

OLSA- How Relevant is it to be a Native Speaker?



Schmidt S^{1*}, O'Brien C¹, Döge J¹, Hackenberg B¹, Bohnert A¹, Chalabi J², Lackner K³, Beutel ME⁴, Münzel T⁵, Wild PS^{2,6,11}, Gianicolo E⁷, Schattenberg J⁸, Tüscher O⁹, Pfeiffer N¹⁰, GHS Research Consortium, Matthias C¹ and Bahr Hamm K¹

¹Department of Otorhinolaryngology, University Medical Center Mainz, Germany

²Preventive Cardiology and Preventive Medicine, Department of Cardiology, University Medical Center Mainz, Germany

³Institute for Clinical Chemistry and Laboratory Medicine, University Medical Center Mainz, Germany

⁴Department of Psychosomatic Medicine and Psychotherapy, University Medical Center Mainz, Germany

⁵Department of Cardiology - Cardiology I, University Medical Center Mainz, Germany

⁶Centre for Thrombosis and Hemostasis (CTH), University Medical Center Mainz, Germany

⁷IMBEL, Institute for Medical Biometrics, Epidemiology and Informatics, Germany

⁸Medical Clinic and Polyclinic I, Germany

⁹Clinic for Psychiatry and Psychotherapy, Germany

¹⁰Eye Clinic and Polyclinic, Germany

¹¹German Center for Cardiovascular Research (DZHK). Partner Site Rhine Mine, Mainz, Germany

Submission: September 09, 2025; **Published:** September 23, 2025

***Corresponding author:** Schmidt S, Department of Otorhinolaryngology, University Medical Center Mainz, 55131 Mainz, Germany

Abstract

Purpose: The Oldenburg Sentence Test (OLSA) is a German matrix test for determining speech recognition thresholds (SRT). It is mainly used for hearing aid and cochlear implant fitting. The aim of this study was to investigate the dependency of language skills on the performance of the OLSA and to establish an age -standardization for non-native speakers without hearing impairment.

Methods: The Gutenberg Health Study is an ongoing population-based study and designed as a single-center observational, prospective cohort study. Participants were interviewed about common ontological symptoms and tested with pure -tone audiometry and OLSA. To participate in the study, participants were required to have a sufficient level of German to be able to complete the entire study, including the questionnaires, without the assistance of an interpreter or translation software. Two groups—subjects with and without hearing loss—were created. The SRT was evaluated for each participant. The results were characterized by age in 10-year cohorts, sex, native speaker/ non- native speaker and speech recognition threshold (SRT).

Results: 88,6% of the participants were born in Germany, the parents of 76,2% of the participants were born in Germany and 88,9% spoke German as a first language. The mean OLSA SRT was – 4.9 dB(A). There was no statistically significant difference in OLSA performance between the groups.

Conclusions: A study with more than 2900 evaluable Oldenburg Sentence Tests is a major study and representative for the population of Mainz and its surroundings. If the German language skills are sufficient to answer the questionnaires, there is no difference between native and non-native speakers in the performance of the OLSA and the OLSA can therefore be used without restrictions for both groups.

Keywords: German matrix test; Hearing loss; Speech intelligibility; Age standardization; Speech audiometry; Native speaker vs non-native speaker

Abbreviations: OLSA: Oldenburg Sentence Test; SRT: Speech Recognition Thresholds; GHS: Gutenberg Health Study; SOP: Standard Operating Procedure; ANOVA: Analysis of Variance; ENT: Ear Nose Throat; WHO: World Health Organisation; HL: Hearing Level; CTVB: Center for Translational Vascular Biology; HINT: Hearing In Noise Test

Introduction

Hearing loss has a very high prevalence worldwide. Chadha et al. cite figures of 1,5 billion people with hearing loss [1]. The

number of people with hearing loss is expected to continue to increase due to demographic changes and the associated increase

in life expectancy. Age-related hearing loss is a gradual process that progresses almost unnoticed by the individual, but has long been recognized as a major health problem in aging societies [1]. The loss of the ability to communicate leads to isolation, loss of quality of life and mental withdrawal [2]. Because hearing loss

usually develops slowly and insidiously, it often goes unnoticed and untreated due to ignorance [3]. International mobility is evident in many countries around the world. According to the German Federal Statistical Office, 2,665,772 people immigrated to Germany in 2022. The trend is increasing (Figure 1).

