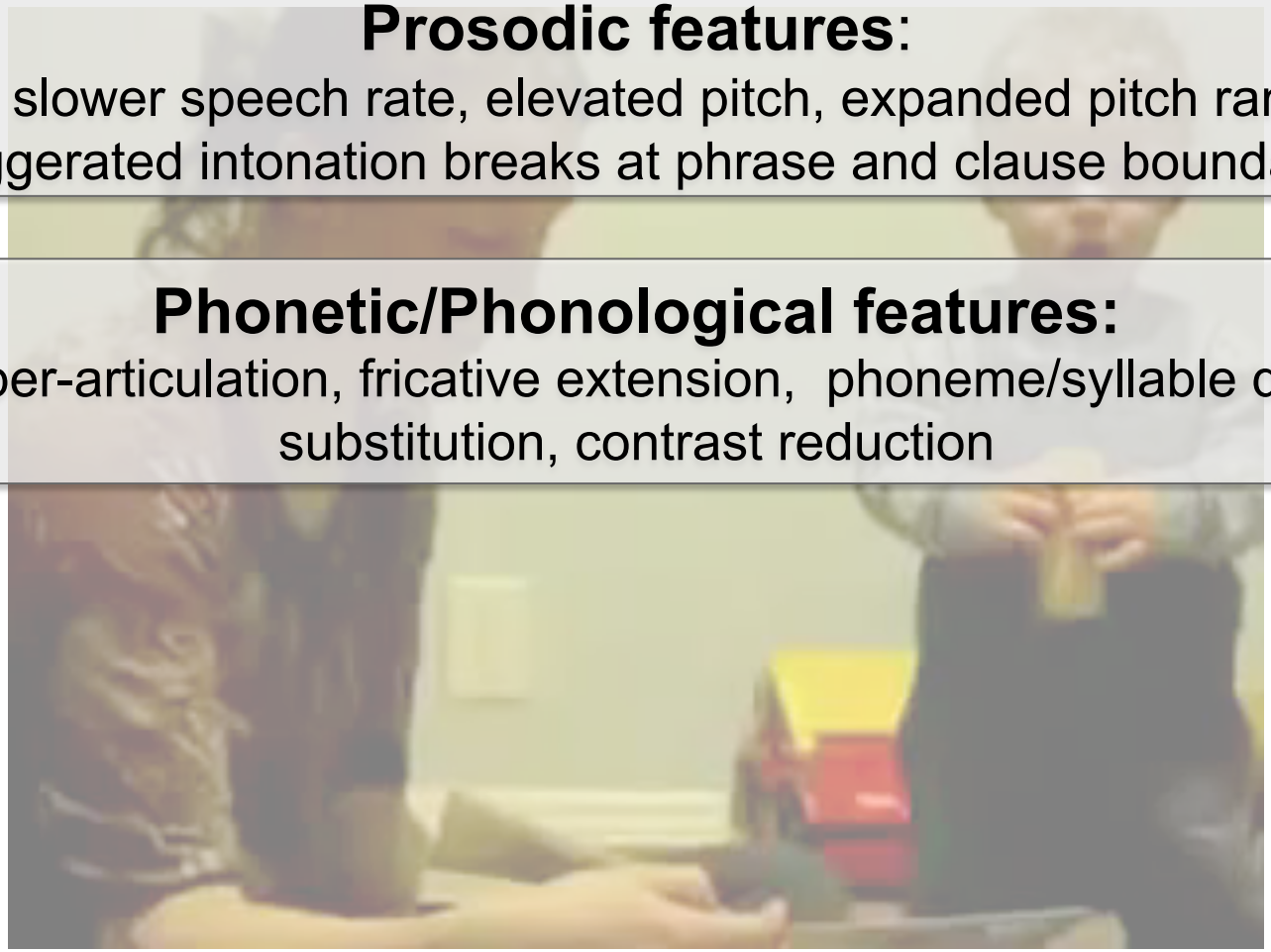




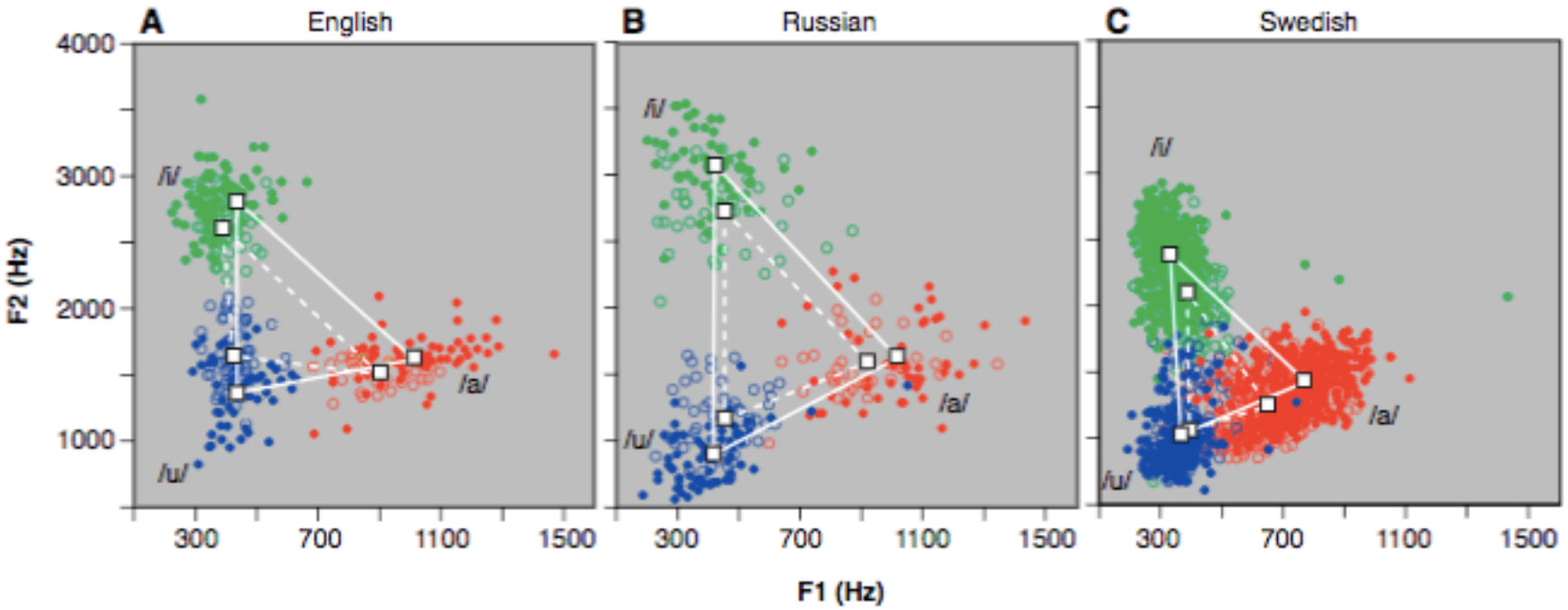
Child-Directed Speech vs. Adult-Directed Speech

Prosodic features:
e.g. slower speech rate, elevated pitch, expanded pitch range, exaggerated intonation breaks at phrase and clause boundaries

Phonetic/Phonological features:
e.g. hyper-articulation, fricative extension, phoneme/syllable deletion, substitution, contrast reduction



Learning Benefits from CDS



Vowel space is expanded in CDS.

Kuhl et al. (1997)

Child-Directed Speech vs. Adult-Directed Speech

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Phonetic/Phonological features:
e.g. hyper-articulation, fricative extension, phoneme/syllable deletion, substitution, contrast reduction

Morphological/Syntactic features:
e.g. diminutives (e.g. *kitty*), hypocoristics, novel words at ends of utterances

Lexical features:
e.g. more onomatopoeia, reduplication (e.g. *choo-choo*)

Diminutives in CDS

bunny

birdy

Patty

milky

doggy

horsie

kitty

binkie

Diminutives in CDS

popje
[little doll]

kipje
[little chicken]

baletje
[little ball]

kikkertje
[little frog]

dakje
[little roof]

hofje
[little garden]

boekje
[little book]

koningkje
[little king]

Diminutives in CDS

rosita
[little rose]

pajarito
[birdy]

naricita
[little nose]

lapicito
[little pencil]

estrellita
[little star]

perrito
[doggy]

ahorita
[little now]

caballito
[little horse]

Diminutives in CDS

kukolka
[little doll]

myachik
[little ball]

myshka
[little mouse]

zajchik
[bunny]

rozochka
[little rose]

stul’chik
[little chair]

sobachka
[doggy]

kubik
[little block]

Grammatical Gender

book

kniga el?

el libro la?

das Buch das?

chair

stul der?

la silla die?

der Stuhl das?

house

dom zholtyj?

la casa zholtaya?

das Haus zholtoye?

Grammatical Gender Marking (Spanish)

gender	transparent		non-transparent	
	simplex			
masculine	***caballo*** *[horse]*			
feminine	***estrella*** *[star]*			

Grammatical Gender Marking (Spanish)

gender	transparent		non-transparent	
	simplex	diminutive	simplex	diminutive
masculine	***caballo*** *[horse]*	***caballito*** *[little horse]*	***lapiz*** *[pencil]*	***lapicito*** *[little pencil]*
feminine	***estrella*** *[star]*	***estrellita*** *[little star]*	***nariz*** *[nose]*	***naricita*** *[little nose]*

Grammatical Gender Marking (Russian)

gender	transparent		non-transparent
	simplex		
masculine	***stakan*** *[glass]*		
feminine	***stena*** *[wall]*		
neuter	***jabloko*** *[apple]*		

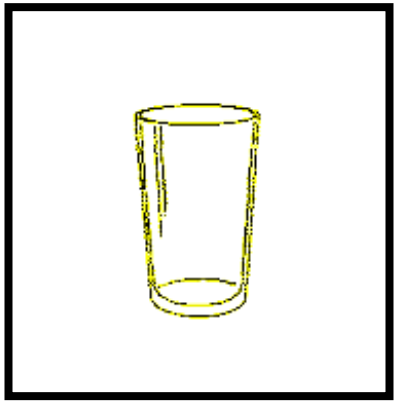
Grammatical Gender Marking (Russian)

gender	transparent		non-transparent	
	simplex	diminutive	simplex	diminutive
masculine	***stakan*** *[glass]*	***stakanchik*** *[little glass]*	***pen'*** *[stump]*	***penyok*** *[little stump]*
feminine	***stena*** *[wall]*	***stenochka*** *[little wall]*	***pech'*** *[oven]*	***pechka*** *[little oven]*
neuter	***jabloko*** *[apple]*	***jablochko*** *[little apple]*		

Can Diminutives Aid Gender Learning?

Group 1:
non-diminutives

zholtyj stakan *[yellow glass]*
zholtaya stena *[yellow wall]*



Group 2:
diminutives

zholtyj stakanchik *[yellow glassDIM]*
zholtaya stenochka *[yellow wallDIM]*

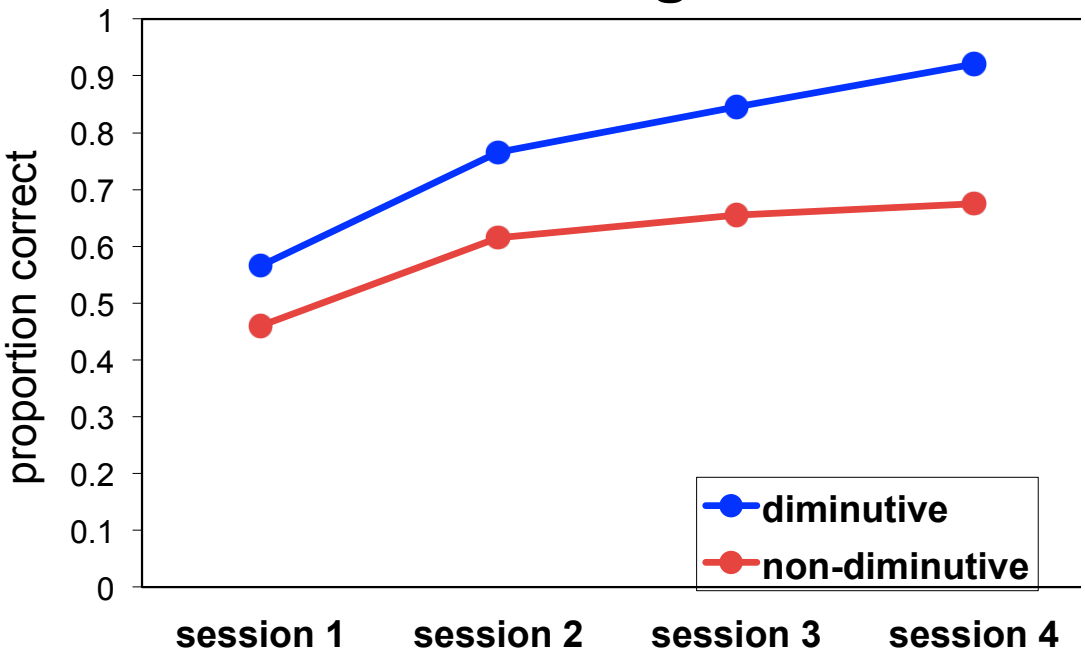
Training Tasks: listen, repeat, picture choice, product**ion**
Test: Produce Adj-Noun-phrases for trained and novel nouns

