

Background

Face masks act as a low pass filter on speech

- Act as a low-pass filtering effect spectral speech information (Corey et al., 2020).
- Attenuate higher frequency information above ~2 kHz across the long-term average spectrum of the speech signal (Atcherson 2021; Corey et al., 2020; Goldin et al., 2020; Maryn et al., 2021).

Speech deficits in Parkinson's disease

- Hypokinetic dysarthria: Common speech disorder in PD (Adams & Dykstra, 2009).
 - Perceptually:** Reduced loudness, breathy/hoarse voice quality (hypophonia), imprecise articulation, mono-pitch/mono-loud.
 - Acoustically:** Reduced speech intensity, centralized vowels, decreased signal to noise ratios, and **reduced spectral balance** (Cushnie-Sparrow, 2021).
- Face masks may be especially detrimental to an already distorted speech signal.

Compensating for masks with effortful speech

- Clear & loud speech → increase speech intensity and enhance mid-to-high frequency energy (Ternström et al., 2006; Smiljanic 2021).
- In young, healthy talkers, using clear or loud speech can compensate for the filtering effect of masks acoustically (Knowles & Badh 2022) and perceptually (Gutz et al., 2021).
- The overall acoustic pattern of the effect of masks is consistent across speech styles (Knowles et al., 2022).

Purpose

Quantify the impact of face masks on the spectral speech acoustics in talkers with PD and determine whether clear and/or loud speech styles compensate for these effects.

Research Questions

For talkers with (and without) PD...

- What is the impact of face masks on spectral distributions of speech?
- What is the impact of clear and loud speech styles without a mask on spectral distributions?
- What is the relationship between face masks and effortful speech styles on speech intensity and measures of spectral balance?

Methods

Participants

- 15 older healthy controls
- 15 people with PD

Speech Task

Read Harvard sentences with and without face masks in 3 speech styles:

- Habitual:** "Everyday speech"
- Clear:** "Overenunciate"
- Loud:** "2x louder than normal"

