Languages' rhythm and language acquisition

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What we say to babies...
Well, Johnny, you've spilled your milk for the last time! I'll not tolerate that behavior any longer!..
What they hear

Phonological bootstrapping

Explaining the acquisition of abstract properties of language:

- Find speech cues or regularities that may signal abstract properties.
- Show that these cues are perceived by infants.
- Show that these cues are actually used by infants to acquire those properties.

Speech rhythm

- Temporal organization of syllables in an utterance.
- Different languages may have different types of rhythm (Pike 1945, Abercrombie 1967, Ladefoged 1975):
  - Germanic & Slavic languages, Arabic, are said to be stress-timed;
  - Romance languages, Turkish, Yoruba, are said to be syllable-timed;
  - Japanese is said to be mora-timed.

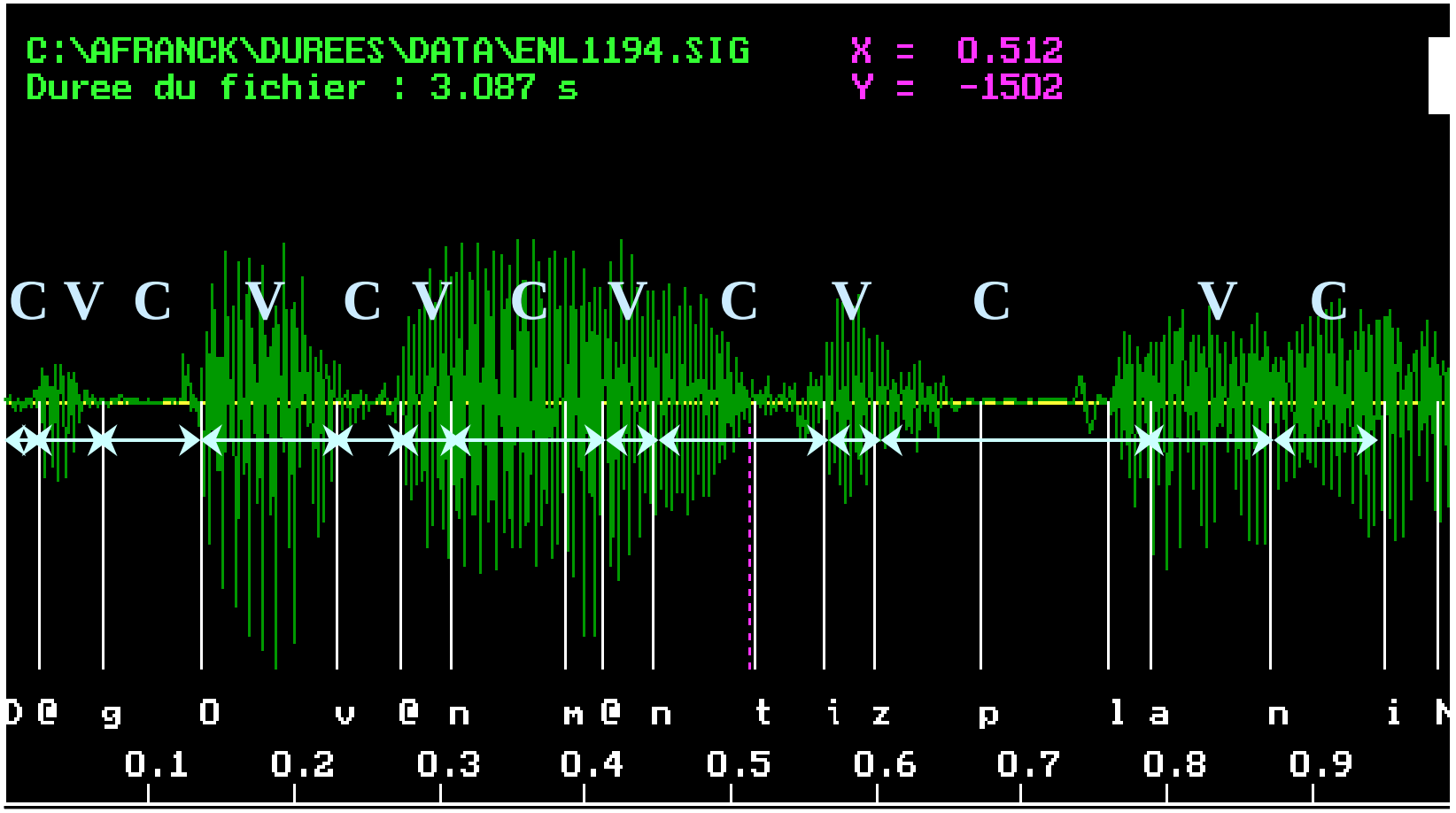
$\Rightarrow$ Rhythm class hypothesis

Correlates of rhythm in the speech signal

- Hypothesis: the infant's perception of speech is centered on vowels, i.e., infants segment speech into vowels + noise (consonants).
- A basic consonant/vowel segmentation could be enough to compute rhythm type.

