# Neural Mechanisms Underlying the Benefit of Using Noise Reduction Algorithms in Hearing Aids

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## Introduction

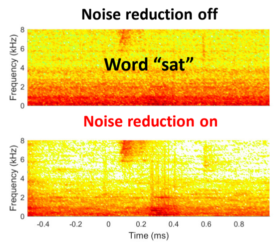
- Difficulty understanding speech in noise is one of the most common complaints from hearing aid (HA) users.
- We can consider applying noise reduction (NR) algorithms, such as spectral subtraction. However, since the speech signal and noise are mostly overlapped in the spectral domain, NR attenuates noise at the cost of distorting speech cues [1, 2].
- Individual differences in NR preference exist; people have different susceptibility to background noise or speech distortion [3].

**Questions:**

1. Group-level efficacy: NR effect on both 1) neural processing and 2) outcomes?
2. Clinical suggestions for individuals: Who gets benefits from NR?

**Study goals:**

1. Find neural markers of good vs. poor speech-in-noise perception (without NR).
2. Test the effect of NR and explore the neural correlates of individual differences in NR benefits




## Study 2.1: Testing the effect of noise reduction on neural processing

**Subjects**: 36 normal-hearing adult listeners

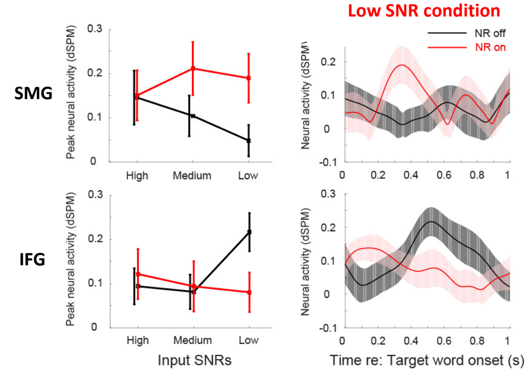
**Tasks**: CVC monosyllabic words in speech-shaped noise with 2 NR conditions (off vs. on) and 3 SNR conditions (SNR at speech reception threshold (SRT)-70, ±3 dB)

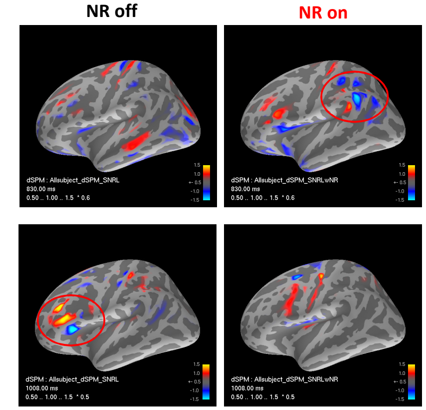
**NR**: A modified spectral subtraction-based NR: Ephraim & Malah algorithm [5].

**Aim**: Within-subject design study to characterize the effect of NR on cortical processing during speech-in-noise tasks

**Hypotheses:**

Listening with NR is more likely to generate strong activity in the earlier region (SMG) and weak activity in the later region (IFG) compared with no NR.




**NR alters cortical processing; 1) Greater short-latency activity in temporal cortex 2) Reduced frontal long-latency activity.**

## Study 1: Find neural markers of good vs. poor speech-in-noise perception [4]

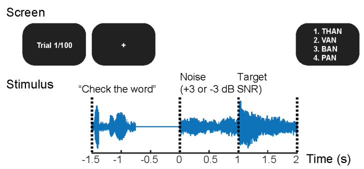
**Subjects**: 26 normal-hearing adult listeners