Face masks

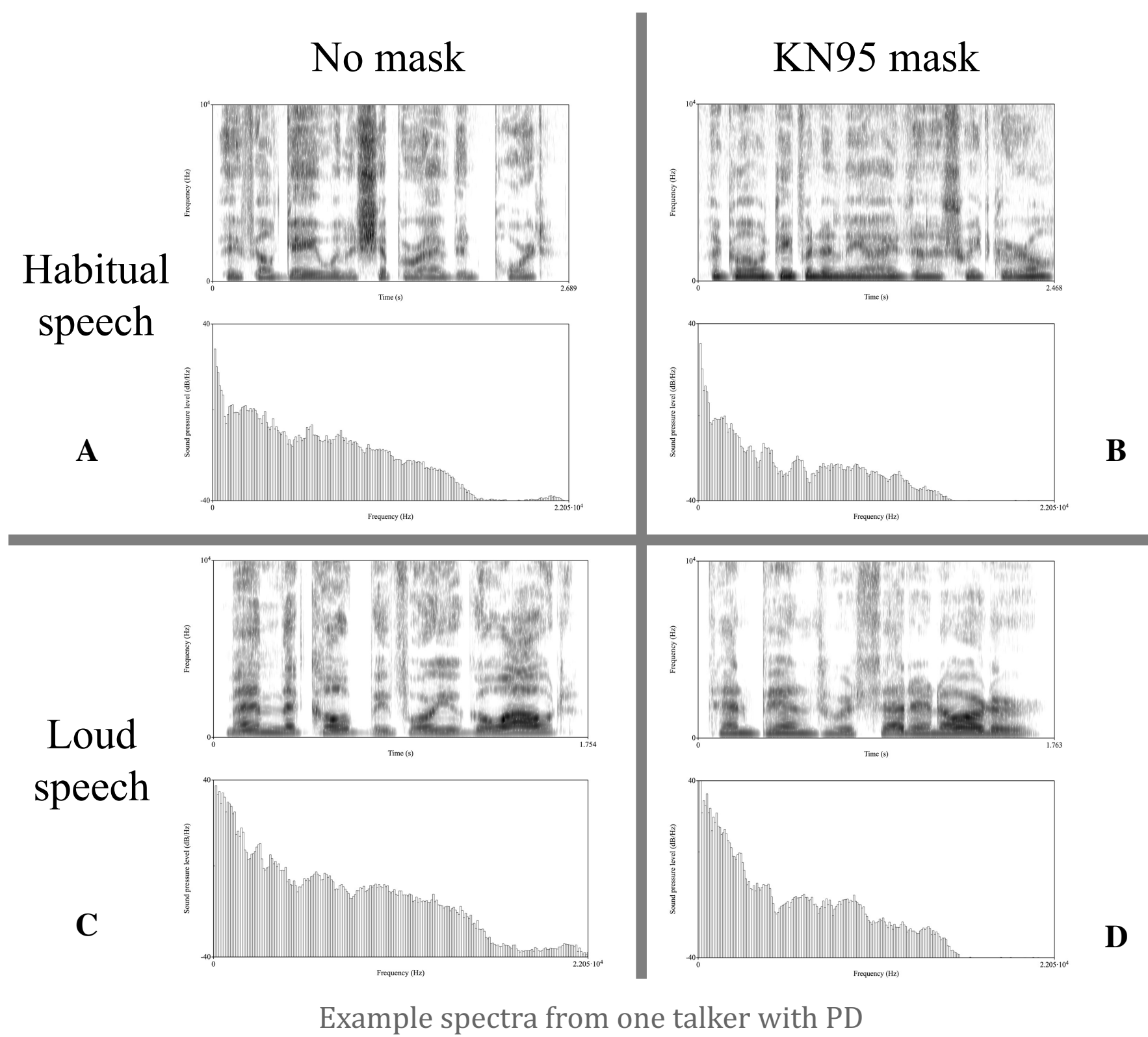
No Mask



Surgical Mask



KN95 Mask



