Documentation of the Database Schema

This document provides a comprehensive overview and detailed description of the database schema, designed to store and manage data from multiple audiological studies. Extensive audiological measurements were conducted on 77 participants, with the collected results systematically stored in a structured database. The database adheres to the FAIR Data Principles, so that the data is Findable, Accessible, Interoperable, and Reusable, thereby facilitating transparency, reproducibility, and broader scientific collaboration.

Product of the Collaborative Research Center (CRC) "Hearing Acoustics: Perceptual Principles, Algorithms, and Applications" (HAPPAA), For more information regarding this project, please follow this link: Sonderforschungsbereich 1330 Hörakustik (HAPPAA) // Universität Oldenburg

The content of database is accessible on ZENODO platform.

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Note: When utilizing the contents of this database, please cite the following source publications which include detailed information on each methodology and their outcomes.

Reference 1: Afghah T., Heeren J., Hartog L., Biermann P., Wulff A. Warzybok A., & Wagener, K. C. (2025). An open access dataset of perceptual measures for individuals with normal hearing and hearing loss. [Preprint]. Zenodo. Doi: 10.5281/zenodo.17085598.

Reference 2: Gerken, M., Schütze, J., Kirsch, C., Seeber, B. U., Ewert, S. D., Heeren, J., Afghah, T., Wagener, K. C., Kollmeier, B., & Warzybok, A. (2025). Perceptual measures of normal and hearing-impaired listeners across defined virtual acoustic scenes. [Preprint]. Zenodo. Doi: 10.5281/zenodo.17086129.

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The study, involving humans, was approved by the "Research Ethics Committee of the Carl von Ossietzky University of Oldenburg", in German: "Kommission für Forschungsfolgenabschätzung und Ethik der Carl von Ossietzky Universität" (Drs.EK/2021/031, Drs.EK/2021/031-02, Drs.EK/2021/031-03, Drs.EK/2021/031-04).

Table of Content

For each measurement, up to three types of files are provided, where applicable:

1. **Original source files** – The raw output generated during the measurement process.
2. **Summary Excel sheets** – Summarized data tables containing the extracted values for easy access to the key results of the measurement.
3. **SQL files** – Contain the measurement data structured according to the FAIR principles.

Database model representation

The Subject table stores the primary information about each participant.

- **VP_ID**: Unique identifier for each participant (Primary Key).

  Min :1 – Max: 82
- **Hearing_aid_status**: Status of hearing loss and hearing aid usage

  1: Normal hearing, 2: Hearing impaired-unaided (non hearing aid users), 3: Hearing impaired-hearing aid user.
- **Gender**: Gender of the participant

  1: Female, 2: Male.
- **Year_of_birth**: Year of birth of the participant.
- **Age_as_of_2022**: Age of the participant as of the year 2022; data collection year.
- **Various Boolean columns**: Indicators for whether specific tests were measured for a specific subject.

  0: The given measurement was not performed for the subject.

  1: The given measurement was performed for the subject.

Pure tone audiometry (PTA)

Audiogram results, Stores collected data performed via PTA measurements (dB HL).

PTA measurements for Air Conduction (AC), Bone Conduction (BC), and Uncomfortable Loudness Level (UCL) for both ears. Average pure tone Audiometry for the better ear and mean pure tone Audiometry of both ears are also provided.
Example column: PTA_AC_right, PTA_BC_left.

Reference Values: Typical Clinical Range: –10 dB HL to 120 dB HL.

WHO Classifications of Hearing Loss Grades: Two commonly used systems are based on the pure-tone average (PTA) of the better ear: Older WHO classification and Updated WHO classification

Both classification systems are provided for reference.

Grade of Impairment (Old, WHO (1991))	**Better Ear Corresponding Audiometric ISO Value**
0 - No impairment	25 dB or better (less)
1 - Slight impairment	26–40 dB
2 - Moderate impairment	41–60 dB
3 - Severe impairment	61–80 dB
4 - Profound impairment including deafness	81 dB or greater

Hearing Impairment Category (New, WHO (2021))	**Better Ear Hearing Level (dBHL)**
Unilateral	<20 in the better ear; ≥35 in the worse ear
Mild	20–34
Moderate	35–49
Moderately Severe	50–64
Severe	65–79
Profound	80–94

Oldenburg sentence test (Oldenburger Satztest OLSA)

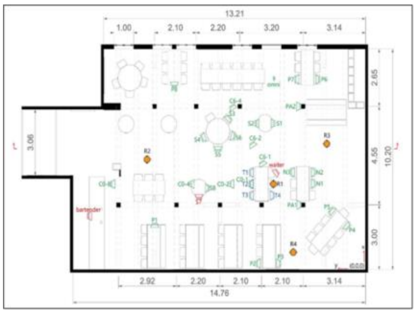
Speech intelligibility test: Speech Recognition of Unpredictable Sentences (Wagener et al., 1999 a,b, c; Wagener, K. C., & Brand, T. (2005))

