Phonological « deafnesses »: Summary of research

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What are phonological ‘deafnesses’?

- *Phonological ‘deafnesses’ = difficulties in perceptual processing of specific non-native speech sounds.*

- Examples:
  - Japanese difficulties with English /r/ vs /l/ (Goto, 1971; Miyawaki et al., 1975)
  - Spanish difficulties with Catalan /e/ vs /ɛ/ (Pallier et al, 1997)

→ *Interpretation:* non-native sounds are ‘assimilated’ to the closest native phoneme category. Deafness arises when two sounds are mapped on the same category (Best , 1994; Flege, 1995; Iverson et al, 2003).

Here, we investigate two new types of deafnesses, suprasegmental and phonotactic. We explore their existence cross-linguistically, their locus within the speech processing system (with RT and brain imagery techniques), and their robustness in bilinguals.

Background: Suprasegmentals and Phonotactics in borrowings

- Vowel *Degemination* in French
  - Phonology:
    - no contrast between short and long vowel
  - Loanwords:
    - “Tokyo” [to:kjo:] → [tokjo]
    - “Kyoto” [kjo:to] → [kjoto]

    → *map long vowels onto short ones*

- Stress deletion in French
  - Phonology:
    - no lexical stress; phrase final stress
  - Loanwords:
    - “Clinton” [kl**í**nton] → [klint**ó**n]
    - “Arizona” [ariz**ó**na] → [arizon**á**]

    → *shift the stress to phrase final position*

- Vowel *Epenthesis* in Japanese
  - Phonology:
    - legal syllables: V, CV, VN, CVN
    - illegal syllables: *CVC, *CCV, ...
  - Loanwords:
    - “Sphinx” → [sufiNkusu]
    - “Christmas” → [kurisumasu]

    → *insert the vowel [u] in illegal consonant strings*

> - *are these effects taking place in perception or production?*
> - *if in perception, where and when?*
> - *how and when do they develop in infants?*
> - *are they phonological or acoustic?*

Stress 'deafness' observed

a) Stress discrimination in French and Spanish

Task: multi-talker ABX (A B and X in different talkers)

e.g.: *A – B – X*

vasúma – vásuma – vásuma

vasúma – vasumá – vasúma

b) Phoneme discrimination (with orthogonal variation in stress)

Task: multi-talker ABX, ignore stress

e.g.: *A – B – X*

vasúma – fásuma – fasúma

vasúma – fasumá – vasumá

c) Stress vs phonemes discrimination in French, simpler task

Task: single talker AX

e.g.: *A – X*

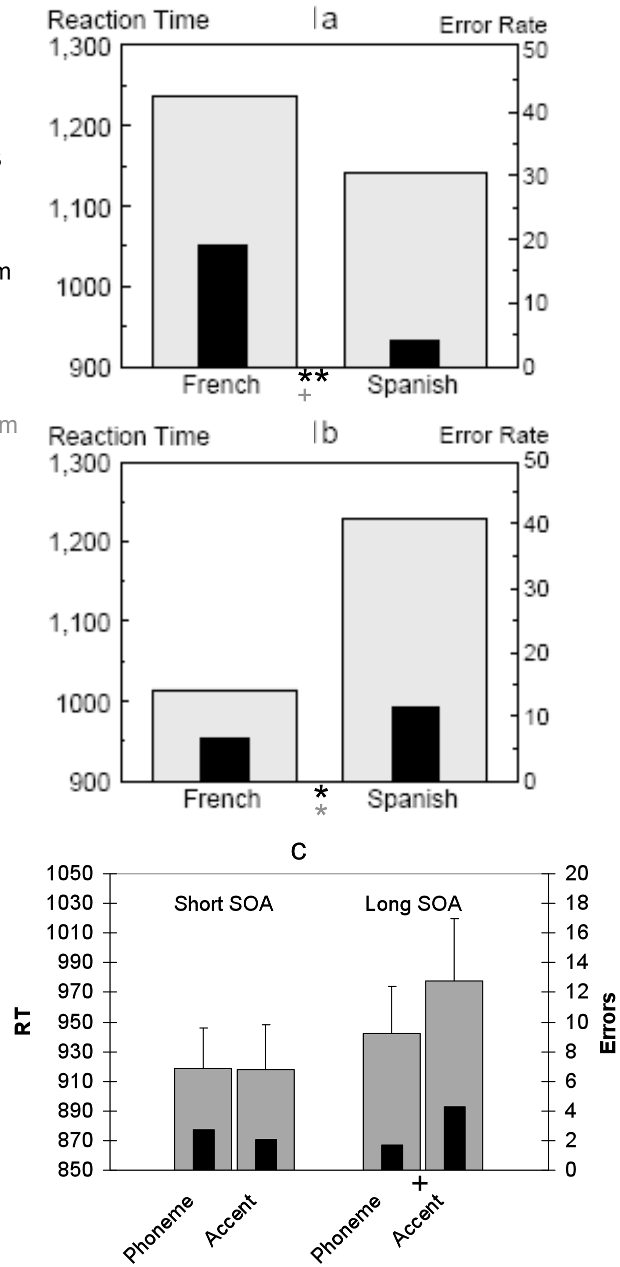
vasúma – vásuma

Errors

** p<.001
* p<.05
+ p<.001 by item

RTs

* p<.05
+ p<.001 by item



→French, not Spanish, have difficulties in discriminating contrastive stress

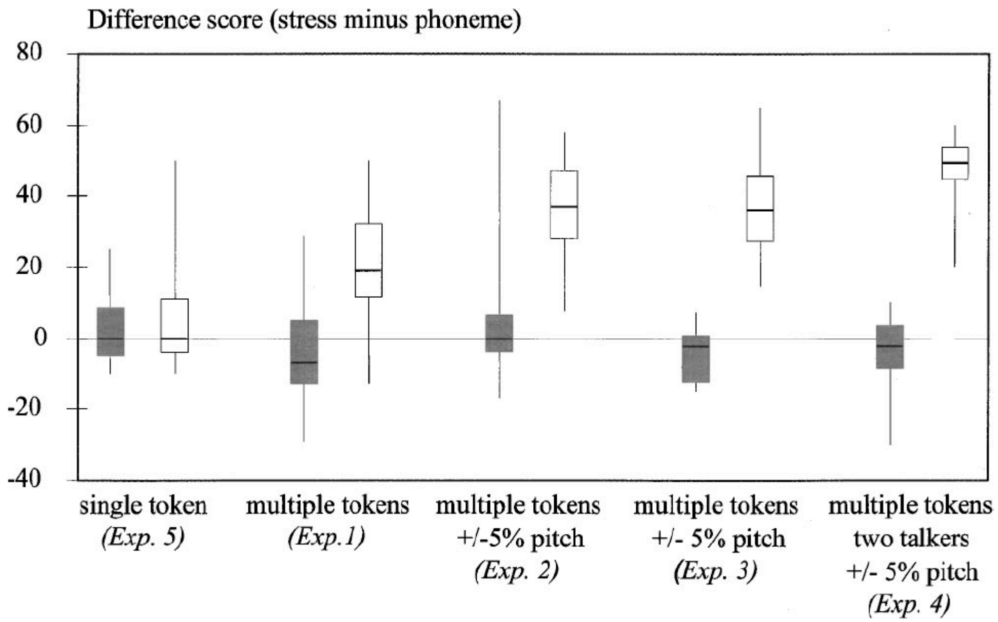
→Spanish, not French have difficulties in ignoring stress when performing phoneme discrimination

→stress 'deafness' disappears in an AX task without talker variability at short SOA

Dupoux, E., Pallier, C., Sebastian, N., & Mehler, J. (1997).
A destressing 'deafness' in French? *Journal of Memory and Language*, **36**, 406-421.

