

How's what sound? Perceptual shortcomings in current hearing-aid personalization

William M. Whitmer^{1,2}, David McShefferty¹, Benjamin Caswell-Midwinter³ & Graham Naylor¹

¹Hearing Sciences – Scottish Section, University of Nottingham, Glasgow, UK ²Institute of Health and Wellbeing, University of Glasgow, UK

³Massachusetts Eye and Ear Infirmary, Harvard Medical School, Boston, MA

Rationale

In the personalisation of hearing aids, it is common practice to adjust gain away from prescription based on feedback from the patient. Underlying this practice are two key assumptions about the perception of those adjustments:

1. The adjustments are adequately large enough and the stimuli adequately long enough to elicit a reliable preference, and
2. The patient's feedback is reliable, and there is a common language for gain adjustments across patients.

In two psychophysical studies we separately explore the viability of these commonly held assumptions.

Summary

• There is no evidence base to current troubleshooting practice

- Making small initial gain adjustments (≤ 3 dB) and asking "how's that sound?" are wastes of precious clinical time
- Patients do not use a common language for sound quality

• Perceptual limitations can be clinical opportunities

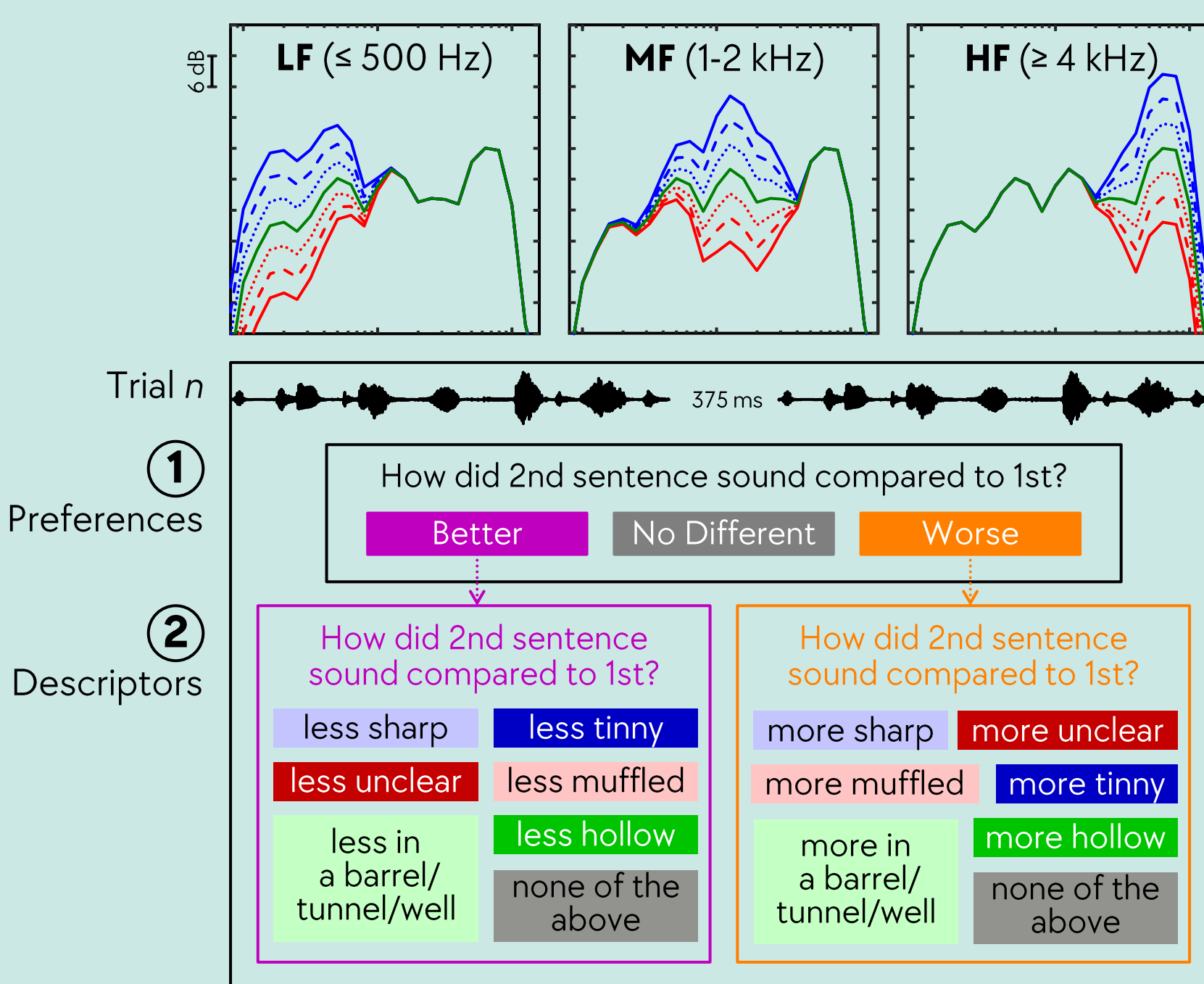
- When fine-tuning, think coarse-tuning: initially use huge steps
- Use alternate, self-guided methods of personalisation
- Focus on individual communication needs & counselling

