ABSTRACT: The discrimination of English vowel contrasts in real and novel words by 40 native English and 40 bilingual Spanish/English participants was examined, with novel words representing new words in a second language. Discrimination was investigated because this factor is the basis of phonological awareness, although most practitioners focus on production when working with bilingual speakers. This study showed an interaction between bilingualism, vowel contrasts, and novel words. Bilingual participants had greater difficulty with certain vowel contrasts that were contained in novel words, whereas native English participants had no significant difficulty with vowel contrasts in either real or novel words. The main variables that affected the bilingual participants’ discrimination were the age of acquisition of English, the report of problems in communication in English, and the overall percentage of time that was devoted to communication in English.

KEY WORDS: bilingual, vowels, discrimination

The Discrimination of English Vowels by Bilingual Spanish/English and Monolingual English Speakers

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Second language (L2) learners must establish phonetic categories for new sounds in a new language or discrimination and/or production may be affected (Flege, 1987, 1988). One difficulty in the acquisition of the sound system of an L2 may derive from the differences between the number and the identity of vowels in the L2 and those in the speaker’s native language. There are also other factors, linguistic and non-linguistic, that may affect discrimination abilities in bilingual speakers.

There are two linguistic factors that may affect Spanish/English speakers’ discrimination and/or production of English vowels. The first linguistic factor concerns the English vowels that are absent in Spanish (i.e., /æ/, /ɛ/, /ɔ/, /eɪ/, /ɪ/, /æ/, and /ɔɪ/), which are frequently confused in discrimination and in production with one another by native Spanish participants (Flege, 1991). In one investigation, monolingual Spanish speakers and Spanish speakers with English as their L2 were presented with the English vowels /i/, /ɛ/, /æ/, and /æ/ in the target words bead, bit, bet, and bat as produced by native English speakers (Flege, 1991). Participants were asked to label the vowels heard in these words by circling one of the Spanish vowels /i/, /ɛ/, /a/, /o/, /u/, or “none.” The participants with experience in English were better able to identify vowels, using the label “none” more frequently than the monolingual Spanish speakers (42% vs. 18%). Results also showed that the vowel /æ/ was more frequently identified as the Spanish vowel /a/ by speakers both with and without experience in English, in spite of the fact that English vowels differ from their Spanish counterparts by virtue of greater duration (Delattre, 1966) and more diphthongized production of diphthongized vowels (Flege, 1989). Production studies also reveal that Spanish speakers’ English productions show the substitution of the vowels /æ/, /ɛ/, and /e/ for the target vowel /æ/; the vowels /i/ and /ɛ/ for the target vowel /ɪ/; and the vowel /æ/ for the target vowel /ɛ/ (Flege, 1990). Examples of words that contain these vowels can be found in Appendix A.

The second linguistic factor that may affect discrimination and/or production concerns the difficulties that both
native and nonnative English participants face in discriminating among certain English vowels (Flege, 1991; Hillenbrand & Gayvert, 1993; Hillenbrand, Getty, Clark, & Wheeler, 1995; Lieberman & Blumstein, 1988; Peterson & Barney, 1952). The primary acoustic cues that allow listeners to discriminate and to identify vowels are found in their formant frequencies (Borden, Harris, & Raphael, 1994). A formant is defined as a peak of resonance in the vocal tract. The first (F1) and second (F2) formants of the vowel produced by a speaker and the relationship between these formants play an important role in vowel identification. Although formant frequencies differ among speakers, the vowel /i/ is always produced with a low-frequency F1 and a high-frequency F2. In contrast, the vowel /a/ is always produced with a lower F1 and F2 than the vowel /i/, that is, with a smaller frequency gap between these formants.

Discrimination and identification are better for vowels that are more dissimilar from one another (Flege, Munro, & Fox, 1994), with similarity based on the relative degree of adjacency of these vowels in the two-dimensional acoustic space defined by F1 and F2. The difficulty in discriminating between certain vowels derives from their closer proximity to one another within this F1–F2 acoustic space, whereas the vowels /a/ and /æ/ have been found to be confused with one another in various dialects of English and in other languages that contain these vowels (Lieberman & Blumstein, 1988) because of their adjacency within the F1–F2 acoustic space.

The ability of phonetically trained native English listeners to identify English vowels was investigated (Hillenbrand & Gayvert, 1993). Listeners were able to identify the target vowel /i/ with the greatest accuracy (95%), followed by the vowels /u/ (85%), /l/ (77%), /æ/ (61%), /æ/ (64%), /a/ (51%), /æ/ (72%), /æ/ (73%), and /a/ (79%). Certain vowels were frequently confused with one another, such as /i/ for the target /i/, /l/ for the target /l/, /æ/ for the target /æ/, /æ/ for the target /æ/, /a/ for the target /a/, and /a/ for the target /a/. However, the further the distance between F1 and F2, the greater the accuracy in vowel identification. For example, the vowels /i/–/a/ were not confused by any participant, but the vowel target /a/ was identified as the vowel /a/ 34% of the time.