Kempe & Brooks (2001/2005)

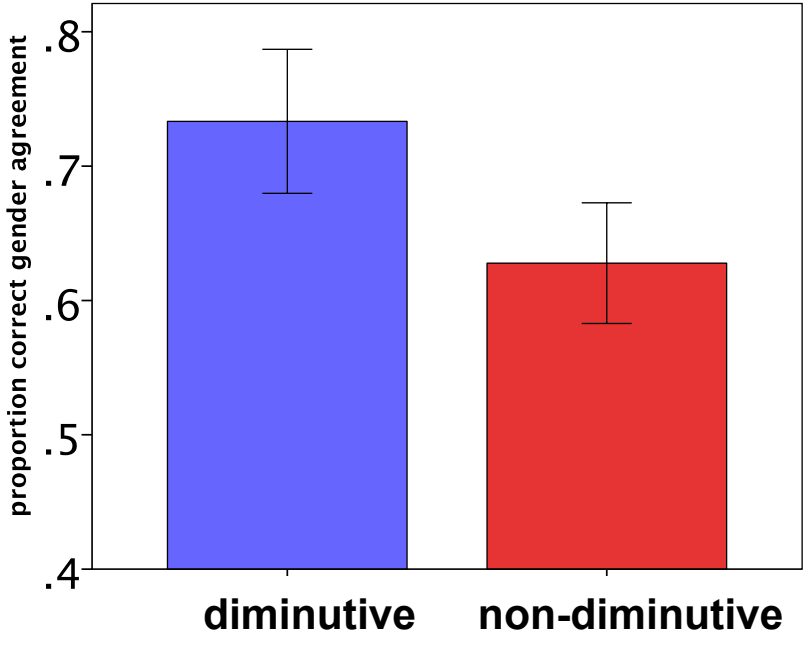
Diminutives Aid Gender Learning

English-speaking adults (n = 36):

Training:



Testing with new nouns



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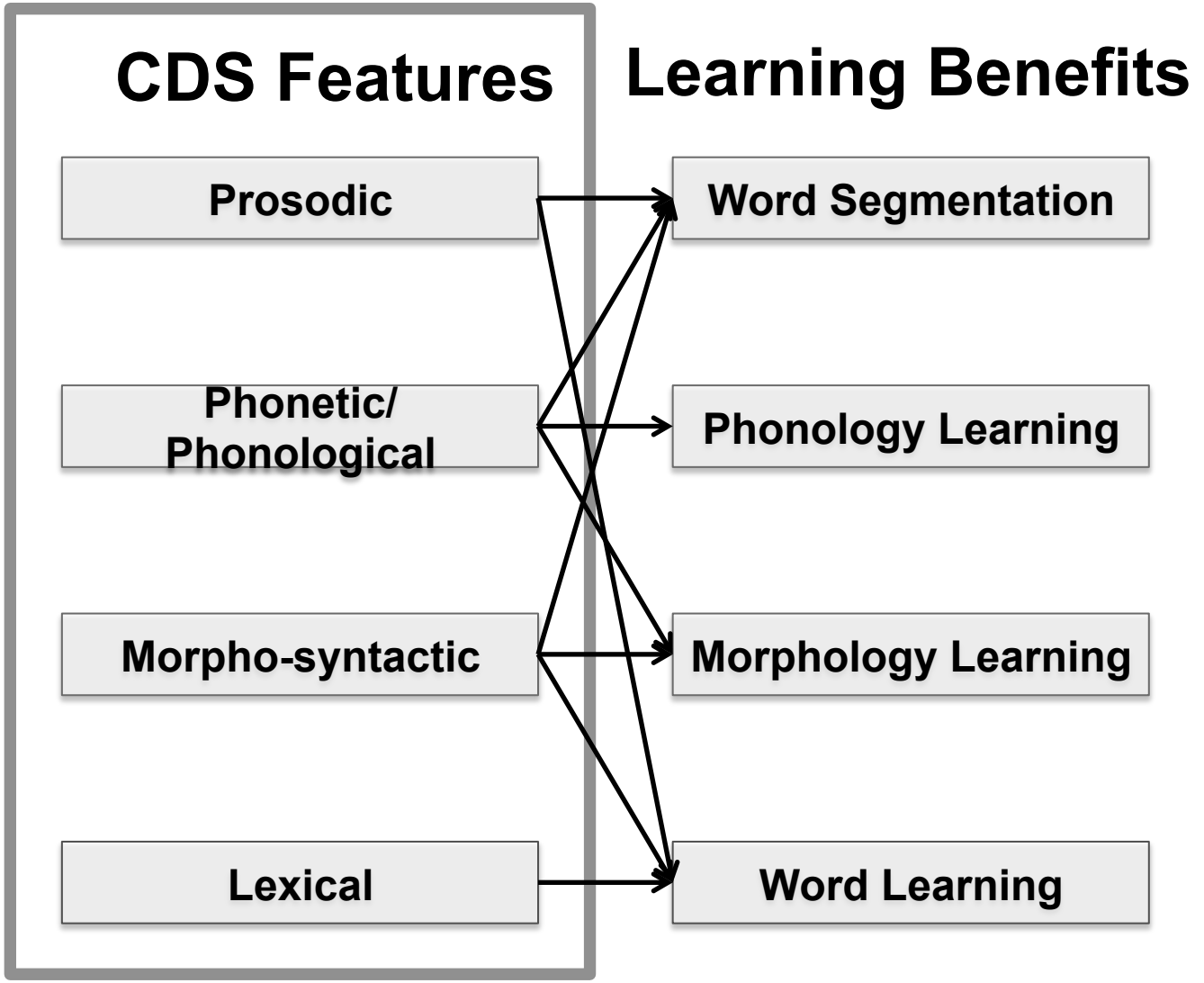
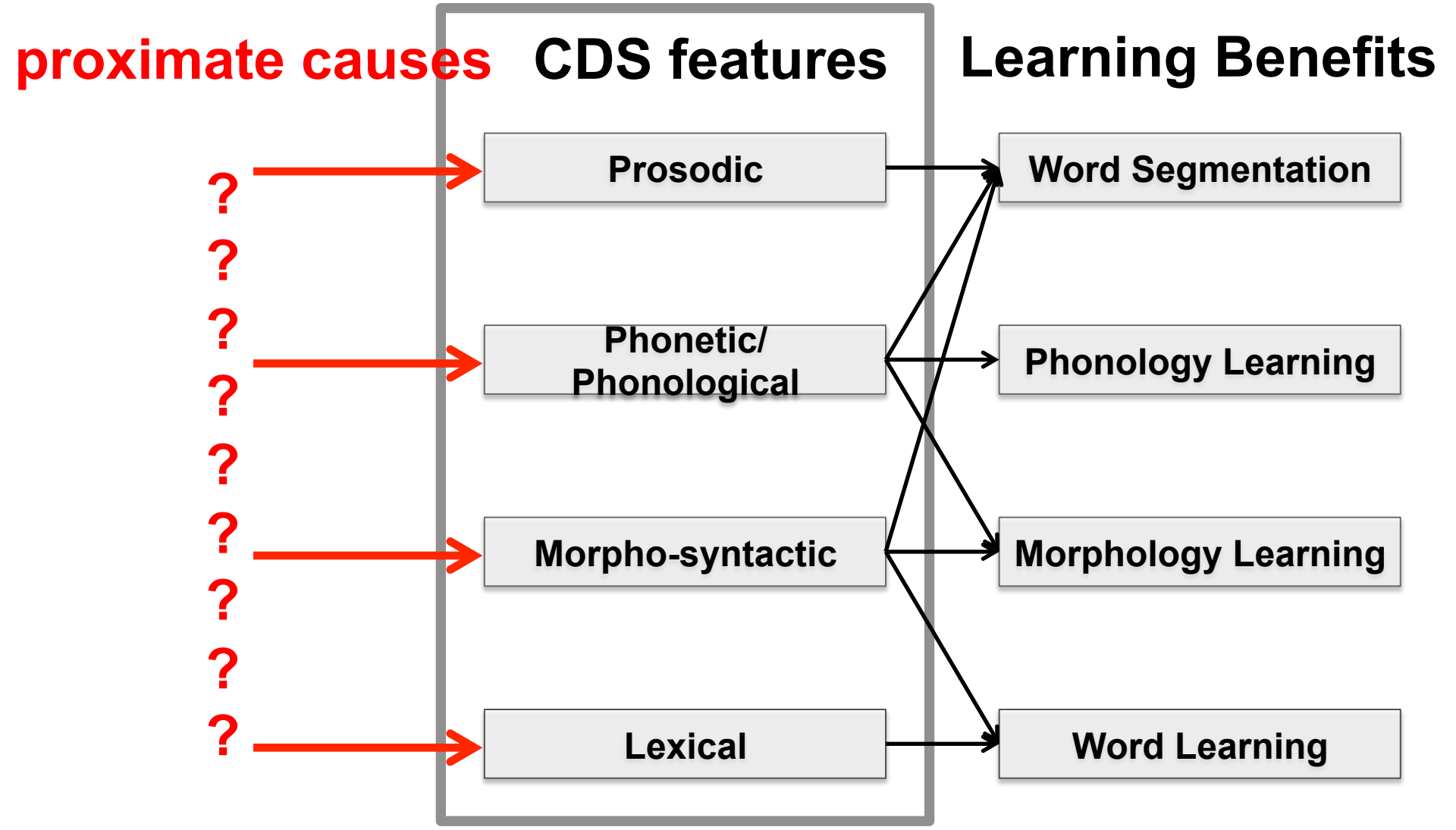


Why does CDS have these features?
Because they help babies learn language.
ultimate cause
Psychologist

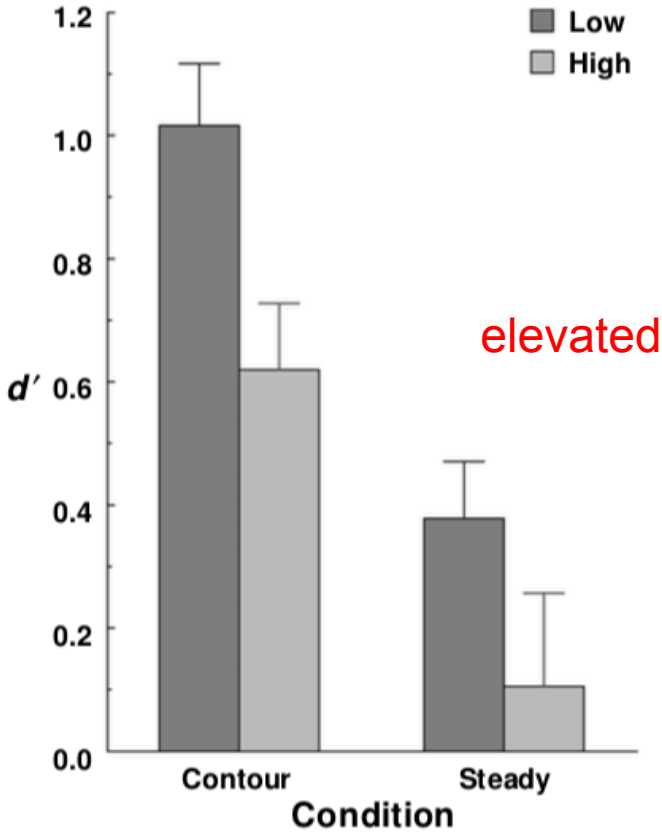
What are the Mechanisms of Input Optimisation?



