For that reason, the current study measured sequential modulation masking, or SMM. These results suggest that some mechanism other than forward masking alone is responsible for how listeners respond to fluctuations. Specifically, for listeners with hearing loss (HI), the amount of unmodulated LFN forward masking was larger for listeners with hearing loss than for those with normal hearing (NH). This suggests that some mechanism other than forward masking alone is responsible for how listeners respond to fluctuations. Specifically, for listeners with hearing loss (HI), the amount of unmodulated LFN forward masking was larger for listeners with hearing loss than for those with normal hearing (NH).

### Methods

#### Participants

- NH: n = 10, Age: 19–30
- HI: n = 10, Age: 29–70

Listeners were compensated for their participation.

#### Procedure and Data Analyses

**Preparation**

- Both unmasked and masked MDTs were measured using a 3FC, 3-step, 1-up/1-down procedure in the modulation domain and depth and tracking the 75% correct point on the psychometric function.
- Maskers were one of four fluctuation levels. For the masker signal, 12 levels were measured, completing the trial: 12 levels. The average of the signal was 2 dB at the beginning of each trial, decreasing by 4 dB after two correct answers, and increasing by 4 dB after one incorrect answer. All other levels were measured with 2 dB below the level. The listeners were given an EMD to estimate MDT.

**Stimuli**

- Stimuli were generated at a sampling rate of 44.1 kHz. An audioclip was used as a reference tone of 500 Hz, and presented nondistorted to the listener through a Tucker-Davis Technologies (TDT) HDD headphone buffer driving a Sennheiser HD800 circumaural headphones.

**Data Analyses**

- For the Continuous Carrier condition, effects of carrier frequency (1000, 4000 Hz) and masker signal (05, 100, 200 ms) were assessed with a repeated-measures ANOVA in SPSS using the general linear model, including one with-subjects factor (NH vs. HI).
- For the Non-Continuous Carrier condition, results of each of the four conditions were treated as a level of within-subjects factor (NH, U-GN, U-LFN, U-LFN). For the repeated measures ANOVA, including one between-subjects factor (HI vs. NH).

**Results**

- Masked MDTs were significantly better at 1000 Hz than at 4000 Hz for both groups.
- Two-way effects of Carrier Frequency (F[1,12] = 20.898, p < 0.005) and Masker Signal Delay (F[1,12] = 5.1, p < 0.05).
- A significant three-way interaction of Masker Signal Delay × Listener group (F[2,24] = 3.584, p < 0.05), suggesting the slightly steeper slopes of recovery for HI than NH listeners may be driving this interaction at both 1000 (NH = 0.22, HI = 0.05) and 4000 Hz (NH = -2.03, HI = -0.4).
- No overall effect of signal delay (F[1,12] = 0.8, p > 0.05).

**Post-hoc tests**

- For planned comparisons:
  - Unmasked MDTs for the Continuous Carrier were better for HI than NH listeners at both 4000 Hz (p<0.05) and 1000 Hz (p>0.05).
  - No differences between NH and HI listeners for any of the masked conditions (p>0.05).

**Discussion**

- For AM forward masking, the physical level of the signal is not changing, only its modulation depth. It has been shown that, due to the linear response of the basilar membrane, listeners are not as well equipped to detect amplitude modulations of a signal at threshold levels.

- In the situation, the linear response of the basilar membrane may actually aid the HI listeners in detecting the peaks and valleys of subtle amplitude modulations. At an overall level of 80 dB SPL, both HI and NH listeners were subjected to stimuli that were well above hearing thresholds.

**Conclusions**

1. AM forward masking was observed for both HI and NH listeners, with no differences between groups.
2. For the unmasked continuous carrier conditions, better MDTs were yielded for HI than NH listeners.
3. For the masked continuous and non-continuous carrier conditions, NH and HI listeners performed similarly, suggesting there is little effect of hearing loss on the magnitude of AM forward masking.
4. For the masked continuous carrier conditions, unmodulated GN yielded significantly more masking than the unmodulated LFN, suggesting that inherent masker envelope fluctuations contributed to the amount of AM forward masking across listener groups.
5. The continuous carrier resulted in better masked modulation for the AM-modulated LFN than the non-modulated carrier, suggesting that AM forward masking is increased by the envelope modulation resulting from gating the carrier.

**Future Directions**

- Because temporal cues are relatively robust for this group of HI listeners, investigating the effects of multi-channel compression, as a filter prescribed for a hearing aid fitting formula, for these same conditions may allow for examining whether or not compressed output of a hearing aid optimizes these cues.

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