

Tempo, information rate, and communicative efficiency in L2 speech

Keynote paper

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Abstract

This presentation seeks links between speech tempo, information transmission rate and communicative efficiency in conversations involving L2 participants. First, we show that L2 speech tempo is influenced by both “state” and “trait” characteristics. Specifically, while L2 speech is invariably slower than L1 speech (L1 vs. L2 “state”), within bilingual individuals L1 rate is a significant predictor of L2 rate (individual “trait”). Next, we show that the slower rate of L2 speech (fewer syllables/second) is compounded by lower L2 information density (more syllables/text) yielding a very low L2 information transmission rate (fewer bits of information transmitted/second). Finally, we show variation in conversation-based cooperative task completion time depending on degree of language background overlap between task participants. Together, these studies provide a scaffold for eventually linking acoustic level temporal variation to discourse level communicative efficiency in L2 speech communication.

Keywords: bilingual speech communication; speech rate; information transmission rate, communicative efficiency.

Introduction

One of the most salient features of speech communication between interlocutors from different language backgrounds is its relatively slow pace. At every step along the speech chain - from lexical selection to speech articulation to word recognition – second-language (L2) speech production and perception proceed more slowly than first-language (L1) speech production and perception. As a consequence, conversational interactions in which one or both of the participants are L2 speakers are generally less efficient than interactions that include only L1 speakers. In this presentation, I will discuss a series of studies of the temporal domain of L2 speech with an emphasis on its communicative consequences. Specifically, these studies will show possible links between speech rate at the phonetic level, density of information coding at the semantic level, and communicative efficiency at the discourse level.

“State” and “trait” characteristics in speech tempo

At the phonetic level, one of the most salient differences between L2 and L1 speech production is the reduced tempo of L2 speech in terms of syllables

produced per second. This reduced L2 speaking rate is well established across L1 and L2 talkers of a given language as well as across languages within bilingual individuals (e.g. Guion et al, 2000; Baese-Berk & Morrill, 2015; Bradlow et al, 2017). Moreover, slower L2 than L1 speaking rates have been demonstrated in several L2s, including Spanish, French, Dutch, and German (García Lecumberri et al, 2017; De Jong et al, 2015; Trouvain & Möbius, 2014). Data from a large corpus of both read and spontaneous speech recordings in both the L1 and L2 of a group of bilingual individuals (n=86) from various language backgrounds (n=10) show that this language-general, group-level difference between L2 and L1 speaking rates exhibits systematicity at the individual talker level. Using automatically extracted speaking rate measurements (syllables/second), a comparison of L1 and L2 speaking rates within individual bilinguals revealed that, while speaking rate was always slower in L1 speech than in L2 speech, L1 speaking rate significantly predicted L2 speaking rate. That is, relatively fast or slow talkers in L1 were also relatively fast or slow in L2, respectively. These results indicate a persistent influence of a talker-specific articulatory setting, or “trait” characteristic, that combines with, rather than is overwhelmed by language dominance (i.e. a L1 versus L2 “state” characteristic) in the global temporal structure of bilingual speech production (Bradlow et al, 2017; see also De Jong et al, 2015 and Derwing et al, 2009).

This combination of “trait” and “state” characteristics in speech tempo suggests that information about both talker-specificity (who is talking) and mode-specificity (L1 versus L2 speech mode) are available to listeners as part of the context for message interpretation. Indeed, studies of foreign-accented speech detection have shown that listeners can determine whether an utterance was produced in L1 speech (i.e. sounds “unaccented”) or L2 speech (i.e. sounds “foreign-accented”) based on very short snippets of speech in a known language (Flege, 1984) as well as in an unknown language (Major, 2007), suggesting that listeners are sensitive to language-general, “state” characteristics of L2 speech even without knowledge of language-specific phonetic contrasts. Moreover, studies of talker identification have shown that listeners can identify specific bilingual talkers based on speech samples from both of their languages (e.g. Winters et al, 2008) indicating that talker-specific “trait” characteristics are accessible and potentially useful for listeners. Global speech tempo is very likely one of the acoustic dimensions that conveys this indexical information about the language “state” (L1 or L2) and talker “trait” (talker identity).

Information transmission rate in L1 and L2 speech

To explore the communicative impact of the slow L2 tempo, we examined the relationship between speaking rate (syllables/second) and information density (number of syllables for a given text) in L1 and L2 recordings of a standard reading passage (NWS, North Wind and the Sun passage) in three languages, English, French, and Spanish. This analysis followed the reasoning and

approach of cross-language comparisons indicating an inverse relationship between speaking rate (syllables/second) and information density (number of speech units for a given meaning) yielding relative cross-language consistency in information conveyed per second (information rate) (Coupé et al, 2019). Extending this approach to L2 speech, we see that L2 productions of the NWS passage in all three languages involved both slower rates and lower information density than their respective L1s. A follow-up comparison of the number of acoustic syllables (intensity peaks in the signal) versus orthographic syllables (dictionary-based counts of phonological syllables in the text) indicated substantial syllable reduction for L1 speech (number of acoustic syllables < number of orthographic syllables) in contrast to either substantial syllable epenthesis (number of acoustic syllables > number of orthographic syllables) for L2 speech (L2 English and L2 French) or no reduction (L2 Spanish). Thus, compared to L1 speech, L2 speech involved information-sparse syllables (i.e. more syllables were produced to convey the same meaning/text) as well as slower speaking rates (fewer syllables per second) yielding a very slow information transmission profile (fewer bits of information conveyed per second) that, at an extreme, may fall outside the optimal range for human information processing of dynamic signals (Bradlow, 2022).

Communicative efficiency in a cooperative task

Finally, to assess the impact of a language barrier in a task with communicative intent rather than in decontextualized, laboratory-based, monologue recordings, we compared task-completion time in a conversation-based, cooperative, picture-matching task, the diapix task (Van Engen et al, 2010; Baker & Hazan, 2011), across pairs of talkers representing various combinations of L1 and L2 talkers. These data showed that, while all pairs successfully completed the task, L2 talker pairs were substantially less efficient than L1 talker pairs in terms of both task-completion time and number of word repetitions (word type-to-token ratio). However, the L2 completion time disadvantage was mitigated when the L2 conversation partners shared L1 as compared to L2 partners from different L1 backgrounds (Van Engen et al, 2010).

Summary and conclusions

Taken together, these studies demonstrate an accumulation of time-related influences of a language barrier on speech communication. At the phonetic level, L2 speech is distinguished from L1 speech by a slow tempo (fewer syllables per second). This relatively slow L2 rate is compounded by a relatively low L2 information density (less syllable-level reduction) yielding a speech signal with a very low information rate for a given text/meaning. While a direct link between information rate at the phonetic level and communicative efficiency at the discourse level remains elusive and is undoubtedly compounded by lexical, syntactic, and other linguistic and cognitive

components of L2 speech production and perception, we can speculate that the temporal character of L2 speech communication is not just a matter of global slowing but instead also involves a distinctive pattern of information encoding.

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