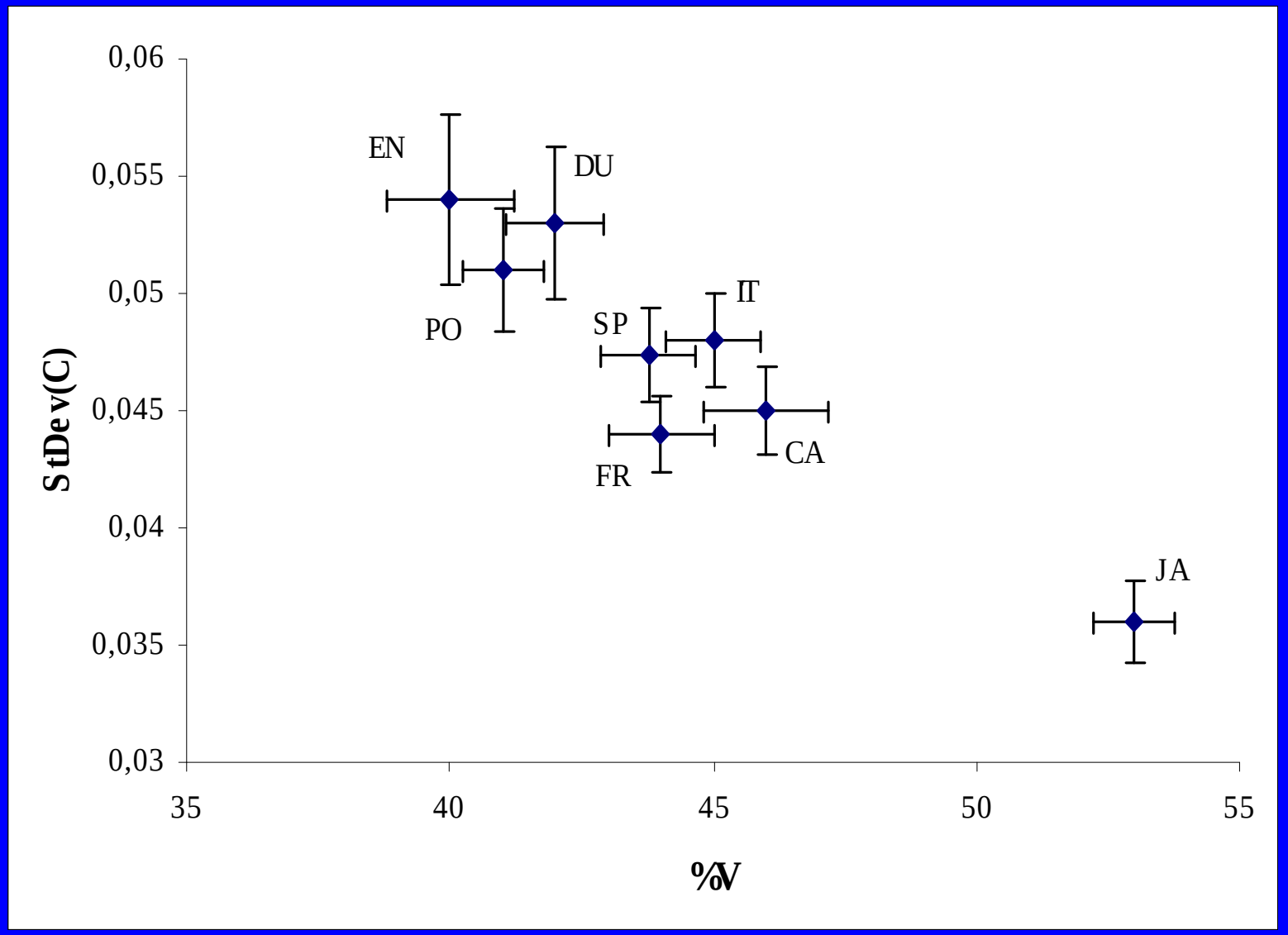
Example:

“The government is planning…”



