Computational modelling of infants’ word acquisition

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Master Thesis intermediate presentation

Department of Computer Science, KU Leuven

Table of contents

Context overview of the work

Twɪŋkəltwɪŋkəllɪtlstar

twinkle, twinkle, little star

[1] Vallabha et al(2007). *PNAS*. [2] Schatz et al. (2021). *PNAS; [3] Kamper et al. (2015).ICASSP; [4]* Matusevych et al. (2015*).CogSci; [*5] Kamper et al. (2019)*.ICASSP*; [6] Goldwater et al. *(2019).Cognition;* [7] Lavechin et al. (2017). *Psyarxive*

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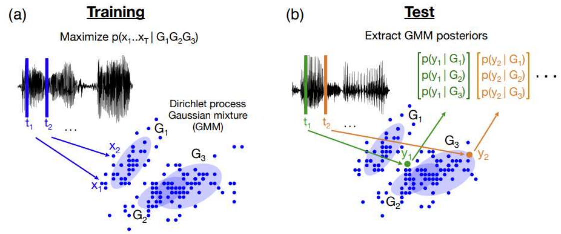
Computational models of language acquisition



- Phonetic learning
- GMM [1][2]
- (Correspondence) autoencoder [3][4]
- (Correspondence) autoencoding recurrent neural network[4][5]

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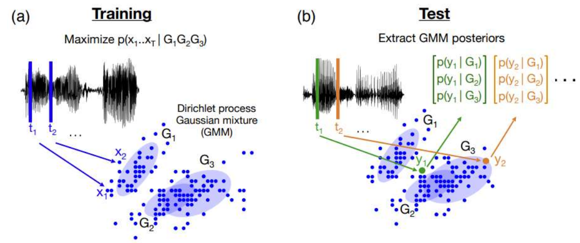
Computational models of langue acquisition



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- Word learning

minimum description length(MDL) Bayesian model [6]

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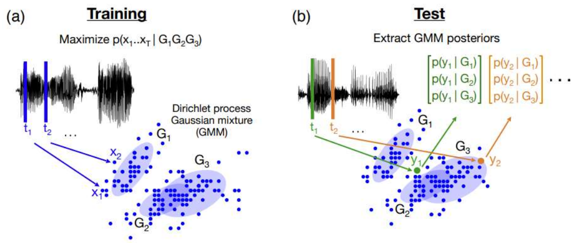

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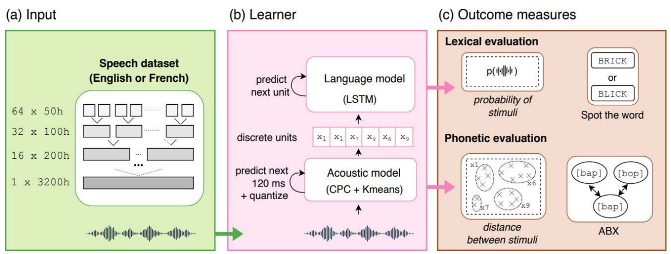
- Joint learning in both phonetic category and lexical knowledge

- STELA (Statistical Learning of Early Language Acquisition)[7]

Acoustic model: Contrastive Predictive Coding

Quantizer: K-means (to simulate phonemes)

Language model: 3-layer LSTM



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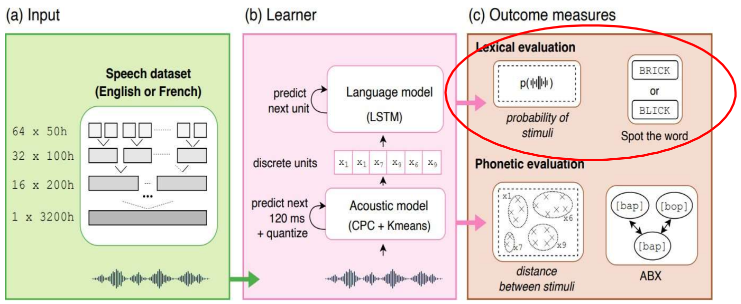
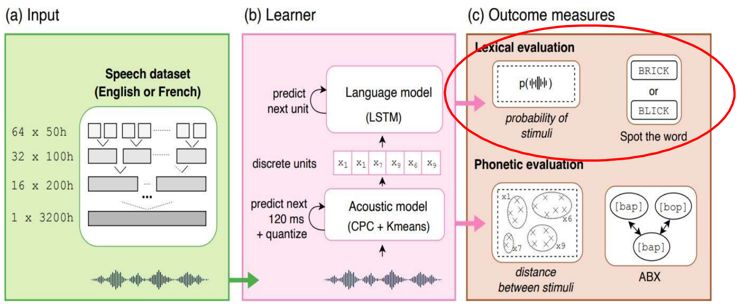
Model evaluation



