

# Stop voicing contrasts in Parkinson's: Effect of modified speaking rate in connected speech

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## Background

**Hypokinetic dysarthria characterized by:** Imprecise articulation, reduced variation in pitch, loudness, abnormal rates: slower, faster, festinating, soft, quiet voice

**Rate modification: What we know**  
**• Slow speech:** common target in therapy (Yorkston et al., 2007), **BUT** limited intelligibility/acoustic enhancements for many with PD (e.g., Van Nuffelen 2010)  
**• Fast speech:** Not usually targeted, **BUT** window into speech motor control, & unexpected improvements for some talkers (Kuo et al., 2016; Knowles et al., 2021)

**Voice onset time in PD**  
**Reduced voicing contrasts are a feature of Parkinson's Disease (PD; Whitfield et al., 2017)**

At modified speech rates (in highly controlled speech stimuli; Knowles et al., in press)...  
 • Talkers with PD *do not enhance VOT voicing contrasts* in slow speech to the same degree that healthy talkers do  
 • Talkers with PD showed *less collapse* of contrasts at faster rates.  
 • Talkers with PD & deep brain stimulation (DBS) produced even smaller contrasts

**Is this the case for more natural speech (e.g., sentences)?**

### Research Question

What happens to the VOT voicing contrast in PD in sentences as talkers modify their speech from

**very slow**  
to  
**very fast?**

## Methods

### Participants

- Healthy Older Controls (n = 17)**
- Parkinson's disease (n = 22)**
- Parkinson's disease & deep brain stimulation (n = 12)**

### Speech task

- Sentence Intelligibility Test;** 5 – 10 words (Yorkston et al., 1996)
- 6 random sentences per rate condition
- Variety of stop contexts

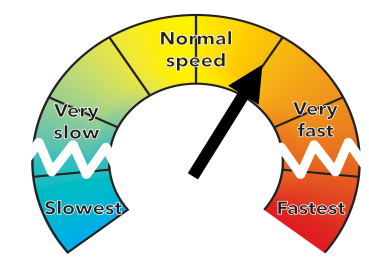
### Rate modification

**7 elicited rates:** Habitual, 3 slower, 3 faster rates

*"Please speak at a rate that feels [2x/3x/4x] [faster/slower]"*

**Mean habitual rate of speech** for each talker  
**Proportional rate of speech** for each utterance:

$$\text{Proportional rate of speech} = \frac{\text{Actual rate of speech (WPM)}}{\text{Mean habitual rate of speech}}$$



Slower-than-typical speech: < 1  
 Faster-than-typical speech: > 1

### Analysis

**Voice onset time:**

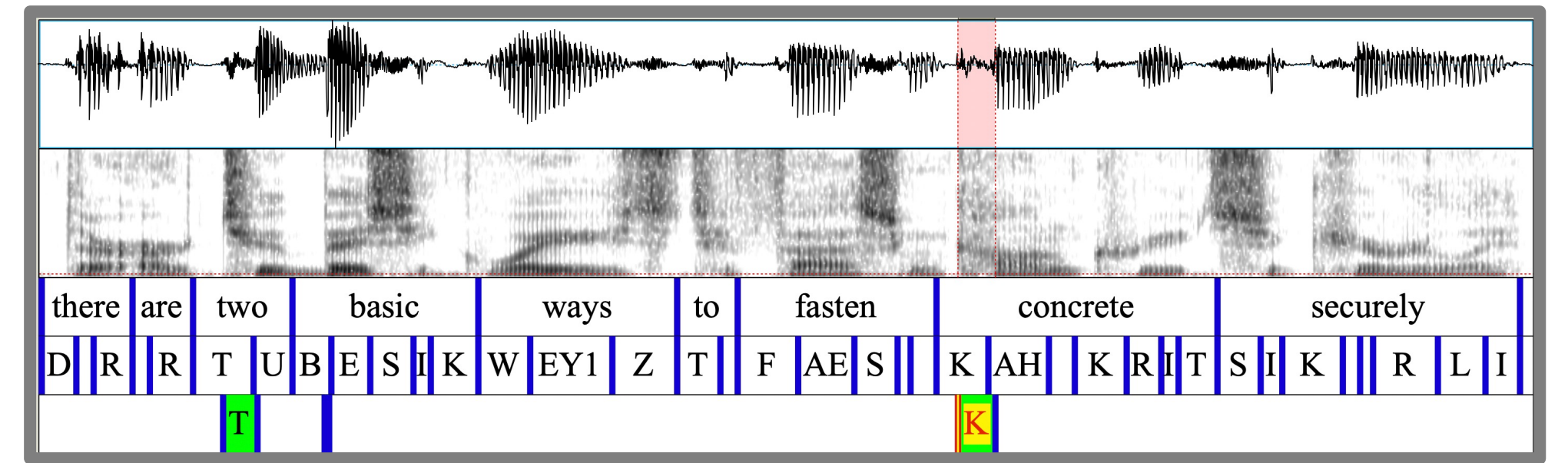
- Measured in word-initial, prevocalic stops (n= ~1300)