Another investigation showed that greater distance between vowels in F1–F2 acoustic space aids listeners’ identification of the dissimilarity of vowels. The ability to perceive the dissimilarity of English and Spanish vowels in contrast pairs (e.g., /a/-/i/) and the differences in the vowels in an oddity task (e.g., /a/-/i/-/i/) were investigated (Flege, Munro, & Fox, 1994). English monolingual and native Spanish/English speakers were presented with vowels that were adjacent (e.g., /a/-/æ/ and /a/-/æ/) or nonadjacent (e.g., /a/-/æ/ and /a/-/æ/) in the F1–F2 acoustic space. The ability to perceive dissimilarity between vowel contrasts increased for both monolingual English and Spanish/English listeners with greater distance between the vowels in the F1–F2 acoustic space. Accuracy was greater for the more experienced Spanish/English participants in the oddity task; accuracy was also greater for those participants reporting less difficulty in the production and comprehension of English.

Sounds in the L1 may also affect the discrimination of new sounds in the L2 (Flege, 1995), based on the assimilation of L1 sounds to those of the L2. Assimilation occurs for sounds in the L1 and the L2 that are similar to one another, especially when the L2 speaker’s underlying representation of a vowel consists of a prototype or an ideal token of a particular sound in the L1 (Rosch, 1975). This prototype has been described to act like a magnet, attracting sounds that more closely resemble the prototype (Kuhl, 1991). This process may account for the vowels in the L1 and L2 that are confused for one another, such as the Spanish vowel /a/ and the English vowel /æ/. On the other hand, it may be less difficult to discriminate between L2 vowels that are less similar to and/or absent from the L1.

In addition to the linguistic factors, there are also two nonlinguistic factors that may affect discrimination: experience with the L2 and the age of acquisition of the L2. The first factor, experience, may provide L2 learners with more accurate discrimination and production abilities (Best & Strange, 1992; Flege, 1993; Flege, Bohn, & Jang, 1997; Flege & Liu, 2001; Kuhl & Iverson, 1995). This experience, in turn, may provide more opportunities to interact with native L2 speakers. These opportunities increase the quantity of native speakers’ L2 input, posited to enhance sound identification in the L2 (Flege & Liu, 2001). Other investigators argue that the quantity of input may correlate only with comprehension, whereas the quantity of output of the L2 may correlate only with production (DeKeyser & Sokalski, 1996).

The second nonlinguistic factor addresses the age of acquisition of the L2. There is a consensus among many investigators that early exposure to an L2 provides an advantage to L2 learners (Singleton, 1995), based on the critical period hypothesis (Lenneberg, 1967). This hypothesis predicts that the ability to learn a new language exists until puberty, around age 12. However, other investigators have found that the ability to discriminate between nonnative sound contrasts declines by 4 years of age (Werker & Teges, 1983), whereas others have found that the ability to induce the linguistic patterns of a language may be lost at 6 to 7 years of age (DeKeyser, 2000).

Snow and Hoefnagel-Höhle (1977) examined the accurate imitation of Dutch words by English speakers (3 years to 60 years old) in a longitudinal investigation. They found that the older participants outperformed the younger participants in initial assessment, but the younger participants outperformed the older participants over time: The older learners’ advantage disappeared after a period of 10 to 11 months; the younger learners exceeded the adults’ accuracy after 18 months.

Investigations show that L2 learners who have acquired English by 7 years of age are able to both judge and produce vowels in a more accurate manner than those who have not (Flege, 1992). Flege and Fletcher (1992) examined the pronunciation of 9–26-year-old Spanish speakers who
had learned English between 1 to 6 years of age, with the majority of English input from 5 to 6 years of age. These speakers were compared with speakers who had learned English as adults. The late learners’ scores were significantly lower than the scores of the early learners.

Although there are other factors that may account for accuracy in the discrimination and production of an L2, such as a language learner’s motivation to learn a new language, these factors may all, to one degree or another, correlate with skills in the discrimination and/or production of the L2. In spite of the fact that discrimination difficulties have been shown to frequently affect communication (Flege, 1987, 1992, 1995; Flege & Liu, 2001), production continues to be the focus of most practitioners who provide services to L2 learners (Rochet, 1995). This emphasis on production ignores the possibility of difficulty in the perception of vowel differences in a new language.

RESEARCH QUESTIONS

The goal of the current study was to determine whether discrimination difficulties affect the discrimination of vowel contrasts in real and novel word pairs. To this end, we studied the discrimination of word pairs that contrasted English vowels by 40 bilingual Spanish/English and 40 native English participants. Vowels were chosen for study because they are affected by dialect variation more often than consonants (MacKay, 1997). In addition, novel words were chosen to represent new words in the L2. The following linguistic research questions were examined in this study to determine whether discrimination difficulties affected both L2 and native English participants.