**Tasks**: CVC monosyllabic words in multi-talker babble noise with 2 signal-to-noise ratios (SNRs) (±3 dB)

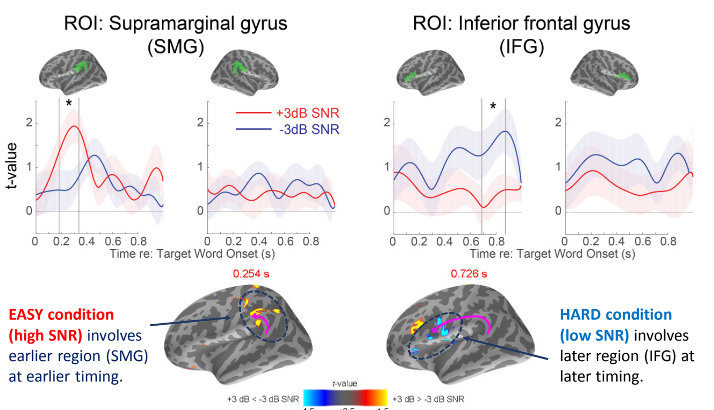
**Aim**: Within-subject design study to characterize SNR effect on cortical processes for speech-in-noise recognition

**Hypotheses:**

- In easy condition according to highest input SNR (+3 dB), listeners will show strong early activity in the earlier region (supramarginal gyrus: SMG).
- In hard condition, listeners will show strong late activity in the later region (inferior frontal gyrus: IFG).




**Results:**



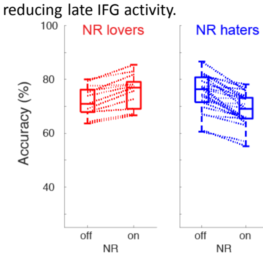

**Hypothesis for study 2.1: NR can change the cortical pattern as it reduce the noise level.**

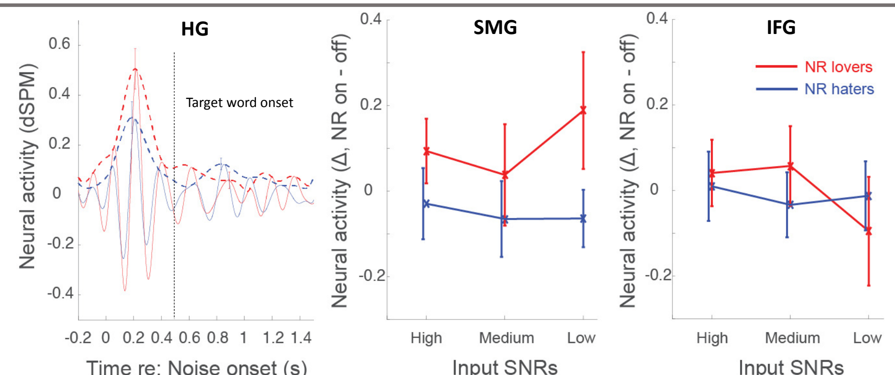
## Study 2.2: Neural correlates of individual differences in noise reduction benefits

**Aim**: Identify factors that predict individual differences in NR outcome.

**Hypotheses:**

People with weaker speech unmasking indexed by Heschl's gyrus (HG) activity will appreciate NR more, showing the effect of NR in enhancing early SMG activity and reducing late IFG activity.




**NR lovers and haters, divided based on accuracy performance, show different speech unmasking ability.**

**NR benefits on neural processing at SMG and IFG were more evident from NR lovers.**

## Discussion and Conclusion

- The benefits of NR can be measured objectively using electroencephalography in such a way that the optimal NR configuration for a given listener would invoke the cortical processing that the reduced noise level can generate in normal-hearing listeners.
- In study 1, we found that the low-level noise (i.e., increased signal-to-noise ratio (SNR)) resulted in an "ideal" pattern of the cortical processing at SMG and IFG.
- In study 2.1, NR alters cortical speech-in-noise processing: More immediate processing through temporo-parietal route.
- In study 2.2, listeners' speech-unmasking ability predict the benefits of NR, in a way that listeners with poorer speech-unmasking exhibit greater NR benefits.
- By understanding how NR affects cortical processing during speech-in-noise recognition, clinicians can provide better NR configuration in an objective manner for each listener.

## References

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