Statistical word segmentation in Korean child-directed speech

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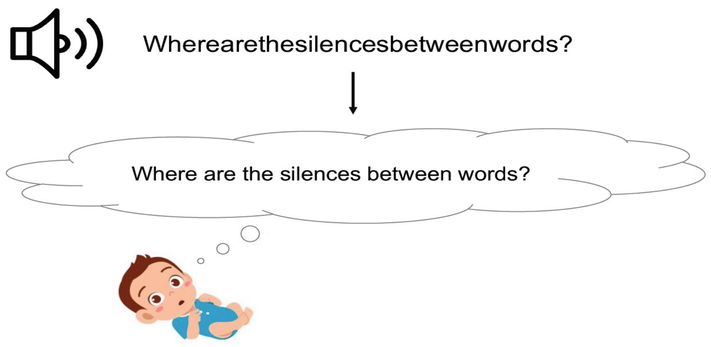
CHILD. LANGUAGE. LAB.

Introduction

- **Word learning:** A prerequisite for infants to build a lexicon for word learning is the ability to segment words out of the speech stream (e.g., Brent & Siskind, 2001; Jusczyk and Aslin, 1995).



- **Background:** Behavioral studies suggest that infant's segments words more easily in CDS (child-directed speech) than ADS (adult-directed speech) (e.g., Fernald, 2000; Thiessen et al., 2005).

- Previous research on statistical segmentation:

Researches	Languages	Algorithms	CDS advantage?
Batchelder (2002)	English, Spanish, Japanese	1	Yes
Fourtassi et al. (2013)	English, Japanese	1	Yes
Ludusan et al. (2017)	Japanese	4	Yes
Cristina et al. (2018)	English	9	Not much
Loukatou et al. (2019)	French	17	Not much

- **Research question:** *Is there CDS advantages over ADS in the statistical segmentation of words in Korean?*

Methods

- **Data:** *Ko corpus* containing 35 mothers freely interacting with their own children for about 40 minutes. The same corpus also contains ADS in which the mother talks to their family members and experimenters for about 10 minutes(Ko et al., 2020).

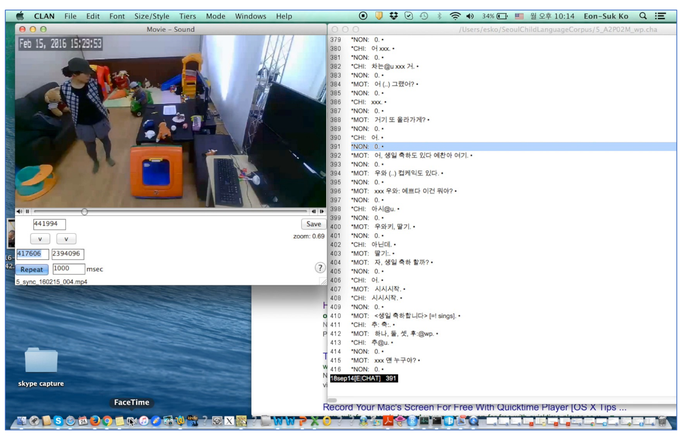


Figure 1: The pictures show the environment of the apartment where the data were collected and the hand-coded transcriptions.

- **Statistical word segmentation models:** We used 9 word segmentation models through Python, by adapting functions provided by WordSeg (Bernard et al., 2019).

9 models

1.Baseline
- Base_02
- Base_05

2.Sub-lexical
- Transitional Probabilities (**TP**) Forward/Backward x Absolute/Relative threshold — tp_ab_f, tp_re_f, tp_ab_b, tp_re_b
- Diphone-Based Segmentation (**DiBS**) Phone-based/Syllable-based — dibs_p, dibs_s

3.Lexical
- Phonotactics from Utterances Determine Distributional Lexical Elements (**Puddle**)

Figure 2: 9 word segmentation models that we used in this study.

Methods

- **Procedure:** We derived phonetic input from phonemic corpus by applying a set of phonological rules by using KoG2P (Hong et al., 2018). After then, we employed 9 word segmentation models through WordSeg (Bernard et al., 2019). Model performance was measured by comparing the word boundaries in the original input sentence with the word boundaries generated via each model.

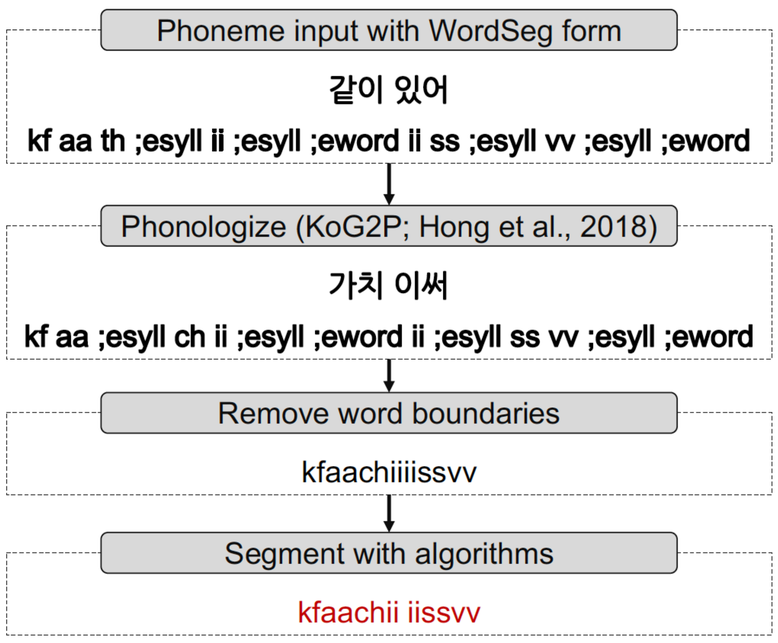


Figure 3: The overview of research process

Results

- **Characteristics of our CDS vs ADS data**

	phoneme					phonetic				
	Sylls	Tokens	Types	MATTR	Utts	Sylls	Tokens	Types	MATTR	Utts
ADS	24,088	11,012	3,227	0.909	2,544	24,088	11,011	3,215	0.909	2,544
CDS	144,609	63,887	8,818	0.837	22,203	144,615	63,826	8,770	0.837	22,203

