ACOUSTIC FEATURES OF VOWEL PRODUCTION IN MANDARIN SPEAKERS OF ENGLISH

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ABSTRACT

English vowel productions were acoustically examined in a group of native Mandarin speakers. The first and second formant frequencies (F1 & F2) of 11 English vowels were examined in the syllable-level productions of 40 Mandarin speakers compared to 40 American English speakers. Results of the comparative acoustic analysis indicated that the Mandarin speakers differed significantly from the American English speakers in their production of several English vowels. Both male and female Mandarin speakers were also found to exhibit a compact vowel space (F1-F2) and less acoustic diversity compared to the native American English speakers. The results were discussed with regard to the impact of L1 (Mandarin) on L2 (English), the modification of articulatory pattern, and the attunement of motor skills for Mandarin speakers during L2 learning.

INTRODUCTION

Individuals who speak two languages are referred to as bilinguals. The language acquired first is referred to as the L1. The second, later acquired language is referred to as the L2. As Flege (1987) noted, L2 learners often speak the L2 with characteristics of the L1 during the initial stages of learning. As individuals acquire more experience, they begin to speak the L2 in a manner which closely approximates the phonetic norm of the L2.

Previous research which has investigated the influence of Mandarin as an L1 on the subsequent production of English as the L2 found that Mandarin speakers experience difficulty with vowel and consonant accuracy, syllable stress, and speaking rate (Flege and Eefting, 1987; Tajima, Port, & Dalby, 1997). Many of these studies focus on perceptual evaluation, as opposed to acoustic measurement of Mandarin speakers of English. Comprehensive acoustic information related to these perceived differences in English production needs to be collected.

Purpose

The purpose of this study was to evaluate the acoustic features of vowel production in Mandarin speakers of English. The Mandarin vowel system consists of the vowels (/β 4 0 4 ʊ/) which are the same vowels which occur in American English. The American English vowel system also contains the vowels (/æ 3 ʌ 0 1 4/) which do not occur in the Mandarin vowel system.

METHOD

Subjects Selection

Two groups of subjects were used in the study. The first group consisted of 40 adults (20 males, 20 females) who speak Mandarin as an L1 and American English as an L2. The average age of the Mandarin male speakers was 33 years with the ages ranging from 30 to 46 years. The average age of the Mandarin female speakers was 28 years with the ages ranging from 21 to 42 years. The second group consisted of 40 adults (20 males, 20 females) who speak American English as an L1. The 40 American speakers were selected to match the Mandarin group in age and gender. The average age of the American male speakers was 27 years with an age range of 23-41 years.

Subject selection criteria for the Mandarin speakers were: (1) They all have a college education, which ensured them being given a regular English education in China. (2) They must be able to speak standard Chinese Mandarin. (3) All Mandarin subjects need to have resided in the U.S. for a minimum of 2 years and their daily English speaking must exceed 30% of their daily conversation. (4) They must also be able to read English fluently.

As for the selection of American English speakers, the primary criterion is that the the American English speakers need to speak American English as their first language. All subjects (Chinese and American) had no speech, language or hearing disorders.

Data Collection

Eleven vowels (/β, ʊ, æ, ʌ, 0, 1, 4/) were placed in an /hVd/ context. Each /hVd/ syllable was embedded in the carrier phrase: "Say /hVd/ again". Each word within the carrier phrase was produced three times by each speaker. All of the recordings were collected in a sound-attenuated booth using audio cassette recorder.

Data Analysis
Each of the 11 /hVd/ syllables was acoustically measured using a speech software package (CSL 4300B). The first two formant frequencies (F1 and F2) of each /hVd/ syllable were measured on the basis of 12-coefficient linear predictive coding (LPC) spectra. The center frequencies of the first two spectral peaks displayed in the LPC spectra were used to represent F1 and F2, respectively (see Figure 1).

**RESULTS AND DISCUSSION**

**Results For “Unfamiliar” Vowels**
(/I, E, Q, Ñ, U, Ò/)

The F1 and F2 values of the “unfamiliar” vowels obtained for Mandarin speakers were compared to those obtained for American speakers (see Table 1). Both Mandarin male and female speakers differed significantly from the American male and female speakers in the production of the six vowels (/I, E, Q, Ñ, U, Ò/) according to either F1 or F2. An additional statistical analysis was performed examining differences in the F1 and F2 values across the six vowels. Results indicated that the Mandarin speakers did not demonstrate significant resonance differences across some of these vowels.

**Discussion For “Unfamiliar” Vowels**
(/I, E, Q, Ñ, U, Ò/)

The vowels (/I, E, Q, Ñ, U, Ò/) are unfamiliar to Mandarin speakers of American English because these vowels do not appear in their L1 (Howie, 1976). At least two possibilities may account for why the Mandarin speakers were unable to produce these vowels accurately:

1. The Mandarin speakers may have failed to perceive accurately the acoustic identities of these vowels as part of the L2 learning and this failure is demonstrated in their inaccurate production of these vowels (Trubetzkoy, 1969; Flege, 1987).

2. The Mandarin speakers might be able to perceive the unfamiliar vowels, but failed to perform the articulatory modifications required to produce the “new” sounds accurately (Briere, 1966; Flege, 1987; Kalikow & Swets, 1972).

