



INTERNATIONAL MATRIX TESTS

Alan	bought	two	big	beds
Berry	gives	three	cheap	chairs
Hannah	got	four	dark	desks
Kathy	has	five	green	maps
Larry	kept	six	large	traps
Mrs	likes	eight	old	shops
Peter	sees	nine	pink	shows
Rachel	sold	ten	red	springs
Steven	wants	twelve	small	trousers
Thomas	wins	some	very	tops

Reliable speech audiometry in noise



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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 Test

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 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 have the same structure (e.g. in English: “Lucy kept nine green flowers”; name, verb number, adjective and noun). Test lists are generated by creating seemingly random sentences from an inven-

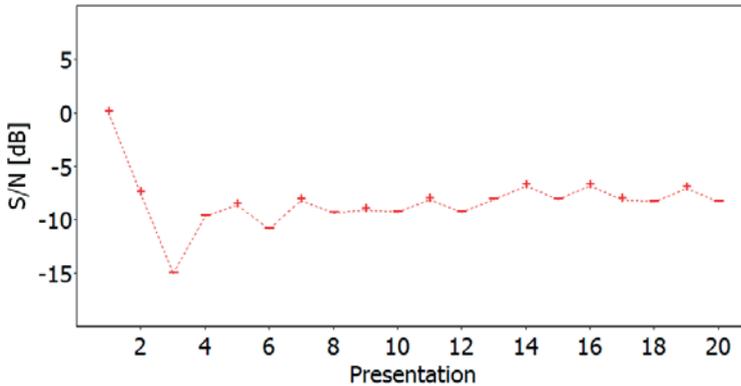
tory (a basis matrix) of fifty words, i.e. ten words per category. Despite the random composition, every sentence is syntactically correct. This way, up to 100,000 different sentences can be generated which makes it impossible to memorize them. Thus, after a short training, Matrix Tests can be repeatedly conducted with the same patient without affecting the test results.

Simplified Matrix Test

The Simplified Matrix Test determines the speech recognition threshold (SRT) with children aged 4 years and up. The speech material is a simplified version (subset) of the Matrix Test. Instead of full sentences the test uses phrases with the same structure of three categories (number, adjective, noun, e.g. “five red flowers”). The phrases are created in a seemingly random combination of an inventory of seven words per category which makes it impossible to memorize them. Thus, after a short training, the test can be repeatedly conducted with the same person without affecting the test result.

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



Sample measurement trace illustrating the adaptive procedure for determining the speech reception threshold (SRT).

The audiometrist does not even have to speak the language of the patient: Matrix Tests can be conducted in a closed-set response 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.

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 usually 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 (can be adjusted to the hearing loss). 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 Simplified Matrix Tests can be performed with test lists of 14 sentences. The duration of a typical 20 item test list is about 4 minutes and a typical 14 item list of the Simplified Matrix test is about 2 minutes. For practical clinical applications, test lists of 20 sentences are usually sufficient. The accuracy in threshold estimation of the 20 item and 14 item test lists usually are on the order of 1 dB. However, if a more reliable measurement of the SRT is desired, 30 item test lists can be used. 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: SoNo (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.

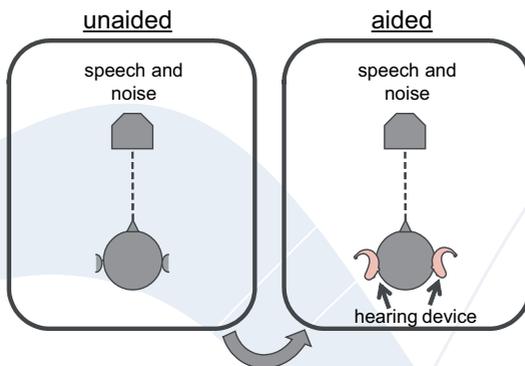
Each sentence consists of five words and always has the same structure: name, verb, numeral, adjective and noun, for example “Peter ordered three large desks”. The sentences are not necessarily meaningful.

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.

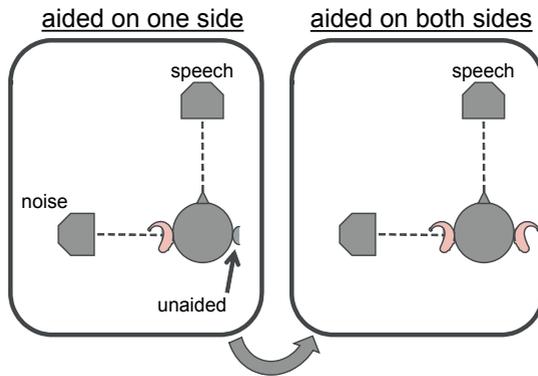
If the sentences are too loud at any point, please let me know.

Do you have any questions?



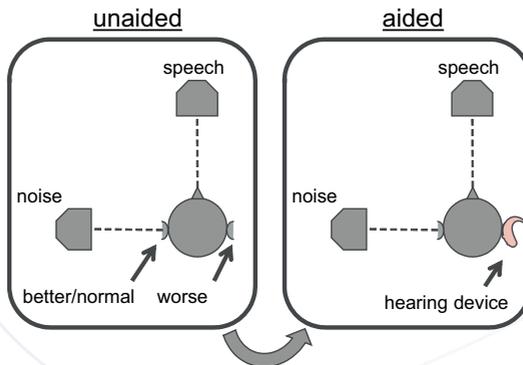
Typical test setup (1) : Benefit of hearing aid provision

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).



Typical test setup (2): Benefit of a second hearing device

The proof of benefit of a second hearing aid can be done with the matrix test in noise (after sufficient training) by first measuring the speech reception threshold (SRT) with monaural hearing device provision (spatial configuration: speech from front, noise from 90° on the aided side). The benefit of a second hearing device is demonstrated if in the same spatial configuration with binaural hearing device provision an improvement (i.e. reduction) of the SRT by a significant amount is reached.



