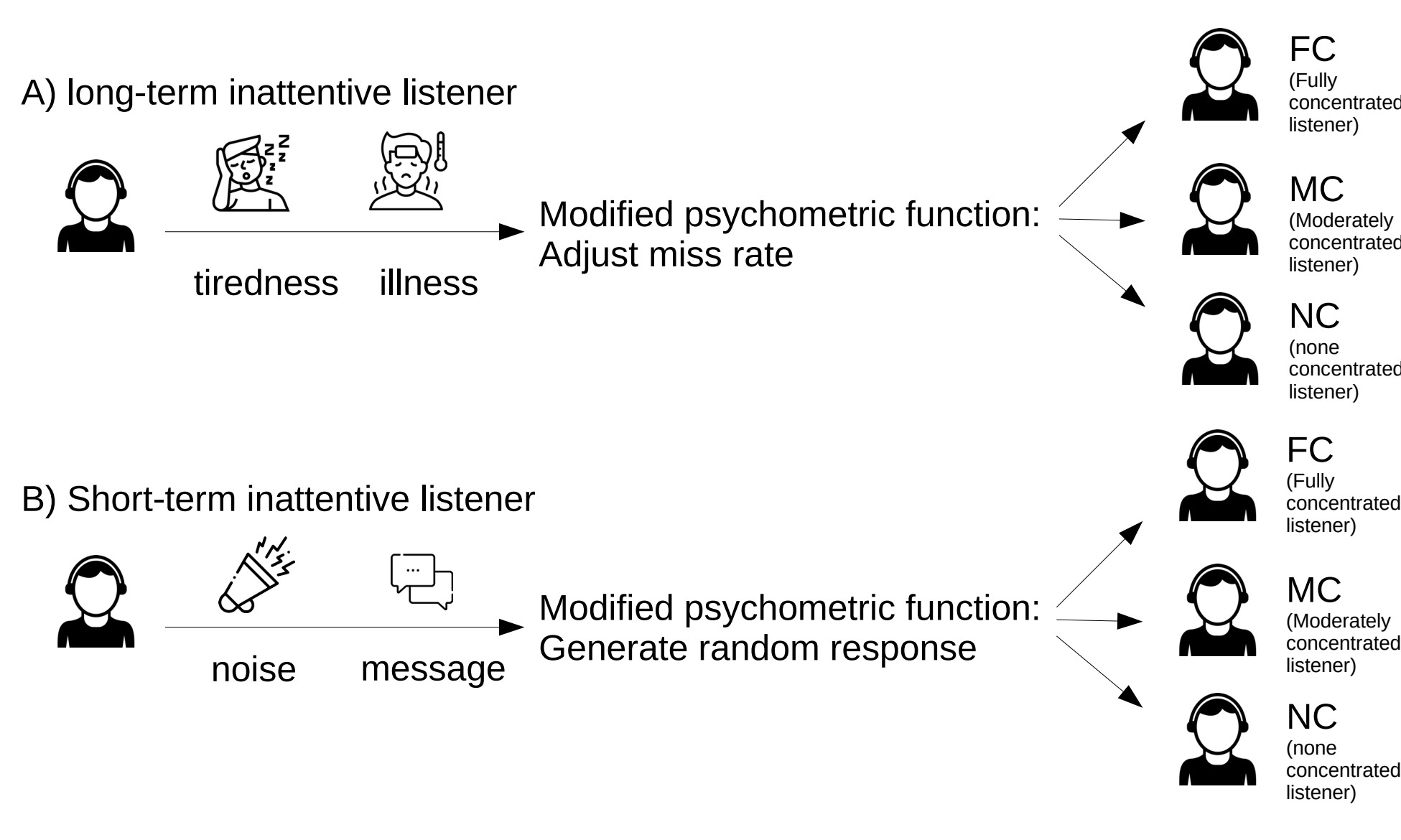


## INTRODUCTION

Mobile devices may provide an easy access to hearing tests, such as threshold measurements. However, measurements with mobile devices are subject to more disturbances than well-controlled measurements in the lab. Such distracting disturbances may originate from the environment (fluctuating background noise, incoming messages or telephone calls) or from the listeners themselves (e.g., variations in motivation or attention or tiredness). Therefore it is necessary to design, validate and apply robust and efficient adaptive procedures for mobile threshold measurement that are largely unaffected by distracting disturbances.