BACKGROUND • CASWELL-MIDWINTER & WHITMER 2021

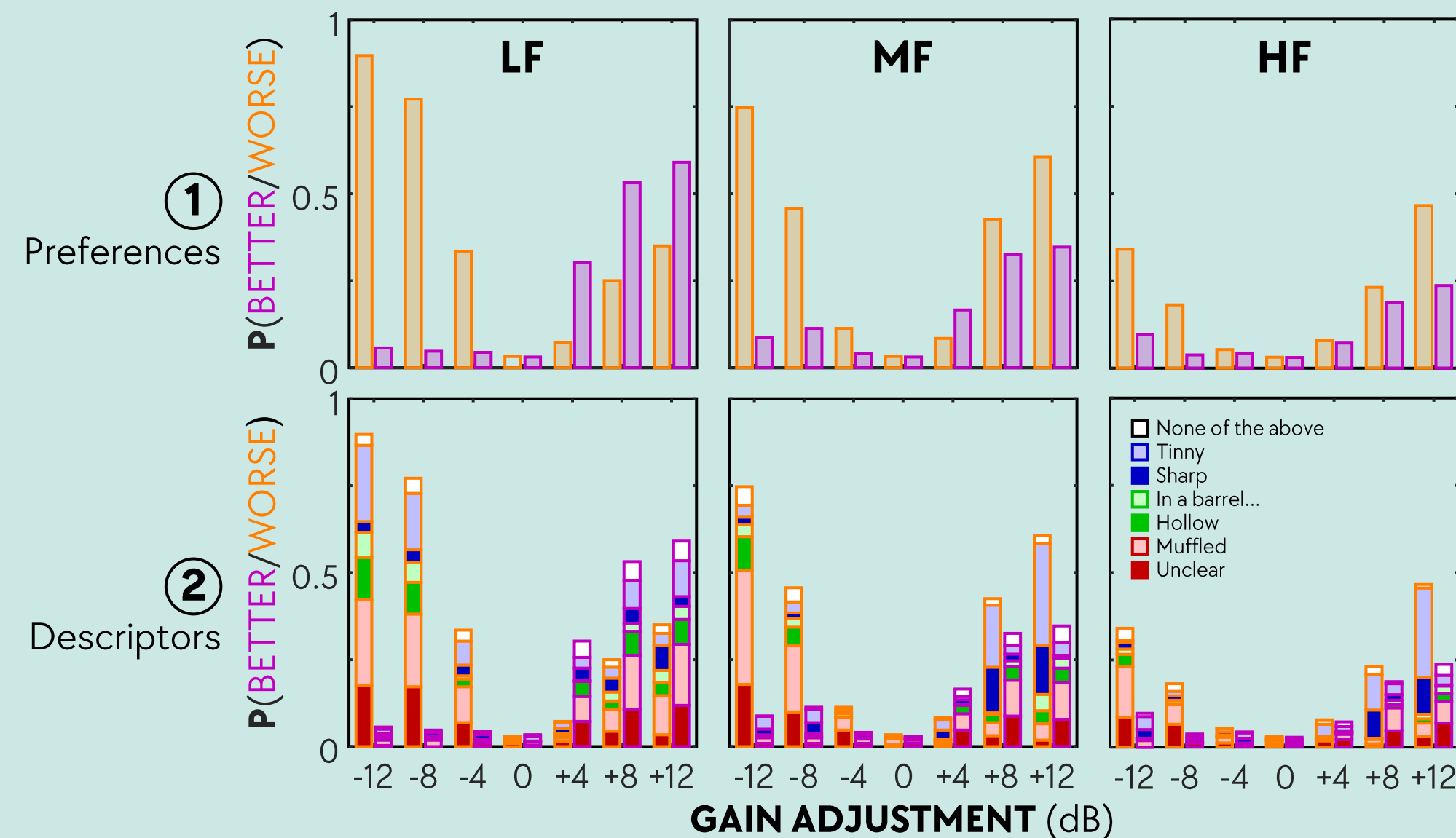
Methods

32 adults with hearing-aid experience listened to short sentences (average duration 1.6 s) presented twice over

- Standard at individual's REIG/NAL gain
- Target ± 0 -12 dB lower or higher in 1 of 3 broad frequency bands



Results – preferences & descriptors as a function of gain adjustment