- Is there a difference in discrimination accuracy between the native English and Spanish/English participants?
- Are there differences among vowels that affect discrimination?
- Is there a difference in discrimination between real words and novel words?

The following nonlinguistic research questions were examined to determine what nonlinguistic variables affect vowel discrimination in bilingual Spanish/English participants.

- Does the age of acquisition of English as an L2 play a role in discrimination accuracy?
- Does the report of problems with communication in English play a role in discrimination accuracy?
- Does the overall percentage of time that is devoted to communication in English play a role in discrimination accuracy?
- Does the age of entry in an English-speaking country play a role in discrimination accuracy?
- Does the language that is spoken at home, work, or with friends play a role in discrimination accuracy?
- Does the method of English acquisition (bilingual school, English school, and/or English class) play a role in discrimination accuracy?
- Does the total number of years that English was spoken play a role in discrimination accuracy?

METHOD

Participants

Eighty participants (40 bilingual Spanish/English-speaking and 40 native English college students, 23–36 years of age) participated in this study (mean = 25.3; median = 25.0). Participants were recruited through posters within the New York City metropolitan area, and each was financially compensated for participation. All participants reported normal hearing, typical development, and unremarkable medical histories. The bilingual participants were presented with and completed a questionnaire that examined their language background relative to the acquisition of English (Appendix B). The bilingual participants’ productions of a short Spanish language paragraph were analyzed by a native Spanish-speaking speaker to determine the accuracy of their productions in Spanish. This nonstandardized test was used to determine if there were problems in communication in Spanish, given that the reports of problems in communication in English were chosen as a variable in the current study. The English-speaking participants were chosen based on being native English speakers with no history of learning or speaking Spanish or any other language other than English. No bilingual participant spoke any language other than Spanish and English.

Bilingual Spanish/English-speaking participants were drawn from a variety of Spanish-speaking backgrounds. Twenty-one participants reported birth in the United States. with 17 reporting that their parents were born in Puerto Rico and 4 reporting that their parents were born in the Dominican Republic. Five participants reported birth in Puerto Rico, and 4 reported birth in the Dominican Republic. Two participants reported birth in Peru, and 2 reported birth in Honduras. Six participants reported birth in other countries. Participants’ backgrounds and certain target questionnaire responses are presented in Table 1.

Procedures

A categorical discrimination task was used to determine whether participants were able to discriminate among the English vowels in target words. Stimuli were presented within triads in an ABX discrimination paradigm, in which A (the first word in the sequence) and B (the second word in the sequence) were different stimuli, and X (the third word in the sequence) was identical to either A or B. For example, a triad may have consisted of the word pawed (A) followed by the word pod (B). The third word would have consisted of either word (A) or word (B). This paradigm was selected to avoid labeling while allowing participants to indicate the category to which the two stimuli belonged.
Each listener was presented with two blocks in this experiment, with each block consisting of 36 trials (Appendix A). Each trial consisted of the presentation of the target words preceded by the carrier phrase (“Say ___”), with stimuli produced by one of three different speakers. Each trial contained three tokens in which each listener heard all three speakers in six possible orders of presentation: 1-2-3, 1-3-2, 2-1-3, 2-3-1, 3-1-2, and 3-2-1. In these ABX trials, participants were presented with either the order ABA or ABB, and X was either A or B in an equal number of cases. Trials were self-paced. All participants’ responses were automatically recorded on Microsoft Excel sheets for later analysis.

Participants were given directions on screen in English, which were also read to them in English (all participants) or in Spanish (bilingual participants). Participants were informed that they would hear three words and that the first word and the second word would be different. They were told that the third word might be the same as the first word or the second word. They were further instructed to click on 1 with the computer mouse if the third word was the same as the first word, or to click on 2 with the computer mouse if the third word was the same as the second word. They were instructed not to verbally repeat the experimental words, so as not to confound the results with their own productions.

Before the experimental task, participants were given a familiarization task that contained 48 word contrasts (24 real English words and 24 novel words that contained the vowel contrasts /i/-/o/ and /e/-/i/), based on the same procedure described in the experimental task. In the familiarization phase, participants were asked to discriminate real and novel words that contained the vowel contrasts that were also used as foils in the experimental task.
phase. Participants were given feedback until it was clear that they understood the task (i.e., selecting I or 2 with 100% accuracy). The words were presented by three speakers who were different from those in the experimental phase. The familiarization phase and the experimental phase together took an average of 30 min.