A robust method to study stress 'deafness'

- Task: sequence repetition
- Stimuli:
  - númi vs numí
- Procedure:
  - learning a two way classification:
    - númi=[1]
    - numí=[2]
  - transcribing a sequence
    - númi numí numí=[122]
  - sequences of increasing lengths: from 2 to 6
- Participants:
  - Monolingual French subjects



→ Stress deafness in a short term memory task only arise when the stimuli incorporate enough acoustic variability to discourage an acoustic response strategy

Dupoux, E., Peperkamp, S., & Sebastian (2001). A robust method to study stress 'deafness'. *Journal of the Acoustical Society of America*, **110**, 1606-1618.

Cross-linguistic stress 'deafness'

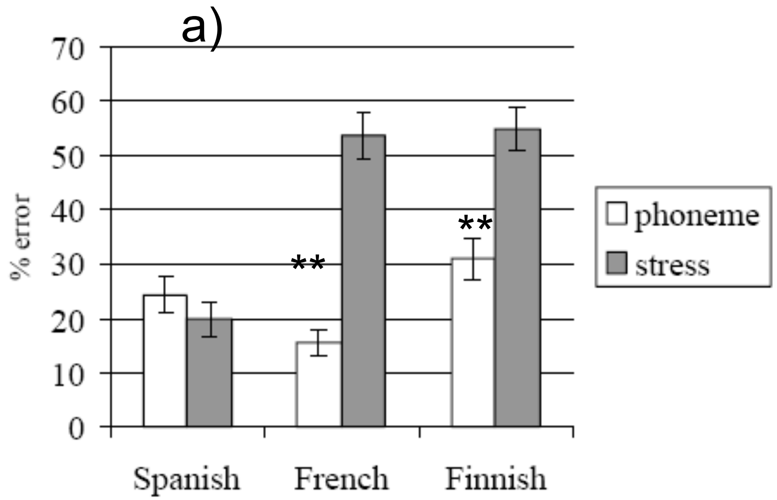
	Spanish	French	Finnish	Hungarian	Polish
Lexical Stress	YES	NO	NO	NO	NO
Stress Pattern (word level)	Variable (last 3 syllables)	Phrase final	Word initial	Word initial	Word penult
Stress Pattern (utterance level)	Variable	Utterance final	Utterance final	Utterance final (modulo function words)	Variable (last or penult)

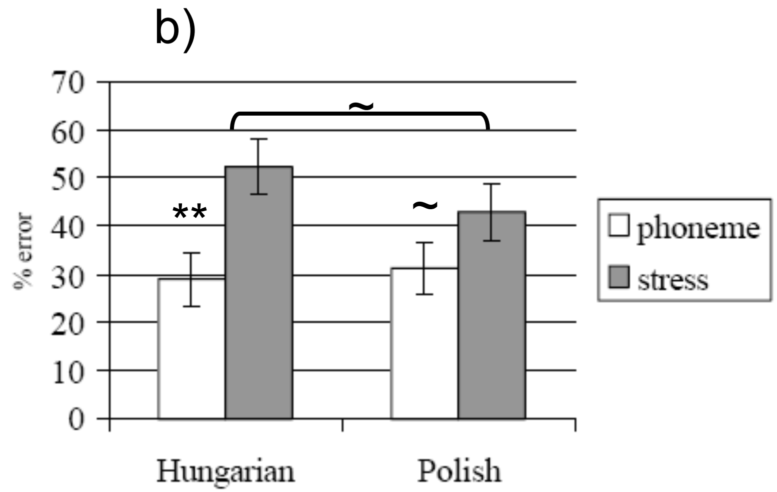
- task: sequence repetition
- sequence lengths: 2-6

→ Stress deafness generalizes to languages with initial stress like Finnish or Hungarian

→Polish, a language with penult stress has only a marginal trend towards stress deafness.

→*interpretation: languages with transparent stress regularities loose the phonological representation of stress; languages with less transparent stress systems tend to keep it.*





** p<.001
~ .01>p>.05

Peperkamp, S. & Dupoux, E. (2002). A typological study of stress 'deafness'. In: C. Gussenhoven & N. Warner (eds.) *Laboratory Phonology 7.* Berlin: Mouton de Gruyter.

Cross-linguistic stress 'deafness' (bis)

Language	domain of stress	contrastive suprasegmentals	variability in position of stress	lexical exceptions
Standard French	phrase	none	fixed [a]	no
Southeastern French	phrase	none	**variable** [b]	no
Finnish	**word**	**vowel length**	fixed [c]	no
Hungarian	**word**	**vowel length**	fixed [c]	no
Polish	**word**	none	**variable** [d]	**yes (0.1%)**
Spanish	**word**	**stress**	**variable** [e]	**yes (17%)**

a. final, b. last non-schwa syllable, c. initial, d. penultimate in polysyllables, final in monosyllables, e. one of the last three syllables

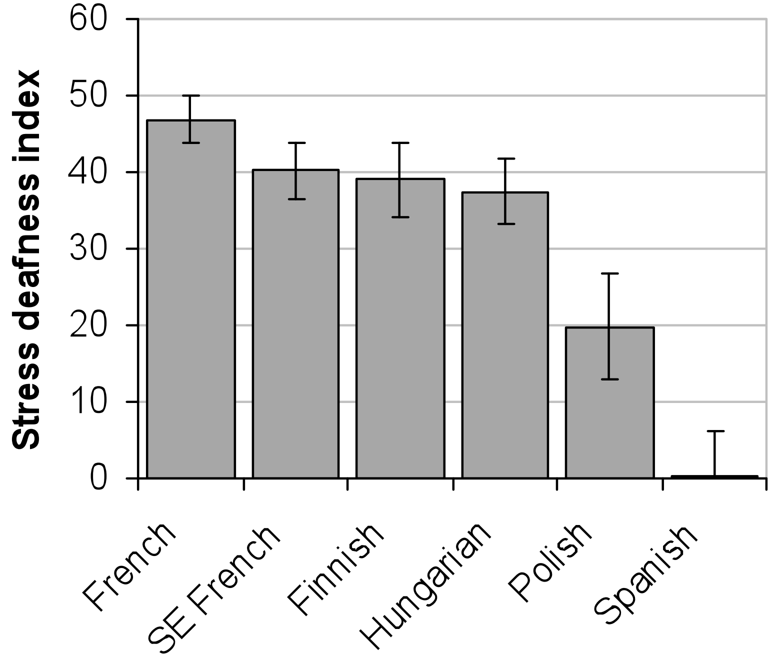
- Subjects: N=12 in each language
- Task: sequence repetition
  - Conditions: stress vs phoneme
  - sequence length: 5

→ Three classes of languages:
- Totally deaf: French, SE French, Finnish, Hungarian
- Partially deaf: Polish
- Not Deaf: Spanish

→ *Interpretation: lexical exceptions make the right predictions*

→ *Problem: incompatible with early acquisition of the French-Spanish contrast*

→*Alternative interpretation: variability in position of stress (modulo sentence-observable phonological rules, ie, b.)*



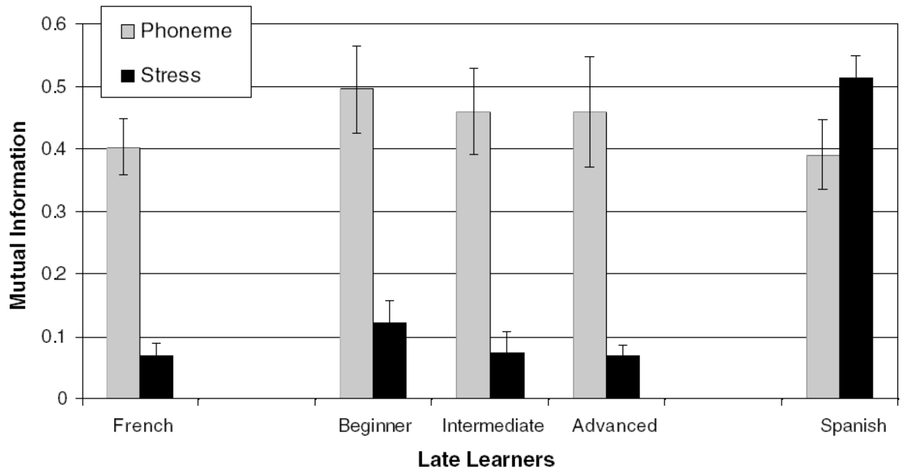
Peperkamp, S., Vendelin, I. & Dupoux, E. (2010). Perception of predictable stress: A cross-linguistic investigation. *Journal of Phonetics*, **38(3)**, 422-430.