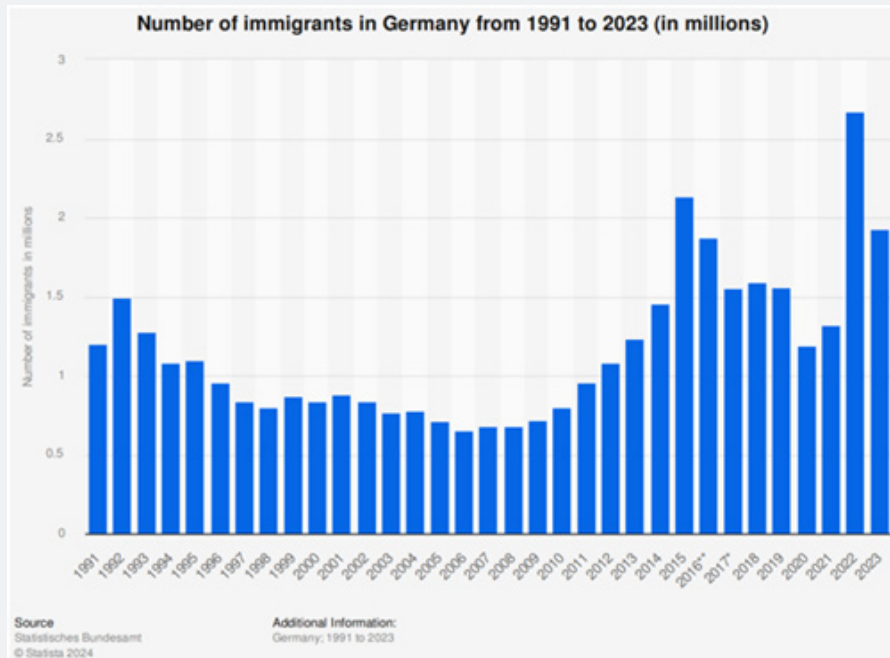


Figure 1: Number of immigrants to Germany from 1991 to 2023.

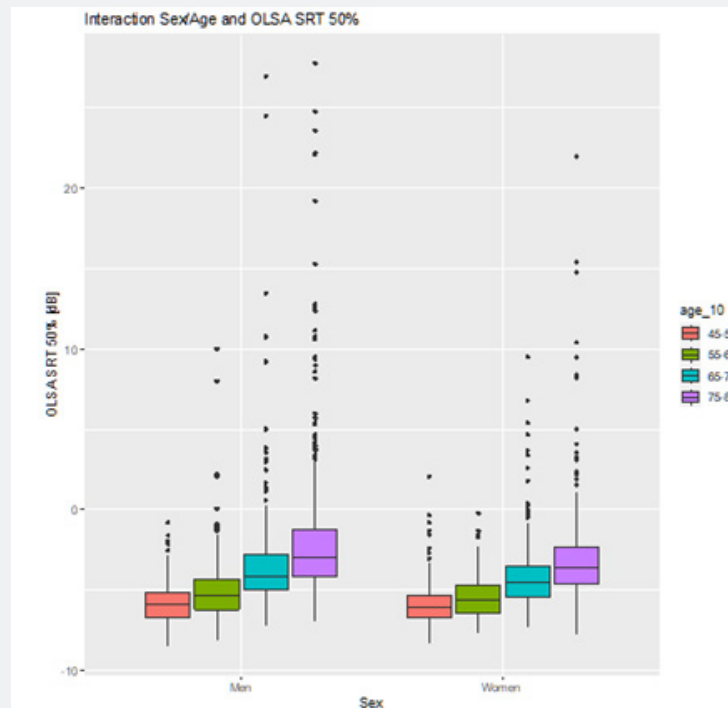


Figure 2: Box plot in dependence of sex and age for the OLSA.