**Stimuli**

Seventy-two monosyllabic words were presented to each participant: 36 real English words and 36 novel words, with 16 of these words consisting of foils (Appendix A). Stimuli were designed to provide vowel contrasts in both real words (e.g., *pa* vs. *paw*) and novel words (e.g., */bæk*/ vs. */bɔk*/), taking the form of consonant–vowel–consonant (CVC) monosyllabic words. Words contained the consonants */p, b, t, d, k, g,*/ chosen from early speech sounds that are typically produced by Spanish-speaking children (Bedore, 1999). Final analysis consisted of the examination of the 28 word pairs that were not foils. English vowels were drawn from the results of previous research (Flege, 1988, 1991, 1995; Flege, Bohn, & Jang, 1997; Flege, Munro, & Fox, 1994; Hillenbrand & Gayvert, 1993) and were based on the following criteria: (a) absence from the inventory of Spanish vowels (i.e., */ɑ/ – */ɔ/); (b) similarity to certain Spanish vowels (i.e., */ɛ/, */u/, and */a*/); (c) similarity to one another in English (i.e., */ɑ/ – */ɔ*/); (d) discrimination difficulty for both native and nonnative English participants (i.e., */ɑ/–*/ɔ/); */ɛ*/–*/œ*/; */ɛ*/–*/æ*/; and */ɛ*/–*/ə*/; and (e) production difficulty for Spanish participants (i.e., the English vowel */ɛ*/ realized as the Spanish vowel */ɛ*/ and the English vowels */æ*/ and/or */u*/ realized as the Spanish vowel */a*/). English vowels that were discriminated and/or produced in a different manner by bilingual native adults in pilot studies of adults’ discrimination and production (Levey, 2002) and of bilingual Spanish/English-speaking 8- to 12-year-old children’s discrimination (Brito & Levey, 2001) were included (i.e., */ɪ*/–*/ɛ*/, */ɪ*/–*/æ*/, */ɪ*/–*/æ*/; */ʊ*/–*/ɑ*/, */ɑ*/–*/ɪ*, */ɑ*/–*/ɛ*/; */ɔ*/–*/æ*/; and */ɑ*/–*/ə*/). The vowel contrast */i*/–*/u*/ was used based on the previous finding that this contrast presents listeners with the least difficulty in discrimination (Hillenbrand & Gayvert, 1993).

**Recording of Stimuli**

Stimuli were recorded by three native English speakers (two males and one female) in a soundproof booth using a Shure (Niles, IL) SM58-LC unidirectional microphone. Recordings were digitized into a Sony (San Diego, CA) PCG-982L computer using Sound Forge software (1991–1998), 22.05 KHz sampling rate, 16-bit resolution, and a mono channel. Calibration was performed such that the DC offset was adjusted and autosnap to zero was selected. The signal level was set such that levels varied from −18 dB to approximately −6 dB, with no clipping. Root mean squared (RMS) power and DC offset were periodically monitored by means of the Sound Forge statistic function to guarantee appropriate levels during speech and silent periods. These recorded files were presented to three native English speakers, experienced in phonetic transcription, who recorded the identity of the vowels in the target words. The stimuli that were chosen for the experiment were those that were judged to be produced in the expected manner. These vowels were again presented to the same three native English speakers, who were asked to identify the best examples of these vowels chosen to represent the target vowel. For example, the best example of the vowel */i*/ was chosen from a sample of those vowels judged to be the vowel */i*/. In this way, it was determined that the vowels were produced in a standard manner.

Recordings of speakers and trials were randomly presented to participants through headphones in a sound-proofed booth using the Paradigm-ID RCL program (Tagliaferri, 2001). The goal was to present the three-word sequence in a more natural manner, similar to a conversation consisting of various speakers. The goal was also to control for the finding that participants are better able to identify similar vowels when they are produced by a single speaker (Lieberman & Blumstein, 1988), a condition that rarely, if ever, exists in natural communicative contexts.

**Statistical Analysis**

A multivariate analysis of variance (MANOVA) was conducted to analyze the effects of the independent variables on discrimination accuracy. All analyses were completed using the Statistica statistical software package (Statistica, 2001). For significant task effects, Scheffé post hoc tests were applied. Planned comparisons (p < .05) were used to test differences among mean scores. Results were also analyzed to determine if frequency of occurrence played a role in discrimination accuracy (MRC Psycho-linguistic Database, 1987).

The mean number of accurate responses that occurred in both the first and second blocks represented the dependent variable (Appendix A). The consistency of accurate responses was examined, focusing on the words that were discriminated accurately in both blocks (e.g., *pod–pawed* in the first block and *pod–pawed* in the second block). Responses were tallied over trials for each vowel pair. An accurate response was defined as responding I when the trial was ABA or 2 when the trial was ABB. This analysis was based on the hypothesis that an error with a particular contrast on one block may have constituted a random error, whereas consistent errors for the same contrast in both blocks indicated a more valid sign of discrimination difficulty.

The linguistic independent variables consisted of (a) native English versus bilingual Spanish/English participants; (b) vowel contrasts; (c) and real versus novel words. The nonlinguistic independent variables were based on the information obtained from the questionnaires: (a) the age of acquisition of English as the L2; (b) the report of problems with communication in English; (c) the overall percentage of time devoted to communication in English (a scale from 10% to 100% of the time each day); (d) the age of entry into an English-speaking country; (e) the language(s)
RESULTS

Discrimination: Linguistic Factors

Native English versus bilingual Spanish/English participants. Analysis revealed a main effect for bilingualism, $F(1, 2184) = 128.75, p < .01$, with greater difficulty in the discrimination of vowel contrasts for the bilingual participants ($M = .89, SD = .25$) than for the native English participants ($M = .98, SD = .12$) (Table 2).

