

Background

Speech intelligibility is lower in face masks than without

- **Masks act as a low-pass filter**, attenuating frequencies above ~1kHz, among other acoustic distortions (Corey et al., 2021; Knowles & Badh, under review; Rahne et al., 2021)
- In the presence of competing background noise, **masks can limit intelligibility** (Rahne et al., 2021; Brown et al., 2021) and listener effort (Curraturo, 2021)

Speech intelligibility is lower in people with Parkinson's than in controls

- **Hypokinetic dysarthria** is a speech disorder associated with Parkinson's disease (PD) that reflects a **downscaling of speech movement size and force** (Duffy, 2019)
- Auditory-perceptual symptoms include **reduced loudness** (Ludlow and Bassich, 1984) and **breathy/hoarse voice quality** (Logemann, Boshes, and Fisher, 1973)
- These symptoms may contribute to **reduced speech intelligibility**, which might be further compounded by the addition of face masks

Clear and loud speech may improve intelligibility in masks

- In PD, **clear and loud** speaking styles have been shown to be **effective in improving speech intelligibility** (Tjaden et al., 2014; Tjaden et al., 2013; Neel, 2009)
- Loud speech, followed by clear speech, is effective in boosting higher frequencies, which helps compensate for the low-pass filtering effect of masks (Knowles & Badh, under review)
- While this is true for people with and without PD, poorer spectral balance in PD is further worsened when masks are worn (Knowles & Badh, under review)

Purpose

1. To quantify the effects of face masks on speech intelligibility and perceived listener effort in talkers with and without PD.
2. To examine the effects of clear and loud speech on these perceptual outcomes in the context of face masks.

Predictions

Prediction 1: Parkinson's vs. Control Speech	Talkers with PD will be overall less intelligible and more difficult to understand than control talkers when pooled across all mask and speech styles; this difference may or may not widen when face masks are worn
Prediction 2: Habitual vs. Clear vs. Loud Speech	Habitual speech will be the least intelligible and most difficult to understand; clear speech will be the most intelligible and easiest to understand
Prediction 3: Masked vs. Unmasked Speech	Talkers wearing KN95s will be overall less intelligible and more difficult to understand than talkers without masks

Methods

Speakers

Participants

- Two groups of speakers:
 - 10 speakers with PD (6 men, 4 women; mean age: 68)
 - 10 age-matched controls (6 men, 4 women; mean age: 65)

Speech Task

- Each speaker read aloud 6 phonetically balanced lists of 10 sentences selected from the first 18 lists of the Harvard Sentence Corpus (IEEE, 1969)
- Speakers read one list per condition (each mask x speech condition)

Conditions

- Two mask conditions
 - **KN95** and **no mask**
- Three speech conditions
 - **Habitual:** Everyday speech
 - **Clear:** "Over-enunciate your speech"
 - **Loud:** "A volume that feels 2x louder"

Mask Condition

KN95



No Mask



Image credit: New York Times

Listeners

Preparation

- Hosted online via the Prolific crowd-sourcing platform
- Sentence audio files were mixed with **+5 dB signal-to-noise ratio of multi-talker background noise**
- Sentences with major hesitations, reading errors, or disruptions were discarded