Learning Benefits as By-Product of Positive Affect Expression?

vowel contrast discrimination in 6-7-months old infants:
/i/ as in heed and /I/ as in hid

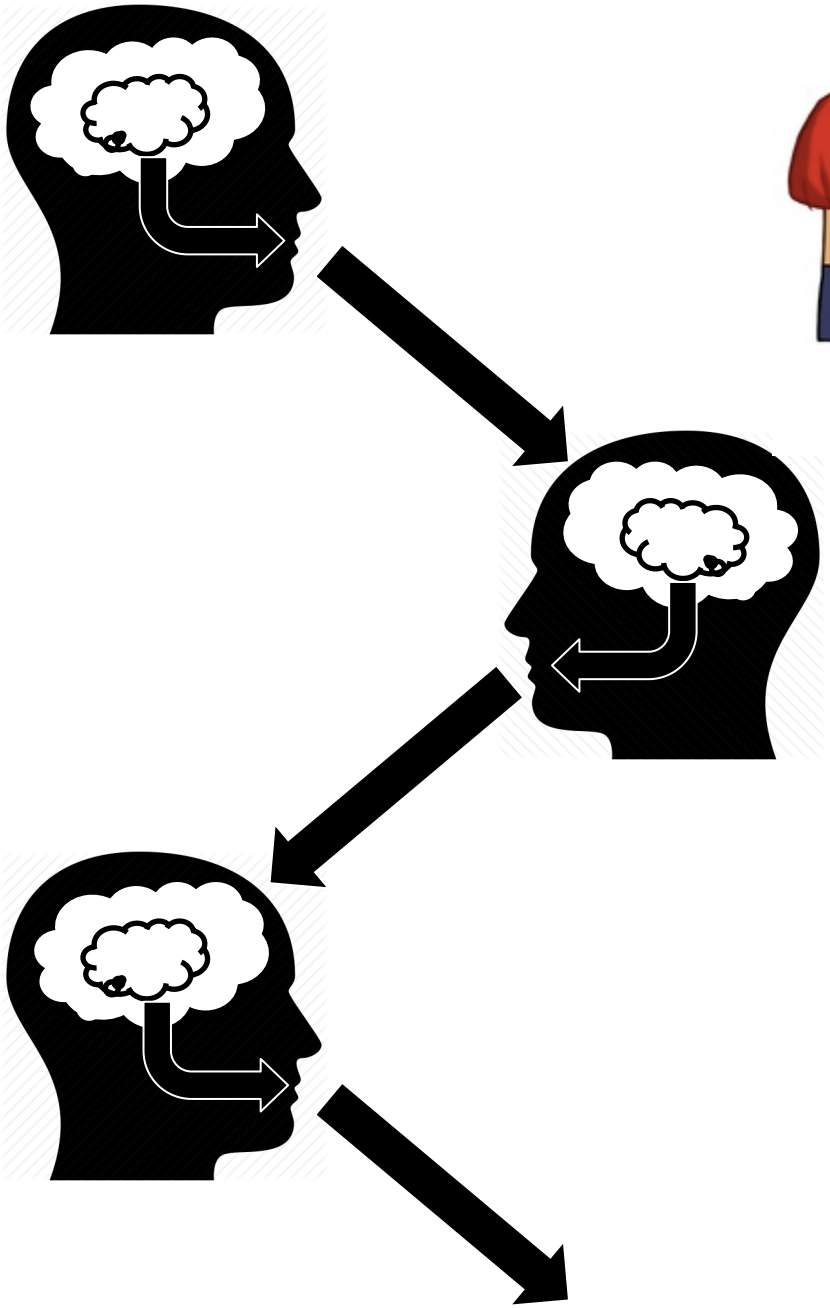
exaggerated CDS pitch contour



elevated CDS pitch

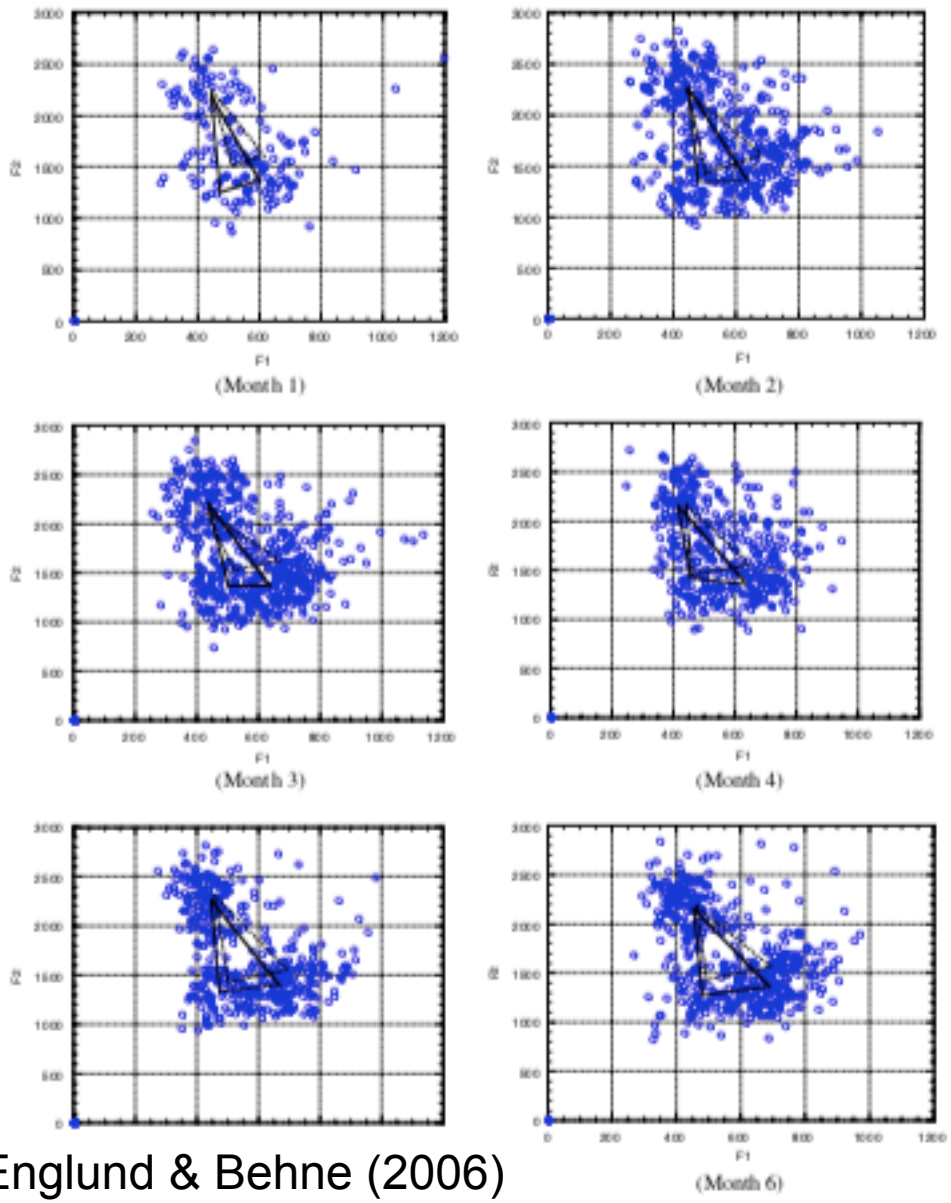
High pitch hinders vowel discrimination.

Trainor & Desjardins (2002)



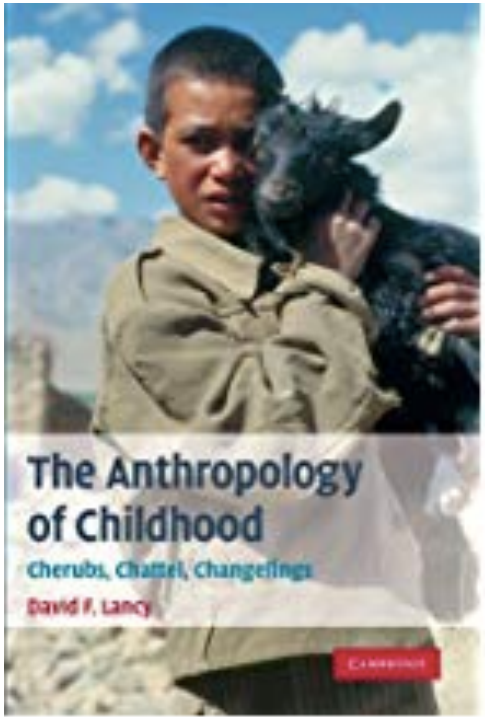
Teaching?

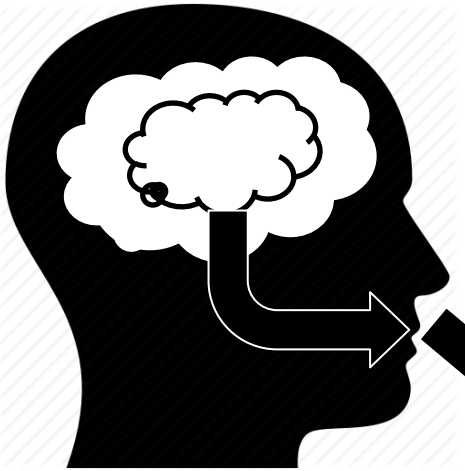
Is Teaching Universal?



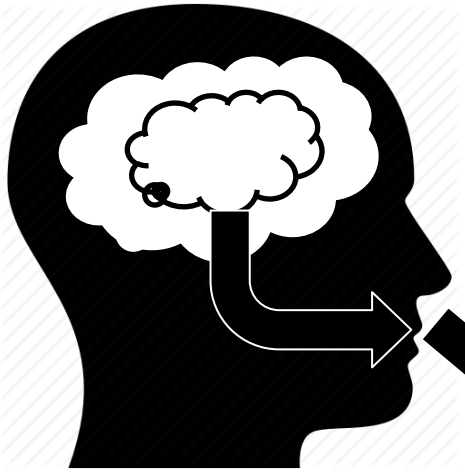
Englund & Behne (2006)

Vowel space expansion in CDS is not universal.





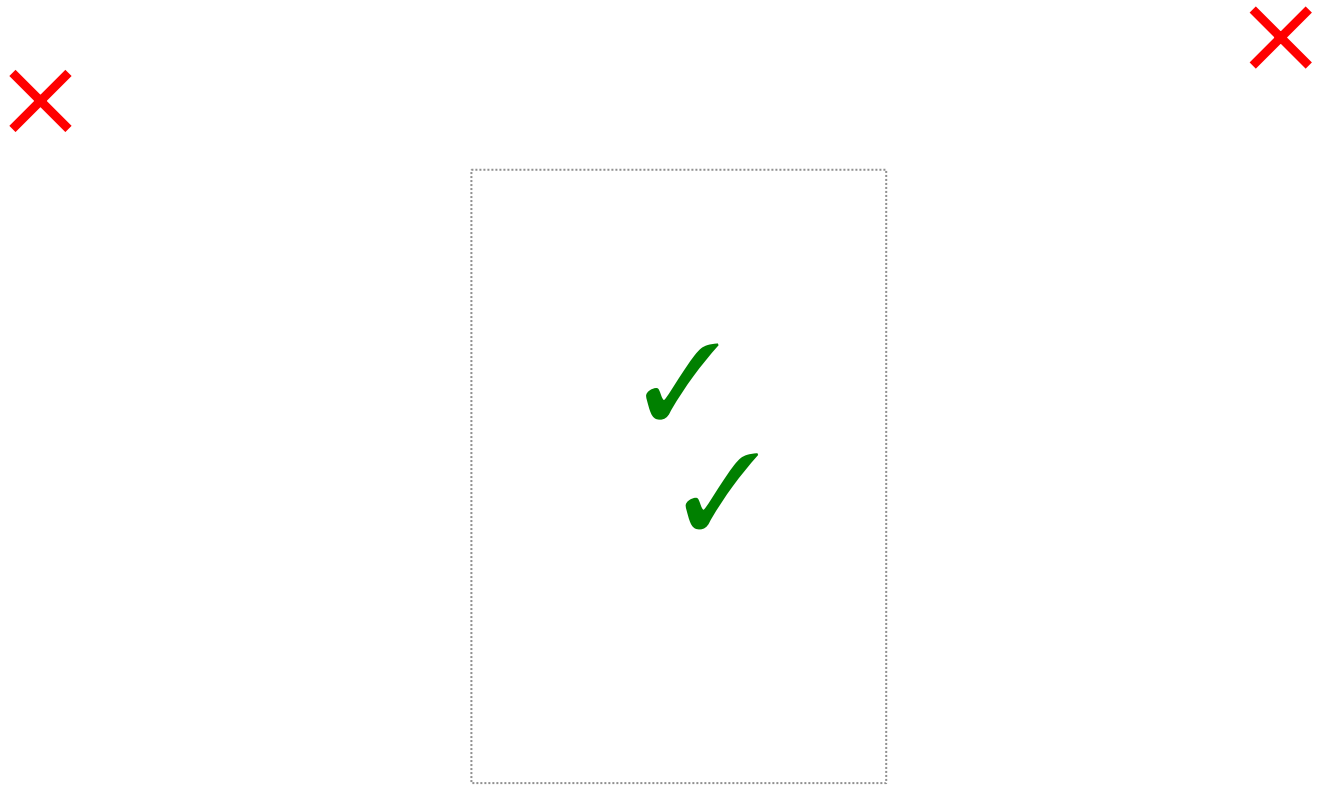
social tolerance	T lets L observe relevant activities
opportunity provisioning	T grants L access to relevant activities
evaluative feedback	T provides positive or negative reinforcement
social/local enhancement	T directs L's attention to relevant aspects of the activity
direct active teaching	T organises access to relevant aspects of the activity



Teaching = behaviour, intentional or not, that promotes learning by narrowing the range of inferences or behavioural options that another individual can pursue (Kline, 2015).

Pedagogical sampling (Shafto & Goodman, 2008), input enhancement.

