Discovering Phonological Representations: The Case of French Liaison

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Overview

In this talk, we'll:

1. Specify a quantitative theory of how children learn abstract underlying representations (URs)

2. Validate it on the problem of French liaison

Underlying representations (URs) in phonology

- How should we evaluate different UR alternatives?
  - Whether they allow for fewer/simpler rules? Similarity to surface representations (SRs)?

- Useful insight can come from language acquisition

- E.g. Alternation Condition (Kiparsky, 1968)

Alternation Condition

- Ensures that features of SRs that are always the same are also the same in the UR and features that are always different are also different in the UR

- Motivated by greater learnability

- Difficult to to verify without quantitative theory for how easily a child could learn different URs

Proposal of UR discovery

- The Surface True Hypothesis (STH)
- Big idea: Children will not posit abstract URs unless **necessary**
- Starting rule: URs are identical to SRs
- Quantification of necessary: Too many alternations to be tolerable to the rule, as defined by the Tolerance Principle (TP; Yang, 2016)

Reformulation of an old idea

- Alternation Condition: restricts URs from being too different from SRs
- Faithfulness constraints of OT
- Invariant Transparency: learners will project SRs into URs unless there’s an alternation to account for (Ringe & Eska, 2013)

Quantification of abstract UR discovery

- When will children posit abstract URs that are different from SRs?

→ With enough evidence of an alternation

What counts as evidence?

→ Multiple phonological representations for the same concept

How do we define enough?

→ Tolerance Principle (TP; Yang, 2016)

What is French liaison?

a. un ami
ãe nami
a friend

b. les ami
le zami
the friends

c. petit ami
pəti tami
little friends

d. joli ami
ʒɔli ami
pretty friend

- Prepending a consonant to a vowel-initial word in specific syntactic and lexical contexts
- Obligatory (vs optional): ungrammatical not to produce liaison in these contexts (80.45% of realized liaisons are obligatory; Meinschaefer et al., 2015)

Why French liaison as a case study?

- Empirical evidence of different stages of liaison acquisition during which children have different URs

- Debate over whether linguistic representations of liaison are phonological or morphological (e.g. Tranel, 1981; Encrevé, 1988; Smolensky & Goldrick 2016 vs. Klausenburger 2001; Storme 2024)

    → Acquisition account can weigh in on this debate

Empirical stages of French liaison acquisition

	Stage 1	Stage 2	Stage 3
Age	Before ~2 years	~2 – ~4 years	After ~4 years
Description	• Heard [nami] so word must be /nami/ • Lexically/consonant-specific	• Heard [nami] but word could be /nami/ or /ami/ (or /tami/) • Know liaison forms are related	• Learning a phonological rule for liaison • Abstract liaison representation
Evidence	• 20-month-olds do not recognize vowel-initial nonce words in isolation after hearing them in liaison contexts	• 24-month-olds recognize the vowel-initial nonce words in isolation • 30-month-olds quickly recognize both frequent liaison forms + vowel-initial form for a word in non-liaison contexts	• Regularization errors on words like “nombril”: produce “zombril” in /z/-liaison context
Study	Babineau & Shi, 2014	Babineau & Shi, 2014; Babineau et al., 2021	Chevrot et al., 2009

Models of acquisition

- Constructionist (Chevrot et al., 2009; Nicoladis & Paradis, 2011)
  - Memorize chunks of speech and segment them based on transition probabilities
  - Transition probabilities favor consonant-initial segmentation for liaison-participating words because of French CV-dominance
  - Segmentations can be inserted into the X slot of “schemas”
  - Example schema: les + X

Construction model stages

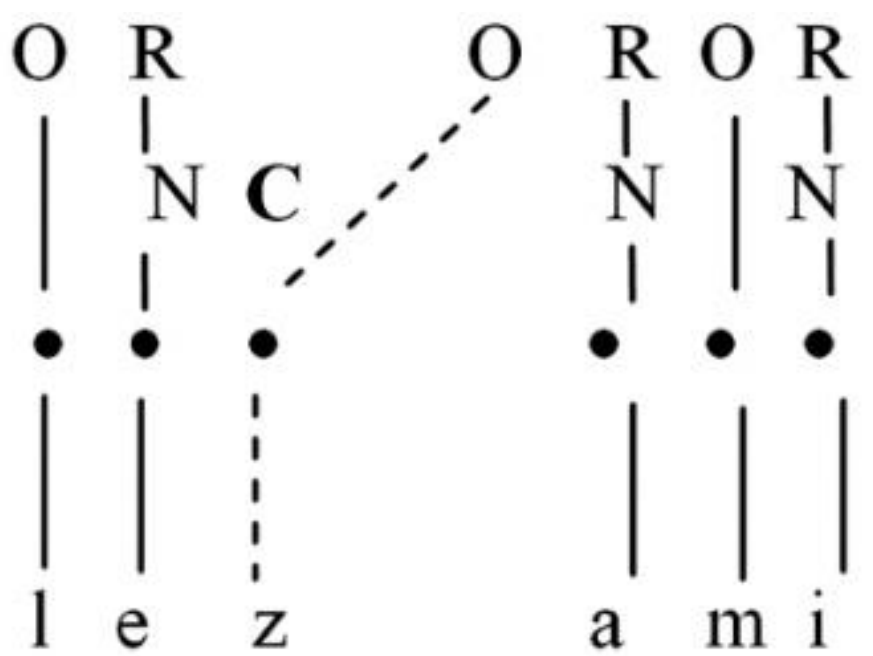
	1st stage	2nd stage
Age	2-4 years	4-5 years
Description	Only have general schema	Construct liaison-specific schema
Example schema	les + X	les + z/X/ z/X/ = /z/-initial phonological variant

