A Phonetic Study of Stress in Korean

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Introduction

- Acoustic property of stress has been controversial. But in general, all or some of fo, duration and intensity integral have been known to be the primary phonetic realizations. (Fry 1959, 1960; Lea; Beckman 1988)

- Stress in Korean (Seoul) has been controversial.
  - the 1st syll. of a word is stressed if it is heavy, otherwise, 2nd syll. (H.B. Lee 1973, 1993)
  - the final syll. of a word (Polivanov, 1936 in H.Y. Lee 1990)
  - the 1st or 2nd syll. of a morpheme (H.Y. Lee 1990)
  - the 2nd syll. of a phrase (Huh 1985)
  - not stressed, but pitch accented (S.B. Cho 1967)

Accentual Phrase (AP) of Seoul Korean (Jun 1993)

- AP is a tonally defined prosodic unit. It is larger than a word and smaller than an intonational phrase (IP).
- The tonal pattern is either LHLH or HHLH depending on the phrase initial segment.
- Each tone is associated with a certain syllable of an AP.
  - initial tone (H or L) ==> the first syll. of AP
  - the second tone (H) ==> the second syll. of AP
  - the third tone (L) ==> the penult of AP
  - the final tone (H) ==> the final syll. of AP.

- The AP final tone (H) is pre-empted by the IP final boundary tone if they are realized on the same syllable (i.e. when the AP is the last AP in an IP).
Thus, a word in isolation (citation form) does not end in a H-tone since it forms 'one AP/one IP' with a declarative boundary tone.

Experiment 1 (Production)

Method

- 3 Seoul speakers (two female and one male)
- 16 words of reiterated syllable /ma/ & /ta/
  - 2 to 5 syll.; light (CV) or heavy (CVC) initial 2 syllables
  - in isolation and sentence initial & medial position
  - sentences in 3 levels of force: soft, normal and loud

Examples: sentence initial & medial position

[mamama mariril manna] 'Mamama meets Mari.'
[mamamama mariril manna] 'Mamamma meets Mari.'
[mamamama mariril manna] 'Mamamma meets Mari.'
[mamamama mariril manna] 'Mamamma meets Mari.'
[mamamama mariril manna] 'Mamamma meets Mari.'
[papa mamama manna] 'Younga meets Mamama.'
[papa mamamama manna] 'Younga meets Mamamma.'
[papa mamamama manna] 'Younga meets Mamamma.'
[papa mamamama manna] 'Younga meets Mamamma.'

- 3 words of reiterated syllable /na/ (2 to 4 syll; all light)
in 16 minimal paired sentences: the target word in
Accentual Phrase (Jun 1993) -initial and -medial position
example sentences (AP is in { }; focused word in bold):

{urii} {nanado} {mariril}{manna} 'Our Nana meets Mari too.'
{urii} nanado {mariril}{manna} 'Our Nana meets Mari too.'
{tau} {nanado} {mariril}{manna} 'That Nana meets Mari too.'
{tau} {nanado} {mariril}{manna} 'That Nana meets Mari too.'

- 6 repetitions
- measure fundamental frequency (fo), duration and
average amplitude for each vowel of reiterated syllable.
Results and Discussion

1. word in citation (/ma/ or /ta/, 2 to 5 syll)

=> In general, the second syll is prosodically stronger in a word of longer than 2 syllables, unless the first syll is heavier and/or has a High tone. For 2-syllable-words, the 1st syll is prosodically stronger (higher f0 and higher intensity).

<table>
<thead>
<tr>
<th># of syll</th>
<th>peak f0</th>
<th>peak intensity</th>
<th>longest</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1st</td>
<td>1st</td>
<td>last</td>
</tr>
<tr>
<td>3</td>
<td>2nd (+1st if H tone)</td>
<td>2nd (1st if it's heavier)</td>
<td>last</td>
</tr>
<tr>
<td>4</td>
<td>2nd (+1st if H tone)</td>
<td>2nd (1st if heavy &amp; H tone)</td>
<td>last</td>
</tr>
<tr>
<td>5</td>
<td>2nd (+1st if H tone)</td>
<td>2nd (1st)</td>
<td>last</td>
</tr>
</tbody>
</table>

shown in (Fig.1) (Fig.2) (Fig.3)

**The longest duration on the last syll is due to the IP final lengthening. Otherwise, the 2nd syll is the longest.

** only light syllables were tested for 2 & 5 syll-words.

3. Amplitude and Syllable Weight

- f0 and amplitude of each vowel in a word change depending on its location within an AP. This was true for both sentence initial and medial APs.

