Hearing aid performance characterized by apparent SNR estimation to predict speech intelligibility in noise with hearing impaired listeners

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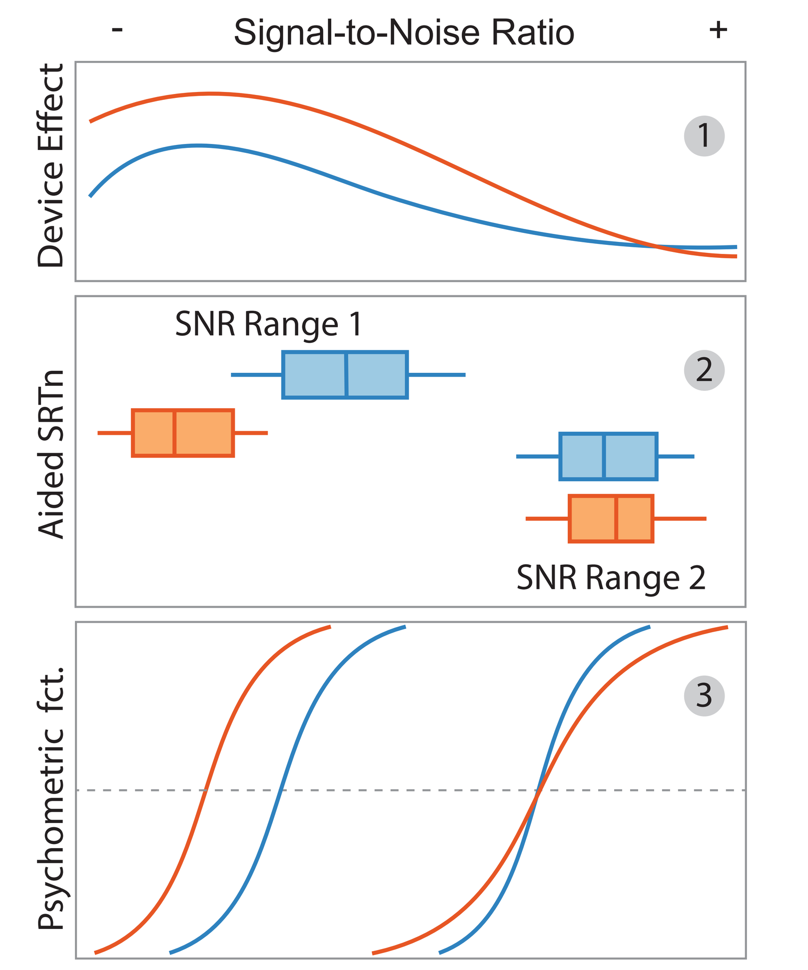
Interpreting changes in SRTn

Adaptive speech reception threshold in noise (SRTn) is one possible measurement used to evaluate and compare different hearing aids or algorithms. Interpreting changes in SRTn might be complex because:

(1) performance of some tested features, algorithms or hearing aids is SNR dependent [5, 6], (2) differences between SRTn depend on the tested SNR range [5, 6] which varies with the noise type, the speech material, the scoring method, speech and noise locations, and (3) SRTn changes represent a threshold shift of the psychometric function (PMF), but don't detect changes in slope or shape [3, 6].

In order to better understand SRTn changes, we propose to estimate the effect of two hearing aids, on output SNR and speech level, and model the experimental data from an adaptive SRTn over a broader SNR range [6, 8].