Vowel contrasts. Analysis showed a main effect for vowel contrasts for both bilingual and native English participants, $F(13, 2184) = 14.84, p < .01$, with the vowel contrasts /ʊ–ʌ/ ($M = .81, SD = .32$) and /æ–ɛ/ ($M = .85, SD = .31$) presenting all participants with the overall greatest difficulty (Table 3). Analysis also revealed an interaction between bilingualism and vowel contrasts, $F(13, 2184) = 5.95, p < .01$. Planned comparisons were performed and a significant difference ($p < .05$) between bilingual and native English participants was found for the words that contained the vowel contrasts /ʊ–ʌ/ ($M = .76, SD = .35$ vs. $M = .86, SD = .29$), /æ–ɛ/ ($M = .74, SD = .38$ vs. $M = .96, SD = .18$), /i–ɪ/ ($M = .79, SD = .34$ vs. $M = 1.00, SD = .00$), and /ʊ–ʌ/ ($M = .79, SD = .33$ vs. $M = .98, SD = .10$) (Table 4).

Real versus novel words. There was no main effect for novel words when results for both native English and bilingual Spanish/English participants were examined. There was, however, an interaction between bilingualism and novel words, $F(1, 2184) = 4.94, p < .05$. There was a significantly greater difficulty for the bilingual participants when the vowel contrasts were presented in novel words ($M = .87, SD = .27$) versus real words ($M = .90, SD = .22$). There was no significant difference in the monolingual English participants when vowel contrasts were presented in real words ($M = .98, SD = .12$) or in novel words ($M = .98, SD = .13$). An item analysis was performed that revealed a total of 30 errors with novel words but only 13 errors with real words for the bilingual participants, whereas the native English participants had a total of eight errors (four errors with novel words and four errors with real words). Analysis revealed a three-way interaction between bilingualism, vowel contrasts, and novel words. Planned comparisons were performed, revealing a significant difference for bilingual participants ($p < .05$) between real words and novel words that contained the vowel contrasts /ʊ–ʌ/ ($M = .65, SD = .36$ vs. $M = .88, SD = .29$), /æ–ɛ/ ($M = .95, SD = .15$ vs. $M = .79, SD = .30$), and /æ–ɛ/ ($M = .95, SD = .15$ vs. $M = .53, SD = .42$).

The possibility that participants may have been more accurate with practice was also examined. There was no significant difference in discrimination accuracy found

Table 2. Multivariate analyses of variance for discrimination accuracy.

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilingual (B)</td>
<td>1</td>
<td>128.75**</td>
<td>.0001</td>
</tr>
<tr>
<td>Contrast (C)</td>
<td>13</td>
<td>14.84**</td>
<td>.0001</td>
</tr>
<tr>
<td>Novel (N)</td>
<td>1</td>
<td>2.68</td>
<td>.10</td>
</tr>
<tr>
<td>B × C</td>
<td>13</td>
<td>5.95**</td>
<td>.0001</td>
</tr>
<tr>
<td>B × N</td>
<td>1</td>
<td>4.94*</td>
<td>.03</td>
</tr>
<tr>
<td>C × N</td>
<td>13</td>
<td>11.49**</td>
<td>.0001</td>
</tr>
<tr>
<td>B × C × N</td>
<td>13</td>
<td>3.05**</td>
<td>.0002</td>
</tr>
</tbody>
</table>

*p < .05. **p < .01.

Table 3. Mean discrimination accuracy: All participants (monolingual and bilingual).

<table>
<thead>
<tr>
<th>Vowel contrasts</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>a–ɔ</td>
<td>.81*</td>
<td>.32</td>
</tr>
<tr>
<td>a–ɛ</td>
<td>.98</td>
<td>.10</td>
</tr>
<tr>
<td>a–ʌ</td>
<td>.94</td>
<td>.17</td>
</tr>
<tr>
<td>e–ɪ</td>
<td>.90</td>
<td>.22</td>
</tr>
<tr>
<td>e–æ</td>
<td>.95</td>
<td>.15</td>
</tr>
<tr>
<td>æ–ʊ</td>
<td>.95</td>
<td>.16</td>
</tr>
<tr>
<td>æ–ɛ</td>
<td>.85*</td>
<td>.31</td>
</tr>
<tr>
<td>i–ɪ</td>
<td>.90</td>
<td>.26</td>
</tr>
<tr>
<td>i–æ</td>
<td>.98</td>
<td>.09</td>
</tr>
<tr>
<td>u–ʊ</td>
<td>.89</td>
<td>.26</td>
</tr>
<tr>
<td>o–ʌ</td>
<td>.98</td>
<td>.10</td>
</tr>
<tr>
<td>e–ɛ</td>
<td>.98</td>
<td>.12</td>
</tr>
<tr>
<td>e–ɛ</td>
<td>.97</td>
<td>.12</td>
</tr>
<tr>
<td>i–u</td>
<td>.98</td>
<td>.10</td>
</tr>
</tbody>
</table>

*p < .01.