- Does not predict regularization errors
  - Explanation is that regularization errors are due to analogy to liaison allomorphs
  - Need a theory of learning by analogy to verify this

- Does not explain why 1st and 2nd stage transition occurs at 4 years

Models of acquisition

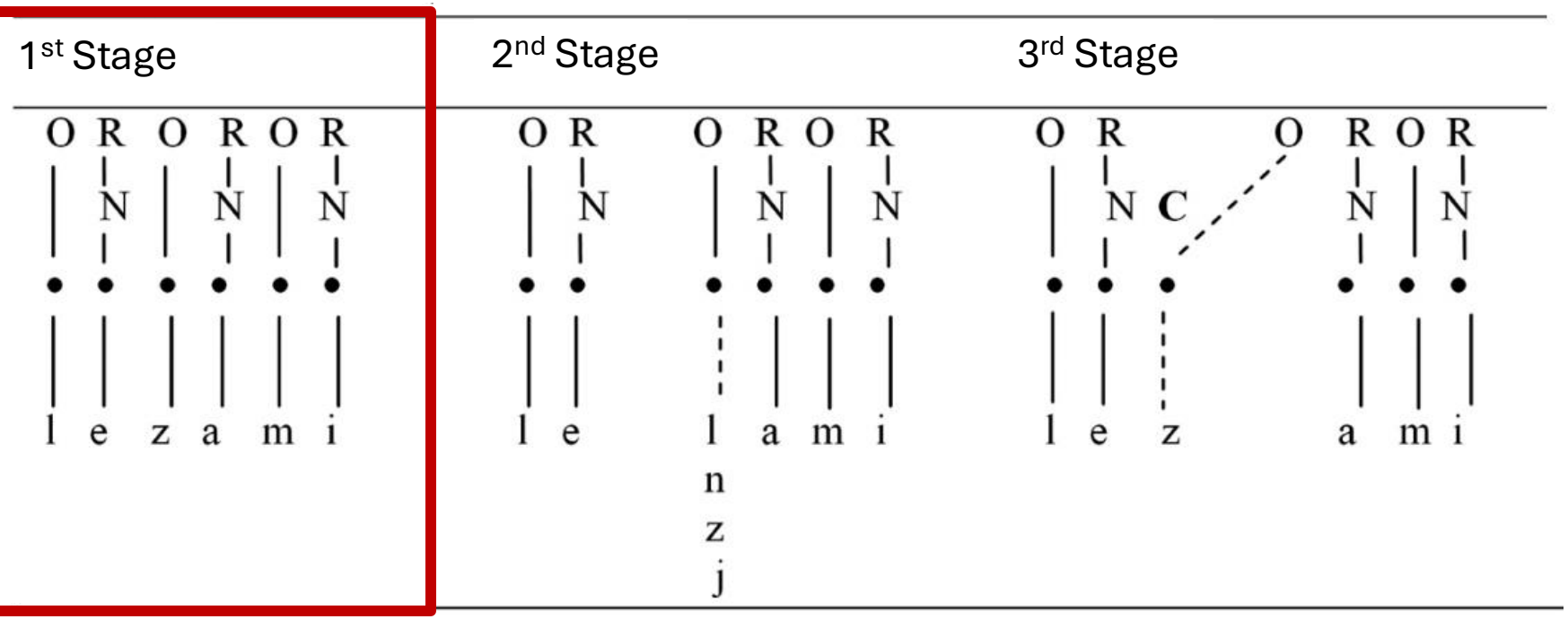
- Phonological (Wauquier-Gravelines & Braud, 2005; Wauquier, 2009)
  - Multilinear URs
  - Liaison consonant in coda of liaison-triggering word becomes anchored to onset position of vowel-initial word