The persistence of stress deafness

Participants: French late learners of Spanish

	Beginner	Intermediate	Advanced
Length of residence in spanish speaking countries	0.7 year	2 years	4.3 years
Regularly speaks Spanish in private life	7%	61%	68%
Regularly speaks Spanish in professional/student life	32%	50%	64%

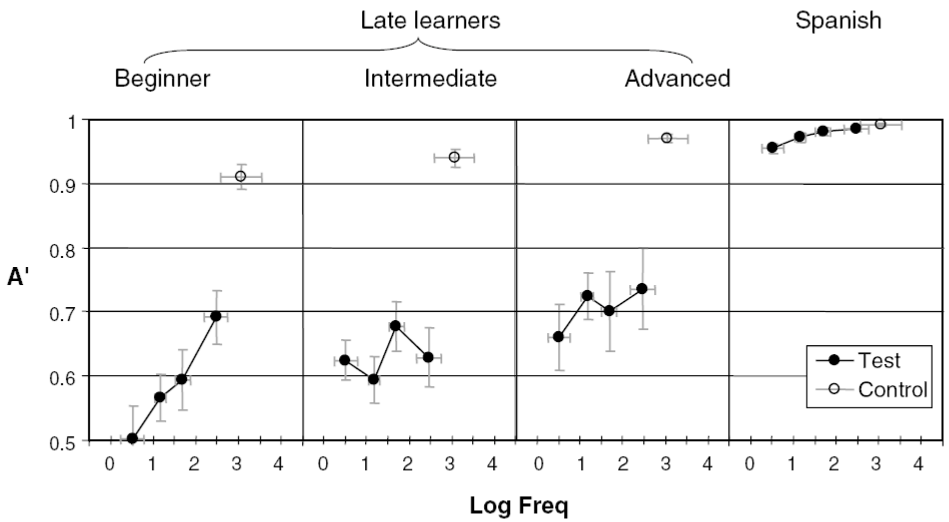
a) information transmitted in sequence repetition



a) Sequence repetition

- conditions:
  - * phoneme: fitu-fiku
  - * stress: num'i vs n'umi
- sequences of size 4

b) minimal pair word/nonword discriminability



b) Speeded lexical decision

conditions:

* test: « balc'on » vs « b'alcon »

* control: « blanco » vs « blanto »

→ Stress deafness is very persistent, and still found in relatively proficient late learners of Spanish

Dupoux, E., Sebastian-Galles, N. Navarete, E., & Peperkamp, S. (2007). Persistent stress `deafness': the case of French learners of Spanish. *Cognition,* **106**(2),682-706.

Stress « deafness » in simultaneous bilinguals?

Subjects:

- 23 simultaneous bilinguals (from birth)
- 20 control Spanish monolinguals
- 20 control French late learners of Spanish

Tasks:

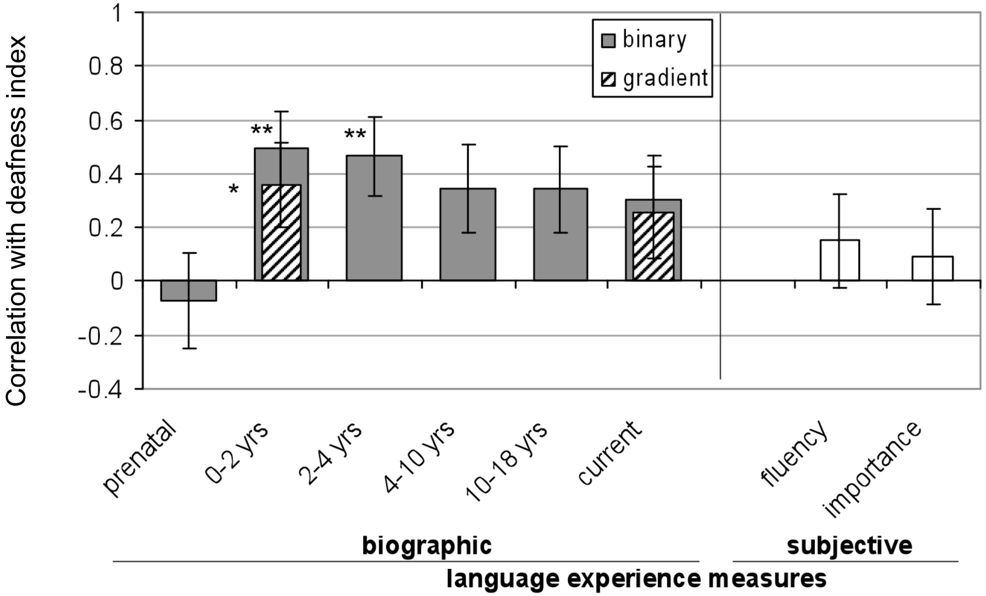
a) Sequence repetition
   - conditions: stress (num'i - n'umi) vs phoneme (fitu-fiku)
   - sequences of size 2-6

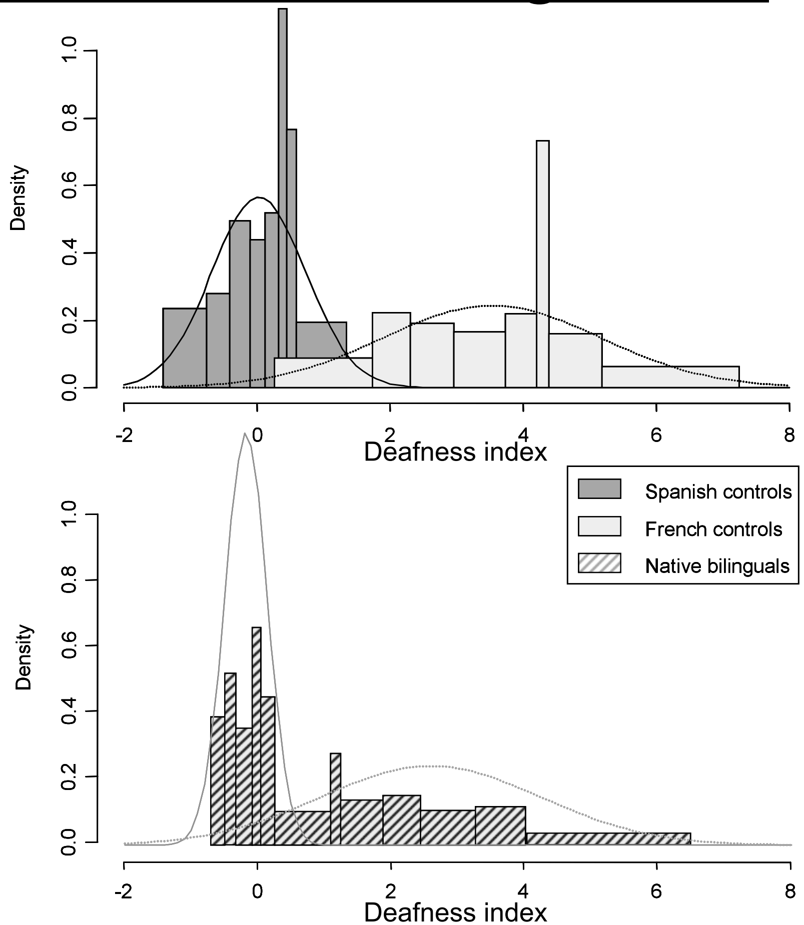
b) Idem with sequences of size 4 only

c) Speeded lexical decision
   - stress word-nonword minimal pairs (bal'on -b'alon)