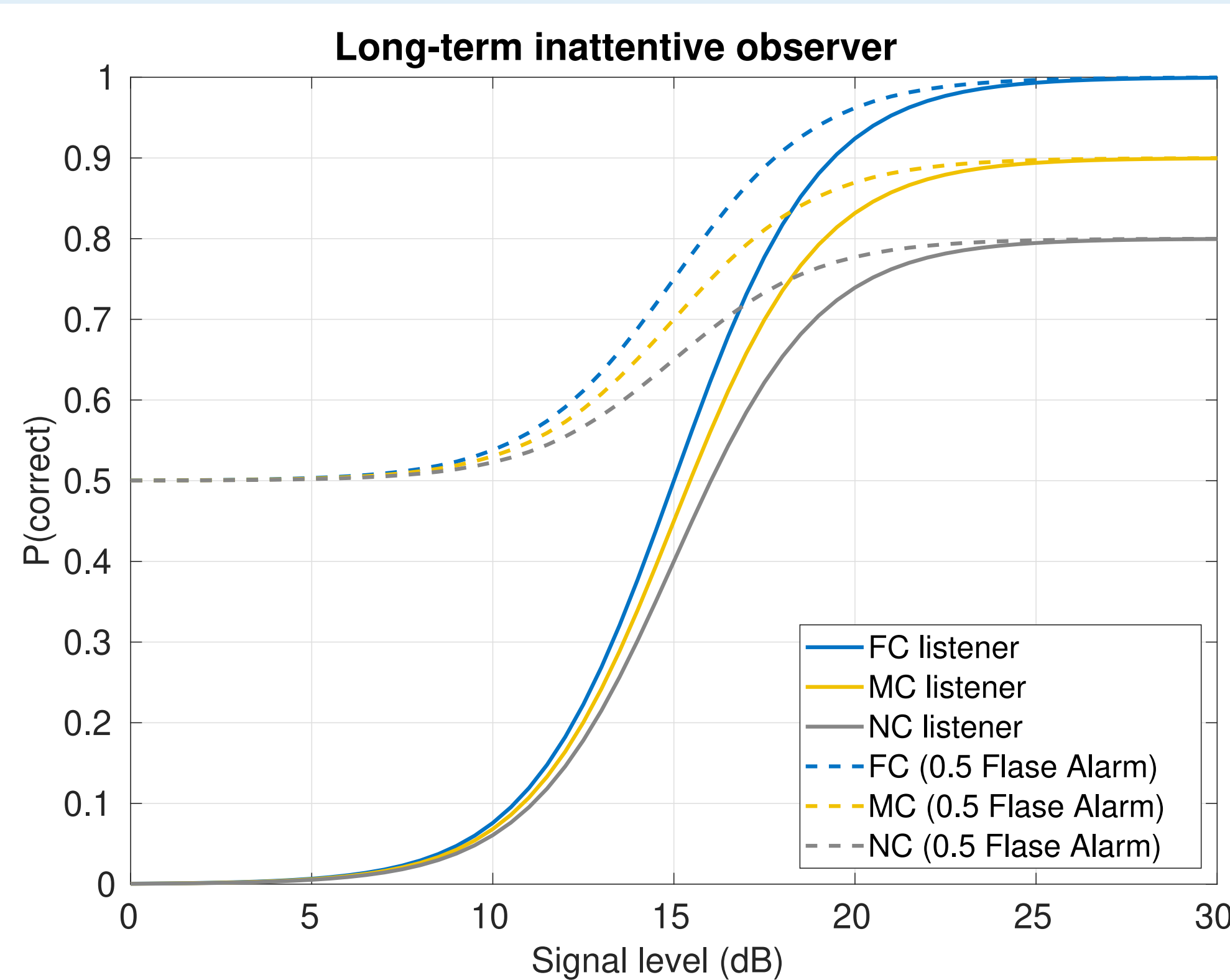
## INATTENTION MODEL



- Fully concentrated listener: normal psychometric function

$$p(L) = p_{max} / (1 + \epsilon^{-s(L-L_{50})})$$

- 1000 Monte Carlo (MC) simulations
- Robustness: threshold estimates  $L_{50}$  (N is approximately 50 for all adaptive procedures, same starting level, same target threshold)
- Efficiency: standard deviation of  $L_{50}$  plotted as a function of number of trials