Teaching as Input Optimisation



Shafto & Goodman (2008)

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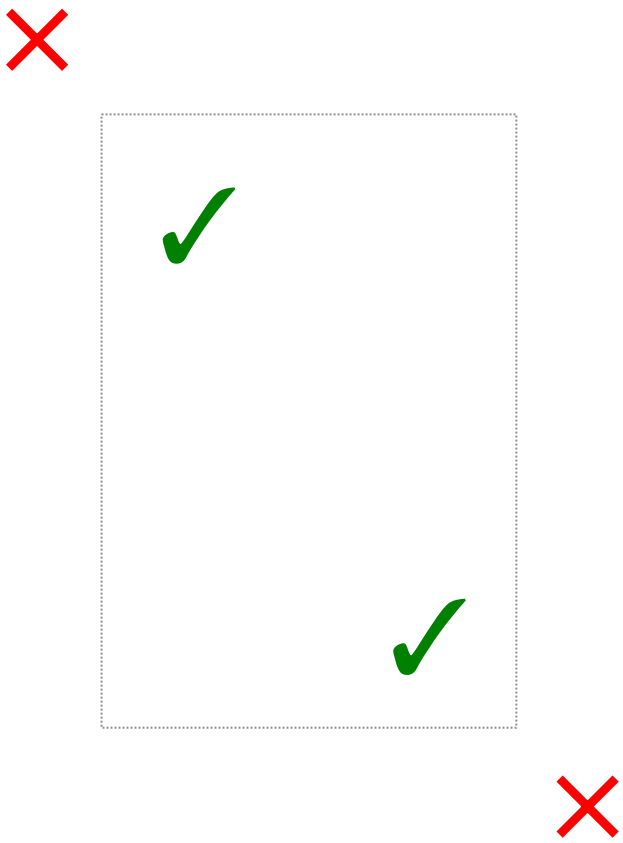

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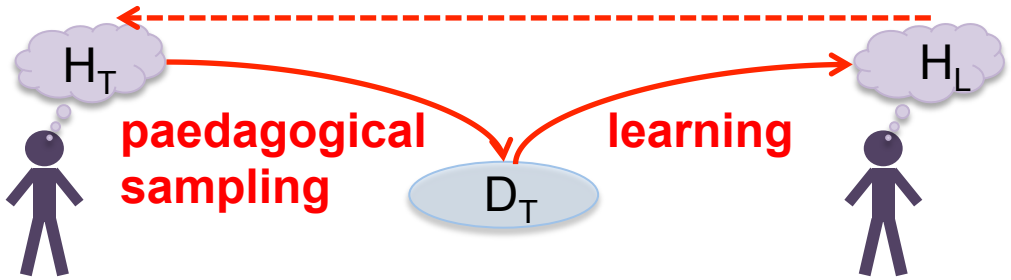
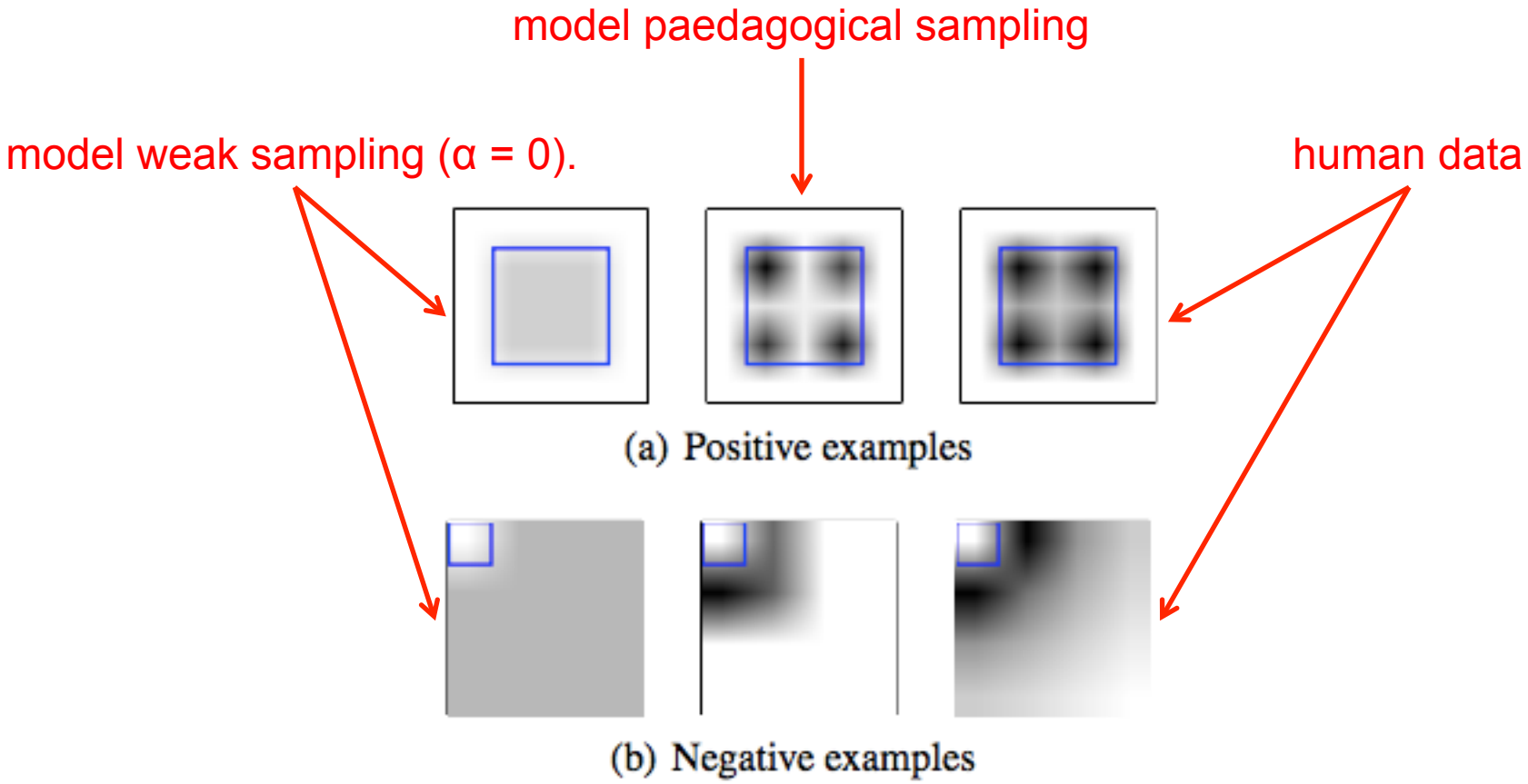


Modelling assumptions:

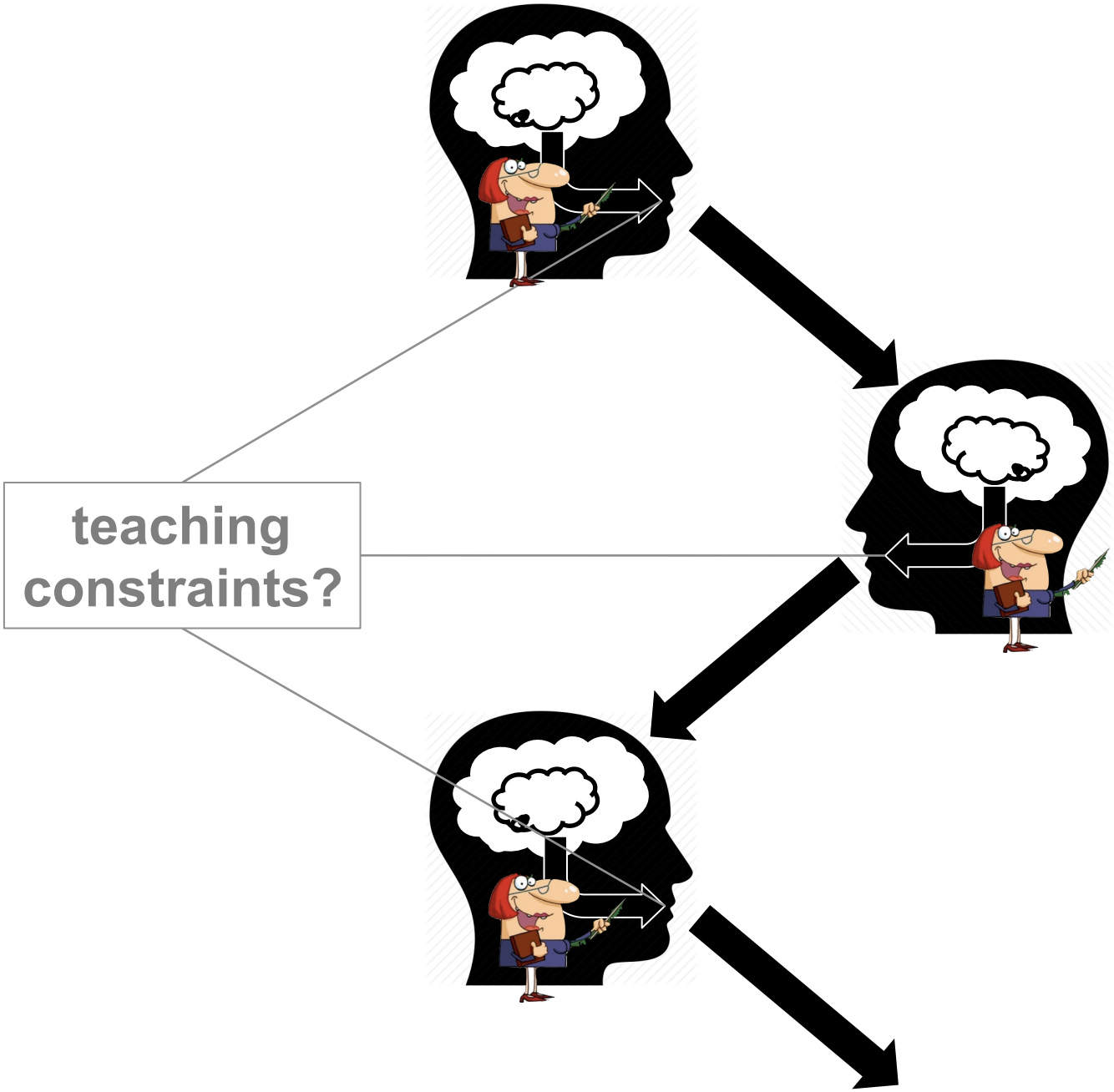
1. Teacher (T) and learner (L) are rational agents who update their beliefs.
2. T assumes that the L will update their knowledge based on the data the teacher provides: $p(H|D)_L \propto p(D|H)_T\, p(H)$
   a) T may also make assumptions about L's prior p(H)
3. L assumes that T will provide data that will help L to arrive at T's H: $p(D|H)_T \propto (p(H|D)_L)^{\alpha}$, where α = degree of goodness of $p(H|D)_L$.
4. Fixed-point iteration (simulating recursive mentalising) to solve this system of equations yields a solution that describes rational paedagogical reasoning.

Shafto & Goodman (2008)

Teaching as Input Optimisation



Shafto & Goodman (2008)


teaching
constraints?

Compare Language Transmission Without and With Teaching

Simple Transmission

- L_n learns language incrementally (2 reps per item)
- L_n gets tested; output copied for learning by L_{n+1}
- 2/8 duplicates withheld to prevent degeneration
- 6 chains of 10 generations each

Teaching

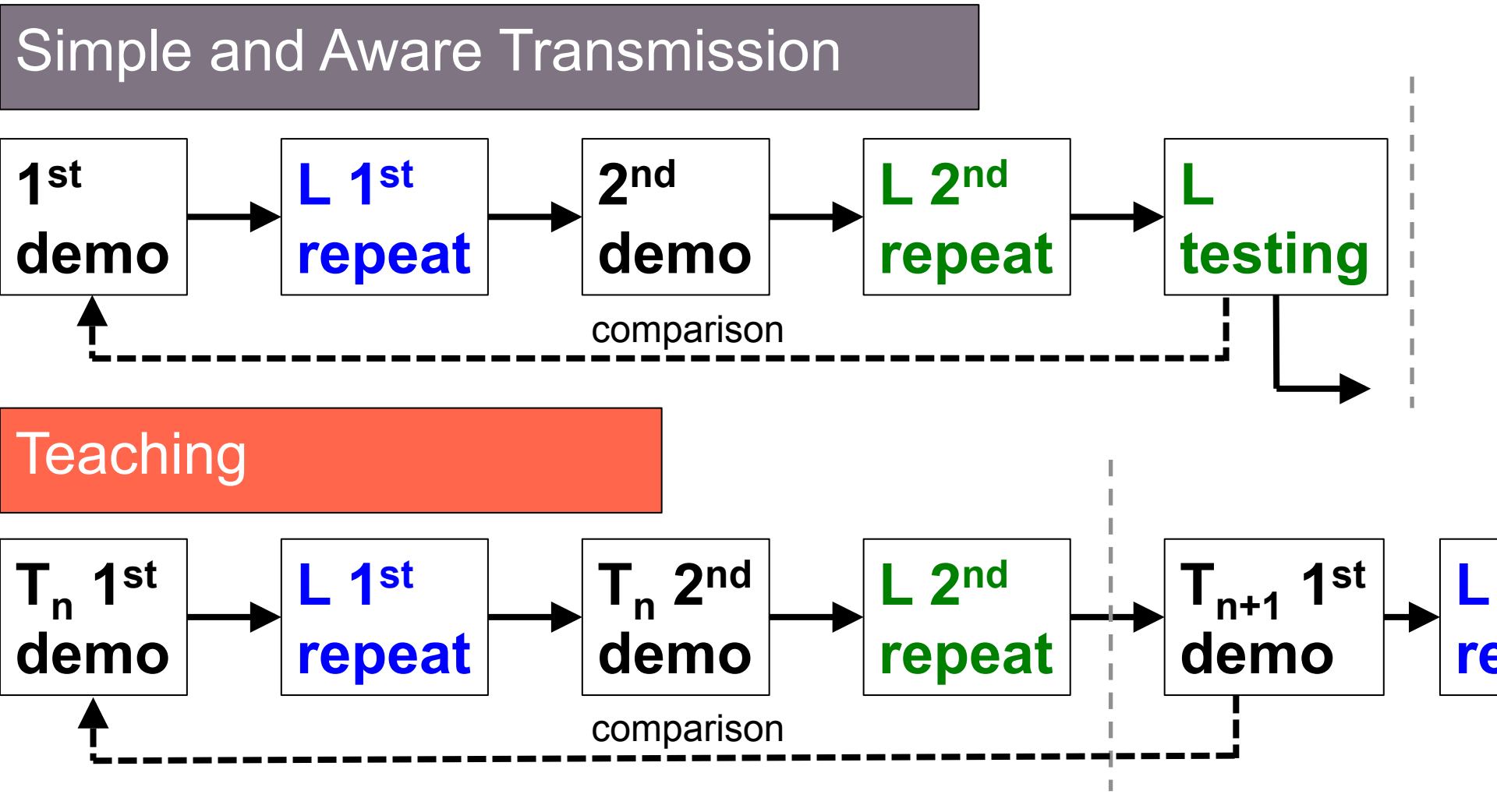
- L_n learns language incrementally (2 reps per item)
- L_n 'teaches' L_{n+1} (no talking!!)

