

Exploring sound environment self-reports from hearing-aid users: Insights and implications for clinical feasibility

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Introduction

- Understanding the real-life experiences of hearing-aid users is essential for delivering personalized care.
- We explore environmental and audiological factors that drive the preferences in a) adaptive directionality and noise reduction (DIR+NR) and b) high-frequency gain (brightness) and soft-sound gain (B+SG) in everyday situations.

Q1: How do the subjective noisiness and difficulty influence the DIR+NR and B+SG preferences in everyday situations?
Q2: How does the audiological profile influence the DIR+NR preferences in everyday speech-in-noise situations?

Materials and Methods

- 123 experienced hearing-aid users (52 f, 71 m), mean age 65.2 years, native speakers of German (82) or Japanese (41).
- Mild to severe bilateral hearing loss.
- Users were fit with hearing aids (Oticon More 1).
- Hearing-aid amplification: REM-adjusted NAL-NL2 (Keidser et al., 2011) for the German population; Utsunomiya method (Shinden et al., 2021; Suzuki et al., 2023) for the Japanese population.
- Audiological measures including bilateral 4-frequency pure-tone-average (PTA4) and aided speech-reception thresholds (SRTs), as described in Zaar et al. (2024).
- A/B comparisons during 6 field periods (FP) where subjects were instructed to provide at least 1 report per day (Figure 1 (a)). Each (FP) ended with a structured interview (Figure 1 (b)). For more details on the study design see Vatti et al. (2024).

