

Acoustic changes along a modified speech rate continuum in Parkinson's disease

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Background

Parkinson's disease (PD): 70-90% of people with PD develop **hypokinetic dysarthria**, characterized by imprecise articulation, speech rate abnormalities, monopitch/monoloudness¹. For some, speech impairment worsens following deep brain stimulation surgery².

Speech rate reduction: Common therapeutic goals to improve speech intelligibility in people with PD & dysarthria³ and is associated with⁴⁻¹⁰:

- Increased segment durations
- Increased acoustic distinctiveness
- Increased speech intensity

Puzzle: Many people with PD and dysarthria do not see improvements in speech intelligibility when they slow their speech rate down¹¹. Faster speech is not necessarily associated with "worse" speech for some talkers with PD¹². Most studies have only elicited one or two speech rates³. What other speech changes are occurring when talkers change their rate of speech?

Purpose

Explore the acoustic changes (phonatory and articulatory) that occur along a modified speech rate continuum for talkers with and without PD.

Methods

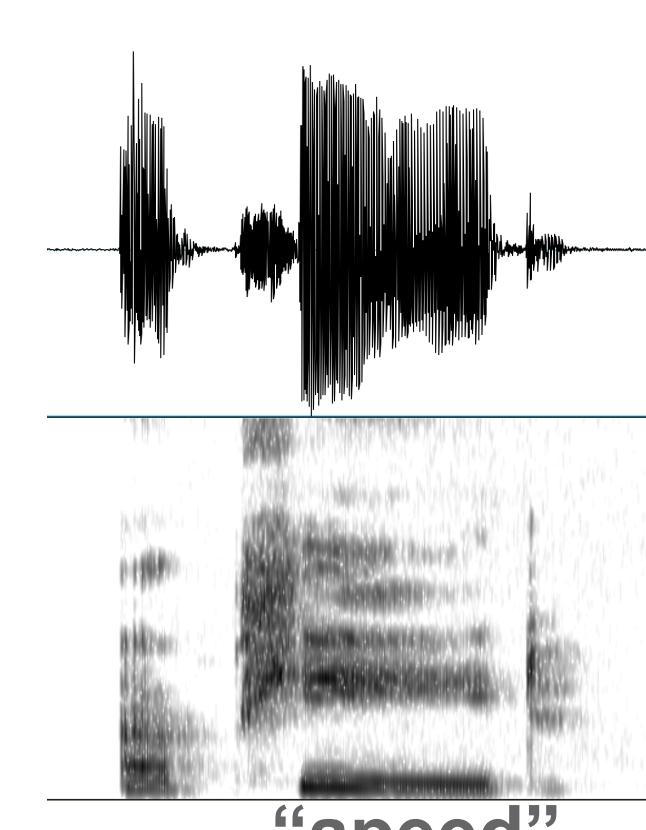
Participants & Experiment

Participants
3 groups
 Older Controls (n = 17)
 PwPD w/out DBS (n = 22)
 PwPD & DBS (n = 17)

