Field Study News

Logatom test

Structure and Evaluation of an Adaptive Logatom Test for Measuring the Identification of Consonants

Summary

To evaluate innovative hearing instrument algorithms and/or adaptive hearing instrument processes, a discrimination measurement method had to be developed which is sufficiently sensitive for cases of mild to moderate hearing loss. This method determines by means of adaptive presentation level control with specific consonants, the recognition threshold for nonsense syllables (logatoms) such as "Asa", "Ata", "Asha" and has proven to be sufficiently reliable and valid.

Introduction

In the case of mild hearing losses, conventional speech discrimination tests (word and sentence tests) often do not offer sufficient sensitivity to demonstrate hearing improvement with hearing instruments because single, non-recognizable phonemes can be discerned in the context of the word or sentence. Discrimination tests that use nonsense syllables (logatoms) do not have this disadvantage. The principle of the logatom test was adapted for our test purposes.

Development goal

The goal was to focus on voiceless, high-frequency consonants, e.g. /sh/, /s/. The syllable material was enunciated by a woman, because, at about 9 kHz, the energy emphasis of the female /s/ is higher than that of the typical male /s/. For each tested consonant, an identification threshold had to be able to be defined. In addition, the syllable material was to be developed such that the various syllables could be distinguished exclusively from the consonants. This was done in order to prevent, after a learning phase, any hints to the consonants from enunciation characteristics of vowel sounds (e.g. tone pitch, loudness, duration).

Test structure

A native German-speaking female speaker enunciated an entire series of each of the syllables Aba, Ada, Afa, Aha, Aka, Ala, Ama, Ara, Asa, Asha, Ata, Awa into a microphone. In this process, she heard a repeated recording of the syllable "Asa" through the headphones. She practiced to match as accurately as possible the length, tone pitch and loudness of the simultaneously enunciated syllables with what she heard. Because the loudness, tone pitch and duration of the enunciated words recorded in this way varied too greatly, the consonants, including the vowel transients, were cut out from the most similarly enunciated syllables (most similar beyond the consonants) and, using cross-fading, were inserted between both /a/'s of the enunciated syllable "Ama". This means that in the resulting stimuli, the initial sound /a/ and final sound /a/ are acoustically identical and the syllables are the same length (Figure 1).

Figure 1: Diagram of the stimulus structure.

Prior to each stimulus presentation in the test, the introductory sentence "My name is" is spoken. The test participant's task is to understand the changing element. A touch screen serves as the response medium.

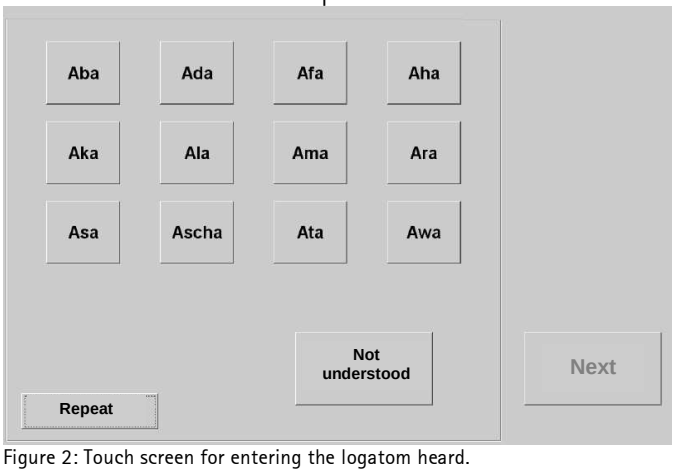

Figure 2: Touch screen for entering the logatom heard.

The participant selects the logatom she hears (Figure 2). If she cannot identify the stimulus, she selects "Not understood". If, during the presentation, she is unable to focus her attention or her hearing is limited due to a noise (e.g.

breathing, rustling of clothing), the participant presses "Repeat" (up to 2 times per stimulus possible; seldom used).
The test software varies the presentation level of the individual stimuli, depending on the accuracy of the entries so that, at the end, 50% of the answers are correct (unforced weighted up-down process from Kaernbach, 2001). The change intervals are long in the beginning, short in the end. For each stimulus, an identification threshold in dB or SNR is obtained, depending on whether the test was conducted in quiet or with background noises.

