Individual factors underlying preference for processing delay in open-fit hearing aids

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INTRODUCTION

In open-fit hearing aids (HAs), the processing delay determines the magnitude of the comb-filter effect that arises from the interaction between the processed and direct sound [1] (Fig. 1). It is an essential factor for perceived HA sound quality. Given that research has shown clear individual differences in preferred processing delay [2], the aim of the current study was to investigate if:

1. Frequency selectivity is related to preference for processing delay
2. Temporal processing is related to preference for processing delay

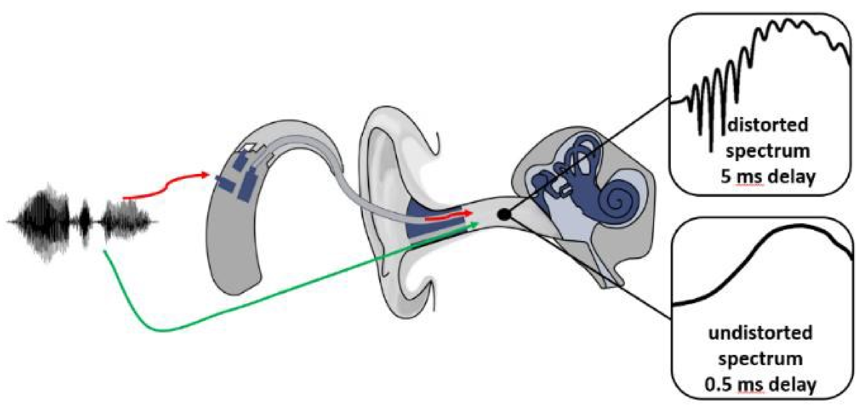

Fig 1. Illustration of comb-filter effect with a typical (5 ms) and short (0.5 ms) processing delay

METHOD

Participants

- 10 with normal hearing (NH) as reference group
- 20 with mild-to-moderate sensorineural hearing losses (HL) (Fig. 2)

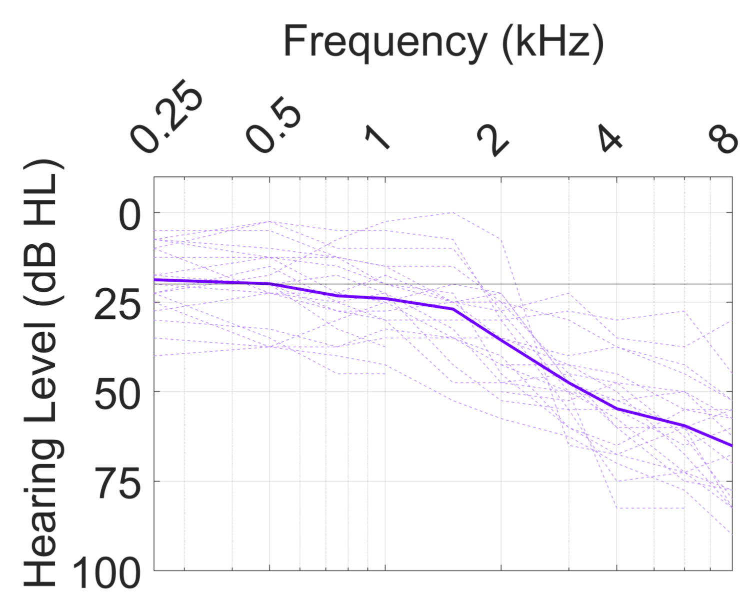

Fig 2. Average audiometric thresholds for HL group

Tests

- Preference for processing delay
- Frequency selectivity assessed using spectral ripple discrimination (SRD)
- Temporal processing assessed using gap detection thresholds (GDT)

Preference task

- Paired comparison task
- Three stimuli: (1) Rain on an umbrella, (2) male talker, and (3) ping-pong ball

SRD and GDT

- Three-alternative forced choice procedure with 1-up 2-down tracking rule [5]
- White noise bandpass-filtered from approx. 400-1300 Hz

Signal processing

HA simulator

- Frequency-independent processing delays of 0, 0.5, 2, 5, and 10 ms
- Signals generated using a realistic simulation of an open-fit HA [3]

Linear amplification

- HL group: Individual insertion gains (IGs) as per NAL-NL2 rule at 65-dB-SPL input level
- NH group: IGs for N2 standard audiogram [4] as per NAL-NL2 rule at 65-dB-SPL input level. Presentation level fixed to 65 dB SPL.

