Electrophysiological Evidence for Early Categorical Processing of Tones

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May, 27, 2012
Outline

- Introduction
- Materials and methods
- Results
- Discussion
- Conclusion
Categorical perception (CP):
- People divide the various speech sounds into certain linguistic categories.

The major signature of CP:

- Tone perception of Mandarin: *categorical perception*
Introduction

- Event-related potentials (ERPs) components:
  -Mismatch negativity (MMN)
  -Auditory N1 wave

In present study:
- Adaptation paradigm
- Active discrimination task

Expect:
- Different responses
- Lateralization
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Materials and methods

- Participants:
  - 12 participants (6 males and 6 females)
  - Right-handed
  - From northern part of China
  - High self-evaluation score of Mandarin
  - Normal hearing.
Materials and methods

Stimuli:

- Speech: syllable [i]
- Nonspeech: triangle waves

Within-category change:
- 1-4, 4-1;
- 8-11, 11-8

Across-category change:
- 4-7, 7-4;
- 5-8, 8-5

No-change:
- 1-1; 5-5;
- 7-7; 11-11
Materials and methods

- **Data analysis:**
  - Behavioral responses: accuracies and RTs.
  - EEG recordings:
    - Re-referenced offline against average-mastoid reference
    - Low-pass filtered at 30 Hz.
    - 100ms to 800ms

- **N1:**
  - F1, F2, F2
  - FC1, FC2, FC2
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Results

Behavioral accuracy

Behavioral mean RT

Two-way (context × category) repeated measures ANOVAs:

- category: \( p < .001 \) ***
- \( p < .001 \)
- category: \( p < .05 \)*
Results

- N1 latency

Three-way (context $\times$ category $\times$ position) repeated measures ANOVAs:
  - **context**: $p<.005$
  - **context $\times$ position**: $p=.05$
    - Marginal means:
      - Speech: 117.8 ms
      - Nonspeech: 125.0 ms
    - The detection of speech stimuli was faster than that of nonspeech stimuli.
Results

N1 amplitude

- Three-way (context × category × position) repeated measures ANOVAs:
  - context: $p < .05$ * (speech: -1.93 $\mu$V; nonspeech: -2.83 $\mu$V)
  - category: $p < .05$ *
  - context × position: $p < .05$ *
  - context × category × position: $p < .05$ *

Results

- Two-way (*category* × *position*) repeated measures ANOVAs

![Graphs showing N1 wave](image)

- Speech
  - *category*: p<.05*
  - *position*: p<.05*

- Nonspeech
  - *category × position*:
Results

- One-way (*category*) repeated measures ANOVAs were limited to speech context.

Left

- *category:* $p < .005$

Right

- *category:* $p = .06$

- *category:* $p < .05$

- *category:* $p = 1.0$

- *category:* $p = .06$

- *category:* $p < .05$
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Discussion

- Van Wassenhove et al. (2005): 

- In present study:
  - speech context < nonspeech context
  - speech context < nonspeech context

better predictor
Discussion

- CP effect exists:
  - Greater CP effects were found in speech than in nonspeech. (Xi et al., 2010; Zheng et al., 2011)
  - Left hemisphere is more responsive to linguistic/phonological functions. (Gandour et al., 2004)

- Speech speech

- Left
In the present study:

- Henkin et al. (2010): the N1 amplitude of congruent stimuli was greater than that of incongruent stimuli.
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The results of N1 latency showed that the detection of speech sounds was quicker than that of nonspeech sounds. N1 amplitude elicited a CP effect only in speech context, indicating a speech-specific processing underling speech perception.

The left hemisphere is more responsive to linguistic/
Acknowledgements

- Prof. Peng Gang
- Members of Cognition Group in AIMS-L, SIAT:
  Xia Quansheng  Wang Dazuo
- Prof. William Wang  Prof. Shi Feng
- Grants from National Science Foundation of China
Thank you!
References

Backup: distribution map

N1:
- F1, Fz, F2
- FC1, FCz, FC2

P2:
- P1, Pz, P2
- POz

N2:
- F1, Fz, F2

P300:
- P1, Pz, P2
- PO3, POz, PO4

P4:
- P1, Pz, P2
- PO3, POz, PO4

- 90 – 150 ms
- 150 – 210 ms
- 240 – 300 ms
- 300 – 500 ms
Three-way (context × category × position) repeated measures ANOVAs:
- Context **
- Category *
- Within category V.S across category *

Two-way (category × position) repeated measures ANOVAs:
- For speech: position p=0.052
The intensity levels of speech and nonspeech stimuli were 65 dB and 75 dB, respectively, so that participants would perceive the two types of stimuli as having comparable loudness.

All stimuli were presented binaurally at a sound pressure level that was comfortable for each subject.
The experiment consisted of four testing blocks, two for each context condition. In each testing block, there were stimulus groups (four for within-category changes, four for across-category changes, and four for fillers) repeated 15 times in a pseudo-random order.
Participants were instructed to press a mouse button at the end of the fourth stimulus to indicate whether they had perceived a change in the stimulus. The hands used to respond "same" and "different" were changed in the middle of each experiment and counterbalanced across participants.