- 6 chains of 10 generations each

Transmission Aware

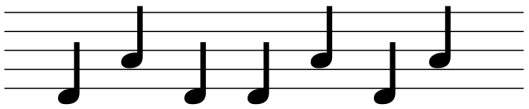
- L_n gets told they are part of a chain
- L_n learns language incrementally (2 reps per item)
- L_n gets tested; output copied for learning by L_{n+1}
- 6 chains of 10 generations each

Procedure



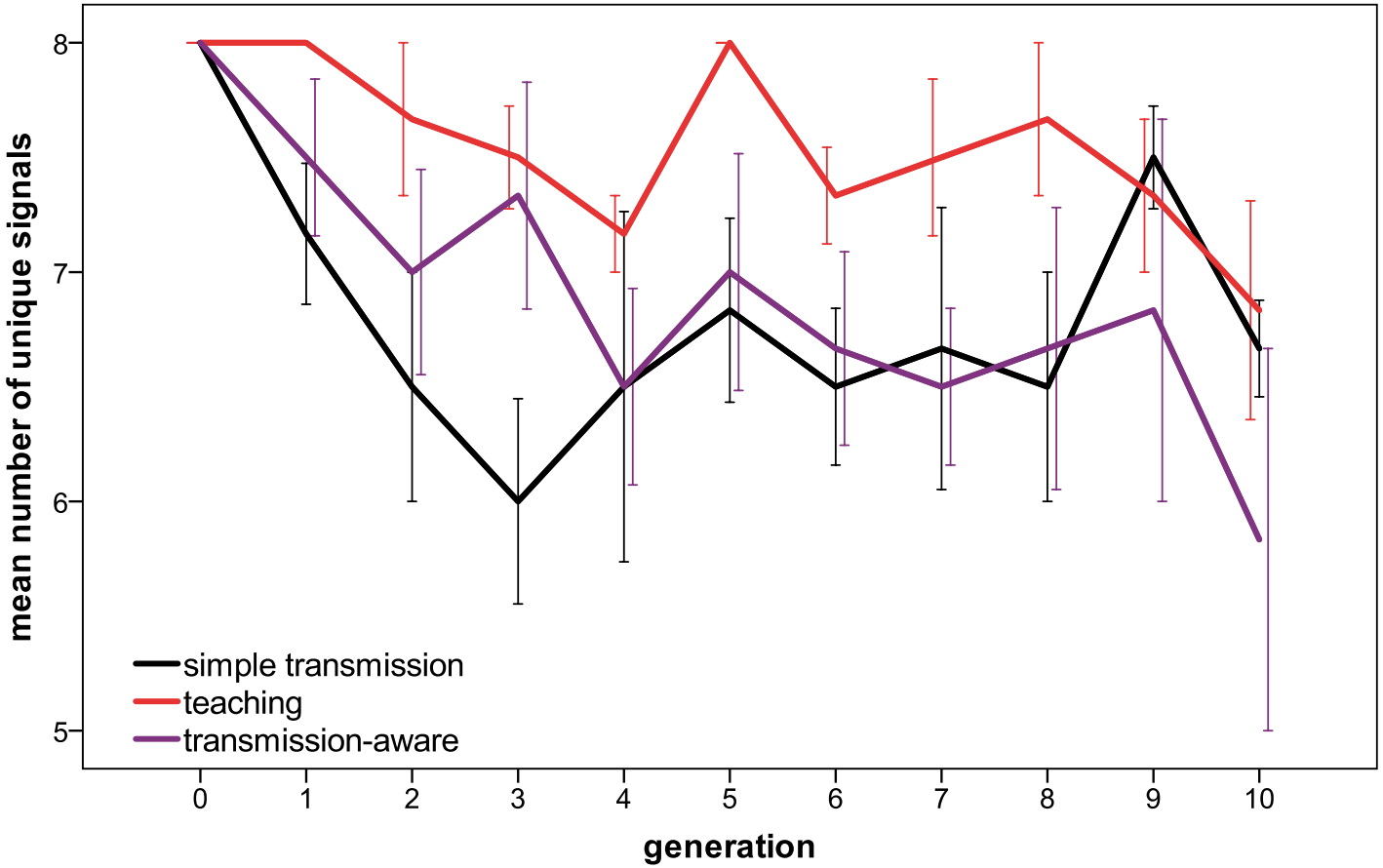
Kempe et al., 2017

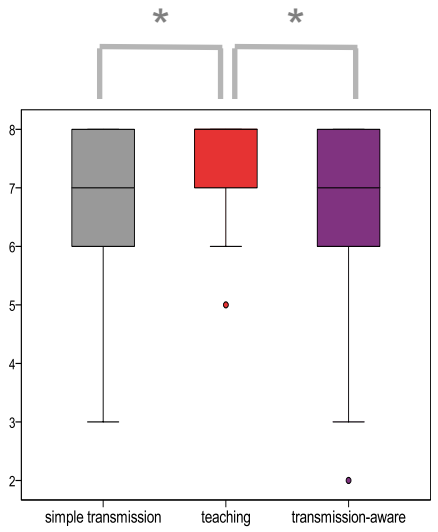
Opportunities for Input Enhancement



- enhanced expressivity?
  - no reduction in number of unique signals
- enhanced learnability?
  - simpler, shorter signals
  - greater fidelity
- enhanced structure?
  - greater compositionality

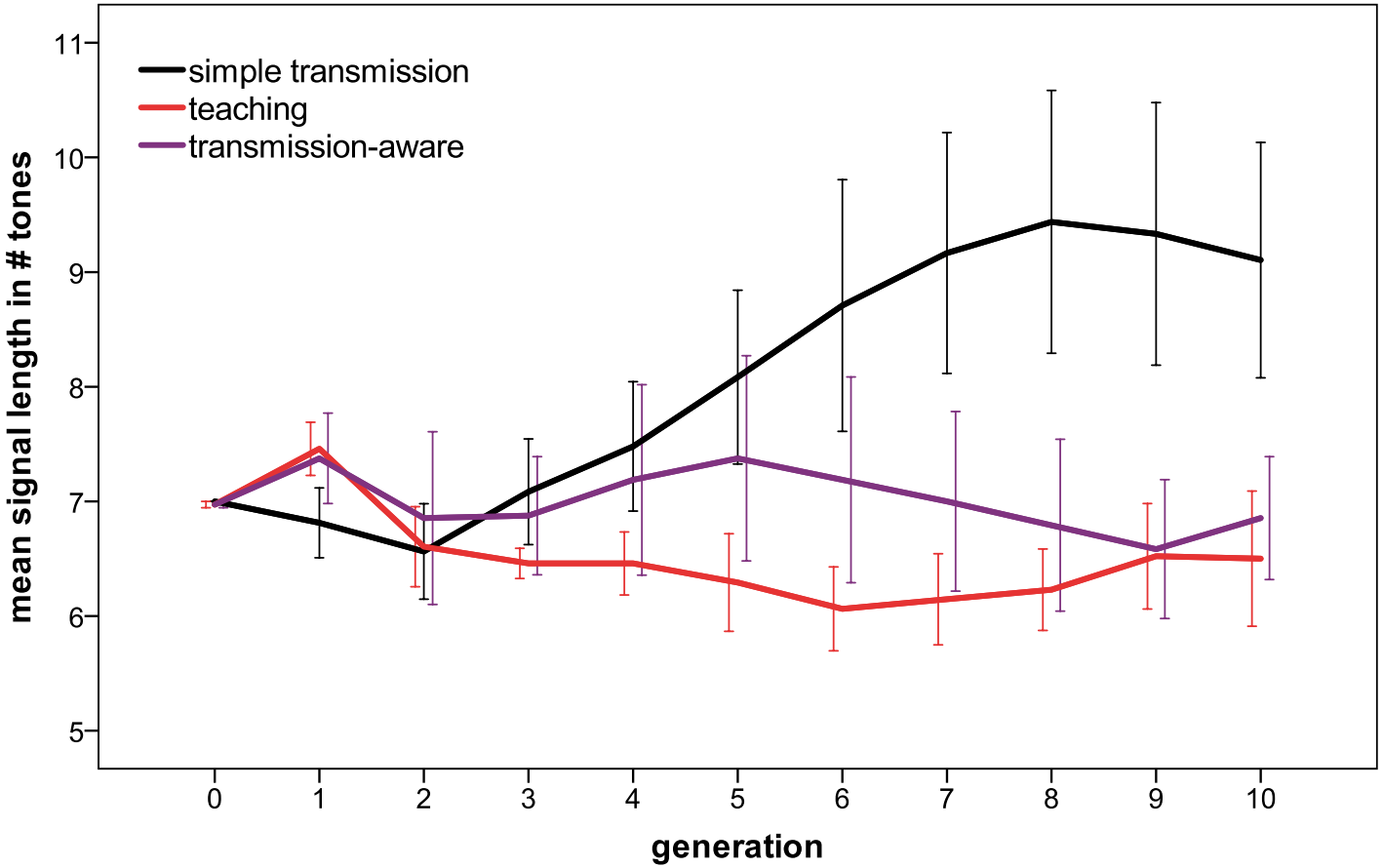
Enhanced expressivity?

