

# Bimodal listening effort in cochlear implant recipients

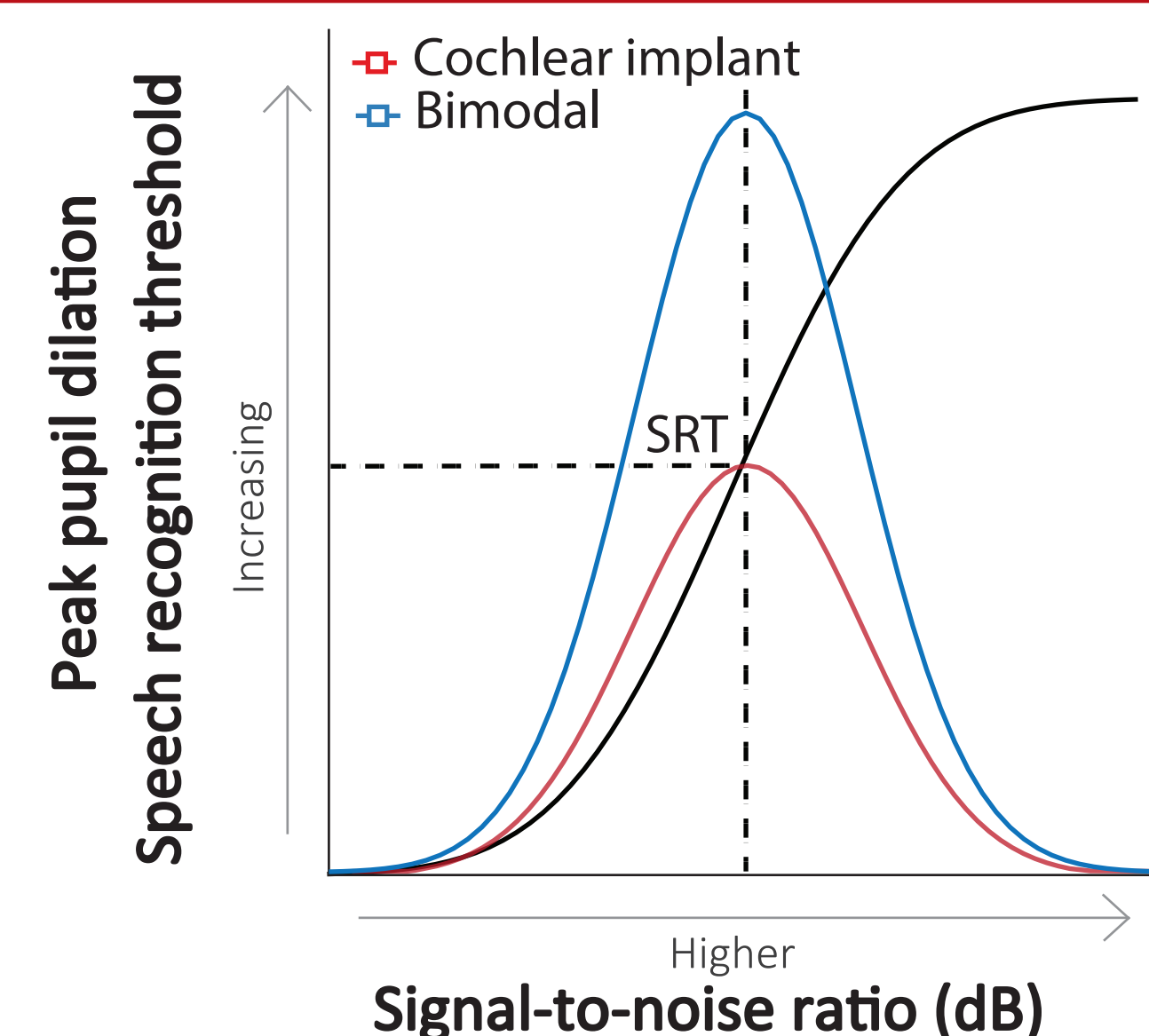
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## INTRODUCTION