Measures:

- Deafness index=composite Z-score across the 3 tasks
- Biographic and subjective dominance measures



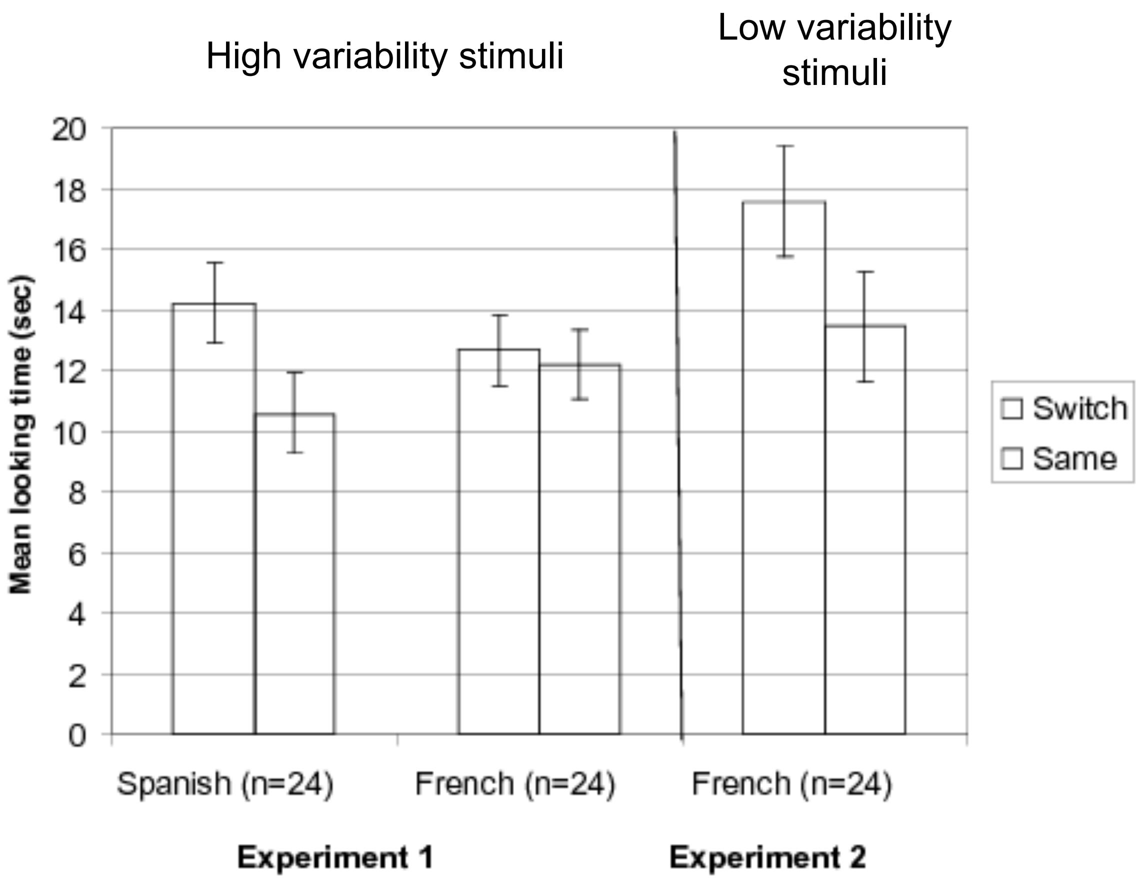


→Simultaneous bilinguals are bimodal, one mode is similar to native spanish, the other to native French (late learners of Spanish)
→Early childhood, not current use or subjective preference, influences which mode is chosen.

Dupoux, E., Peperkamp, S, & Sebastian-Galles (2008) Limits on bilingualism revisited: stress 'deafness' in simultaneous French-Spanish bilinguals. *Cognition*. **106(2)**, 682-706.

The acquisition of stress 'deafness'

- Subjects
  - Spanish 9 month olds
  - French 9 month olds
- Experiment 1
  - switch design
  - High variability stimuli: (d'atu, s'api, k'iba, etc) vs (dat'u, sap'i, kib'a, etc.)
- Experiment 2:
  - Low variability stimuli: p'ima vs pim'a

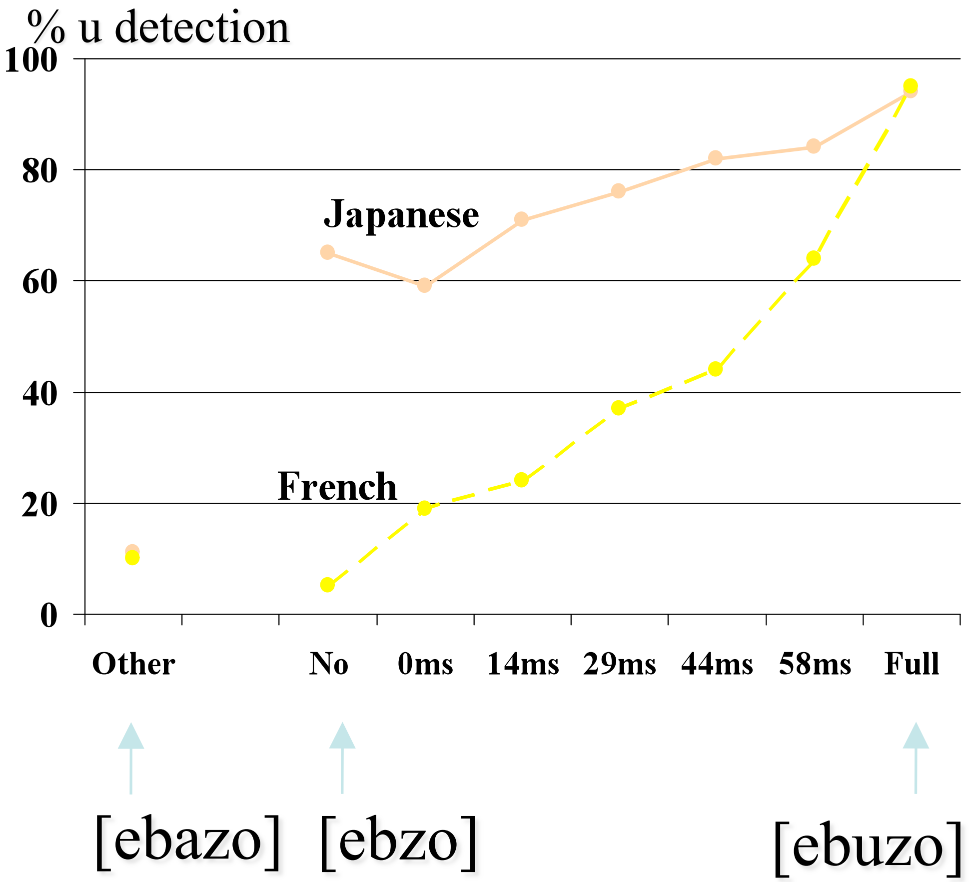


→ At 9 months, French infants have already the stress 'deafness effect'
→the acquisition of the distinction between predictable and unpredictable stress cannot be lexically driven