One of the most common chronic conditions and the most common sensory deficit in the aging population is hearing loss [3]. In fact, presbycusis is underdiagnosed and undertreated [4]. A 2018 systematic review on the prevalence of hearing loss in Germany identified only 6 studies providing data on the prevalence of hearing loss in Germany [5]. One study found a prevalence of 12.7% for moderate to profound hearing loss [6]. A number of large cohort studies have been published reporting audiometric data. Different definitions of hearing loss and different testing methods make it difficult to compare the results [3]. Problems with communication and speech perception in various levels of background noise are often the first sign of hearing loss. Presbycusis develops gradually over time and has a significant impact on daily life. There are an increased risk of memory loss [7] and accelerated development of dementia [8] and depression [9]. Loehler et al. [5] proposed a representative epidemiological study. It should take into account age- and frequency-specific definitions of hearing loss [5]. People with hearing loss, especially those with profound hearing loss, have a 13 % higher risk of developing dementia [10]. The German Matrix Test (OLSA) is a test of speech perception in a noisy environment with a large number of repeatable test lists [11]. It is also effective for cochlear implant listening tests, although it is not commonly used to measure speech intelligibility in noise [12]. Age standardization of the OLSA for adults has been postulated [13]. The OLSA requires some attention, concentration, auditory working memory [14], cognitive ability, daytime fitness [2] and most importantly language skills. This is the largest study evaluating OLSA data in Germany known to the authors.

Methods

The Gutenberg Health Study (GHS) is a large, ongoing population-based study, designed as a single-center, observational, prospective cohort study. It was initiated in 2007 at the University Hospital of Mainz, Germany, and is planned to cover the population of the city of Mainz and its district of Mainz-Bingen, Germany. It was approved by the Institutional Review Board (Ethics Commission of Rhineland-Palatinate, Reference No. 837.020.07). Written informed consent, in accordance with the Declaration of Helsinki, was obtained from all participants before participation in the study. The population sample was randomly selected from the civil registry and stratified by age, sex and residence (rural vs. urban). Physical and mental disabilities that might prevent the participant from attending the study site were an exclusion factor. Insufficient knowledge of the German language was also an exclusion criterion. In 2017, (10-year follow-up) additional otological examinations were included in the study. A full description of the study design has been published previously [15].

All examinations of the participants took place on the premises of the University Hospital Mainz. The study nurses were trained and continuously educated by certified audiology

assistants from the Department of Otolaryngology and Audiology at the University Hospital Mainz. The implementation of a standard operating procedure (SOP) ensured the validity of the audiological examinations, the Ear Nose Throat (ENT) evaluation, and thus the OLSA. After an interview about common otological symptoms (i.e., tinnitus), pure tone audiometry for air- and bone conduction was performed separately for both ears at the following frequencies: 0.125, 0.25, 0.5, 0.75, 1, 2, 3, 4, 6, 8, and 10 kHz. All tests were performed with an Auritec AT1000 clinical audiometer and in a soundproof booth. The adaptive procedure of the commercially available German Matrix Test (OLSA) was used as described by Brand et al. 2002 in an open version [16]. The software for the German Matrix Test is called "Oldenburger Messprogramme" by Hortech R&D. Before the speech audiometry, an otoscopy (observation of the external auditory canal and the tympanic membrane) was performed to rule out any impairment of the auditory canal. In addition, the OLSA was administered in two consecutive runs (trial and test, each with 20 sentences). The SRT was documented for each participant for both runs. The OLSA consists of five words (name Ver number adjective object) with a possible combination of 50 words. It is a randomized, adaptive procedure with a fixed noise level to a varying speech level or a varying speech level to a fixed noise level. The noise signal was generated by summing and averaging the time signals of many OLSA test sentences (long-term speech spectrum). Participants with missing data at 0.5, 1, 2 or 4 kHz were excluded from the study, as were those with missing data for OLSA.

