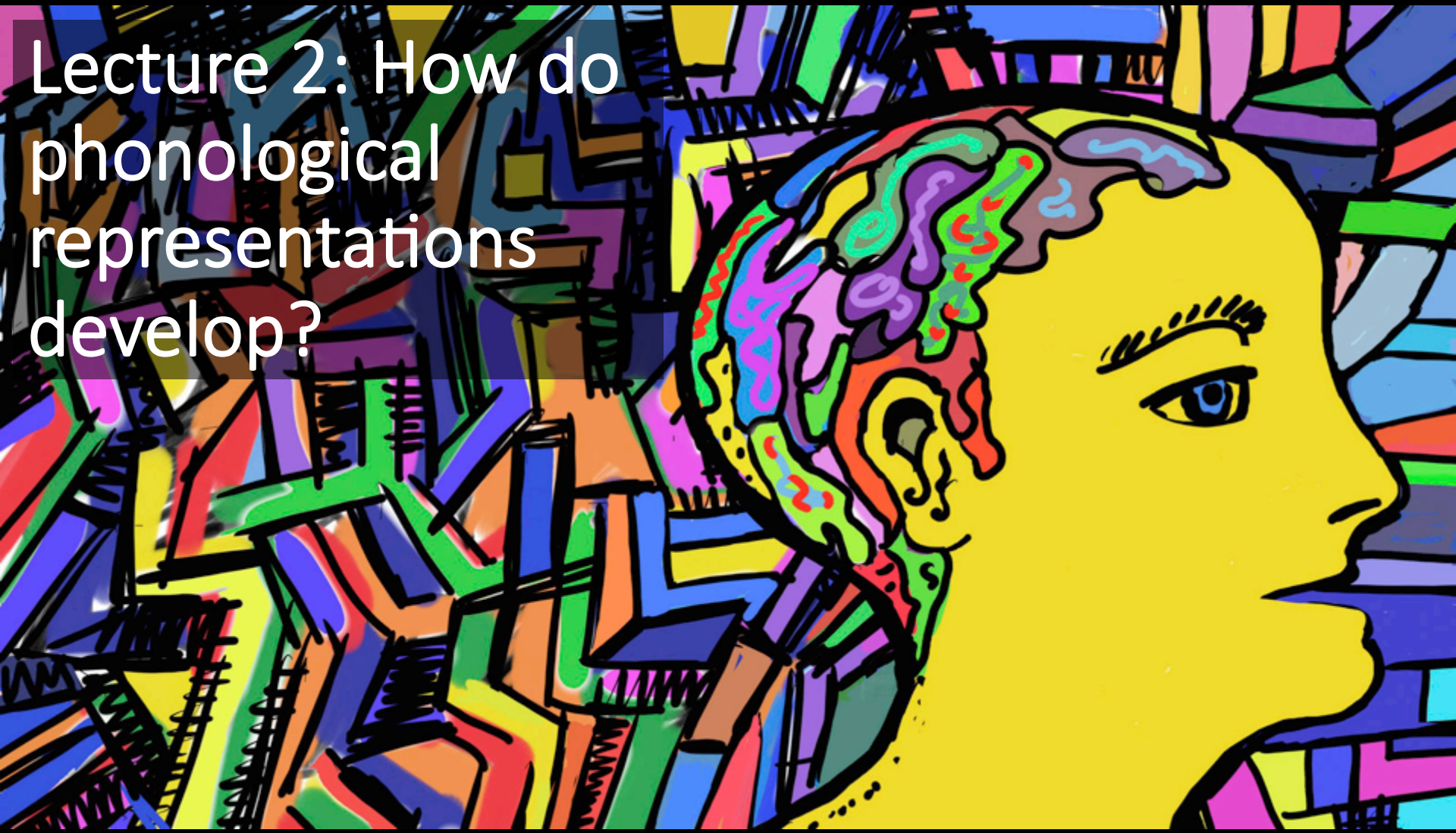
The relationship between early phonological and lexical development

Lecture 2: How do phonological representations develop?

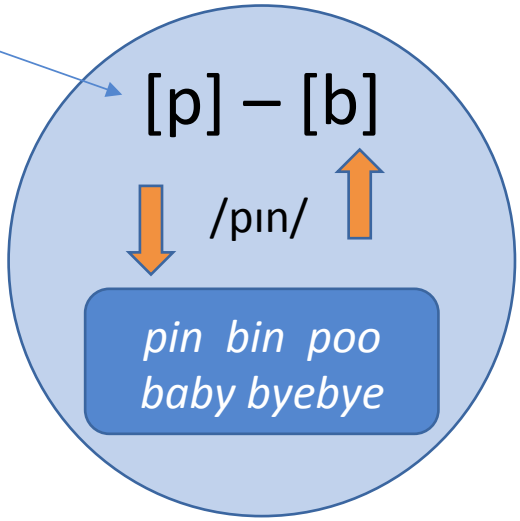


Mits Ota
University of Edinburgh

Summer School of Linguistics, 2019
mits-ota.github.io/SSoL2019.html

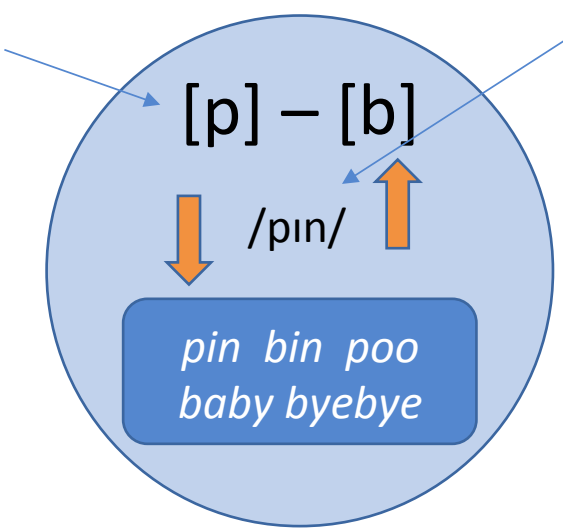
Last time

Can sounds be learned independent of words?



This lecture

Can sounds be learned independent of words?



