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 (Duffy, 2013).

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, 1994), whereas in Parkinson's disease (PD) the jaw may contribute the most to the dysarthria (Forrest & Weismer, 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 response patterns 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 (Mefferd, 2017).

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)

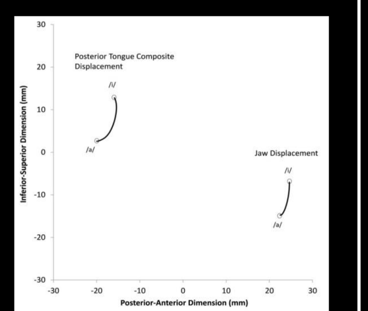
Speech severity ranged from mild to moderate in talkers with PD and mild to moderate-severe in talkers with ALS. All participants passed a hearing screening and cognitive screening.

Experimental Tasks

"See a kite again" 5x using typical, slow, loud, and clear speech

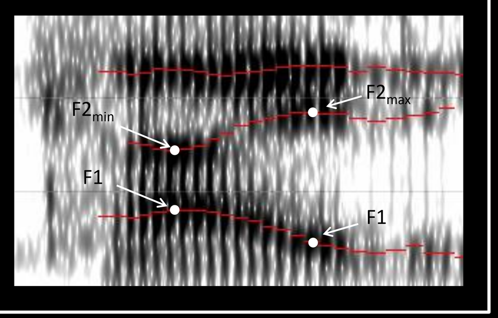
Kinematic Data

Speech kinematic recordings with 3D EMA (AG501)
NormPos: Headcorrection and bite plane rotation
SMASH: Parsing of /ai/ in "kite", decoupling



Acoustic Data

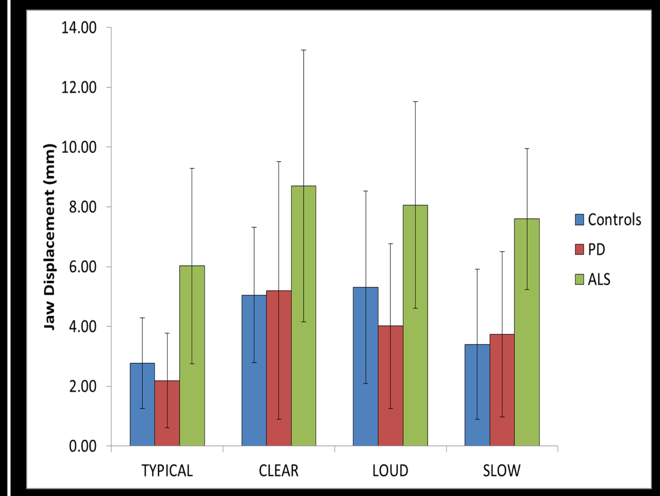
- TF32: $F2_{min}$ for /a/, $F2_{max}$ for /i/ and corresponding F1 values
- 2D Euclidean distance between /a/ and /i/ in F1-F2 vowel space



RESULTS

Group and Task Effects

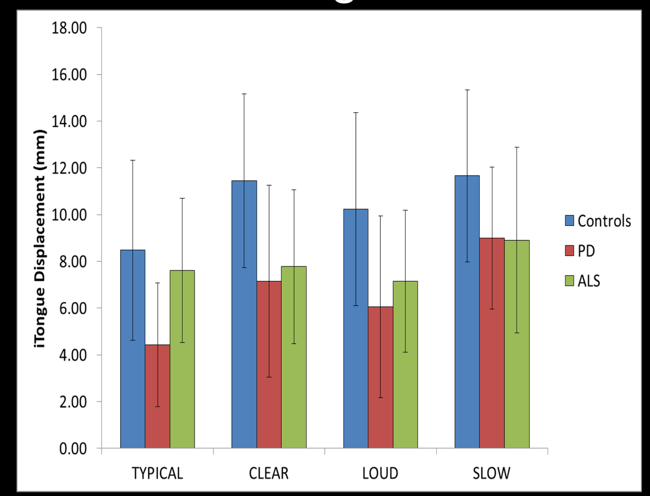
Jaw



Controls: typical = slow < clear = loud ($p \leq .02$)
PD: typical < slow = loud < clear ($p < .02$)
ALS: typical = slow ($p = .09$)
typical < loud = clear ($p \leq .01$)

