The 19th Manchester Phonology Meeting, May 19-21, 2011

Defining phonological relationships: the role of alternation

Yu-an Lu
yu-an.lu@stonybrook.edu
Stony Brook University

1. Introduction

- The concept of phoneme/allophone (e.g., Jaeger 1980, Marslen-Wilson & Warren 1994, Norris et al. 2003).

- The traditional definition: Distribution (e.g., Bloch 1950, Harris 1951, Hualde 2005).

2. Allophones of the same phoneme: two (phonetically similar) sounds in complementary distribution

3. Contrast: two sounds occurring in the same environment and hence unpredictable

4. Gradient non-discrete phoneme category: predictability (Hall 2009)

5. Optimality Theory: a close match between underlying and surface representation except where allomorphic alternation requires two surface forms to derive from a single UR

6. Lexicon Optimization principle (Kager 1999)

7. The Identity Map hypothesis (Alderete & Tesar 2002; Hayes 2004; Prince & Tesar 2004)

Goal

- To determine the relative contributions of distribution and alternation in leading speakers to group sounds as members of the same category.

Languages

- English: s and sh are contrastive with a phonetic level alternation or morphological alternations (Johnson & Babel 2010).
  
  e.g., miss [mɪs] ~ miss you [mɪʃju]
  oppress [ɒpɛs] ~ oppression [ɒpɛʃən]

- Korean: s and sh are in complementary distribution and participate in morphological alternation
  e.g., [sal] ‘flesh’   [si] ‘poem’
  [nas-e] ‘sickle-loc’   [nas-i] ‘sickle-nom’

- Mandarin: s and sh are in complementary distribution without morphological alternations (Duanmu 2007)
  e.g., [sa] ‘speak’   [ci] ‘west’
Experiments

- Similarity rating
  - Speakers tend to rate allophones as more similar than phonemes (e.g., Boomershine et al. 2008; Johnson & Babel 2010)

- Semantic priming
  - Facilitation between variants of a category, but not between sounds belonging to different categories (Sumner & Samuel 2005)

Predictions

<table>
<thead>
<tr>
<th>Languages</th>
<th>Mandarin</th>
<th>Korean</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complementary Distribution</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Alternation</td>
<td></td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

- Variants of the same phoneme are processed differently than contrastive phonemes (Beckman & Pierrehumbert 2000; Sumner & Samuel 2005)

- Distribution alone defines phonological relationships.

Expt I: Similarity rating

- “Phonological relationship increases the perceived phonetic similarity of the sounds” (Johnson & Babel 2010)

- Similarity judgments of [ð], [d], and [r] by English and Spanish speakers (Boomershine et al. 2008)

- Phonological grouping of [ð], [d], and [r]
  - English: [ð], [d], [r]
  - Spanish: [ð], [d] [r]

- Native language effect: English speakers rated [d] and [r] as most similar, but Spanish speakers rated [ð] and [d] as most similar.
Participants: 20 Eng., 20 Mand., 20 Kor.

Stimuli: 15 VCV with s, sh ([ɕ] and [ʃ]), f, h in three vowel contexts (a_a, i_i, u_u), produced by a native Mandarin speaking trained phonetician.

AX paradigm. E.g., asa-aha, ifi-i with 1000ms ISI

Participants were asked to rate how similar the stimuli were on a scale of 1 to 5

May 19-21, 2011

Results

- Standardized z-score transformation: reduce variability

- The standardized scores were centered around zero, with scores above zero indicating 'more different' and scores below zero indicating 'more similar.'

Results (Appendix A)

Mandarin listeners rated s and sh (both [s-ɕ] and [s-ʃ]) significantly more different from each other than did Korean listeners.

The Mandarin results support the hypothesis that alternation does play a role.

This suggests that Mandarin listeners, like English listeners, perceive s and sh as different categories.

Discussion

We found that Korean listeners rated s and sh (both [s-ɕ] and [s-ʃ]) more similar to each other than did English listeners.

The different phonological relationships are reflected in their similarity rating.
### Predictions

<table>
<thead>
<tr>
<th>Complementary Distribution</th>
<th>Mandarin</th>
<th>Korean</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternation</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

- Sumner & Samuel (2005): facilitation on lexical decision when hearing a target after a semantically related prime e.g., *music → flute*
- priming with canonical [t], coarticulated [ʔtʰ] and glottalized [ʔ]
- no priming with a contrastive phoneme *[flus]*

### Method

- Ernestus & Baayen (2007): lexical decision faster on *[hand]* than on *[krand]* in Dutch

  ```
  ```

- The extent to which s primed sh, or vice versa in Mandarin, English, and Korean.