- **Lexical score**

- Spot the word task: present the network with a minimal pair of word and non-word (e.g., ’brick’ versus ’blick’)
- The accuracy score was averaged across all of the pairs in the test set
- Non-words are generated by the Wuggy toolbox

Model evaluation



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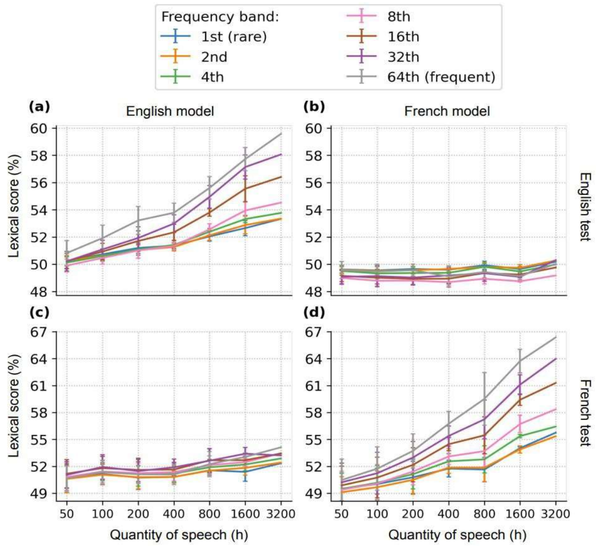

- **Training efficiency**

-> slower increase

Q: How to increase the training efficiency to better simulate infants' acquisition of lexical knowledge?

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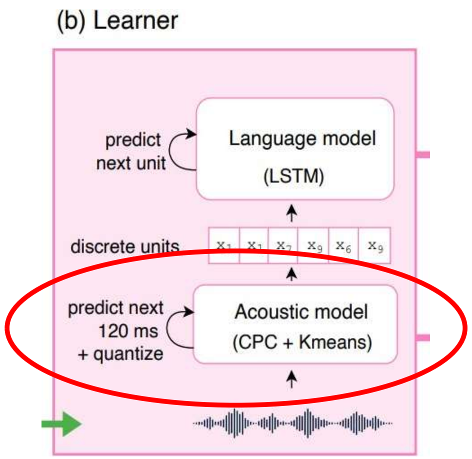
Literature review and hypotheses



- Hypothesis I: Speech segmentation algorithms

1) matching-first models [1-4]

Aim to find high quality pairs of identical segments and cluster them based on similarity

2) segmentation-first models[5-7]

Bayesian Segmental GMM and Embedded Segmental K-Means

(ES-KMeans)

3) segmentation-only models [8-9]

discover directly the likely word boundaries

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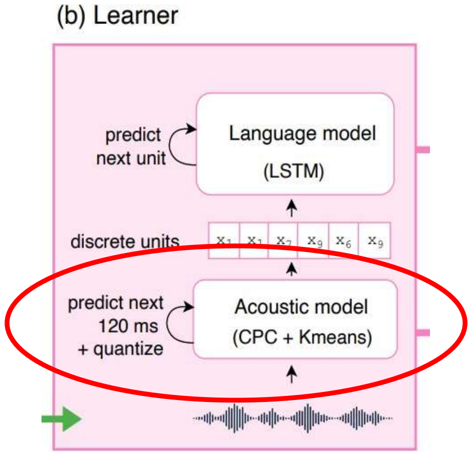
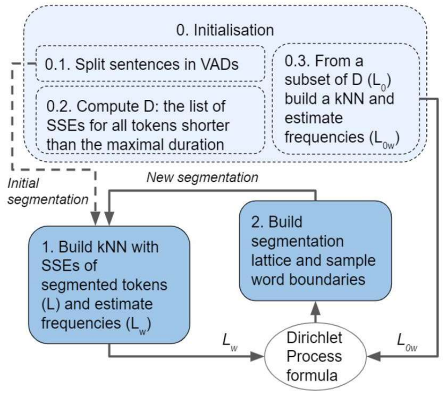
Literature review and hypotheses





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3) segmentation-only models [8-9]

e.g. segmental contrastive predictive coding (SCPC) framework

4) combination of 2) and 3)

DP-Parse[10]