Participants

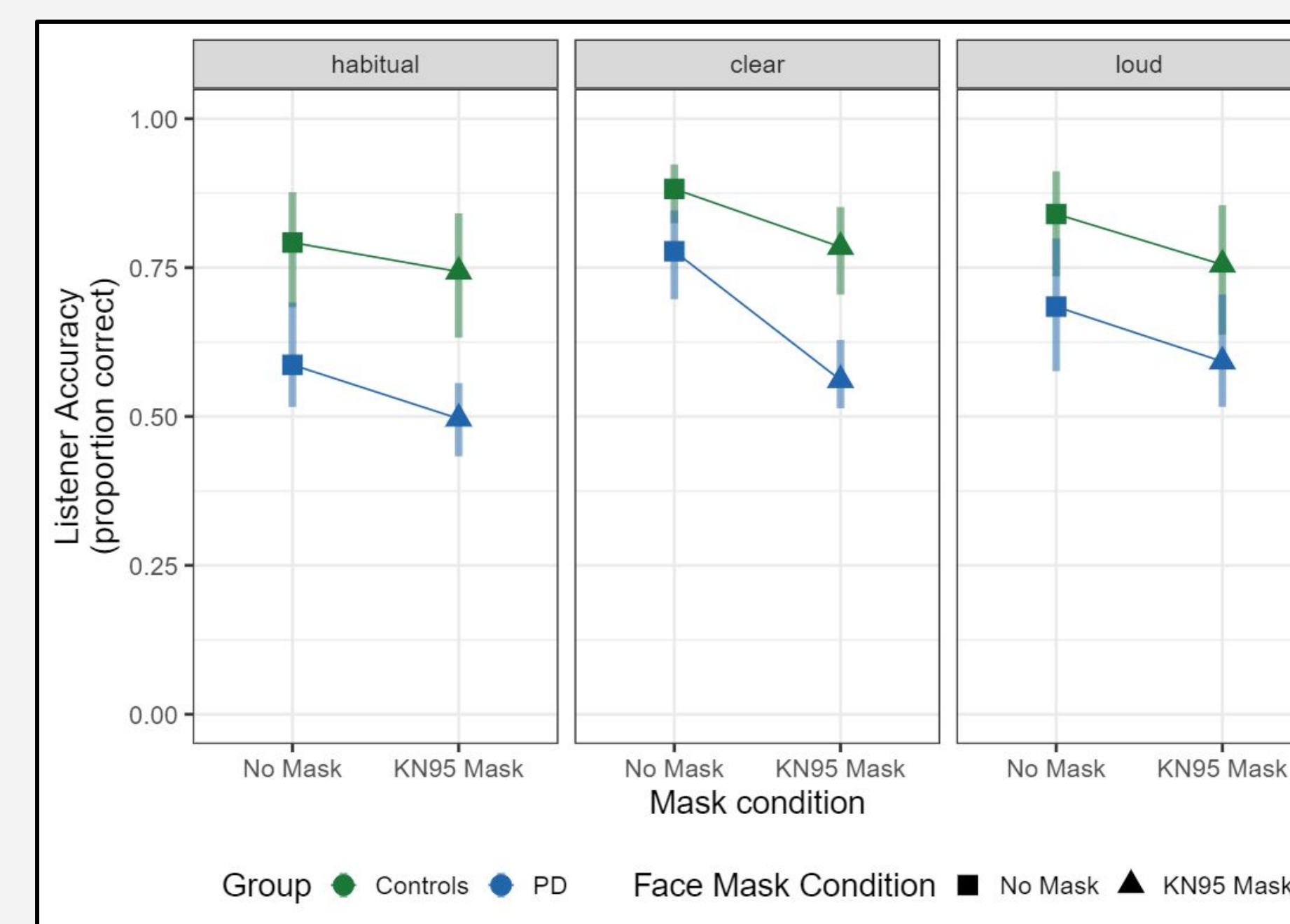
- **192 listener participants** after exclusionary criteria (reporting speech, language, or hearing concerns, not being native North American English speakers, or not wearing headphones)
- Each listener heard audio files from one talker (n = ~60 stimulus items)
- Each talker was heard by a minimum of **9 listeners** (maximum: 11)
- After a brief practice period, listeners were presented with each sentence and asked to
 1. **transcribe** exactly what they heard, and
 2. **rate how effortful** the speech was to understand using a visual analog scale
- Transcriptions were assessed using **five target words** from each sentence based on grammatical prominence