Material

- 8 languages, 4 speakers per language, and 5 sentences per speaker = 160 sentences.
- Segmentation into consonantal and vocalic intervals.
- Three variables computed for each sentence:
  - %V proportion of vocalic intervals (= 1 - %C);
  - ΔV standard deviation of vocalic interval durations within the sentence;
  - ΔC standard deviation of consonantal interval durations within the sentence;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StDev(C)
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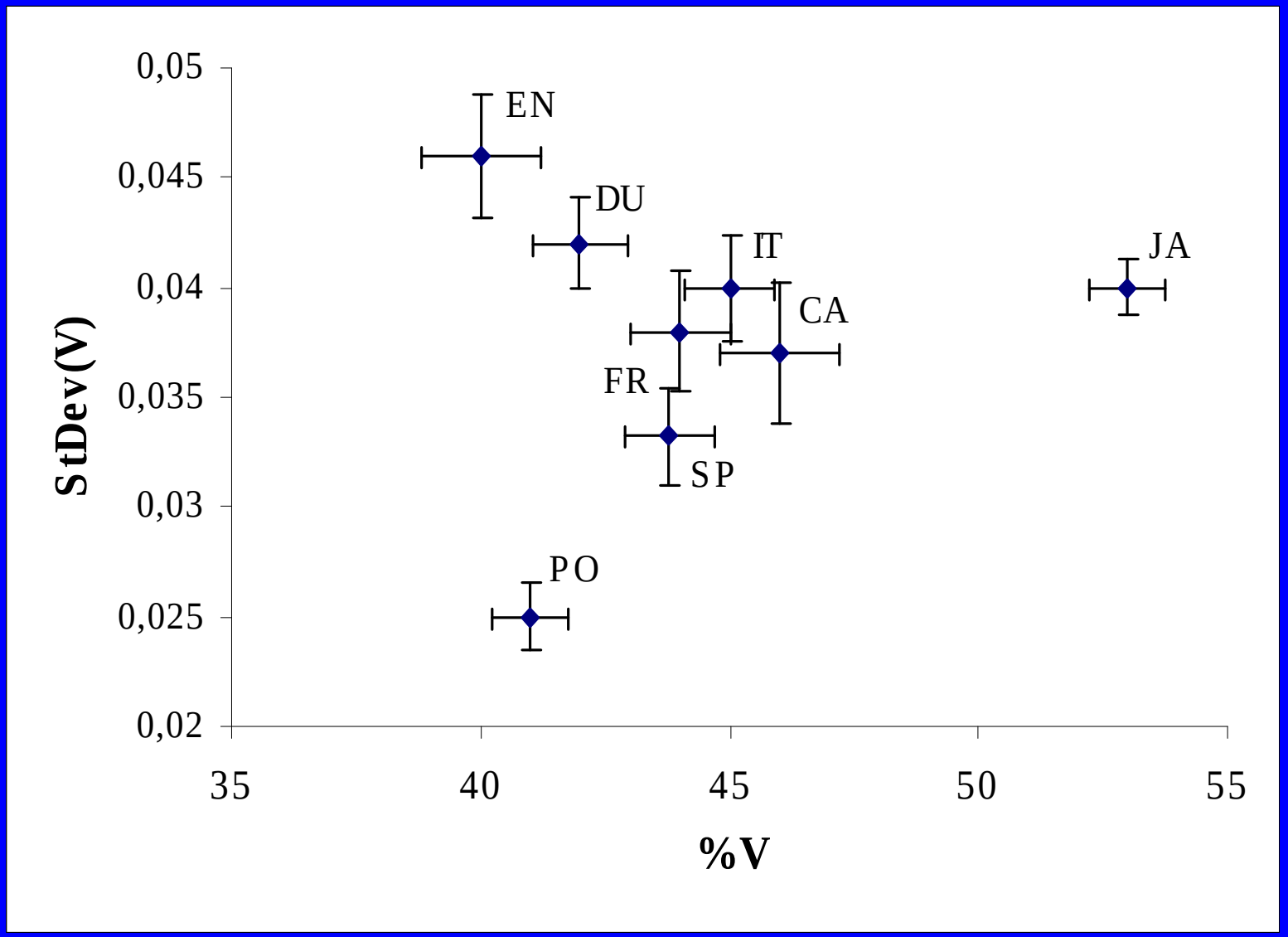
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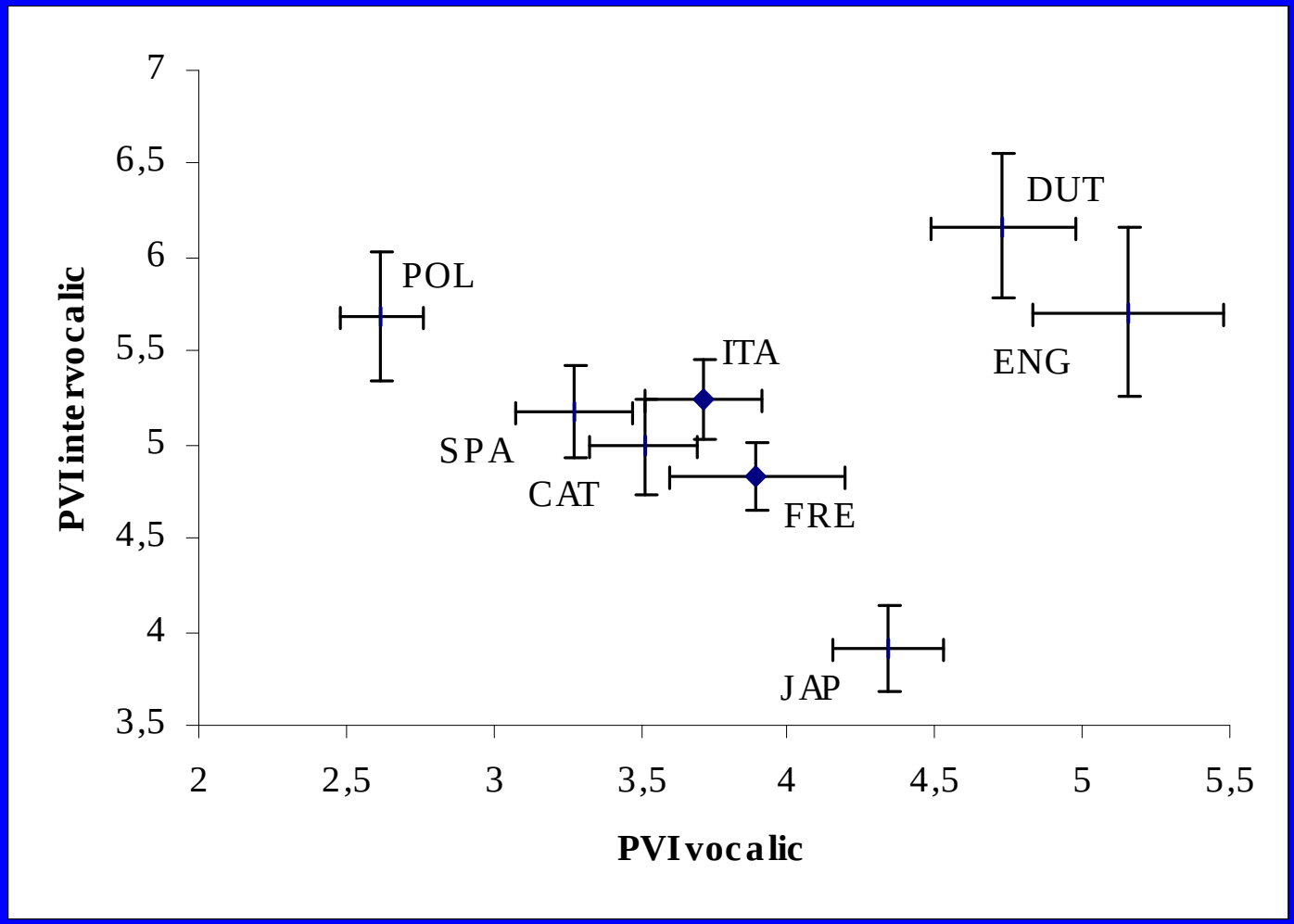
Pairwise variability index (Grabe et al.)



Simulations of language discrimination experiments by adults. Variables %V, ΔV and ΔC

	Eng.	*Dut..*	*Fre.*	*Ita.*	*Cat.*	*Spa.*	*Jap.*
Dut.	57.5						
Fre.	85	70					
Ita.	75	60	55				
Cat.	90	80	57.5	57.5			
Spa.	77.5	75	40	60	47.5		
Jap.	100	100	92.5	90	80	95	
Pol.	100	90	77.5	80	60	60	100

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Evidence for speech rhythm perception by newborns

- Newborns discriminate:
  - English/Italian;
  - French/Russian;
  - English/Spanish;
  - English/Japanese;
  - English+Dutch/Spanish+Italian.
- Newborns don’t discriminate:
  - English/Dutch;
  - Catalan/Spanish.
  - English+Italian/Dutch+Spanish;

+ low-pass filtering of speech (400 Hz).