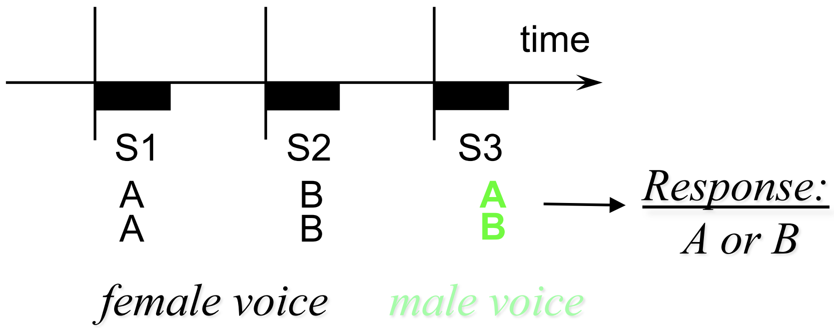
Skoruppa, K., Pons, F., Christophe, A., Bosch, L. Dupoux, E. Sebastián-Gallés, N., Limissuri, R.A., Peperkamp, S. (2009) Language-Specific stress perception by nine-month-old French and Spanish infants. *Developmental Science,* **12:6**, 914-919

phonotactic ‘deafness’ observed: perceptual epenthesis

Vowel detection



ABX Task



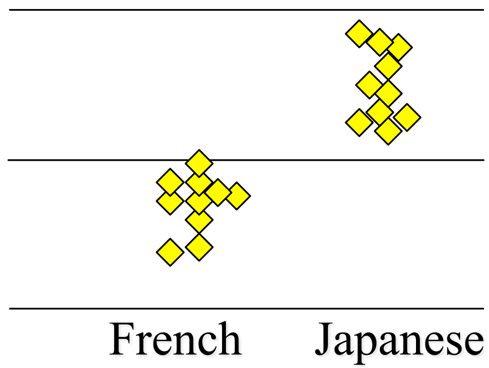
Conditions:

cluster: ebuzo-ebzo

vowel length: ebuzo

-ebu zo

Cluster - Vowel score (%)

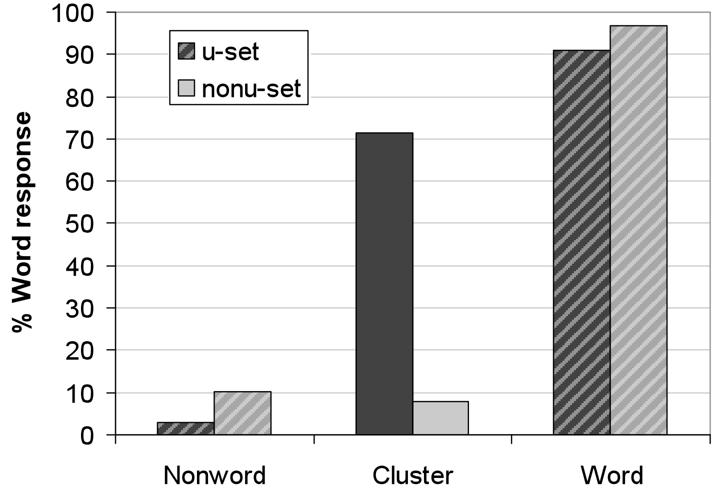


Dupoux, E., Kakehi, K., Hirose, Y., Pallier, C., & Mehler, J. (1999). Epenthetic vowels in Japanese: A perceptual illusion? *Journal of Experimental Psychology: Human Perception and Performance*, **25(6)**, 1568--1578.

Phonotactic deafness is prelexical

- Speeded lexical decision
  - words:
    - u-set: sokudo
    - nonuset: mikado
  - nonwords created by changing the vowel (u→a or vice versa)
  - cluster items created by removing the vowel
  - Participants:
    - monolingual Japanese subjects

	u-set	nonu-set
Nonword	sokado	mikudo
Cluster	sokdo	mikdo
Word	sokudo	mikado

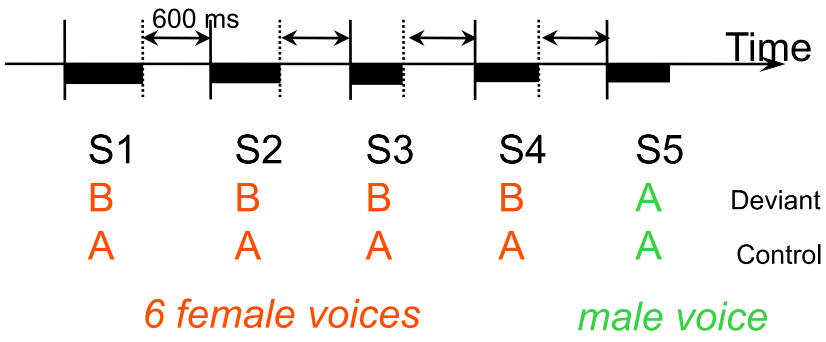


→the insertion of epenthetic /u/ occurs prior to lexical access

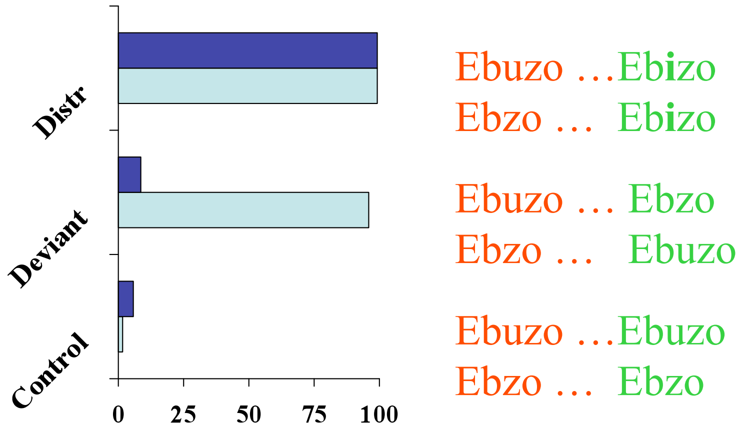
Dupoux, E., Pallier, C., Kakehi, K., & Mehler, J. (2001). New evidence for prelexical phonological processing in word recognition. *Language and Cognitive Processes*, **5(16)**, 491-505.

The time course of phonotactic deafness

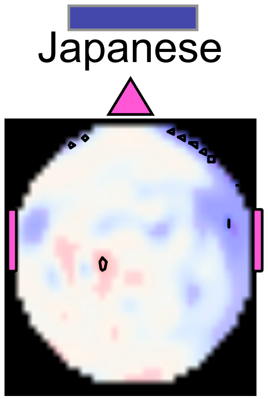
Mismatch detection paradigm



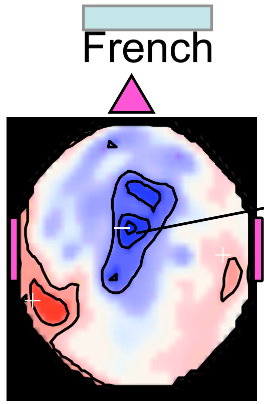
Behavioral results

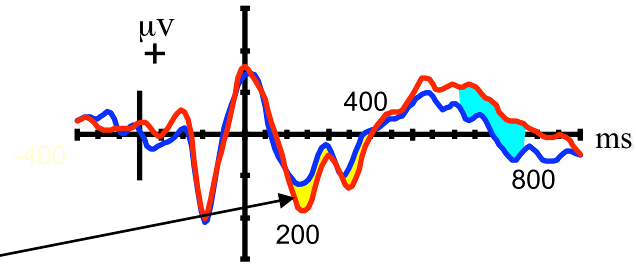


High density ERPs results

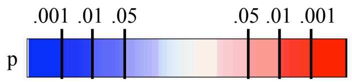


[ebuzo] vs [ebzo] (deviant vs control)