- ① **Preference JNDs** (gain necessary to elicit better/worse preferences) were 4-12 dB for short sentences in quiet
⇒ **Would longer duration stimuli improve JNDs & reliability?**
- ② **Negligible intra- & inter-rater agreement when applying most common descriptors** (Jenstad et al. 2003) to gain adjustments
⇒ **Do individuals reliably use personally defined terms?**

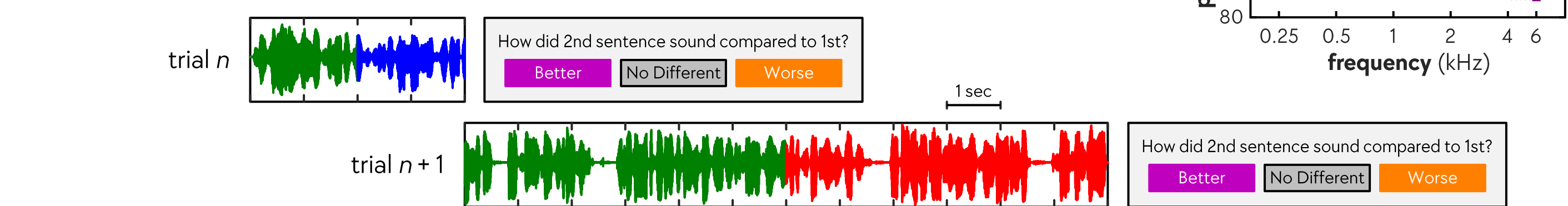
STUDY 1 • Speak longer & fit better? Spoiler : Yes, but limited improvement