Speech task:
"Please say aCVd again" *

- 24 nonce words
- C: /p, t, k, b, d, g/
- V: /i, u, ae, a/

* Part of a larger battery of speech tasks



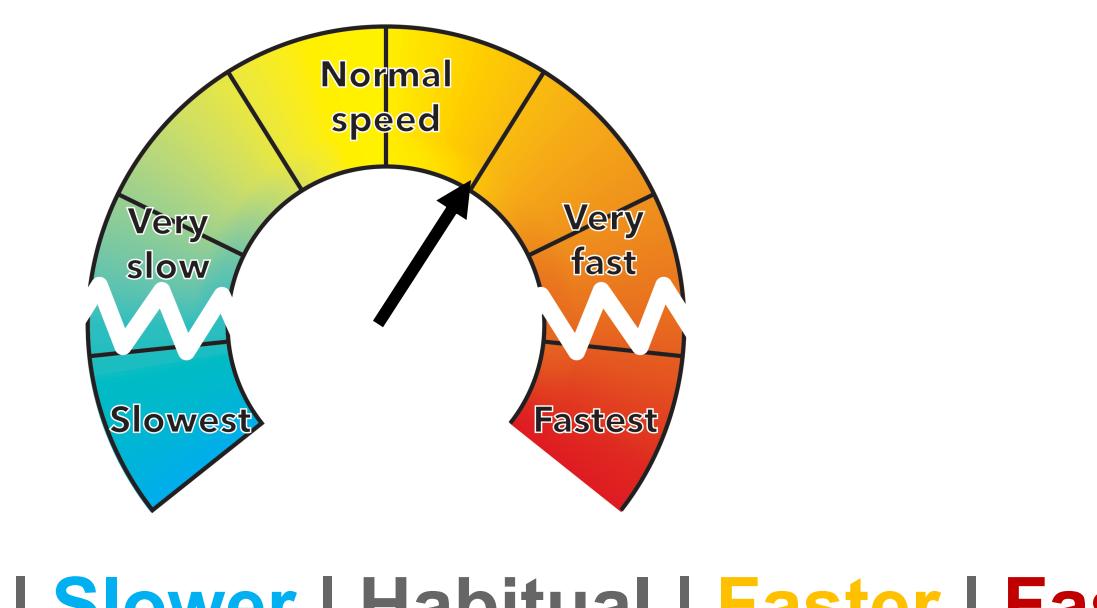
Analysis

Acoustic analysis

- Words per minute (WPM) of the carrier phrase
- Vowel intensity
- Vowel harmonics-to-noise
- 4-Vowel articulation index (QVAI)¹³
- Voice onset time (VOT)

Statistical analysis

- Linear mixed regression models for acoustic variables of interest:
 $DV \sim Group * Rate + \dots + (\dots / Participant) + (1 / Item)$
- **Base model fixed effects** included Group + Rate + Group x Rate. Additional variables were iteratively added as appropriate (e.g., consonant voicing), and kept if model fit improved (e.g., consonant voicing).
- **Group:** Helmert contrasts: OC vs. PD/DBS, PD vs. DBS
- **Rate:** Treatment contrasts: each proportional rate compared to habitual speech
- Speech rate differences compared using Welch 2-sample t-tests