→ Same distribution and timing as Mismatch Negativity

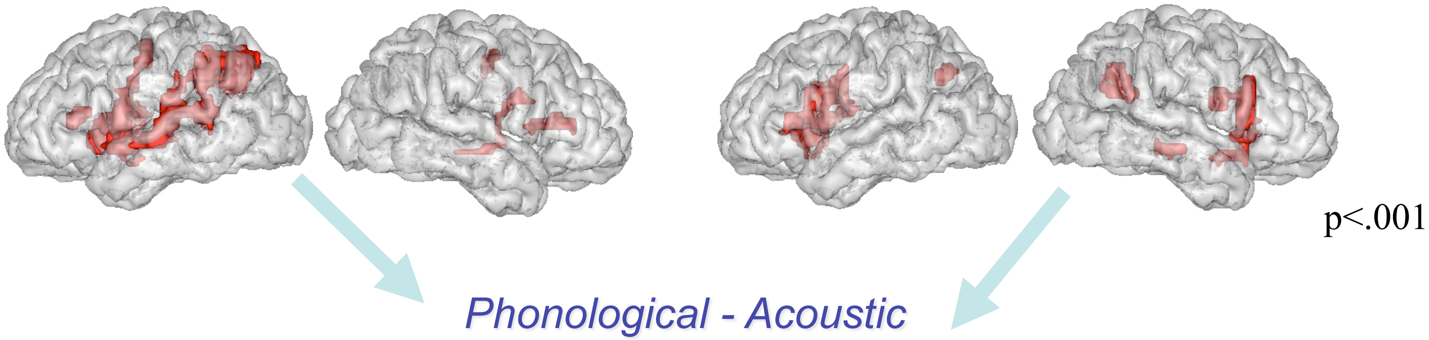


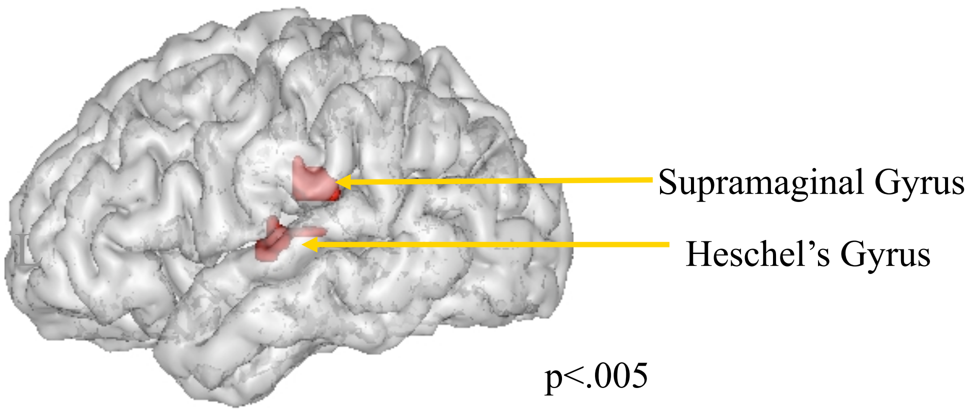
Dehaene-Lambertz, G., Dupoux, E., & Gout, A. (2000). Electrophysiological correlates of phonological processing: a cross-linguistic study. *Journal of Cognitive Neuroscience*, **12**, 635-647.

The brain correlates of phonotactic deafness

Conditions / Participants	Phonological	Acoustic
Japanese	*ebuzo – ebuzo – ebuuzo*	*ebuzo – ebuzo – ebzo*
French	*ebuzo – ebuzo – ebzo*	*ebuzo – ebuzo – ebuuzo*
Mean errors	*5.6%*	*13.6%*
Mean RTs	*707 ms*	*732 ms*

- Task: AAX discrimination, single talker.
- Participants: French and Japanese monolinguals



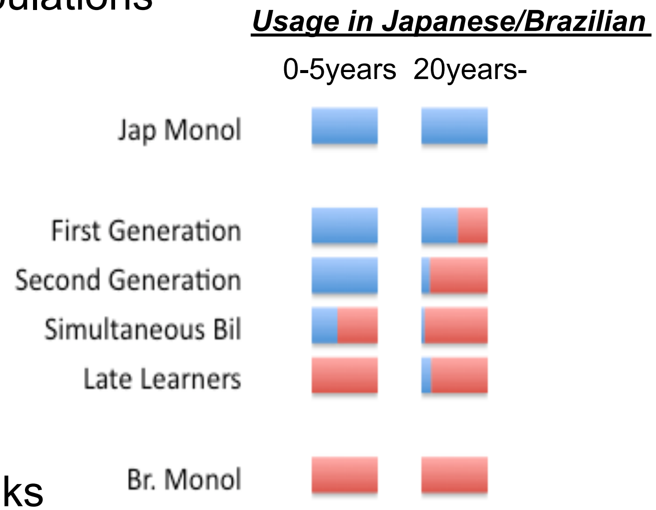


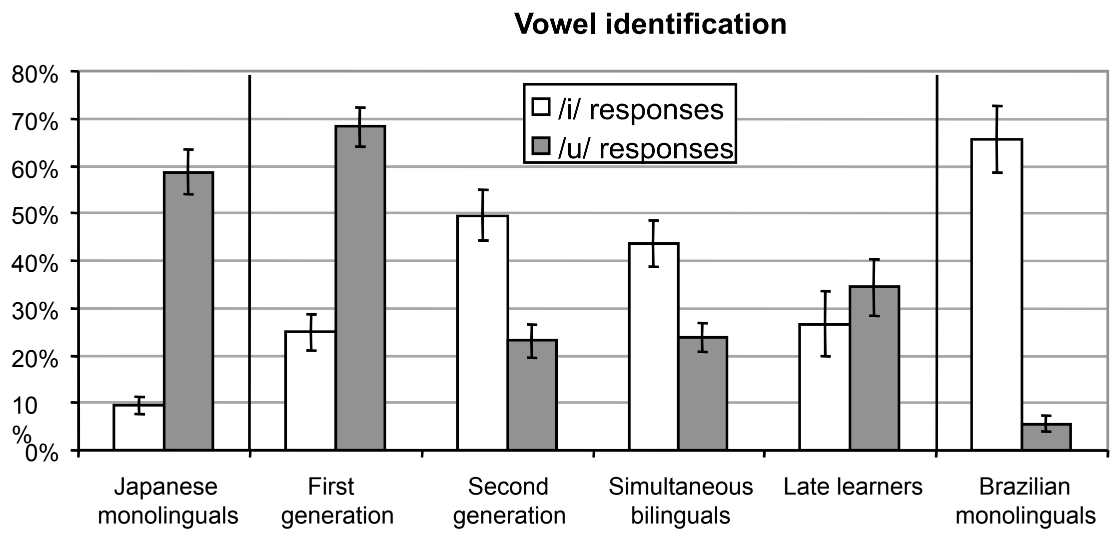
→Phonological processing involves early acoustic processing areas, and areas involved in short term memory.

Jacquemot C., Pallier C., Lebihan D., Dehaene S. & Dupoux E. (2003). Phonological grammar shapes the auditory cortex: a functional Magnetic Resonance Imaging study. *Journal of Neuroscience*, **23(29)**:9541-9546.