- The results were compared with the priming effects when s and sh were changed into a contrastive sound (f in Mandarin and English, and fortis s’ and sh’ in Korean).

- We expect facilitation of lexical decision to a semantically related target to a sh-prime or to a sh-prime e.g., *[samba]* samba primes dance
- We should find no/less facilitation when s/sh are changed into a contrastive sound e.g., *[samba]* → *[famba]*
- If we find facilitation when s is changed into sh or vice versa, then the two fricatives should be variants of the same category e.g., *[samba]* → *[famba]*

- Participants: 60 Eng, 60 Mand, 30 Kor
- Conditions: Same, Swapping, Contrastive
- Norming pretest
- Stimuli:

<table>
<thead>
<tr>
<th>Between-subject design</th>
<th>72 primes</th>
<th>36 related targets</th>
<th>Fillers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36 unrelated targets</td>
<td>18 real words</td>
<td>90 pseudowords</td>
</tr>
</tbody>
</table>
Method

<table>
<thead>
<tr>
<th>Language</th>
<th>Condition</th>
<th>Prime</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAME</td>
<td>[samba] 'samba'</td>
<td>'dance'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[foldə] 'shoulder'</td>
<td>'arm'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cf. [ʃi:də] 'shadow'</td>
<td>'fruit'</td>
<td></td>
</tr>
<tr>
<td>SWAPPING</td>
<td>[ʃəmbə] 'dance'</td>
<td>'arm'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cf. [ʃɑ:dbə]</td>
<td>'fruit'</td>
<td></td>
</tr>
<tr>
<td>CONTRASTIVE</td>
<td>cf. [ʃərdə]</td>
<td>'fruit'</td>
<td></td>
</tr>
</tbody>
</table>

### Results—English

- The mean RTs and the priming effects (the difference between Related and Unrelated) with standard deviations in parentheses

<table>
<thead>
<tr>
<th>Relation</th>
<th>SAME</th>
<th>SWAPPING</th>
<th>CONTRASTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related</td>
<td>829.05 (114.65)</td>
<td>938.82 (160.66)</td>
<td>894.47 (106.20)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>886.65 (108.27)</td>
<td>947.11 (120.07)</td>
<td>890.72 (85.17)</td>
</tr>
<tr>
<td>Priming</td>
<td>57.6</td>
<td>8.29</td>
<td>-3.75</td>
</tr>
</tbody>
</table>

### Results—English (Appendix B)

<table>
<thead>
<tr>
<th>Relation</th>
<th>SAME</th>
<th>SWAPPING</th>
<th>CONTRASTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related</td>
<td>910.67 (112.81)</td>
<td>948.91 (89.83)</td>
<td>984.35 (125.24)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>1007.22 (102.42)</td>
<td>1018.10 (159.54)</td>
<td>1051.72 (149.17)</td>
</tr>
<tr>
<td>Priming</td>
<td>96.55</td>
<td>69.19</td>
<td>67.37</td>
</tr>
</tbody>
</table>

### Results—Korean

<table>
<thead>
<tr>
<th>Relation</th>
<th>SAME</th>
<th>SWAPPING</th>
<th>CONTRASTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related</td>
<td>900.69 (112.81)</td>
<td>938.91 (89.83)</td>
<td>984.35 (125.24)</td>
</tr>
<tr>
<td>Unrelated</td>
<td>1007.22 (102.42)</td>
<td>1018.10 (159.54)</td>
<td>1051.72 (149.17)</td>
</tr>
<tr>
<td>Priming</td>
<td>96.55</td>
<td>69.19</td>
<td>67.37</td>
</tr>
</tbody>
</table>
Results—Korean (Appendix C)

![Graph showing RT for Same, Swapping, and Contrastive conditions for Related and Unrelated]

Results—Korean

![Graph showing Priming effect for Same, Swapping, and Contrastive conditions]

Results—Mandarin

<table>
<thead>
<tr>
<th>Condition</th>
<th>Same</th>
<th>Swapping</th>
<th>Contrastive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related</td>
<td>1014.94</td>
<td>1019.19</td>
<td>1062.26</td>
</tr>
<tr>
<td>Unrelated</td>
<td>1137.34</td>
<td>1123.48</td>
<td>1133.46</td>
</tr>
<tr>
<td>Priming effect</td>
<td>122.4</td>
<td>104.29</td>
<td>71.2</td>
</tr>
</tbody>
</table>

Results—Mandarin (Appendix D)

![Graph showing RT for Same, Swapping, and Contrastive conditions for Related and Unrelated]

Discussion

- English: no facilitation in Swapping or Contrastive conditions → s and sh as separate categories
- Korean and Mandarin: facilitation for all 3 conditions, even for contrasting phonemes
- There is no three-way difference in RT corresponding to same, allophonic, or contrastive sounds.
**Discussion**

- Differences: illegal sequences in Mandarin and Korean vs. legal sequences in English.