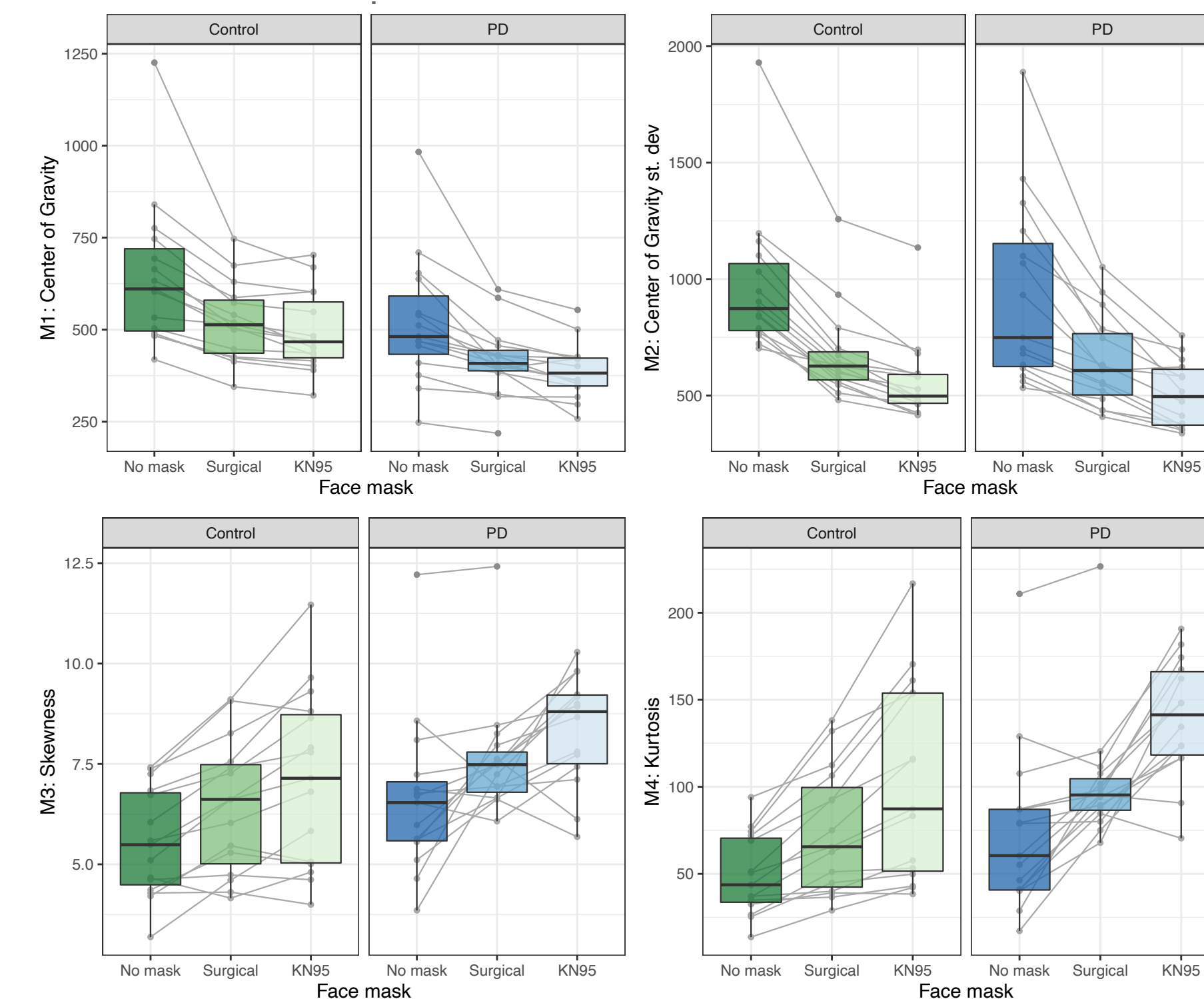
Acoustic measures selected to include measures likely sensitive to:

- High-frequency filtering effects of masks
- Hypokinetic dysarthria
- Speech intelligibility/speech severity

RQ	Data	Fixed Effects	Outcome Measures
1	Habitual speech condition; All face mask conditions	Group * Mask + Gender	Spectral moments of the LTAS: Characterize the shape and tendency of the spectral distribution of each utterance. <ul style="list-style-type: none"> M1: Spectral mean M2: Spectral st. dev M3: Skewness M4: Kurtosis
2	No Mask condition; All speech styles	Group * Speech style + Gender	Spectral tilt: Difference in 0 – 1 kHz and 1 – 10 kHz energy (LTAS)
3	All face mask and speech style conditions	Group * Mask * Speech style + Gender	Mid-range frequency energy: Mean energy in 1 – 3 kHz range; (LTAS) Speech intensity

Results & Discussion

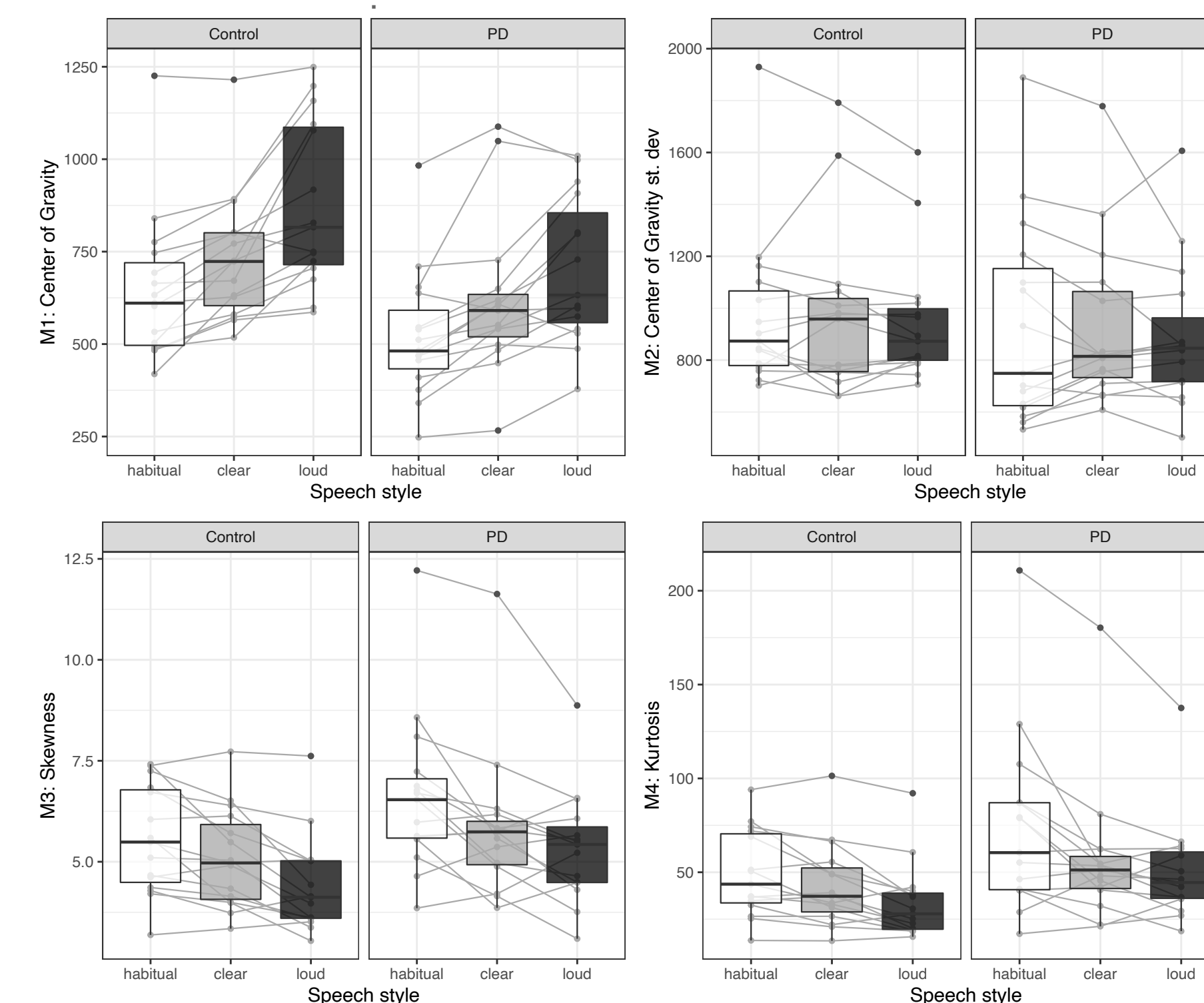
1: Effect of masks in habitual speech



Masks attenuate higher frequency energy
KN95 > Surgical > No mask:

- ↓ Spectral means, spectral st. dev
- ↑ Spectral skewness, kurtosis
- Overall: Damping of higher frequency energy.
- Medium to large effect sizes on spectral moments.
- Larger effect for KN95 than surgical mask.

2: Effect of effortful speech without a mask



Effortful speech boosts higher frequency energy
Loud > Clear > Habitual:

- ↑ Spectral means (medium effect) in clear, loud
- ↓ Spectral skewness, kurtosis (small effect) in clear, loud
- Overall: Effortful speech boosts higher frequency energy.
- Opposite effect of masks.

