Measuring prosodic deficits in oral discourse by speakers with fluent aphasia

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Introduction

Prosody refers to the part of phonology that includes speech rhythm, stress, and intonation (Gandour, 1998). Proper intonation is crucial for expressing one's emotion and linguistic meaning. Most studies examining prosodic deficits have been primarily focused on Broca's aphasia (e.g., Danly & Shapiro, 1982). The current study proposed a computer-assisted method for systematic and objective examination of intonation patterns in aphasic oral discourse. The speech materials were in Hong Kong Cantonese, which is known of being rich in tones. Since surface F0 contour is the result of complicated interplay between sentence-level intonation and syllable-level lexical tones, the challenge is on how to extract meaningful representations of intonation from acoustic signals.

Methods

Four individuals with fluent aphasia (two anomic and two transcortical sensory) and four gender-, age-, and education-matched controls participated. Based on the Cantonese AphasiaBank protocol (Kong, Law, & Lee, 2009), narrative samples and corresponding audio recordings were collected using discourse tasks of personal monologue, picture and sequential description, and story-telling. There were eight recordings for each subject.

Each oral discourse was divided into sentences by manual inspection of the orthographic transcription and the respective acoustic signal. A sentence was defined as a sequence of words that in principle covers a complete thought. However, it was common in spontaneous oral discourse, especially in aphasia, that some of the sentences did not end with a completed expression but switched to a new topic. Occasionally, an obvious interjection was observed during an attempt of restarting a statement.

Phoneme-level automatic time alignment was performed on each audio recording using hidden Markov model (HMM) based forced alignment technique (Lee, Kong, Chan, & Wang, 2013). F0 was estimated from the acoustic signal at intervals of 0.01 second by applying three different algorithms, including PEFAC (Gonzales & Brookes, 2011), RAPT (Talkin, 1995), Voicebox (Brookes, 1997), and YIN (de Cheveigné & Kawahara, 2002), and combining their results.

For each syllable, the F0 values of all voiced frames were considered. The median value was used as the representative F0 level of the syllable. This was motivated by our interest in intonation-related variation of F0 level over a sentence. Since Cantonese is rich in tones, the

surface F0 measurement depends greatly on the tone identities. To address this problem, a novel method of tone normalization that attempts to produce a tone-independent F0 level for each syllable was applied (Li, 2003). Using the normalized F0 values, a sentence-level intonation curve was derived by performing linear regression. A positive slope of the intonation curve implied a trend of increasing pitch. Descriptive statistics on the slopes of intonation curves were conducted for both groups.

Results

Sentences in the aphasic group were significantly shorter than those by controls. Aphasic speech also contained significantly more sentences with rising intonation; this difference was more noticeable for shorter sentences. Concerning the effect of discourse task on speech prosody, story-telling discourses by speakers with aphasia tended to contain more rising intonation than descriptive discourses. Such a difference was absent in controls (see Table 1).

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Keywords: Prosodic deficits, Aphasia, discourse, intonation, Cantonese
Conference: Academy of Aphasia 53rd Annual Meeting, Tucson, United States, 18 Oct - 20 Oct, 2015.
Presentation Type: Poster
Topic: Not student first author

Citation: Lee T, Kong A and Lam W (2015). Measuring prosodic deficits in oral discourse by speakers with fluent aphasia. *Front. Psychol. Conference Abstract: Academy of Aphasia 53rd Annual Meeting.* doi: 10.3389/conf.fpsyg.2015.65.00047
Received: 22 Apr 2015; Published Online: 24 Sep 2015.

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