Methods

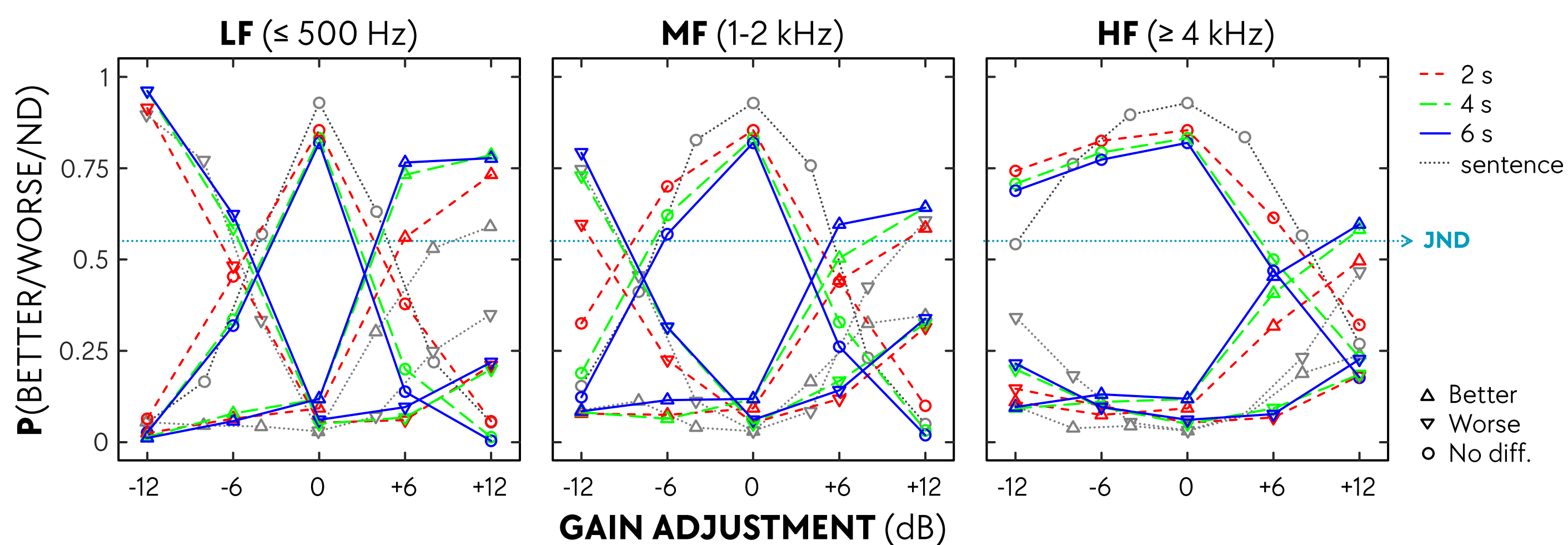
29 adults with hearing-aid experience listened to 2, 4 & 6-s segments of a continuous monologue (story, reader) presented successively over

- 1st at each individual's REIG/NAL gain
- 2nd with a 0, ± 6 or ± 12 dB adjustment in 1 of 3 broad frequency bands
- Minimal interstimulus interval (< 50 ms), fixed interval order