Statistical Analyses

Descriptive statistics were computed separately for age intervals (10-year intervals), sex and the OLSA speech recognition threshold (SRT). Participants were divided into groups according to their age.

- I. Group 1: 45–54 years of age (y),
- II. group 2: 55–64 y,
- III. group 3: 65–74 y,
- IV. group 4: 75–86 y.

Each age group was subdivided by sex. Means and standard deviations are presented. The subdivisions are:

"born in Germany", "parents born in Germany" and "have German as main language". Each subject had to had to speak German well enough to understand everything, so no interpreter was needed. Analysis of Variance (ANOVA) was performed to test the contribution of hearing loss and age to the SRT. A subcohort including only individuals without hearing loss [mean hearing loss < 20 dB at frequencies 0.5, 1, 2 and 4 kHz according to World Health Organisation (WHO)] was created and analyzed separately to exclude the effect of hearing loss. Continuous variables are shown as mean (SD) and tested with T-test, or if /skewness/>1 by median (Q1, Q3) and tested with U-Test. Binary variables are

described through relatives and absolute frequencies and tested with chi-square test. All statistical analyses were performed using R version 3.6.1 (2019-07-05) and ggnplot (5.4.2) software for graphical design. Linear regression models using the results

from the OLSA as the dependent variable were used to test if there was a difference in the OLSA results between native and non-native speakers or participants whose parents have been born in Germany or not (Table 2).

Table 1: Baseline characteristics by age (decades).

Variable	All	45-54 Years (Group 1)	55-64 Years (Group 2)	65-74 Years (Group 3)	75-86 Years (Group 4)	P for Trend
	2807	623	770	783	631	
Age	64.4 (10.5)	50.2 (2.5)	59.4 (2.8)	69.1 (2.8)	78.7 (2.7)	<0.0001***
Language / Nationality						
Born in Germany	88.6% (2400/2708)	90.7% (565/623)	90.8% (699/770)	87.2% (682/783)	85.2% (453/532)	<0.0001***
Parents born in Germany	76.2% (2056/2699)	74.7% (464/621)	74.4% (571/767)	76.1% (594/781)	80.6% (427/530)	0.019*
First language (german)	93.0% (2610/2807)	95.5% (595/623)	96.0% (739/770)	96.3% (754/783)	82.7% (522/631)	<0.0001***

Table 2: Baseline characteristics by native/non-native speakers.

Variable	All	Non-Native German	Native German	P
	2936	326	2610	
Sex (women)	48.4% (1420/2936)	44.8% (146/326)	48.8% (1274/2610)	0.18
Age [y]	63.1 (12.0)	56.3 (19.5)	64.0 (10.3)	<0.0001***
Language/Nationality				
Born in Germany	88.6% (2400/2708)	9.2% (9/98)	91.6% (2391/2610)	<0.0001***
Parents born in Germany	76.2% (2056/2699)	8.2% (8/98)	78.7% (2048/2601)	<0.0001***
What is your first language (german)?	88.9% (2610/2936)	0% (0/326)	100% (2610/2610)	<0.0001***

Table 3: Baseline characteristics by sex.

Variable	All	Men	Women	P
Sex	2936	1516	1420	
Age (y)	63.1 (12.0)	63.8 (12.0)	62.5 (11.9)	0.0037
Age [10y]				
45-54	22.2% (623/2807)	19.3% (282/1455)	25.3% (342/1352)	
55-64	27.4% (770/2807)	28.0% (408/1455)	26.8% (362/1352)	
65-74	27.9% (783/2807)	28.3% (412/1455)	27.4% (371/1352)	
75-86	22.5% (631/2807)	24.3% (354/1455)	20.5% (277/1352)	
Hearing aid				
No Hearing aid right	91.7% (2676/2917)	90.4% (1362/1506)	93.1% (1322/1411)	0.0013
No Hearing aid left	91.7% (2676/2917)	90.4% (1362/1506)	93.1% (1314/1411)	0.0087
Language / Nationality				
Born in Germany	88.6% (2400/2708)	88.6% (1234/1392)	88.6% (1166/1316)	1
Parents born in Germany	76.2% (2056/2699)	76.9% (1066/1386)	75.4% (990/1313)	0.37
What language do you speak? (german)	88.9% (2610/2936)	88.1% (1336/1516)	89.7% (1274/1420)	0.18

Table 4: OLSA SNR 50%: Linear regression model.