Slowest | Slower | Habitual | Faster | Fastest

Results & Discussion

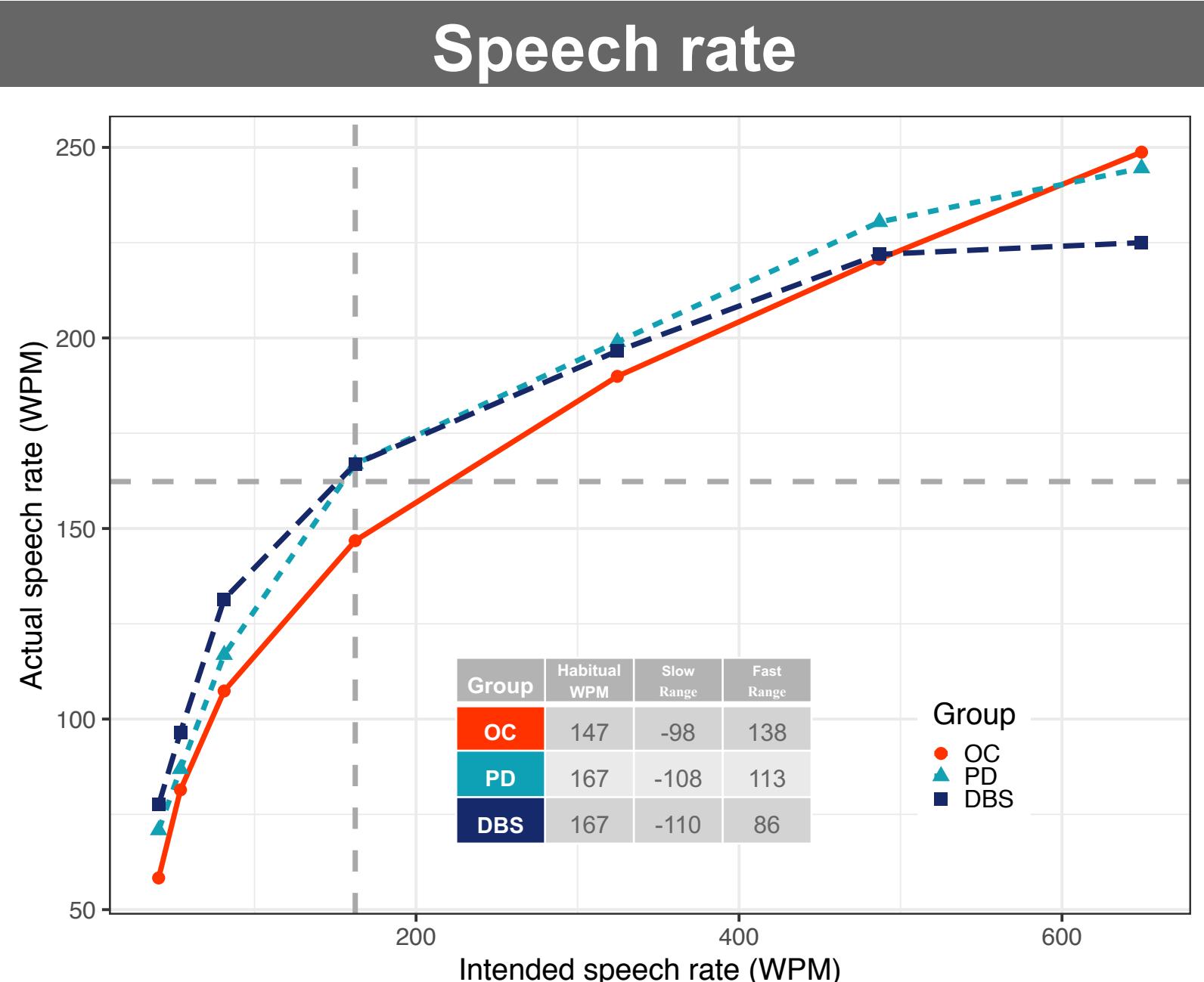


Figure 1: Actual speech rate (WPM; y-axis) vs intended speech rate (rate condition; x-axis). Grey dotted lines represent grand means.