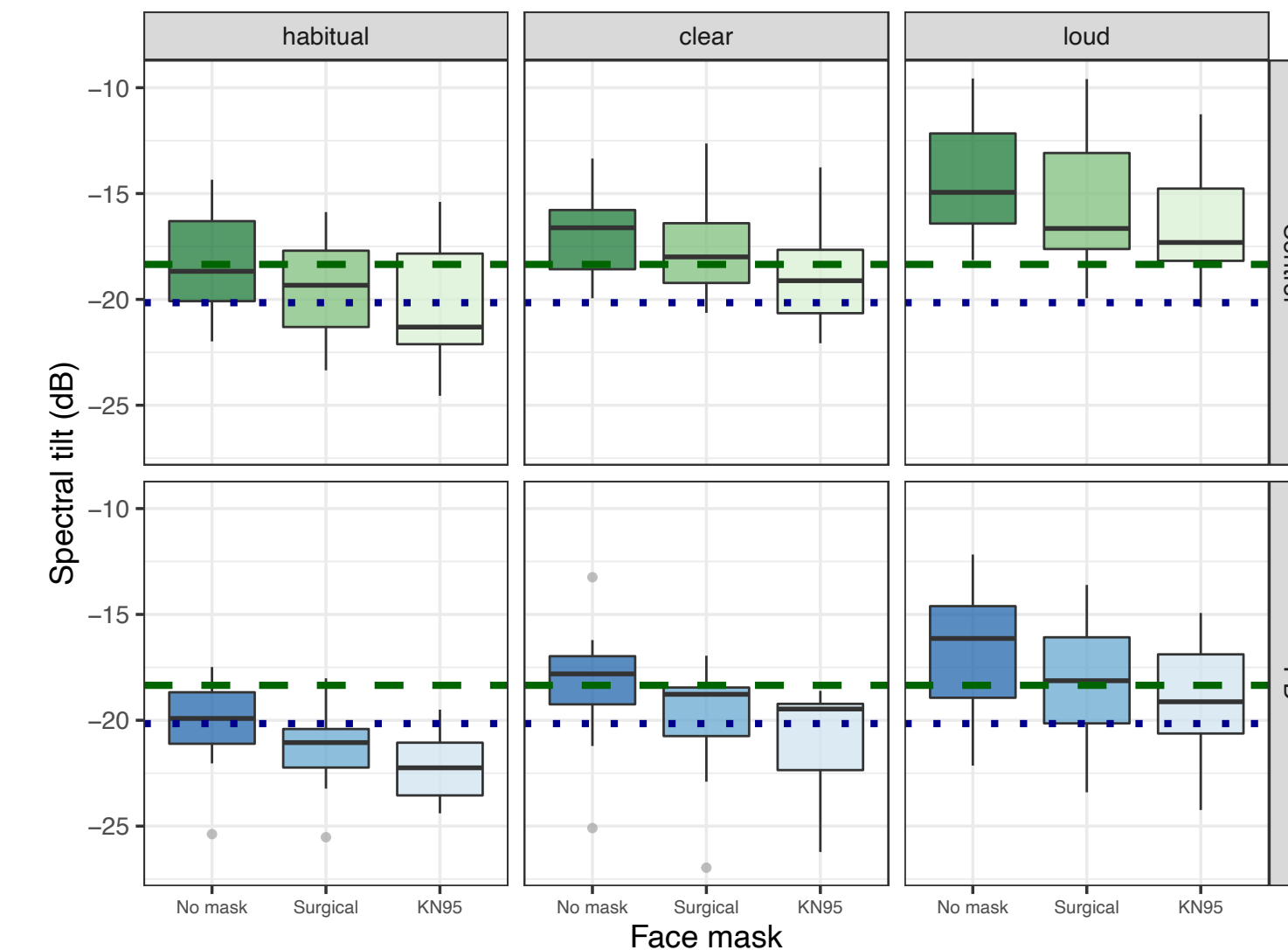
3: Effect of masks & effort on spectral tilt, mid-range frequency energy, and speech intensity

Talkers with PD have poorer spectral balance

- ↓ spectral tilt, 1 – 3 kHz energy, spectral mean (small effect)
- ↑ spectral skewness, kurtosis in habitual speech

Face masks, especially KN95s, attenuate high-frequency spectral information

- ↓ spectral tilt (small effect),
- ↓ 1 – 3 kHz energy (very small effect)
- ↓ speech intensity (very small effect)
- Larger effect for KN95 than surgical (except intensity)