	R ₂	N	Estimate	L 95% CI	U 95% CI	p-value
OLSA SNR 50% (signal to noise ratio)	0.09133	2699				
Sex			-0.822	-1.29	-0.349	0.00067***
Age [centered]			0.187	0.0608	0.312	0.0037**
Native vs. non-native speaker (German)			-0.98	-2.45	0.49	0.19
Native/non-native *Age [centered]			-0.00469	-0.132	0.123	0.94
Born in Germany			-0.667	-1.68	0.341	0.19
Parents born in Germany			0.0869	-0.68	0.697	0.98

Table 5: OLSA SNR 50% values for people (not) born in Germany/parents (not born) in Germany [Median].

	Born in Germany	Not born in Germany
Parents born in Germany	-4.2	-4.8
Parents not born in Germany	-4	-5.3

Results

10.000 participants were invited to visit the study center for their 10-year follow-up examination in the Gutenberg Health Study. Complete OLSA data were available for 2936 participants as the main cohort after follow-up with unavailable ENT data or incomplete pure tone audiometry. Looking at the baseline characteristics by age in decades, 88,6% (2400/2708) of the surveyed were born in Germany, the parents of 76.2% (2056/2699) of the participants were born in Germany and 93.0% (2610/2807) at all speak German as the first language. Most of the participants were above 65years old. Between the ages of 45-64, most were born in Germany and their first language was German, although their parents were least likely to have been born in Germany. Contrary to the expectation that children born in Germany from parents who were also born in Germany are the group with the most German speakers, this is not the case here (Table 1). Furthermore, (Table 2) shows us the baseline characteristics by native and non-native speakers with 88.6% (2400/2708) of all born in Germany, 76.2% (2056/2699) parents born in Germany and more participants with the birth in Germany have German as their first language in 93,0% (2610/2807). The chi-squared tests for trend in proportions shows that there is a significant difference between the three groups. There is no difference in the age groups between 45-75. But the oldest age group between 75 -86, German is the least common first language. Looking at the other baseline characteristics 91.7% (2676/2917) of the observation group had no hearing impairment on the right side and 91.7% (2676/2917) had no hearing impairment on the left side (Table 3).

But broke down by gender, there are significantly more men with hearing aids than women. The Chi- Squared test shows show a significant difference in the results of the OLSA in the age decades, as previously examined [13]. Whereas there is no significant difference among the sexes concerning the three groups examined in the OLSA tests. Our cohort has a significantly higher

number of native speakers than non-native speakers overall in each age decade (Table 2). Nevertheless, the overall number of non-native speakers in the cohort who have taken a test is high and therefore statistically robust. The Box plot diagram of (Figure 3) visualises the results that have been discusses so far. There is a significant difference in OLSA between age groups in decades, but no significant difference between the sex and in our study groups. When the median is considered (Table 5), slightly different results emerge, but these are due in particular to age and gender.

Discussion

In this study, we determined the language dependence of the German Matrix Test (OLSA) in adults representing the general population of the city of Mainz and its district of Mainz-Bingen, Germany. We found that there was no significant difference in the performance of the OLSA between the language skill groups. We can postulate, that the OLSA is valid regardless of whether the speaker is a native or non- native speaker, provided their language skills are sufficient to participate in testings without a translator. The strength of this study lies in the clinical rigor of testing all participants with pure-tone audiometry in a soundproof booth, the pure number of participants for the OLSA, and the standards of the University Department of Otolaryngology. This design offers representative audiometric data from the largest adult cohort in Germany known by the authors to date. This study cohort consists of citizens from a combination of urban and rural areas, although urban and rural areas are geographically adjacent. We do not expect a difference between urban and rural participants, as both are located in a highly industrialized and densely populated region. The most common complaint of people with sensorineural hearing loss is difficulty understanding speech in situations with some background noise („cocktail party phenomenon“) [17]. Pure-tone threshold alone is a poor predictor of the ability to understand speech in noise [18]. Functional speech in noise tests have been developed to assess this type of hearing loss [19]. The reference values for the OLSA (in adults) are given as – 7.1