Typical test setup (3): Benefit of a single hearing device

The proof of benefit of a single hearing aid can be done with the matrix test in noise (after sufficient training) by first measuring the speech reception threshold (SRT) without hearing device provision (spatial configuration: speech from front, noise from 90° on the better side). The benefit of a hearing device is demonstrated if in the same spatial configuration with hearing device provision on the worse ear an improvement (i.e. reduction) of the SRT by a significant amount is reached.

Arabic Matrix Test

Adjective	Noun	Number	Name	Verb	
جديدة	كتب	عدة	علي	يريد	Ali wants many new books.
بنية	اطباق	خمسة	نبيل	اشترى	Nabil bought five brown plates.
صغيرة	كراسي	عشرة	زين	يصنع	Zain makes ten small chairs.
كبيرة	كؤوس	أربعة	ناجي	ربح	Naji won four large cups.
خفيفة	قمصان	ستة	عمر	يفضل	Omar prefers six light shirts.
حمراء	خواتم	سبعة	هاشم	لون	Hisham colored seven red rings.
قديمة	بيوت	بضع	وائل	نال	Wael got a few old houses.
ثمينة	سكاكين	تسعة	بلال	يأخذ	Bilal takes nine precious knives.
زرقاء	أعلام	ثمانية	أمين	أخرج	Amin removes eight blue flags.
جميلة	ألواح	ثلاثة	فواد	يعطى	Fuad gives three beautiful boards.

Properties of the Arabic Matrix Test

Reference: Buschermöhle M, Zokoll MA, Abdulhaq N, Hochmuth S, Kollmeier B, Saleh S, Said N, Abdulhadi K (in preparation). Development of a test procedure for speech audiometry in noise for Modern Standard Arabic: The Arabic Matrix Sentence Test



in association with



Chinese Matrix Test

Name	Verb	Number	Adjective	Noun	
郭毅	带走	一个	彩色的	板凳	Guo Yi took away one colored stool
李锐	借来	两个	大号的	茶杯	Li Rui borrows two large cups
沈悦	看见	三个	很旧的	灯笼	Shen Yue saw three old lanterns
王石	留下	四个	便宜的	饭盒	Wang Shi left four cheap lunch-boxes
徐敏	买回	五个	漂亮的	花瓶	Xu Min bought five beautiful vases
杨硕	拿起	六个	普通的	戒指	Yang Shuo picked six ordinary rings
张伟	弄丢	七个	奇怪的	闹钟	Zhang Wei lost seven strange alarm-clocks
郑贤	收好	八个	全新的	书包	Zheng Xian put away eight brand-new bags
周明	需要	九个	特别的	水壶	Zhou Ming needed nine special kettles
朱婷	找出	十个	用过的	玩具	Zhu Ting found ten used toys

Properties of the Chinese Matrix Test

SVS (dB SNR)	STD (SVS)	S ₅₀ [%/dB]	STD (S ₅₀)	Source	Response input	Length of testlist
-9,3	1,0	13,5	1,8	Hu et al. (2017)	open	20
-10,1	1,0	13,5	1,8	Hu et al. (2017)	closed	20

Comments:

- The reference values for adaptive measurements shall also be used for non-adaptive measurements.
- The value for the slope is always the value determined for non-adaptive measurements.
- The SVS STD value for open response was rounded up to 1.0 dB.

Reference: Hu, H. et al. (2017). Construction and evaluation of the Mandarin Chinese matrix (CMNmatrix) sentence test for the assessment of speech recognition in noise, submitted to International Journal of Audiology

Danish Matrix Test

Name	Verb	Number	Adjective	Noun	
Anders	ejer	tre	fine	biler	Anders owns three fine cars.
Birgit	får	fem	flotte	blomster	Birgit gets five beautiful flowers.
Henning	finder	seks	gamle	gaver	Henning finds six old gifts.
Ingrid	havde	syv	hvide	huse	Ingrid had seven white houses.
Kirsten	købte	otte	nye	jakker	Kirsten bought eight new jackets.
Linda	låner	ni	pæne	kasser	Linda borrows nine neat boxes.
Michael	ser	ti	røde	masker	Michael saw ten red masks.
Niels	solgte	tolv	sjove	planter	Niels sold twelve fun plants.
Per	valgte	fjorten	smukke	ringe	Per chose fourteen beautiful rings.
Ulla	vandt	tyve	store	skabe	Ulla won twenty large closets.



Properties of the Danish Matrix Test

Expected SRT range for normal hearing individuals: $-8,4 \pm 1$ dB SNR (mean \pm standard deviation) for adaptive measurements

Slope of psychometric function: 13,2 %/dB

Reference: Wagener, K. Josvasse, J. L. and Ardenkjær, R. (2003). "Design, optimization and evaluation of a Danish sentence test in noise." Intern. J. Audiol. 2003; 42, 10-17

Dutch Matrix Test

Name	Verb	Number	Adjective	Noun	
David	draagt	twee	beige	bedden	David carries two beige beds.
Ellen	heeft	drie	blauwe	boten	Ellen has three blue boats.
Emma	kiest	vier	bruine	doeken	Emma chooses four brown cloths.
Jacob	koopt	vijf	gele	dozen	Jacob buys five yellow cans.
Jeroen	krijgt	zes	grijze	fietsen	Jeroen gets six gray bikes.
Johan	leent	acht	groene	jassen	Johan lends eight green coats.
Lucas	maakt	tien	paarse	kousen	Lucas makes ten purple stockings.
Sara	wint	elf	rode	manden	Sara wins eleven red baskets.
Sofie	ziet	twaaif	witte	pennen	Sofie sees twelve white pencils.
Thomas	zoekt	veel	zwarte	ringen	Thomas searches a lot black rings.