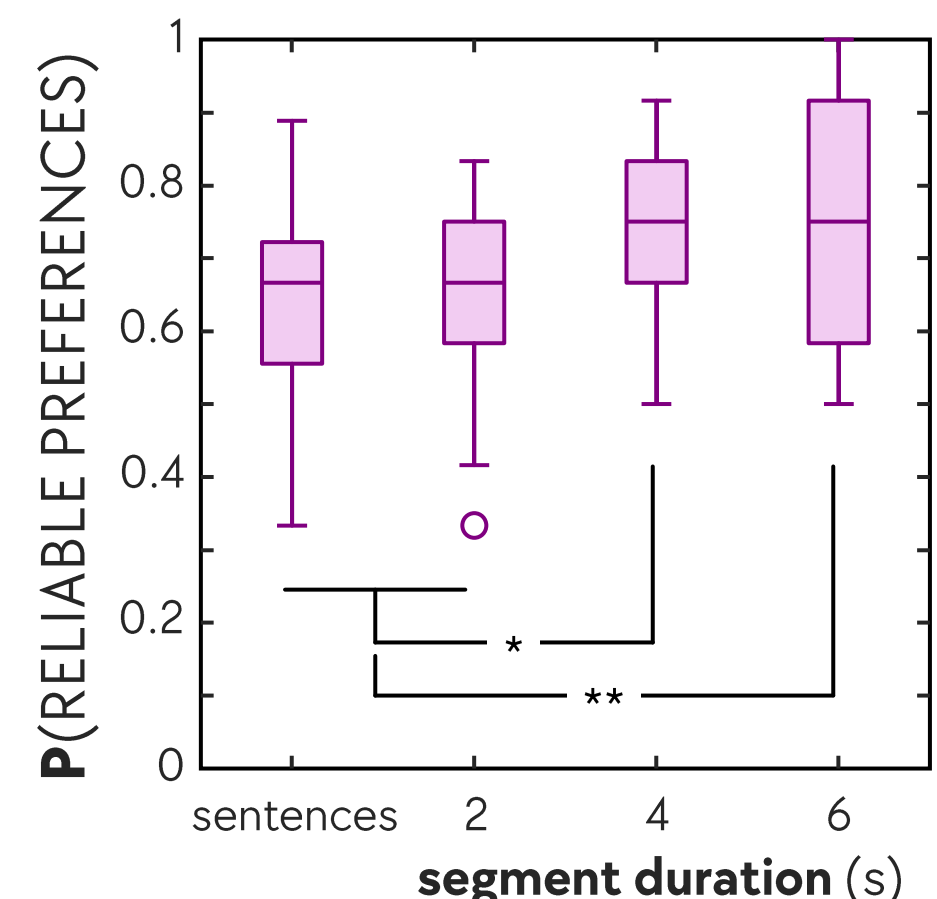
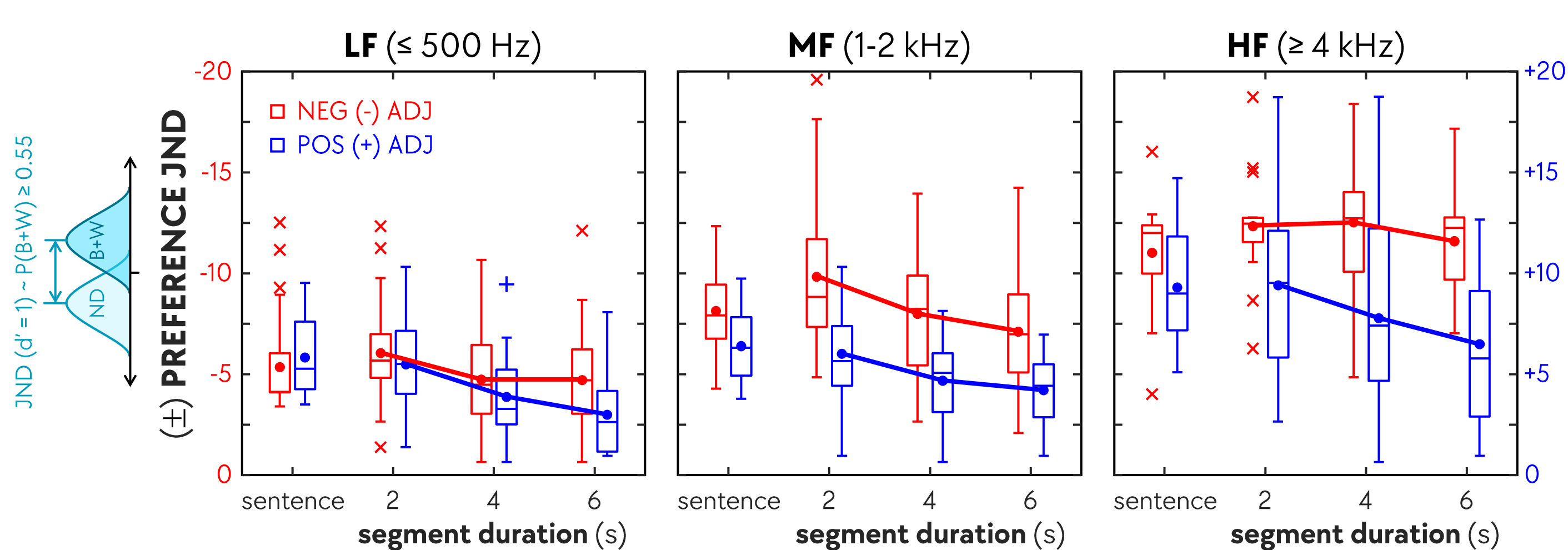
Participants judged if 2nd segment was better, worse or no different from 1st