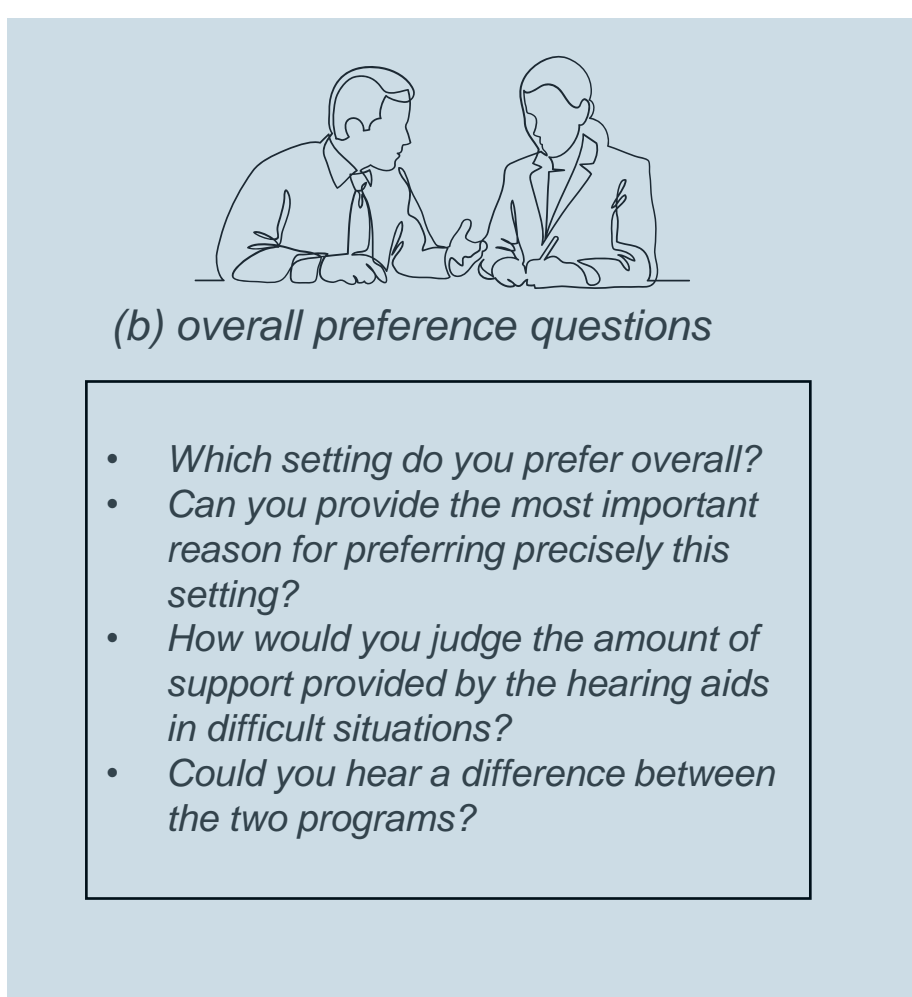
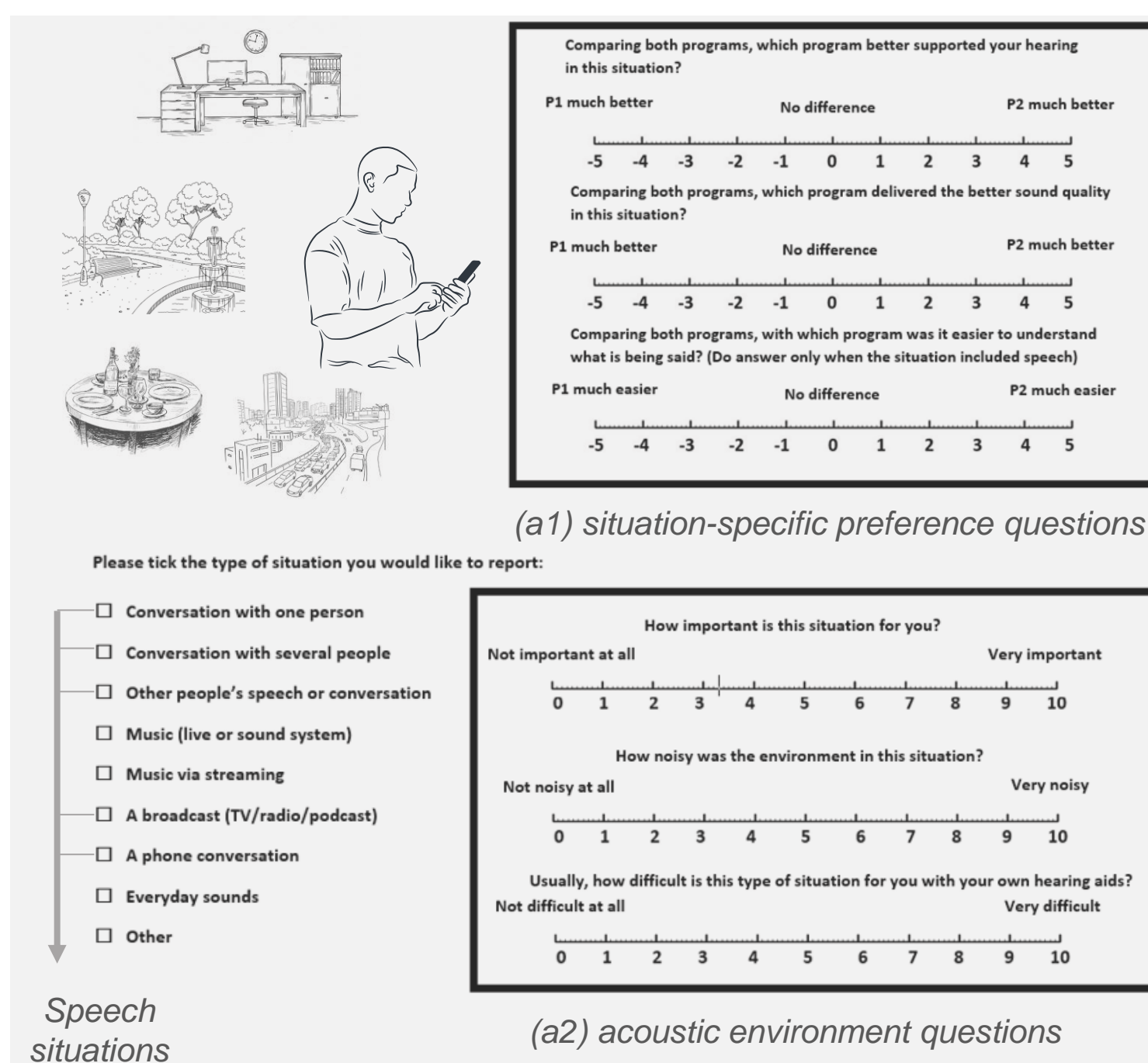