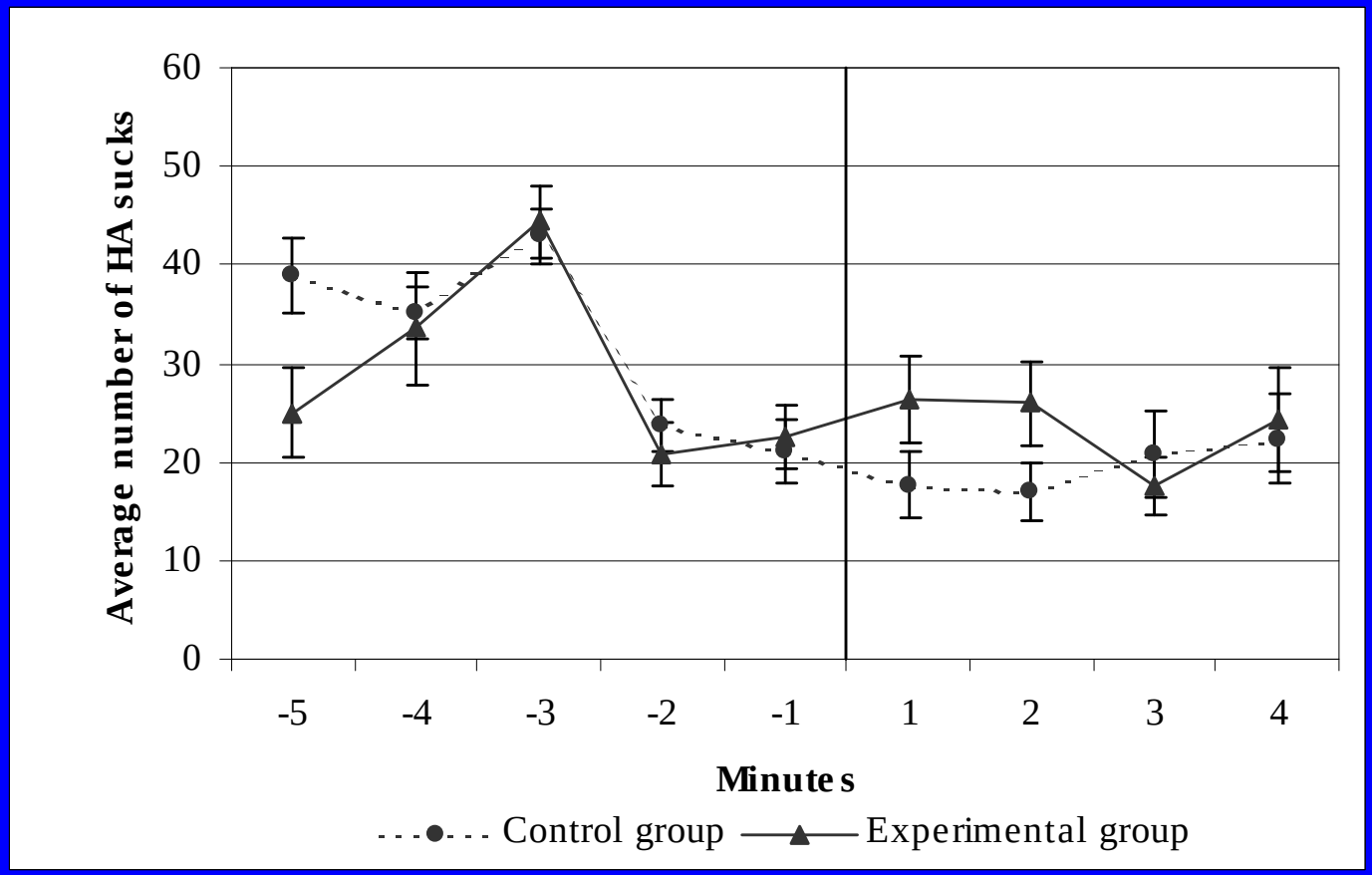
Saltanaj resynthesised speech

- Measure fundamental frequency (F0);
- Identify the phonemes and measure their duration;
- Phoneme transformation:
  - fricatives → /s/
  - vowels → /a/
  - liquids → /l/
  - plosives → /t/
  - nasals → /n/
  - glides → /j/
- Feed into voice synthesis software (MBROLA; Dutoit et al. 1996);
- Example:
  - The next local elections will take place during the winter
  - 
  - sanatstlatlalatsnsjaltaattlaastjansajanta