Plasticity of phonotactic deafness: Japanese Brazilian immigrants

Populations





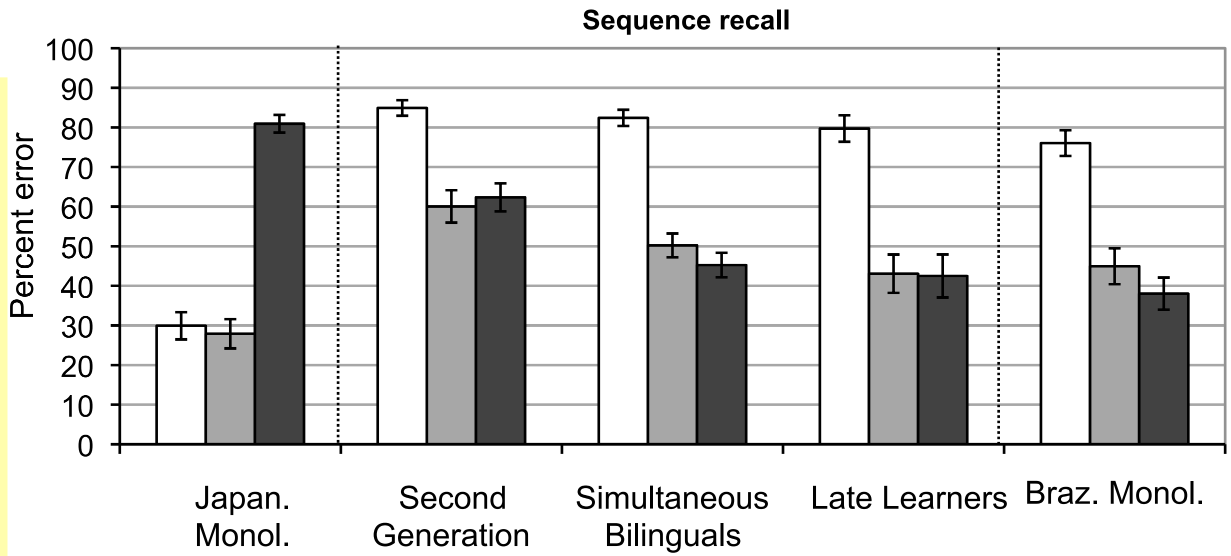
Tasks

- Explicit: Vowel identification in illegal clusters *(ebzo)*
- Implicit: Sequence recall

→ Early learners (2nd Gen & Simult) drop the phonology of their mother tongue in favor of the dominant language in the environment.

→Late learners (1st Gen & Late) retain the phonology of their childhood language.

→Implicit or on-line tasks show a more categorical, monolingual processing profile than explicit or off-line tasks.

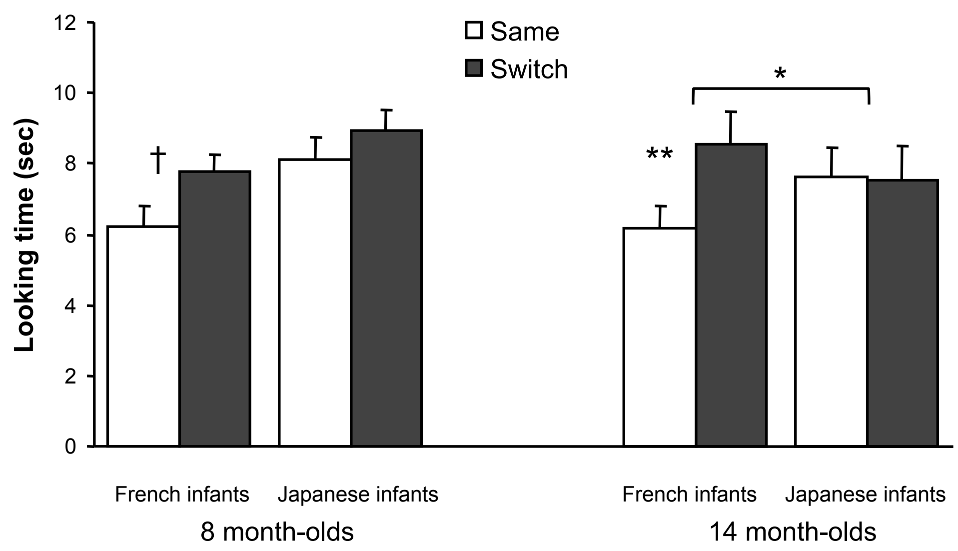


Parlato, E., Christophe, A, Hirose, Y., & Dupoux, E., (2010). Plasticity of illusory vowel perception in Brazilian-Japanese bilinguals. *Journal of the Acoustical Society of America*, **127**, 3738-3748.

The acquisition of phonotactic deafness

- Experiment 1
  - switch design
  - High variability stimuli: (abuna, ebudo, iguna, etc) vs (abna, ebdo, igna, etc.)
  - participants: 8month olds and 14 month olds, Japanese and French infants
- Experiment 2:
  - Low variability stimuli: abuna vs abna

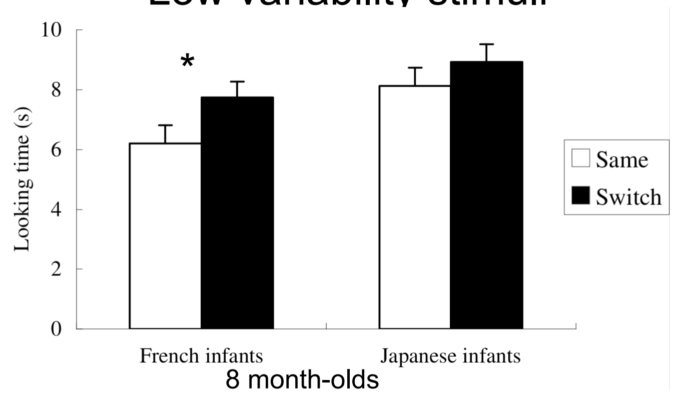
High variability stimuli



† p= .053 * p< .03 ** p< .003

→At 14 months, Japanese infants already have the epenthesis effect
→At 8 months, the acquisition is underway
→the acquisition of the epenthesis effect cannot be lexically driven

Low variability stimuli

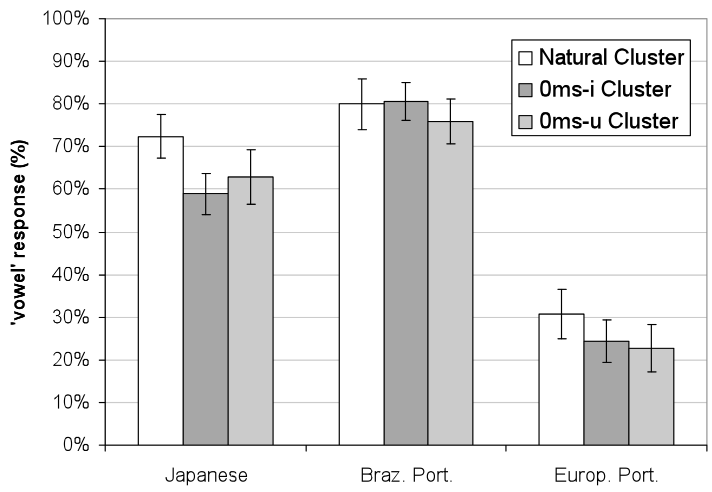


Mazuka, R., Cao, Y., Dupoux, E., Christophe, A. (in press). The development of a phonological illusion: A cross-linguistic study with Japanese and French infants *Developmental Science*

Is phonotactic deafness phonological or phonetic?

