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Compensatory mechanisms in apraxic speech: preliminary acoustic evidence for the interaction between nasality and voicing

Anna Marczyk[1], Melissa Redford[2], Yohann Meynadier[1], Yulia Gaydina[1] & Maria-Josep Solé[3]

[1] Aix Marseille Univ, CNRS, LPL, Aix-en-Provence, France, [2] University of Oregon, US
[3] Universitat Autònoma de Barcelona, Spain

Objectives

This paper is concerned with the phonetic realization of the voicing contrast by two Spanish speakers with surgery-related apraxia of speech (AOS) and two matched control speakers. Specifically, it examines whether speakers with AOS, widely reported to have a deficit in laryngeal control, use nasal leak as a compensatory mechanism aimed at facilitating the initiation of voicing in word-initial stops.

Rationale

Apraxia of speech is a motor speech disorder of neurological origin that affects selectively phonetic encoding processes (Ziegler, 2002) and results in distortions of the sound shape of words. Phonetic investigations of apraxic speech has yielded evidence for impaired laryngeal control, timing and coordination with supralaryngeal articulators (Blumstein et al., 1980). This deficit results in frequent devoicing errors, a hallmark of AOS across languages, especially in utterance or word-initial consonants. However, the initiation of voicing is difficult not only for speech impaired speakers. Indeed, aerodynamic conditions in word-initial contexts require additional motor adjustments to favour voicing. In languages that show voicing lead in voiced stops, such as Spanish, nasal leakage has been reported to be a common facilitatory mechanism associated with voicing onset (Solé, 2009). In this paper, we seek to determine whether 2 Spanish speakers with AOS use this strategy to enhance voicing perception, and how they differ from normal speakers.

Methods

Two Spanish female speakers aged 34 and 37, both right-handed, diagnosed with apraxia of speech related to tumour resection, and two matched controls took part in this study. The impairment resulted from a glioma tumour involving frontal operculum in the left hemisphere. Production was elicited in isolated word reading and repetition tasks. We used material compiled for a larger study on phonetic realisation of Spanish consonants (Baqué et al., 2008), from which we selected bi- or tri-syllabic Spanish words with initial voiceless and voiced stops. Consonant productions were transcribed independently by two phoneticians and classified as on-target or error (i.e. devoiced). Three acoustic parameters of voicing were investigated: VOT, number of noise bursts and nasal murmur duration during occlusion phase. In cases where periodicity was uninterrupted from the onset of voicing to the noise burst generated at the constriction (whether due to passive tissue expansion only or its co-occurrence with nasal leak), we considered it as negative VOT (Figure 1). If voicing was initiated but ceased after a few tens of ms (passive devoicing), presumably due to failure to maintain nasal leak, we measured the duration of three portions separately: nasal murmur, devoicing and VOT (Figure 2).

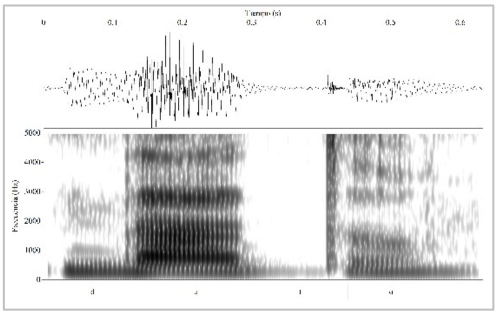

Figure 1. Waveform and spectrogram for the word *dato* → /'*dato* for an apraxic speaker/.

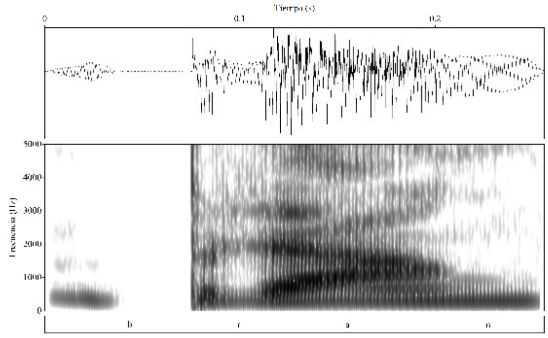

Figure 2. Waveform and spectrogram for the first syllable of the word *blanco* →/'*branko*/, for an apraxic speaker/.

Results

Out of 151 word-initial voiced stops produced by the speakers with AOS, 59% were perceived as voiceless (error) and 41% were correctly perceived as voiced. All consonants perceived as voiceless displayed short positive VOT values. In terms of this parameter, there was no difference between on-target voiceless stops and devoiced stops ($F(1) = 0.7$, $p = .400$; $M = 29$ (1.89) voiced vs $M = 27$ (1.44) voiceless). For correctly perceived voiced stops in both groups, VOT varied from that for voiceless stops ($F(1) = 173.19$, $p = .000$; $M = -30$ (4.81) vs $M = 26$ (4.46)). Lack of group effect suggested that apraxic on-target productions were phonetically similar to typical speech, despite differences in distributional properties of VOT (Figure 3). Similar results were found for the number of noise bursts.

With respect to nasal murmur analyses, 56% and 70% of correctly perceived voiced stops showed the presence of murmur in apraxic and typical speakers respectively. No nasal murmur was observed for initial voiceless stops in any of the groups. The differences in duration of murmur between groups (54 ms in AOS vs 39 ms in control group) failed to reach significance ($F(1) = 2.18$, $p = .147$).

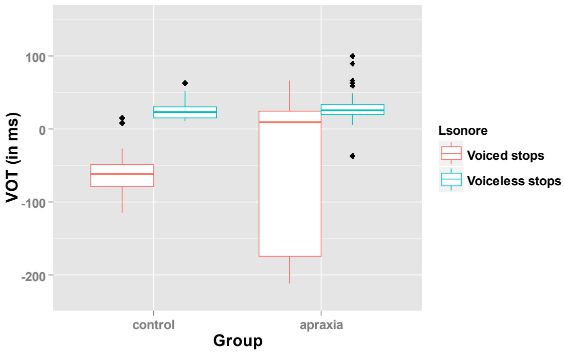

Figure 3. Distributional properties of VOT for correct stops in AOS and control group.

Overall, these results suggest that Spanish speakers with AOS may achieve glottal vibration, presumably through nasal leak to enhance vocal fold vibration in word-initial voiced stops. The results, however, should be taken with caution due to the limitation of the acoustic analysis which will be further complemented with aerodynamic data.

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