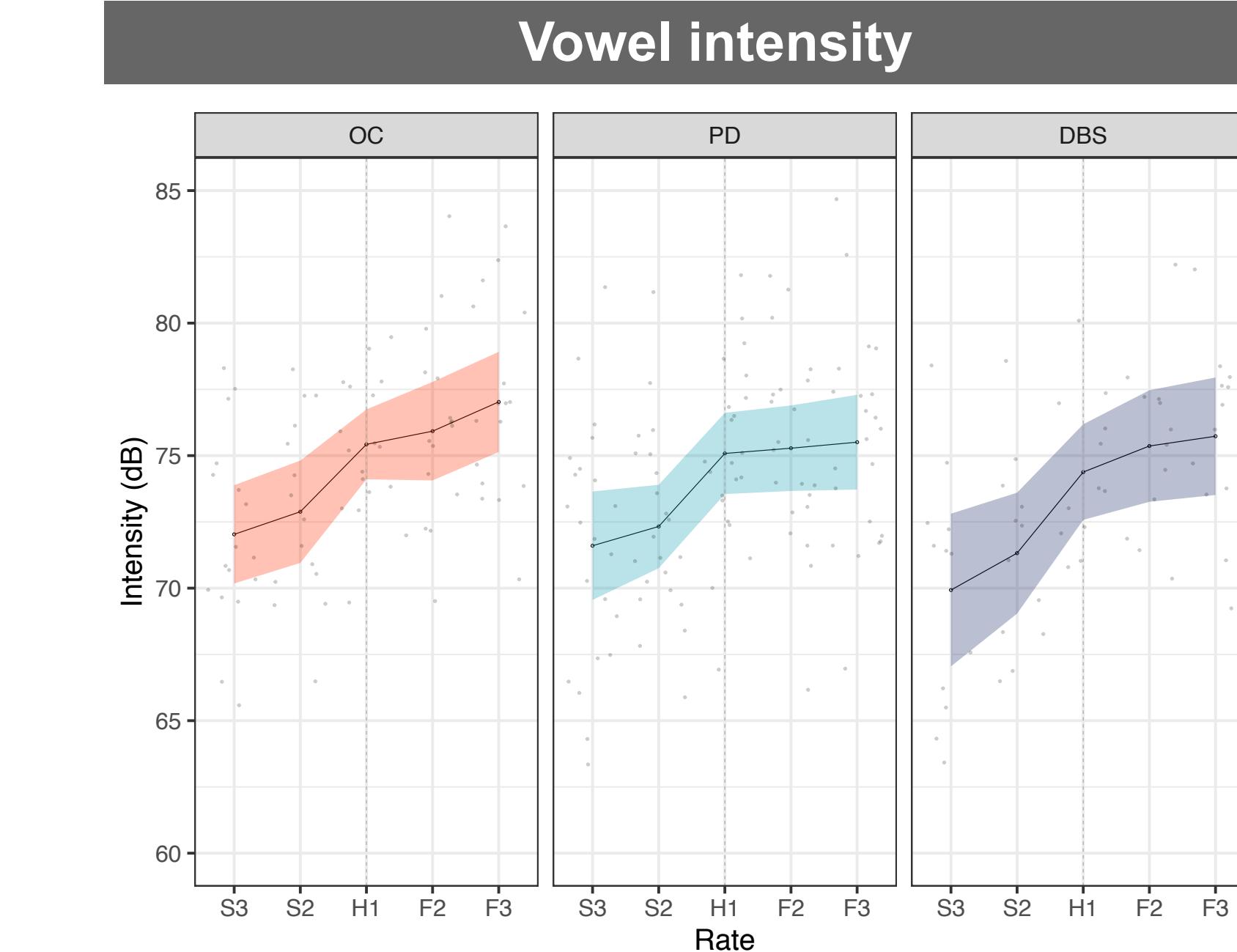


Figure 2: Vowel intensity (dB) by speaker group and speech rate, averaged over participants. Shaded band represents the 95% confidence interval.

- **Habitual speech:** Both PD groups had faster habitual speech rate than OC ($p < 0.05$). PD and DBS did not differ from one another (n.s.).
- **Slow rates:** Groups did not significantly differ from each other (n.s.).
- **Fast rates:** OC produced wider range than DBS group ($p < 0.01$). PD did not significantly differ from either of the other groups.

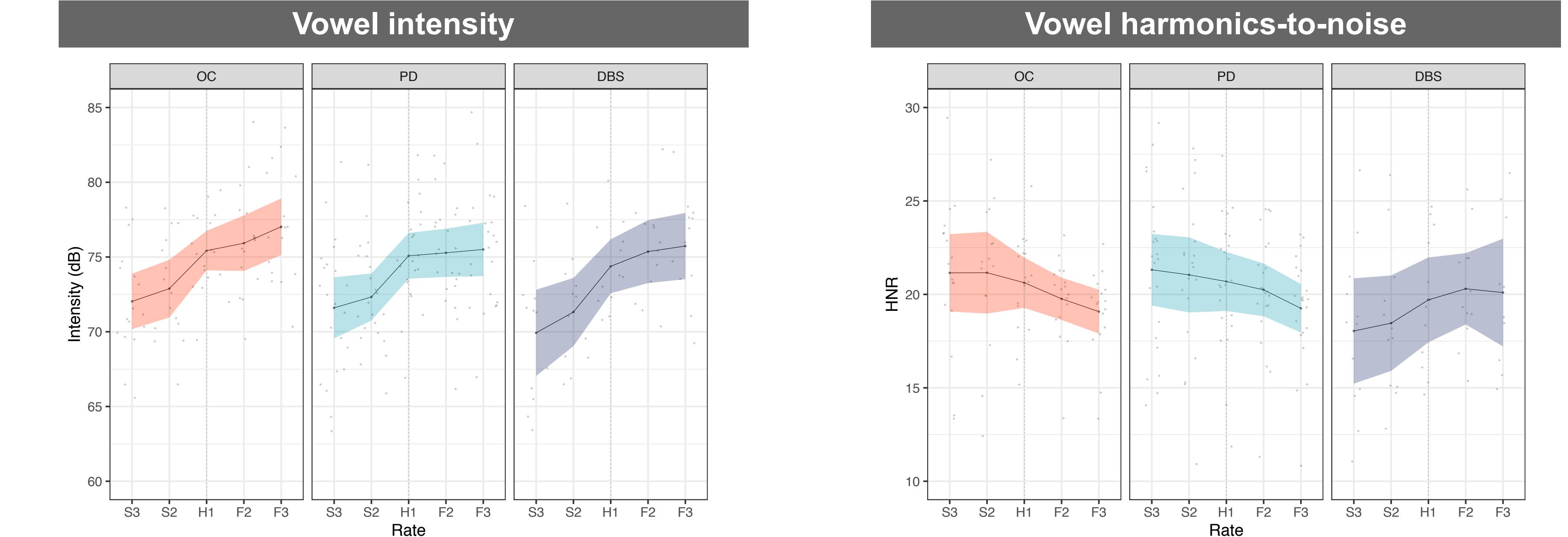


Figure 3: Vowel harmonics-to-noise ratio by speaker group and speech rate, averaged across participants. Shaded band represents the 95% confidence interval.