Raw results – Similar pattern of preference for increased LF gain across durations



Preference JNDs = gain adjustments necessary to elicit better or worse preferences



JNDs decrease & reliabilities increase with duration

- Providing longer stimuli – **talking longer** – improves likelihood of patients providing reliable judgments of gain adjustments

But duration has limited & diminishing effect

- 6-s segments still required at least **3+ dB** gain adjustments to elicit preference
- Decreasing effect slope $-0.8 \rightarrow -0.4$ dB/s
- Duration effect was greater for those with worse cognitive scores (monitoring tasks)

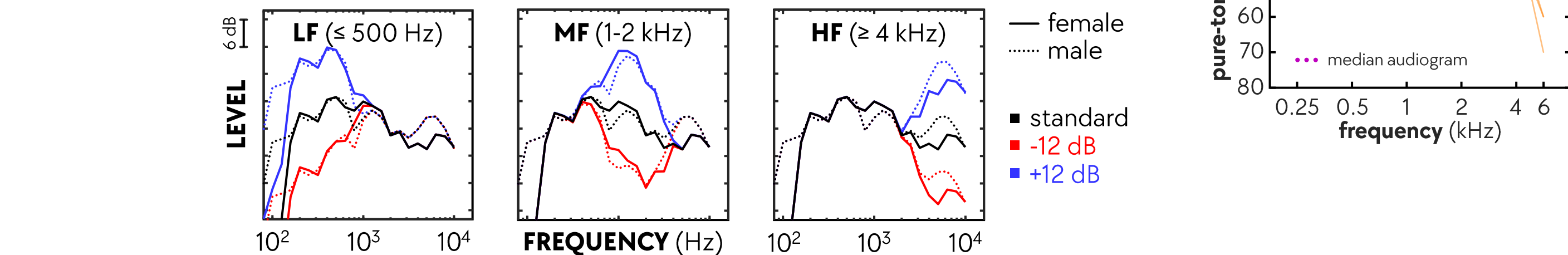
WHITMER, CASWELL-MIDWINTER & NAYLOR 2021

STUDY 2 • Are gain descriptors useful? Spoiler : No, too little agreement

Methods

28 adults with thresholds ± 10 dB HL @ 5-6 freqs. of median online audiogram listened to 6-s speech segments (another story) with alternating reader sex

- 1st segment at NAL-R gain for median audiogram
- 2nd segment at ± 12 dB adjustment in 1 of 3 broad frequency bands



Participants could listen repeatedly to segments before two tasks per trial

1. **Discrimination** • Do you hear a difference in quality between 2 segments?
2. **Description** • If you heard a difference, describe difference in 1-2 words