	Japanese	Braz. Port.	Europ. Port.
Syllabic structure	$^{*}CVC_{-nasal}$	$^{*}CVC_{+stop}$	$^{*}CVC_{+stop}$
Phonetic structure	i and u devoicing	i and u devoicing	Unstressed vowel deletion
Epenthesis in the grammar	u or i	no	no
Epenthesis in loanwords	u	i	no

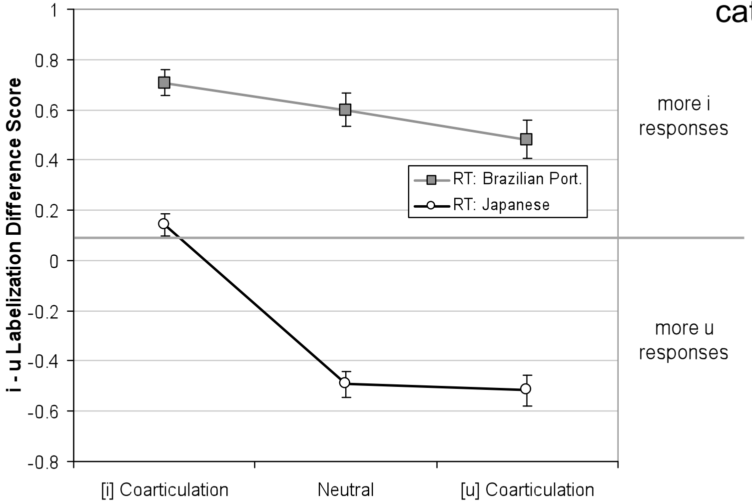
a.Epenthesis effect across languages



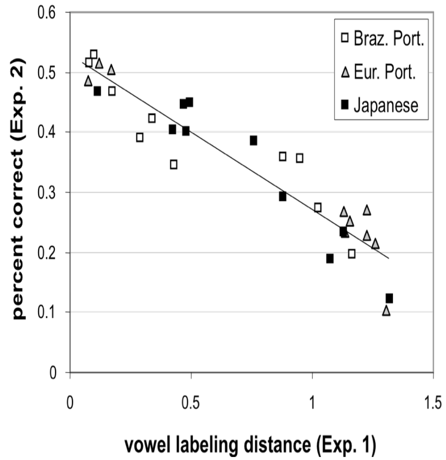
- Task 1: Vowel categorization
  stimuli: - *ebizo→ eb(i)zo continuum*
  - *ebuzo→eb(u)zo continuum*
  - *natural cluster ebzo*
- Task 2: Speeded multitalker ABX discrimination
  stimuli: - *ebizo, ebuzo, eb(i)zo, eb(u)zo,ebzo*

→No epenthesis in EP, despite same syllabic constraints as BP.
→ In BP and Jap, coarticulation cues influences the epenthetic vowel
→same results in vowel cat. & ABX tasks
→*interpretation: perceptual epenthesis is phonetically driven*

b. Coarticulation effect in choice of i vs u



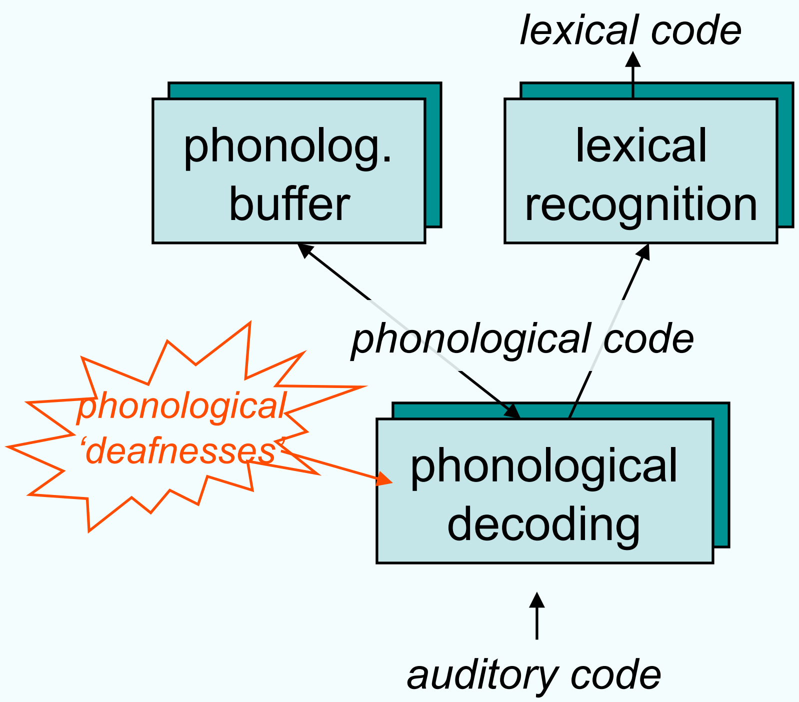
c. Correlation between Vowel catego and errors in speeded ABX



Dupoux, E., Parlato, E., Frota, S., Hirose, Y., Peperkamp, S. (in press) Is perceptual epenthesis phonological? *Journal of Memory and Language*

In brief

- What we know about phonological 'deafnesses'
  - it takes place in perception
    - before lexical recognition
    - before input to short term memory buffer
    - after acoustic/auditory analysis
  - it is very robust (if acoustic strategies are prevented)
  - it is driven by the phonological/phonetic properties of the language
  - it strongly resists training through the late acquisition of a second language
  - It is acquired during early childhood (9-14 months)



- What we don't know
  - how phonological (as opposed to phonetic) are the effects?
  - What are the learning mechanisms involved?
  - what consequences for models of perceptual processing?
  - what consequences for models of loanword adaptations?

See also

- Language-specific listening *(other papers by E. Dupoux)*

- Phonotactic effects on perception
  - Hallé, P., Segui, J., Frauenfelder, U. H., & Meunier, C. (1998). The processing of illegal consonant clusters: A case of perceptual assimilation?. *Journal of Experimental Psychology: Human Perception and Performance* **24**, 592–608.
  - *Berent, I.*, Steriade, D., Lennertz, T & Vaknin, V. (2007). What we know about what we have never heard: Evidence from perceptual illusions. *Cognition*. **104**(3), 591-63.
  - Jusczyk, P. W., Luce, P. A., & Luce, C. J. (1994). Infants' sensitivity to phonotactic patterns in the native language. Journal of Memory and Language, **33**, 630–645.
  - Kabak, B. & W. Idsardi (2007). Perceptual distortions in the adaptation of English consonant clusters: Syllable structure or consonantal contact contraints? *Language & Speech* **50**(1), 23-52.

- Suprasegmental 'deafness'

- Segmental 'deafness'
  - Goto, H. (1971). Auditory perception by normal japanese adults of the sounds 'r' and 'l'. *Neuropsychologia*, 9, 317–323
  - Miyawaki K, Strange W, Verbrugge R, Liberman AM, Jenkins JJ, Fujimura O (1975) An effect of linguistic experience: the discrimination of /r/ and /l/ by native speakers of Japanese and English. *Percept Psychophysics*, **18**, 331–340.
- Loanwords
  - Peperkamp, S. (2005) A psycholinguistic theory of loanword adaptations. In: M. Ettlinger, N. Fleischer & M. Park-Doob (eds.) *Proceedings of the 30th Annual Meeting of the Berkeley Linguistics Society*. Berkeley, CA: The Society, 341-352.

Thanks

- Bosch, L.
- Cao, Y.
- Christophe, A.
- Dehaene, S.
- Dehaene-Lambertz, G.
- Frota, S.
- Gout, A.
- Hirose, Y.
- Jacquemot C.
- Kakehi, K.
- Lebihan D.
- Limissuri, R.A.
- Mehler, J.
- Nakamura, K.
- Navarete, E.
- Pallier C.
- Parlato, E.
- Peperkamp, S.
- Pons, F.
- Sebastian-Galles, N.
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- Vendelin, I.