Properties of the Dutch Matrix Test

Expected SRT range for normal hearing individuals: $-9,5 \pm 1,0$ dB SNR (mean \pm standard deviation) for adaptive measurements

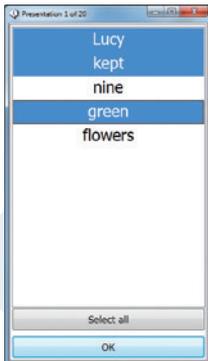
Slope of psychometric function: 13, 9 %/dB

Reference: Luts H., Jansen S., Dreschler W., and Wouters J. (2014), "Development and normative data for the Flemish/Dutch Matrix test", <https://lirias.kuleuven.be/handle/123456789/474335>.



English Matrix Test (US)

Name	Verb	Number	Adjective	Noun	
Peter	got	three	large	desks	<i>Peter got three large desks.</i>
Kathy	sees	nine	small	chairs	<i>Kathy sees nine small chairs.</i>
Lucy	brought	seven	old	tables	<i>Lucy brought seven old tables.</i>
Alan	gives	eight	dark	toys	<i>Alan gives eight dark toys.</i>
Rachel	sold	four	heavy	spoons	<i>Rachel sold four heavy spoons.</i>
William	prefers	nineteen	green	windows	<i>William prefers nineteen green windows.</i>
Steven	has	two	cheap	sofas	<i>Steven has two cheap sofas.</i>
Thomas	kept	fifteen	pretty	rings	<i>Thomas kept fifteen pretty rings.</i>
Doris	ordered	twelve	red	flowers	<i>Doris ordered twelve red flowers.</i>
Nina	wants	sixty	white	houses	<i>Nina wants sixty white houses.</i>



Properties of the American English Matrix Test

Expected SRT range for normal hearing individuals: -8.6 ± 0.9 dB SNR (mean \pm standard deviation) for adaptive measurements

Slope of psychometric function: 13.3 %/dB

Reference: Zokoll MA, Warzybok A, Carroll R, Kreisman B, Allen P, Wagener KC, Kollmeier B (in preparation). Design, Optimization, and Evaluation of an American English Matrix Sentence Test in Noise.

English Matrix Test (UK)

Name	Verb	Number	Adjective	Noun	
Alan	bought	two	big	beds	Alan bought two big beds.
Barry	gives	three	cheap	chairs	Barry gives three cheap chairs.
Hannah	got	four	dark	desks	Hannah got four dark desks.
Kathy	has	five	green	mugs	Kathy has five green mugs.
Lucy	kept	six	large	rings	Lucy kept six large rings.
Nina	likes	eight	old	ships	Nina likes eight old ships.
Peter	sees	nine	pink	shoes	Peter sees nine pink shoes.
Rachel	sold	ten	red	spoons	Rachel sold ten red spoons.
Steven	wants	twelve	small	tins	Steven wants twelve small tins.
Thomas	wins	some	thin	toys	Thomas wins some thin toys.

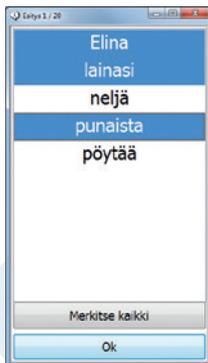
Properties of the UK English Matrix Test

Reference: Hewitt, D. R. (2007), "Evaluation Of An English Speech-In-Noise Audiometry Test" MSc thesis, University of Southampton.



Finnish Matrix Test

Name	Verb	Number	Adjective	Noun	
Elina	etsii	pari	halpaa	autoa	<i>Elina searches a pair of cheap cars.</i>
Harri	huomasi	kaksi	kallista	bussia	<i>Harri notices two expensive buses.</i>
Johanna	järjesti	kolme	keltaista	kelloa	<i>Johanna arranged three yellow watches.</i>
Kerttu	lainasi	neljä	pientä	kenkää	<i>Kerttu borrowed four small shoes.</i>
Mikko	näkee	viisi	punaista	kirjaa	<i>Mikko sees five red books.</i>
Juhani	ostaa	kuusi	sinistä	kuppia	<i>Juhani buys six blue cups.</i>
Olga	pyysi	seitsemän	suurta	mattoa	<i>Olga asked seven big carpets.</i>
Petteri	tahtoo	kahdeksan	tuttua	pöytää	<i>Petteri wants eight familiar tables.</i>
Sofia	tarvitsi	yhdeksän	uutta	rengasta	<i>Sofia needed nine new wheels.</i>
Ville	valitsee	kymmenen	vanhaa	sukkaa	<i>Ville chooses ten old socks.</i>



Properties of the Finnish Matrix Test

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

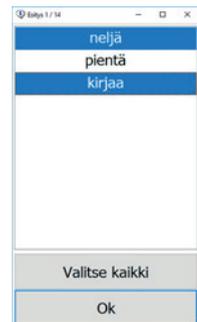
Slope of psychometric function: 16.7 %/dB

Speech rate: 226 ± 19 syllables per minute

Reference: Dietz A, Buschermöhle M, Aarnisalo AA, Vanhanen A, Hyrynen T, Aaltonen O, Löppönen H, Zokoll MA, Kollmeier B (2014). The development and evaluation of the Finnish Matrix Sentence Test for speech intelligibility assessment. *Acta Oto-Laryngol.*

Finnish Simplified Matrix Test

Number	Adjective	Noun	
kaksi	pieniä	kenkää	two small shoes
kolme	suurta	kirjaa	three big books
neljä	uutta	pöytää	four new tables
kuusi	vanhaa	sukkaa	six old socks
kahdeksan	keltaista	autoa	eight yellow cars
yhdeksän	punaista	bussia	nine red buses
kymmenen	sinistä	kuppia	ten blue cups



Properties of the Finnish Simplified Matrix Test

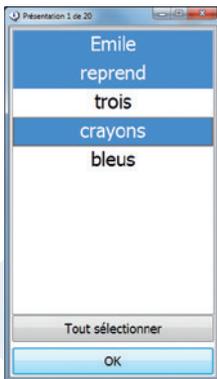
Expected SRT range for normal hearing individuals: $-11,2 \pm 1,0$ dB SNR (mean \pm standard deviation) for adaptive measurements