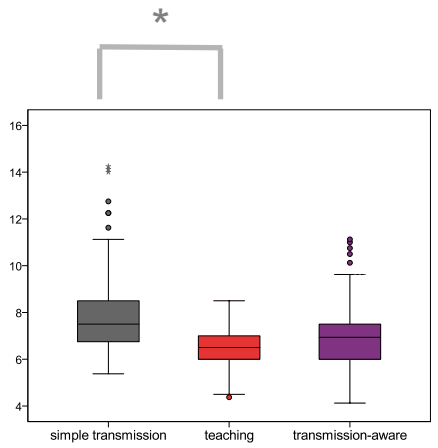




Kempe et al., 2017

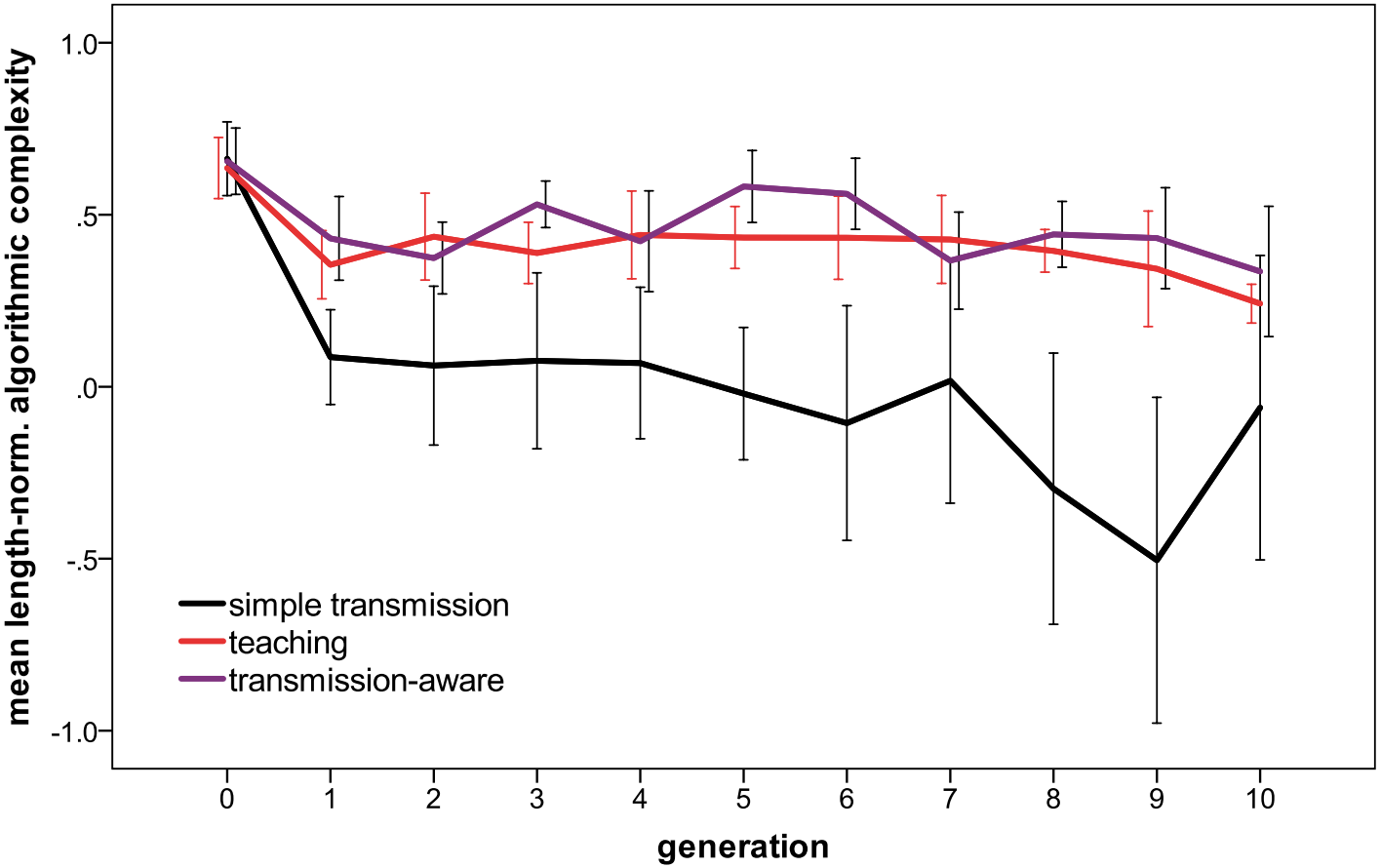
Enhanced signal simplicity?

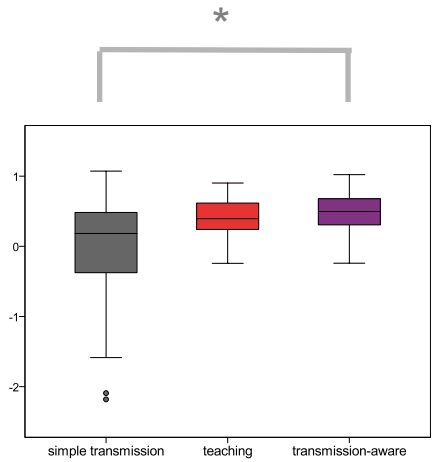




Kempe et al., 2017

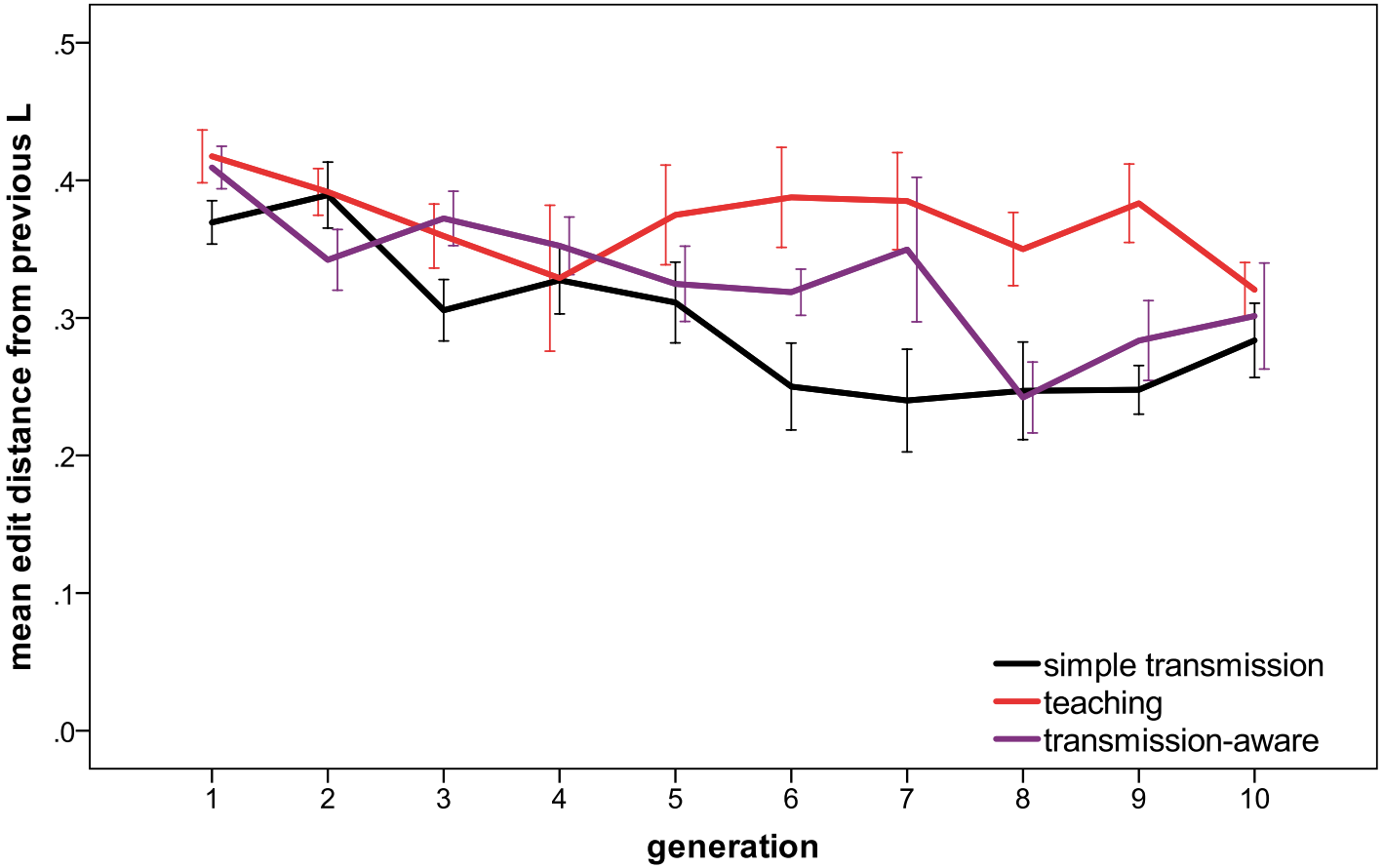
Lower signal complexity?

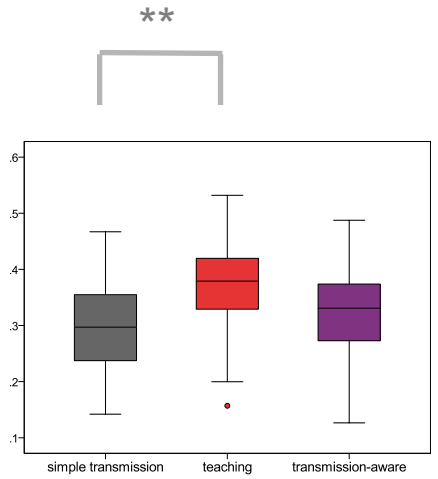




Kempe et al., 2017

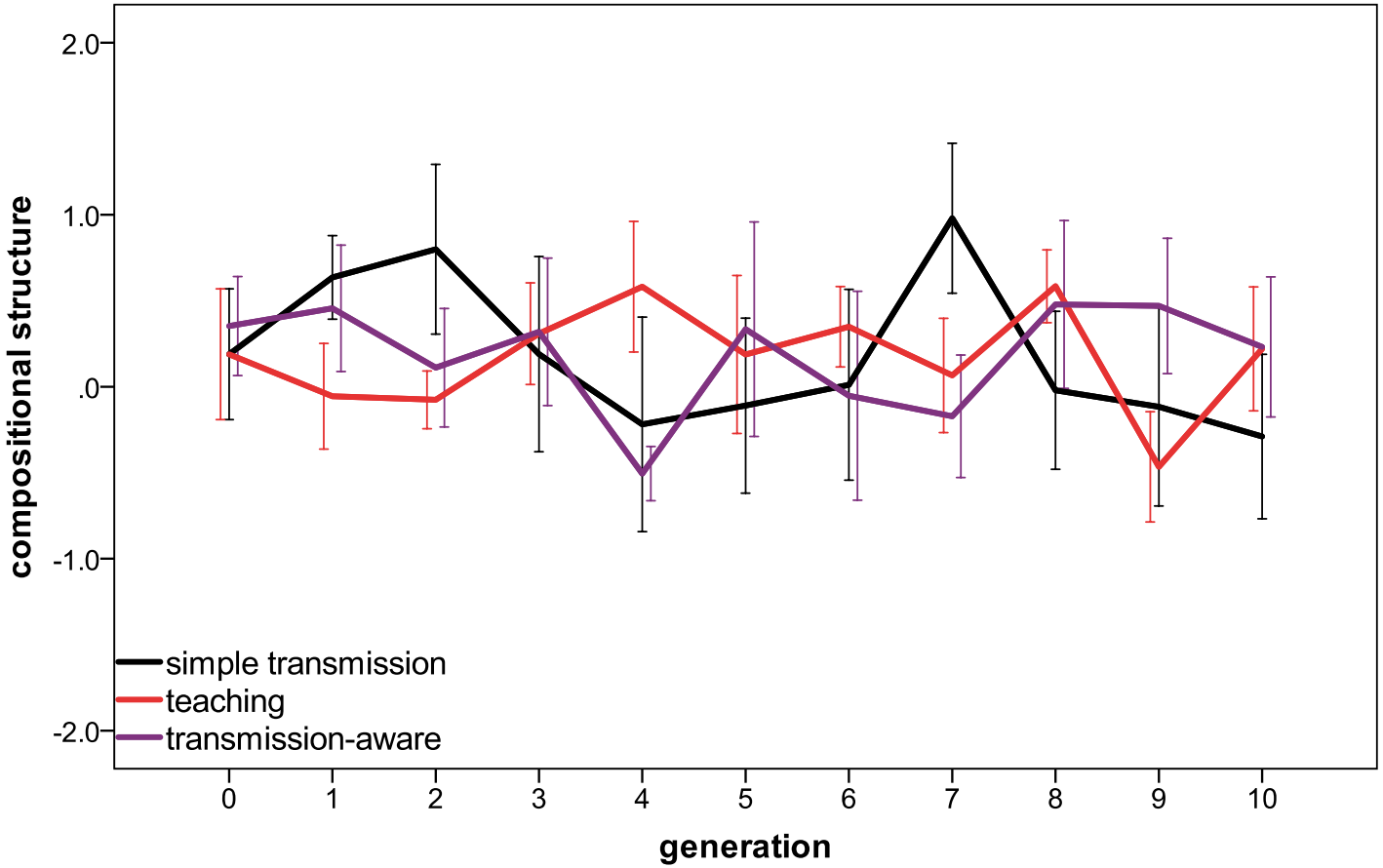
Enhanced learnability?





