Magnitude of SRT manipulators

for a spatial speech-in-speech test that takes SNR confounds and ecological validity into account

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Four ways of shifting the speech reception threshold (SRT) for five-word sentences were investigated:

* Change the spatial separation between target and maskers (15°, 30°, 45°, 75°).
* Change the number of maskers (2, 4, 6).
* Change the adaptation target (50% words, 50% sentences).
* Change the masker talker gender (female, male).

Background

Adaptive SRT procedures have drawbacks related to the unbounded nature of the Signal-to-Noise Ratio (SNR) at which the SRT is achieved [1].

(LACK OF) ECOLOGICAL VALIDITY: Often the SRT is much lower than the SNR found in realistic listening conditions. If the test involves aided listening, the hearing aid may therefore be subjected to conditions for which it was never intended. This has the potential to cause misleading results.

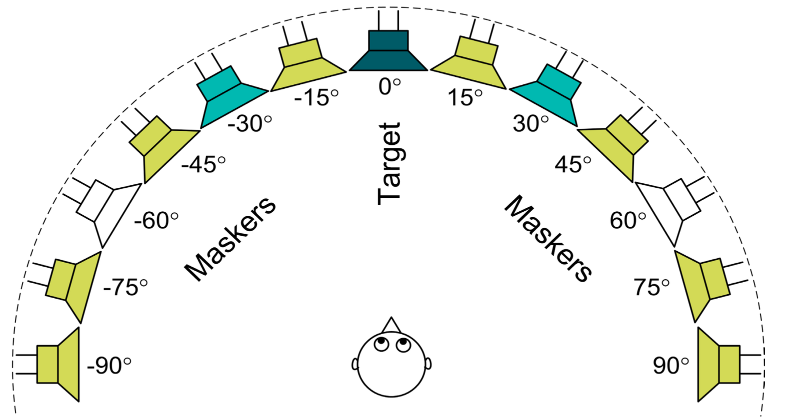
SNR CONFOUNDS: Aided hearing-impaired listeners often show a wide spread in SRT. Therefore, the hearing aids under test will be subjected to very different SNRs among different listeners. These differences in SNR can affect hearing-aid signal processing and can in turn potentially confound the test results [2,3].

LONG-TERM GOAL OF RESEARCH: To devise a spatial speech-in-speech intelligibility test addressing ecological validity and SNR confounds. This could be obtained by selecting appropriate test conditions to shift the individual listener's SRT towards a common desired SNR.

Methods

LISTENERS: *N* = 20 hearing-impaired listeners with sensorineural hearing loss participated. Pure Tone Average (PTA) hearing loss across 0.5, 1, 2, and 4 kHz ranged from 29 dB HL to 69 dB HL, with a mean of 51 dB HL and a standard deviation of 11 dB HL. Subjects were listening binaurally aided using their own hearing aids, which had directionality and noise management disabled during testing.

Figure 1. Loudspeaker set-up for experiment. Configurations used can be read off Table 1. The configuration with two maskers at ±30° served as a reference condition.



TARGET SPEECH: Danish HINT sentences [4], all consisting of five words, presented from 0°.

MASKER SPEECH: Running speech (reading from a fairytale), speech pauses cut down to 65 ms. Two female talkers or two male talkers, used in pairs arranged symmetrically around the listener, see Figure 1.

PRESENTATION LEVELS: The target level was fixed at 70 dB SPL (C). The masker level was varied adaptively. The SRTs, i.e. SNRs corresponding to 50% correct words or sentences, were found by a maximum likelihood approach, based on lists of 20 sentences.

SPECTRAL MATCHING: Target and maskers were spectrally matched to a female speech spectrum.

SNR REFERENCE: SRT levels are referenced to the SNR experienced at the position of one of the hearing aids (SNR_{HA}), thus including the shadowing effect of the head and the number of maskers.

Test conditions

Table 1. Overview of included test conditions (A-T).

Masker gender	Adaptation target	Masker configuration						
		2 maskers				4 maskers		6 maskers
		±15°	±30°	±45°	±75°	±30/90°	±15/45°	±15/45/75°
Male	Word	A	B	C	D	E	F	G
	Sentence	H	I	J	---	K	L	---
Female	Word	M	N	O	---	P	Q	---

Results

Figure 2. Individual SRTs for 20 test subjects in 17 test conditions labelled A-T according to Table 1.