**Statistical analysis:**

linear mixed eff. regression  
 $VOT = \text{Group} * \text{Proportional rate} + \text{Voicing} * \text{Place} + \text{Mean habitual rate} + (1 | \text{Participant})$

**Two models:**

- "Slower" (Prop. rate < 1)
- "Faster" (Prop. rate ≥ 1)



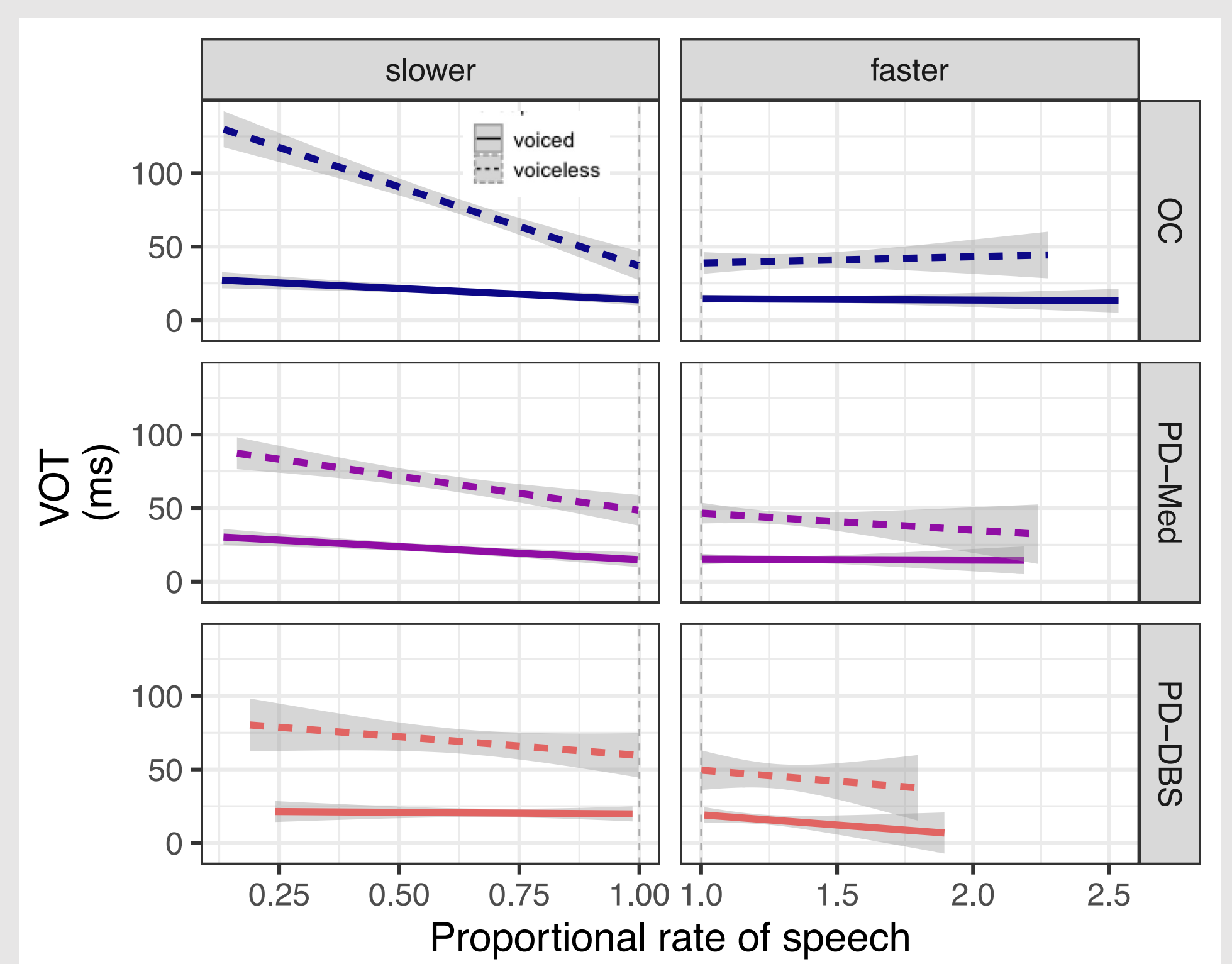
## Results

**Overall, reduced VOT voicing contrasts for talkers with PD at slower rates of speech. Similarly reduced contrasts for all groups at faster rates.**

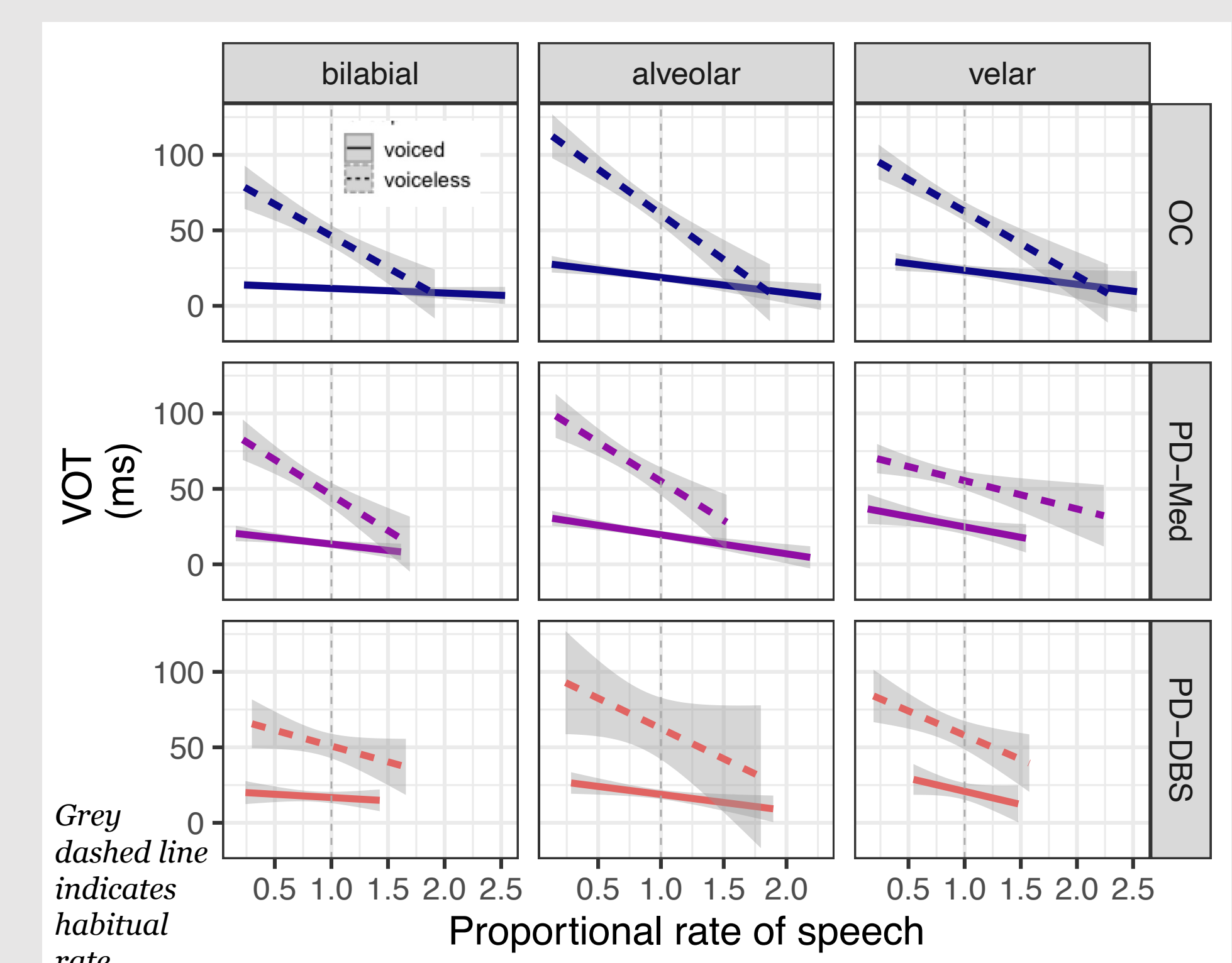
Contrasts more attenuated for velar stops in PD groups.