Fig.8 (syllable weight and mean amplitude, 3 & 4 syll AP)

3 syll. AP: 2nd is stronger unless the 1st is heavy.
4 syll. AP: 2nd is stronger in general

Fig.9 f0: [tʃo nananado mariri manna] (subj. ss)
'that Nanana-also Mar-Prev. to meet'

> 'That Nanana meets Mar too.'

(a) [tʃa nananado] [mariri] [manna] - f0 peak on 2nd /na/
(b) [tʃa nananado] [mariri] [manna] - f0 peak on 1st /na/

Fig.10. amplitude: same sentences as above (subj. sk)
: amplitude peak changes as ir f0 change above.

4. Summary of Production Data

- a certain syllable is prosodically stronger (higher f0 and greater amplitude) than others. Thus, we can say there is 'stress' in Seoul Korean.

- But, the prosodically strong ('stressed') syll of a word changes depending on its position within an AP. Thus, stress is the property of the Accentual Phrase, not of the word.

- the 1st syll. of AP is 'stressed' in a 2 syll. AP.
- the 2nd syll. of AP is 'stressed' in a 3 or more syll. AP.

- If a syll has a High tone, then the syll often has a high amplitude, i.e. 'stressed'. (but not necessarily longer duration)

Experiment 2 (Perception)

Method

- 3 Seoul speakers (2 female (S1, S2), 1 male, S3)
- 22 listeners (early 20s - early 40s, speakers of different languages - English (17), French (1), Chinese (2), Japanese (1), Italian (1)).
- tape (12 min.) contains 28 real words (single N; ten 2-syll words, nine 3-syll words, and nine 4-syll words) in isolation read by all three speakers and additional 27 words (modifier+N) in citation read by S2.
- (The modifier (Adj./Det./Poss. ProN) is either 1 or 2 sylls, so that the whole mod+N forms one Accentual Phrase)
- listeners were asked to circle any prominent syllable(s) if there is any.

Results and Discussion

1. In general, the syllable perceived prominent was on the same position as in the production result.

- i.e. the 2nd syll was most often perceived as prominent. In addition, for all speakers, stress tended to shift to the 1st syll if that syll is heavier than the 2nd syll and has a H-tone.

2. two response patterns among 3 speakers (Fig.11)
- the most common stressed syll was 2nd for S1 & S2 when the word/phrase was of 3 to 6 sylla. For 2 syll. word, the most common stress was on the 1st.
- the most common stressed syll was final for S3 in words/phrases of less than 3 syll. and 2nd & final for 4 to 6 syll words/phrases.
3. Two response patterns for three speakers.
   Why?
   
   : speakers S1 and S2 used a low boundary intonation pattern (L%) while S3 used a falling boundary intonation pattern (HL%) expecting the following word in the list (like a continuation rise boundary tone).
   As found in production data, a syll. of higher f0 also has stronger amplitude in Seoul Korean, thus perceived as ‘stressed’.

   Fig. 12. waveform and f0 tracks: example words

(b) when 3 syll nouns (2nd syll stressed) are preceded by a monosyll modifier within the same AP:
   -> stress moved to the 1st syll of the noun.
   i.e. the 2nd syll. of the AP.

(c) when 4 syll nouns (1st syll stressed) are preceded by 2 syll modifier within the same AP:
   -> stress moves to the 2nd syll of the modifier, i.e., the 2nd syll of the AP.

4. Same word in AP initial vs. AP medial position
   => stress moves to the 2nd syll of an AP regardless of the location of the word stress in isolation.