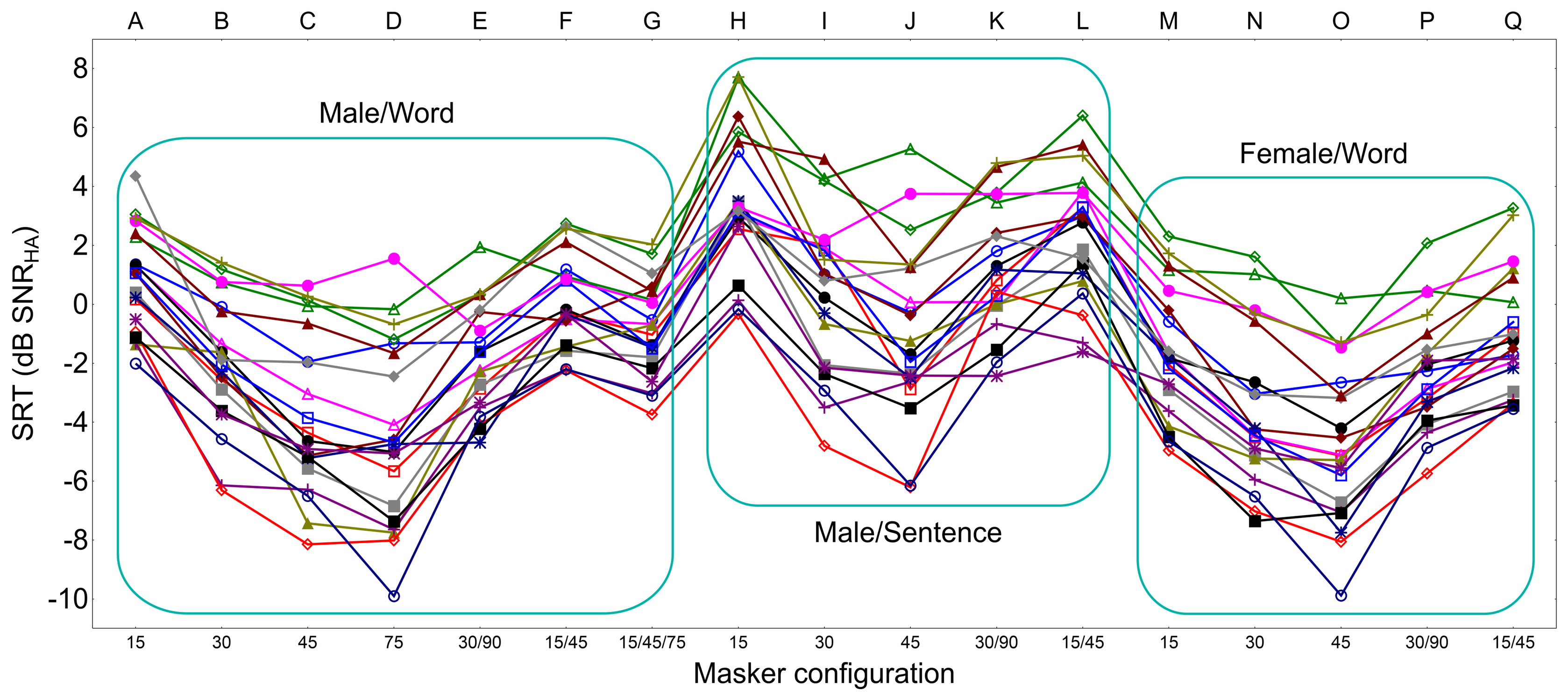
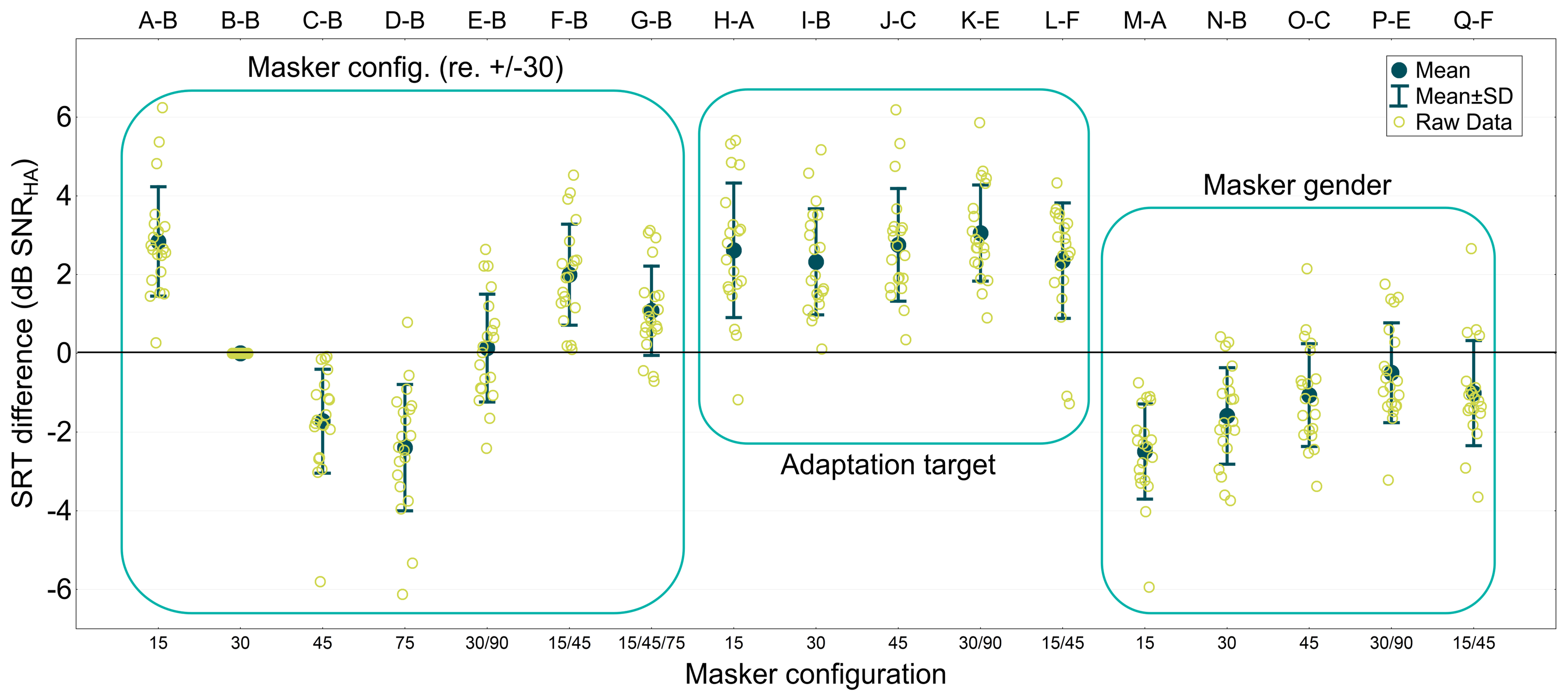