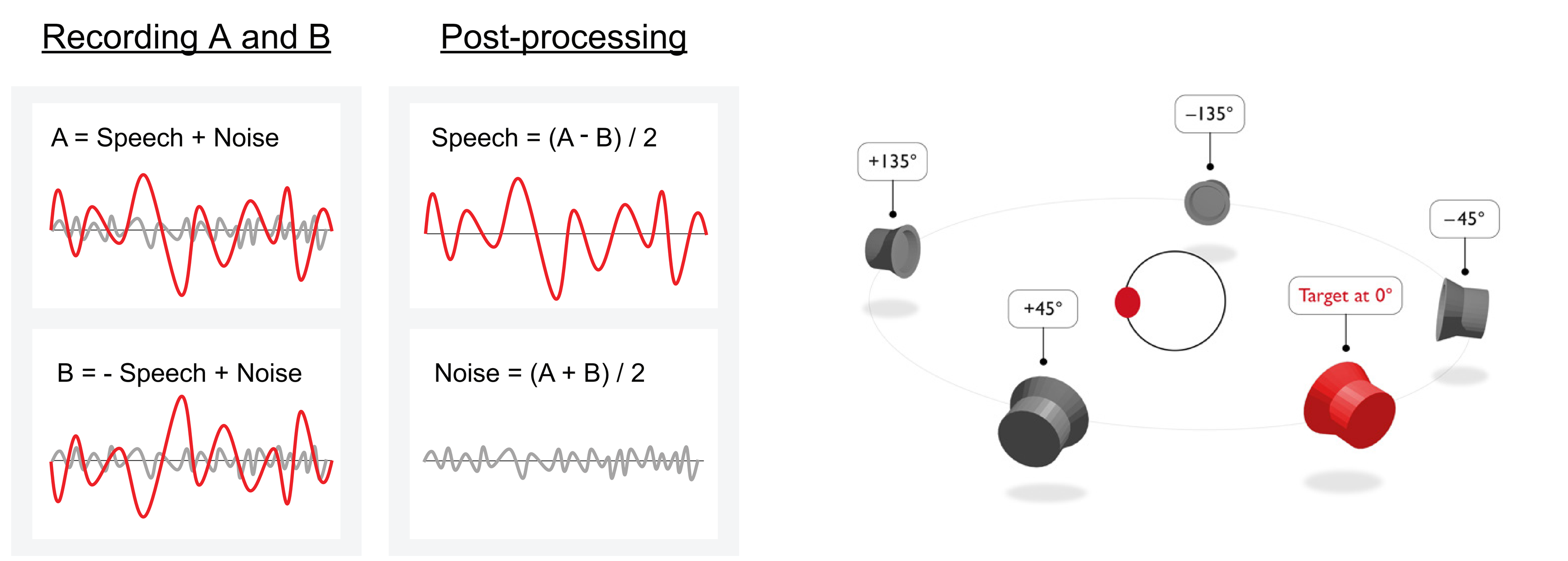
1 Device evaluation

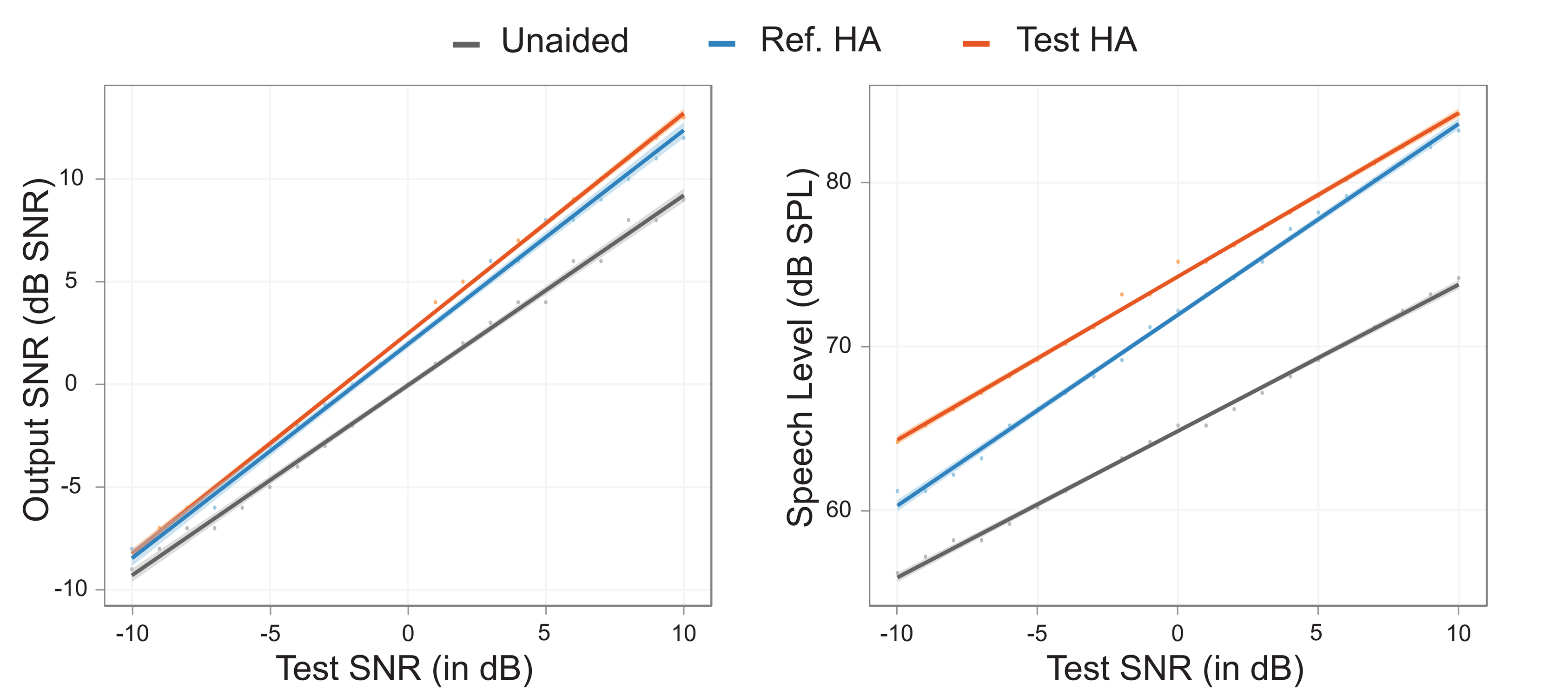
Evaluation of 2 hearing aids (HA) with the same dynamic compression architecture. Directionality and noise reduction systems are different for the:

- Reference HA with pinna cue like directivity and modulation based noise reduction in 4 bands,
- Test HA with SNR optimized directivity and fast noise reduction in 16 bands.

HA fitted with a N3 hearing loss [1], NAL NL2 rationale and closed dome on KEMAR. Measured variables: HA output SNR and speech level.

HA evaluation with inversion technique [2] to separate two signals at the HA output: OLSA speech and noise from recording A and B. Fixed noise level at 65 dB SPL from ±45° and ±135° and speech from 0° [55-75 dB SPL].



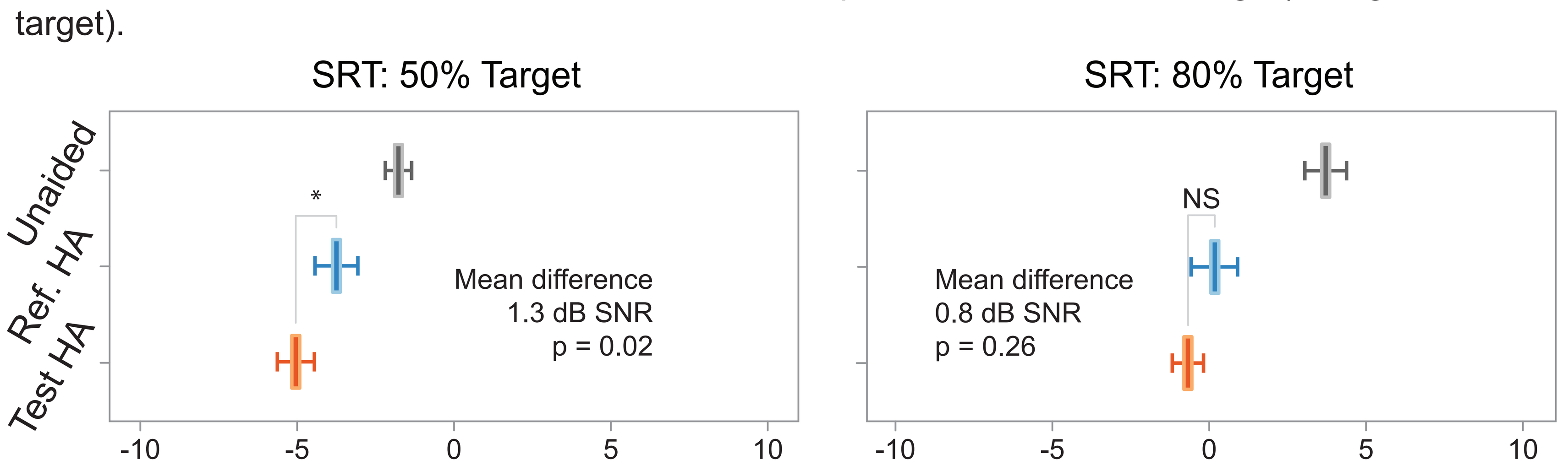


2 SRTn analysis

Subjects: 29 experienced hearing aid users, mild to severe hearing loss, HA gain based on NAL-NL2 rationale. Age range between 38 and 86 years old.

OLSA test: adaptive SRTn procedure targeting 50% and 80% intelligibility. Fixed noise at 65 dB SPL from ±45° and ±135° and adaptive speech from 0° starting at +5 dB SNR.

Differences between the reference and tested HAs depend on the SNR test range (changes with the % target).