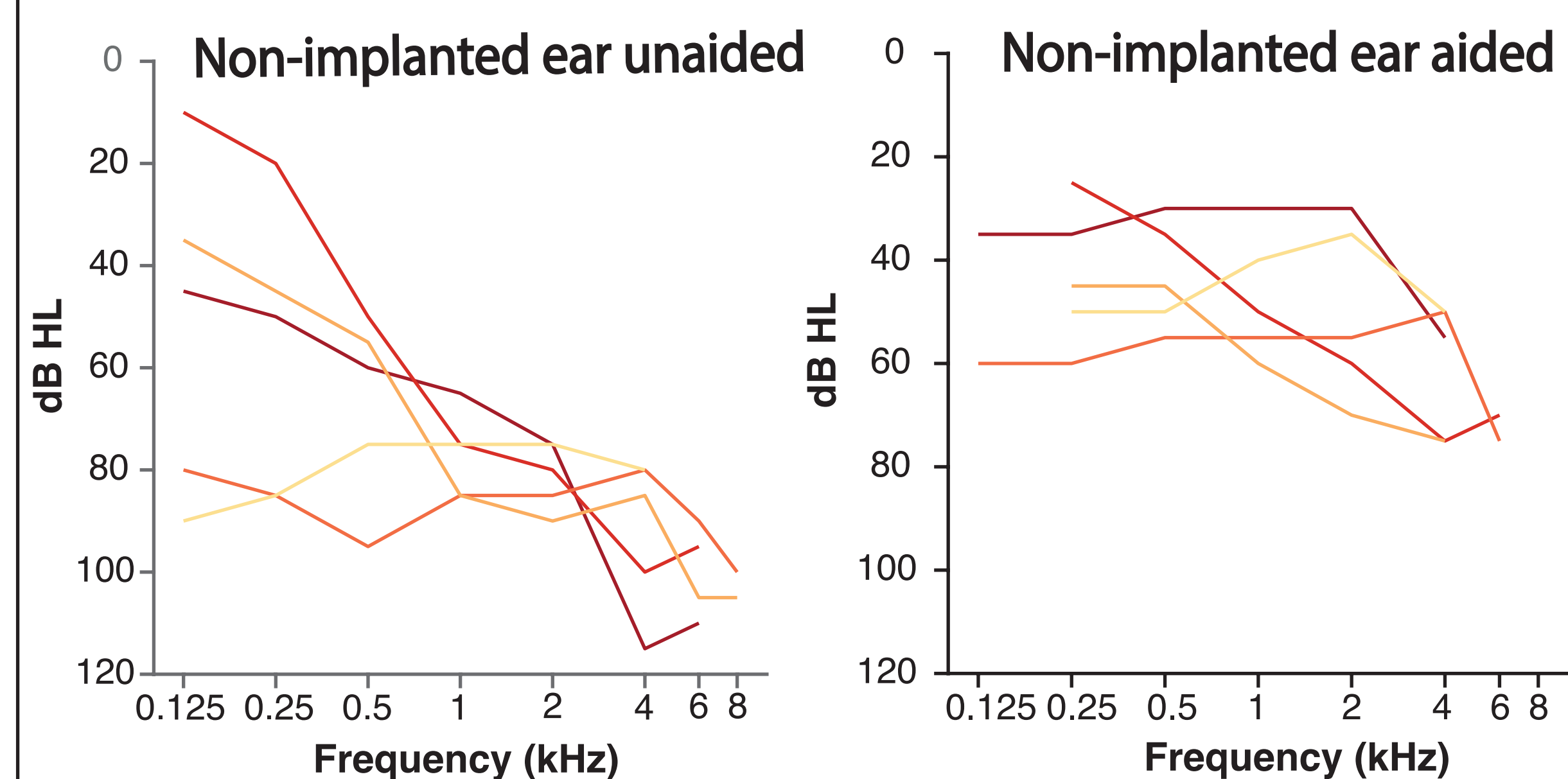
Pupillometry as an objective measure of listening effort continues to gain popularity in the hearing research domain. For cochlear implant (CI) users, discrepancies between listeners' perceived effort and physiologically indicated effort by measures of pupil dilation are of interest to improve speech recognition outcomes.

An earlier study on single-sided deafness suggests that individuals with both electric and acoustic amplification experience binaural interference<sup>1</sup>. We test this in a pilot study in newly implanted bimodal users, who have very different modes of stimulating the cochlea, i.e. a CI in one ear and a hearing aid (HA) in the other. Maximum effort should be elicited by peak pupil dilation (inverted U-shape) at 50% correct speech recognition threshold (SRT).