- Illegal sequences, phonetic similarity, and context help to map into possible legal sequences in Mandarin and Korean.

- Follow-up: adding a 4th condition with less phonetic similarity ([t]): 20 Mandarin participants.

---

**Results—Mandarin (Appendix E)**

<table>
<thead>
<tr>
<th>Language</th>
<th>Condition</th>
<th>Prime</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAME</td>
<td>[si-jan]</td>
<td>‘breed’</td>
<td>[t-on-wu]</td>
</tr>
<tr>
<td></td>
<td>[ci-jan]</td>
<td>‘banquet’</td>
<td>[tcje-hun]</td>
</tr>
<tr>
<td>SWAPPING</td>
<td>*ci-jan</td>
<td></td>
<td>[t-on-wu]</td>
</tr>
<tr>
<td>Mandarin</td>
<td>*si-jan</td>
<td></td>
<td>[tcje-hun]</td>
</tr>
<tr>
<td>CONTRASTIVE</td>
<td>*fi-jan</td>
<td></td>
<td>[t-on-wu]</td>
</tr>
<tr>
<td></td>
<td>*fi-jan</td>
<td></td>
<td>[tcje-hun]</td>
</tr>
<tr>
<td>(illegal)</td>
<td>[ti-jan]</td>
<td></td>
<td>[t-on-wu]</td>
</tr>
<tr>
<td>(legal)</td>
<td>[ti-jan]</td>
<td></td>
<td>[tcje-hun]</td>
</tr>
</tbody>
</table>
Discussion

- We found priming even for [t], but significantly less than the other three conditions
- No significant facilitation for legal sequences
- Priming due to illegal sequences, contexts, and phonetic similarity

Acknowledgment

THANK YOU!
- This work was supported by NSF grant BCS 07460227 to Ellen Broselow, Marie Huffman, and Nancy Squires.
- Special thanks to Yuwen Lai for making the subject-recruiting and experiment-running possible in Taiwan.

Appendix A: Results

- Repeated measure (Language x Pair) [Mand, Kor, Eng] [10 pairs]
- Main effects of Language ($F(2,57) = 7.950, p < .01$), and of Pair ($F(9,57) = 8.627, p < .001$)
- Significant interaction ($F(18,513) = 8.647, p < .001$)

Appendix B: Results—English

- Two-way ANOVAs (Condition x Relation) [same, swapping, contrastive] [related, unrelated]
- F₂ (by subject), F₂ (by item)
- Main effects of Relation ($F(1, 57) = 9.193, p < .005$; $F(1, 210) = 4.722, p < .05$), and of Condition ($F(2, 57) = 2.669, p = .078$; $F(2, 210) = 9.967, p < .001$)
- Significant interaction ($F(1, 57) = 12.210, p < .05$; $F(2, 210) = 2.364, p = .097$)
- Simple comparisons: significant Relation in Same condition ($F(1, 19) = 61.571, p < .001$), but no effect in the other two conditions (both $p > .1$)

References

Appendix C: Results—Korean

- Main effect of Relation
  \(F(1,27)=47.241, p<.001\)

- Significant simple effect of Relation in Same condition (F(1, 9)=36.451, \(p<.001\)), in Swapping (F(1, 9)=8.183, \(p<.05\)), and in Contrastive (F(1, 9)=14.666, \(p<.01\)).

Appendix D: Results—Mandarin

- Main effects of Relation \(F_{1}(1, 57) = 171.660, p<.001; F_{2}(1, 210) = 47.836, p<.001\)

- The factor Condition yielded a significant effect in an analysis on priming \(F_{2}(2, 117)=4.356, p<.05\).

- Pairwise comparisons: the priming effects in the Same & Contrastive conditions were statistically different \((p<.05)\); the other two pairwise comparisons (Same & Swapping, Swapping & Contrastive) were not \((both p>.1)\).

Appendix E: Results—Mandarin

- Simple effect of Relation in \(t\) condition \(F(1, 39) = 9.211, p<.005\)

- Pairwise comparisons: the priming effects in the \(t\) & other conditions were all statistically different \((all p<.05)\)

- Simple effect of Relation in \(t\) (illegal) condition was significant \(F(1, 19)=9.173, p<.01\)

- Simple effect of Relation in \(t\) (legal) condition was not significant \(F(1, 19)=2.597, p=.124\)