Syllable tier

Segmental tier

Phonological model stages

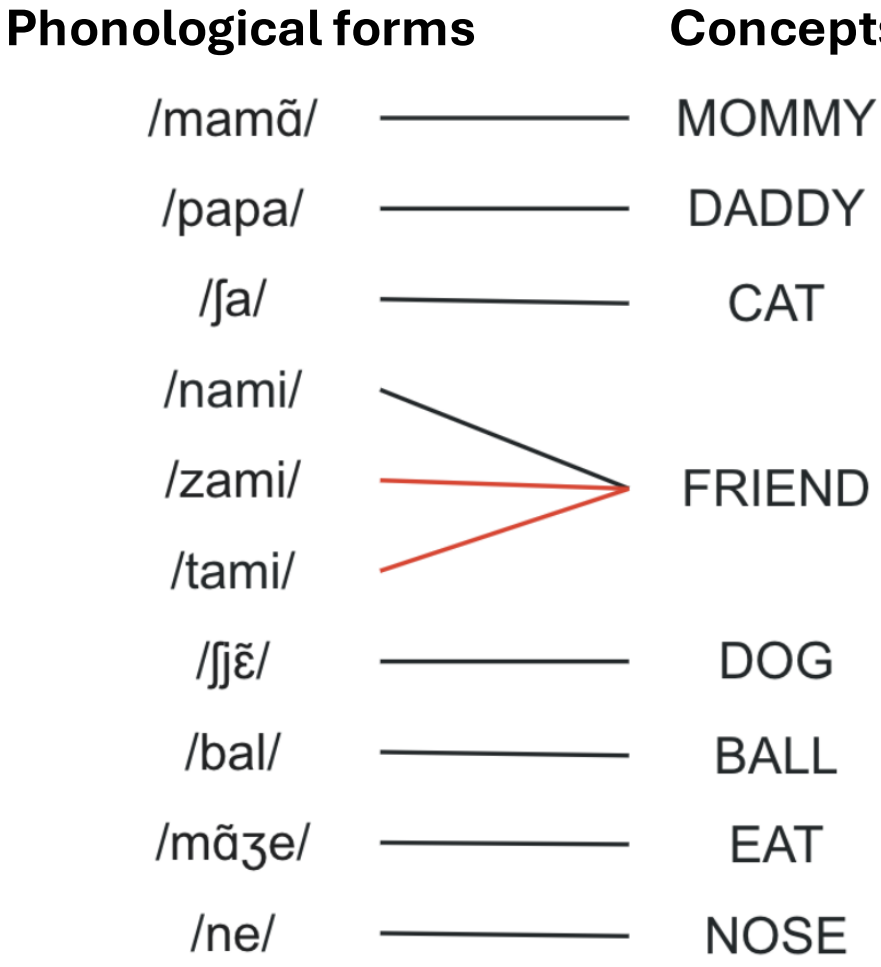


From Chevrot et al. 2013

Consistent with STH!

- Does not predict when children will transition between stages

Applying our proposal to liaison

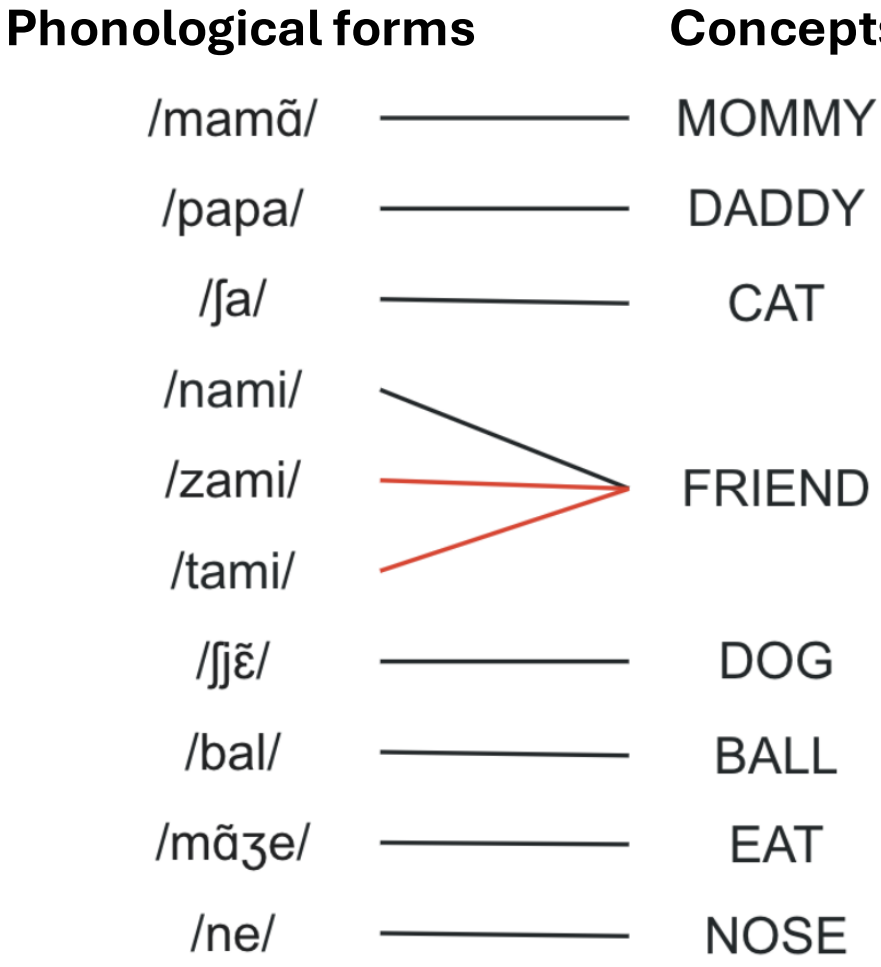


Model depends on:

- Ability to tell whether words are the same or different from words already in the lexicon (i.e. essentially lemmatize)
  - Empirical evidence of this: Infants as young as 6 months old can relate inflected nonce words to their stems

(Shi & Cyr, 2008; Marquis & Shi, 2012; Mintz, 2013; Kim & Sundara, 2021)

Applying our proposal to liaison



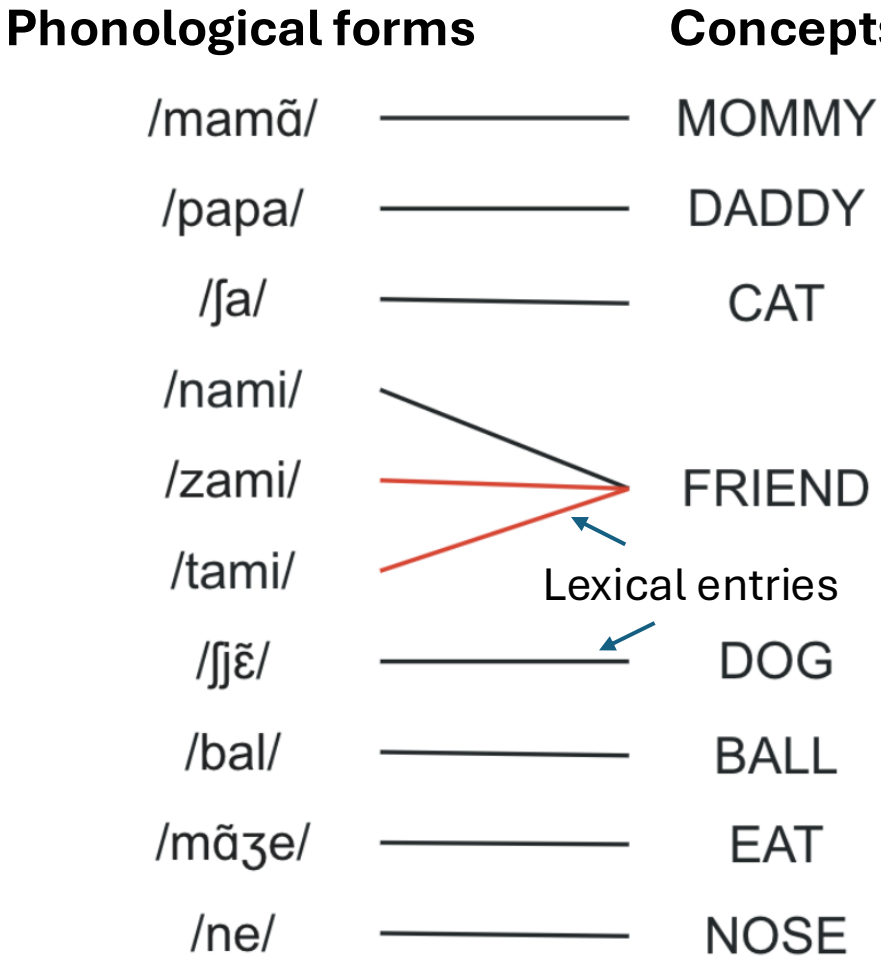
- STH encoded as 1-to-1 mapping constraint on phonological form to concept mappings
- Multiple liaison forms result in many-to-1 mappings
  - Empirical evidence that children expect 1-to-1 mappings: Infants have mutual exclusivity bias (against many-to-1 mappings)

(Markman et al., 2003; Halberda, 2003)

  - Phonological similarity makes storing liaison forms even more difficult

(Swingley & Aslin, 2007)

Applying our proposal to liaison



What counts as evidence against the STH?

- Exceptions (e): Additional phonological forms beyond the first for any lemma, =2 for this example

How much evidence is enough evidence to reject the STH?