Typical: PD = C ALS > C ($p < .01$)
Clear: PD = C ALS > C ($p < .03$)
Loud: PD = C ALS = C ($p = .09$)
Slow: PD = C ALS > C ($p = .01$)

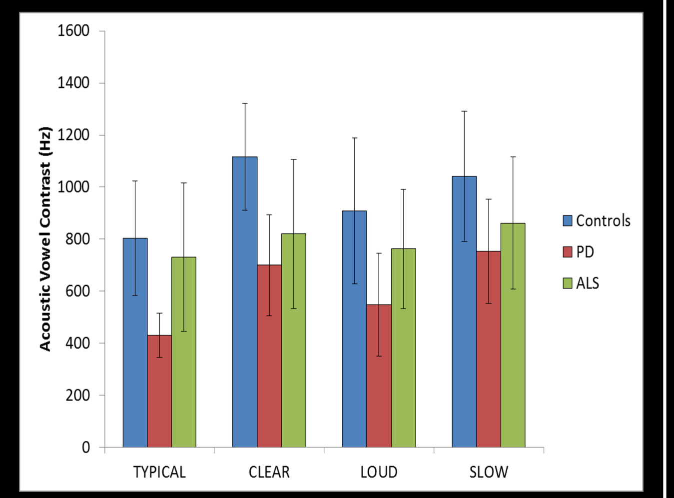
iTongue



Controls: typical < loud < clear = slow ($p < .01$)
PD: typical < clear/slow ($p \leq .02$)
typical = loud; clear < slow ($p = .05$)
ALS: no significant comparisons

Typical: PD < C ($p < .01$) ALS = C
Clear: PD < C ($p < .03$) ALS = C ($p = .07$)
Loud: PD < C ($p = .04$) ALS = C
Slow: PD = C ALS = C

Acoustic Vowel Contrast

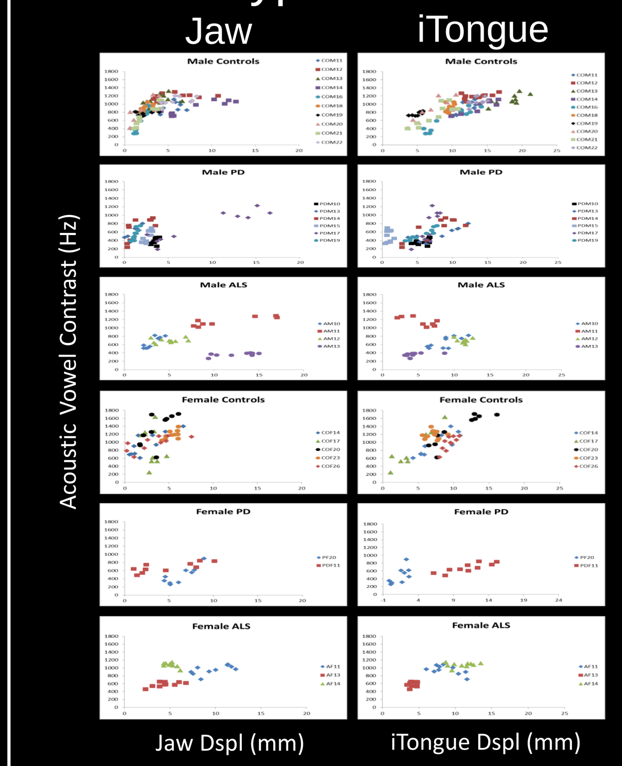


Controls: typical = loud < clear = slow ($p \leq .02$)
PD: typical = loud < clear = slow ($p \leq .01$)
ALS: typical = loud < slow ($p \leq .03$)
typical = clear ($p = .06$); clear = slow