Figure 3. Mean and individual **SRT differences** (manipulator effects) for 17 pairs of test conditions. The labelling of the pairs is according to Table 1.



ANOVA: The raw SRT data were analysed with a mixed-model main-effects ANOVA, see Table 2.

TRAINING EFFECTS: There were significant within- and between-visit training effects. These effects were corrected for in the analysis and presentation of data, including the plot of the individual SRTs in Figure 2.

Table 2. ANOVA main-effect results.

Effect	*F*-value	*p*-value
Masker configuration	$F_{6,369}$ = 136	< .00001
Adaptation target	$F_{1,369}$ = 341	< .00001
Masker gender	$F_{1,369}$ = 84.7	< .00001
Listener (random)	$F_{19,369}$ = 68	< .00001
Within-visit	$F_{1,369}$ = 6.2	.0004
Between-visit	$F_{1,369}$ = 7.8	.005

Discussion

THE VARIATION IN SPATIAL SEPARATION, with the ±30° condition as reference, showed SRT shifts of +2.8 dB (±15°), -1.7 dB (±45°), and -2.4 dB (±75°) for the two-masker configurations. In all cases, the standard deviation (SD) was close to the expected minimal value (1.3 dB) of any SRT difference due to the HINT test-retest SD alone [4]. Thus, Cohen's effect size *d* (= mean/SD) was well above the 0.8 value required for a 'large' effect [5]. Using this as criterion, **changing spatial separation between target and maskers is an excellent SRT manipulator candidate.**

ADDING ADDITIONAL MASKERS to the ±15° and ±30° conditions changed SRT only marginally. Thus, **changing the number of maskers is not a recommended SRT manipulator**; at least for the present hearing-impaired listeners.