- When the e > TP threshold (N/ln(N))
- N = number of lexical entries (phonological form to concept mappings) = 10 for this example lexicon
- 2 < 10/ln(10) ≈ 4 → don't reject STH

Simulation of French liaison acquisition

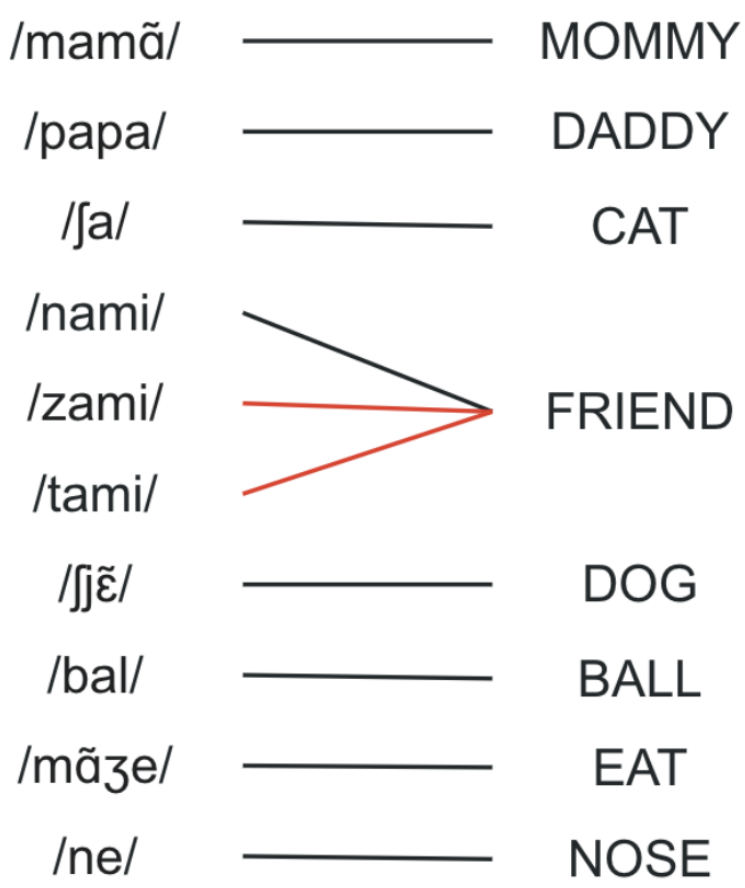
- To answer the question: How many words does a French-learning child need in their (receptive) vocabulary to abandon the STH?

- Sampled words from the top 1000 most frequent words across15 French CHILDES (MacWhinney, 2014) corpora
  - Word frequency is a good predictor of a word's age of acquisition

  (Braginsky et al., 2016; Swingley & Humphrey, 2018; Braginsky et al., 2019)

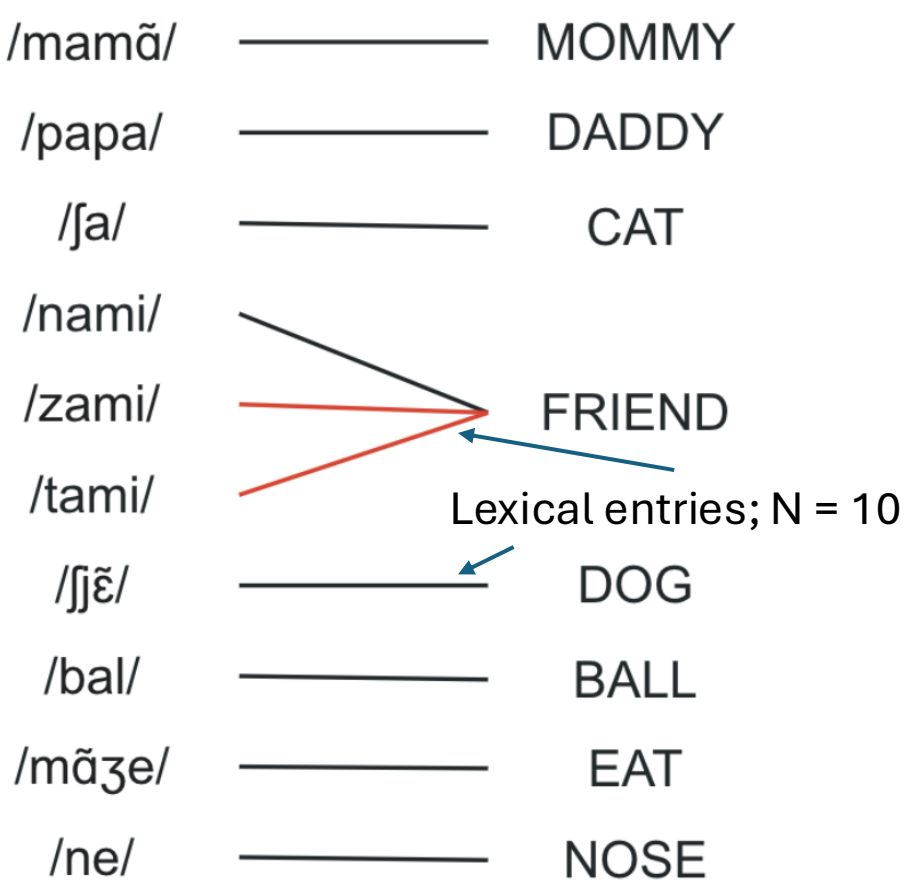
Simulation of French liaison acquisition