How do phonological representations develop?

mits-ota.github.io/SSoL2019.html

What phonological information is encoded in a word form?

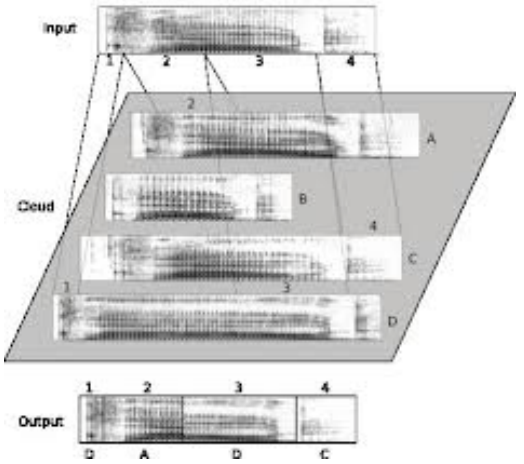
Generative phonology

/ p a n /

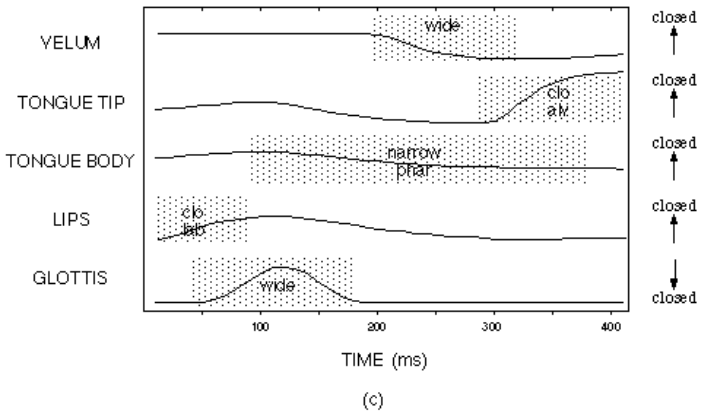
[-son] [+syll] [+son]
[-cont] [+high] [+nas
[+lab] [+back] [+cor]
[-voice]

‘pan’
[pʰãn]