Slope of psychometric function: 19,4 %/dB

Reference: Willberg T, Kärteva K, Zokoll M A, Buschermöhle M, Sivonen V, Aarnisalo AA, Kollmeier B, Löppönen H, Dietz A. (in preparation). The simplified Finnish matrix sentence test for the assessment of speech intelligibility in children and in elderly;

French Matrix Test

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



Properties of the French Matrix Test

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

Slope of psychometric function: 14.0 %/dB

Reference: Jansen S, Luts H, Wagener KC, Kollmeier B, Del Rio M, Dauman R, James C, Fraysse B, Vormès E, Frachet, B, Wouters J, van Wieringen A (2012). Comparison of three types of French speech-in-noise tests: A multi-center study. *Int. J. Audiol.* 51(3) 164-173

French Simplified Matrix Test

Number	Adjective	Noun	
deux	anneaux	blancs	two white rings
trois	ballons	bleus	three blue balloons
cinq	crayons	bruns	five brown pencils
six	jetons	jaunes	six yellow tokens
sept	piquets	noirs	seven black posts
huit	rubans	rouges	eight red ribbons
neuf	vélos	verts	nine green bikes



Properties of the French Simplified Matrix Test

Expected SRT range for normal hearing individuals:

Age	mean \pm standard deviation	Slope of psychometric function
5-6 years	-4,2 dB \pm 1,3 dB SNR	10,3%/dB
7-8 years	-4,6 dB \pm 1,2 dB SNR	10,1%/dB
9-10 years	-5,5 dB \pm 1,5 dB SNR	10,0%/dB
Adults	-7,1 dB \pm 1,4 dB SNR	12,0%/dB

Reference: Buschermöhle, M. Exter, M. (2018) "Internal project report French Simplified Matrix Test."

German Matrix Test

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

Properties of the German Matrix Test

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

Slope of psychometric function: 17.1 %/dB

Speech rate: 233 \pm 27 syllables per minute

Reference: Wagener KC, Brand T, Kollmeier B (1999). Entwicklung und Evaluation eines Satztests für die deutsche Sprache Teil III: Evaluation des Oldenburger Satztests. Z. Audiol. 38(3):86-95



German Simplified Matrix Test

Number	Adjective	Noun	
drei	große	Blumen	three big flowers
neun	kleine	Tassen	nine small cups
sieben	schöne	Autos	seven beautiful cars
acht	nasse	Bilder	eight wet pictures
vier	rote	Messer	four red knives
fünf	grüne	Schuhe	five green shoes
zwei	weiße	Steine	two white stones

Properties of the German Simplified Matrix Test

Expected SRT range for normal hearing individuals:

Age	mean ± standard deviation	Slope of psychometric function
1 st grade	-5,6 dB ± 1,0 dB SNR	12,2%/dB
2 nd grade	-6,1 dB ± 1,0 dB SNR	12,0%/dB
3 rd grade	-6,7 dB ± 1,1 dB SNR	12,5%/dB
4 th grade	-6,6 dB ± 1,0 dB SNR	13,8%/dB
adults	-7,2 dB ± 1,3 dB SNR	13,7%/dB

Reference: Wagener, K. und Kollmeier, B. (2005), „Evaluation des Oldenburger Satztests mit Kindern und Oldenburger Kinder-Satztest“, Z Audiol 2005; 44(3) 134-143

Buschermöhle, M., Wagener, K.C & Kollmeier, B. (2016), „Sprachaudiometrische Messungen mit dem verkürzten Oldenburger Satztest OLKISA bei Erwachsenen“, Z Audiol 2016; 55 (1) 6-13.

Hebrew Matrix Test

Name	Verb	Number	Adjective	Noun	
אופיר	הביא	שלושה	כסאות	גדולים	Ofir brought three large chairs
אייל	החזיק	ארבעה	מטבעות	זולים	Eyal held four cheap coins
ארז	לקח	חמישה	מעילים	חדשים	Erez took five new coats
גלעד	מצא	שישה	נרות	יפים	Gilad found six beautiful candles
גפן	נתן	שבעה	סולמות	ירוקים	Geffen gave seven green ladders
יובל	סידר	שמונה	סכינים	ישנים	Yuval arranged eight old knives
עדן	צייר	תשעה	סנדלים	מבריקים	Eden painted nine shiny sandals
עודד	קיבל	עשרה	ספרים	צהובים	Oded received ten yellow books
רועי	קנה	מאה	עפרונות	קטנים	Roy bought hundred small pencils
תומר	רצה	כמה	פרחים	שחורים	Tomer wanted some black flowers

Properties of the Hebrew Matrix Test

SVS (dB SNR)	STD (SVS)	S ₅₀ [%/dB]	STD (S ₅₀)	Source	Response input	Length of testlist
-8,2	1,3	13,5	1,5	Koif- man, S. (2016)	open	20

Comments:

- The reference values for adaptive and non-adaptive measurements have been summarised.
- The value for the slope is always the value determined for non-adaptive measurements.
- No reference values are available for closed response input

Reference: Koifman, S. (2016), Internal project report of the project „Hebrew Matrix Test“,

Indonesian Matrix Test

Name	Verb	Number	Adjective	Noun	
Agus	melihat	dua	bola	bagus	Agus sees two nice balls
Arif	membawa	tiga	buah	baru	Arif brings three new fruits
Ayu	membayar	empat	buku	berat	Ayu pays four heavy books
Fajar	memilih	lima	cangkir	bersih	Fajar chooses five clean cups
Ika	mencari	enam	gitar	kecil	Ika searches six small guitars
Made	mendapat	tujuh	kaleng	keras	Made got seven hard cans
Maya	mengangkat	delapan	kotak	kotor	Maya lifts eight dirty boxes
Putri	mengganti	sembilan	kunci	kuning	Putri replaces nine yellow keys
Putu	menjual	sepuluh	sendok	mahal	Putu sells ten expensive spoons
Sari	menyimpan	seratus	sofa	putih	Sari keeps hundred white sofas

Properties of the Indonesian Matrix Test

SVS (dB SNR)	STD (SVS)	S ₅₀ [%/dB]	STD (S ₅₀)	Source	Response input	Length of testlist
-9,3	1,0	13,5	1,8	Hu et al. (2017)	open	20
-10,1	1,0	13,5	1,8	Hu et al. (2017)	closed	20

Comments:

- The standard deviations of the SVS were rounded up for measurements with the „Noise Indonesian Matrix Test“.
- The reference values for adaptive measurements are also used for non-adaptive measurements.