Figure 1: Excerpt of questionnaires used in each field period during (a) the everyday situations and (b) the structured interviews at the end of each field period.

Results: Descriptive statistics

- On average 92% of the users wore their hearing aids for more than 8 hours per day.
- ~ 50% of the users compliant to self-reporting frequency requirements (submitting > 22 self-reports per FP).
- 72% self-reports in speech situations and 41% self-reports rated as noisy (subjective noisiness >5 in Figure 1(a2)).
- Clear preference ratings: defined as ratings [-5, -1] & [1, 5] in Figure 1 (a1). Comprised 48% and 76% of the self-reports for all DIR+NR and B+SG setting comparisons respectively (also see Figure 5 in Vatti et al. (2024)).
- Table 1 shows compliance and clear preference for DIR+NR based on FP3 (adaptive-settings group comprising 55% of the users in that FP) and for B+SG based on FP5 (see Vatti et al. (2024)). For analyzing Q1, we used the data from the 'Clear preferences for compliant users' column and for analyzing Q2, we used the data from the 'Clear preferences in speech-in-noise for compliant users' column.

Table 1. Number of users and self-reports expressing clear preferences for better support (question 1 in Figure 1(a1)), when performing A/B comparisons with adaptive DIR+NR or B+SG settings with high and low strength.

	All participants	Compliant users	Clear preferences for compliant users	Clear preferences in speech-in-noise for compliant users
Adaptive DIR+NR				
Nr of self-reports	1210	886	366	80
Nr of users	59	28	19	16
B+SG				
Nr of self-reports	1943	1501	1210	275
Nr of users	90	46	45	42

Results: Factors influencing DIR+NR & B+SG preferences in everyday situations

- Here we removed noisy preference ratings by considering only: compliant users and clear preferences for better program support ratings, i.e., first question in Figure 1 (a1).
- Clear preferences were converted to ordinal values categorized as 'high' and 'low' DIR+NR or B+SG program strength. We used a Generalized Linear Mixed-Effects Model (GLMM) with a binomial distribution, incorporating a random effect for each user.

(Q1): Influence of everyday situations on DIR+NR and B+SG preference

- We modeled preference for better DIR+NR and B+SG support based on the subjective noisiness and difficulty of the situations (Figure 1 (a2)).
- Topic classification on text data from the structured interviews (question 2 of Figure 1(b)) by manually identifying the most common words.
- For B+SG, both difficulty and noisiness were significant predictors with positive and negative effects, respectively (Figure 3 in red). For DIR+NR, noisiness but not difficulty was a significant predictor with positive effect (Figure 3 in blue).
- Similar trend reported by the users during structured interviews (Figure 4).
- Corroborating literature: Pasta et al. (2022), Bosman et al. (2021).