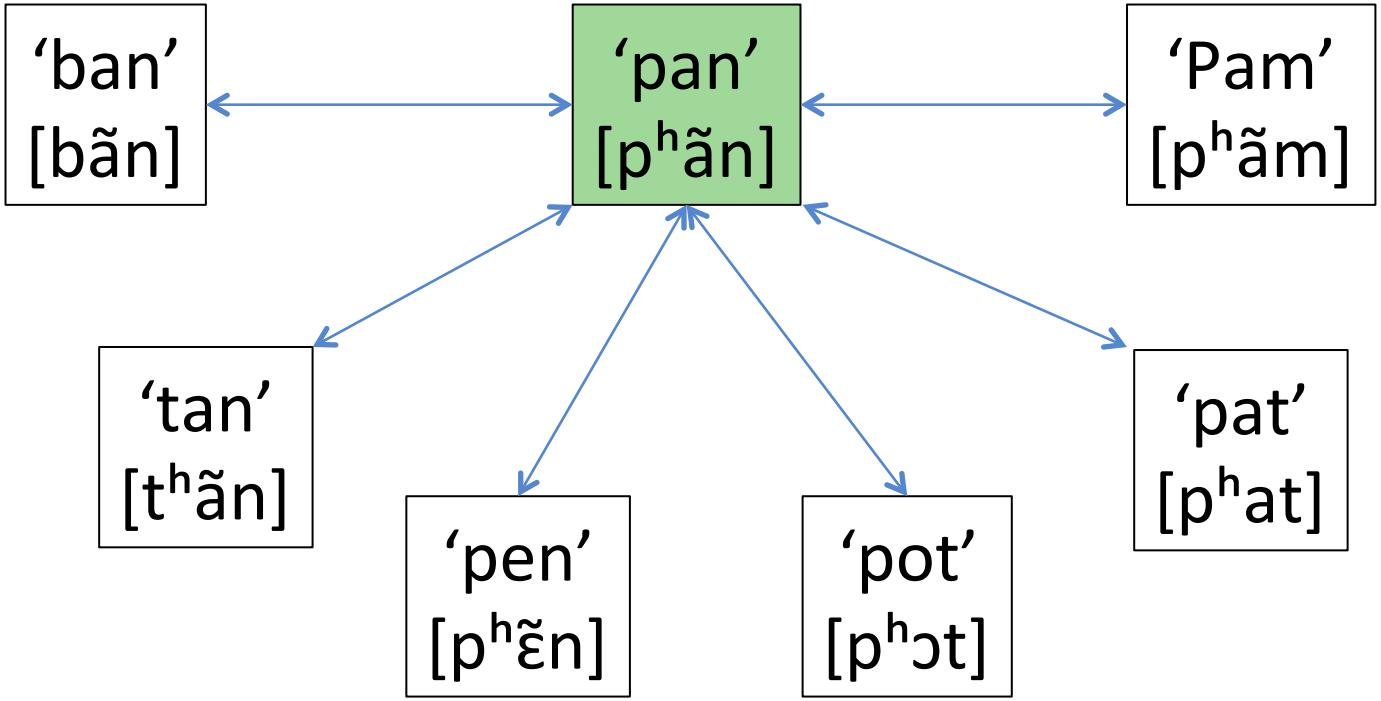
Exemplar theory



Articulatory phonology



For our purpose: Any information necessary to maintain lexical contrasts

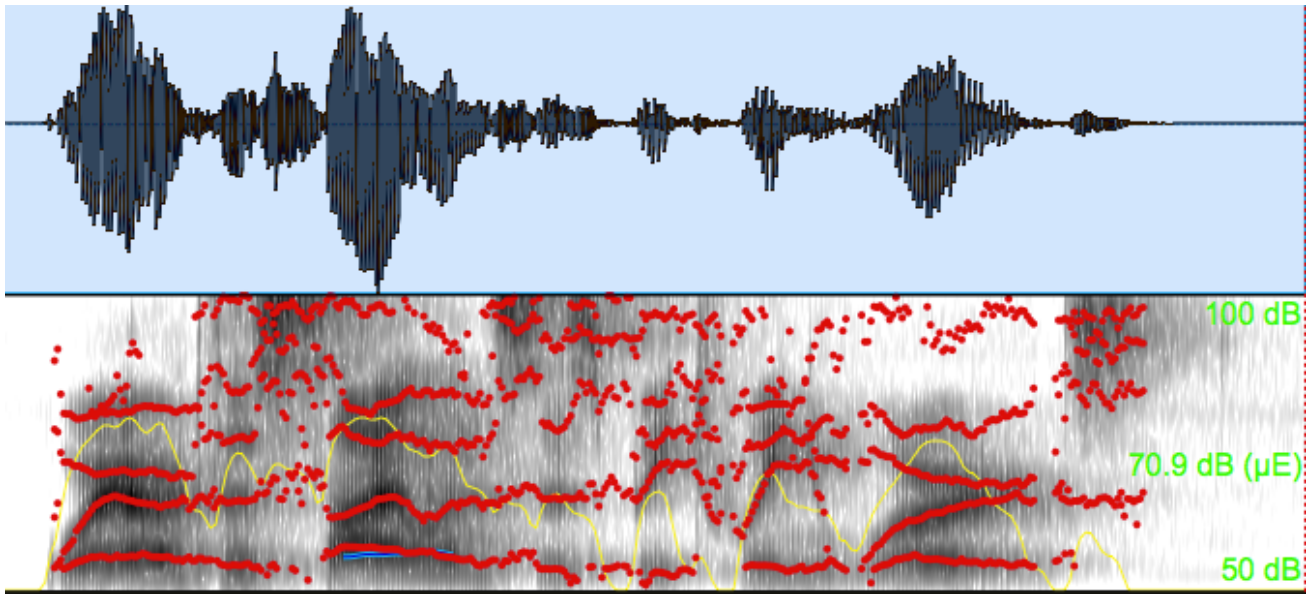


Part 1

How do infant begin to learn word forms?

Identifying word forms in fluent speech (word segmentation) is not a trivial task

- Single word utterances in infant-directed speech ≈ 9% (Brent & Siskind, 2001).
- No consistent silences between words.



Three types of information infants can use to segment words

1. Transitional probabilities
2. Learned phonological patterns
3. Learned words

Transitional probabilities (TPs) can tell which sequences are more likely to be part of the same word

tɪ > be

0.03%

[prɪ tɪ be bi] → [prɪ tɪ] # [be bi]

prɪ > tɪ

80.00%

Transitional probabilities of /prɪ/ to /tɪ/ and /tɪ/ to /be/ in infant-directed speech (Saffran, Aslin, & Newport, 1996)

Infants as young as 5- to 8-months can track TPs between syllables

Training stimuli in Saffran, Aslin & Newport (1996) for 8-month-olds

daropitibudopabikugolatudaropi
pabikutibudogolatupabikudaropi
tibudogolatutibudo ...

Infants as young as 5- to 8-months can track TPs between syllables

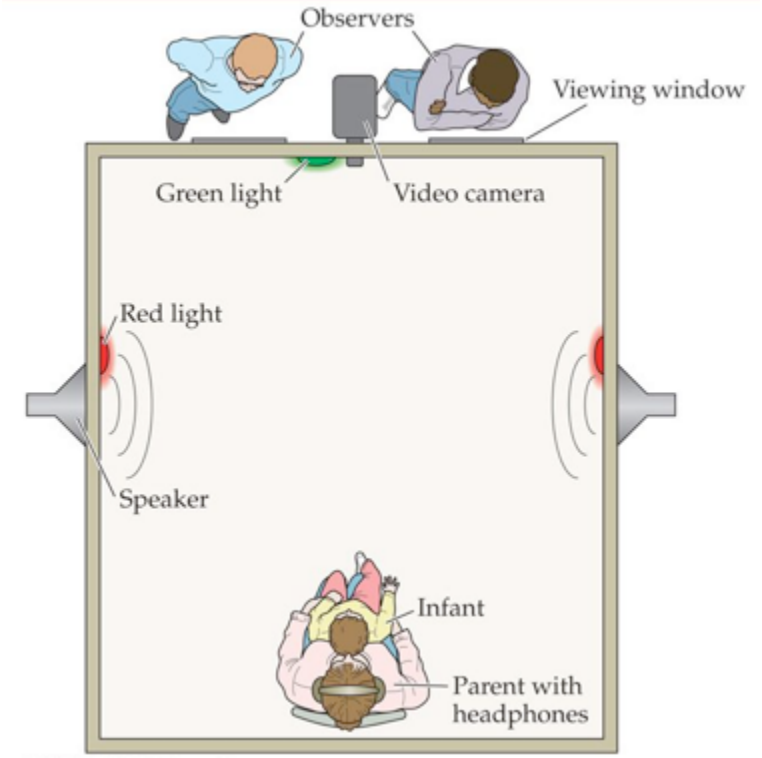
Training stimuli in Saffran, Aslin & Newport (1996) for 8-moonth-olds

daropitibudopabikugolatudaropi
pabikutibudogolatupabikudaropi
tibudogolatutibudo ...

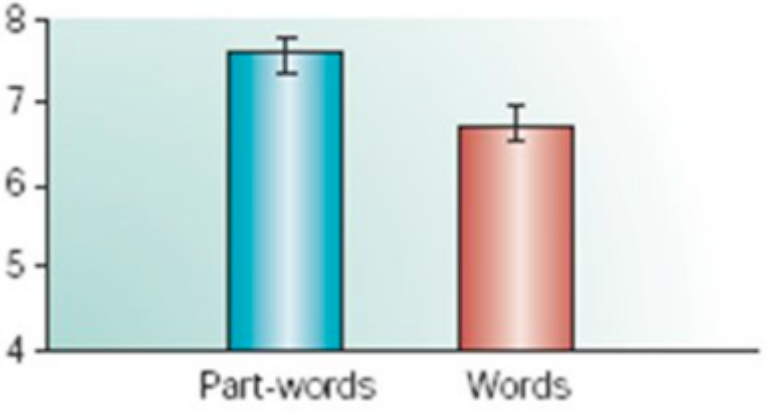
Cf. Stimuli in Thiessen and Erickson (2013) for 5-month-olds:
diti, bugo, dapu, dobi