Reference: Primadita, F. (2017) Development and Clinical Validation of The Indonesian Matrix Sentence Test. Master Thesis, Carl von Ossietzky Universität Oldenburg
 Primadita, F. et al. (2018). Matrix test as speech recognition test in noise for Indonesian language, Paper in preparation.

Italian Matrix Test

Name	Verb	Number	Noun	Adjective	
Andrea	cerca	due	bottiglie	azzurre	<i>Andrea searches two blue bottles.</i>
Anna	compra	quattro	macchine	belle	<i>Anna buys four beautiful cars.</i>
Chiara	dipinge	cinque	matite	bianche	<i>Chiara paints five white pencils.</i>
Luca	manda	sette	palle	grandi	<i>Luca sends seven big balls.</i>
Marco	possiede	otto	pietre	nere	<i>Marco has eight black stones.</i>
Maria	prende	nove	porte	normali	<i>Maria takes nine normal doors.</i>
Matteo	regala	dieci	scatole	nuove	<i>Matteo gives ten new boxes.</i>
Sara	trascina	venti	sedie	piccole	<i>Sara pulls twenty small chairs.</i>
Simone	vede	poche	tavole	rosse	<i>Simon sees a few red tables.</i>
Sofia	vuole	molte	tazze	utili	<i>Sofia wants many useful cups.</i>



Properties of the Italian Matrix Test

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

Slope of psychometric function: 14.3 %/dB

Reference: Giuseppina EP, Warzybok A, Hochmuth S, Visentin C, Astolfi A, Prodi N, Kollmeier B (2015). An Italian matrix sentence test for the evaluation of speech intelligibility in noise. *Int. J Audiol.* 52 (S2), 44-50.

Italian Simplified Matrix Test

Number	Adjective	Noun	
due	macchine	azzurre	two blue cars
quattro	matite	bianche	four white pencils
cinque	palle	grandi	five big balls
sette	pietre	nere	seven black stones
otto	porte	nuove	eight new doors
nove	sedie	piccole	nine small chairs
dieci	Tavole	rosse	ten red tables



Properties of the Italian Simplified Matrix Test

Expected SRT range for normal hearing individuals:

Age	mean \pm standard deviation	Slope of psychometric function
5-6 years	-5,6 dB \pm 1,2 dB SNR	11,3%/dB
7-8 years	-6,5 dB \pm 1,3 dB SNR	11,3%/dB
9-10 years	-6,5 dB \pm 1,3 dB SNR	14,0%/dB
Adults	-8,0 dB \pm 1,0 dB SNR	12,1%/dB

Reference: Warzybok A, Garbaruk E.S, Goykhuburg M, Merza Z, Puglisi G.E, Montuschi C, F di Berardino, Zanetti D, Sellami F, Wagener K.C, Holube I, Astolfi A, Albera R, Pavlov P.A, Tavartki-ladze G.A, Kollmeier B (2017) Evaluation of internationally compatible speech test in noise for the pediatric population. 13th Congress of the European Federation of Audiology Societies, June 7-10, 2017, Interlaken, Switzerland.

Japanese Matrix Test

Name	Verb	Number	Adjective	Noun	
薫は	青い	おもちゃを	一個	置いた	Kaoru placed one blue toy
茂は	赤い	花瓶を	二個	かいた	Shigeru had two red vases
節子は	大きい	サイコロを	三個	買った	Setsuko bought three large dice
太郎は	軽い	宝石を	四個	探した	Taro searches four light jewels
花子は	かわいい	めがねを	五個	しまった	Hanako got five tiny glasses
英男は	黄色い	湯のみを	六個	取った	Hideo took six yellow drinks
ひろみは	白い	指輪を	七個	見つけた	Hiromi found seven white rings
恵は	小さい	磁石を	八個	持った	Megumi got eight small magnets
二郎は	古い	電池を	九個	渡した	Jiro gives nine old batteries
純子は	安い	ビー玉を	十個	出した	Junko delivered ten cheap marbles

Properties of the Japanese Matrix Test

SVS (dB SNR)	STD (SVS)	S ₅₀ [%/dB]	STD (S ₅₀)	Source	Response input	Length of testlist
-9,0	1,0	13,3	1,8	War- zybok (2018)	open / closed	20

Comments:

- The reference values for adaptive and non-adaptive measurements have been summarised.
- The value for the slope is always the value determined for non-adaptive measurements.
- The value for the SVS STD with open response input was rounded up to 1.0 dB.

Reference: Warzybok (2018). Interner Projektbericht „Entwicklung Japanischer Matrixtest - Referenzwerte“

Korean Matrix Test

Name	Verb	Number	Adjective	Noun	
건우는	새로운	책상	한 개를	본다	Geono sees one new desk
철수는	작은	의자	두 개를	받았다	Cheolsu received two small chairs
준호는	파란	주사위	세 개를	판다	Junho sells three blue dice
은서가	커다란	장난감	네 개를	좋아한다	Eunseo likes four big toys
슬기가	가벼운	술가락	다섯 개를	빌렸다	Seugli borrowed five light spoons
민준이는	예쁜	반지	여섯 개를	만든다	Minjoon made six beautiful rings
동준이는	깨끗한	접시	일곱 개를	주웠다	Dongjoon picked up seven clean plates
유진이가	멋진	바구니	여덟 개를	산다	Eugene buys eight nice baskets
서영이가	빨간	연필	아홉 개를	발견했다	Seoyoung found nine red pencils
지민이가	하얀	풍선	열 개를	주문했다	Jimin ordered ten white balloons

Properties of the Korean Matrix Test

Measurements for reference data are currently in progress.