Outcome Measures

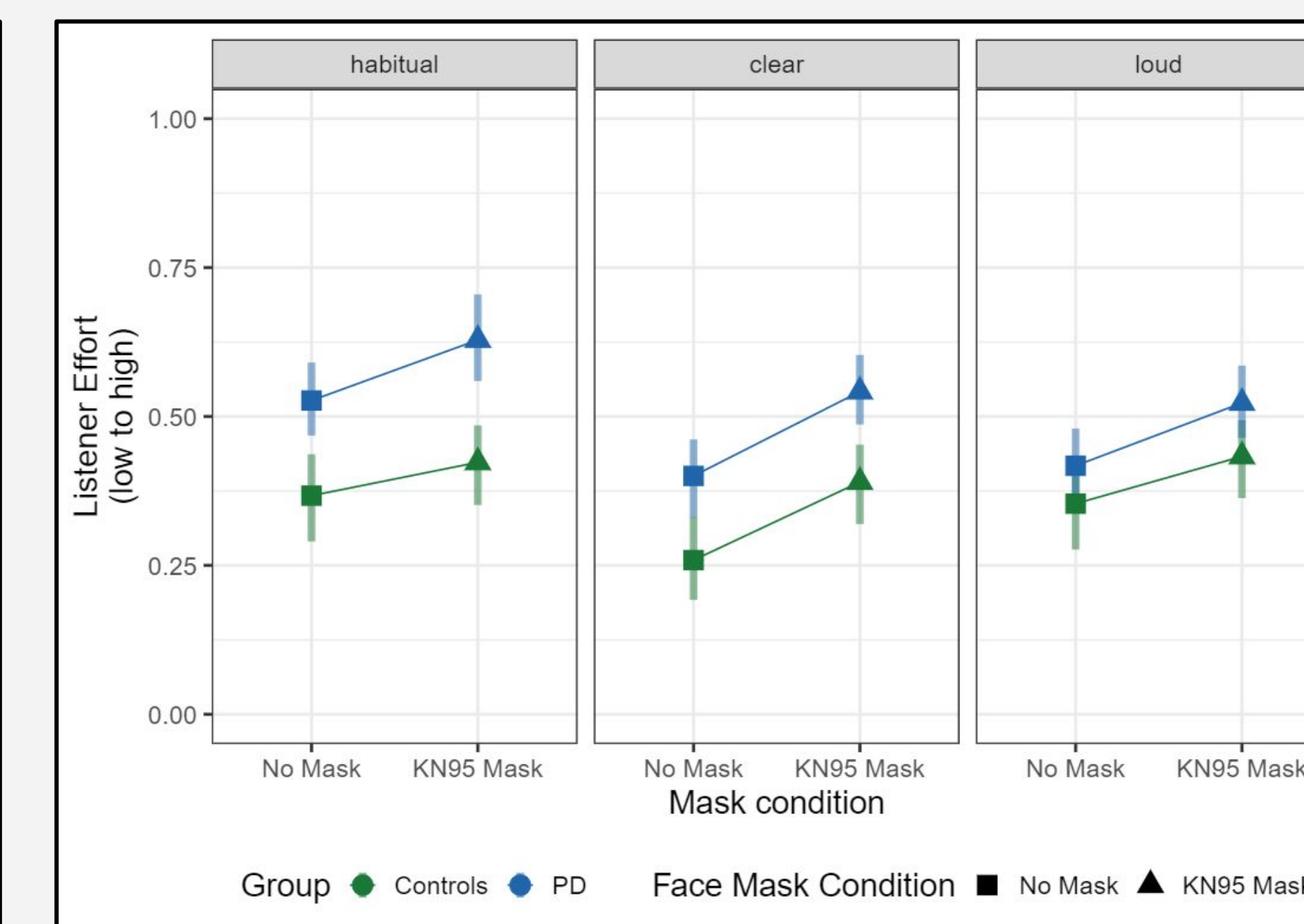
- **Listener Accuracy** via assessment of listener transcriptions
- **Listener Effort/Ease of Understanding** via effort ratings
- Outcomes logit-transformed and modeled as a function of group, mask, and speech condition using linear mixed-effects regression