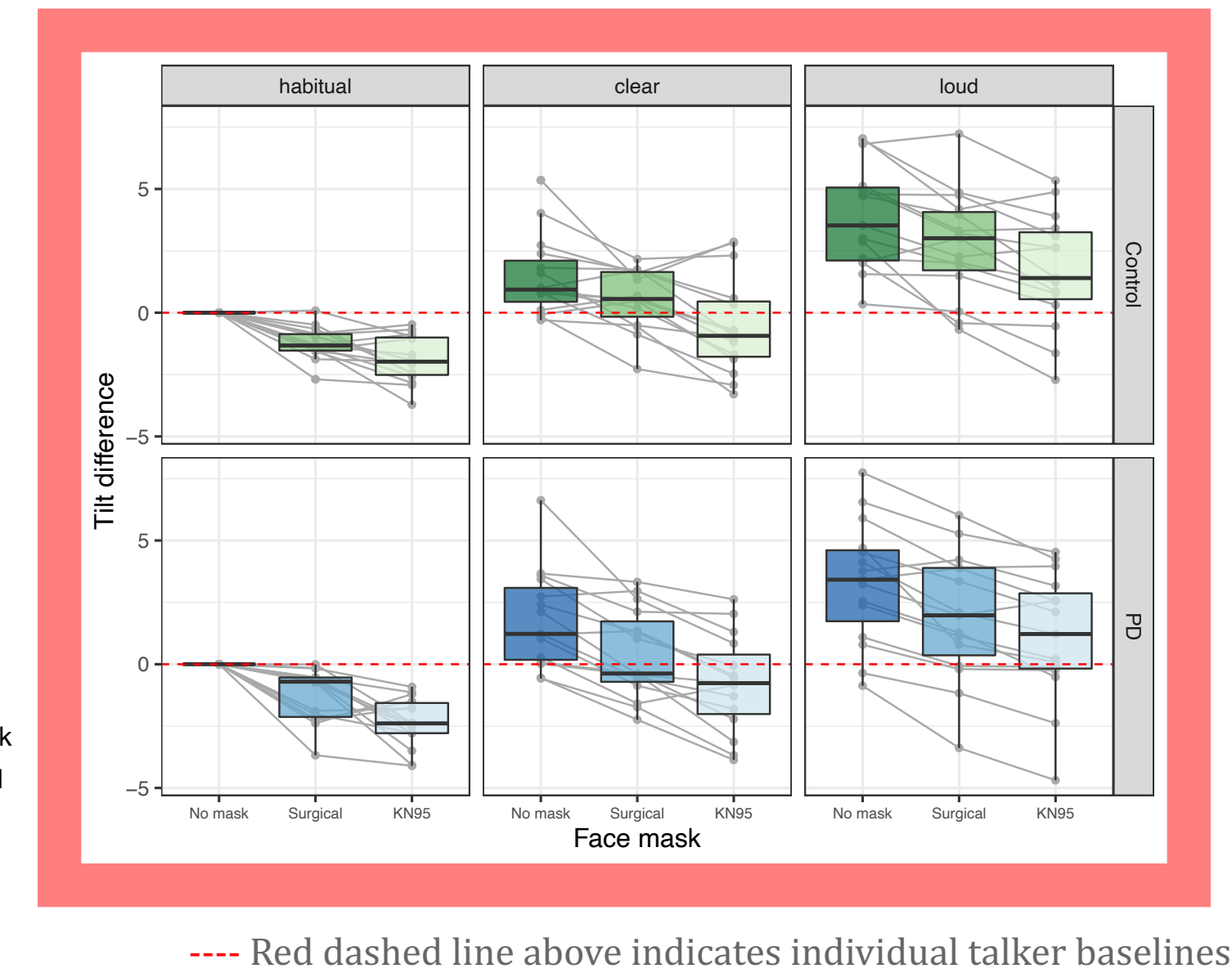
Effortful speech, especially LOUD speech, boosts spectral balance. Larger effect of effort than of masks.

- ↑ spectral tilt (medium effect)
- ↑ 1 – 3 kHz energy (large effect)
- ↑ speech intensity (large effect)
- Larger effects for loud than clear speech
- Larger overall effects for effortful speech than for masks

Patterns persist within masks, speech styles, and groups

- Few interactions – pattern is consistent
- However...

- Masks reduce gains made by talkers with PD when using clear/loud speech
- Perceptual consequences?



Summary

- Face masks (especially KN95s) attenuate higher frequency energy in speech for talkers with and without PD. Consistent pattern across speech styles.
- Loud speech, followed by clear speech, is effective in boosting higher frequency energy & compensating for the effect of masks.
- However, while the general pattern of the masks is the same across groups, talkers with PD who have lower spectral balance to begin with see reduced gains when using clear or loud speech with a mask on.
- Not all acoustic measures are equally affected. Do these changes also impact intelligibility? (Spoiler: yes)