Table 4. Mean and standard deviation of discrimination accuracy for vowel contrasts in real and novel words for bilingual Spanish/English and native English participants.

<table>
<thead>
<tr>
<th>Vowel contrasts</th>
<th>Bilingual participants</th>
<th>Native English participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>a–ɔ</td>
<td>.76**</td>
<td>.35</td>
</tr>
<tr>
<td>a–ɛ</td>
<td>.96</td>
<td>.14</td>
</tr>
<tr>
<td>a–ʌ</td>
<td>.88</td>
<td>.25</td>
</tr>
<tr>
<td>e–ɪ</td>
<td>.87</td>
<td>.15</td>
</tr>
<tr>
<td>e–æ</td>
<td>.91</td>
<td>.19</td>
</tr>
<tr>
<td>æ–ʊ</td>
<td>.93</td>
<td>.20</td>
</tr>
<tr>
<td>æ–ɛ</td>
<td>.74***</td>
<td>.38</td>
</tr>
<tr>
<td>i–ɪ</td>
<td>.79**</td>
<td>.34</td>
</tr>
<tr>
<td>i–æ</td>
<td>.99</td>
<td>.12</td>
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<tr>
<td>u–ʊ</td>
<td>.79*</td>
<td>.33</td>
</tr>
<tr>
<td>o–ʌ</td>
<td>.98</td>
<td>.11</td>
</tr>
<tr>
<td>e–ɪ</td>
<td>.96</td>
<td>.12</td>
</tr>
<tr>
<td>e–ɛ</td>
<td>.94</td>
<td>.16</td>
</tr>
<tr>
<td>i–u</td>
<td>.97</td>
<td>.12</td>
</tr>
</tbody>
</table>

*p < .05. **p < .01. ***p < .0001.
between the first and second block for native English participants ($M = .98$, $SD = .14$ vs. $M = .98$, $SD = .14$) or for bilingual participants ($M = .90$, $SD = .30$ vs. $M = .91$, $SD = .29$). There was also no main effect for word frequency.

**Discrimination: Nonlinguistic Factors**

**Age of acquisition.** The participants who had learned English at 0–3 years of age ($M = .95$, $SD = .16$), at 4–7 years of age ($M = .91$, $SD = .23$), or at 8–12 years of age ($M = .90$, $SD = .23$) had significantly less discrimination difficulty than those who had learned English later than 12 years of age ($M = .84$, $SD = .29$), $F(4, 1436) = 11.79$, $p < .01$. There was no significant difference in discrimination accuracy between the participants who had acquired English between 13–18 years of age ($M = .84$, $SD = .01$) and 19 years of age or older ($M = .85$, $SD = .02$). Analysis showed a decline in discrimination accuracy as the age of English acquisition increased.

**The report of problems versus no problems in English communication.** Discrimination accuracy was significantly greater for the participants reporting no problems with communication in English ($M = .91$, $SD = .23$) than for those who reported problems ($M = .85$, $SD = .26$), $F(1, 1438) = 13.83$, $p < .01$. Item analysis revealed an average of six errors per participants who reported problems, with an average of three errors per participants who reported no problems.

**The percentage of time devoted to communication in English.** The participants who reported the use of English to be more than 50% to 100% of time per day and/or week achieved greater discrimination accuracy ($M = .91$, $SD = .22$) than the participants who reported the use of English to be less than 50% of the time ($M = .86$, $SD = .28$), $F(1, 1438) = 13.34$, $p < .01$.

The remaining nonlinguistic variables had no significant effect on discrimination accuracy: the age of entry into an English-speaking country; the language(s) spoken at home, at work, or with friends; the method of acquisition of English; the total number of years English was spoken; and the skill level reported for speaking or understanding languages other than English. Results revealed no significant difference for the mean scores for use of Spanish versus the use of both English and Spanish at home ($M = .91$, $SD = .23$ vs. $M = .90$, $SD = .24$), with friends ($M = .92$, $SD = .23$ vs. $M = .90$, $SD = .23$), or at work ($M = .91$, $SD = .23$ vs. $M = .90$, $SD = .23$). Analysis also revealed no significant difference in the mean scores for education in bilingual schools versus education in English-only schools ($M = .90$, $SD = .25$ vs. $M = .91$, $SD = .22$), nor for a history of attending versus not attending classes conducted to teach English for the bilingual participants who attended bilingual schools ($M = .89$, $SD = .25$ vs. $M = .91$, $SD = .22$). There was no difference in the mean scores for participants who reported asking another person to speak for them versus those who used no other person to speak for them ($M = .91$, $SD = .23$ vs. $M = .87$, $SD = .26$). Finally, there was no significant difference among the mean scores for the country of origin.

