PHONOTACTIC INFLUENCES ON THE PERCEPTION OF A CONSONANT CLUSTER BY ENGLISH AND POLISH LISTENERS

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Behavioral and Event-Related Potential study using a phonological priming task

OUTLINE

• INTRODUCTION
• METHOD
• BEHAVIORAL DATA
• EVENT-RELATED POTENTIAL DATA

Event-Related Potentials were recorded while participants performed the behavioral task
INTRODUCTION
**PRODUCTION**
Davidson and Stone, 2003
Lack of exposure to a consonant cluster in the native language such as /zɡ/ in the nonsense word “*zɡomu*” prevents English speakers from producing the cluster in the same way as native speakers
- Mistiming of articulatory gesture

**PERCEPTION**
Dupoux, E., Hirose, Y., Kakahi, K., Pallier, C., & Mehler, J., 1999
Consonant clusters are essentially non-existent in the phonotactic structure of Japanese
- A nonsense word such as *ebzo* is perceived as *ebuzo* by Japanese listeners

- Consonant clusters *tl* and *dl* that are illegal phonotactic structures in French are perceived as *kl* or *gl* legal forms
What if the consonant cluster occurs in one phonotactic position in the syllable or word but not in all phonotactic positions?

CONSONANT CLUSTER “PT”

KEPT
TRIPPED

PT ILLEGAL PHONOTACTIC FORM IN WORD ONSET

“THE VOLCANO WILL ERUPT IN A YEAR”

*PTINA

CONTRAST “PT” AND “PvowelT”

TRUMPED/TRUMPET
METHOD
ADULT PARTICIPANT GROUPS

• 13 NATIVE-ENGLISH LISTENERS
  “pt in word final position, slept, except
  “pt” illegal phonotactically in word onset

• 14 NATIVE-POLISH LISTENERS
  “pt” exists in word onset ptak (bird)
STIMULI

NONSENSE WORDS

• Natural speech
• Recorded from a bilingual Polish-English speaker came to US at age six
DESIGN

Phonological Priming Task

ERP RESEARCH
800 PAIRS OF NONSENSE WORDS

Potential real words in Polish and English with the exception of all nonsense words that begin with pt

Vowels used in both Polish and English

e as in bet ptema
i as in hit seticha
o as in hot ptoga
e as in beet seteesha
u as in Sue ptuza
800 PAIRS OF NONSENSE WORDS

250 ms ISI
2000 ms ITI

FOUR PT CONDITIONS

FOUR ST CONDITIONS (Control stimuli )

“ST” and the contrast segment “S\textsuperscript{VOWEL}T” are legal phonotactic forms in both Polish and English
800 PAIRS OF NONSENSE WORDS

PT CONDITION

1. Two tokens of the same word and the second word has two syllables (100 PAIRS)
   pteba-pteba
   ptila-ptila

2. Two tokens of the same word and the second word has three syllables (100 PAIRS)
   peteecha-peteecha
   petoza-petoza

3. A different word pair, the second word has two syllables (100 PAIRS)
   petoga-ptoqa
   petema-ptema

4. A different word pair, the second word has three syllables (100 PAIRS)
   ptuza-petuza
   ptiva-petiva
800 PAIRS OF NONSENSE WORDS

ST CONDITION

1. Two tokens of the same word and the second word has two syllables (100 PAIRS)
   steba-steba
   stula-stula
2. Two tokens of the same word and the second word has three syllables (100 PAIRS)
   seteesha-seteesha
   setona-setona
3. A different word pair, the second word has two syllables (100 PAIRS)
   seteeza-steeza
   seticha-sticha
4. A different word pair, the second word has three syllables (100 PAIRS)
   stina-setina
   stoka-setoka
SAMPLE OF EXPERIMENT
You will hear pairs of nonsense words. Your job is to decide if the second word in the pair has two syllables or three syllables. If the second word in the pair has two syllables, press the response key that says 2; if the second word in the pair has three syllables, press the response key that says 3.
BEHAVIORAL and ERP MEASURES

Decide if the second word in the nonsense word pair has two or three syllables

Event-related potentials (ERP) are recorded while the subject performs the behavioral task

Behavioral Task
• Perception or End Result

Event-Related Potentials
• Underlying processes occurring over time in the auditory system
EVENT-RELATED POTENTIALS (ERP)

We record electrical signals at the surface of the scalp time-locked to an auditory signal.

The electrical activity measured at the scalp reflects the summation of neural activity:

- Amplify the signal
- Many trials added and averaged
MUST A CONSONANT CLUSTER EXIST IN A CERTAIN PHONOTACTIC POSITION IN A LANGUAGE IN ORDER TO BE PERCEIVED

*PT IS AN ILLEGAL PHONOTACTIC FORM IN WORD ONSET A LEGAL FORM AT THE END OF WORDS
RESULTS
BEHAVIORAL DATA
90% OR GREATER ON ALL FOUR CONDITIONS
p=.4800 (Fisher-Exact Test)

- 12 out of 12 Polish participants
- 11 out of 13 English participants
PT CONDITIONS FOR POLISH AND ENGLISH PARTICIPANTS

<table>
<thead>
<tr>
<th>PT CONDITIONS</th>
<th>MEAN SCORES</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAME 2</td>
<td>90</td>
<td>18.4</td>
</tr>
<tr>
<td>DIFF 2</td>
<td>43</td>
<td>33.0</td>
</tr>
<tr>
<td>SAME 3</td>
<td>94</td>
<td>8.4</td>
</tr>
<tr>
<td>DIFF 3</td>
<td>36</td>
<td>27.4</td>
</tr>
</tbody>
</table>

70% OR GREATER ON ALL FOUR CONDITIONS
p=.00002 (Fisher-Exact Test)

80% OR GREATER ON ALL FOUR CONDITIONS
p=.0052 (Fisher-Exact Test)
CONCLUSIONS
BEHAVIORAL DATA
The sound cluster must occur in the particular phonotactic position within the native language in order to be perceived.

“The volcano will erupt in a year” *ptina

From this study it appears that in perception the phoneme itself taken out of its phonotactic context (*ptina) cannot be a unit in auditory processing.

As opposed to the phoneme –in perception-the syllable is essential in auditory processing of the signal.

Perception is altered by native-language experience and during development of the native-language, perception becomes sensitive to the acoustic features of the sound segment which vary with the phonotactic context such as acoustic events preceding the phoneme segment and patterns of stress.
IS THERE NEUROPHYSIOLOGICAL EVIDENCE THAT THE PT CLUSTER IN WORD ONSET IS DISTINGUISHED FROM THE CONTRAST SEGMENT, $P_{\text{vowel}}T$ IN WORD ONSET IN ENGLISH LISTENERS EVEN THOUGH THEY DO NOT PERCEIVE THE DISTINCTION?
RESULTS
EVENT-RELATED POTENTIAL
PT 3 SYLLABLE TARGET

**ENGLISH**

- **Polish grand mean pt same 3**
- **Polish grand mean pt different 3**

- **English grand mean pt same 3**
- **English grand mean pt different 3**
CONCLUSIONS ERP DATA

The ST contrast is a more robust physiological response than the PT contrast for both language groups

Neuro-physiological support for the view:
The difference between [#st_] and [#sVt_] is more salient than [#pt_] and [#pVt] consistent with the notion of [#pt_] being more marked than [#st]

The physical contrast in the PT same and different pairs for both Polish and English groups may be detected and evident in the electrophysiological response

The linguistically-relevant differences observed between the English and Polish native-language groups appear to be evident in the electrophysiological response

These physically and linguistically-relevant distinctions appear to arise from different brain sources