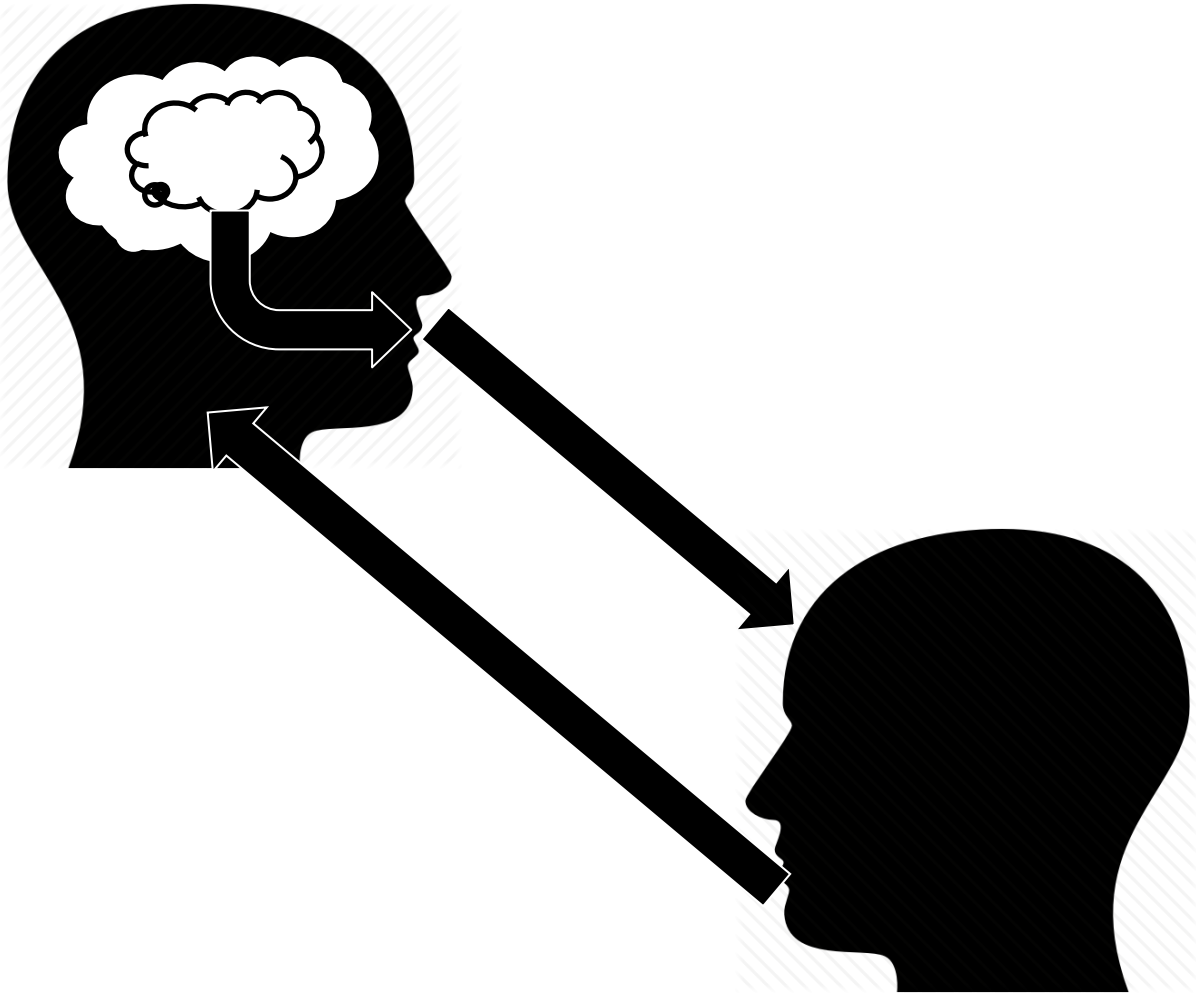
Kempe et al., 2017

No compositional structure ☹

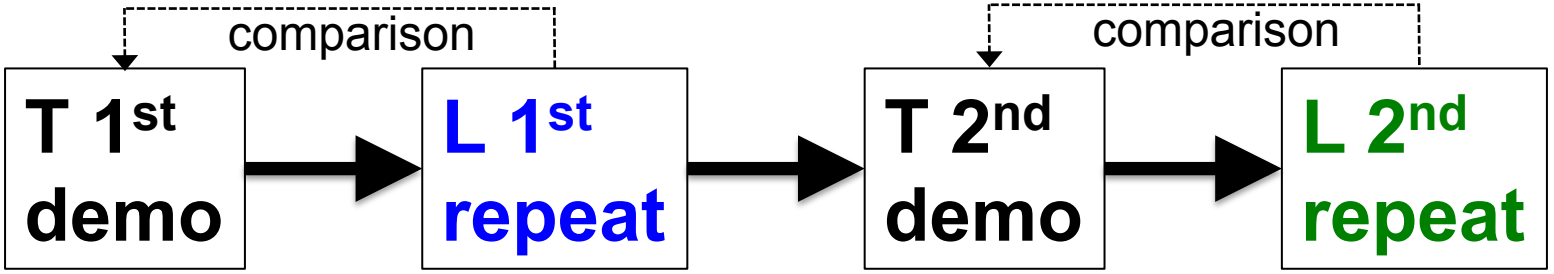


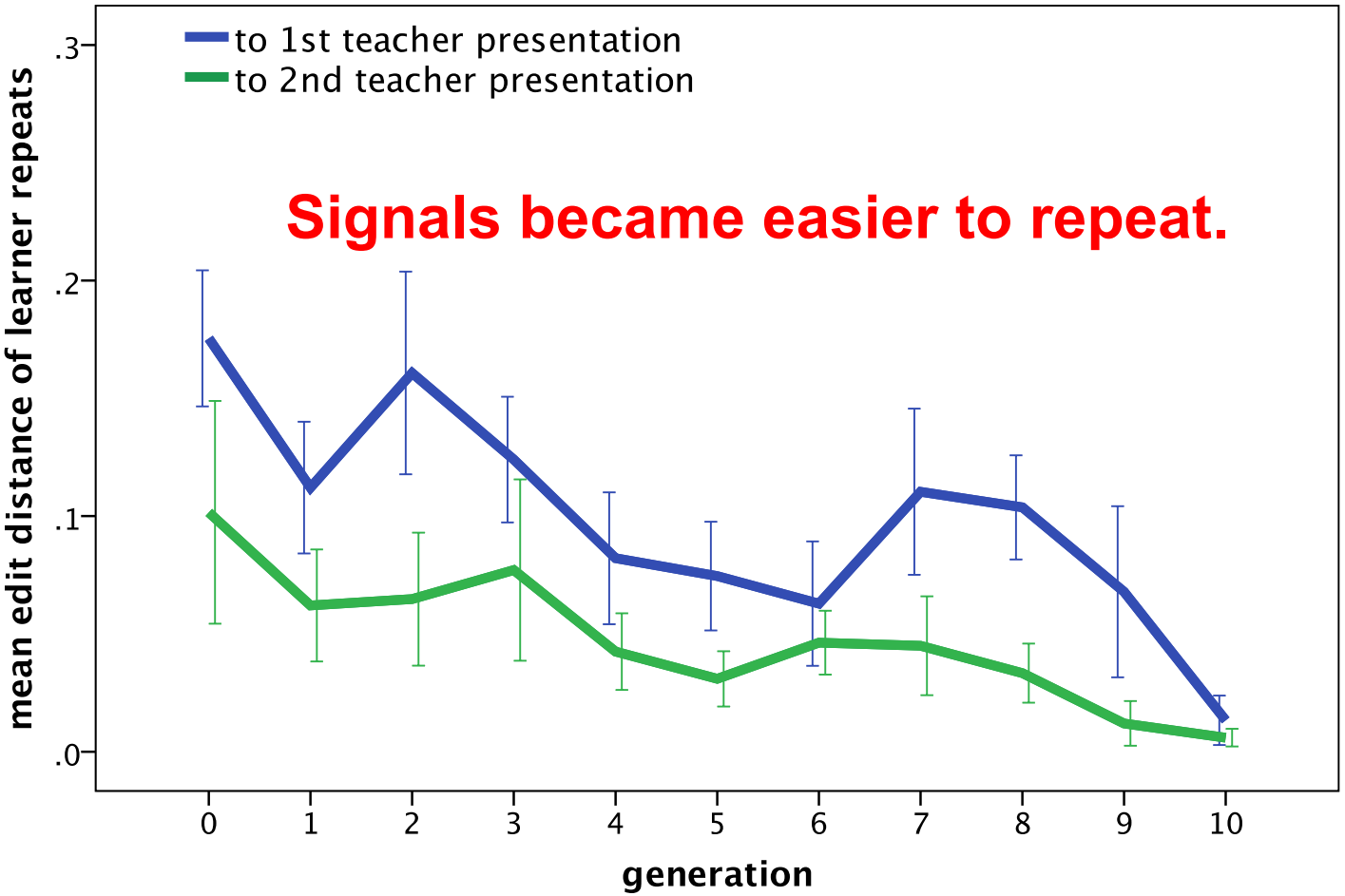
Kempe et al., 2017

Source of Teacher Innovations



Source of Teacher Innovations





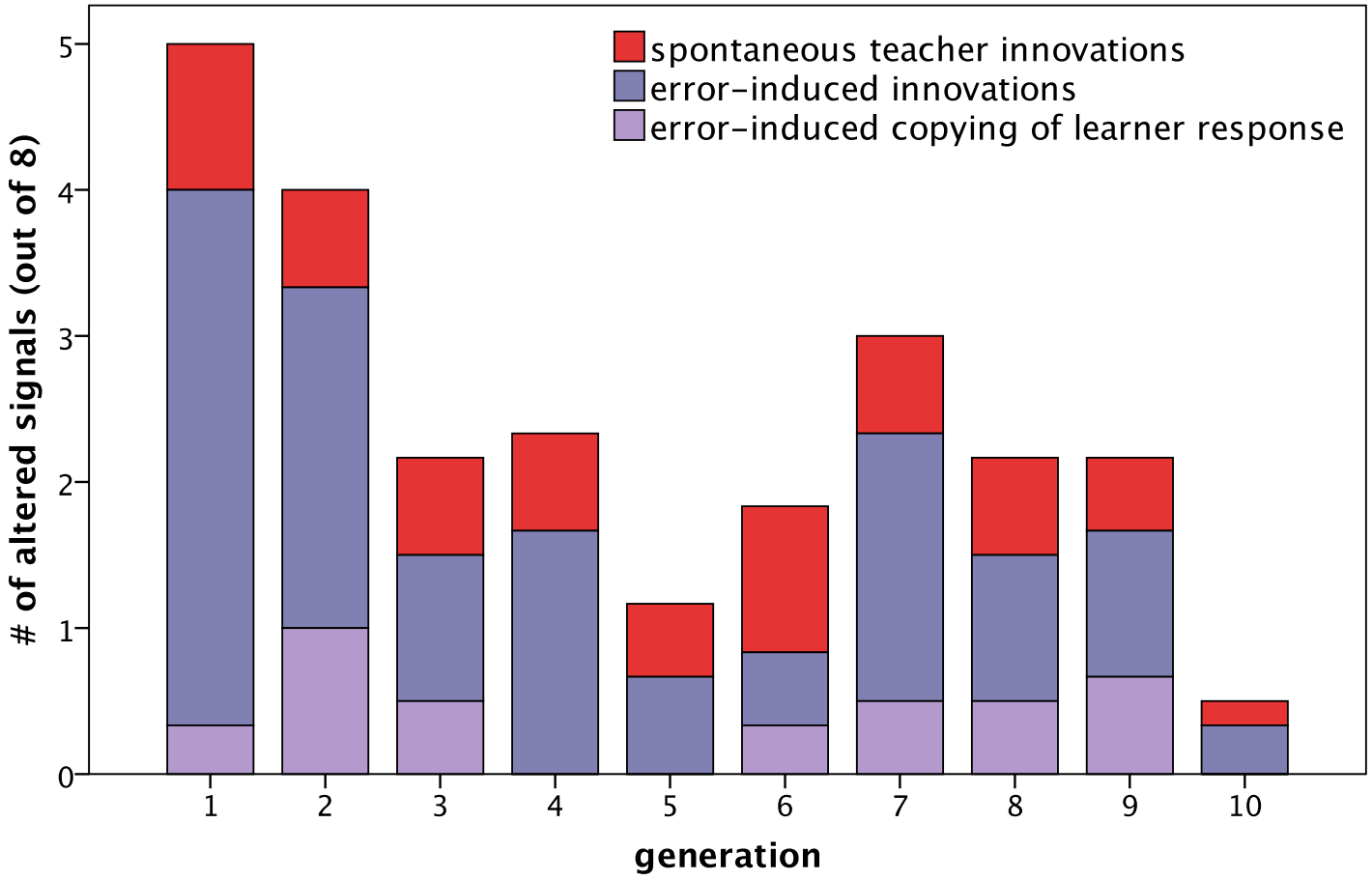
ED to 1st presentation:
Generation
β = -0.01,
t = -3.84, p < .01