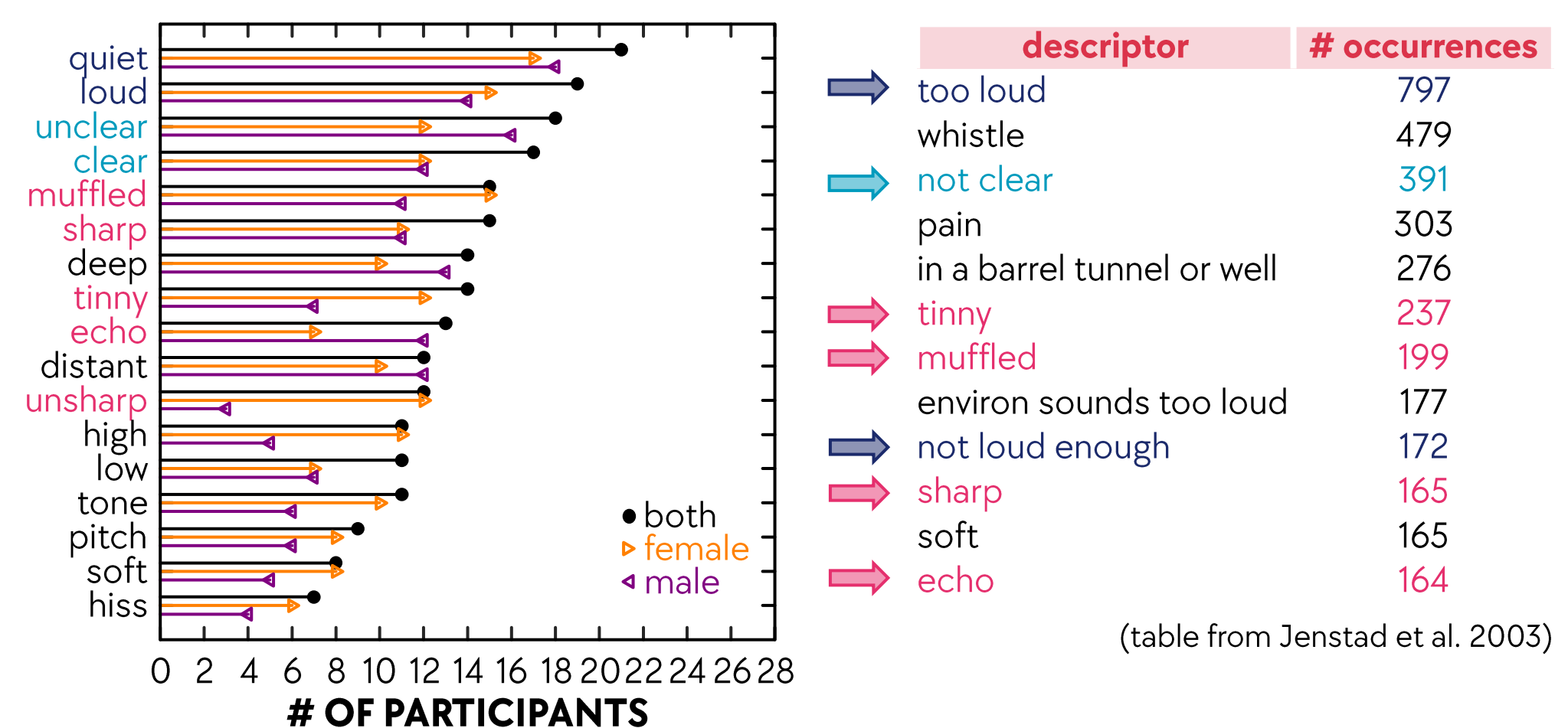
Discrimination results • Do you hear a difference?

Decrease in discriminability with increasing centre frequency } same as previous studies
Discriminating decrements more difficult than increments
No difference in discriminability between ♀ & ♂ voices

Descriptor results • Describe the difference

Conversion of all responses to refer to adjusted re standard segment
Condensation of phrases (e.g., "farther away" \rightarrow "distant")

Many participants showed signs of difficulty in describing adjustments



"Don't know how but made me imagine a Tabletop with it lengthwise in front of me with the slope going away from me"

Descriptor frequencies

The most frequent terms given at least once by participants compared favourably to rankings of most frequent complaints of hearing-aid patients as reported by audiologists

- **Very little agreement across participants ($\leq 25\%$)** when applying a 50% intra-reliability criterion (i.e., descriptor was used for half of the trials for any given adjustment by a participant)
- **Ambiguous gain patterns for common terms** (e.g., clear & unclear) \rightarrow **Descriptors aren't useful**