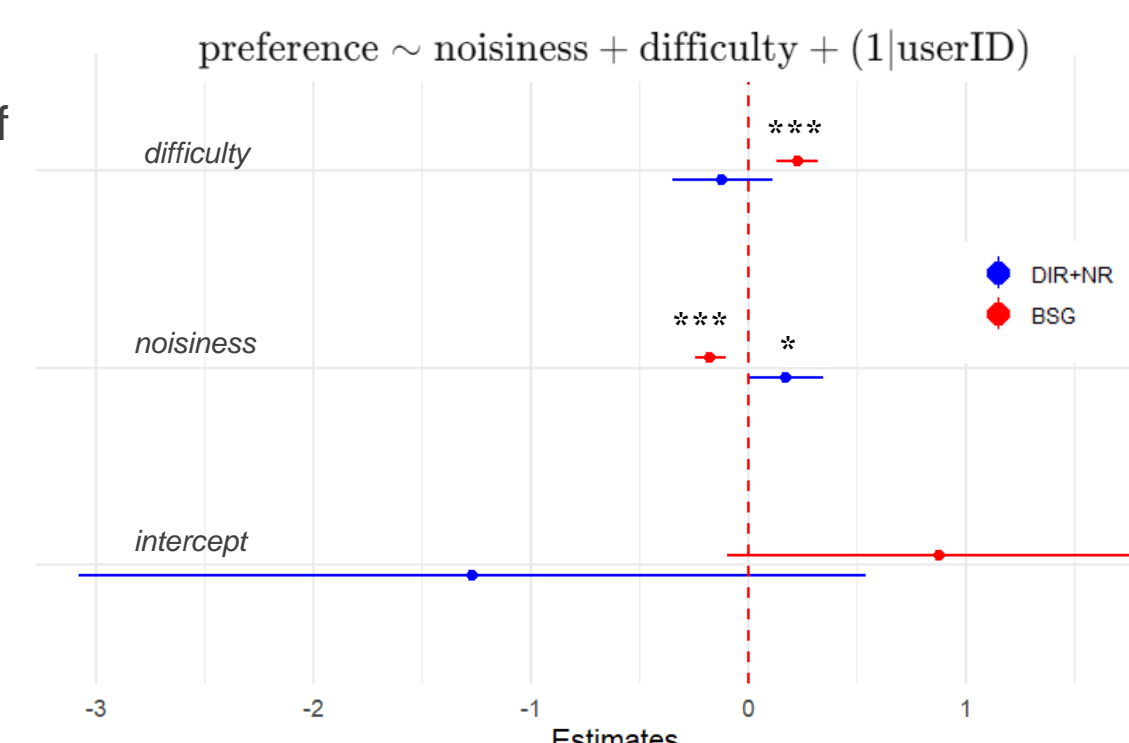


Figure 3: The estimated coefficients and 95% confidence intervals for predicting preference for better support from subjective noisiness and difficulty ratings. Two GLMMs were fitted separately for the DIR+NR (blue) and the B+SG (red) preference.