Consistent with our previous findings of VOT contrasts in controlled nonsense words (Knowles et al., in press)

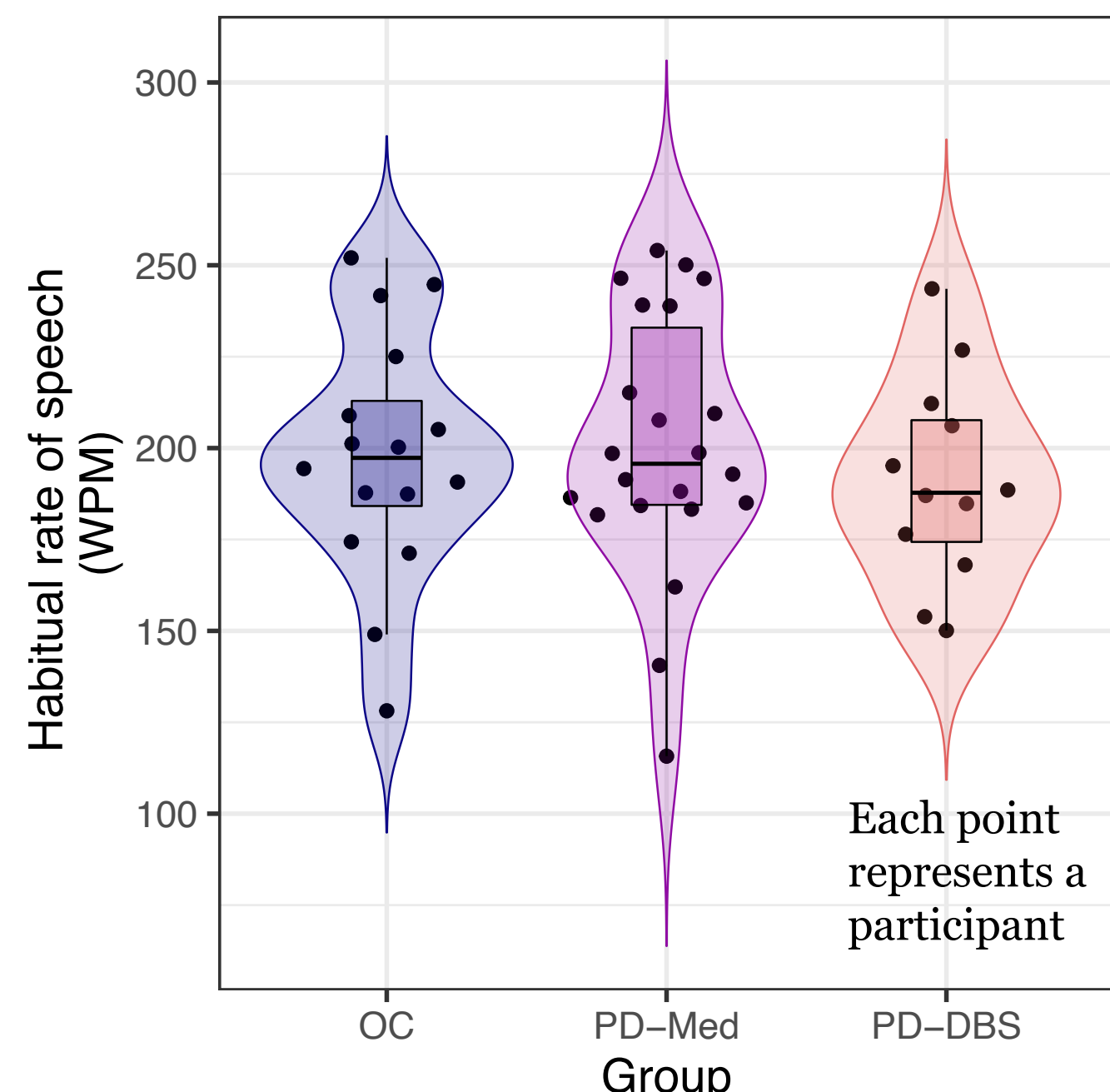
### VOT contrast by rate and group



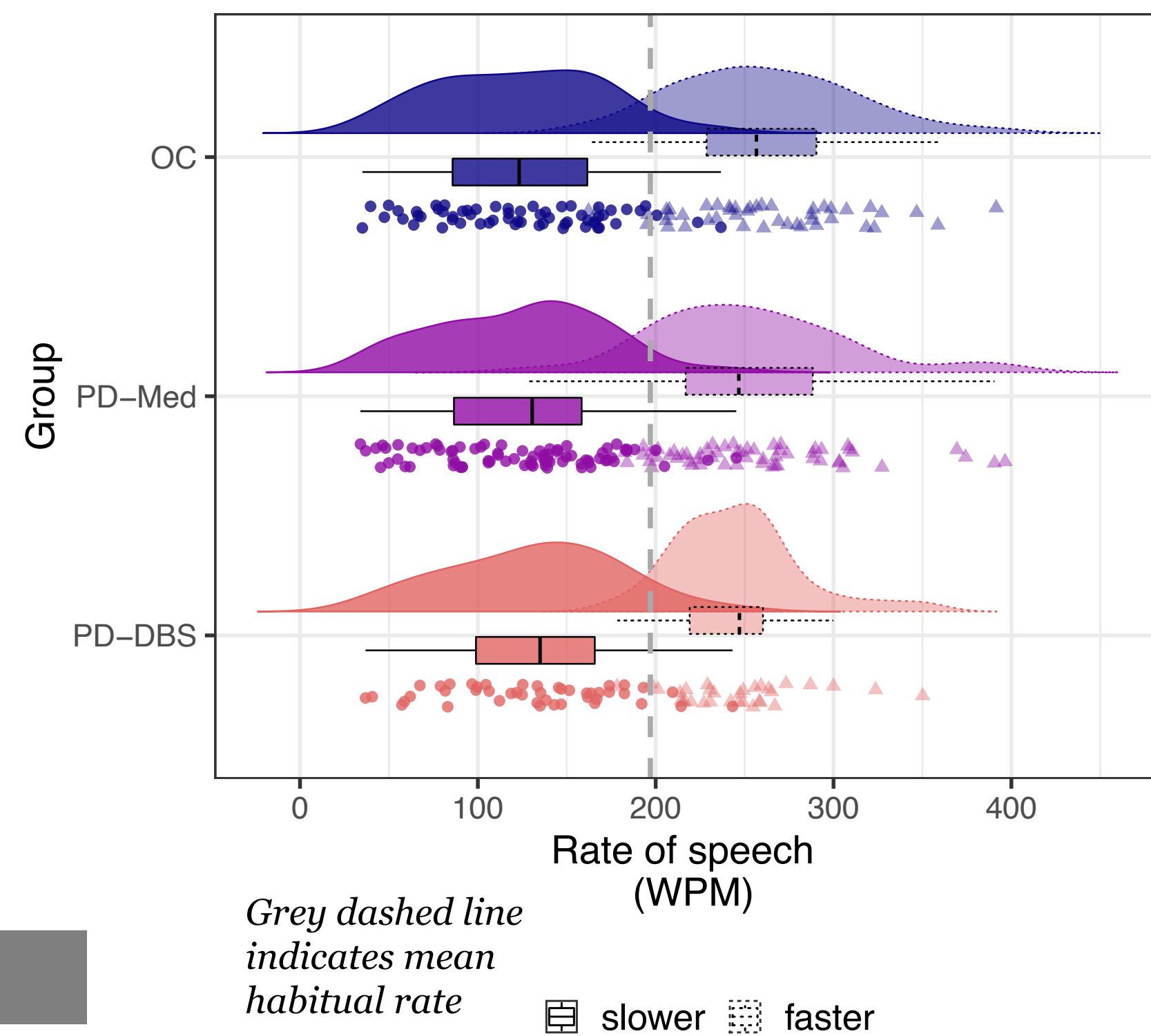
- At slower rates, controls increase the voicing contrast; PDs do not (less "fanning out").
- At faster rates, shorter overall VOT across groups, but no interactions (i.e., constant, minimal contrastiveness)
- Similar degrees of collapse, attenuated degree of enhancement of voicing contrasts in PD at modified rates
- Group asymmetries across distinct places of articulation: more voicing collapse for velars



