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# Listening challenge: How noise and dysphonic voice may disrupt children's spoken language processing

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# Background

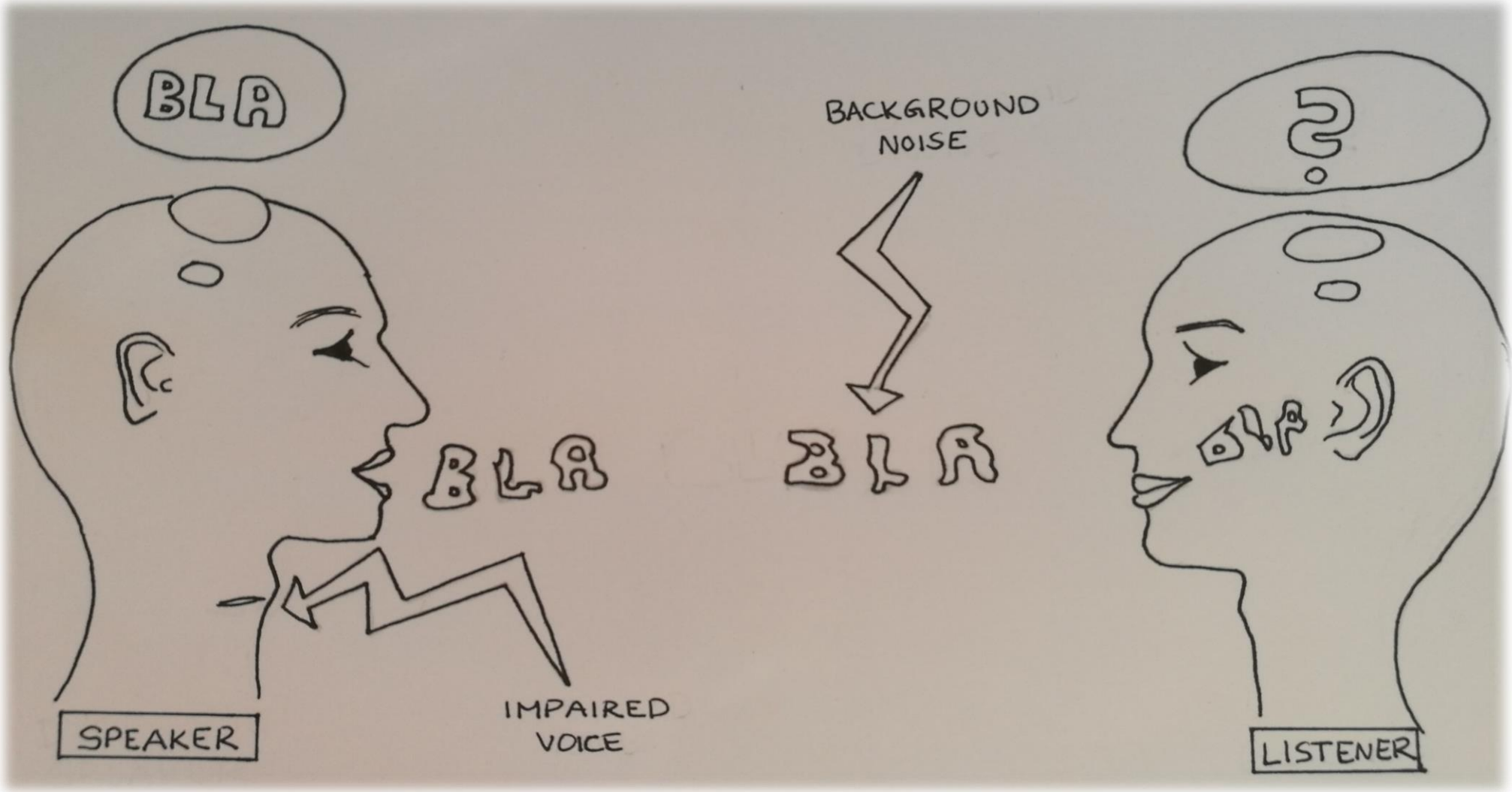
# Spoken language processing

- Processing of acoustic information into linguistic information that the listener can use and keep in memory.
- Auditory, cognitive, and linguistic mechanisms