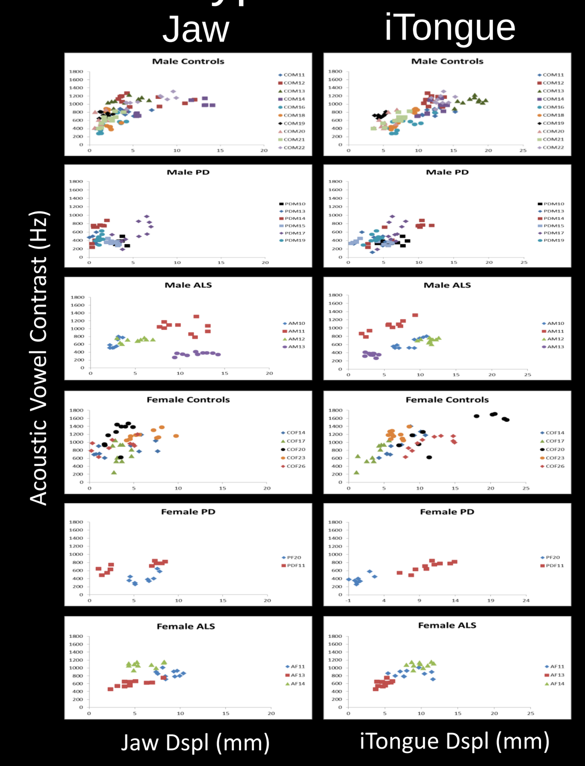
Typical: PD < C ($p < .01$) ALS = C
Clear: PD < C ($p < .01$) ALS < C ($p = .03$)
Loud: PD < C ($p = .04$) ALS = C
Slow: PD < C ($p = .02$) ALS = C