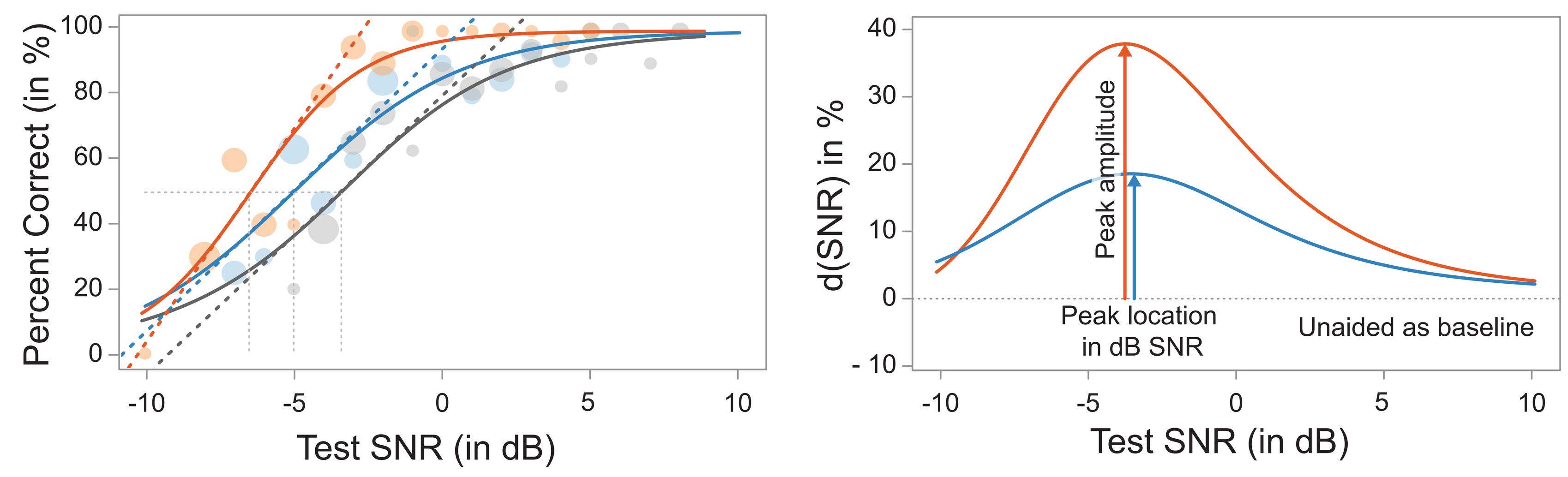


3 Individual d(SNR)

For each test subject, data are fitted over a broader SNR range based on a logistic distribution function with each tested condition [4, 8].

From the illustration, we observe that changing to the test HA, improved the SRT_{50} but also increased the slope of the PMF.

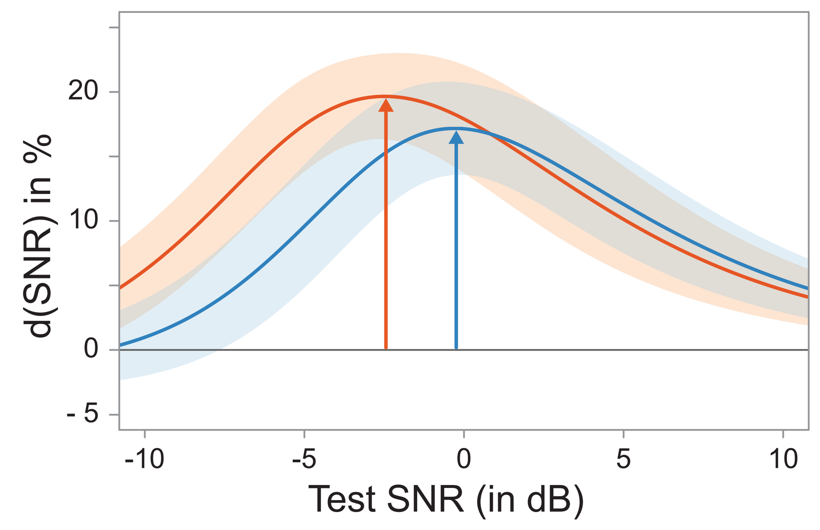
Difference between aided and unaided PMFs is expressed as the d(SNR)[6]. Peak location and amplitude are indicators to find the SNR that gives the maximum amplification benefit.