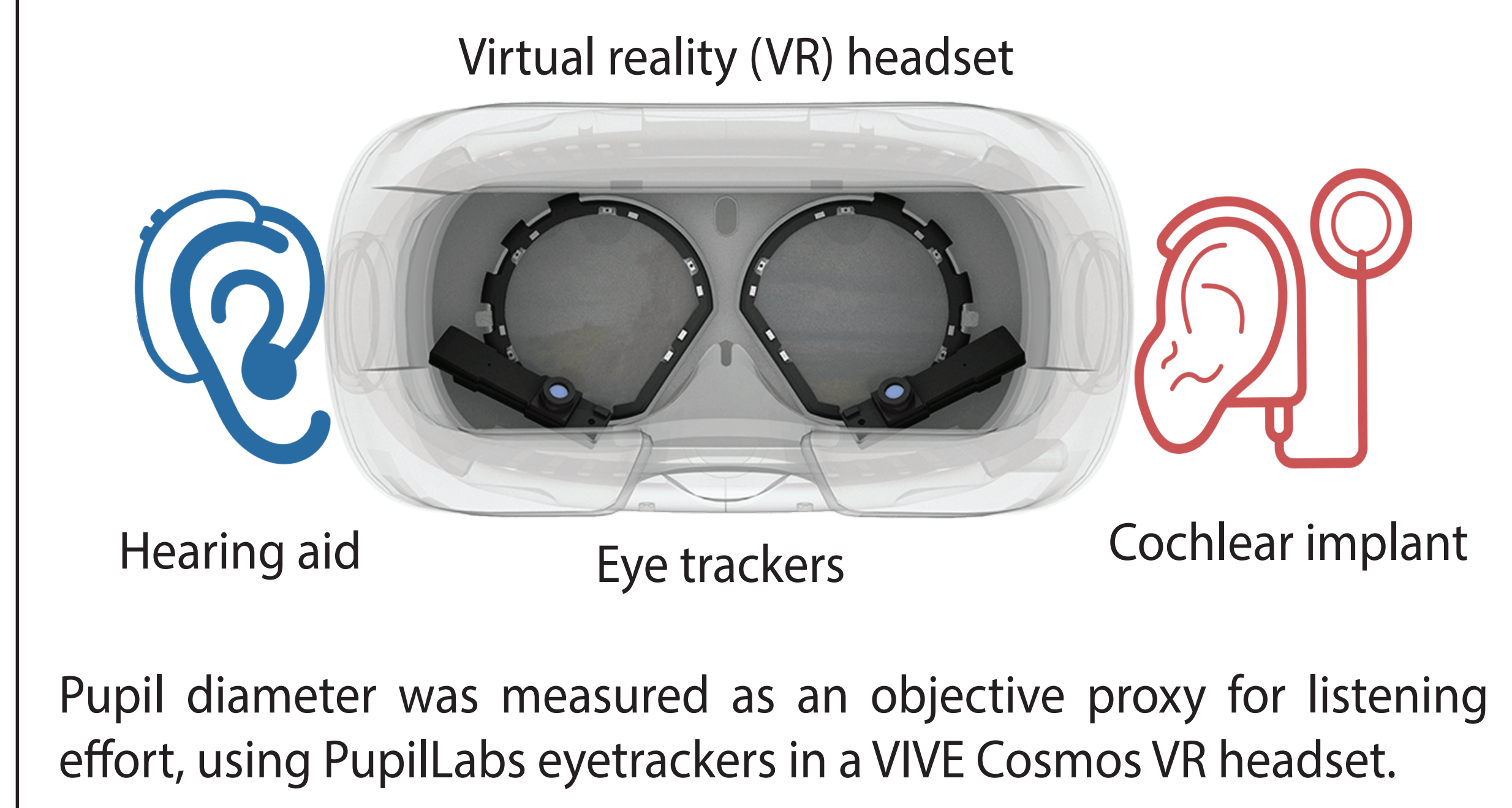


## METHODS

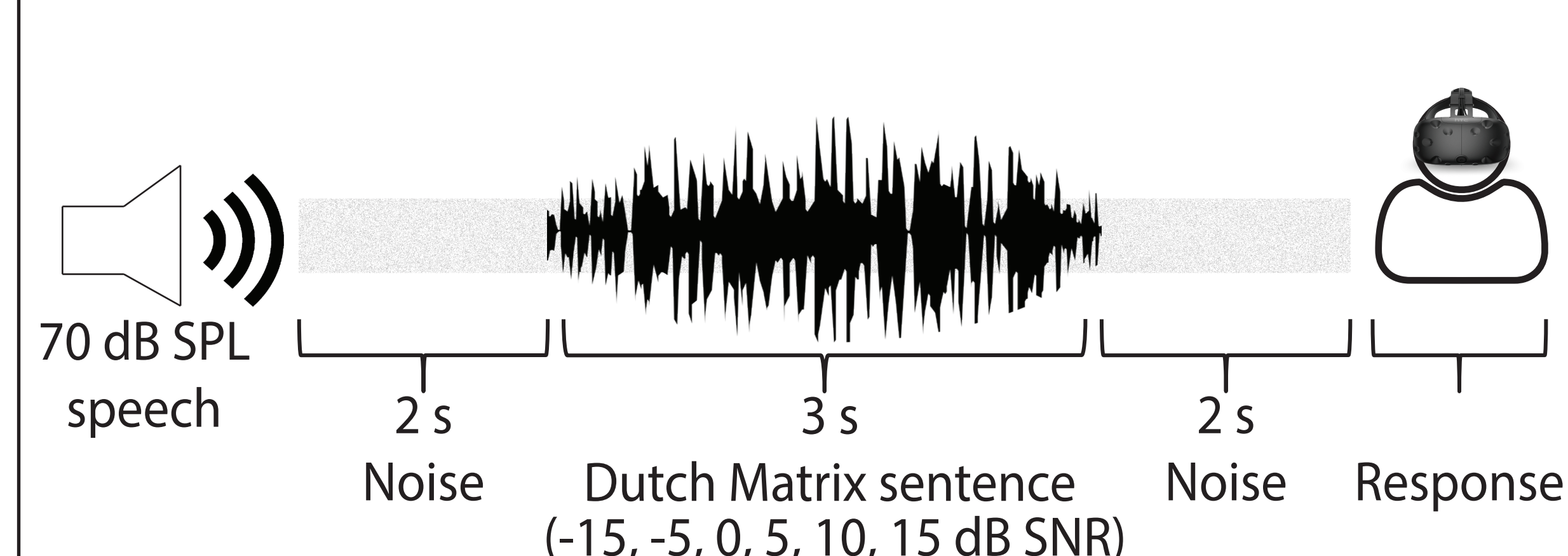
### PARTICIPANT DEMOGRAPHICS



### PUPIL TRACKING



### SPEECH RECOGNATION IN NOISE

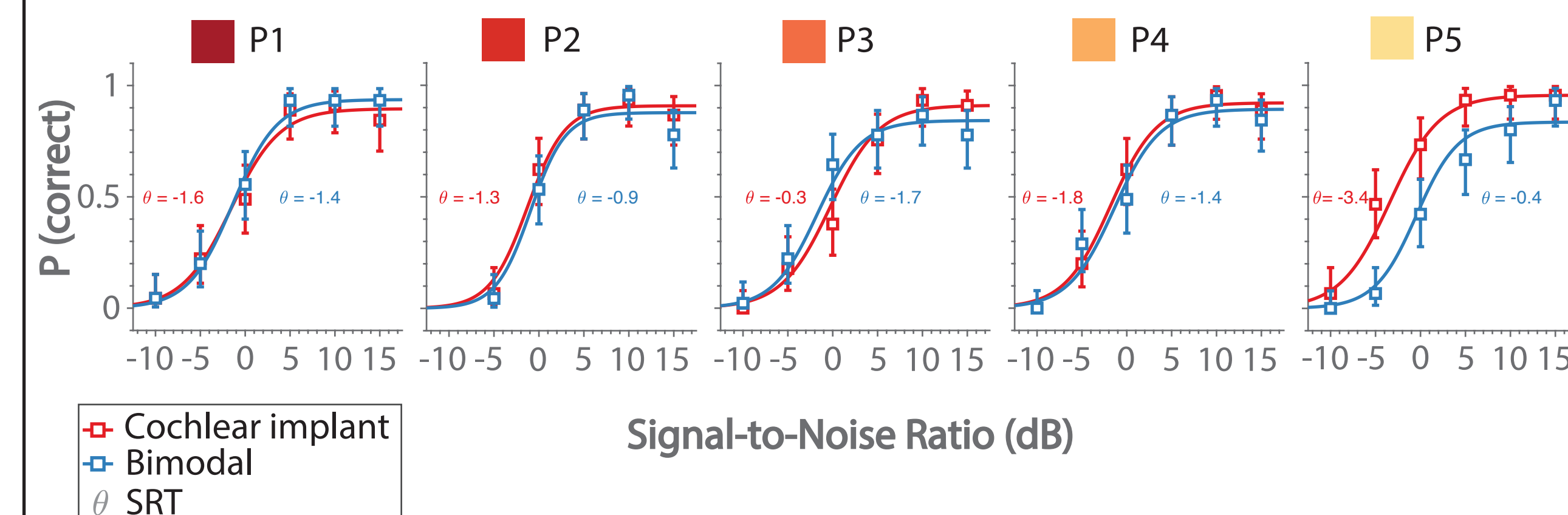


Speech recognition was measured using the Dutch Matrix test. 10 sentences were presented in six consecutive blocks, with each new block at a lower signal-to-noise ratio (SNR). All measurements were conducted in two conditions: hearing aid & cochlear implant (bimodal) and cochlear implant alone, in that order.

Participants were asked to rate "On a scale of 0-10, how effortful were those 10 sentences for you?"