Medwetzky, 2011

# The listening challenge

## …or how noise and impaired voice reduce intelligibility



# The listening challenge in classrooms

## Noise

- Speech-in-noise processing develops until late adolescence Hazan & Barrett, 2000; Johnson, 2000
- Recommended signal-to-noise ratio (SNR) for children: ≥+15 dB Crandell & Smaldino, 2000
- SNRs in classrooms: -7 to +5 dB American Speech-Language-Hearing Association, 2005; Crandell & Smaldino, 2000; Finitzo-Hieber, 1988
- Young pupils face highest noise levels Picard & Bradley, 2001
- General effects: hearing loss, annoyance, reduced attention, reduced memory functions Shield & Dockrell, 2003
- Effects on spoken language processing: reduced performance and increased listening effort in listening tasks Jamieson et al., 2004; Klatte et al. 2010, Elliott et al., 1979, Howard et al., 2010, Houben et al., 2013

# The listening challenge in classrooms

## Impaired voice

- Vocal loading in teachers Schiller et al., 2018
- Risk for voice disorders: teachers > general population Roy et al., 2004
- Acoustic characteristic: increased noise components Yanagihara, 1967
- Perceptual characteristic: Hoarseness De Bodt et al., 2016
- General effects: nevative attitude, reduced memory functions Brännström et al., 2018, Morton, & Watson, 2001
- Effects on spoken language processing: reduced performance and increased listening effort in listening tasks Brännström et al., 2018, Chui & Ma, 2018, Lyberg-Åhlander et al., 2015a, Morsomme et al., 2011, Morton & Watson, 2001, Rogerson & Dodd, 2004

# The listening challenge in classrooms

## Combination of noise and impaired voice

- Sentence comprehension:
  - No effect on performance Lyberg-Åhlander et al., 2015b
  - Slower responses Sahlén et al. 2017
  - Negative opinions Brännström et al., 2015
- Passage comprehension:
  - No effect on performance Brännström et al, 2018, von Lochow et al., 2018, Rudner et al. 2018

# Objective

To investigate the effect of noise and impaired voice on speech perception and sentence comprehension in first grade primary school children.

## Hypotheses

1. Either noise or impaired voice will impede spoken language processing.
2. Spoken language processing will be most affected by a combination of noise and impaired voice.

# Methods

# Experimental Set-Up

- **Participants:**
  - 53 children (5-6 years)
  - No history of speech/language or hearing impairments
  - Age-adequate vocabulary and selective auditory functioning
- **Procedure:**
  - Individual testing at school (2 x 20 min.)
    1. Assessment of inclusion criteria
    2. Experiment (speech perception and listening comprehension)

# Tasks


/zil/ - /zij/ - same word or two different words?