**Table 1.** Comparison of mean values for the F1 and F2 frequencies of vowels (/I, E, Q, Ñ, U, Ò/) between Mandarin and American speakers.

<table>
<thead>
<tr>
<th></th>
<th>F1 (Hz)</th>
<th>F2 (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CM</td>
<td>AM</td>
</tr>
<tr>
<td>/I/</td>
<td>412</td>
<td>432</td>
</tr>
<tr>
<td>/E/</td>
<td>557</td>
<td>550</td>
</tr>
<tr>
<td>/Q/</td>
<td>693</td>
<td>575</td>
</tr>
<tr>
<td>/Ã/</td>
<td>728</td>
<td>614</td>
</tr>
<tr>
<td>/U/</td>
<td>377</td>
<td>455</td>
</tr>
<tr>
<td>/Ò/</td>
<td>633</td>
<td>681</td>
</tr>
</tbody>
</table>

**Results For “Familiar” Vowels**
(/i, e, u, o, A/)

The F1 and F2 values for the five vowels (/i, e, u, o, A/) obtained for Mandarin speakers were compared to those obtained for American speakers (see Table 2). Both Mandarin males and females did not differ from the American speakers in the production of /e, o/; while significant differences were found between Mandarin and American speakers in the production of /i, u, A/ according to F1 or F2. In general, the Mandarin males demonstrated slightly better performance than the Mandarin females in producing the five vowels. An additional statistical analysis of F1 and F2 across the five vowels indicated that Mandarin speakers demonstrated significant resonance differences across these vowels.

**Table 2.** Comparison of mean values for the F1 and F2 frequencies of vowels (/i, e, u, o, A/) between Mandarin and American speakers.

<table>
<thead>
<tr>
<th></th>
<th>F1 (Hz)</th>
<th>F2 (Hz)</th>
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<tbody>
<tr>
<td></td>
<td>CM</td>
<td>AM</td>
</tr>
<tr>
<td>/i/</td>
<td>428</td>
<td>283</td>
</tr>
<tr>
<td>/e/</td>
<td>422</td>
<td>394</td>
</tr>
<tr>
<td>/u/</td>
<td>368</td>
<td>315</td>
</tr>
<tr>
<td>/o/</td>
<td>444</td>
<td>437</td>
</tr>
<tr>
<td>/A/</td>
<td>742</td>
<td>745</td>
</tr>
</tbody>
</table>

**Discussion For “Familiar” Vowels**
(/i, e, u, o, A/)

(2) The Mandarin speakers might be able to perceive the unfamiliar vowels, but failed to perform the articulatory modifications required to produce the “new” sounds accurately (Briere, 1966; Flege, 1987; Kalikow & Swets, 1972).
The five vowels (/i, e, u, o, A/) occur in both Mandarin and American English languages (Howie, 1976; Wu, 1964). Not surprisingly, the Mandarin speakers showed clear differences across these vowels regarding to F1 and F2. However, some of the five “familiar” vowels produced by the Mandarin speakers were found to significantly different from those produced by the American speakers. There are two possibilities accounting for why the Mandarin speakers differ from the American speakers in producing some of the five vowels:

1. Sounds with similar IPA symbols vary acoustically across languages (Flege, Bohn, & Jang, 1997). The differences obtained between groups may represent an overgeneralization of the IPA symbols for the two languages.

2. Non-linguistic factors (e.g., size and length differences in the vocal tract) between the Mandarin and American speakers may contribute to the observed resonance differences (Yang, 1996).

Results For Vowel Space

Vocal tract vowel space was estimated by plotting each group’s mean formant values along an F1 vs. F2 plane. The comparisons of vowel spaces are presented in Figure 2 and Figure 3. Examination of these figures indicates that the vowels of each language group occupy similar relative positions and constitute a comparable quadrilateral-shaped space. The Mandarin speakers appeared to produce the corner vowels (/i, u, o, A/) with distinct F1 and F2 frequencies. However, for both Mandarin male and female speakers, the overall quadrilaterals appear to be smaller, and the vowel distributions are more compact compared to the American speakers.

Discussion For Vowel Space

The smaller vowel quadrilaterals and more compact vowel distributions among the Mandarin speakers would indicate less acoustic diversity in producing the various English vowels compared to American speakers. The lack of acoustic diversity may be attributed to the introduction of the six unfamiliar vowels to the Mandarin speakers vowel repertoire. This may have increased uncertainty for the Mandarin speakers in reaching the correct articulatory targets. In addition, non-linguistic factors (e.g., size and length differences in the vocal tract) between the Mandarin and American speakers, may contribute to the vowel space differences. Yang (1996) has suggested that non-linguistic factors should be considered when comparing the acoustic and spectral characteristics of vowel productions between different racial groups.

CONCLUSION

There is an overwhelming shortage of multilingual speech-language pathologists (Cheng, 1987). This is especially the case when considering the Mandarin language. Only a few trained Speech-Language Pathologists (SLPs) in the U.S. are proficient enough in Mandarin to provide services to Mandarin speakers. The results obtained in this study indicate that Mandarin speakers experience difficulty accurately producing the vowels of American English. The information provided in this investigation may prove to be clinically useful to monolingual English-speaking SLPs who are confronted with an individual whose first language is Mandarin.

REFERENCES