ED to 2nd presentation:
Generation
β = -0.01,
t = -3.18, p < .01

Kempe et al., 2017

Teacher Innovations

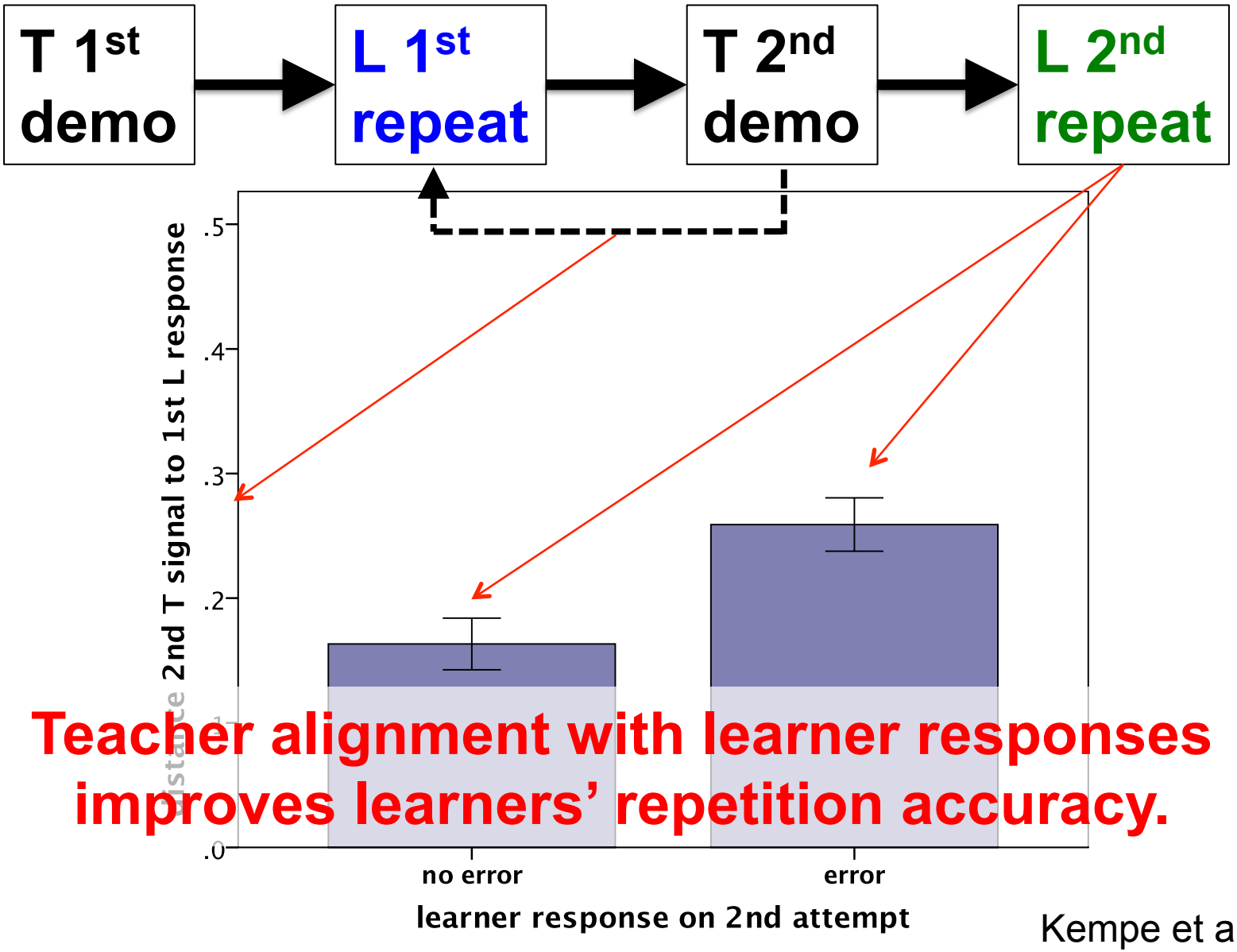
T 1st demo → L 1st repeat → **T 2nd demo** → L 2nd repeat



Most signal changes are triggered by learner errors.

Kempe et al., 2017

Result of Alignment



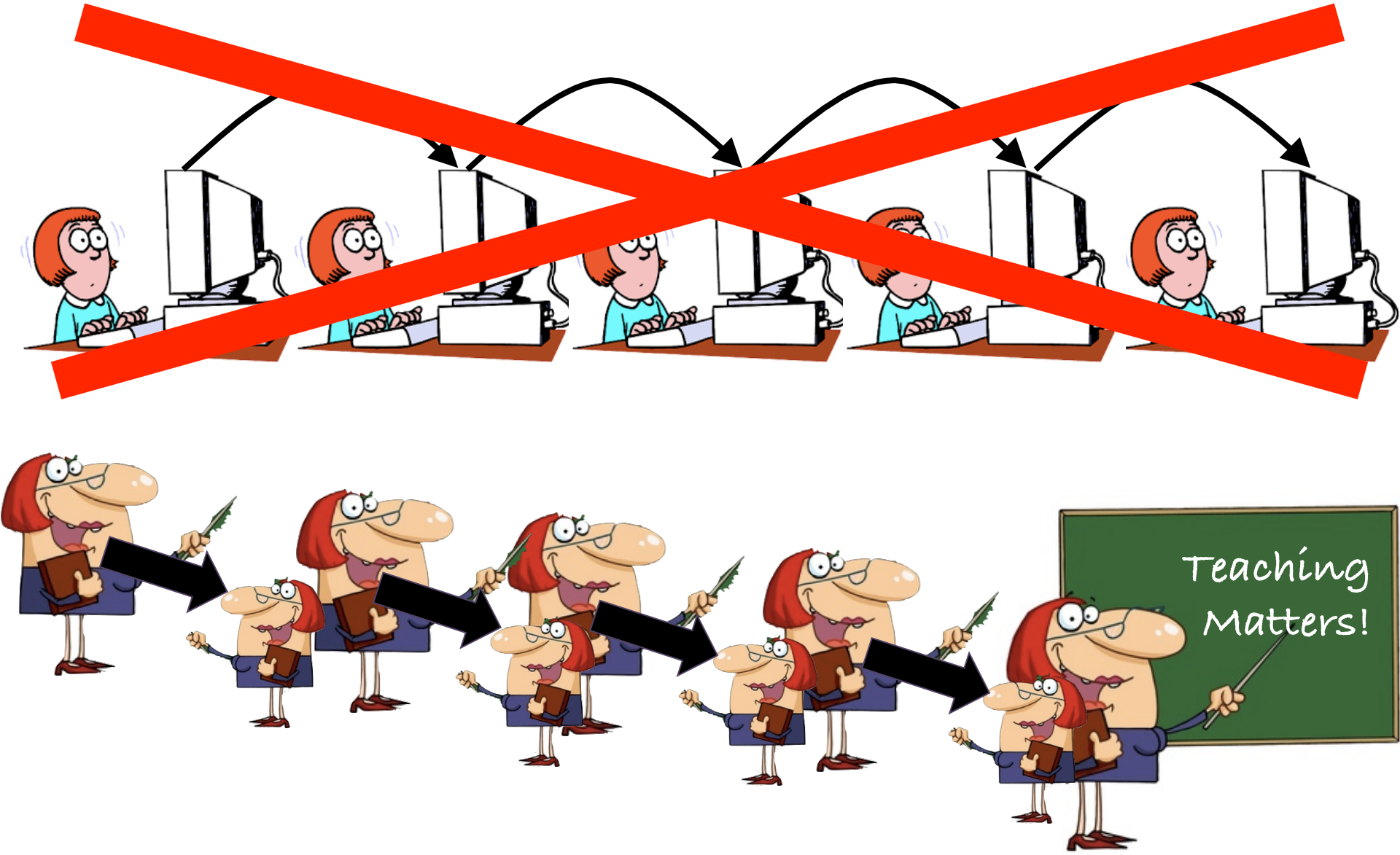
Teacher alignment with learner responses improves learners' repetition accuracy.

Kempe et al., 2017

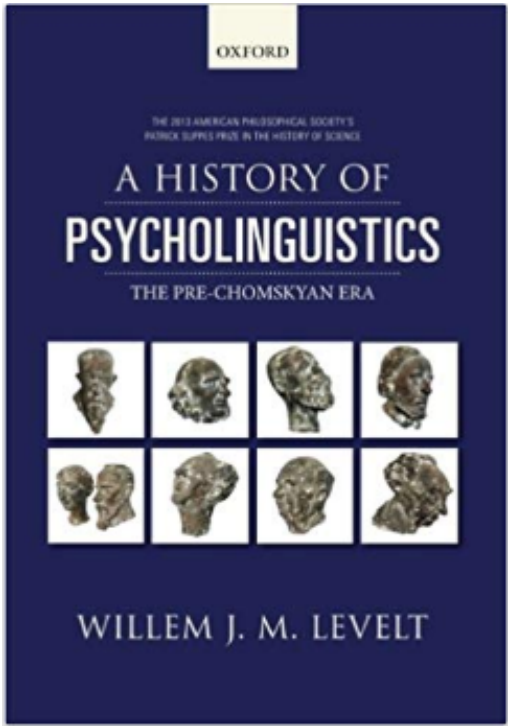
Summary: Teaching

- **Teaching awareness simplifies the output.**
- **Teaching increases expressivity (reduces ambiguity) of the language.**
- **Teacher innovations occur in response to feedback from the learner.**
- **Aligns with developmental data: overlap of maternal with child's speech, but not vice versa, predicts language development** (Che et al., 2018)**.**

Summary: Teaching



In the learning (L) series, the learner repeated the names after his teacher; he did not overtly anticipate his teacher's responses. Each S learned at one sitting and immediately thereafter taught his successor, unless his learning period had occurred at the end of a day. In that case he was again tested on the following day before acting as teacher. If in four recognition (R) series he was unable to name all of the figures as they had been taught to him by his predecessor, I gave him a few L series (usually two were sufficient), using the same pronunciations as those which had been recorded for his teacher. 'Errors' (variations from his learning criteria) which S made as teacher were not corrected; the variations indicated in Table 1 are those taught by the respective Ss to their pupils.

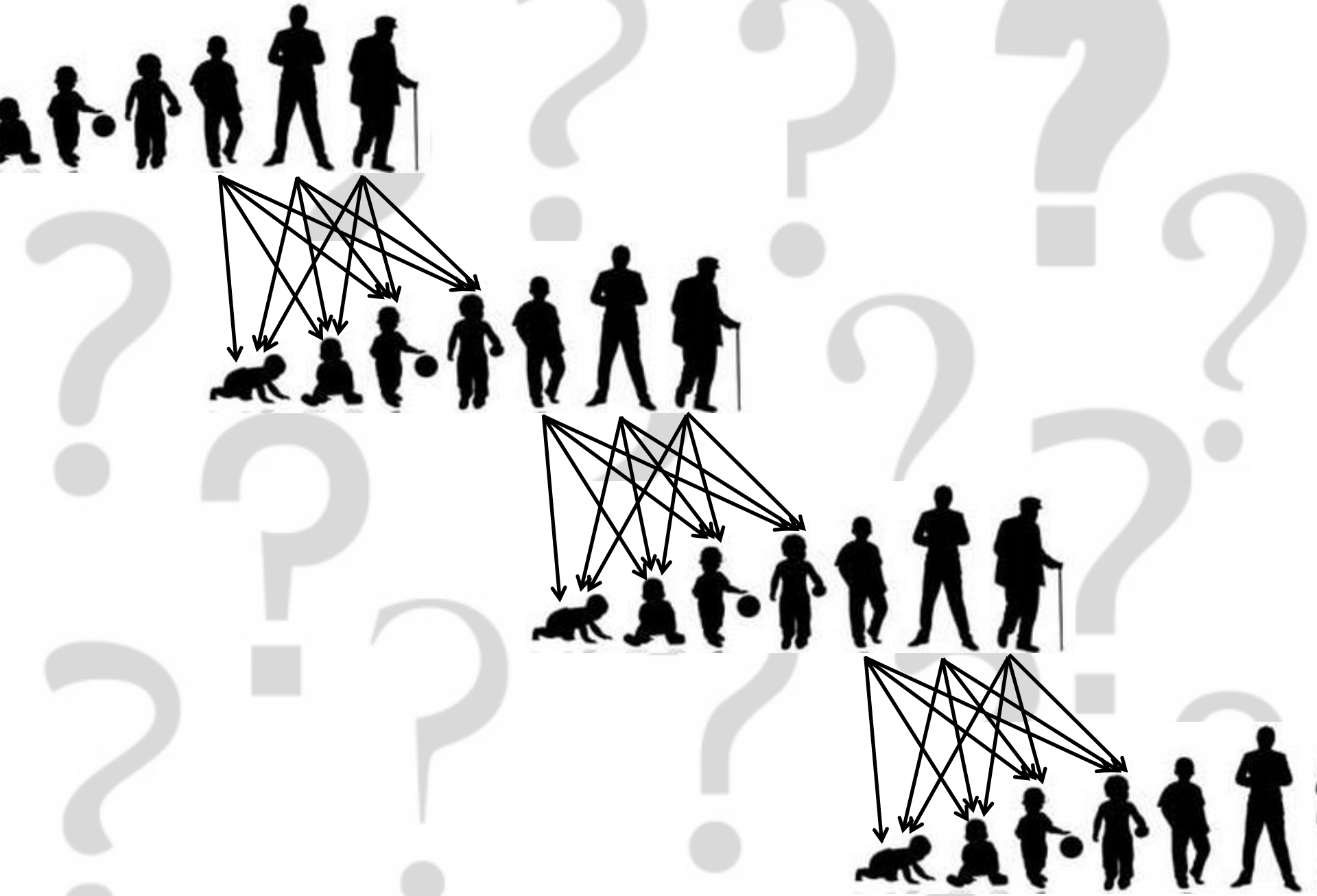


Esper, 1966

1. How is the outcome of iterated learning experiments shaped by constraints imposed by different agents, e.g. children?
2. What can these experiments tell us about the potential role of different agents in language evolution and language change?

- **Iterated learning studies are a promising paradigm to study language evolution and change.**
- **To be generalisable, more factors need to be explored systematically:**
  - **affordances of different signalling domains**
  - **constraints of different learners**
  - **different mechanisms of transmission**

- **To understand language evolution we need to specify the constraints that arise at different stages of cognitive and social development:**
  - **E.g. although children tend to over-use entrenched forms, which leads to both over-generalisation and item-based learning, they hardly innovate systematically to reduce unpredictability.**
- **Future research should integrate iterated language and experimental semiotics studies with research on lifespan development to better understand what may drive linguistic innovation at different stages in life.**



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slides at: https://language.abertay.ac.uk/SSoL2018/