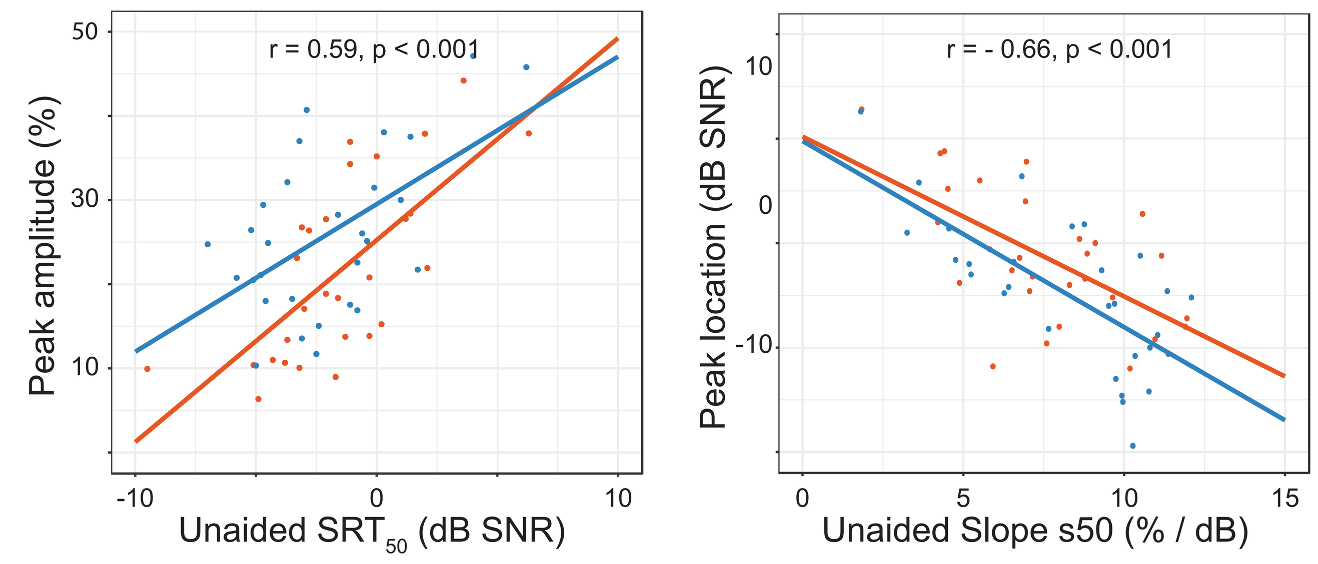


Group d(SNR)

Averages and confidence intervals of d(SNR)s show 1) an overlap between both HAs for positive test SNRs (ceiling effect), and 2) a shift in peak location and an increase in peak amplitude with the tested HA at negative test SNRs.

Individual performances described by unaided SRT_{50} and slope s50 [3] are respectively associated with peak amplitude and peak location, i.e. individuals with more difficulties have larger peak amplitude and higher peak location. Benefit from amplification depends on individual characteristics.





Predicting intelligibility changes

Explanatory variables: test subject (4 frequency pure tone average, age, unaided SRT_{50}, and s50), test condition (device, changes in speech SPL and output SNR at the peak location). Subjects are included as random effect.

Model selection: backward stepwise selection [7]. 1) Removing influencial observations based on Cook's distance. 2) Limiting collinearity with variation inflation factors below 2. 3) Testing models without low contributing fixed effect based on likelihood ratio test.

Peak location:
- the test device will shift the peak by -1.4 dB SNR,
- is lower for listeners with low unaided SRT and steep unaided slopes.

Effect	Estimate	SE	t.value	p
device	-1.42	0.38	-3.71	< 0.001
delta.SNR	1.77	0.66	2.65	0.01
unaided SRT_{50}	0.37	0.11	3.34	0.002
unaided s50	-67.8	10.7	-6.34	< 0.001
age	-0.02	0.03	-0.64	0.53

Peak amplitude:
- is increase by 5% with the test device,
- is higher for listeners with high unaided SRT and steep unaided slopes.

Effect	Estimate	SE	t.value	p
device	0.05	0.13	0.85	0.04
delta.SNR	0.01	0.03	0.41	0.69
unaided SRT_{50}	0.02	0.004	4.36	< 0.001
unaided s50	0.85	0.44	1.94	0.06
PTA	0.002	0.002	1.29	0.21
age	-0.001	0.001	-0.77	0.45

Unaided SRT and slopes have different effects in peak location and amplitude.

Discussion

- Differences in SRTn between test conditions depend on the SNR range and on listeners' characteristics. Modelling the PMF and measuring device performance over a broader SNR range should help to evaluate the differences between test conditions.
- The SNR range where the test HA reduces the target loss corresponds to the SNR range where the differences in intelligibility are maximized.
- A significant difference or an absence of changes in traditional SRTn are not enough to generalize the findings. Reality might be more complex.

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Both devices are commercially available: **Juna 9** for the reference and **Zerena 9** for the tested device.

References

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