Method

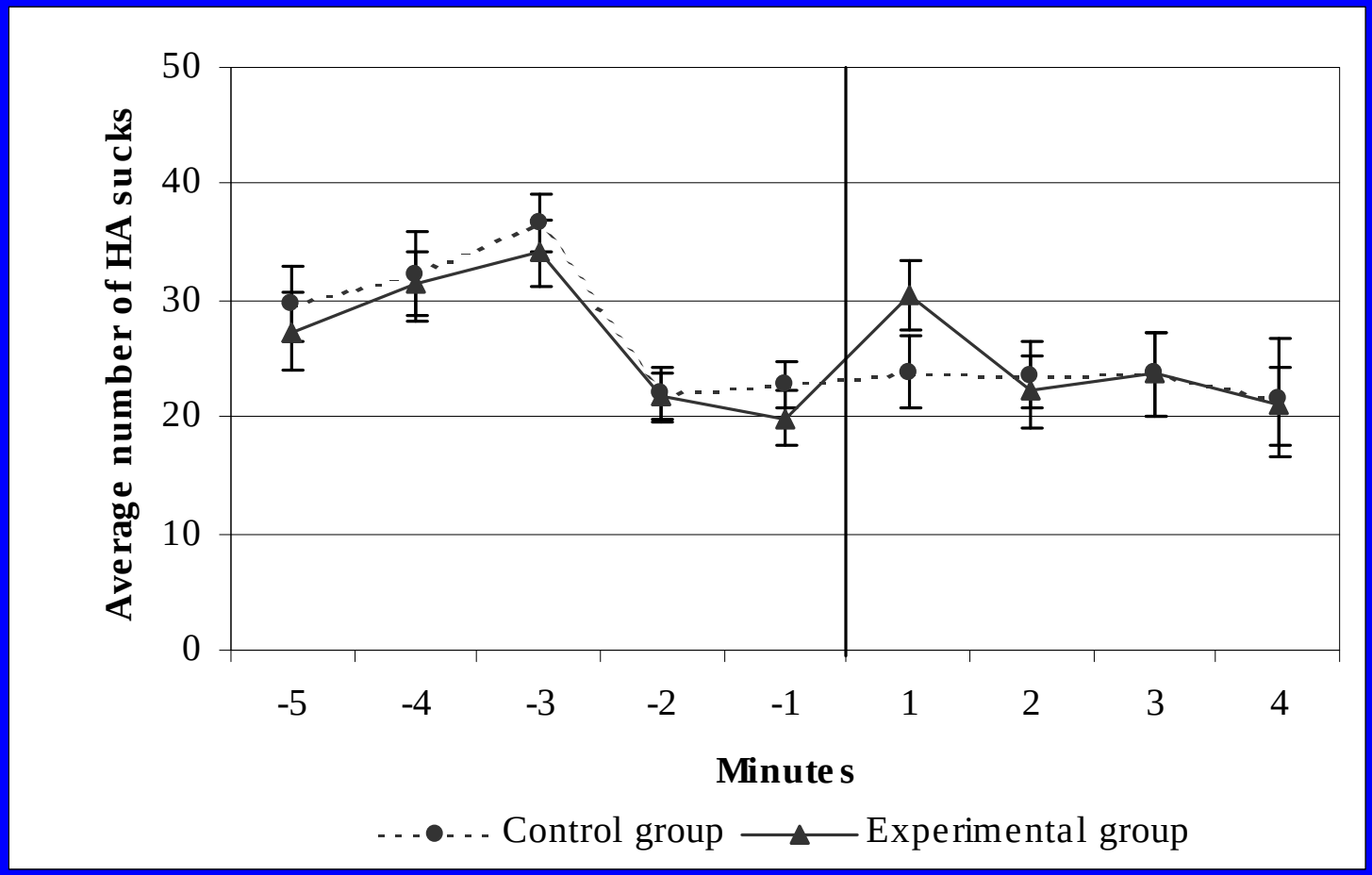
- Selection criteria
- Non-nutritive sucking
- Habituation paradigm
- 2 groups, e.g.:
  - Dutch 1, 2 → Dutch 3, 4
  - Dutch 1, 2 → Jap. 1, 2
- Rejection criteria
- Experimenter blind

Dutch/Japanese, *saltanaj* speech



F(1,29)=6.3, p=0.018

Dutch/Japanese, *saltanaj* speech with flat intonation



F(1,37)=4.98, p=0.03

Newborns are able to discriminate between different types of rhythm

So what?

Syllabic grammar

- English, Dutch, Arabic… : highly complex syllables (CCCVCC).
  Ex: « strings » [♦♦❐✋☠⌘☸
- Spanish, Italian, Yoruba… : less complex syllables (CCVC).
- Japanese, Tamil… simple syllables (CVN).
  Ex: « sphinx » → [sufinkusu]

Syllabic grammar (2)

- Principles and Parameters (Chomsky, 1981):
  - +/- Coda
  - +/- ComplexCoda
  - +/- ObligatoryOnset
  - +/- ComplexOnset
- Optimality Theory (Prince & Smolensky, 1993):
  - Onset
  - NoCoda
  - NoComplexOnset
  - NoComplexCoda
  - Fill
  - Parse

Correlation between rhythm and syllabic structure

- Stress-timed languages ⇔ very complex syllables (CCCVCC).
- Syllable-timed languages ⇔ less complex syllables (CCVC).
- Mora-timed languages ⇔ simple syllables (CVN)

The role of rhythm in the acquisition of syllables

Principles & Parameters	**Optimality Theory**
mora-timed language	
[- Complex Onset]	NoComplexOnset,
[- Complex Coda]	NoComplexCoda >> Fill, Parse
syllable-timed language	
[+ Coda]	Fill, Parse >> NoComplexOnset,
[+ Complex Onset]	NoCoda
stress-timed language	
[+ Coda]	Fill, Parse >> NoComplexOnset,
[+ Complex Onset]	NoComplexCoda,
[+ Complex Coda]	NoCoda

Language-specificity

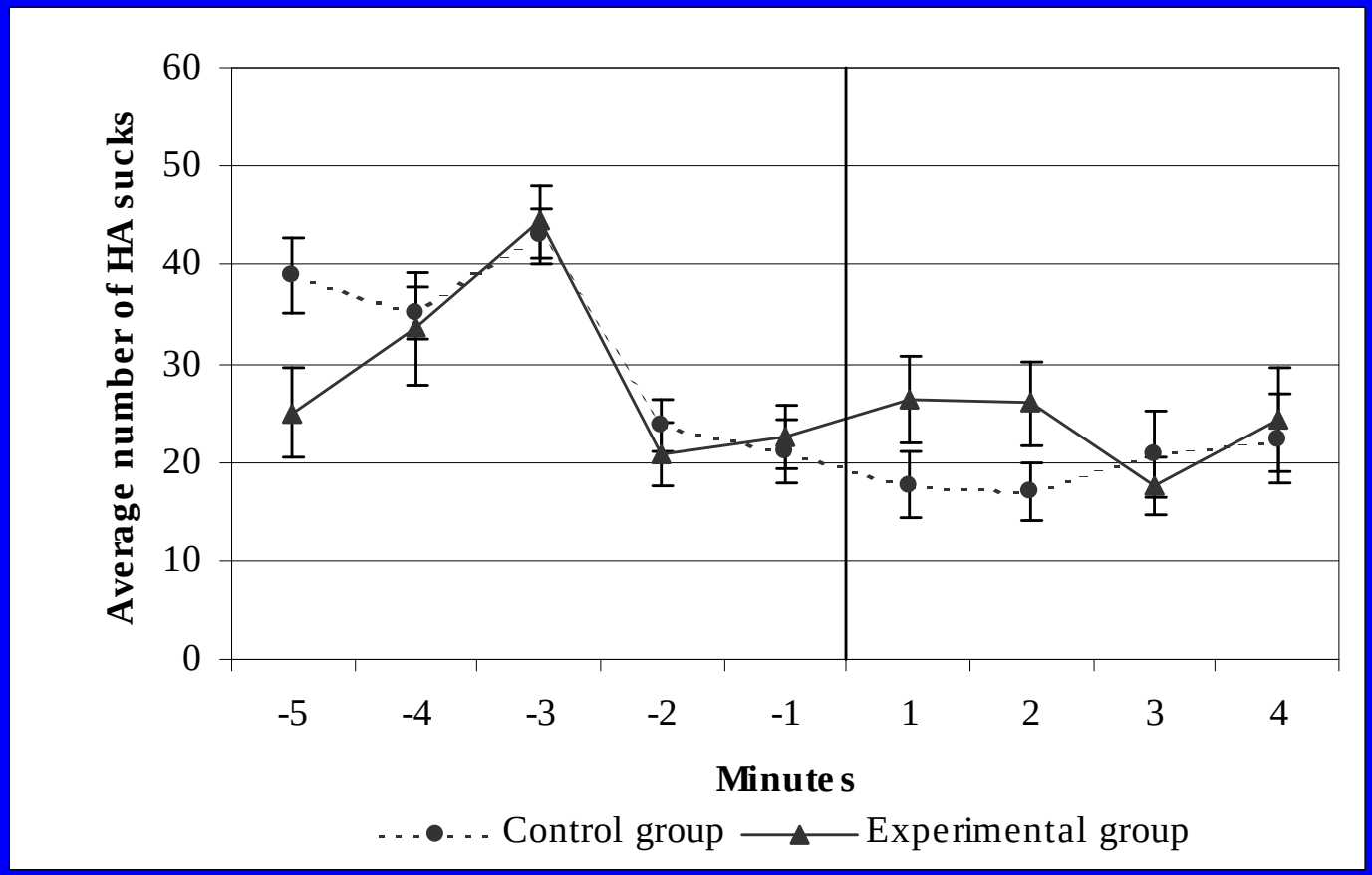
The capacity to process speech rhythm:

- has evolved specifically for the purpose of perceiving speech and acquiring a language?

Or:

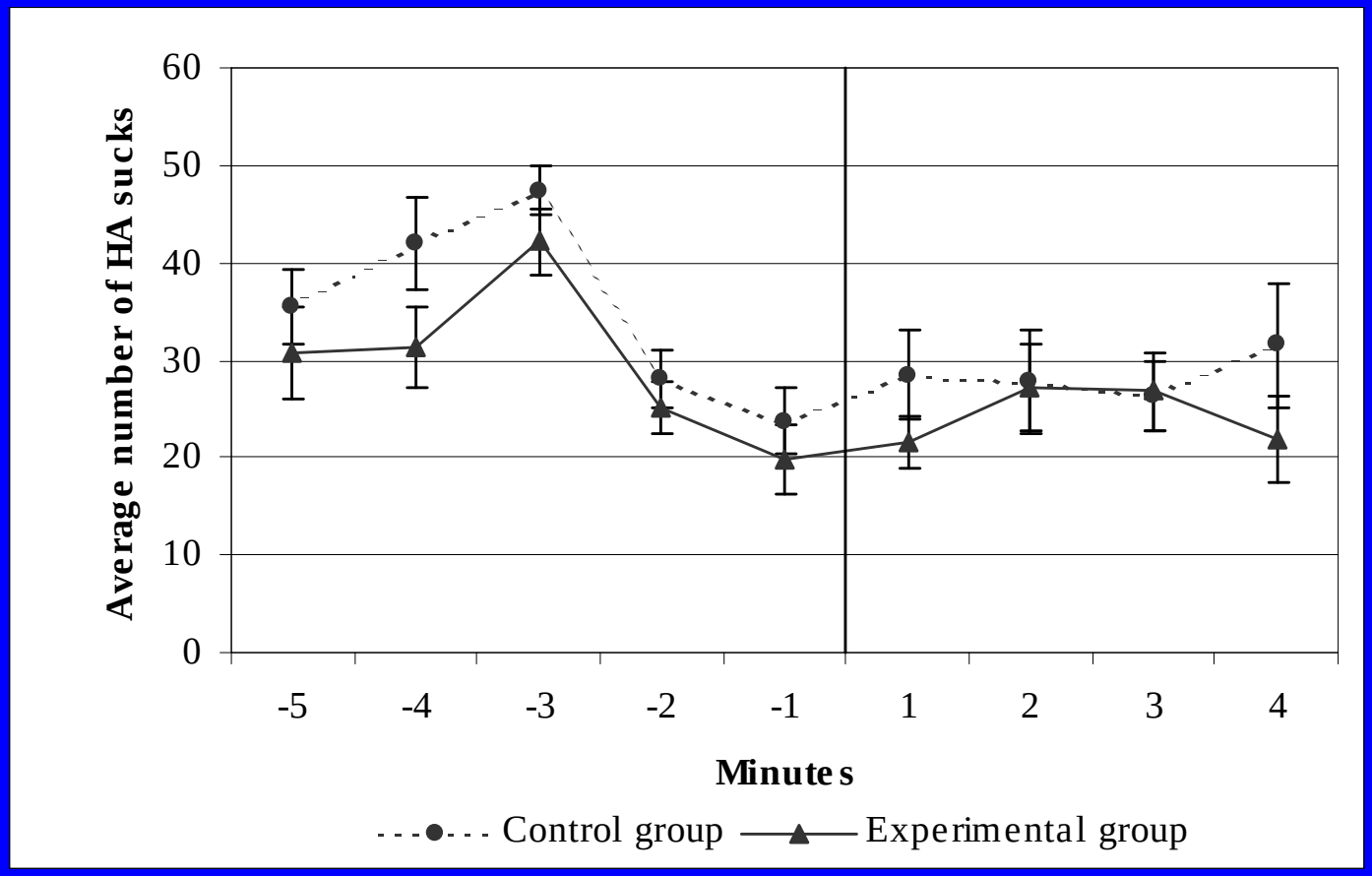
- is attributable to the general properties of our auditory system?