### Habitual speech rate

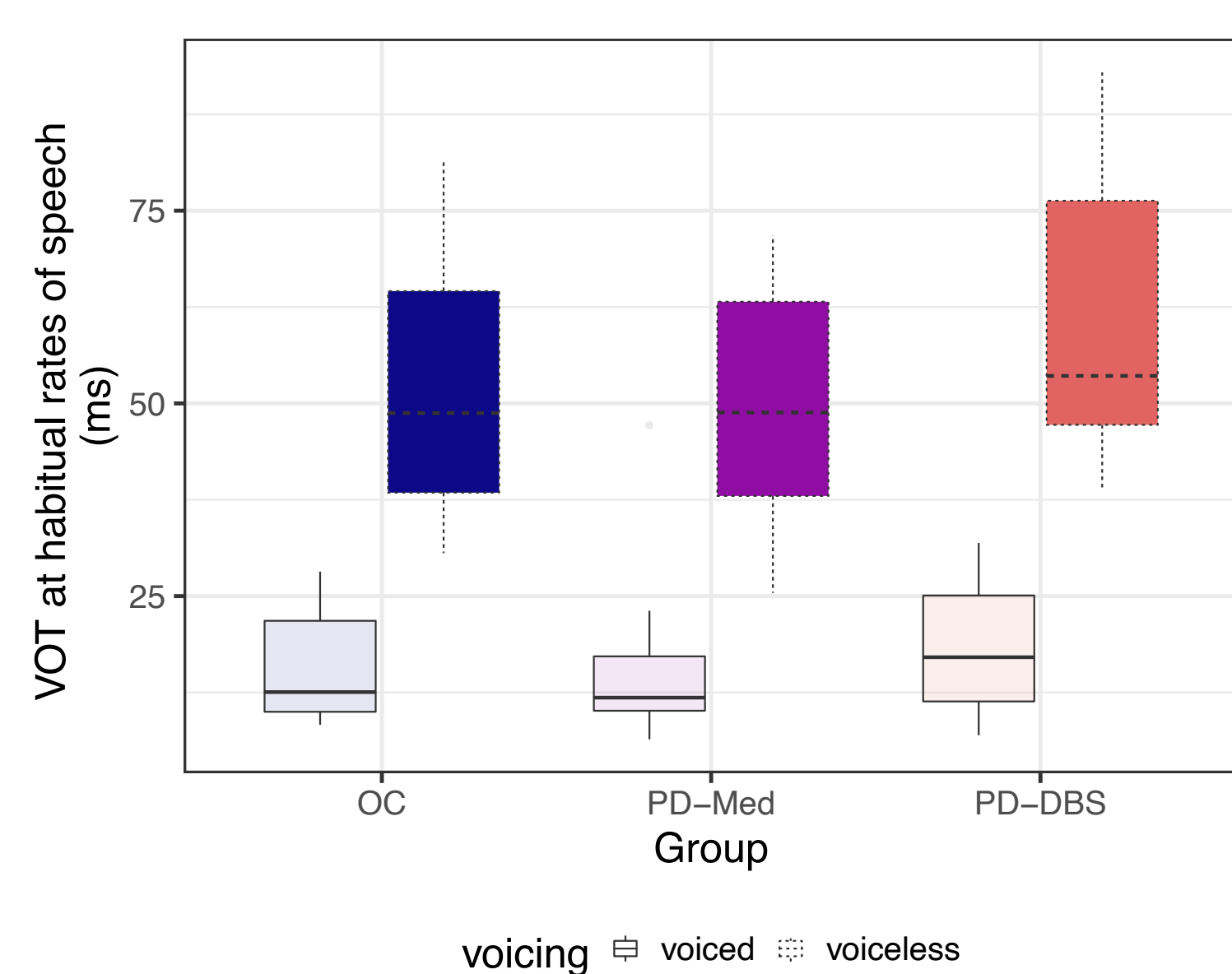


### Rate modification



Grey dashed line indicates mean habitual rate  
 slower faster

### Habitual VOT contrasts



- Similar mean habitual rates of speech for all groups across sentences
- Overall similar degree of rate modifications across groups (slightly more restricted fast range for DBS)
- Longer VOT overall for PD-DBS talkers