- Sampled W words until we had M lemmas (W ≥ M)
- Checked transcript bigrams of any of the W words for obligatory liaison conditions
  - E.g. sampling “un” and “ami” would result in adding /nami/
  - Also sampling “les” would give us /zami/, resulting in a STH exception



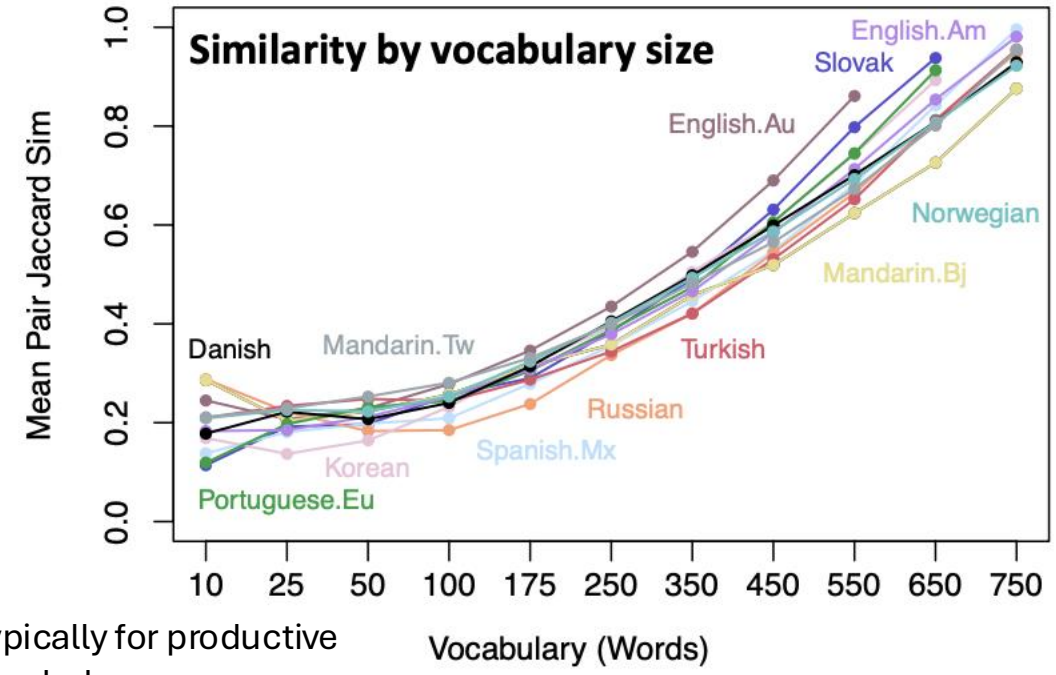
Simulation of French liaison acquisition

- Built 100 lexicons for each of M lemmas
- M-sized lexicons have different numbers of lexical entries (N) depending on the number of liaison forms
- Calculated proportion of lexicons for which we exceed the TP threshold based on their value of N