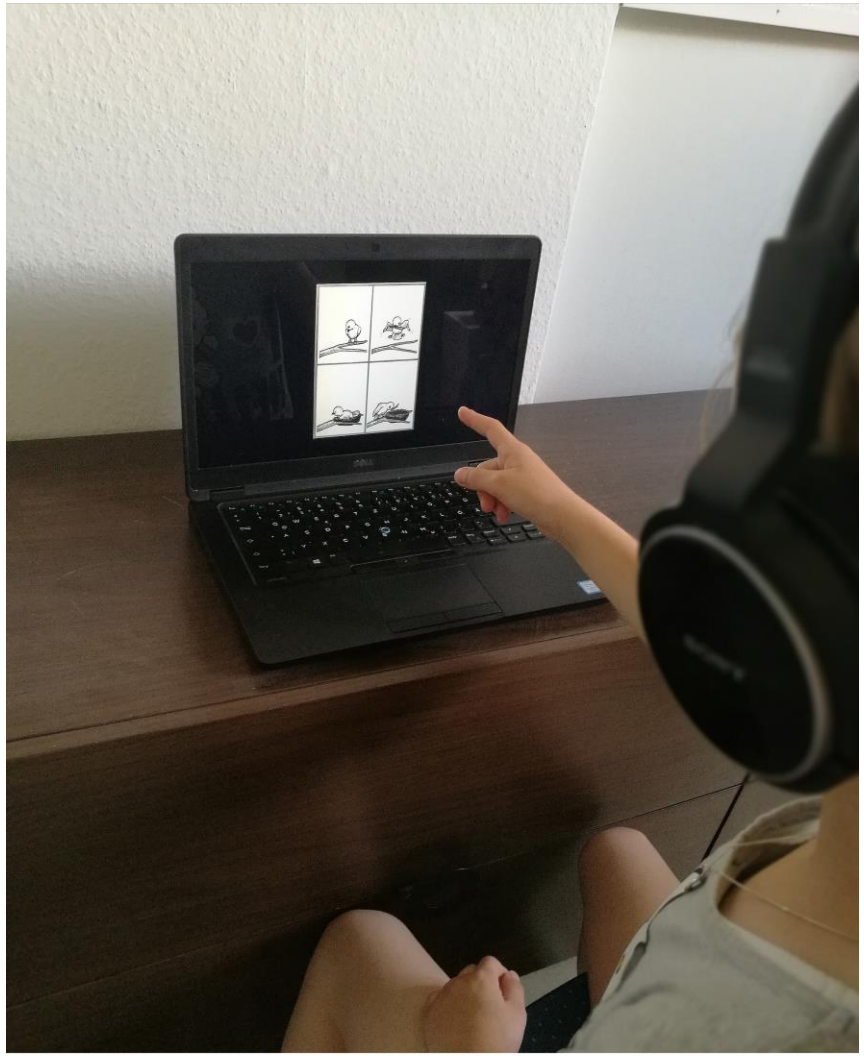
## Speech Perception

Minimal-Pair Discrimination Task

Conditions:
(1) Normal voice – no noise
(2) Impaired voice – no noise
(3) Normal voice – speech shaped noise
(4) Impaired voice – speech shaped noise

Outcome:
- Answer accuracy (Performance)
- Reaction time (Listening effort)

# Tasks



"L'oiseau a fait son nid." - Which picture corresponds?