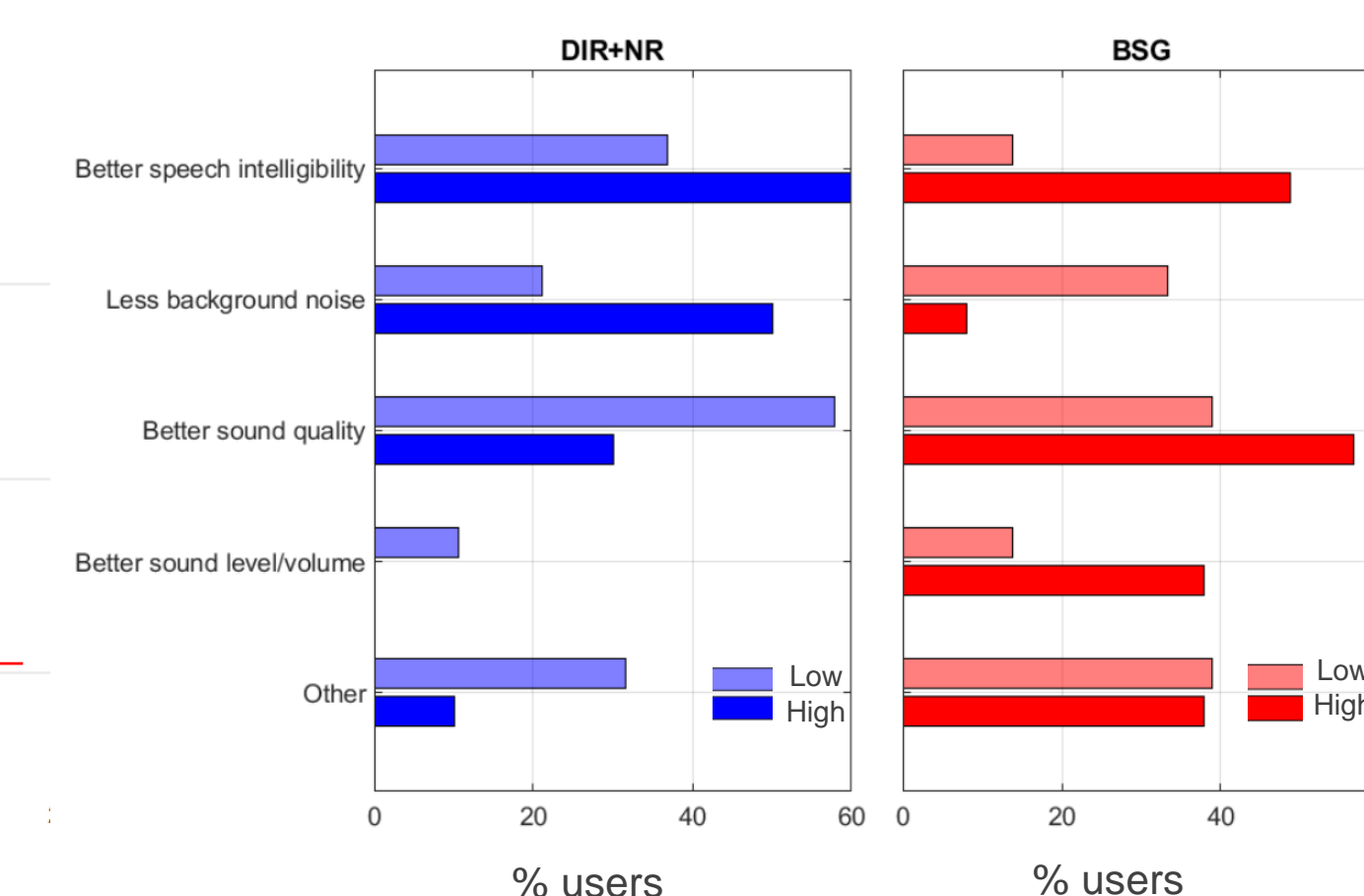


Figure 4: Reasons for high/low preference (for German users only) for the adaptive DIR+NR (left) or B+SG (right) settings. Derived from the structured interviews at the end of each FP (see Figure 1 (b)).

(Q2): Audiological factors driving DIR+NR preference in everyday speech-in-noise situations

- We modeled preference for better DIR+NR support based on (scaled) audiological predictors.
- When included together in the model, PTA4 and age were significant predictors of the DIR+NR preference, with positive and negative effects, respectively (Figure 5). Aided SRTs for DIR+NR off demonstrated a positive trend, though not reaching statistical significance.
- Cognitive changes associated with aging may influence DIR+NR preferences, however, the impact of age on these preferences should be interpreted with caution.