Results & Discussion

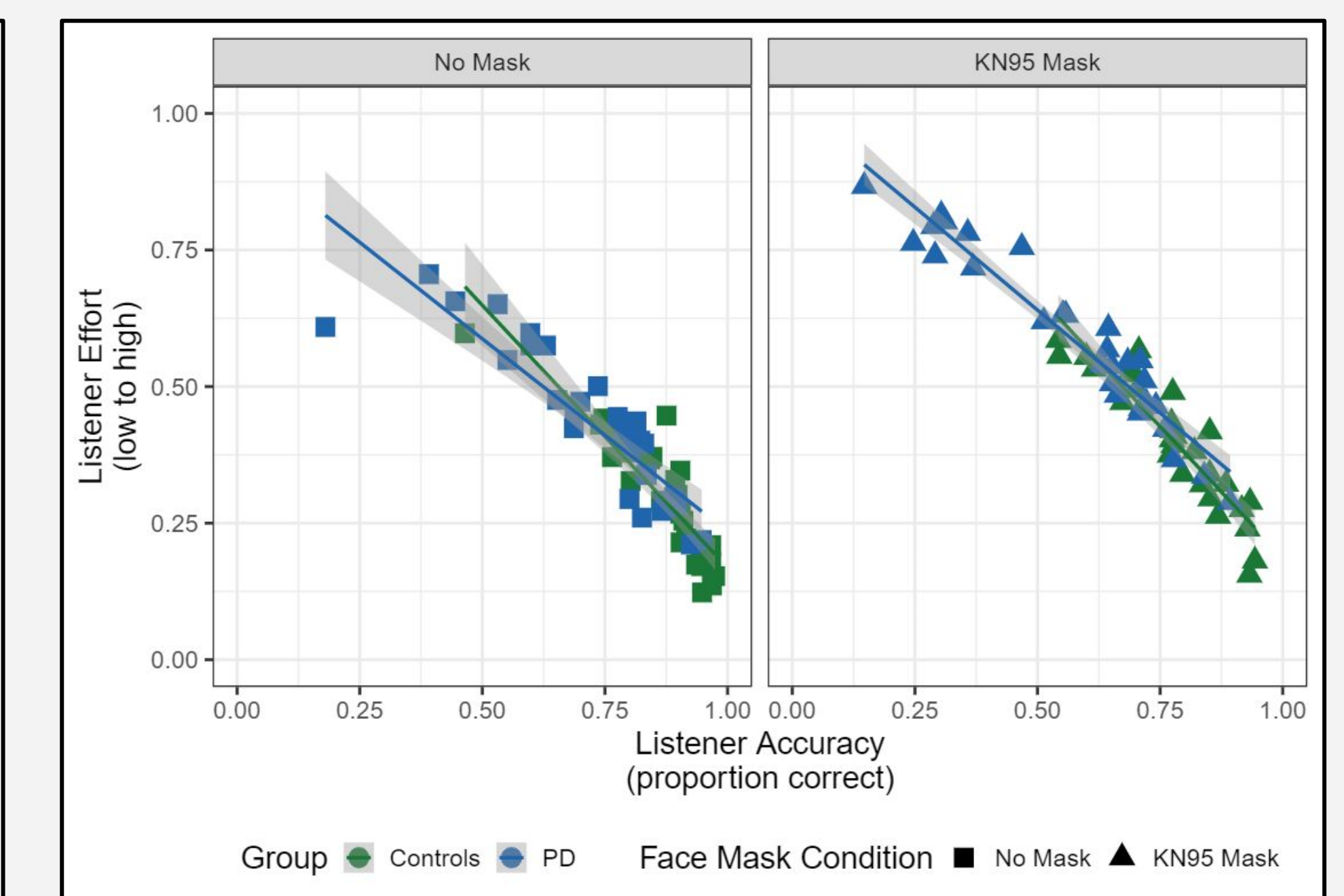
Listener Accuracy



Listener Effort



Listener Accuracy and Effort



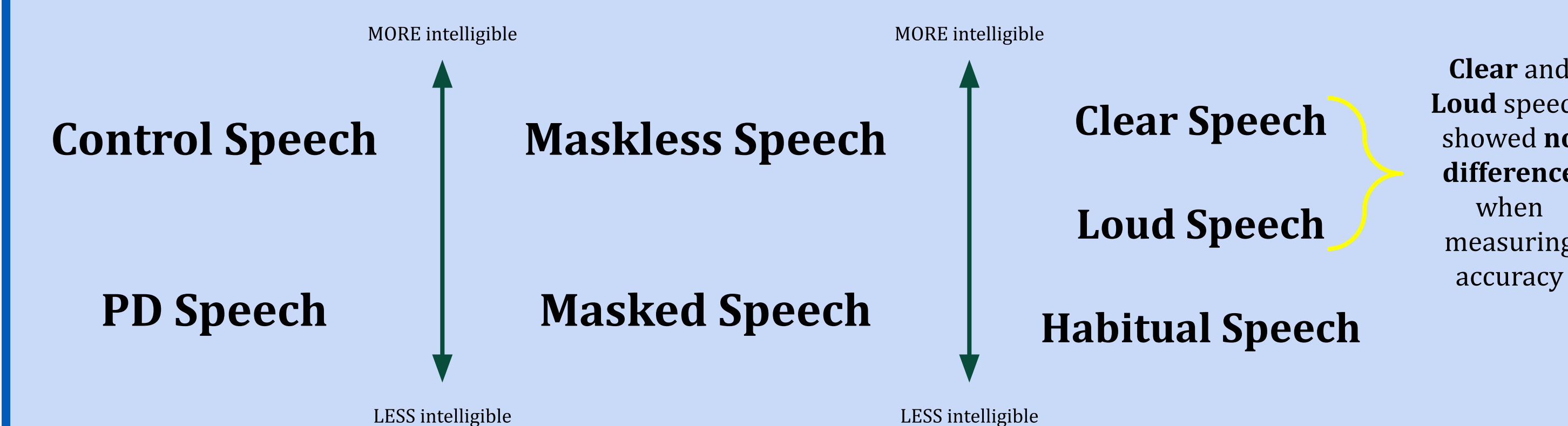
NM: $r = -0.81, p < 0.001$ | KN: $r = -0.94, p < 0.001$

Across All Mask and Speech Style Conditions:

- ✓ **Prediction 1:** PD speech was **least accurate/easy to understand** compared to control speech and were **more disadvantaged when wearing masks**
- ✓ **Prediction 2:** Clear and loud speech were understood **more accurately/easily** than habitual speech. Clear speech was **easier for listeners to understand than loud speech**, but listeners were **no more accurate for clear versus loud speech**
* Clear and loud speech showed **no difference** regarding listener accuracy
- ✓ **Prediction 3:** Masked speech was **least accurate/easy to understand** compared to unmasked speech

Accuracy correlated strongly with Ease of Understanding

Conditions ordered from MOST to LEAST accurate/easy to understand:



Interactions with the Speaker Group

	Clear speech perceived as the easiest to understand by listeners compared to habitual and loud speech styles
	Even more disadvantaged when wearing masks Listeners less accurate and reported greater effort when listening to PD talkers with versus without a mask compared to controls (Two-way Group x Mask interactions: $\beta = -0.101, p < .001$; effort: $\beta = 0.074, p < .001$)
PD Speech:	Clear speech intelligibility benefit disappeared while masked <ul style="list-style-type: none"> • Maskless: PD talkers showed a large intelligibility benefit of clear compared to habitual and loud speech • Masked: intelligibility in clear speech showed the steepest decline for PD talkers • Clear speech was transcribed more accurately than loud speech without a mask, but with a mask, they were equally accurate; this asymmetry was not reflected in listener effort (Three-way Group x Mask x Speech Condition interaction for listener accuracy: $\beta = -0.155, p < .001$)
Control Speech:	Clear and loud speech perceived as easier to understand than habitual, however: listener scores did NOT differ between clear and loud speech
AKA: Loud speech did not help listeners understand talkers with PD more easily	
Clear Speech:	Most easily and more accurately understood without a mask
Loud and Clear Speech:	Similarly understood when speakers wore a mask

Discussion

Further evidence that **clear and loud speaking styles are successful** in accommodating for the low-pass filtering effects of masks; however, **masks are more detrimental to speech for people with PD**

Support for **loud and clear speech styles improving intelligibility** in people with PD

- Our group is currently investigating causal explanations for why masks undermine speech intelligibility in clear speech especially



Questions? Comments?
← Contact us here!