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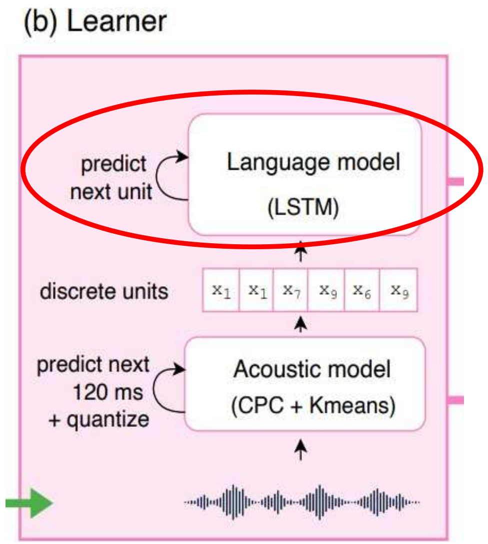


- Hypothesis II: External memory [1-4]

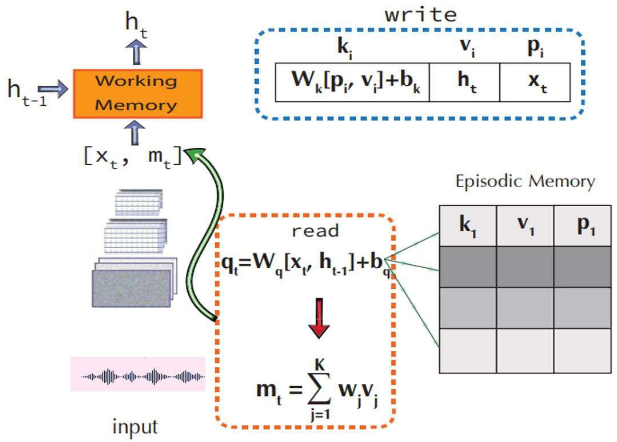
- store representations of examples or experiences

- Memory replay mechanism

-> add previously stored instances either during training[2] or test phases [3]

- Selective mechanism[4]

Similarity-based v.s. Surprise-based



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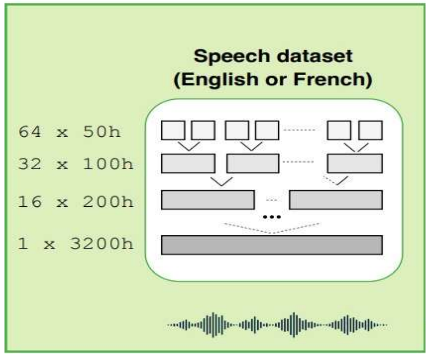
Experiment Design

- Environment of the infant

- Models trained on varying training lengths



Experiment Design

- Environment of the infant: varying training lengths
- Model Design

Unit level	Boundary type	Model	Abbreviation
Characters	Without	Baseline LSTM	Baseline char without bound
		Memory-augmented LSTM	Memory char without bound
	Gold boundary (word)	Baseline LSTM	Baseline char without bound
		Memory-augmented LSTM	Memory char without bound
	Automatic boundary	Baseline LSTM	Baseline char with auto bound
		Memory-augmented LSTM	Memory char with auto bound
Phonemes	Without	Baseline LSTM	Baseline phon without bound
		Memory-augmented LSTM	Memory phon without bound
	Gold boundary (word)	Baseline LSTM	Baseline phon without bound
		Memory-augmented LSTM	Memory phon without bound
	Automatic boundary	Baseline LSTM	Baseline phon with auto bound
		Memory-augmented LSTM	Memory phon with auto bound
Speech	Automatic boundary	Baseline LSTM	Baseline speech with auto bound
		Memory-augmented LSTM	Memory speech with auto bound

- Input: different input modalities

- Automatic boundary: DP-Parse

- Language models

Baseline: 3-layer LSTM

Memory-augmented: local memory at test time

Progress and future work

		Feb	Mar	Apr	May	Jun	Jul	Aug
Pre-processing	Char with/out bound							
	Phonemize (g2p)							
	DP-Parse							
LSTM construction	Baseline							
	Memory-augmented							
Evaluation	Wuggy test (p2g)							
Model type		Baseline Char with/out bound	Memory char with/out bound	Baseline/Memory char with auto bound	Baseline /Memory Phon	Baseline /Memory Phon	Baseline/Memory speech with auto bound	
Thesis writing								

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Thesis writing								

- If time permits:
- Test different selective mechanisms: surprise-based v.s. similarity-based
- Morphological rules and oov words
- Other aspects of evaluation task: semantic

Thanks for your attention!