**Summary**

There was a significant difference in discrimination accuracy between the bilingual and the native English participants. Both vowel contrasts and novel words presented bilingual participants with greater difficulty than they did the native English participants. The vowel contrasts /æ–/ and /æ–/ presented both bilingual and native English participants with difficulty, although there was significantly greater difficulty for the bilingual participants than for the native English participants. There was also greater difficulty for the bilingual participants when vowel contrasts were presented in novel words than in real words, whereas native English participants had no significant difficulty with vowel contrasts in either real or novel words. The bilingual participants’ reports of early age of acquisition of English, a greater percentage of time devoted to communication in English, and the report of no difficulty in communication in English were found to be the nonlinguistic variables that played the greatest role in discrimination accuracy.

**DISCUSSION**

This study examined the discrimination ability of bilingual Spanish/English speakers. The most important findings were that (a) the monolingual English speakers had no difficulty in discrimination whereas the bilingual speakers had some difficulty in discrimination, (b) the vowels that were absent in the Spanish language presented more difficulty for the bilingual speakers, (c) the bilingual speakers who learned English earlier had less difficulty than those speakers who learned English later, and (d) the novel words presented the bilingual speakers with difficulty. This study suggests that vowels that are absent in other languages may affect learning an L2. The results also suggest that early learning of an L2 may provide an advantage to L2 learners. Finally, new words may also affect bilingual learners, given that novel words affected discrimination ability.

The vowel contrasts that presented bilingual participants with the greatest difficulty were precisely those that are absent in Spanish (i.e., /æ/, /æ/, /æ/, /æ/, and /æ/). Consequently, these vowels were confused with one another or with another English vowel (i.e., /æ/ and /æ/). The vowel contrasts /æ–/ and /æ–/ presented the bilingual participants with the greatest difficulty, especially when presented in novel words. Given that the novel words were chosen to represent words in the L2 that are unfamiliar to participants, they played a similar role to the new words in an L2 learning situation.

Previous investigations of discrimination have found that the English vowel contrast /æ–/ presents monolingual English listeners with difficulty (Hillenbrand & Gayvert, 1993; Lieberman & Blumstein, 1988), whereas there are significantly fewer errors with the vowel contrast /æ–/. Consistent with these previous results, both bilingual Spanish/English and monolingual participants had no difficulty with the vowel contrast /æ–/. In contrast, errors
appeared in the discrimination of the words that contained the vowel contrast /a–u/, with a greater number of errors in the discrimination of the bilingual participants. In addition, the vowel contrast /a–u/ affected discrimination accuracy in both real and novel words for the bilingual participants.

Three of the nonlinguistic variables had a significant effect: (a) the age of acquisition of English, (b) the report of problems with communication in English, and (c) the overall percentage of time that was devoted to communication in English. Consistent with previous investigations, the later age of acquisition of English and the lower percentage of time devoted to communication in English were factors that presented the bilingual Spanish/English participants with difficulty (Flege, 1992; Flege & Liu, 2001). The difference found in discrimination ability for real versus novel words also suggests that greater familiarity with the words in a new language may provide better discrimination ability of L2 communication. The bilingual participants’ reports of difficulty in communication in English also correlated with discrimination difficulty, suggesting that discrimination should be considered in practitioners’ work with bilingual language learners.

### IMPLICATIONS FOR SPEECH-LANGUAGE PATHOLOGISTS AND L2 PRACTITIONERS

It should be noted that the current study is not the first investigation to determine that discrimination is a factor in bilingual language learners’ acquisition of L2 sound systems. Flege, Bohn, and Jang (1997), Flege, Munro, and Fox (1994), and Strange (1995) have found that discrimination is a factor in L2 learners’ difficulties in the acquisition of a new language. These and the current results suggest that practitioners should consider assessing discrimination abilities before focusing on production when working with L2 learners who seek help.

The results of the current study also suggest that practitioners should consider the role and the characteristics of vowels in words, given that these segments present L2 learners with the greatest difficulty as they acquire a new language (MacKay, 1997). Frequently, there is a concentration on consonants that are produced incorrectly, although research has shown that vowels play a major role in discrimination and production (Levey & Schwartz, 2002) because these segments provide listeners with more prosodic information in words than do consonants (Werker & Polka, 1993).

The results of the current study also suggest that practitioners should initially present L2 learners with words that are more familiar, given that novel words presented the bilingual Spanish/English listeners with greater discrimination difficulty than the real words used in this study. Other investigators have also found that discrimination was better for words that were more familiar to participants (Werker & Polka, 1993), even for children as young as 1 to 3 years of age.

Statistics show that there are more than 1,000 speech-language pathologists treating languages not spoken by them, with most speech-language pathologists providing treatment to Spanish speakers (Weiss, 2002). It is necessary that practitioners be aware of differences among languages so that they can differentiate between disorders and typical differences in L2 learners and determine whether discrimination difficulties are present in these L2 learners.

