Tongue- and Jaw-Specific Contributions to Acoustic Vowel Contrast Changes in Talkers with Dysarthria: The Effects of Slow, Loud, and Clear Speech

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INTRODUCTION

Dysarthria is a collective term for neurogenic motor speech disorders that occur when articulatory movements become impaired due to paralysis, weakness, and/or loss of coordination (Ozyurt, 2012). The relative impairment of the tongue, jaw, and lips can vary tremendously across talkers with dysarthria. In amyotrophic lateral sclerosis (ALS), for example, the tongue is predominantly impaired (DePaul & Brooks, 1993; Langmore & Lehman, 1984), whereas in Parkinson’s disease (PD) the jaw may contribute the most to the dysarthria (Fahn & Elble, 1995). Treatments for dysarthria, however, do not consider the specific articulatory impairment profile of the talker.

In healthy talkers, slow, loud, and clear speech can elicit task-specific responses in terms of tongue and jaw movements. In turn, articulators contribute differentially to speech acoustic changes. That is, the tongue contributes most to acoustic changes during slow speech whereas jaw and tongue contribute fairly equally during clear speech. In ALS, jaw displacements only significantly increased across all 3 speech modifications (with similar magnitude) whereas tongue displacements and vowel acoustic contrasts were comparable to those of controls during typical speech, the abnormally large jaw movements may not serve to support sufficient tongue function.

A similar level of understanding about the articulatory mechanisms underlying task-related speech acoustic changes is needed for talkers with dysarthria. Such knowledge will help optimize treatment selection. Clinicians can select a specific speech modification that can target the articulator that contributes most to the dysarthria based on the talker’s specific articulatory impairment profile.

METHODS

Participants
8 talkers with dysarthria due to PD (6 M, 2 F)
7 talkers with dysarthria due to ALS (4 M, 3 F)
15 age- and sex-matched controls (10 M, 5 F)

Speech severity ranged from mild to moderate in talkers with PD and mild to moderate-severe in talkers with ALS. All participants passed a hearing screening and cognitive screening.

Experimental Tasks
“See a kite again” 5x using typical, slow, loud, and clear speech

Kinematic Data
Speech kinematic recordings with 3D EMA (AG501)
NormPos: Head correction and bite plane rotation
SMASH: Parsing of /ai/ in “kite”, decoupling

Acoustic Data
• TF32: F2pos for /a/, F2max for /i/ and corresponding F1 values
• 2D Euclidean distance between /a/ and /i/ in F1-F2 vowel space

RESULTS

Group and Task Effects

Jaw

iTongue

Acoustic Vowel Contrast

Tongue- and Jaw-Specific Contributions to Acoustic Change

Which Articulator “Drives” Vowel Acoustic Contrast Change?

DISCUSSION

Group Effects
PD: Findings suggest that a tongue-specific articulatory impairment (and not a jaw-specific or generalized speech motor deficit) underlies the reduced vowel contrast in talkers with PD (see also Yunusova et al., 2012).
ALS: Significantly larger jaw displacements in the ALS group are congruent with previous reports. In PD, given that tongue displacements and vowel acoustic contrasts were comparable to those of controls during typical speech, the abnormally large jaw movements may not serve to support insufficient tongue function.

Task Effects
PD: Jaw displacement changes paralleled those of controls. However, tongue displacements did not significantly increase during loud speech, which was in contrast to the tongue displacement changes observed in controls. Congruent with previous findings, clear and slow speech elicited greater acoustic contrast gains than loud speech (Tadesse et al., 2013).
ALS: In ALS, jaw displacements significantly increased across all 3 speech modifications (with similar magnitude) whereas tongue displacements only significantly increased during slow speech.

In both groups, acoustic contrast was maximized during slow speech suggesting that additional time can best address the speed constraint of the tongue in these talkers.

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