Norwegian Matrix Test

Name	Verb	Number	Adjective	Noun	
Benjamin	eide	to	fine	boller	Benjamin has two fine balls.
Eivind	flytter	tre	gamle	duker	Eivind moves three old cloths.
Hedda	ga	fire	hele	kasser	Hedda gives four full boxes.
Ida	grep	fem	lette	knapper	Ida grabbed five light buttons.
Ingvild	har	seks	lyse	kurver	Ingvild has six bright curves.
Jonas	låner	sju	mørke	luer	Jonas borrows seven dark hats.
Magnus	ser	åtte	nye	penner	Magnus sees eight new pens.
Malin	tok	elleve	store	ringer	Malin took eleven large rings.
Thea	vant	tolv	svarte	skåler	Thea won twelve black bowls.
Thomas	viser	atten	vakre	vanter	Thomas shows eighteen beautiful gloves.



Properties of the Norwegian Matrix Test

Expected SRT range for normal hearing individuals: $-6,8 \pm 1,2$ dB SNR (mean \pm standard deviation) for adaptive measurements

Slope of psychometric function: 11,1 %/dB

Reference: Øygarden, J. (2009), “Norwegian Speech Audiometry”, PhD thesis, Trondheim, Norwegian University of Science and Technology, Faculty of Arts, Department of Language and Communication Studies

Polish Matrix Test

Name	Verb	Number	Adjective	Noun	
Tomasz	nosi	pięć	dobrych	piłek	<i>Thomas carries five good balls.</i>
Paweł	woli	sześć	tanich	gazet	<i>Paul prefers six cheap papers.</i>
Adam	widzi	siedem	drogich	soków	<i>Adam sees seven expensive juices.</i>
Maciej	bierze	osiem	pięknych	dzwonów	<i>Matthew takes eight beautiful bells.</i>
Michał	daje	dziewięć	nowych	opon	<i>Michael gives nine new tyres.</i>
Anna	ma	dużo	starych	stołów	<i>Anne has a lot of old tables.</i>
Ewa	robi	sto	białych	kłocków	<i>Eve makes hundred white bricks.</i>
Maria	kupi	tysiąc	żółtych	toreb	<i>Mary will buy thousand yellow bags.</i>
Zofia	wygra	wiele	czarnych	okien	<i>Sophie will win many black windows.</i>
Julia	sprzeda	kilka	dziwnych	koszy	<i>Julia will sell several strange boxes.</i>

Properties of the Polish Matrix Test

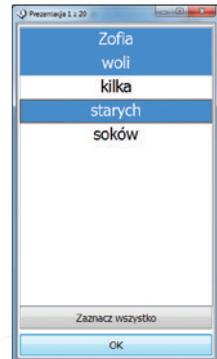
Expected SRT range for normal hearing individuals: -8.0 ± 1.3 dB SNR (mean \pm standard deviation) for adaptive measurements

Slope of psychometric function: 21.8 %/dB

Reference: Ozimek E, Warzybok A, Kutzner D (2010). Polish sentence matrix test for speech intelligibility measurement in noise, *Int. J. Audiol.* 49:444-454

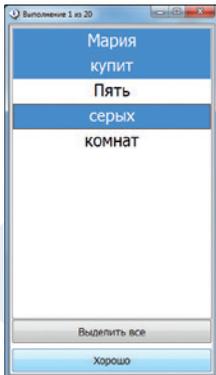
Note:

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



Russian Matrix Test

Name	Verb	Number	Adjective	Noun	
Саша	ищет	Пять	больших	фильмов	<i>Sascha searches five big films.</i>
Павел	хочет	девять	главных	улиц	<i>Paul wants nine important streets.</i>
Пётр	видит	десять	старых	книг	<i>Peter sees ten old books..</i>
Коля	даёт	мало	нужных	шаров	<i>Kolya gives some necessary balls.</i>
Иван	делает	много	чужих	газет	<i>Ivan makes many foreign newspapers.</i>
Юрий	любит	семь	целых	рядов	<i>Yurij likes seven whole rows.</i>
Анна	найдёт	сто	разных	комнат	<i>Anna will find hundred different rooms.</i>
Лена	помнит	восемь	серых	часов	<i>Lena will remember eight gray clocks.</i>
Яна	берёт	шесть	лучших	залов	<i>Jana takes six better halls.</i>
Мария	купит	двести	красных	марок	<i>Maria will buy two hundred red stamps.</i>



Properties of the Russian Matrix Test

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

Slope of psychometric function: 14.0 %/dB

Reference: Warzybok A, Zokoll M, Wardenga N, Ozimek E, Boboshko M, Kollmeier B (2015). Development of the Russian matrix sentence test. *Int. J. Audiol.* 52 (S2), 35-43.

Spanish Matrix Test

Name	Verb	Number	Noun	Adjective	
Claudia	tiene	dos	libros	grandes	<i>Claudia has two big books.</i>
Carmen	hace	tres	barcos	viejos	<i>Carmen makes three old ships.</i>
Elena	toma	doce	platos	nuevos	<i>Elena takes twelve new plates.</i>
Teresa	busca	siete	regalos	pequeños	<i>Teresa searches seven small gifts.</i>
Josefa	quiere	seis	guantes	enormes	<i>Josefa wants six huge gloves.</i>
José	compra	diez	zapatos	azules	<i>José buys ten blue shoes.</i>
Antonio	pinta	cuatro	juegos	bellos	<i>Antonio draws four beautiful games.</i>
Carlos	mira	veinte	dados	lindos	<i>Carlos sees twenty nice dice.</i>
Pedro	pierde	ocho	sillones	baratos	<i>Pedro loses eight cheap armchairs.</i>
Manuel	vende	mil	anillos	negros	<i>Manuel sells thousand black rings.</i>