- **Rate effect:** Overall, Compared to habitual speech, all groups demonstrated lower speech intensity at slower rates ($p < 0.001$) and did not significantly differ at faster rates.
- **Group effect:** No significant group differences.
- **Group x rate:** Overall, DBS showed steeper decline in slow speech ($p < 0.001$).

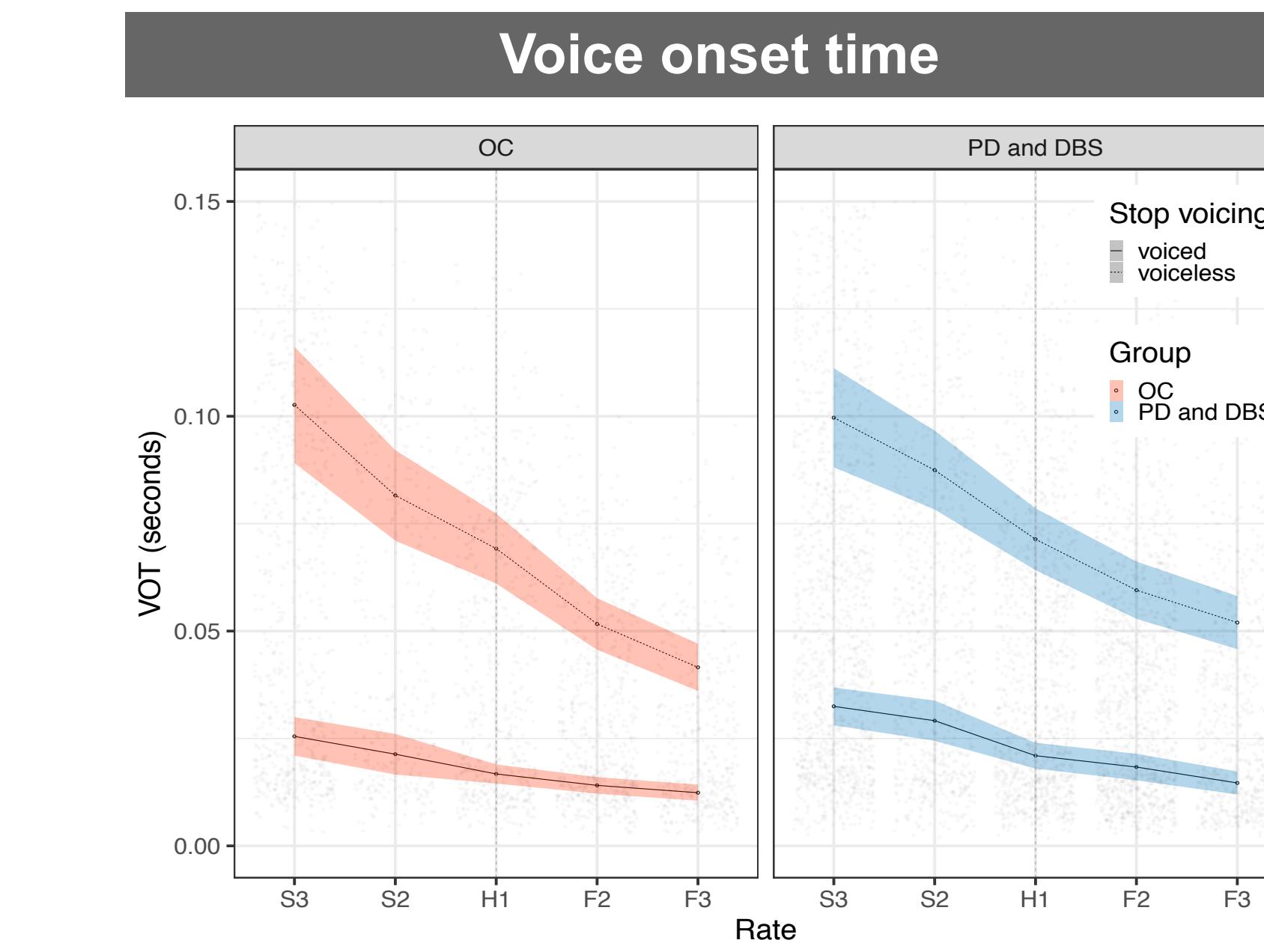


Figure 4: VOT by group, rate, and stop voicing, averaged across participants. Shaded band represents the 95% confidence interval.