dB SRT with an increase of 17.1% pp (percentage points)/dB of the absolute speech understanding score/ signal-to-noise ratio change of 1dB [5,14]. To the best of the authors' knowledge, there

has not been a study on the scale of the presents study with 2936 documented OLSAs.

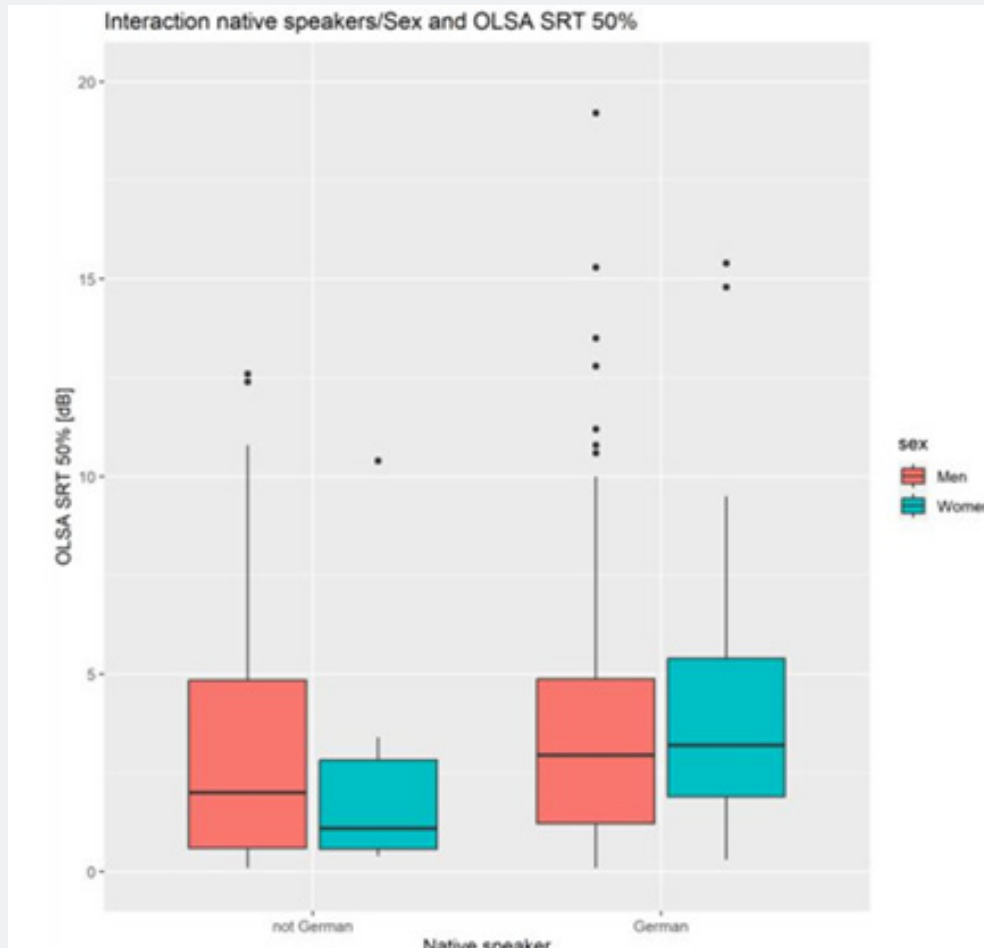


Figure 3: OLSA SRT 50% (dB) from native/non-native men and women.