Figure 4: Characteristics of the ADS and CDS portions of the corpus by phoneme input and phonetic input.

Feature	CDS	ADS	p
Word length (s)	1.68 (.11)	1.74 (0.16)	.101
Utterance length (s)	6.54 (.88)	9.21 (2.76)	2.671e-06 ***
% 1-w phrase	.33 (.06)	.33 (.12)	.77
MATTR	.84 (.07)	.91 (.03)	6.595e-07 ***
% hapaxes	.22 (.05)	.49 (.07)	< 2.2e-16 ***

Figure 5: Results of statistical analysis, t-tests measuring feature differences across CDS and ADS in phonetic form.

- ✓ The utterance length of ADS is longer than CDS.
- ✓ The MATTR (i.e., moving average type to token ratio) is high in ADS compared with CDS. This indicates that ADS has more types of words than CDS in a fixed window of 20 words.
- ✓ At the last, the proportion of hapaxes is high in ADS compared with CDS, which means that the portion of words that are used only one time in the corpus is higher in ADS than in CDS.

Results

- **Does CDS have a segmentation advantage over ADS?**

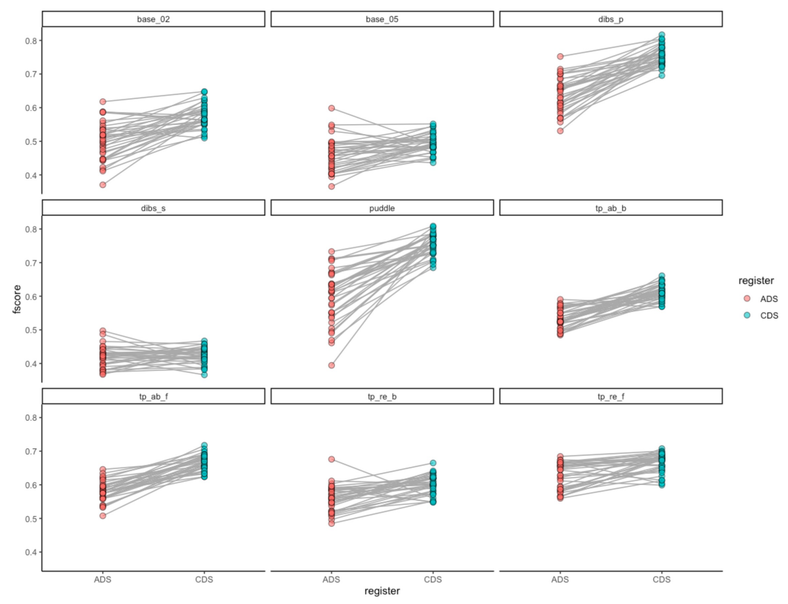


Figure 6: Token F-scores obtained by each algorithm for CDS and ADS.

- **Statistical modelling for CDS segmentation advantages**

Formula: f-score ~ register + unit + corpus size + (1+register|algo) + (1+register|baby)

factor	Estimate (β)	Std. Error	df	t value	p
register (CDS)	0.0888	0.021	24.9677	4.2318	0.0003 ***
unit (phonetic)	0.0014	0.0012	1173.0969	1.1634	0.2449
corpus size	.0	.0	36.4052	-1.5532	.129

Figure 7: Result of linear mixed effects regression models to statistically test the difference in the f0 ratio by registers and units

- **Which corpus properties have an effect on the segmentation advantages CDS?**

Formula: f-score ~ word length (s) + utterance length (s) + % hapaxes + % 1-w phrase+ MATTR + (1+register|algo)+(1+register|baby)

factor	Estimate (β)	Std. Error	df	t value	p
Word length (s)	-0.1059	0.0139	63.6124	-7.6212	0 ***
Utterance length (s)	-0.0093	0.0011	57.7701	-8.2175	0 ***
% hapaxes	-0.0295	0.0205	68.1422	-1.44	0.1545
% 1-w phrase	1.00E-04	0	35.1851	2.8841	0.0067 **
MATTR	-0.0347	0.0191	40.2442	-1.8166	0.0767 .

Figure 8: Result of linear mixed effects regression models to investigate the relationship between model performance and the corpus properties.

- **Conclusion & Discussion**
  - ✓ CDS has a significantly greater advantage in word segmentation than ADS.
  - ✓ Properties of CDS that lead to segmentation advantages include the following:
    - Shorter word-length and utterance-length
    - Greater proportion of one-word phrases
    - Greater ratio of repetition (MATTR)
- **Future directions**
  - ✓ Examine the role of sound symbolism and word play in segmentation.
  - ✓ Control of corpus size with additional ADS corpus.

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