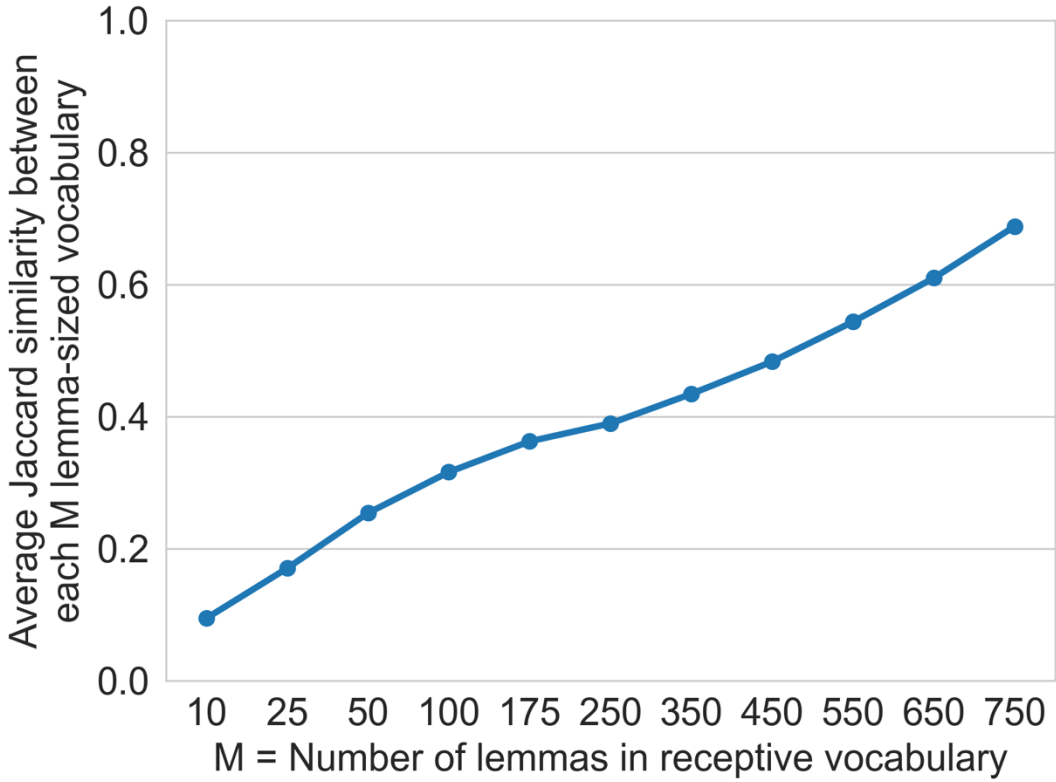
Validation of the sampling procedure

Reference Jaccard similarity on children's vocabularies estimated via CDI-checklists* (from Richter, 2021a)

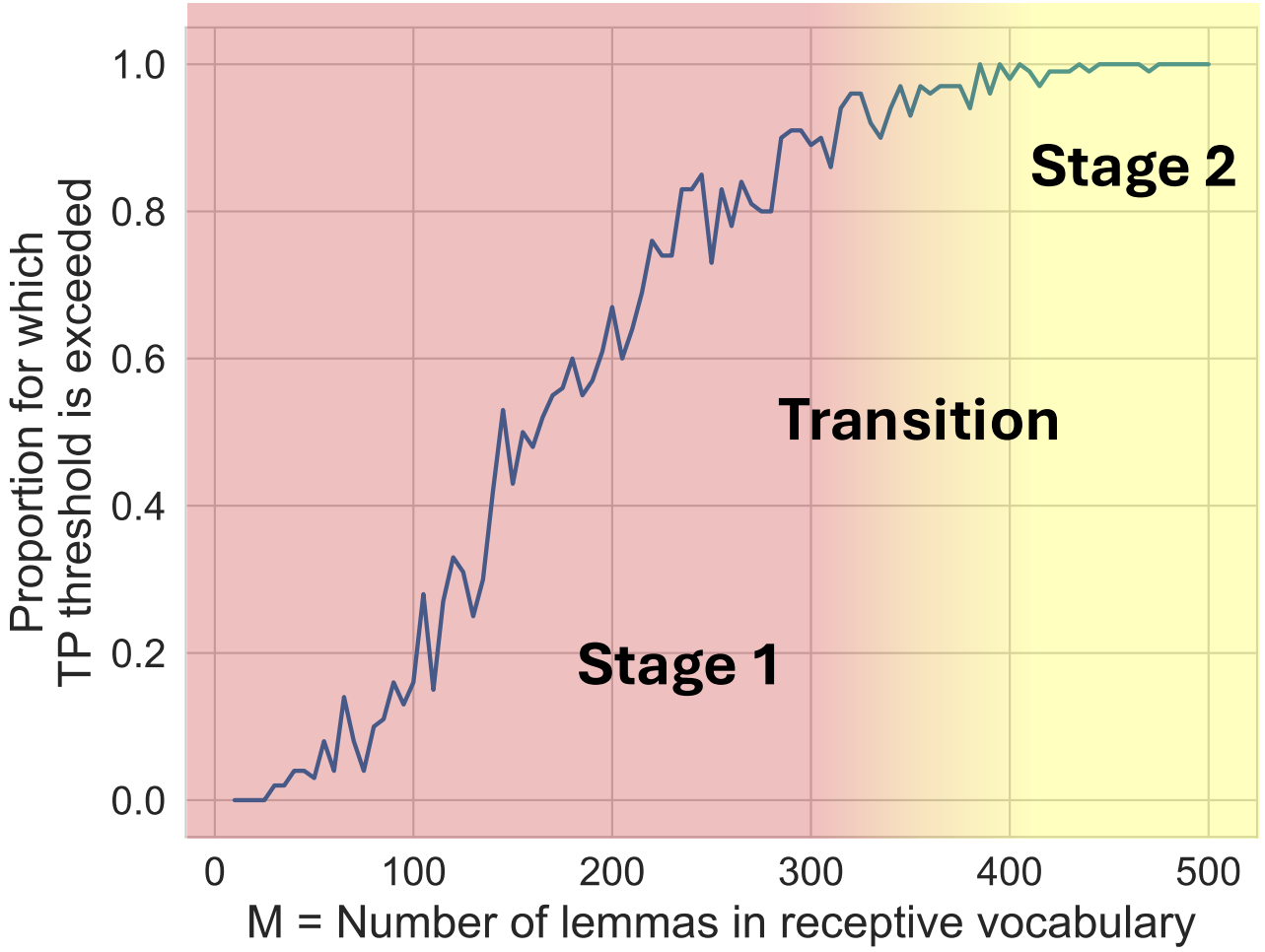


*Typically for productive vocabulary

Average Jaccard similarity of 100 vocabularies with M lemmas



Results



- Stage 1 to stage 2 transition occurs at about 24 months

- Expressive vocabulary of 250-275 at 24 months (Bouchard et al., 2009; Trudeau & Sutton, 2011)