There has been a long debate about the usefulness of speech tests for foreigners and non-native speakers. Another speech audiometric test is the Freiburg Speech Test. It consists of a numerical test and a monosyllabic test. It is easy and quick to administer and is the most widely used speech test in Germany [20]. In 1987, Padzineak performed pure tone audiometric and speech audiometric tests on 50 randomly selected non-German-speaking foreigners and determined their hearing ability to hear whispered speech. In this group, it was demonstrated that the speech audiogram in the form of the Freiburg speech test can be used to assess the hearing ability of foreigners without knowledge of the German language [21]. The Freiburg Speech Audiogram tests listening comprehension of individual words and not the comprehension of complex sentence constructinos like the OLSA.

Wardegna noted that the OLSA can be applied to subjects with a wide range of hearing losses . At a fixed noise presentation level of 65dB SPL, the SRT is determined by listening in noise for PTAs <47dB Hearing level (HL), and above that by listening in quiet. An Oldenburger sentence test is much more complex and requires a much higher level of language competence with language comprehension, where hearing alone is not enough [22]. Other studies examining the influence of speech recognition test complexity and second language proficiency on speech recognition thresholds (STRs) in noise in nonnative- listeners show that clinical audiology should use measurements with a closed speech test such as OLSA in non- native listeners rather than open speech tests such as Göttinger Sentences Test (GöSA) or Hearing in Noise Test (HINT).

Weissgerber et al. showed that the OLKISA can be used to assess speech perception with comparable accuracy to adults, with the advantage of a higher sensitivity compared to single word tests. No testing between native and non-native Speakers is offered for the OLKISA, so that no statement can be made in the regard so far. The Göttinger Sentence Test is less time-consuming than the OLSA but has a high risk of list redundancy because it has only 20 test lists, each of which is variable in ten sentences. Otherwise, the OLSA can be administered to the same subject as often as desired because of the many variable test lists. A study on the performance and comparison of native and non-native speakers is missing. In conclusion, the OLSA appears to be more clinically relevant, because of the number of test lists in the Göttinger sentences test and the lack of complex sentences in the Freiburg Speech Test. Clinical data and modelling work show that the SRT (measured with the German Matrix Test) increases with increasing average hearing loss approximately < 1 dB SRT loss per 10 dB hearing loss- independent of age. This study has several limitations, which are discussed below. First, the GHS is designed as a population-based cohort study and is mainly representative of the population of Mainz (city) and Mainz-Bingen (country), Germany. Otologic and audiometric evaluation was only introduced to the GHS at the 10-years-Follow-up.

We are not able to quantify German language skills in this study. The respondent must be able to complete the test alone without help. However, we have no way of drawing conclusions about actual language competence. Standardized tests to test language skills like Level A1- C3 were not carried out here. 2936 participants came to the otologic examination. The absence of study staff was generally responsible for this. Our assumption is that this is a random phenomenon. The inability to differentiate more precisely between language skills seems problematic under certain circumstances. A categorisation into: can complete the test alone and cannot complete the test alone, seems superficial. In this setup, all language skills between level A1 and level C2 might all be included. Another exclusion criterion for the GHS study was physical and mental disability, as the prevalence of hearing loss is higher in people with comorbidities. Exclusion of these participants from a study could lead to an underestimation of the prevalence of hearing loss and to an overestimation of OLSA performance. The removal of subjects with hearing loss from the subcohort has minimized this variable. We cannot completely rule out the possibility that some residual participants with subthreshold or high frequency hearing loss are included, as they may have slipped through our > 20 dB criterion and thus have remained in the subgroup.

Conclusion

A study with more than 2900 evaluable Oldenburg Sentence Tests is representative for a normal population. It showed an independence of language skills when testing with OLSA, if the person speaks the language well enough to fill all the

questionnaires. This is the first study to prove that the OLSA can be used with both, native and non- native speakers. Apart from the gender and age- related differences there is no difference between native and non-native speakers. Therefore, we can use the OLSA for all persons with hearing loss and are provided with a hearing aid or hearing implant.

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DOI: [10.19080/GJO.2025.27.556222](https://doi.org/10.19080/GJO.2025.27.556222)

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