Reference data and reliability

Katrin Meisenbacher conducted the tests for evaluating this measurement method as part of her graduate thesis (University of Applied Science, Oldenburg, 2008) in Stäfa, Switzerland.
The accuracy of the logatom test method was tested on 20 test subjects between the ages of 25 and 40 with normal hearing, and reference data was determined that apply to normal hearing. The test subjects completed the test twice in quiet and twice with background noises, during which the sequence was altered. Prior to the actual test, the test subjects became accustomed to the stimulus material and learned how to operate the touch screen.

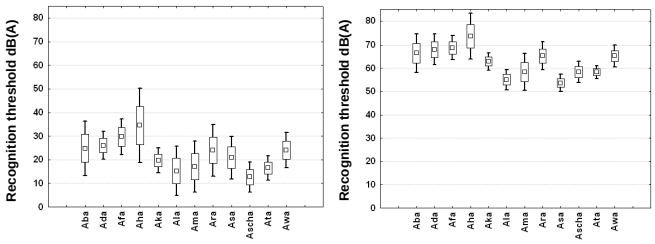

Figure 3: Mean logatom identification thresholds (vowel sound level) of the normal hearing test subjects in quiet (left) and with pink noises of 60 dB(A) (right).

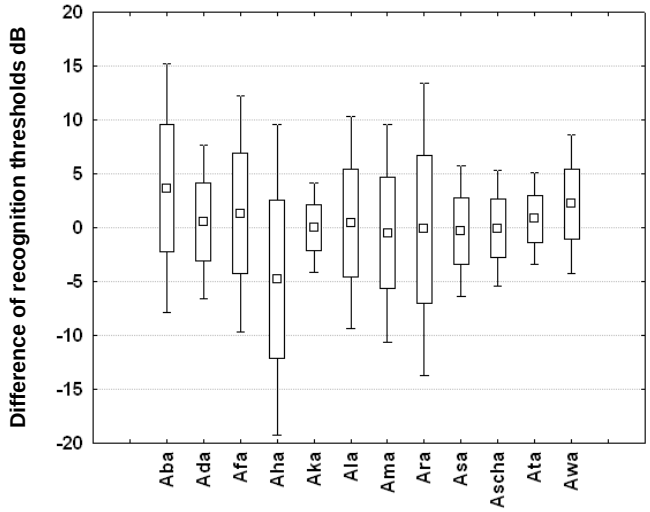

Figure 4: Differential spread between the first and second measurements of the test subjects with normal hearing.

Figures 3 and 4 show the reference data in quiet and the background noises used, and also the deviations between the first and second measurements. For most logatoms, the average difference in the identification threshold is 0 dB. Moreover, the syllables /Ada/, /Aka/, /Asa/, /Ascha/, /Ata/ indicate a low differential spread. They are particularly suited for accurately measuring identification.

Validity

For the first validity test, three low-grade hearing impaired test subjects were tested using this procedure. Their identification thresholds are therefore higher than those of test subjects with normal hearing and demonstrate the sensitivity of the test (Figure 5).

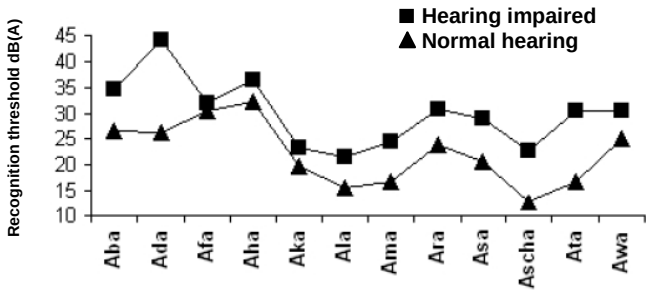

Figure 5: Average identification thresholds of the three hearing-impaired test subjects (SH) compared to the average threshold of test subjects with normal hearing (NH).

In a further study of people with mild to moderate hearing loss (reported in Field Study News, May, 2009), the logatom test was used to show that with traditional amplification, the identification thresholds for /d/, /f/, /sch/, /t/ and /s/ can be reduced. In addition, the use of frequency compression was able to further improve the identification threshold for /s/. This, too, is an indication of the validity of this measurement method.

Outlook

Currently, in addition to the German version, an English version is available, soon French and Flemish versions will also be available. A modified version of this measurement method intended to increase accuracy is currently being reviewed.

References

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Meisenbacher, K. (2008). Development and Evaluation of an Adaptive Logatom Test to Determine Consonant Understandability. [in German: Entwicklung und Evaluation eines adaptiven Logatomtests zur Ermittlung der Konsonantenverständlichkeit] Graduate thesis, University of Applied Sciences Oldenburg, 2008.

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