Tongue- and Jaw-Specific Contributions to Acoustic Change

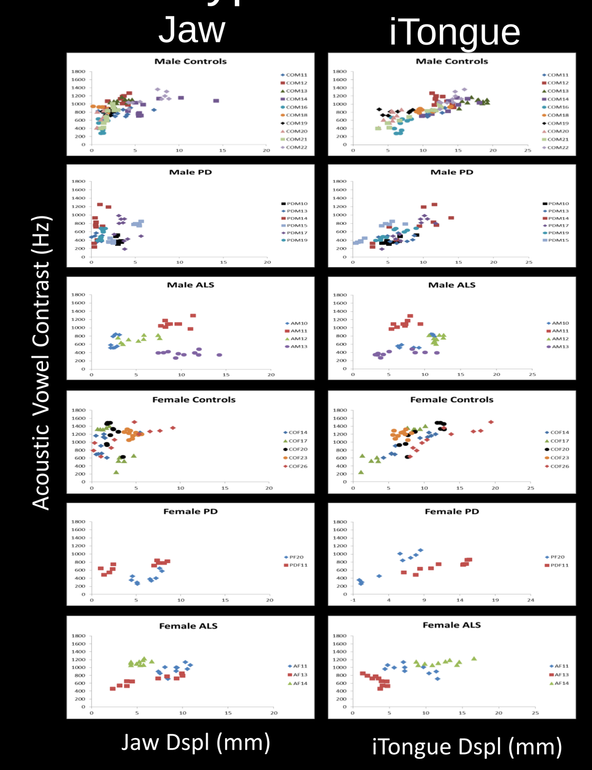
Typical-Clear



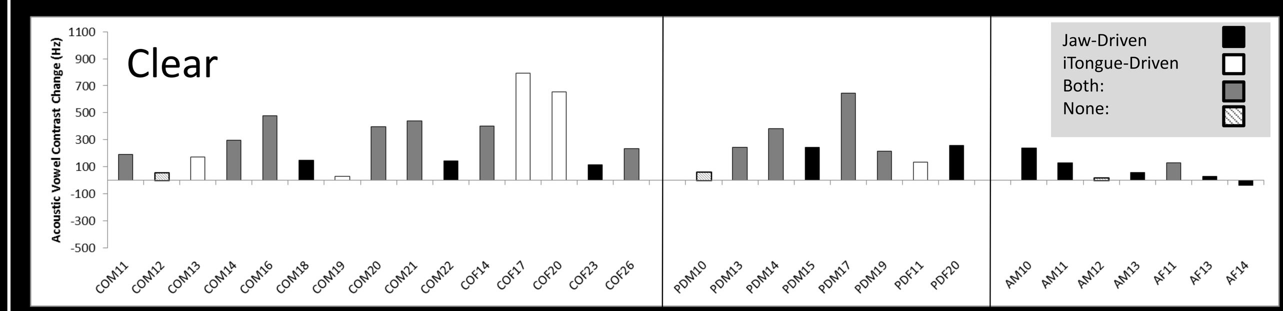
Typical-Loud

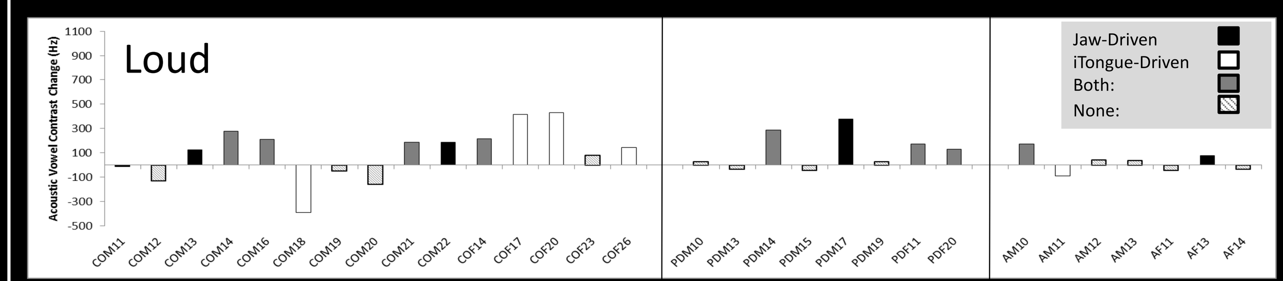


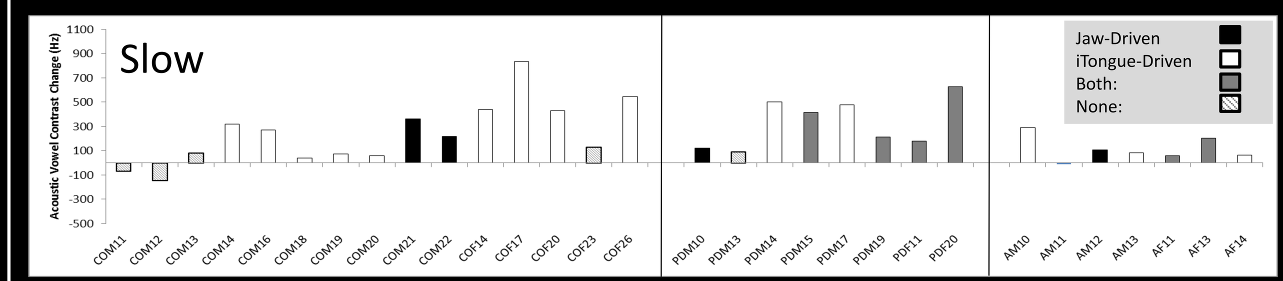
Typical-Slow



Which Articulator "Drives" Vowel Acoustic Contrast Change?







Clear

	Jaw	iTongue	Both	None
C	3	4	7	1
PD	2	1	4	1
ALS	5	0	1	1

Loud

	Jaw	iTongue	Both	None
C	2	4	4	5
PD	1	0	3	4
ALS	1	1	1	4

Slow

	Jaw	iTongue	Both	None
C	2	9	0	4
PD	1	2	4	1
ALS	1	3	2	1

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., 2008).

ALS: Significantly larger jaw displacements in the ALS group are congruent with previous reports (e.g., Rong et al., 2015; Yunusova et al., 2012). However, 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 (Tjaden 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 constrain of the tongue in these talkers.

Tongue- and Jaw-Specific Contributions to Vowel Acoustic Changes

Clear Speech: Most talkers with PD exhibited tongue- and jaw-driven vowel acoustic changes whereas most talkers with ALS exhibited jaw-driven vowel acoustic changes.

Loud Speech: No clear patterns emerged because changes in vowel contrast were minimal in most talkers with dysarthria.

Slow Speech: In talkers with ALS acoustic change was mostly tongue-driven whereas in talkers with PD acoustic change was mostly driven by both, the tongue and jaw.

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