Rate variation as a talker-specific property in bilingual talkers

Midam Kim*, Lauren Ackerman, L. Ann Burchfield, Lisa Dawdy-Hesterberg, Jenna Luque, Kelsey Mok and Ann R. Bradlow

*Corresponding author's address: Linguistics, Northwestern University, Evanston, IL 60208, midamkim@gmail.com

Nonnative talkers tend to exhibit slower speech rates than native talkers at the group level. Here we ask whether individual variation in rate is language-general to the extent that L1 rate is a significant predictor of L2 rate within bilinguals. 62 nonnative English talkers participated in three speech production tasks in both their L1 (14 Cantonese, 14 Mandarin, 11 Korean, 4 Portuguese-Brazilian, 6 Spanish, 13 Turkish) and L2 (English), namely, reading a paragraph, spontaneously answering questions, and spontaneously describing a picture story. Two measurements of rate were automatically extracted from the recordings: speech rate (syllables per second), and articulation rate (syllables per second excluding silent pauses). As expected, L2 speech and articulation rates were overall slower than L1 speech and articulation rates for all tasks. Importantly, L2 speech rates and articulation rates were positively related to L1 speech rates and articulation rates, respectively. There were also significant differences in L2 speech rates and L2 articulation rates depending on L1 background and tasks. However, the positive relationship between L1 and L2 rates still holds with these other effects taken into consideration, suggesting that overall rate variation is partially an individual-specific property that transcends L1 and L2 within bilinguals.

Published by the Acoustical Society of America through the American Institute of Physics
INTRODUCTION

Second-language talkers tend to exhibit speech patterns that differ from first-language talkers’ at various levels of speech production (e.g. at the segmental level, as well as at the global level including overall speech rate). One source of this variation is the influence of the bilingual’s first language (L1) on the second language (L2). This possibility has been explored extensively within the frameworks of models of cross- and second language speech perception and production (e.g. Best et al., 2001; Flege, 1995; Kuhl et al., 2008). These models have provided principled explanations of the varying degrees of success in bilingual talkers’ acquisition of specific sound contrasts by comparing the sound structures of the first and second languages.

In addition to specific L1-L2 structural interactions, there are two other sources of bilingual speech variation. First, the cognitive-linguistic demands of second-language speech production can generally impact second-language speech regardless of the bilinguals’ first and second languages. For example, second-language talkers’ speech rate is typically slower than first-language talkers’ speech rate (e.g. Guion et al., 2000). Second, there might be some talker-specific variability that contributes to second-language talkers’ speech patterns, regardless of their particular first and second languages or the general demands of second-language production. For example, work on speech production by monolingual (first-language) talkers has shown substantial variation across talkers in global acoustic-phonetic features such as speech rate and overall clarity (e.g. Bradlow et al., 1996; Hazan & Markham, 2004). Therefore, these talker-specific speech features might transfer from first-language to second-language speech production by bilingual talkers, making bilingual talkers’ first-language idiolectal features a significant predictor of their second-language speech patterns.

The current work examines all three sources of second-language speech variability in bilingual talkers: language-specific influences, general second-language speech demands, and talker-specific individual characteristics. In this paper, we present our analyses of the speech rates of 62 bilinguals for whom English is the second-language and 24 monolingual English talkers. Our specific research questions are:

1) Does first-language speech rate vary across languages? (a language-dependent influence)
2) Is the speech rate of bilingual talkers generally slower in the second-language (English) than in the first-language regardless of the particular first-language? (a language-general/status-specific influence), and
3) Within the group of bilingual talkers, is first-language speech rate positively correlated with second-language (English) speech rate? (a talker-specific influence)

METHODS

Procedures

We analyzed speech samples from the ALLSSTAR Corpus (Archive of L1 and L2 Scripted and Spontaneous Transcripts and Recordings), a corpus of digital recordings of bilingual talkers from various native language backgrounds each producing scripted and spontaneous speech both in their first-language and in their second-language, English. The bilingual talkers included in the ALLSSTAR Corpus were recorded on two consecutive days. On the first day, all participants answered a language background questionnaire and performed an English sentence-in-noise recognition test (the HINT test, Soli & Wong, 2008). They were then recorded reading sentences and a paragraph (North Wind and the Sun, NWS) in English. Finally, samples of spontaneous speech in English were recorded in response to six open-ended questions (QNA) and two simple picture stories (ST). On the second day, the bilingual
talkers returned for a comparable recording session in their first-language. The corpus also includes English recordings from a group of monolingual American-English talkers. The only difference in the materials for the monolingual talkers was that for the picture stories (ST), the monolingual talkers described four stories in English, while the bilingual talkers described two of the stories in their first-language and the other two in their second-language (English). All scripted materials were presented in the standard orthography of the language. All participants were recorded in a sound-proof room using a Shure SM81 Condenser Microphone and a Marantz PMD 670 flash recorder. For further details, refer to Bradlow et al. (2011).

Participants

Of the full set of first-languages currently available in the ALLSSTAR Corpus, we included only those with more than three talkers for the analyses of the current paper. This set includes recordings from 62 bilingual talkers representing the following six first-languages: Cantonese (n=14), Mandarin (n=14), Turkish (n=13), Korean (n=11), Spanish (n=6), and Brazilian-Portuguese (n=4). In addition, we include English recordings from 24 monolingual American-English talkers (see Table 1 for details). The average age of the bilingual talkers was 23.9 years with a range of 19-34 years. The average age of the monolingual English talkers was 19.8 years with a range of 18-26 years. All talkers reported normal speech and hearing at the time of testing and were paid for their participation or received course credit.

