Intelligibility of German digit triplets test by non- native listeners

Anna Warzybok[1], Kirsten Carola Wagener[2], Thomas Brand[3]

1 Institute of Acoustics, A. Mickiewicz University, Poznań
2 Hörzentrum Oldenburg GmbH
3 Medizinische Physik, Carl-von-Ossietzky Universität Oldenburg

INTRODUCTION

The German digit triplets test has been developed as an objective self-screening test for speech intelligibility in noise (Wagener et al, 2006a, Smits et al, 2004). It measures the speech reception threshold (SRT) i.e. the signal-to-noise ratio that yields 50% speech intelligibility. In this test digit triplets are used as speech material, for example 6-2-4 (pronounced as six-two-four). Thanks to the use of digits it is possible to automate the test and to apply it via telephone. Another advantage is that the digit triplets test consists of only a few simple words. Therefore the test may also be usable with non-native listeners. The aim of this study was to investigate the results of the German digit triplets test with non-native listeners.

METHODS

35 normal-hearing international students who spent a few months at Oldenburg University participated in this experiment. The subjects differed in German skills and on the basis of their skills they were divided into 4 groups (grouping was done by the German language school they attended). The listeners of the first group had a very limited German knowledge and the fourth group's listeners had the best knowledge. A pure-tone audiogram was recorded at the octave frequencies of 250- 8000 Hz. All participants had pure-tone thresholds not exceeding 15 dB HL. For all listeners measurements with the German digit triplets were performed in following order:

1 training list via headphones using an adaptive procedure

1 list via headphones using an adaptive procedure

1 list via telephone using an adaptive procedure

3 list via headphones at three different fixed signal-to-noise ratios

1 list via telephone using an adaptive procedure

1 list via headphones using an adaptive procedure

Each list of the German digit triplets test consists of 27 triplets. As speech material only monosyllabic digits were used. Triplets were presented in speech shaped noise (same long term spectrum as the speech material). Triplet scoring was used to analyze the responses: A response is correct only when all three digits were entered correctly.

The applied adaptive procedure was a simple up-down method with a fixed step size of 2 dB. The fixed signal-to-noise ratios for the method of constant stimuli were chosen as follows: 1. SNR= individual SRT (obtained from the first measurement via headphones using the adaptive method), 2. SNR= individual SRT +1dB, 3. SNR= individual SRT- 1dB.

In the measurements via headphones the participants had to enter their responses on a touch screen that looks like a telephone keypad. In the measurements via telephone the telephone keypad was used as entering device.

As an additional experiment, the German Oldenburg sentence test (OLSA, Wagener et al, 1999) was also used with some of the participating subjects. At first 1 training list was presented in quiet at a fixed sound pressure level of 65 dB SPL. In the next step two lists in noise were presented using an adaptive method to determine SRT in noise. These measurements were done to compare the non-native listener's results of a test with more difficult speech material to the 'easy' digit triplets test.

RESULTS

Speech reception thresholds from measurements via headphones using the adaptive procedure for the different groups of non-native German listeners are given in Table 1. It can be seen that the SRT of the digit triplets test of non- native listeners is independent of language skills. When the measurements are performed via headphones the mean non-native SRT results showed no significant differences to the SRT reference value (-9.3 dB ± 0.2) of German native listeners (Wagener at al., 2006b). Poorer speech reception in noise and significant differences across non-native listeners and between non-German and German listeners (reference value -6.4 dB ± 0.1; Wagener at al., 2006b) can be observed in the telephone measurements.

Number of group	HADPHONES		TELEPHONE	
	SRT ± σ [dB] 1. measure	**SRT ± σ [dB]** 2.measure	**SRT ± σ [dB]** 1. measure	**SRT ± σ [dB]** 2.measure
4	-8,8 ± 0,6	-9,4 ± 0,7	-4,1± 2,59	-5,1± 1,15
3	-8,9 ± 0,3	-9,3 ± O,9	-4,3± 1,07	-4,0± 0,68
2	-8,4± 0,9	-8,9 ± 0,6	-3,6± 1,06	-4,4± 1,87
1	-8,6± 0,6	-8,8± 0,7	-3,3± 1,87	-4,1± 1,87
Mean SRT ± σ	**-8,7 ± 0,6**	**-9,2 ± 0,7**	**-3,9± 1,7**	**-4,3± 1,5**

Table 1. Results of non-native listeners for the digit triplets test via headphones and telephone using the adaptive procedure: mean SRT values with inter-individual standard deviations for each language group.

Psychometric functions were fitted to the results of the measurements with fixed signal-to-noise ratios, using a logistic model function (Kollmeier and Wesselkamp (1997), Wagener (2006b)). The intelligibility function was characterized by two main parameters: SRT and S_{50}, i.e. the steepness of the function at the SRT point. These two parameters were obtained for each listener. The mean SRT values obtained from these results of constant stimuli method show no differences to the SRTs obtained using the adaptive procedure. The intelligibility functions of non-German listeners tend to be steeper than the intelligibility functions of German listeners.

In figure 2 the SRT results with the OLSA test are presented for 9 non-native participants. It can be seen that speech reception thresholds strongly vary between subjects but this fact is connected rather with inter-individual differences than with their German skills.

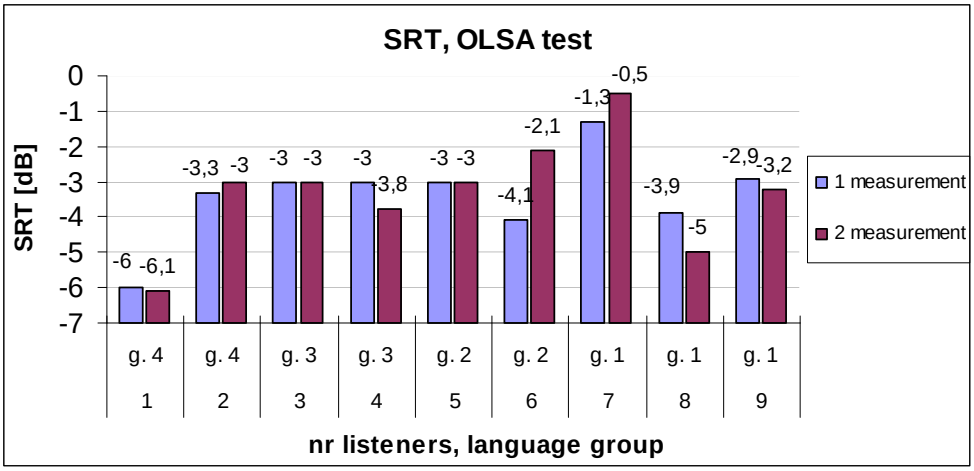

Fig. 2 Speech reception thresholds for OLSA test in first and second measurement.

CONCLUSIONS

The aim of this study was to investigate the German digit triplets test on non-native German listeners and to prove the usability of this test in determining speech intelligibility of non-native listeners. The SRT results of this test provide no significant differences to the SRT reference values of German listeners as far as measurements are done via headphones. Therefore the test can also be used as screening test for speech intelligibility in noise with non-native listeners without any changes in reference values when performed via headphones. However, when performing the test via telephone, the non-native listeners showed poorer speech

perception in noise compared to native listeners. Also, the intelligibility differences between subjects were larger via telephone than via headphones with the digit triplets and also larger in the OLSA test (performed via headphones) that requires larger verbal skills compared to the digit triplets test.

Second, GSL subjects obtained poorer perception scores than the native subjects across all of the SNRs (Figure II). Moreover, the performance decrement between the two groups remained almost constant at the various SNRs.

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