Infants as young as 5- to 8-months can track TPs between syllables

Heard-Turn Preference Procedure



Mean listening times



33% 100%

tu da ro pa bi ku

100% 100%

Already learned phonological patterns can be used to identify word onset/offset

[prí tɪ bé bi] → [prɪ tɪ] # [be bi]

S w S w

The most common prosodic word type in English: Strong–weak disyllables (Cutler & Carter, 1987). Strong syllable = word onset 95% of time in infant-directed speech (Kelly & Martin, 1994)

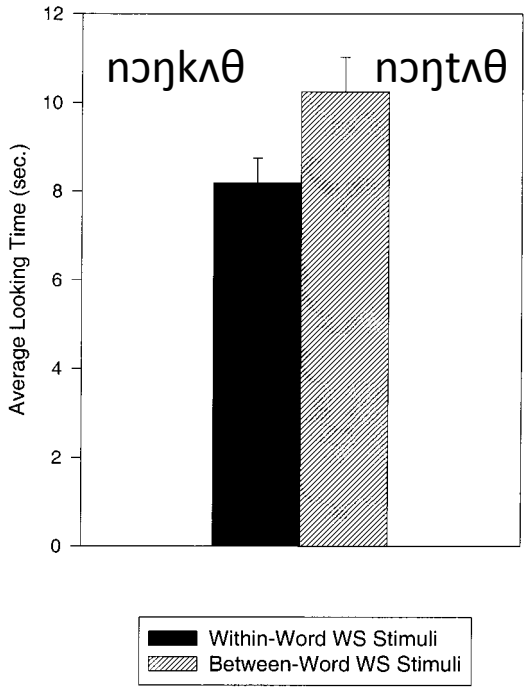
Infants use predominant prosodic patterns to segment words

Familiarisation	**Testing**
*Your **hámlet** lies just over the hill. Another **hámlet** is in the country...*	Respond to 'hamlet'
*The man put away his old **guitár**. Your **guitár** is in the studio...*	Do not respond to 'guitar'
*That red **guitár** is brand new. The pink **guitár** is mine...*	Do not respond to 'guitar', but to 'taris'

7.5-month-olds English-learning infants' segmentation patterns (Jusczyk, Houston, & Newsome, 1999)

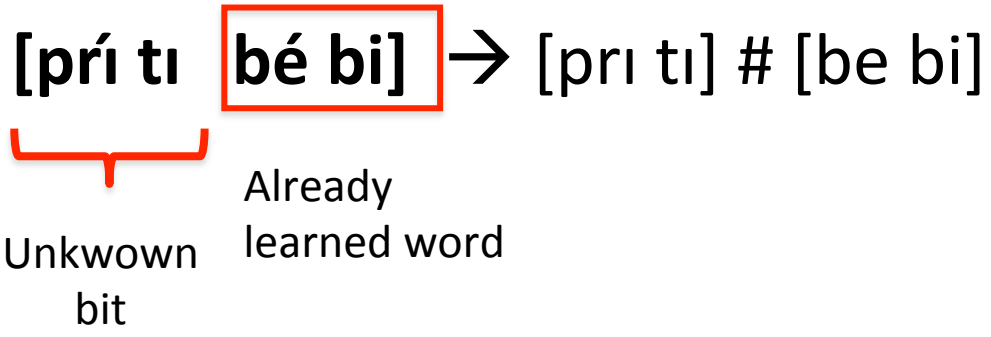
Infants are sensitive to phonotactic probabilities in words

	Type of cluster		
		Between-word	
	Within-word	A	B
	[ŋ.k]	[ŋ.t]	[m.k]
	[f.t]	[f.h]	[v.t]
	[v.n]	[v.m]	[z.n]
	[m.θ]	[m.h]	[n.θ]
	[k.ʧ]	[k.ʃ]	[p.ʧ]
	[ŋ.g]	[ŋ.b]	[n.g]
Between-word frequency:	1.00	19.17	18.83
Within-word frequency:	22.33	0.17	0.00



9-month-olds English-learning infants' segmentation patterns (Mattys et al, 1999). Frequency counts based on the Bernstein corpus (1982)

Already-learned words can be used to identify other words



Infants use familiar words for further segmentation

Familiarisation	**Testing**
The girl laughed at mommy's feet. Even the toes on mommy's feet are large...	Respond to *feet*.
The girl laughed at Hannah's feet. Even the toes on Hannah's feet are large...	Respond to *feet*.
The girl laughed at Lola's feet. Even the toes on Lola's feet are large...	Do not respond to *feet*.

6-month-olds' segmentation. Example of a child named *Hannah* (Bortfeld et al., 2005)

Summary: How do infants begin to learn word forms?

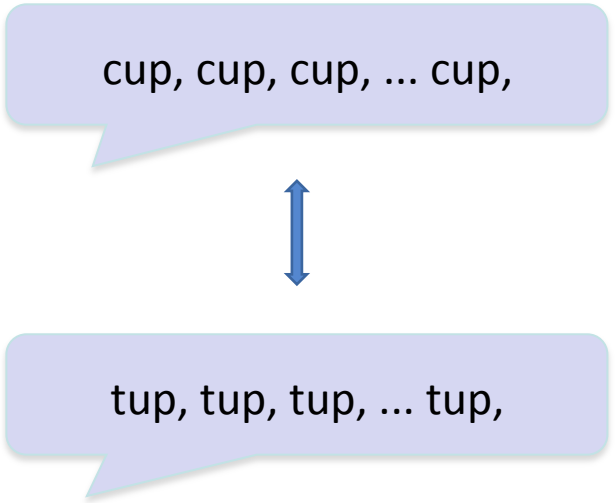
- Different strategies of word segmentation
  - Transitional probabilities
  - Learned phonological patterns
  - Learned words
- Learning builds upon learning

Part 2

How accurate are the phonological representations in early words?