Properties of the Spanish Matrix Test

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

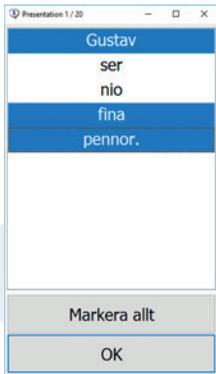
Slope of psychometric function: 13.1 %/dB

Reference: Hochmuth S, Brand T, Zokoll MA, Zenker Castro F, Wardenga N, Kollmeier B (2012). A Spanish matrix sentence test for assessing speech reception thresholds in noise. *Int. J. Audiol.* 51(7) 536-544



Swedish Matrix Test

Name	Verb	Number	Adjective	Noun	
Anna	ägde	två	fin	bullar	Anna took two nice balls
Bosse	flyttar	tre	gamla	dukar	Bosse moves three old cloths.
Britta	gav	fyra	hela	knappar	Britta gave four whole buttons.
Elsa	har	sex	lätta	korgar	Elsa has six light baskets.
Gustav	höll	sju	ljusa	lådor	Gustav was seven bright boxes.
Jonas	köpte	åtta	mörka	mössor	Jonas bought eight dark hats.
Karin	lånar	nio	nya	pennor	Karin lends nine new pencils.
Märta	ser	elva	stora	ringar	Martha sees eleven large rings.
Peter	tog	tolv	svarta	skålar	Peter took twelve black bowls.
Svante	visar	arton	vackra	vantar	Svante shows eighteen beautiful gloves.



Properties of the Swedish Matrix Test

Reference: Hagerman, B. (1982), "Sentences for testing speech intelligibility in noise", Scand Audiol 11: 79-87

Turkish Matrix Test

Name	Number	Adjective	Noun	Verb	
Gönül	yedi	mavi	sepet	haketmiş	<i>Gönül earns seven blue baskets.</i>
Zuhal	bir	yeni	kilim	verdi	<i>Zuhal gives one new carpet.</i>
Fırat	sekiz	beyaz	yatak	satmış	<i>Fırat sells eight white beds.</i>
Hikmet	üç	küçük	çatal	getirdi	<i>Hikmet brings three small forks.</i>
Tuncay	altı	yeşil	cımbız	bulmuş	<i>Tuncay finds six green tweezers.</i>
Nurşen	beş	temiz	gömlek	çizdi	<i>Nurşen draws five clean shirts.</i>
Poyraz	dokuz	renkli	balon	fırlatmış	<i>Poyraz throws nine colorful balloons.</i>
Seyhan	on	bordo	minder	gördü	<i>Seyhan sees ten brown cushions.</i>
Meltem	iki	güzel	terlik	kazanmış	<i>Meltem wins two beautiful slippers.</i>
Dilek	dört	siyah	fincan	yolladı	<i>Dilek sends four black cups.</i>

Properties of the Turkish Matrix Test

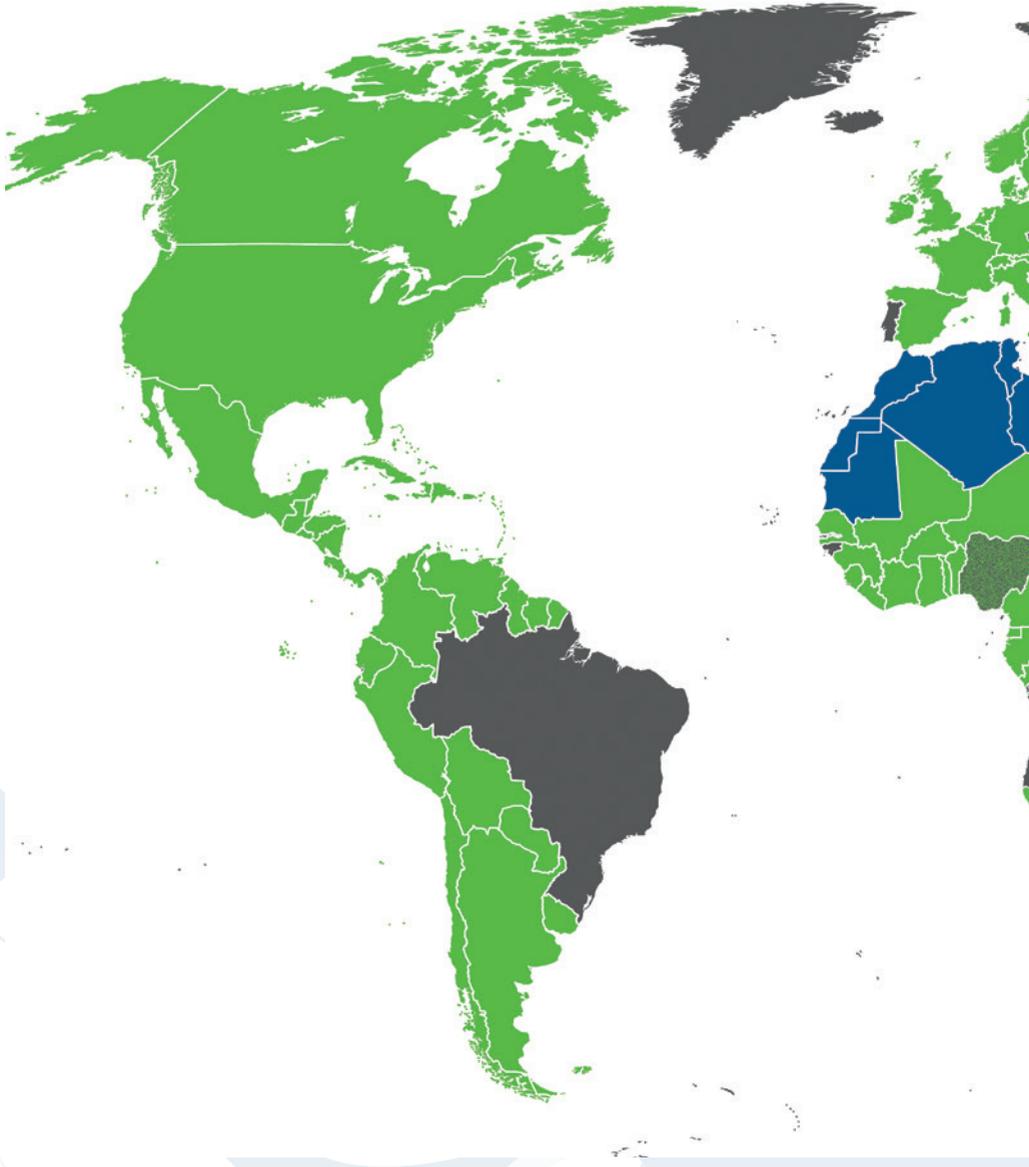
Expected SRT range for normal hearing individuals: -7.2 ± 0.8 dB SNR (mean \pm standard deviation) for adaptive measurements