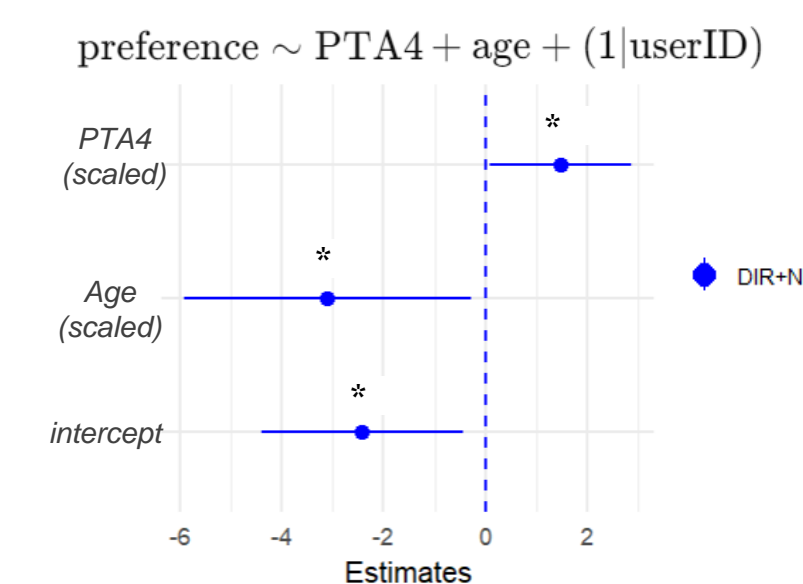


Figure 5: The estimated coefficients and 95% confidence intervals of the GLMM for predicting DIR+NR preference for better support from PTA4 and age.

Conclusions

- ~ 50% of the users complied with the self-reporting requirements, suggesting that novel methods should be explored that are designed to reduce the intrusiveness of the current self-report methods and to encourage more responses.
- Both DIR+NR and B+SG were found to have a dependency on the subjective noisiness of the environment (users reduced B+SG and increased DIR+NR in noisy situations). Adaptive systems in hearing aids should address these dependencies. The B+SG's significance in difficult situations highlights the need to better understand these scenarios for the individual user. Ongoing natural language analysis on open-text statements.
- For speech-in-noise situations, the PTA4 and age jointly influenced the DIR+NR preference, with older adults preferring less DIR+NR strength. These findings should be interpreted with caution as the analysis is based on a subgroup of study participants.

References

Bosman, A.J.; Christensen, J.H.; Rosenbom, T.; Patou, F.; Janssen, A.; Hol, M.K.S. Investigating Real-World Benefits of High-Frequency Gain in Bone-Anchored Users with Ecological Momentary Assessment and Real-Time Data Logging. *J. Clin. Med.* 2021, 10, 3923. <https://doi.org/10.3390/jcm10173923>

Pasta, A., Petersen, M.K., Jensen, K.J. et al. Measuring and modeling context-dependent preferences for hearing aid settings. *User Model User-Adap Inter* 32, 977–998 (2022). <https://doi.org/10.1007/s11257-022-09324-z>

Shinden, S., N. Suzuki, N. Oishi, D. Suzuki, S. Minami, and K. Ogawa. (2021). Effective sound therapy using a hearing aid and educational counseling in patients with chronic tinnitus. *Auris Nasus Larynx*, 48(5), 815-822.

Suzuki, D., Nishiyama, T., Tanaka, C., Santurette, S., Zapata-Rodriguez, V., Oishi, N., Hosoya, M., Fujita, H., Wakabayashi, T., Tsuzuki, N., Ueno, M., Shimanuki, M., Kitama, T., Ogawa, K., & Shinden, S. (2023). ISAAR 2023 poster. Personalizing hearing-aid accommodation and gain settings based on speech recognition with the Utsunomiya method of hearing rehabilitation: Clinical outcomes in Japanese patients

Vatti, M., Vølund, A.K., Ihly P., Nishiyama, T., Tanaka, C., Zaar, J., Laugesen, S., Jones, G., Suzuki, D., Kitama, T., Ogawa, K., Tchorz, J., Shinden, S., Jürgens, T., Santurette, S. (2024). Real-life preferences of hearing-aid users for adjustment of advanced features. WCA 2024 ePoster.

Zaar, J., Simonsen, L.B., and Laugesen, S.(2024). "A spectro-temporal modulation test for predicting speech reception in hearing impaired listeners with hearing aids", *Hearing Research* 443.