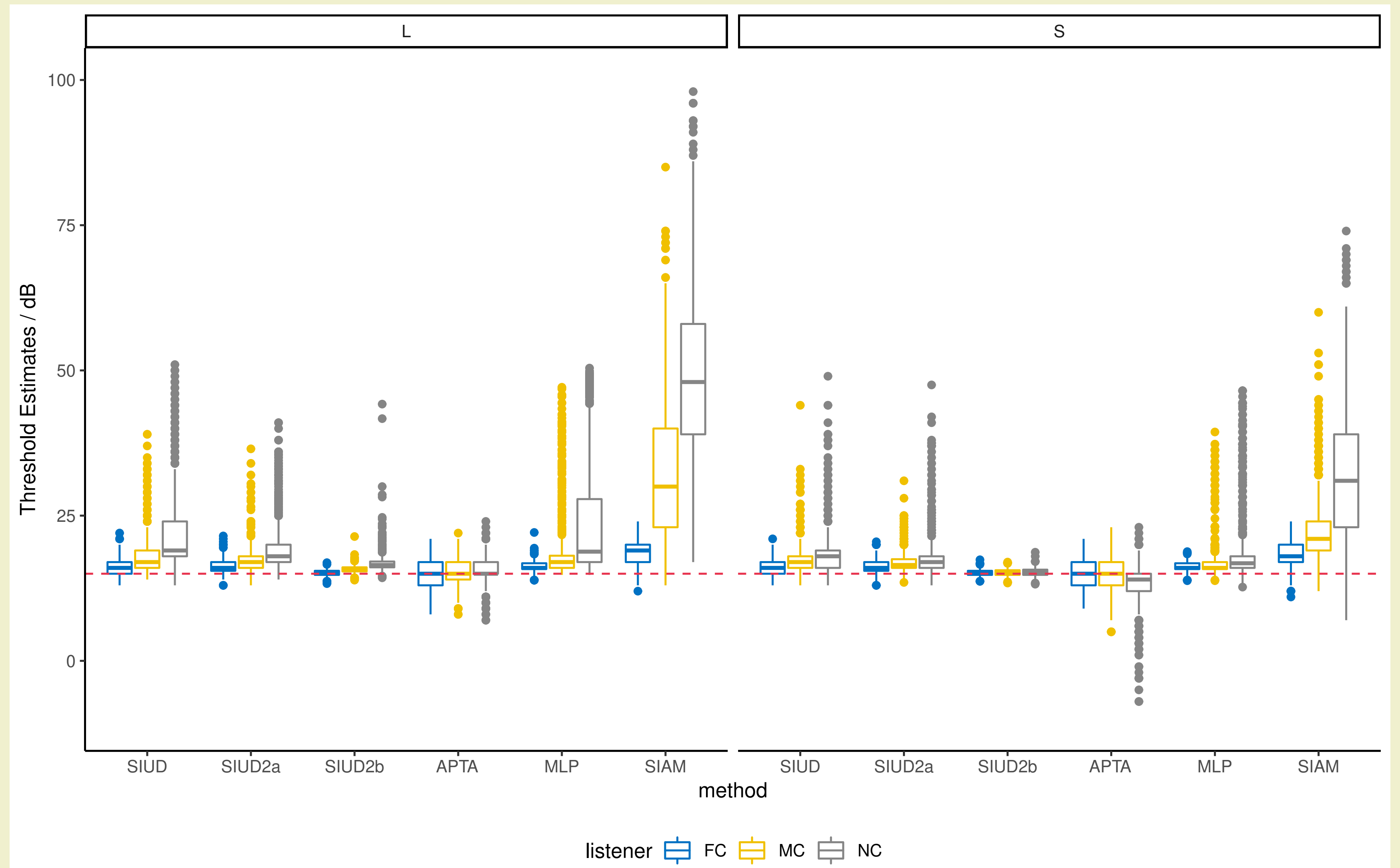
Adaptive Procedure	Reference
Maximum-Likelihood Procedure	MLP [1]
Automated Pure-Tone Audiometry	APTA [2]
Single-Interval Adjustment Matrix	SIAM [3]
Single-Interval Up and Down	SIUD [4]
SIUD2a/SIUD2b	—