RESULTS

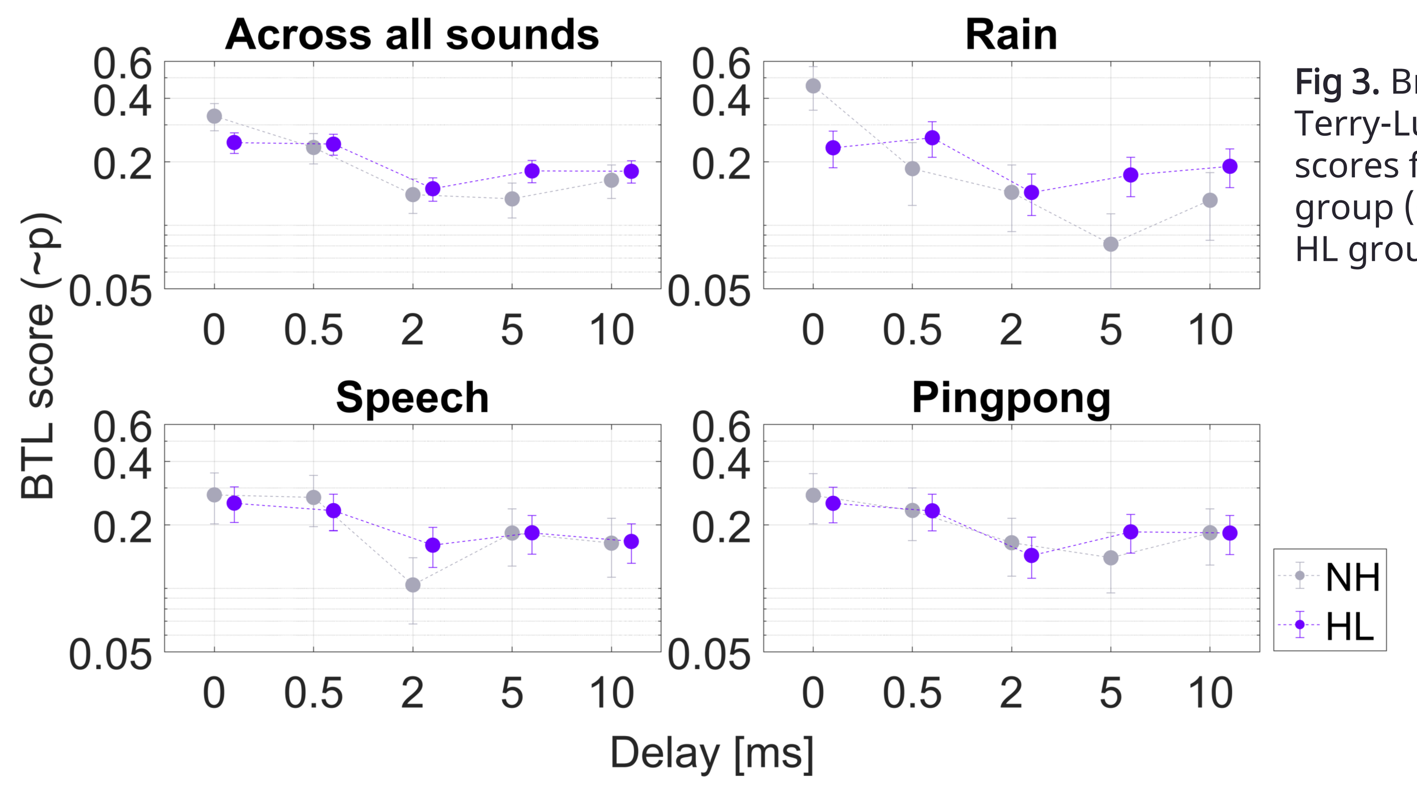

Fig 3. Bradley-Terry-Luce (BTL) scores for NH group (gray) and HL group (purple)