Infants can remember some phonetic details of word forms by 7 months

The **cup** was bright and shiny. A clown drank from the red **cup**. The other one picked up the big **cup**. His **cup** was filled with milk. Meg put her **cup** back on the table. Some milk from your **cup** spilled on the rug

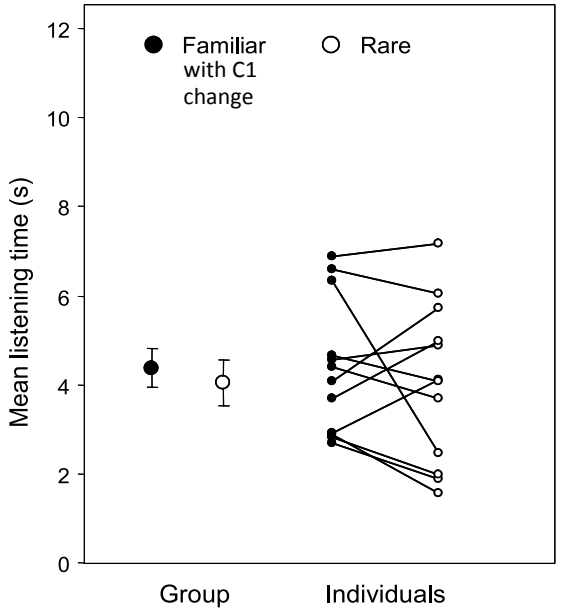


Juszyk & Aslin (1995)

Some phonologically-relevant phonetic details are encoded in familiar word forms by 12m

Familiar words	C1 change	Rare words
bubbles	*mubbles*	*budget*
tummy	*summy*	*tenor*
nappy	*dappy*	*piffle*
dirty	*nirty*	*monger*

HTPP results

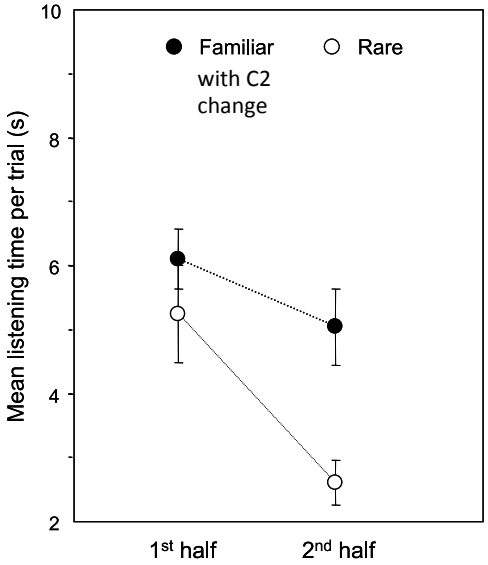


11-month-olds treat familiar word forms with onset C mispronunciation as unfamiliar forms (Vihman et al., 2004)

But some contrast manipulations do not block word recognition

Familiar words	C2 change	Rare words
bubbles	*bummles*	*budget*
tummy	*tuvvy*	*tenor*
nappy	*nammy*	*piffle*
dirty	*dirny*	*monger*

HTPP results
(Vihman et al, 2004)



Similar effects with stress change (e.g., *ˈbaby → baˈby*; Vihman et al., 2004) and offset change (e.g., Dutch: *sxaːp* 'sheep' → *sxaːf*; Swingley, 2005)

Interpretations

- Encoding is less robust for certain phonological features/ positions.
  - Onset-bias in infant perception (Jusczyk, Goodman, & Baumann, 1999)
- Some phonological mismatches are more likely to cause lexical activation.
  - [beˈbi]/[ˈbemi] are not equated with *baby*, but they activate lexical access it.
  - Incremental activation (Marslen-Wilson, 1987)

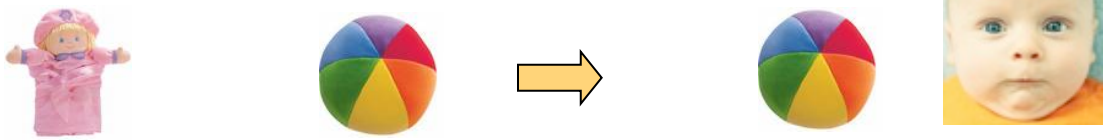
By 14m, some phonologically-relevant phonetic details are encoded in familiar words (with referents)

- Detection of 'mispronunciations' of known word-meaning mappings (Swingley & Aslin, 2002):

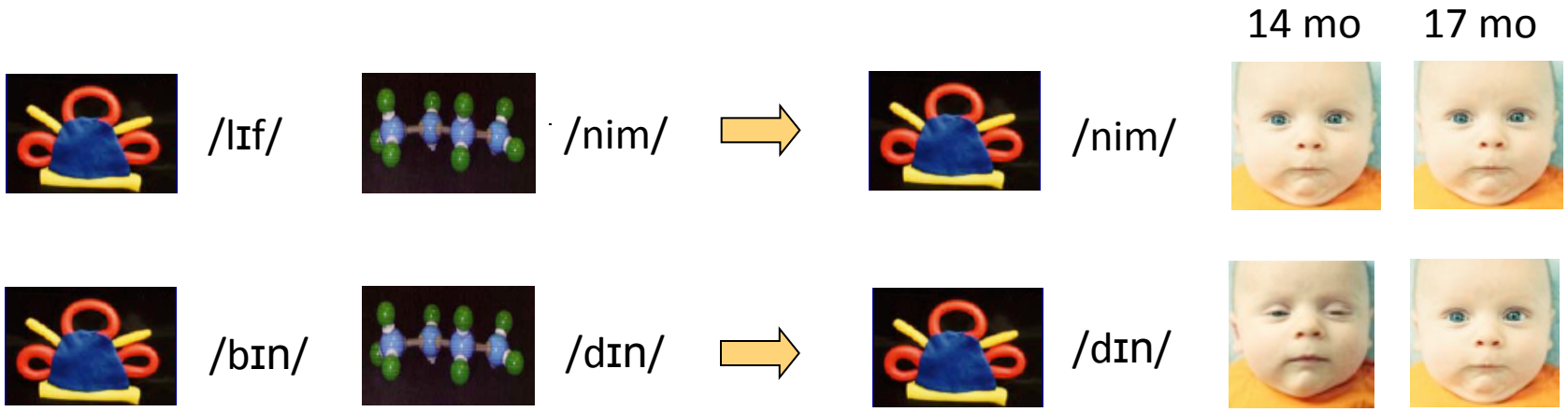
baby *vaby*

- Detection of pairing violations between two known words and their referents (Fennell & Werker, 2003):

doll *ball* *doll*



But until 17m, infants have difficulties in immediately encoding contrasts in novel words