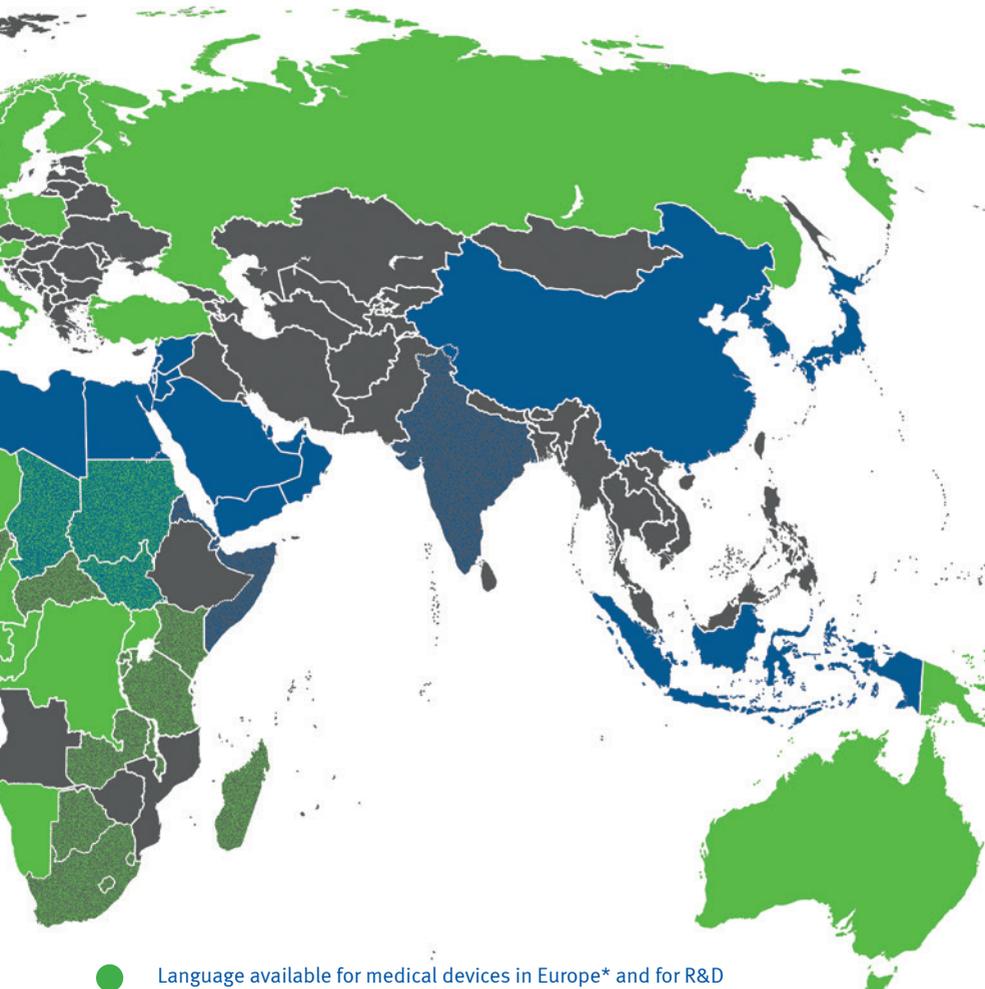
Slope of psychometric function: 14.7 %/dB

Reference: Zokoll M, Fidan D, Türkyılmaz D, Hochmuth S, Ergenc I, Sennaroglu G, Kollmeier B (2015). Development and evaluation of the Turkish matrix sentence test. *Int. J Audiol.* 52 (S2), 51-61.



Available for more than 60% of the world's population





- Language available for medical devices in Europe* and for R&D
- Language available for R&D

Further languages are under development. HörTech is always looking for cooperation partners for the development and evaluation of further languages.

*and additional in Switzerland, Arabian Peninsula, Turkey, currently no service partner in Spain and UK

Oldenburg Measurement Applications

The „Oldenburger Messprogramme“ software provides hearing care professionals and audiologists with an instrument that enables them to quickly and easily perform modern, adaptive measurement procedures such as sentence tests to determine the speech intelligibility threshold or loudness scaling. The software automatically calculates and adjusts the level before each individual presentation based on the patient's answers.

The software offers a wide range of options for speech tests, e.g. different background noises, measurement with continuously presented background noise or virtual acoustics for spatial measurements using headphones. The configuration of the measurement is user-friendly and any preconfigured measurements can be stored in separate measurement profiles for reuse.



OMA 2.0 - Features

- Adaptive sentence tests in noise or quiet
- International Sentence tests (matrix tests)
- Sentence test and word test for children
- Adaptive categorical loudness scaling
- Virtual spatial acoustics for speech tests with headphones
- Language tests now with additional background noise possible (e.g. ICRA)
- Continuous noise during speech tests possible
- Detailed or compact printout in tabular form
- Automatic generation of PDFs of the Results possible
- Supports Windows 10® 64-bit
- Supports SQL Server database server in the network
- Scope of delivery includes „Firebird“ database server
- Can use already installed „Firebird“ or „Microsoft®“ „SQL Server“ database Server

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If you need a medical device, please contact your audiometer manufacturer.

If you are interested in a version for research & development, please contact HörTech gGmbH directly.



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 audiometric 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.

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