Delay preference

- Linear mixed-effects model with BTL score as dependent variable and stimulus type, hearing status and processing delay as predictors
- The model was analyzed with a type-III ANOVA showing a main effect of processing delay, $F(4, 109.9) = 14.23, p < 0.001$
- No effects of hearing status or stimulus type. In the following analyses, the data were therefore pooled across stimulus type and hearing status (NH and HL).

RESULTS cont'd

- Paired comparisons using estimated marginal means with Bonferroni correction (Fig. 4)
- Based on the results, the data for 0 and 0.5 ms ("ShortDelay"), as well as for 2, 5, and 10 ms ("LongDelay") were pooled.

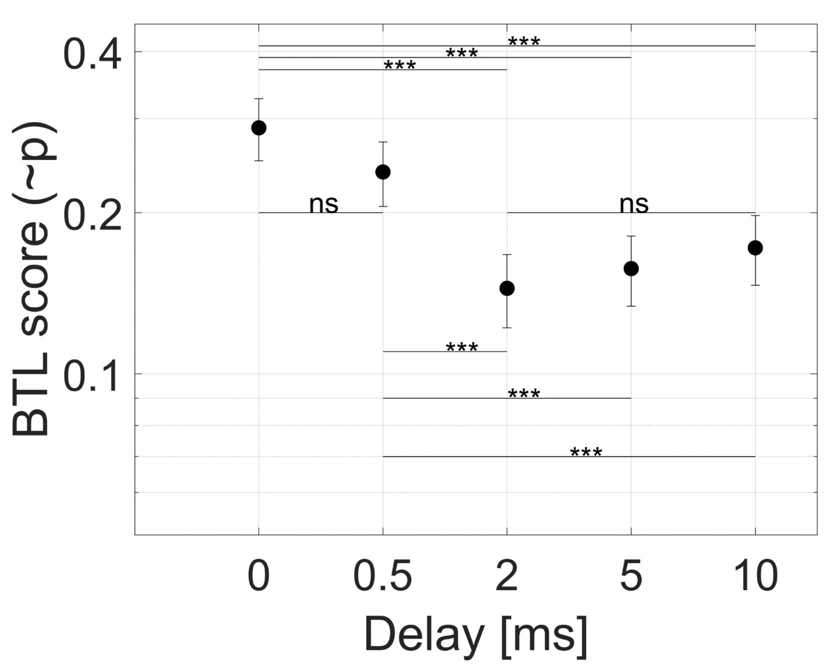

Fig 4. Results of post-hoc analysis for NH and HL group combined

Identification of HL group with good spectral and temporal processing abilities

- *SRD*: The NH group had a mean of 56.6 Hz (range: 42.3-68.8 Hz). The HL group had a mean of 91.9 Hz (range: 57.5-208.3 Hz) (Fig. 5a).
- *GDT*: The NH group had a mean of 7.5 ms (range 6-6.8 ms). The HL group had a mean of 8.8 ms (range: 6.1-12 ms) (Fig. 5b).