## Listening Comprehension

Sentence-Picture Matching Task

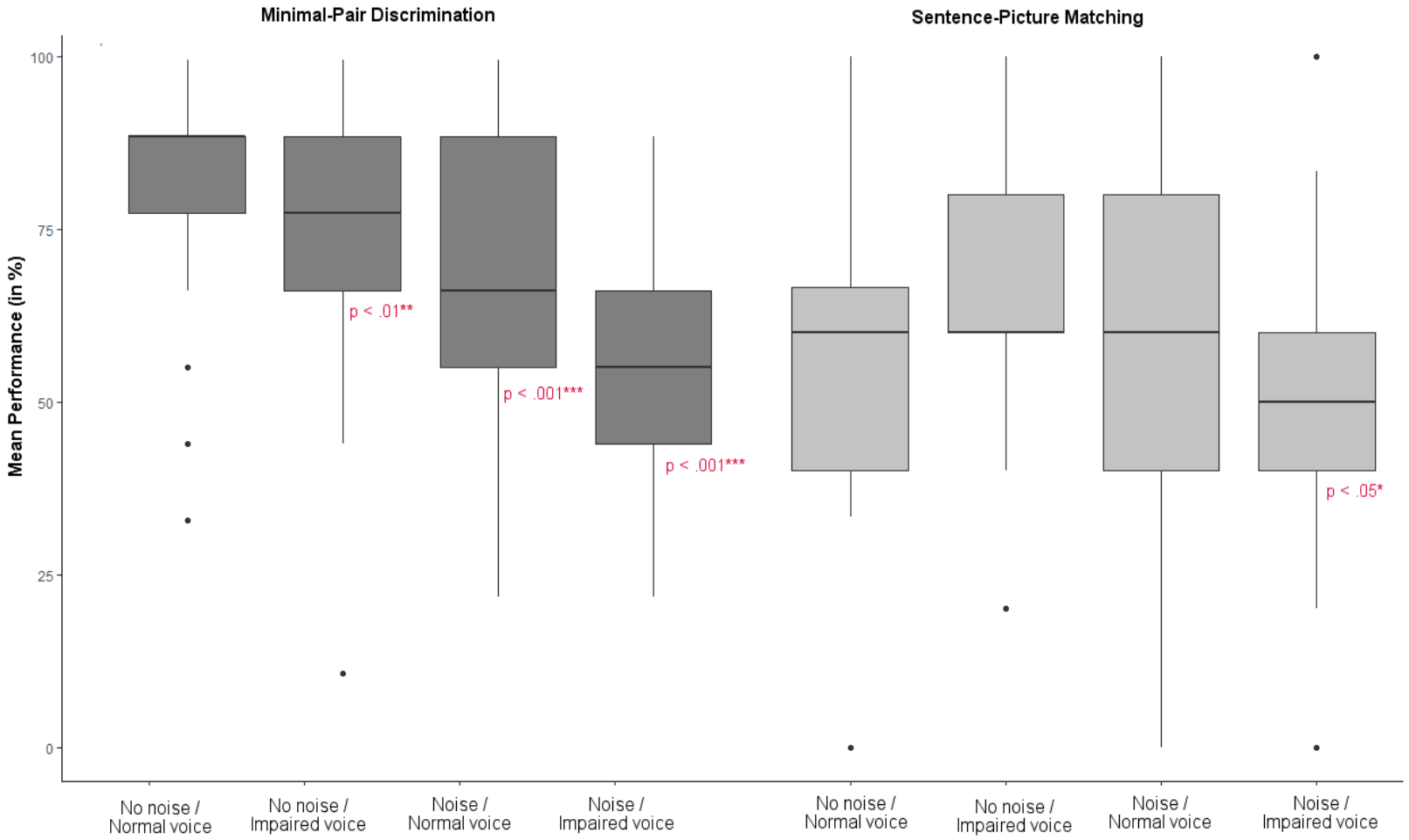
Conditions:
(1) Normal voice – no noise
(2) Impaired voice – no noise
(3) Normal voice – speech shaped noise
(4) Impaired voice – speech shaped noise

Outcome:
- Answer accuracy (Performance)
- Reaction time (Listening effort)

# Results

# Task performance

- Speech perception (MPD): performance decreased for noise ($z$ = -6.57, $p$ < .001) or impaired voice ($z$ = -3.18, $p$ = .001)
- Listening comprehension (SPM): no isolated effects
- Speech perception & listening comprehension: lowest performance when noise and impaired voice were combined ($p$-values < .01**)