→ Corresponds to predicted vocabulary size of 350-400 at time of transition

Discussion

- Surface True Hypothesis model predicts age of transition between stage 1 and stage 2 of French liaison acquisition

- First model to predict **when** and **why** children progress through these stages
  - Major advantage over constructionist and phonological models

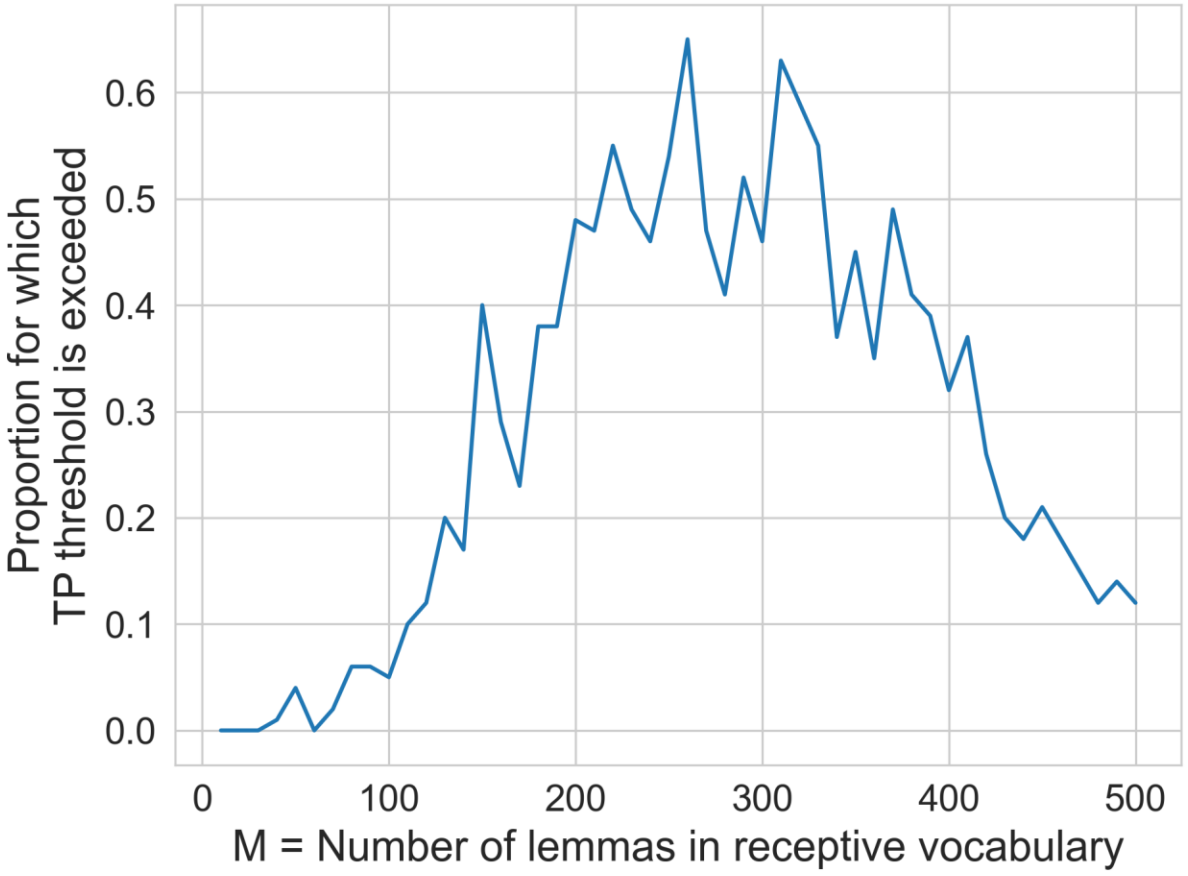
Discussion

- Able to discover that abstract URs are necessary via alternations in the input data
  - Assuming minimal morphological knowledge
- Acquisition of other morphophonological phenomena explained via a similar learning story
  - American English medial flap allophony (Richter, 2021b)
  - Dutch voicing alternation (Belth, 2024)
- Nothing about the model/method is specific to phonology, could also be used for morphological/syntactic acquisition

Implications and next steps

- Next children need to discover what the abstract URs are after deeming them necessary
- What this might look for liaison: Having 2 phonological forms for liaison triggering-words (e.g. /lez/ and /le/ for “les”)
- Modeled vocabulary acquisition with this representation (vs the multiple representations for the liaison-participating words)

Implications and next steps



- Does not become intolerable so this is a viable representation
- Suggests that children learn liaison as allomorphy AND as a phonological process

Acknowledgements

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Any errors are my own.

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