- The HL group was split into two groups with reference to the NH data. "Good" HL data were within the NH range.
- Seven HL participants ("goodSRD") had SRD thresholds within the NH range
- 10 HL participants ("goodGDT") had GDTs within the NH range

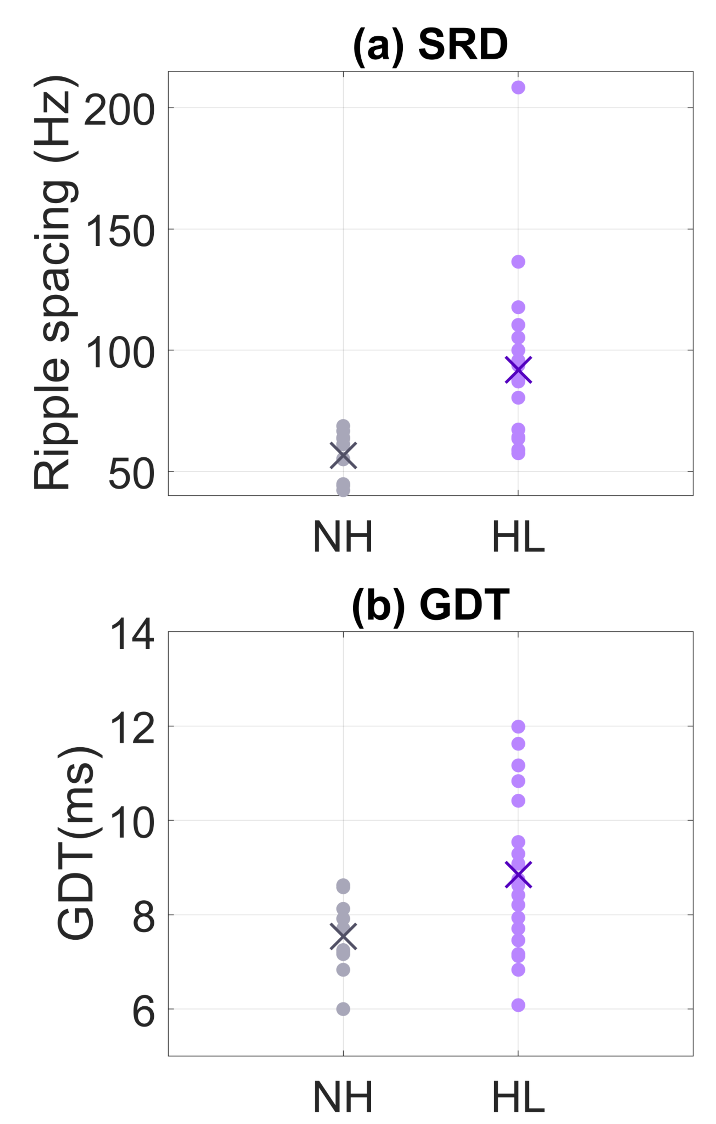

Fig 5. SRD thresholds (a) and GDTs (b) for NH group (gray) and HL group (purple).

Relationship between spectral and temporal processing and delay preference

- The relationship between SRD and delay preference was analyzed using a contingency table analysis (Table 1). A chi-squared test showed a *significant association* between SRD and delay preference, $\chi^2(1) = 11.12, p < 0.001$.
- The relationship between GDT and preference for delay was analyzed in the same manner (Table 2). No association between GDT and delay preference was found, $\chi^2(1) = 0.14, p = 0.71$.

Table 1. Contingency table, frequency selectivity

			Expected Frequency		
Pref.	Short delay	Long delay		Short delay	Long delay
Good SRD	249 (66%)	129 (34%)	Good SRD	223.3	154.7
Bad SRD	389 (55%)	313 (45%)	Bad SRD	414.7	287.3

Table 2. Contingency table, temporal processing

			Expected Frequency		
Pref.	Short delay	Long delay		Short delay	Long delay
Good GDT	322 (60%)	218 (40%)	Good GDT	319	221
Bad GDT	316 (59%)	224 (41%)	Bad GDT	319	221

DISCUSSION AND CONCLUSIONS

- Overall, the HL group showed a stronger preference for shorter processing delays (i.e., 0 and 0.5 ms) than for longer ones
- When dividing the HL group based on their spectral and temporal processing abilities, participants with good frequency selectivity preferred shorter delays significantly more than participants with poorer frequency selectivity
- No association between delay preference and temporal processing abilities was found
- These results are well explained by previous findings showing that colorations perceptually dominate for delays up to 12 ms [e.g., 6]

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