Table 1. Participants used in the current study

<table>
<thead>
<tr>
<th>First-Language</th>
<th>Gender</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Bilinguals (n = 62)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Second-language = English)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cantonese</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Mandarin</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Turkish</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Korean</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Spanish</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Brazilian-Portuguese</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Monolinguals (n = 24)</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>47</td>
</tr>
</tbody>
</table>

Materials

For the current paper, we analyzed recordings of the paragraph reading (NWS), picture narratives (ST), and answers to the six open-ended questions (QNA). For each of the bilingual talkers, we analyzed four recordings (1 NWS, 1 QNA, and 2 ST) in each of their two languages. For each of the monolingual talkers, we analyzed six recordings in English (1 NWS, 1 QNA, and 4 ST). In total, we analyzed 392 English recordings (62 bilingual x 4 recordings + 24 monolinguals x 6 recordings) and 248 non-English recordings (62 bilinguals x 4 recordings).

Analyses

From each recording we calculated the speech rate as follows. First, we obtained the number of syllables using an automatic syllable counting algorithm implemented as a Praat script (de Jong & Wempe, 2009). This script counts the number of intensity peaks in a digitized speech signal that are preceded and followed by intensity troughs excluding peaks that are not voiced. To get a measure of speech rate the total number of peaks (syllabic nuclei) is divided by the duration of the recording with
We conducted linear mixed effects regression model analyses with speech rate as the dependent measure using the lme4 package (Bates, Maechler, & Bolker, 2011) and the languageR package (Baayen, 2011). First, we tested whether speech rate varies across first-languages (language-specific speech rate). Here, monolingual and bilingual talkers’ first-language speech rate was the dependent measure. The fixed effect factors were first-language (Cantonese, Mandarin, English, Korean, Brazilian-Portuguese, Spanish, and Turkish), task (NWS, QNA, ST), and utterance length. First-language and task were treatment-coded with Cantonese and NWS as the baselines, respectively. The interaction between first-language and task was added to the model. The random intercept was talker, and utterance length was added as the random slope for talker. None of the other factors including gender, age, HINT perception scores and the interactions among them were added to the model, since they did not improve the model fit. Critical conclusions from this analysis are summarized as follows:

1. A main effect of language (faster rates in Turkish and Mandarin than the other languages)
2. A main effect of task (slower rates for QNA than for ST and NWS)
3. A main effect of utterance length (faster rates in longer utterances)
4. An insignificant interaction between language and task

Second, we tested whether there was a general difference in first-language versus second-language speech rate within the group of bilinguals. In this regression model, the dependent measure was speech rate of the bilinguals. The fixed effect factors were language status (L1, L2), task (NWS, QNA, ST), first-language (Cantonese, Mandarin, Korean, Brazilian-Portuguese, Spanish, and Turkish), and utterance length. The interactions among language status, task, and first-language were included. Language status was contrast coded. The random intercept was talker, and utterance length was added as random slope for talker. Critical conclusions from this analysis are summarized as follows:

1. A main effect of language status (faster rates for L1 than L2)
2. A main effect of task (faster rates for NWS than for QNA and ST)
3. A main effect of first-language (faster rates in Turkish and Mandarin than the other languages)
4. A main effect of utterance length (faster rates in longer utterances)
5. A significant interaction between language status and task (In L1, faster rates for NWS than QNA and ST, while in L2, fastest rates for NWS, middle-ranged rates for QNA, and slowest rates for ST)

Finally, we tested whether individual variation in bilingual talkers’ L1 speech rates impacts their L2 speech rates. In this analysis, the dependent measure was bilingual talkers’ second-language (English) speech rates. The fixed effect factors were L1 speech rate, task (NWS, QNA, ST), first language (Cantonese, Mandarin, Korean, Brazilian-Portuguese, Spanish, and Turkish), and second-language utterance length. The interactions among L1 speech rate, task, and L1 were added. The random intercept was talker, and L2 utterance length was included as the random slope for talker. Critical conclusions from this analysis are summarized as follows:

1. In the read speech samples (NWS), L1 speech rate did not significantly predict L2 speech rate.
2. In the spontaneous speech samples (QNA and ST), L1 speech rate had a significantly positive
influence on L2 speech rate (relatively fast bilinguals in L1 were also relatively fast in L2).

3. SUMMARY AND CONCLUSION

In this research, we examined three potential factors as sources of speech rate variation. First, in our analysis of first-language speech rate in various languages, we found some evidence for language-specific speech rate variation. Second, in our comparison of bilinguals’ first-language speech rates and second-language (English) speech rates, we found generally slower second-language speech rates than first-language speech rates regardless of the bilinguals’ first-language. Finally, the novel contribution of these results is that, within a group of bilinguals, spontaneous speech rates in second-language (English) were positively correlated with spontaneous speech rates in first-language. In sum, these results indicate language-specific, status-specific (first- vs. second-language), and talker-specific influences on speech rate variation.

ACKNOWLEDGEMENTS

Vanessa Dopker and Chun Liang Chan. Work supported by Grant R01-DC005794 from NIH-NIDCD.

REFERENCES


Bates, D., Maechler, M., & Bolker, B. (2011). lme4: Linear mixed-effects models using S4 classes. R package version 0.999375-42. http://CRAN.R-project.org/package=lme4