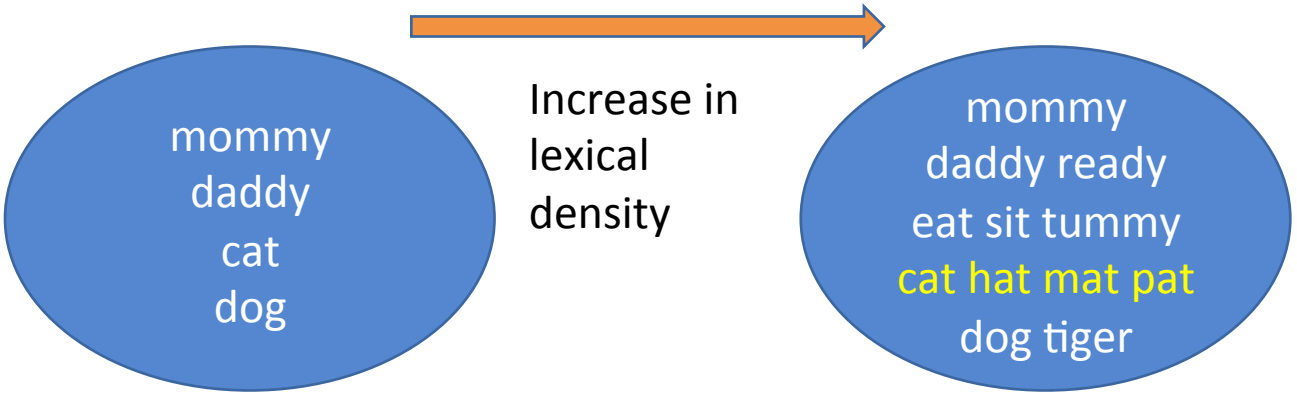
Habituation-dishabituation paradigm (a.k.a. the 'switch' test): Stager & Werker, 1997; Werker et al., 1998; Pater, Stager, & Werker 2004)

Part 3

What drives encoding of phonological representations in early words?

Pressure from the lexicon? The lexical restructuring hypothesis (Metsala & Walley, 1998)

"[T]he increased size of the lexicon may serve as an impetus for the child to develop more detailed, adult-like representations of the words in the lexicon in order to keep individual items distinct in memory " (Logan, 1992)

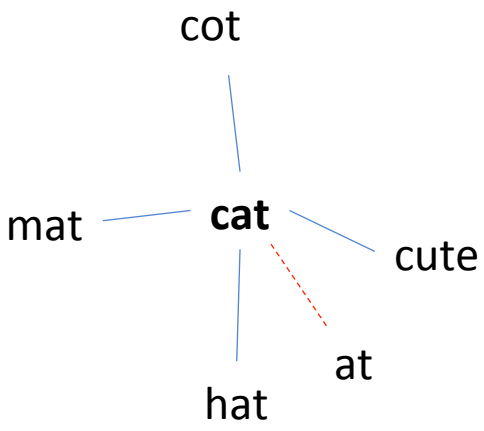


C[a]C is sufficient to separate 'cat' from others

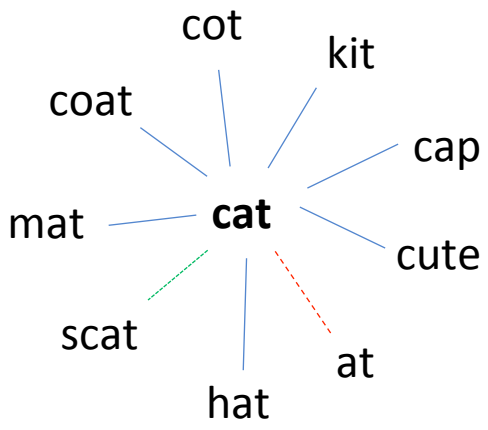
'cat' now needs enough phonetic details for [k] vs. [h, m, p]

Is it true that young learners need to differentiate fewer phonologically contrastive words?

Phonological neighborhood density = Number of words that differ from the target word by a one-phoneme substitution, deletion or addition (Landaurer & Streeter, 1973)