Overall...

Across a rate continuum, PwPD:

- Made *similar* proportional adjustments to their rate of speech from very slow to very fast when compared to older controls.
- Made *smaller* adjustments in consonant voicing distinctiveness at both slower and faster ends of the continuum.

At slower rates:

- Quieter, poorer quality speech for all talkers (and especially those with DBS).

At faster rates:

- Phonatory and vowel space changes did not significantly differ compared to habitual speech.
- Some talkers with DBS actually got louder and had better voice quality.

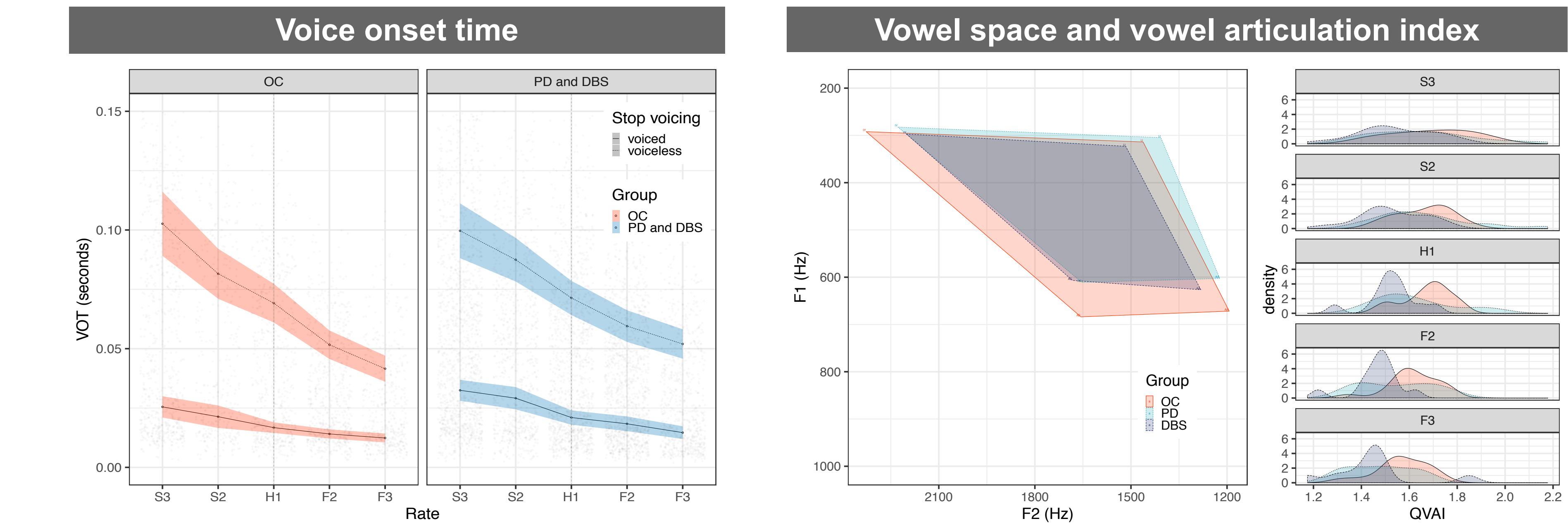


Figure 5: Left: Vowel polygons produced in the first and second formant space by each speaker group. Right: density plots showing the distribution of QVAI for each group at each rate (ordered top to bottom from slow to fast).

- **Rate effect:** Overall, longer VOT in slower speech & shorter VOT in faster speech ($p < 0.001$).
- **Group effect:** OC > PD > DBS ($p = 0.02 - 0.06$)
- **Group x rate:** No significant interaction.
- **Group x rate x voicing:** OC showed greater voicing contrast at their slowest rates ($p < 0.05$), and smaller voicing contrast at all faster rates. PD & DBS did not differ from one another. Pairwise comparisons showed group differences were usually greatest for voiced stops.

References available upon request



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