   Figure 13. ‘ö’ refers to a stressed syllable.
   (a) when 2 syll nouns (1st syll stressed) are preceded by a modifier within the same AP, stress changes depending on the number of syllables of the modifier and the weight of the syllable:
   (i) when Modifier is 1 syll and heavy, stress moved to the modifier, i.e., AP initial syllable
   (ii) when Modifier is two sylls, stress moves to the 2nd syll of the Modifier, i.e., AP second syllable
   (iii) when Modifier is 1 syll, stress remains on the 1 syll of the Noun, i.e., AP second syllable

5. Summary of Perception Data
   • As shown in the production data, the second syllable of an AP is perceived as the most prominent for two out of three speakers.

   • As shown in the production data, the prominence of a syllable is influenced by the weight and tone of the syllable. Heavy syll and High tone syll are perceived as prominent.

   • Different patterns of perception response for speaker S3 confirm that high f0 (and possibly greater intensity) triggers prosodic prominence in Korean.

Conclusion
Both production and perception data support that
• there is stress in Seoul Korean but it is not a property of the word but of the phrase, Accents Phrases.
• the most common location of stress in a 2 syll or longer AP is the second syllable of the AP.
• the most common location of stress in a two syllable AP is the first syllable of the AP.
• stress tends to shift to the first syll of an AP if the first syll begins with a H tone and/or is heavy.

References
Fig. 3
Duration of a word in citation form

- /ta/ syllable (all light)
- /na/ syllable (all light)

Fig. 4
Sentence Initial AP - f0 values

- 5 syll word (ma.ma.ma.ma.ma)
- 4 syll word (ma.ma.ma.ma)
- 3 syll word (ma.ma.ma)
- 2 syll word (ma.ma)

Bars represent:
- soft
- normal
- loud
Fig. 5

Initial AP - amplitude in three force levels

- 5 syll word (ma,ma,ma,ma,ma)
- 4 syll word (ma,ma,ma,ma)
- 3 syll word (ma,ma,ma)
- 2 syll word (ma,ma)

Fig. 6

Initial AP - duration

- 5 syll word (ma,ma,ma,ma,ma)
- 4 syll word (ma,ma,ma,ma)
- 3 syll word (ma,ma,ma)
- 2 syll word (ma,ma)
**Fig. 7** Sentence AP - amplitude

<table>
<thead>
<tr>
<th>5 syll word (ma.ma.ma.ma.ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4 syll word (ma.ma.ma.ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3 syll word (ma.ma.ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2 syll word (ma.ma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Fig. 8** Amplitude and syll weight

**Initial AP (normal)**

3 syll and 4 syll word

- ma.mam.ma.(ma)
- Light + Heavy

- mam.ma.ma.(ma)
- Heavy + Light

**Medial AP (normal)**

3 syll and 4 syll word

- ma.mam.ma.(ma)

- mam.mam.ma.(ma)
- Heavy + Heavy
Fig. 10

(a) AP Medial

(b) AP Initial

"That nanana (not this nanana) meets Mari, too." ⇒ H on 1st syll na in nanana.

1st syll na is louder

(see spectrogram)
2 syllable word (10 words): only one word is perceived as having stress on 2nd syll.

3 syllable word (9 words)

4 syllable word (9 words)

Speaker 2
stressed syll. =>
2nd in 3 or more syll. words;
1st in 2 syll words.

2 syllable word (10 words)

3 syllable word (9 words)

4 syllable word (9 words)

Speaker 3
stressed syll.
=> last syll. or heavy/H-tone initial syll.

number of tokens (stressed syllable)
Fig. 12

Speaker 2

Same pattern as Speaker 1

number of tokens (perceived syllable)

number of syllables

number of words
same word in AP initial vs. AP medial position

=> stress moves to the 2nd syll of an AP regardless of the location of the word stress in isolation.

\(= \text{2 syll-word in isolation} \) \(= \text{modifier + 2 syll-words} \)

Fig. 13. (a) 2 syllable word AP (upper) vs. 2nd word in AP (down)

(i) \((\sigma \, \sigma)\) 1 word

(ii) \((\sigma \, \sigma)\) 2 words

(iii) \((\sigma \, \sigma)\) 2 words

Poss. Adj. + Noun

Poss. Det. + Noun

(b) 3 syll-word and (c) 4 syll-word in isolation (upper)

vs. the same word in AP medial position (down)

(b) \((\sigma \, \sigma \, \sigma)\) - 6 words

(c) \((\sigma \, \sigma \, \sigma \, \sigma)\) - 1 word

Poss. + Noun