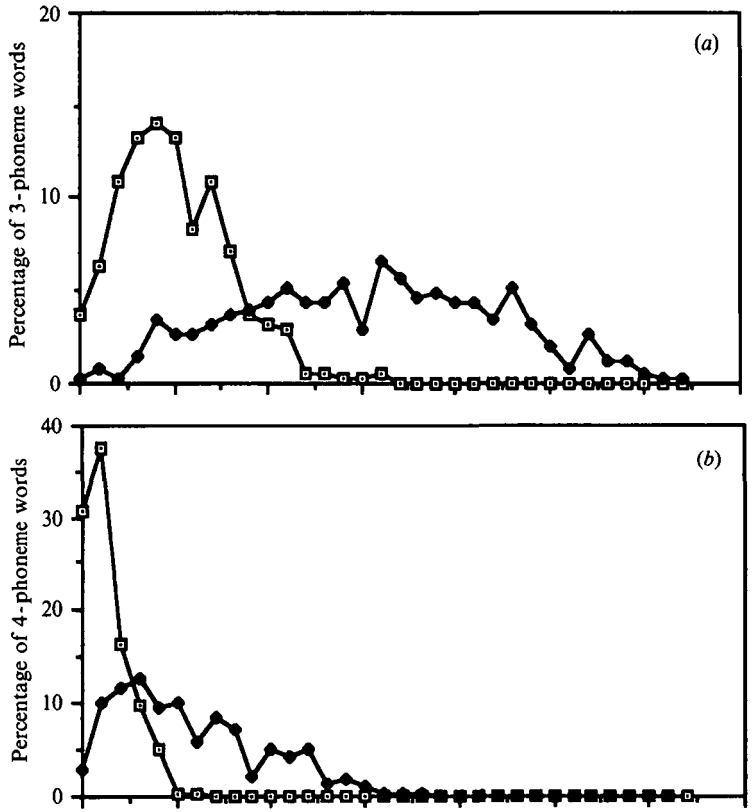


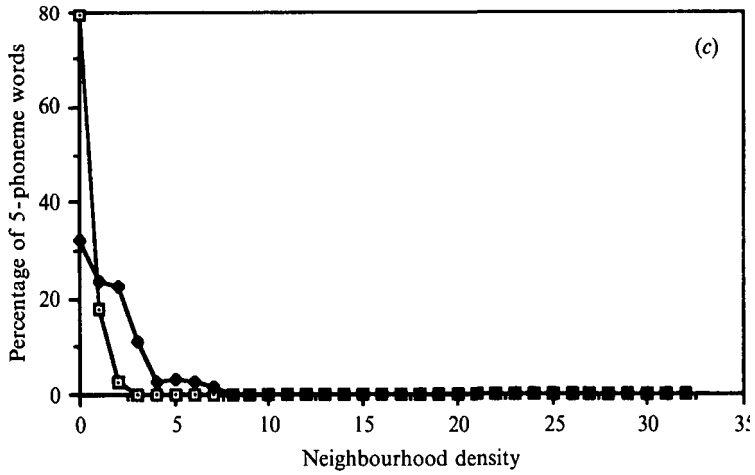
Density around 'cat': 5



Density around 'cat': 9

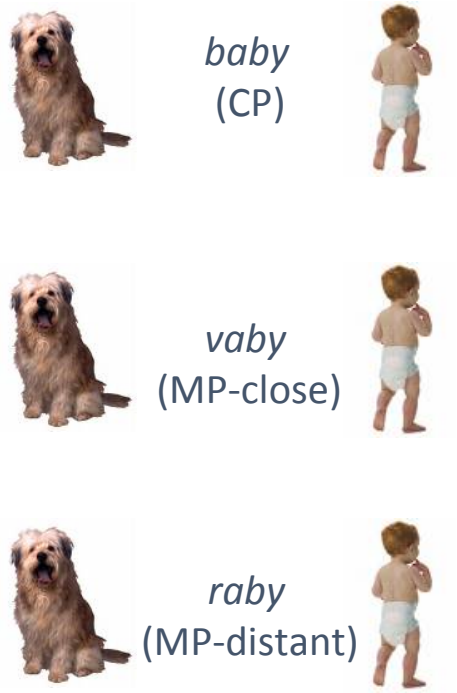
Yes, lexical input to children has sparser phonological neighborhoods

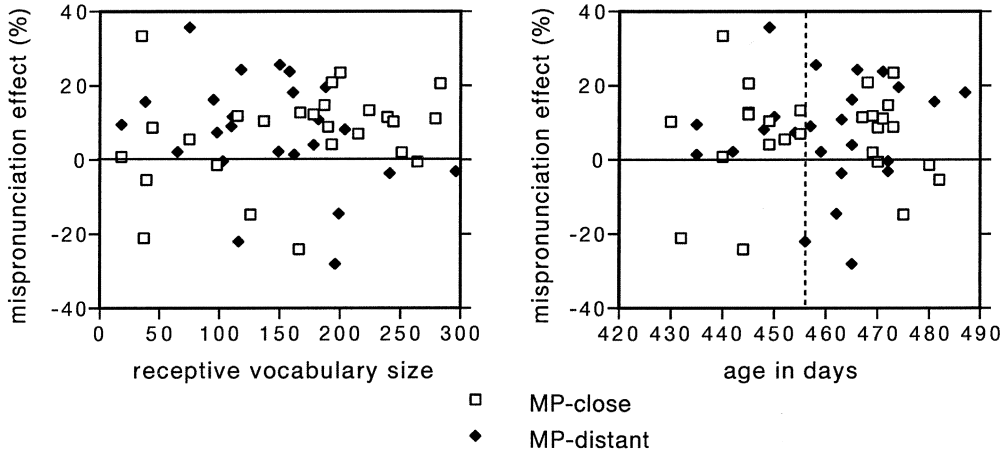




Neighborhood density for 3-, 4- and 5-phoneme words in a child lexicon (unfilled squares) versus adult lexicon (filled diamonds) (Charles-Luce & Luce, 1995)

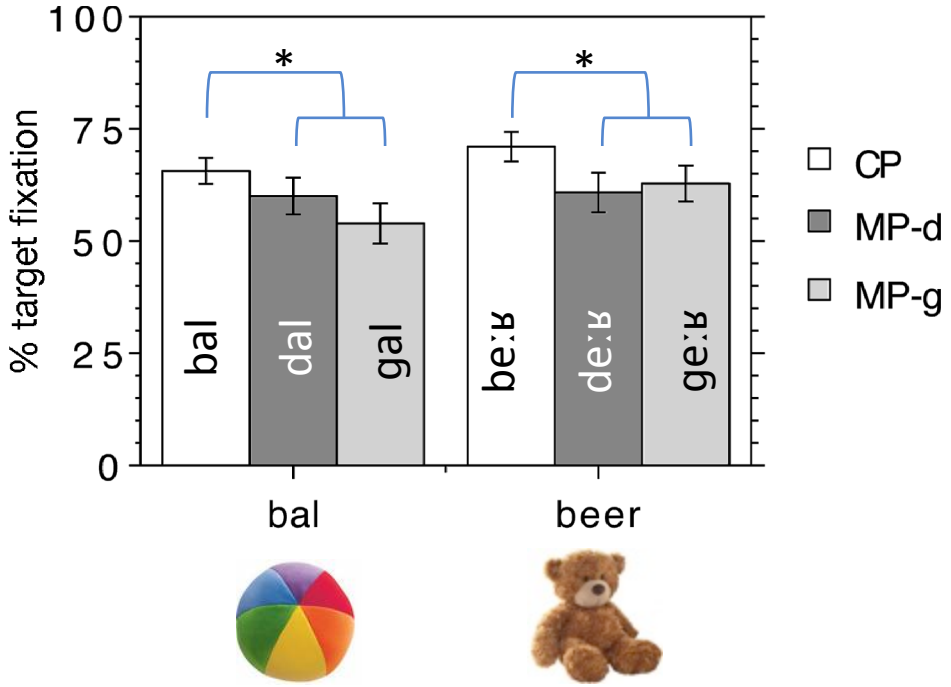
But measures of phonological encoding are not related to vocabulary size