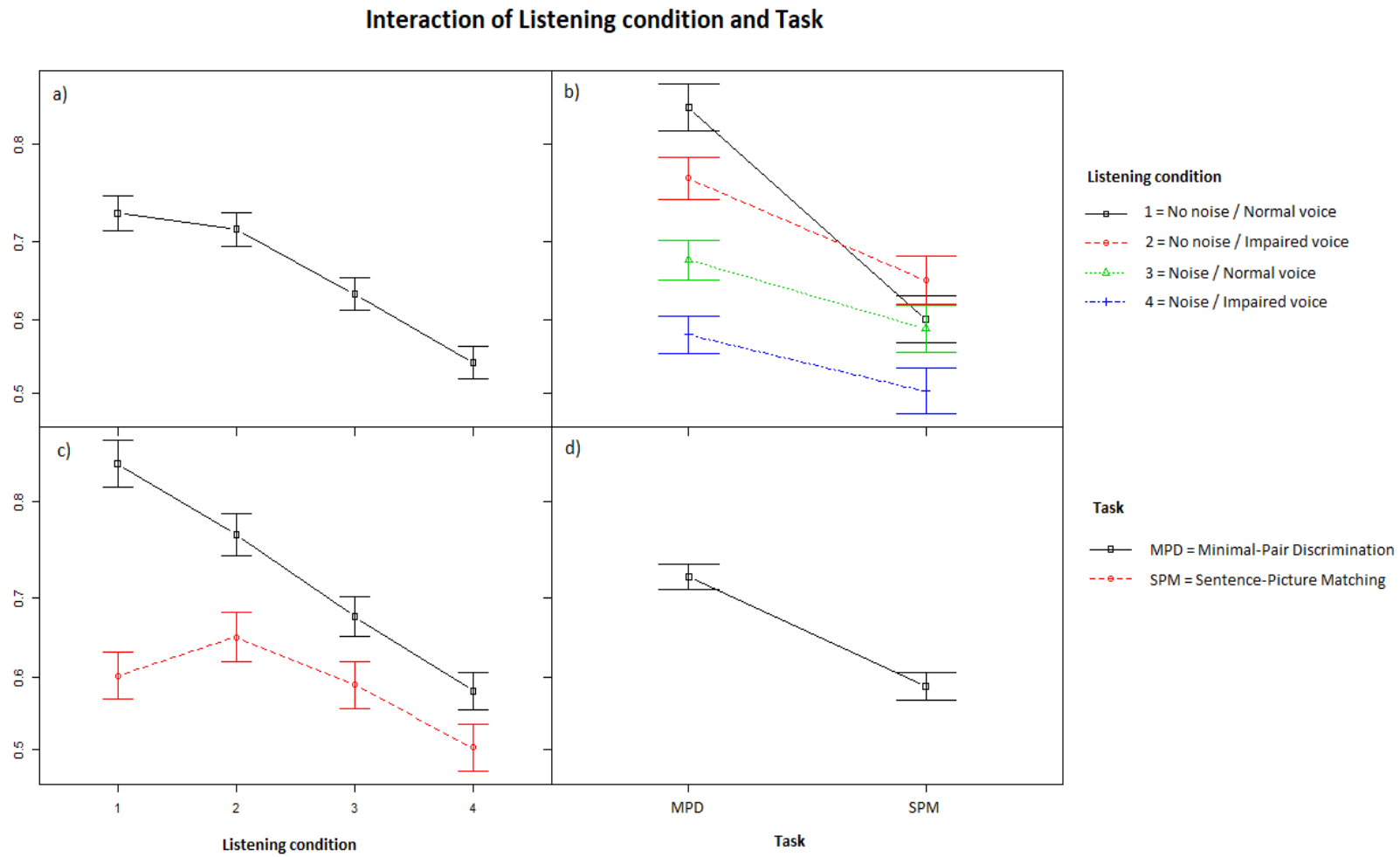


# Task performance

a) Performance decreased with listening condition (control > impaired voice > noise > noise & impaired voice)