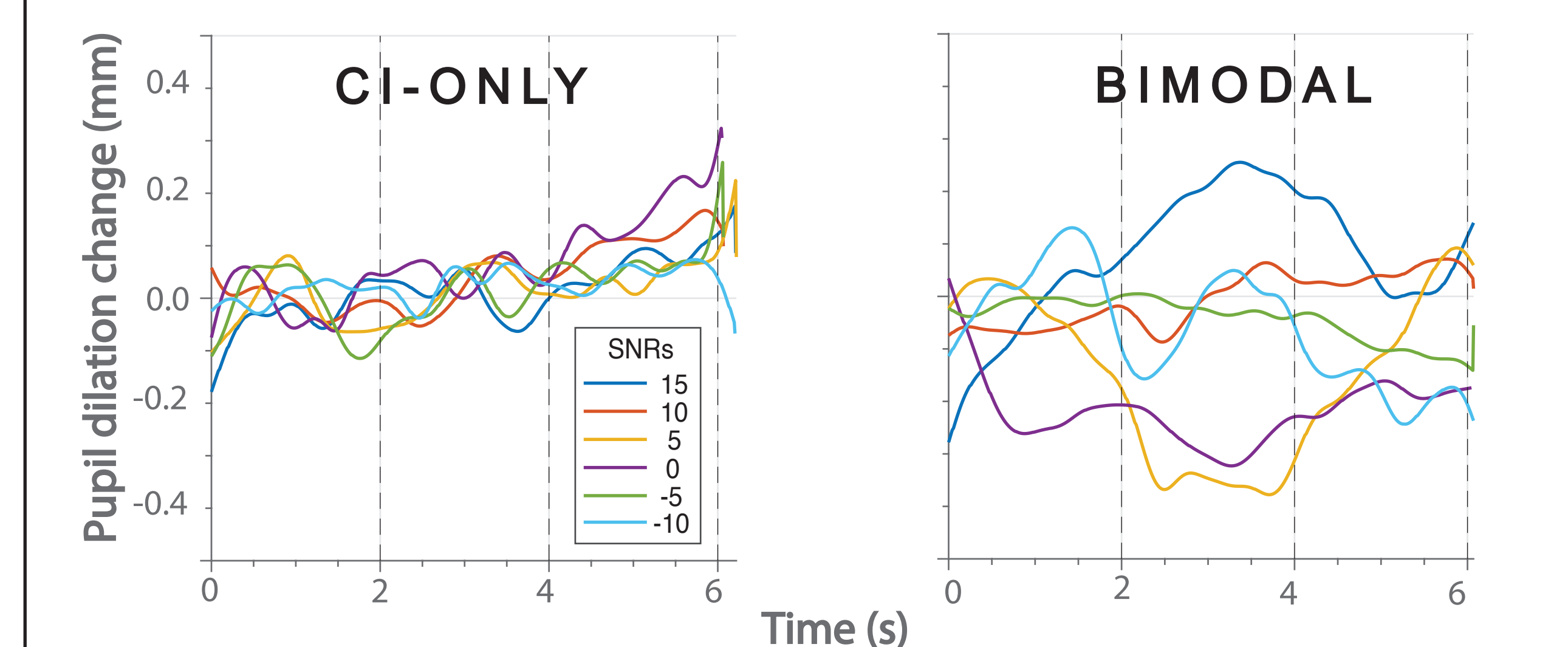
## RESULTS

### SPEECH RECOGNITION



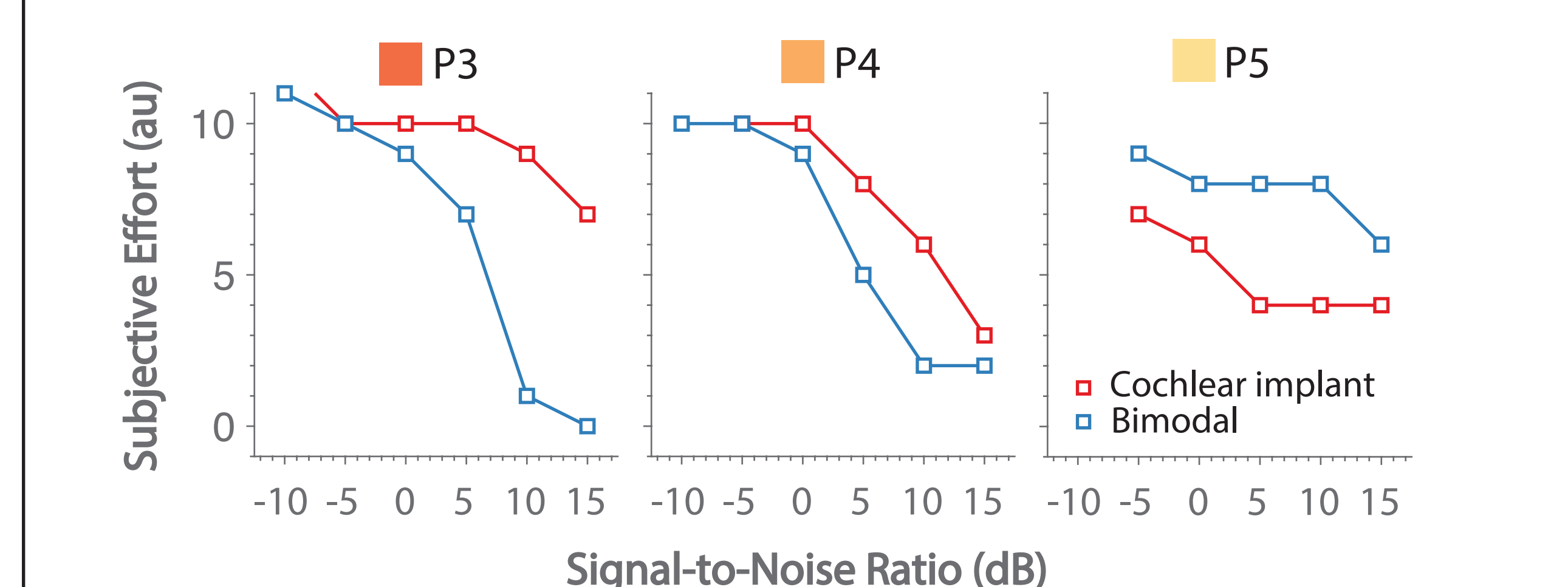
All five listeners were good performers with thresholds around -1 dB. P5 had the best threshold (-3.4 dB) when listening with a CI only. Bimodal listening worsened speech recognition accuracy for this listener.

### PUPIL DILATION



Pupil diameter measurements were of low quality for the majority of participants. For P1 (who had good quality data), pupil dilation changes were more variable for the bimodal listening condition.

### SUBJECTIVE EFFORT



Subjective effort monotonically decreased with increasing signal-to-noise ratio. P5 reported bimodal listening as being more effortful, which corresponds with speech recognition accuracy.

## DISCUSSION

Bimodal listening does not appear to improve speech recognition in noise. Pupil size variation is only observed in the bimodal condition and not the CI-only condition.

We hypothesize that listening effort is maximal for the CI ear at all signal-to-noise ratios, where objective effort (pupil dilation) is a flat line. Subjective effort may reflect other variables, such as performance and listening mode.

This is currently being tested in a larger study population. Participants will also be retested at 12 months post-implantation to look for changes in listening effort and speech recognition performance.

<sup>1</sup> Ausili, S. A., Backus, B., Agterberg, M., van Opstal, A. J., & van Wanrooij, M. M. (2019). Sound Localization in Real-Time Vocoder Cochlear-Implant Simulations With Normal-Hearing Listeners. Trends in Hearing, 23, 2331216519847332. <https://doi.org/10.1177/2331216519847332>