Mispronunciation effects by 14/15-month-olds receptive vocabulary and age in days (Swingley & Aslin, 2002)

Mispronunciation effects are found even when there is no direct lexical pressure



- In Dutch, [g] does not have a phonemic status.
- [deːʁ] is not a word and [dal] ('valley') is not a word that 19-month-olds know.

Mispronunciation effects by 19-month-old Dutch learners (Swingley, 2003)

Exposure effect?

- Infants' phonological representations of words may become more accurate as a function of exposure to individual words.
- Fairly accurate phonological representations of familiar words (Vihman et al., 2004; Swingley & Aslin, 2002).
- Fragile representations of novel words learned in lab experiments (Stager & Werker, 1997; Pater, Stager, & Werker, 2004)

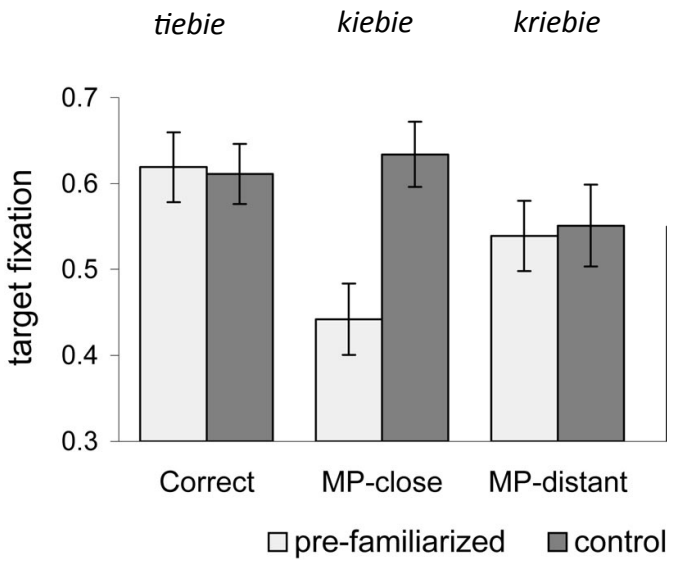
Exposure frequency is related to accuracy of representation

Pre-familiarized group

Control group

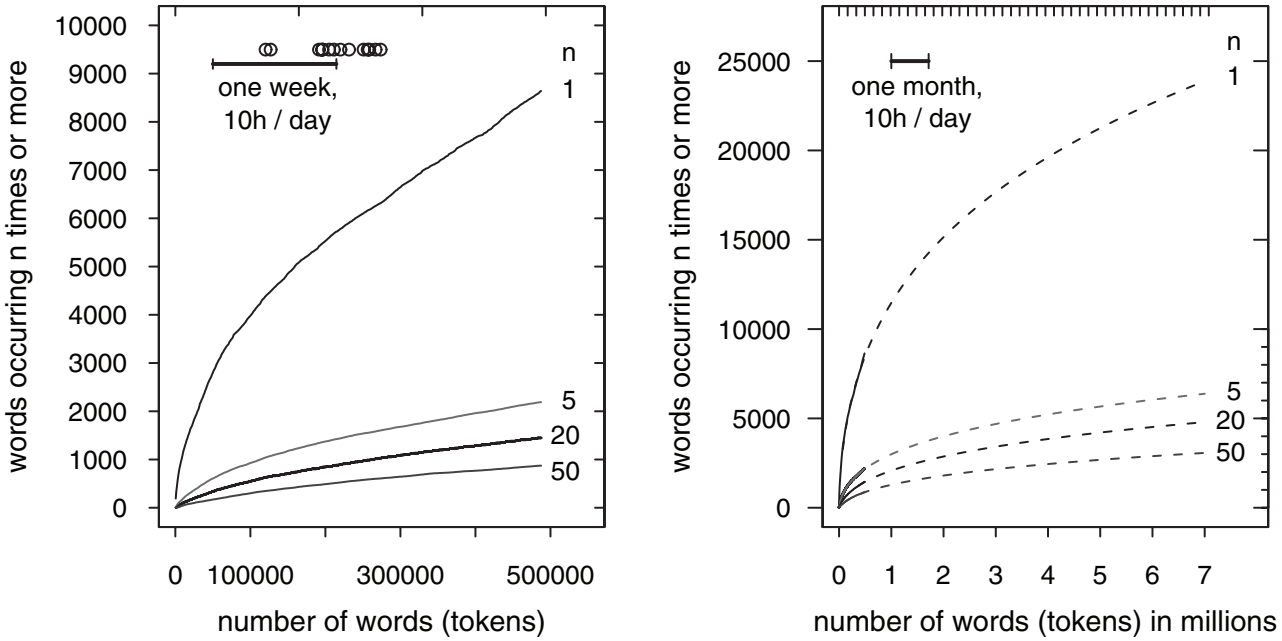
… *tiebie* … *tiebie* … + *tibie* x 14

"Dit is een *tiebie*" x 8



Difference in mispronunciation effects by 18-20-month-olds: Exposure x22 vs 8 (Swingley, 2007)

What does exposure of c20 times mean in real life?



Word frequency in infant-directed speech based on the Brent Corpus (Swingley, 2007). In 10 months, children are likely to be exposed to about 5000 word forms at least 20 times each.

Summary

- Infants can employ various strategies to segment words from running speech.
- Phonological representations of early familiar words are fairly accurate, but until about 17 months, infants do not instantly acquire representations of novel word forms. The process takes many exposures.
- Acquisition of phonological representations does not seem to be driven by the need to maintain lexical contrasts.