## CONCLUSION

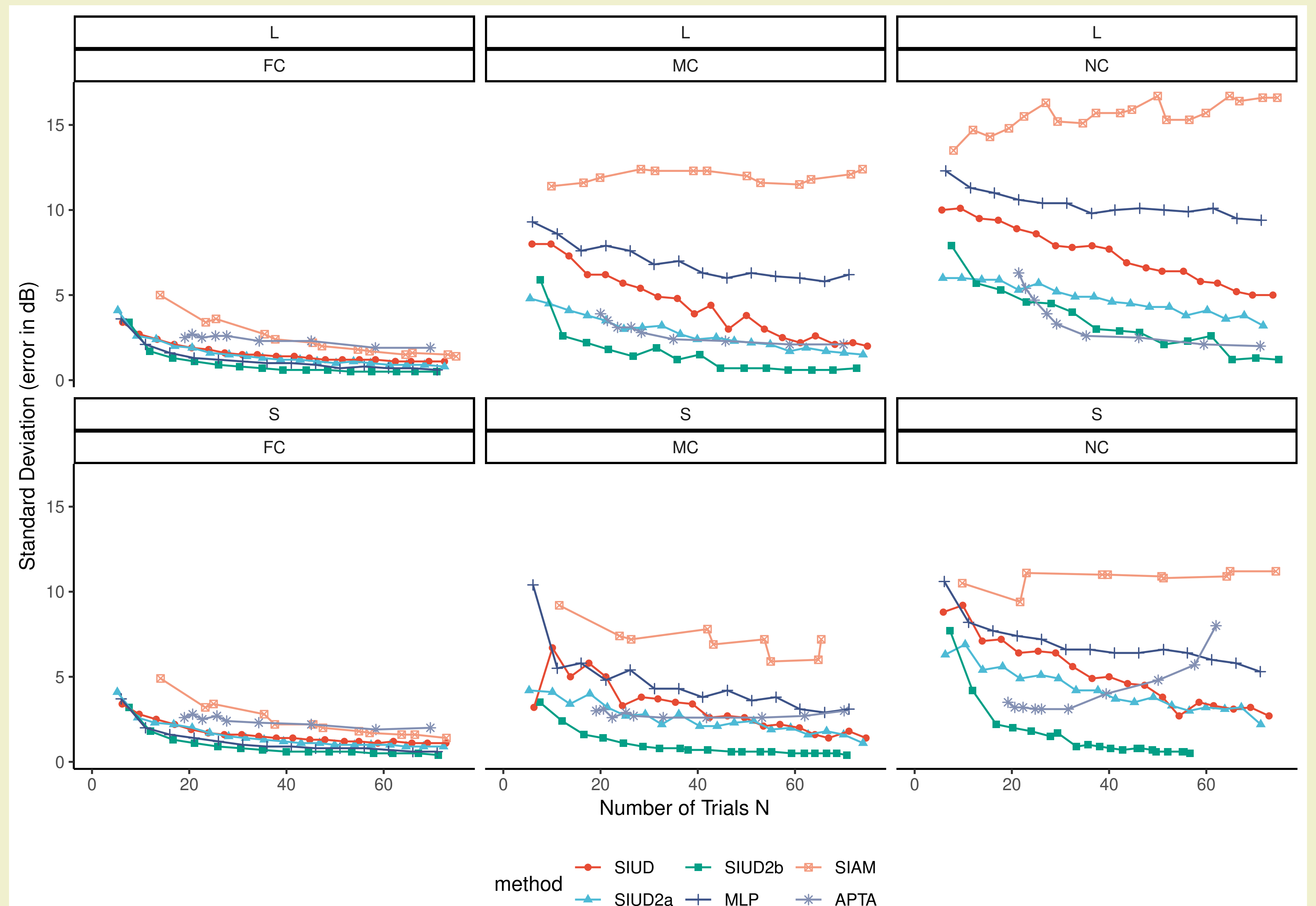
- Adaptive procedures that are based on probabilistic assumptions are prone to errors for inattentive listeners. Methods that use two tones presented at different levels in combination with a simple adaptation rule (two-alternative counting) appear to be more robust.

## RESULTS

- All adaptive procedures measured the hearing threshold precisely for the FC listener group. The NC listener yielded the highest median threshold estimates.
- SIAM produced the largest offset compared with the target threshold (the red dash line), therefore the least robust. MLP estimated the hearing threshold precisely for the FC listener, however, severely overestimated for the MC and NC listener.
- SIUD2b outperformed the other adaptive procedures, hence was the most robust. Compared with the baseline SIUD procedure, SIUD2a and SIUD2b were closer to the target, thus more robust.



- The standard deviation got smaller with the increase of the number of trials for all the adaptive procedures for the groups of the FC listener.
- The standard deviation of all adaptive procedures except for SIAM fell for the long-term MC and NC listener. APTA did not converge for the short-term MC and NC listener.
- SIUD2b seemed to be the most efficient among all adaptive procedures.



[1] David M Green. A maximum-likelihood method for estimating thresholds in a yes-no task. *The Journal of the Acoustical Society of America*, 93(4):2096–2105, 1993.  
 [2] Thomas Bisitz and Andreas Silzle. Automated pure-tone audiometry software tool with extended frequency range. In *Audio Engineering Society Convention 130*. Audio Engineering Society, 2011.  
 [3] Christian Kaernbach. A single-interval adjustment-matrix (siam) procedure for unbiased adaptive testing. *The Journal of the Acoustical Society of America*, 88(6):2645–2655, 1990.  
 [4] Wendy Lecluyse and Ray Meddis. A simple single-interval adaptive procedure for estimating thresholds in normal and impaired listeners. *The Journal of the Acoustical Society of America*, 126(5):2570–2579, 2009.