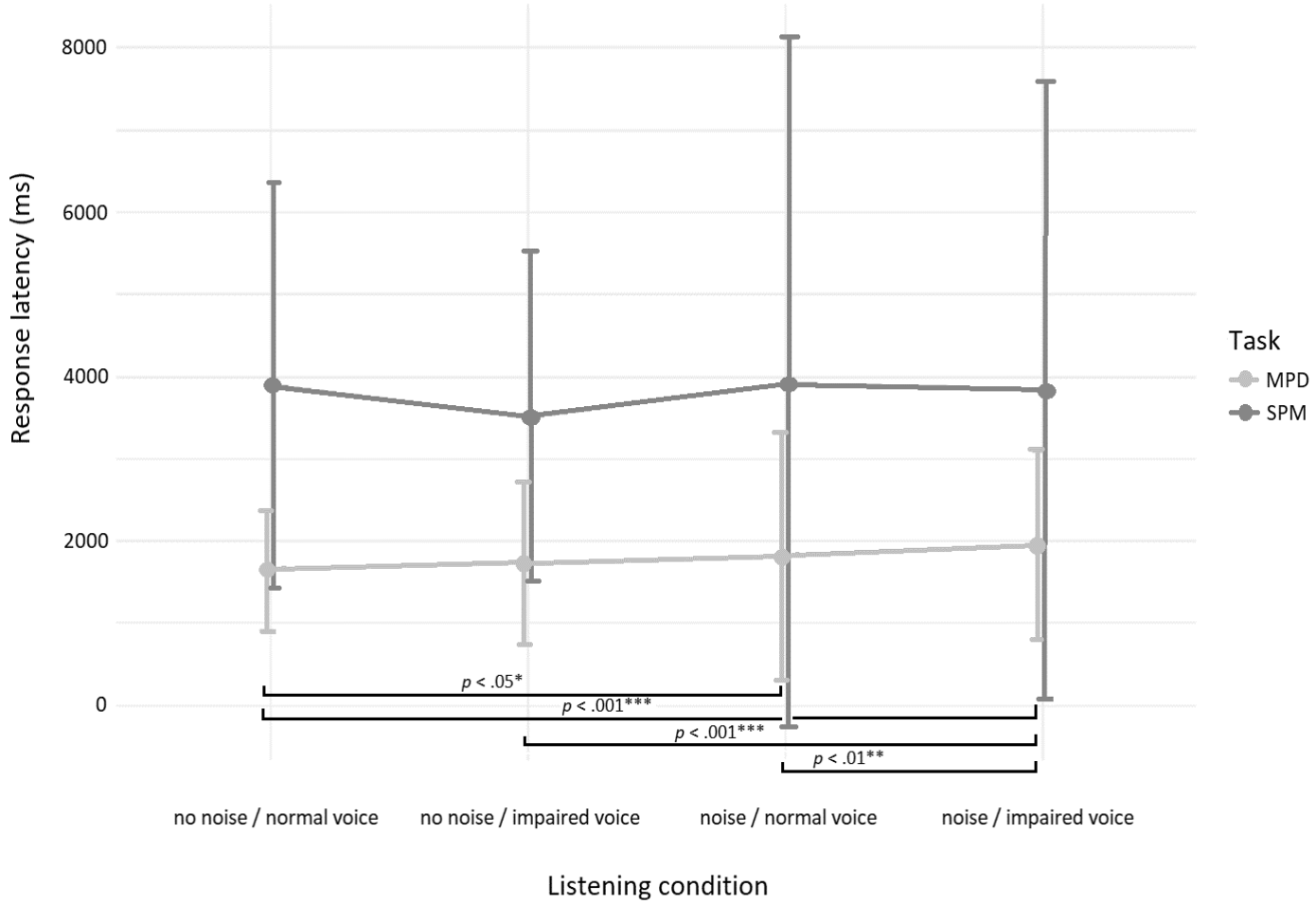
b & d) Performance generally higher for MPD than SPM → guessing probability

c) Performance in listening comprehension better for impaired than normal voice



# Response time

- Speech perception (MPD):
  - Increased response latencies for noise compared to control ($z$ = 2.823, $p$ = .025)
  - Longest response latencies when noise and impaired voice combined ($p$-values < .01**)



# Summary of the results

- Speech perception
  - Noise: performance ↘, response time ↗
  - Impaired voice: performance ↘
  - Noise & impaired voice: performance ↘↘, response times ↗↗
- Listening comprehension
  - No isolated effects
  - Noise & impaired voice: performance ↘↘

# Discussion

## Noise or impaired voice disrupted speech perception

- Past studies found effects on speech perception AND listening comprehension

Noise: Jamieson et al., 2004; Klatte et al. 2010, Elliott et al., 1979, Howard et al., 2010

Impaired voice: Brännström et al. 2018, Chui & Ma, 2018, Morton & Watson, 2001, Rogerson & Dodd, 2004

- Interaction of noise source and linguistic task Klatte et al., 2010
- Facilitating effect of context cues Morsomme et al., 2011

## Combination of noise and impaired voice more disruptive than each factor in isolation

- Energetic masking: more noise components in speech signal Pollack, 1975
- Informational masking: inhibition of two "noise" signals Pollack, 1975, Watson, 2005

## Good task performance does not tell the entire story…

- Spoken language processing may still be affected (→ listening effort) Houben et al., 2013

## Implications for the educational setting

- Motivation loss, memory impairment, lower learning outcome Shield & Dockrell, 2003
- Negative student-teacher relationship Brännström et al., 2018, Morton, & Watson, 2001

## Limitations and future directions

- Ecologic validity vs. control

# Conclusion

- Noise and impaired voice may compromize spoken language processing
- Important to improve classroom listening conditions

# Thank you for your attention!

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