Dutch/Japanese, *saltanaj* speech



F(1,29)=6.3, p=0.018

Dutch/Japanese, *saltanaj speech* backwards

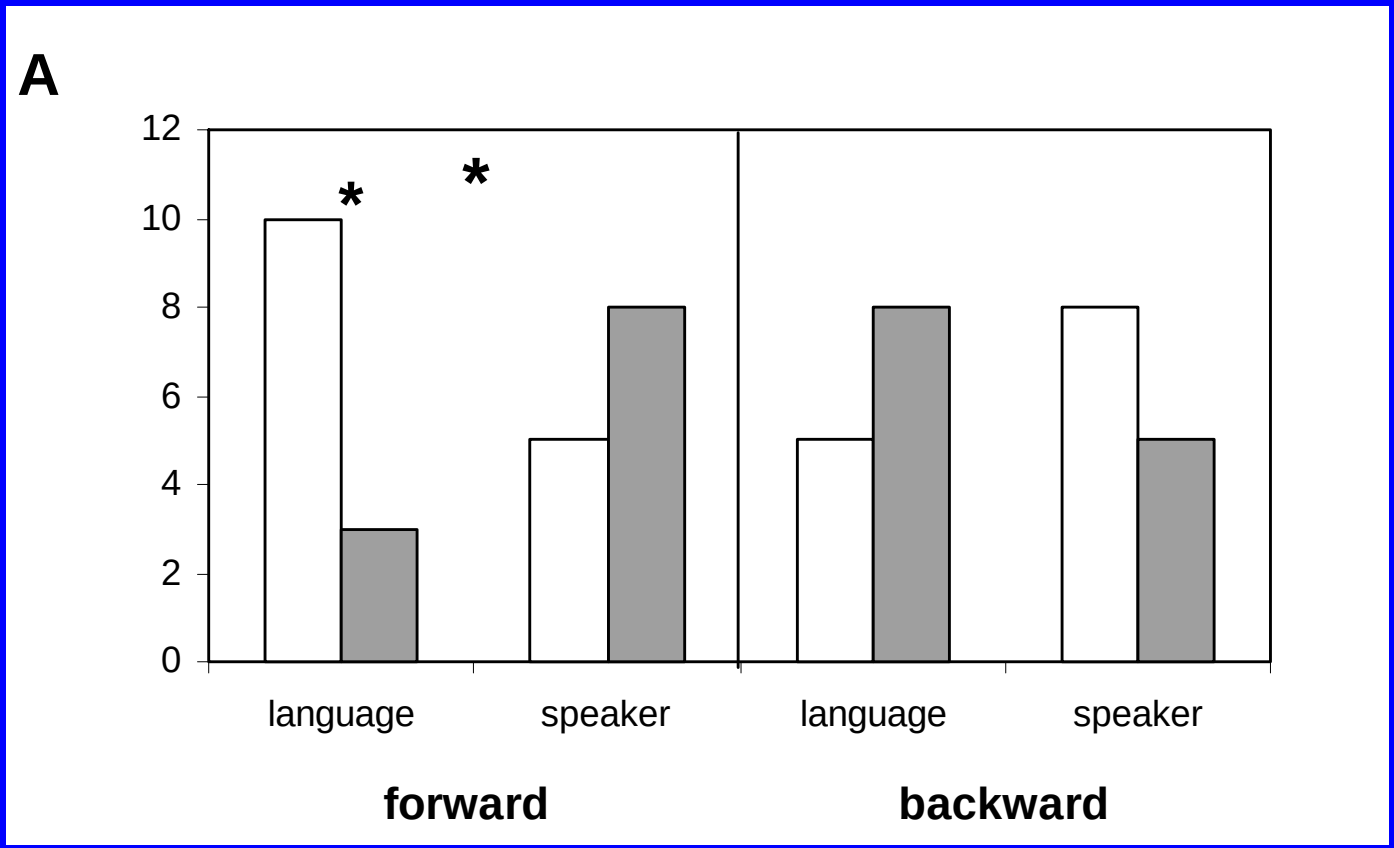


Forward/backward interaction: F(1,59)=3.56, p=0.06

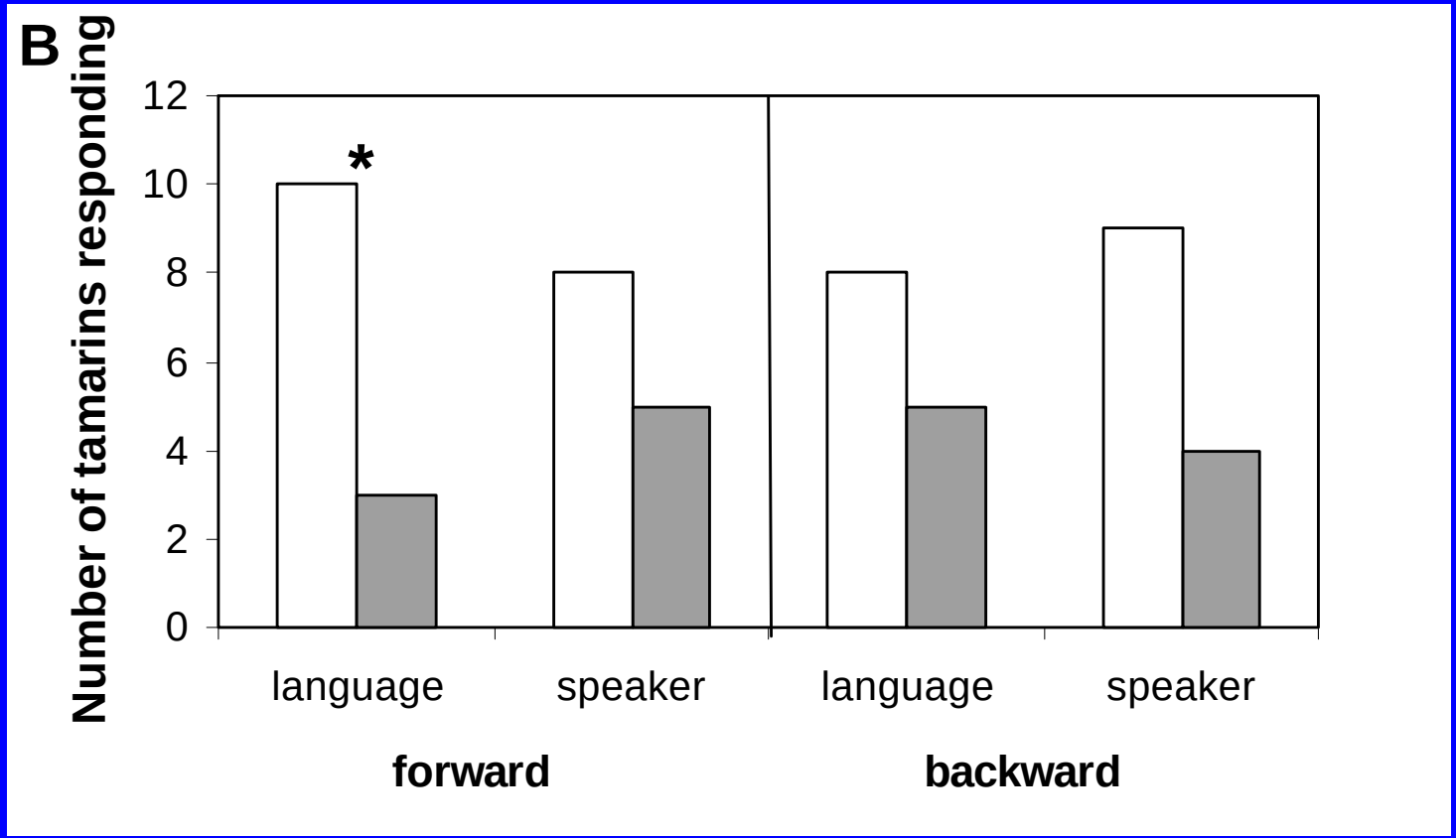
Habituation procedure with tamarins

- 13 tamarins;
- each tamarin in 4 conditions: group X (forward, backward);
- behavioural measure: orientation towards the loudspeaker.

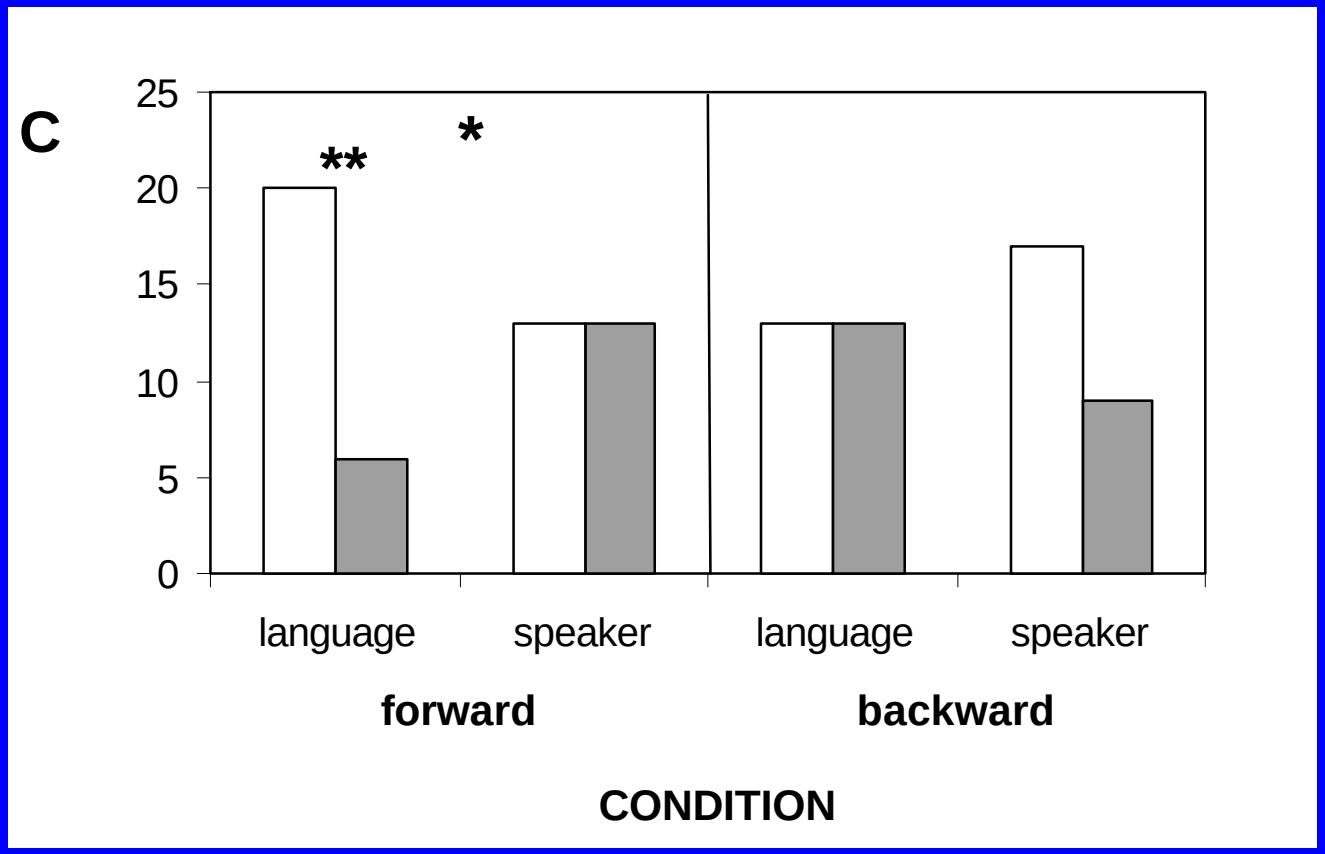
Tamarins
Dutch/Japanese discrimination
natural speech



Tamarins
Dutch/Japanese discrimination
saltanaj stimuli



Tamarins
Dutch/Japanese discrimination
pooled analysis




What we say to babies...
Well, Johnny, you've spilled your milk for the last time! I'll not tolerate that behavior any longer!
What they hear
+ CODA
+ COMPLEX - CODA
+ COMPLEX - ONSET
dawn


What we say to babies...
Well, Johnny, you've spilled your milk for the last time! I'll not tolerate that behavior any longer!
What monkeys hear
What on earth does +COMPLEXCODA mean?