THE EFFECT OF CHANGING THE ADAPTATION TARGET from 50% words to 50% sentences was 2.6 dB on average across masker configurations. This is less than the 5.1 dB found with the Dantale II corpus (Danish Matrix test) in a previous study [6]. However, this was expected due to the HINT sentences' greater redundancy. As above, SDs were close to the 1.3-dB lower limit value. Using Cohen's *d* = 0.8 as criterion, **the Word/sentence SRT manipulator is an excellent candidate.**

THE EFFECT OF MASKER TALKER GENDER depended on Masker configuration. The results in Figure 4 indicate that the benefit of having an opposite-gender masker is greatest when the spatial cues are least powerful (small target-masker separation). Using Cohen's *d* = 0.8 as criterion, **the Masker gender SRT manipulator is, on its own, only relevant for the ±15° and ±30° two-masker configurations.**

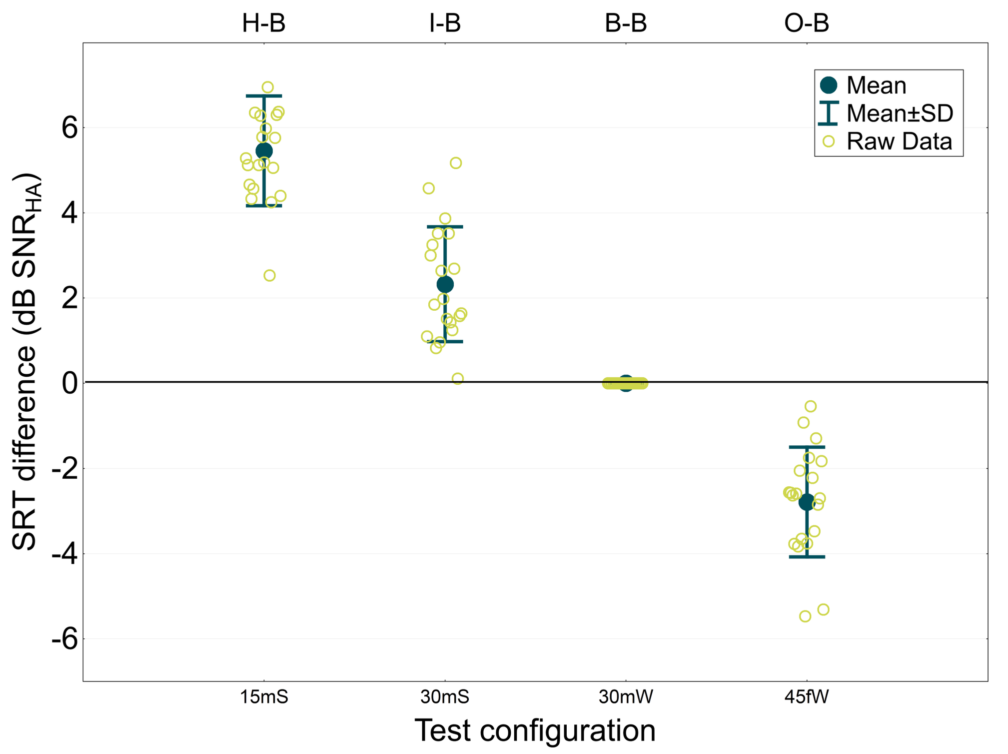
Perspectives for a future test paradigm

Four SRT manipulated conditions were chosen for the design of a future test. The baseline condition was chosen to be the *30mW*, denoting that the masker is composed of male talkers (m), at ±30° angles, that are scored in words (W). The other three chosen conditions were *15mS* (male, ±15°, Sentence), *30mS* (male, ±30°, Sentence) and *45fW* (female, ±45°, Word).

The effects of applying each of the SRT manipulators are shown In Figure 4, in comparison with the baseline condition.

The planned test paradigm for the future test is; first, to measure the SRT of an individual test subject in the baseline condition. Second, to determine how far from the target SNR the subject is performing. Third, to choose the SRT manipulator suitable to shift the individual SRT as close as possible to the target SNR. Fourth, to carry out the rest of the test in the individually SRT manipulated condition. This is expected to result in a smaller across subject standard deviation, and an average SRT closer to the target SNR.

Figure 4. Mean and individual **SRT differences** (manipulator effects) for the four selected pairs of test conditions. The upper labelling of the pairs is according to Table 1, the lower denotes the condition compared to the baseline condition. The number refers to the masker-angles, the lower case letter to the masker talker gender (male, female), and the capital letter to the adaptation target (Sentence, Word).



Conclusion

Three useful SRT manipulators were identified that will allow the SRT of an individual listener to be shifted over approximately a 8-dB range. This is promising regarding the development of a spatial speech-in-speech test that includes means of addressing SNR confounds and provides some control of the SNR at which testing takes place.

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