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## APPENDIX A. WORD PAIR CONTRASTS

<table>
<thead>
<tr>
<th>Area of difficulty</th>
<th>Contrast</th>
<th>Real words</th>
<th>Novel words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discrimination (English)</td>
<td>α  ṭ</td>
<td>pod  pawed</td>
<td>bok  bok</td>
</tr>
<tr>
<td>Discrimination (Spanish)</td>
<td>α  e</td>
<td>pot  pet</td>
<td>dop  dop</td>
</tr>
<tr>
<td>Discrimination (Spanish and English)</td>
<td>α  ∧</td>
<td>dock  duck</td>
<td>bop  bop</td>
</tr>
<tr>
<td>Discrimination (Spanish and English) and production (Spanish)</td>
<td>e  i</td>
<td>bet  bit</td>
<td>ped  ped</td>
</tr>
<tr>
<td>Production (Spanish)</td>
<td>æ  α</td>
<td>cap  cop</td>
<td>pæg  pag</td>
</tr>
<tr>
<td>Production (Spanish)</td>
<td>æ  e</td>
<td>bat  bait</td>
<td>kæg  keg</td>
</tr>
<tr>
<td>Discrimination (pilot study)</td>
<td>i  i</td>
<td>pit  Pete</td>
<td>dit  dit</td>
</tr>
<tr>
<td>Discrimination (pilot study)</td>
<td>i  æ</td>
<td>kit  cat</td>
<td>git  gæt</td>
</tr>
<tr>
<td>None (easily discriminated by English listeners)</td>
<td>i  u</td>
<td>beat  boot</td>
<td>dib  dub</td>
</tr>
<tr>
<td>Foils</td>
<td>o  e</td>
<td>go  gay</td>
<td>bop  bep</td>
</tr>
<tr>
<td>Foils</td>
<td>e  i</td>
<td>bake  beak</td>
<td>teb  tib</td>
</tr>
<tr>
<td>Foils</td>
<td>i  o</td>
<td>tea  toe</td>
<td>kig  kog</td>
</tr>
<tr>
<td>Foils</td>
<td>e  i</td>
<td>Kay  key</td>
<td>deg  dig</td>
</tr>
</tbody>
</table>
APPENDIX B. QUESTIONNAIRE

1. At what age did you enter an English-speaking country?
2. How many years have you lived in an English-speaking country or countries?
3. At what age did you begin to learn English?
4. Does your family speak English at home? Yes____ No____
5. What languages are spoken at home?
6. What language or languages do your parents speak with you?
7. If there are other family members living at home, what languages do they speak with you?
8. What language do you speak with friends?
9. What language do you speak at work?
10. Do you ever have anyone speak for you? Yes____ No____
11. If you answered yes to question (10), please explain your answer.
12. Where did you learn to speak English (i.e., in school, from friends, from tapes)?
13. If you learned in school, did you learn English in an English-only school? Yes____ No____
14. If you learned in school, did you study English in a single, academic class in a Spanish-speaking school? Yes____ No____
15. Did you study English in an English-as-a-second-language (ESL) class? Yes____ No____
16. If none of the above, please describe how you learned English.
17. How many years (in total) have you studied English?
18. Did you study English consistently over these years? Yes____ No____
19. If you answered no to question (18), please describe the length of time that you studied English.
20. What was your country of origin?
21. Have you lived in any other country or countries? Yes____ No____
22. If you answered yes to question (21), please list the countries in which you lived and the languages spoken (by you and to you) in these countries.
23. Do you speak any other languages besides Spanish and English? Yes____ No____
24. If you answered yes to question (23), please list these languages (in order of learning) and circle the skill level for each language (e.g., excellent, good, fair, poor).
   First language learned: ______________________________ excellent/good/fair/poor
   Second language learned: ______________________________ excellent/good/fair/poor
   Third language learned: ______________________________ excellent/good/fair/poor
   Fourth language learned: ______________________________ excellent/good/fair/poor
25. Do you also read one or more of the languages listed above? If you do, please list these languages that you are able to read and circle the skill level of reading (e.g., excellent, good, fair, poor).
   First language read: ______________________________ excellent/good/fair/poor
   Second language read: ______________________________ excellent/good/fair/poor
   Third language read: ______________________________ excellent/good/fair/poor
   Fourth language read: ______________________________ excellent/good/fair/poor
26. Do you have problems speaking or understanding English? Yes____ No____
27. If you answered yes to question (26), what do you view as your main problem(s)?
28. Have you ever received ESL treatment or speech therapy? Yes____ No____
29. If you answered yes to question (28), please describe this therapy (e.g., where, how long, the focus of this therapy).
30. Who was your English instructor (e.g., native English speaker or other language background speaker)?
31. How often do you speak English each day/and or week (10%, 25%, 50%, 75%, or 100% of the time)?
32. During these periods, (a) who are you speaking with (e.g., friends, your parents) and (b) where are you speaking English (e.g., at work, at school)?

Additional comments: