INTERNATIONAL MATRIX TESTS

Reliable speech audiometry in noise
International Matrix Tests
Reliable speech audiometry in noise

Speech communication is one of the most important aspects of the human auditory system. In everyday life, conversations usually occur in the presence of background noise. Hearing impaired listeners very often complain especially about problems with understanding speech in noisy situations. Therefore, the diagnostics and rehabilitation of hearing loss should include speech audiometry in noise.

Matrix Tests resemble everyday situations (listening to complete sentences in noise) while being very accurate measurement tools. Therefore Matrix Tests can be used to test the performance of hearing devices in realistic situations and to show differences between various devices. Matrix Sentence Tests are adaptive speech in noise tests for determining the speech reception threshold (SRT) with a precision in the range of ±1 dB. The sentences of Matrix Tests are composed with the same structure (e.g. in English from the categories: name, verb number, adjective and noun, like “Lucy kept nine green flowers”). Test lists are generated by creating seemingly random sentences from an inventory (a matrix) of fifty words, i.e. ten words per category. Despite the random composition, every sentence is syntactically correct. This way, up to 100,000 different sentences can be generated which makes it impossible to memorize them. Thus, after a short training, Matrix Tests can be repeatedly conducted with the same patient without affecting the test results.

The audiometrist does not even have to speak the language of the patient: Matrix Tests can be conducted in a closed test format, meaning that the patient sees the matrix of possible words on a computer screen and can select the words that he or she just heard. This means that Matrix Tests can be used anywhere in the world where speech audiometry in the respective language might be necessary. Because of the similar structure of all Matrix Tests, the results of different language versions can easily be compared.

Key Features of International Matrix Tests
- Relevant for daily life
- Quick and reliable threshold measurement
- Unlimited repeated measurements possible
- Suitable for any degree of hearing loss
- Wide language portfolio

Application of Matrix Tests

Matrix Tests are implemented in professional audiology software for use with patients (Oldenburg Measurement Applications, OMA). The software is compatible with several commercially available audiometers. Matrix tests are usually conducted with an adaptive procedure aiming for the 50% threshold of speech intelligibility in noise (the SRT). It is also possible to adapt to other thresholds between 20% and 80% speech intelligibility.

For the adaptive measurements, the noise level is kept constant at a level that is clearly audible to the patient (default is 65 dB). The first sentence is presented with a signal to noise ratio (SNR) of 0 dB. For the following presentations, the speech level is adapted according to the preceding response of the patient. This is done automatically by the software. If the patient correctly repeats three to five of the presented words, the speech level of the next presentation is reduced. If the patient correctly repeats less than three words, the speech level of the next presentation is increased. The step sizes are variable. The adaptive procedure approaches the SRT which is determined using a maximum likelihood estimator.

The patient usually listens to the sentences presented from the frontal loudspeaker or monaurally via audiometric, free-field equalized headphones. The sentences are presented along with the test-specific noise. In typical cases, the noise is only played back during the presentation of a sentence. If desired, the software also allows for continuous playback of the noise during the whole measurement. This can be of importance in case of measurements with hearing devices in order to ensure that the devices are in their optimal operating mode all the time.
Matrix Tests can be conducted with test lists of 20 or 30 sentences. The duration of a typical 20 item test list is about 4 minutes. For practical clinical applications, test lists of 20 sentences are usually sufficient. However, if a more reliable measurement of the SRT is desired, 30 item test lists can be used. The accuracy in threshold estimation of the 20 item test lists usually is on the order of 1 dB. Due to the training effect of Matrix Tests, a training session with two 20 item test lists is necessary.

The typical procedure that has been described so far is especially useful for diagnostics. If the SRT obtained in one fixed spatial configuration is compared to reference SRT distributions for normal hearing test subjects in the same configuration, the amount of hearing impairment related to speech intelligibility in noise can be established. Small differences in SRT can mean considerable differences in speech intelligibility. This is due to the steep intelligibility function of Matrix Tests. An SRT difference of just 3 dB can mean a difference in speech intelligibility of up to 40% for normal hearing listeners.

In addition to diagnostics, the Matrix Test can also be used for comparing different situations for the same patient, e.g. aided vs. unaided, pre-op vs. post-op, different hearing devices or different settings of the same hearing device. In these cases the test is usually presented via loudspeaker. As the Matrix Test is a speech in noise test, speech and noise can also be presented from different directions. That way, a wider range of realistic situations can be assessed.

**Typical use of Matrix Tests**

- Standardized test instruction for each patient (see next page)
- Training with two test lists (first at constant, clearly above threshold SNR; then with adaptive procedure)
- Noise level: 65 dB (or higher if required to be audible)
- Start SNR for adaptive procedure: 0 dB SNR
- Target SRT: 50% speech reception threshold
- Spatial configuration for free field presentation: S0N0 (i.e. speech and noise from the same loudspeaker from the front). Other configurations are possible.
- For diagnostics: monaural headphone measurement
- Aided measurements should be performed with continuous noise setting

**Suggested test instructions for Matrix Tests**

This is a test which assesses your ability to hear speech in noisy situations. For this purpose, you will be presented with a list of twenty sentences with background noise.

Each sentence consists of five words and always has the same structure: name, verb, numeral, adjective and noun, for example “Peter ordered three large desks”. The sentences are not necessarily meaningful.

Please repeat the sentence after each presentation. Each word counts as a point, so if you cannot get the entire sentence, repeat any word you hear. You may guess if you are uncertain.

There will be some sentences that are easy to understand and others where you might not understand any of the words. That is part of the test so do not get discouraged, just repeat what you can.

If the sentences are too loud at any point, please let me know.

Do you have any questions?

**Typical test setup (1) : Benefit of hearing aid provision**

To check the result of hearing device provision in free field using the matrix test (after sufficient training), the speech reception threshold (SRT) measured binaurally with speech simulating noise has to be improved (i.e. reduced) by a significant amount in the same spatial configuration (e.g. SoNo).
Expected SRT range for normal hearing individuals: -8.6 ± 0.9 dB SNR (mean ± standard deviation) for adaptive measurements

Slope of psychometric function: 13.3 %/dB

The Finnish Matrix Test

**Properties of the Finnish Matrix Test**


**Expected SRT range for normal hearing individuals:** -9.7 ± 0.7 dB SNR (mean ± standard deviation) for adaptive measurements

**Slope of psychometric function:** 16.7 %/dB

**Speech rate:** 226 ± 19 syllables per minute


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The Arabic Matrix Test

**Properties of the Arabic Matrix Test**

The French Matrix Test

Properties of the French Matrix Test

Expected SRT range for normal hearing individuals: -6.0 ± 0.6 dB SNR (mean ± standard deviation) for measurements at constant level

Slope of psychometric function: 14.0 %/dB


<table>
<thead>
<tr>
<th>Name</th>
<th>Verb</th>
<th>Number</th>
<th>Noun</th>
<th>Adjective</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jean-Luc</td>
<td>ramasse</td>
<td>trois</td>
<td>classeurs</td>
<td>jaunes</td>
<td>Jean-Luc picked up three yellow folders.</td>
</tr>
<tr>
<td>Émilie</td>
<td>voudrait</td>
<td>deux</td>
<td>livres</td>
<td>rouges</td>
<td>Émilie wants two red books.</td>
</tr>
<tr>
<td>Agnès</td>
<td>attrape</td>
<td>quinze</td>
<td>crayons</td>
<td>verts</td>
<td>Agnès caught fifteen green pencils.</td>
</tr>
<tr>
<td>Julien</td>
<td>dessine</td>
<td>huit</td>
<td>piquets</td>
<td>bruns</td>
<td>Julien draws eight brown posts.</td>
</tr>
<tr>
<td>Étienne</td>
<td>demande</td>
<td>douze</td>
<td>vélos</td>
<td>bleus</td>
<td>Étienne wants twelve blue bikes.</td>
</tr>
<tr>
<td>Michel</td>
<td>ramène</td>
<td>onze</td>
<td>jetons</td>
<td>mauves</td>
<td>Michel brings eleven purple tokens.</td>
</tr>
<tr>
<td>Eugène</td>
<td>reprend</td>
<td>neuf</td>
<td>ballons</td>
<td>roses</td>
<td>Eugène takes nine pink balloons.</td>
</tr>
<tr>
<td>Félix</td>
<td>achète</td>
<td>six</td>
<td>annéaux</td>
<td>blancs</td>
<td>Félix buys six white rings.</td>
</tr>
<tr>
<td>Charlotte</td>
<td>propose</td>
<td>cinq</td>
<td>rubans</td>
<td>gris</td>
<td>Charlotte offers five gray ribbons.</td>
</tr>
<tr>
<td>Sophie</td>
<td>déplace</td>
<td>sept</td>
<td>pions</td>
<td>noirs</td>
<td>Sophie displaces seven black pawns.</td>
</tr>
</tbody>
</table>

The German Matrix Test

Properties of the German Matrix Test

Expected SRT range for normal hearing individuals: -7.1 ± 1.1 dB SNR (mean ± standard deviation) for measurements at constant level

Slope of psychometric function: 17.1 %/dB

Speech rate: 233 ± 27 syllables per minute


<table>
<thead>
<tr>
<th>Name</th>
<th>Verb</th>
<th>Number</th>
<th>Adjective</th>
<th>Noun</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter</td>
<td>bekommt</td>
<td>drei</td>
<td>großes</td>
<td>Blumen</td>
<td>Peter gets three big flowers.</td>
</tr>
<tr>
<td>Kerstin</td>
<td>sieht</td>
<td>neun</td>
<td>kleine</td>
<td>Tassen</td>
<td>Kerstin sees nine small cups.</td>
</tr>
<tr>
<td>Tanja</td>
<td>kaufte</td>
<td>sieben</td>
<td>alte</td>
<td>Autos</td>
<td>Tanja buys seven old cars.</td>
</tr>
<tr>
<td>Ulrich</td>
<td>gibt</td>
<td>acht</td>
<td>nasse</td>
<td>Bilder</td>
<td>Ulrich gives eight wet pictures.</td>
</tr>
<tr>
<td>Britta</td>
<td>schenkt</td>
<td>vier</td>
<td>schwere</td>
<td>Dosen</td>
<td>Britta presents four heavy cans.</td>
</tr>
<tr>
<td>Wolfgang</td>
<td>verleiht</td>
<td>fünf</td>
<td>grüne</td>
<td>Sessel</td>
<td>Wolfgang lends five green armchairs.</td>
</tr>
<tr>
<td>Stefan</td>
<td>hat</td>
<td>zwei</td>
<td>teure</td>
<td>Meesser</td>
<td>Stefan has two expensive knives.</td>
</tr>
<tr>
<td>Thomas</td>
<td>gewann</td>
<td>achtzehn</td>
<td>schöne</td>
<td>Schuhe</td>
<td>Thomas won eighteen beautiful shoes.</td>
</tr>
<tr>
<td>Doris</td>
<td>nahm</td>
<td>zwölf</td>
<td>rote</td>
<td>Steine</td>
<td>Doris took twelve red stones.</td>
</tr>
<tr>
<td>Nina</td>
<td>malt</td>
<td>elf</td>
<td>weiße</td>
<td>Ringe</td>
<td>Nina paints eleven white rings.</td>
</tr>
</tbody>
</table>
The Italian Matrix Test

Properties of the Italian Matrix Test

Expected SRT range for normal hearing individuals: -6.7 ± 0.7 dB SNR (mean ± standard deviation) for adaptive measurements

Slope of psychometric function: 14.3 %/dB


The Polish Matrix Test

Properties of the Polish Matrix Test

Expected SRT range for normal hearing individuals: -8.0 ± 1.3 dB SNR (mean ± standard deviation) for adaptive measurements

Slope of psychometric function: 21.8 %/dB


Note:
The adaptive procedure of the Polish Matrix Test employs sentence scoring.
The Russian Matrix Test

Properties of the Russian Matrix Test

Expected SRT range for normal hearing individuals: -8.8 ± 0.8 dB SNR (mean ± standard deviation) for adaptive measurements

Slope of psychometric function: 14.0 %/dB


The Spanish Matrix Test

Properties of the Spanish Matrix Test

Expected SRT range for normal hearing individuals: -6.2 ± 0.8 dB SNR (mean ± standard deviation) for adaptive measurements

Slope of psychometric function: 13.1 %/dB

The Turkish Matrix Test

<table>
<thead>
<tr>
<th>Name</th>
<th>Number</th>
<th>Adjective</th>
<th>Noun</th>
<th>Verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gönül</td>
<td>yedi</td>
<td>mavi</td>
<td>sepet</td>
<td>hâketmiş</td>
</tr>
<tr>
<td>Zuhal</td>
<td>bir</td>
<td>yeni</td>
<td>klim</td>
<td>verdi</td>
</tr>
<tr>
<td>Fırat</td>
<td>sekiz</td>
<td>beyaz</td>
<td>yaşak</td>
<td>satmiş</td>
</tr>
<tr>
<td>Hikmet</td>
<td>üç</td>
<td>küçük</td>
<td>Tấtal</td>
<td>getirdi</td>
</tr>
<tr>
<td>Tunçay</td>
<td>altı</td>
<td>yeğil</td>
<td>ombiz</td>
<td>bulmuş</td>
</tr>
<tr>
<td>Nurşen</td>
<td>beş</td>
<td>temiz</td>
<td>gömlek</td>
<td>çizdi</td>
</tr>
<tr>
<td>Poyraz</td>
<td>dokuz</td>
<td>renkli</td>
<td>banan</td>
<td>fırlatmış</td>
</tr>
<tr>
<td>Seyhan</td>
<td>on</td>
<td>bordo</td>
<td>minder</td>
<td>gördü</td>
</tr>
<tr>
<td>Meltem</td>
<td>iki</td>
<td>güzel</td>
<td>terlik</td>
<td>kazarmış</td>
</tr>
<tr>
<td>Dilek</td>
<td>dört</td>
<td>siyah</td>
<td>fincan</td>
<td>yolalı</td>
</tr>
</tbody>
</table>

Properties of the Turkish Matrix Test

Expected SRT range for normal hearing individuals: -7.2 ± 0.8 dB SNR (mean ± standard deviation) for adaptive measurements

Slope of psychometric function: 14.7%/dB


International Matrix Tests

Available as Medical Device
- German
- Polish
- English (US)
- Russian
- Turkish
- French
- Spanish
- Italian
- Finnish

In Development
- English (UK)
- Persian
- Swedish
- Dutch
- Danish
- Japanese (scheduled)
- Norwegian
- Chinese (scheduled)
- Hebrew
- Hindi (scheduled)
- Arabic
The Center of Competence HörTech, a non-profit organization located in Northern Germany and owned in part by the University of Oldenburg and led by Prof. Dr. Dr. Birger Kollmeier as scientific director, has a long standing expertise in the field of developing speech audimetric test procedures in various languages. More than twenty speech tests have been developed here, and many of them are in widespread use all over the world.

The aims of this non-profit organisation are to support science and research and to develop new methods and expertise concerning hearing. The institute has its origins in a national contest of the German Federal Ministry of Education and Research. Since then, it has come to enjoy international appreciation. Its efforts in basic research, which are widely renowned, have contributed to improvements in hearing aid technology. HörTech is based in the „House of Hearing“ in Oldenburg.