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 /ε/ (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:] $\rightarrow$ [tokjo]
    - “Kyoto” [kjo:to] $\rightarrow$ [kjoto]
    - *map long vowels onto short ones*

- **Stress deletion in French**
  - Phonology:
    - no lexical stress; phrase final stress
  - Loanwords:
    - “Clinton” [klíntôn] $\rightarrow$ [kli:ntôn]
    - “Arizona” [arízôna] $\rightarrow$ [aríziná]
    - *shift the stress to phrase final position*

- **Vowel Epenthesis** in Japanese
  - Phonology:
    - legal syllables: V, CV, VN, CVN
    - illegal syllables: *CVC, *CCV, ...
  - Loanwords:
    - “Sphinx” $\rightarrow$ [suñNkusu]
    - “Christmas” $\rightarrow$ [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
   vasümá – vásüma – vásüma
   vasümá – vasmá – vasmá

b) Phoneme discrimination (with orthogonal variation in stress)
   Task: multi-talker ABX, ignore stress
   e.g.: A – B – X
   vasümá – fásümá – fasümá
   vasmá – fasümá – vasümá

c) Stress vs phonemes discrimination in French, simpler task
   Task: single talker AX
   e.g.: A – X
   vasümá – vásümá

→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

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

Cross-linguistic stress ‘deafness’

- 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 lose the phonological representation of stress; languages with less transparent stress systems tend to keep it.

Cross-linguistic stress ‘deafness’ (bis)

<table>
<thead>
<tr>
<th>Language</th>
<th>domain of stress</th>
<th>contrastive suprasegmentals</th>
<th>variability in position of stress</th>
<th>lexical exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard French</td>
<td>phrase</td>
<td>none</td>
<td>fixed *</td>
<td>no</td>
</tr>
<tr>
<td>Southeastern French</td>
<td>phrase</td>
<td>none</td>
<td>variable b</td>
<td>no</td>
</tr>
<tr>
<td>Finnish</td>
<td>word</td>
<td>vowel length</td>
<td>fixed c</td>
<td>no</td>
</tr>
<tr>
<td>Hungarian</td>
<td>word</td>
<td>vowel length</td>
<td>fixed c</td>
<td>no</td>
</tr>
<tr>
<td>Polish</td>
<td>word</td>
<td>none</td>
<td>variable d</td>
<td>yes (0.1%)</td>
</tr>
<tr>
<td>Spanish</td>
<td>word</td>
<td>stress</td>
<td>variable e</td>
<td>yes (17%)</td>
</tr>
</tbody>
</table>

- 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.)

The persistence of stress deafness

Participants: French late learners of Spanish

<table>
<thead>
<tr>
<th></th>
<th>Beginner</th>
<th>Intermediate</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of residence in Spanish speaking countries</td>
<td>0.7 year</td>
<td>2 years</td>
<td>4.3 years</td>
</tr>
<tr>
<td>Regularly speaks Spanish in private life</td>
<td>7%</td>
<td>61%</td>
<td>68%</td>
</tr>
<tr>
<td>Regularly speaks Spanish in professional/student life</td>
<td>32%</td>
<td>50%</td>
<td>64%</td>
</tr>
</tbody>
</table>

a) Sequence repetition
- conditions:
  * phoneme: fitu-fiku
  * stress: num’i vs n’umi
  - sequences of size 4

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

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.

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

phonotactic ‘deafness’ observed: perceptual epenthesis

Vowel detection

ABX Task

% u detection

Japanese

French

Other  No  0ms  14ms  29ms  44ms  58ms  Full

S1  S2  S3

A  B  A

Response: A or B

Female voice  Male voice

Conditions:

Cluster: ebuzo-ebzo
Vowel length: ebuzo -ebu  zo

Cluster - Vowel score (%)

French  Japanese

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

\[ \text{the insertion of epenthetic /u/ occurs prior to lexical access} \]

\[ \begin{array}{|l|l|l|}
\hline
 & u-set & nonu-set \\
\hline
Nonword & sokado & mikudo \\
Cluster & sokdo & mikdo \\
Word & sokudo & mikado \\
\hline
\end{array} \]

The time course of phonotactic deafness

Mismatch detection paradigm

S1  S2  S3  S4  S5
B    B    B    B   A
A    A    A    A   A

6 female voices

male voice

Behavioral results

Ebuzo … Ebizo
Ebzo … Ebizo
Ebuzo … Ebzo
Eboz … Ebuzo
Ebuzo … Ebuzo
Ebzo … Ebzo

High density ERPs results

Japanese

French

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

→ Same distribution and timing as Mismatch Negativity

The brain correlates of phonotactic deafness

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Phonological</th>
<th>Acoustic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>French</td>
<td>ebuozo – ebuozo – ebzoz</td>
<td>ebuozo – ebuozo – ebuuzzo</td>
</tr>
<tr>
<td>Mean errors</td>
<td>5.6%</td>
<td>13.6%</td>
</tr>
<tr>
<td>Mean RTs</td>
<td>707 ms</td>
<td>732 ms</td>
</tr>
</tbody>
</table>

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

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

Plasticity of phonotactic deafness: Japanese Brazilian immigrants

**Populations**

**Usage in Japanese/Brazilian**

<table>
<thead>
<tr>
<th></th>
<th>0-5years</th>
<th>20years-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jap Monol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Generation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second Generation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simultaneous Bil</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late Learners</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Tasks**

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

→ Early learners (2\textsuperscript{nd} 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.

The acquisition of phonotactic deafness

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

- **Experiment 2**:
  - Low variability stimuli: abuna vs abna

→ 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

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?

- Task 1: Vowel categorization
  - Stimuli: - ebizo \(\rightarrow\) eb(i)zo continuum
    - ebuzo \(\rightarrow\) eb(u)zo continuum
    - Natural cluster ebzo
  - Epenthesis in the grammar: u or i
  - Epenthesis in loanwords: u or i

- 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 influence the epenthetic vowel.
→ Same results in vowel cat. & ABX tasks.
→ Interpretation: perceptual epenthesis is phonetically driven.

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<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Syllabic structure</td>
<td>*CVC_nasal</td>
<td>*CVC_stop</td>
<td>*CVC_stop</td>
</tr>
<tr>
<td>Phonetic structure</td>
<td>i and u devoicing</td>
<td>i and u devoicing</td>
<td>Unstressed vowel deletion</td>
</tr>
<tr>
<td>Epenthesis in the grammar</td>
<td>u or i</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Epenthesis in loanwords</td>
<td>u</td>
<td>i</td>
<td>no</td>
</tr>
</tbody>
</table>

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**

- **Suprasegmental ‘deafness’**

- **Segmental ‘deafness’**

- **Loanwords**
Thanks

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