Neural processing of phonetic and talker information in a tone language: An fMRI study

Caicai Zhang1,2, Kenneth R. Pugh3,4,5, W. Einar Menc6,2, Peter J. Molfese3, Stephen J. Fros7, James S. Magnuson3,4, Gang Peng1,2, and W. S-Y. Wang1,2

1CUHK-PKU-UST Joint Research Centre for Language and Human Complexity; 2Department of Linguistics and Modern Languages, The Chinese University of Hong Kong; 3Haskins Laboratories; 4Department of Psychology, University of Connecticut; 5Department of Linguistics, Yale University

INTRODUCTION

- 1. Interdependence of phonetic and talker processing (Cowan, Tomasi & Kiebel, 1997; Kagermeier et al., 2000; McManus & Poutiainen, 1990; McManus, Poutiainen & Martin, 1985).
- Variability of talker identity (e.g. female/male) in speech stimuli interferes with phonetic classification (e.g. b/v).
- Variability in phonetic category (e.g. b/p) in speech stimuli interferes with talker classification (e.g. female/male), but to a less degree.
- Perceptual encoding of phonetic representations from acoustic signals depends on processing of talker information.

2. Neural locus of such interdependence

- Integral perceptual processing of common acoustic parameters
- Posterior superior temporal gyrus/sulcus (STG/STS) that is activated in speech recognition tasks, is sensitive to vocal tract length change that differentiates talker identity size (von Kriegstein et al., 2007; 2009, Kiebel; Gedan & von Kriegstein, 2016).
- Integral representation
- Neural representation of real words stored in left middle temporal gyrus (MTG) could be talker-specific (Chandrasekaran, Chan & Wong, 2011; von Kriegstein et al., 2003).

3. This fMRI study

- We investigated the integral perceptual processing of fundamental frequency (F0) in a tone language, where F0 distinguishes phonetic categories and correlates with talker identity.

METHODS

- Stimuli change (No change, Talker change, Phonetic change, Phonetic & Talker change) × Task (Phonetic & Talker judgment)
- Stimuli: Same Male Tone 55 / Male Tone 25 / Same Female Tone 55 / Female Tone 25

Task: Phonetic

<table>
<thead>
<tr>
<th>Same</th>
<th>Different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Tone 55</td>
<td>Standard</td>
</tr>
<tr>
<td>Female Tone 55</td>
<td>Standard</td>
</tr>
</tbody>
</table>

No change (1550 ms)

- Phonetic change (1550 ms)
- Phonetic & Talker change (1550 ms)

Task: Talker

<table>
<thead>
<tr>
<th>Same</th>
<th>Different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Tone 55</td>
<td>Standard</td>
</tr>
<tr>
<td>Female Tone 55</td>
<td>Standard</td>
</tr>
</tbody>
</table>

Same

- Phonetic task: Bilateral STG;
- Talker task: Bilateral STG, L declive, L postcentral gyrus, R parahippocampal gyrus.

RESULTS

1. In-scanner behavioural performance

- Phonetic task: L STG;
- Talker task: R STG.

- Phonetic & Talker change vs. No change
  - Phonetic task: L STG;
  - Talker task: R STG.

2. fMRI cluster analysis (uncorrected p<0.001, FWE corrected p<0.05)

1. Phonetic change vs. No change
- Phonetic task: No effect;
- Talker task: Bilateral STG, R thalamus, R cingulate gyrus, L inferior frontal gyrus, R middle frontal gyrus.

2. Talker change vs. No change
- Phonetic task: Bilateral STG;

3. fMRI ROI analysis (STG)

- 1. Bilateral STG activated in response to stimuli with phonetic changes in the talker discrimination task, and to stimuli with talker changes in the phonetic discrimination task.
- It confirms the role of STG in integral processing of phonetic and talker information indexed by F0 in tone languages.
- No evidence for MTG involvement (presumably due to task influence).

- 2. Left and right STG weighted differentially in linguistic (phonetic discrimination) and non-linguistic (talker discrimination) tasks in response to stimuli with phonetic and talker changes.

- 3. Right parahippocampal gyrus activated to stimuli with talker changes in the talker discrimination task.
- On-line learning of talker-related acoustic information.

REFERENCES


Acknowledgements: This study is supported in part by grants from the National Basic Research Program of the Ministry of Science and Technology of China (973 Grant: 2012CB720700), and Research Grant Council of Hong Kong (GRF 455910). Thanks to Mr. Ivan Zou for help with data collection, and to members of Centre for Language and Human Complexity for useful discussions.