The Development of the SiB-test
A Swedish Test of Phonetic Perception in Noise, for Adult Persons with Hearing Loss.

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Our aim is that the SiB-test will very precisely measure differences in a person’s ability to perceive speech sounds in background noise, and consequently provide a new and reliable evaluation tool in audiological rehabilitation.

Introduction
Hearing ability is most commonly measured using pure tone audiometry. Pure tones however, differ largely from natural speech. In order to attain a valid measure of speech perception, a speech test in which real speech signals are presented in an ecologically valid auditory background would be preferred. In the Swedish language, several such speech audiometry tests exist (1, 2, 3), all measuring the ability to correctly identify whole words or sentences.

Current Swedish clinical speech audiometry
• Phonemic balance (the same proportion of speech sounds in the language)
• Averaging of test results over all speech sounds
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• Phonemic similarity calculation, based on principles from automatic speech recognition (4). The two phonemes most similar to each phoneme were identified and grouped. Where possible, also zero phonemes (absence of initial or final consonant) were added to the groups.

The SiB-test:
• will yield results separately for different speech sounds / groups of speech sounds
• will contrast the speech sounds most easily confused / difficult to distinguish
• will use optimization of phoneme levels for maximum reliability

Taking together, this means that the SiB-test will detect smaller changes in hearing ability than current Swedish speech tests.

Test trial composition
The test is constructed to be run in a typical audiologist clinic: The test person sits in front of a touch screen, and the test sound is delivered via sound field speakers, some distance away from the listener. Each auditory test stimulus consists of speech signals mixed with background noise, at specific signal-to-noise ratios (SNR). In order to attain high reliability, the test word has a stationary noise in the background. And to attain high ecological validity, the SNR is upheld at all other times by mixing an international standardized speech signal (ISTS) with a standardized noise signal (ICRA nr 8). Optimal audibility in noise can also be attained by applying gain specifically to the test phoneme.

The graphic interface

Test person

The auditory stimulus
The SiB-test will indicate which speech sounds that a person hears well and which sounds are problematic. Hence the test could be used as a tool in audiological rehabilitation in order to assess patients’ communicative strengths and weaknesses.

Communicative diagnosis

The results of the SiB-test will indicate which speech sounds that a person hears well and which sounds are problematic. Hence the test could be used as a tool in audiological rehabilitation in order to assess patients’ communicative strengths and weaknesses.

Hearing aid / cochlear implant benefit

The SiB-test can be used to evaluate the benefit of a hearing aid fitting or a cochlear implant. As the test is more sensitive to smaller changes in phonetic perception than other speech tests, such result will be more reliable than existing Swedish speech audiometric tests.

Evaluation of specific signal processing
Modern hearing aids use many, very intricate, signal processing algorithms for the patient. The SiB-test can be an efficient tool to evaluate the benefit of such algorithms for the patient.

Effectiveness of auditory training
Analytic auditory training is a feasible intervention in audiological rehabilitation. However, verifying its effectiveness has been a longstanding problem, in large due to the lack of instruments sensitive enough of capturing the type of improvements that can be expected (6). Also here, it is hoped that the SiB-test can shed some light and serve as a way to determine the effects from analytic training.

References

1. Test word recording (of children): Five psychoacoustically valid “toddler speech” recordings of each test word by one male and one female speaker (1, 2, 3).
2. Statutory speech weighted noise: The same long time spectrum as ICRA nr 8 below:
3. ISTS Unweighted natural sounds, one-speaker (13).
4. ICRA nr 8: Pure-tone masking with the noise with the same amplitude modulation and long time spectrum as its speakers with raised vocal effort (14).
5. The SiB-test was segmented phonetically, and contrasting phonemes were analyzed in the frequency domain, using overlapping triangular Bark filters (5).
6. Time warped acoustic distances between all contrasting phonemes were calculated, using dynamic time warping (6) of the Euclidian distance between time windows.

Clinical validation
The SiB-test is undergoing clinical validation in a set of experiments on people with normal hearing and hearing loss. The validation process is outlined in the steps below.

• Perceptual validation of the test word recordings, without background noise, on normal hearing subjects. Perceptual validation is performed at test phoneme gains of 0, -6 and -12 dB. The limits of ± 4 dB has been chosen as the maximum allowed phoneme gain adjustment.
• Validation of the SiB-test on subjects with mild to severe non-recurrent hearing loss.