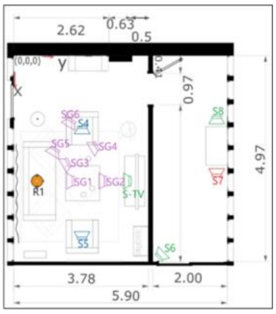
Speech Reception Thresholds (SRT) for different scenarios were measured in OLSA procedure with adaptive speech level (procedure A1 from Brand and Kollmeier, 2002). For HA users, the measurements were performed in both aided and unaided settings [Adapted from Ref 1].

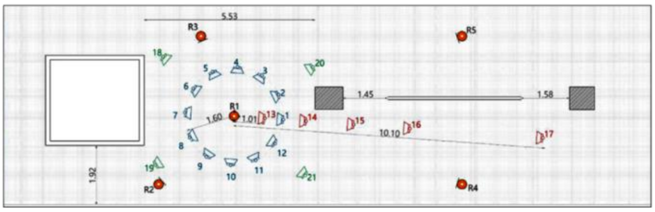
Typical Clinical Range for presentation in noise: –30 to 10 dB SNR (depending on spatial condition and interfering noise, where noise assumed to be audible).

The measurements of OLSA and ACALES were repeated in six different listening conditions, using four virtual auditory scenes [Van De Par et. al, 2022], and typical spatial settings (S0N0 and S0N90).

Four scenes were applied, including two layouts of a Livingroom (referred to as Living Room 1 with asymmetric masker sound locations (label: LR_asym) and Living Room 2 with symmetric ones (label: LR_sym)), Pub, and Underground. For the details regarding these virtual scenes, refer to Ref 1 and Ref 2.







Original source files: .mat files and a single Excel file including the SRT values corresponding to each listening situation and the initial training, along with the corresponding test list of orders.

Summary Excel sheets: The extracted SRT value for each condition.

SQL files: *OLSA_SRT_values:* It includes SRT values.

Adaptive Categorical Listening Effort Scaling (ACALES)

Subjective listening effort scaling measurements (Krueger et al., 2017)

Stores SNR (dB) values corresponding to the ESCU values at six different conditions/virtual scenes: S0N0, S0N90, Livingroom 1, Livingroom 2, Pub, and Underground. Participants rated their listening effort on a 13-point categorical scale, in the range of "no effort" to "extreme effort" corresponding to Effort Scaling Categorical Unit (ESCU) 1 to 13. The category "no effort" corresponded to 1 ESCU, "very little effort" to 3 ESCUs, "little effort" to 5 ESCUs, "moderate effort" to 7 ESCUs, "considerable effort" to 9 ESCUs, "very much effort" to 11 ESCUs, "extreme effort" to 13 ESCUs (Krueger et al., 2017).

Original source files: .XML files, categorized based on the usage of hearing aids and the listening conditions (Pub, underground, ...).

Example file name: VP01_aided_LivingRoom1_2022-10-12-13-36-16

Summary Excel sheets: The values corresponding to ESCU 1,3,5,7,9,11,13 for each listening condition are given in a separate Excel file. Each file includes the results for both unaided and aided (for hearing aid users).

SQL files: The ESCU values in different conditions, measured in aided and unaided settings. Example: 3xESCU_Pub_aided.

Binaural broadband loudness scaling

Loudness perception with narrowband loudness compensation (Oetting et al., 2016, 2018; Suck et al., 2020; Zimmer et al., 2024)

Binaural broadband loudness functions of IFnoise and UEN17, measured with individual audiogram-based narrowband loudness compensation via headphones.

- Lcut: Loudness functions intersection point
- mlow: Loudness functions lower slope values
- mhigh: Loudness functions upper slope values

- BBS80: Level difference between 80 dB SPL in the normal-hearing reference function and the level at which the participant's loudness function reached the same CU value.

Original source files: "LVM_BBLS_GOESA_TL".mat file, named "LVM_BBLS_GOESA_TL": A MATLAB data file that includes a MATLAB structure. In this structure, navigate to open the subject's corresponding struct under KLS column. UEN17 and IFNOISE are stored in two separate structures.

Summary Excel sheets: In Binaural broadband loudness scaling Excel file, fit parameters of IFNOISE and UEN17 as well as BBS80 are provided. In addition, the presentation levels at 0 CU, 5 CU, 15 CU, 25 CU, 35 CU, 45 CU, 50 CU are provided for both IFnoise and UEN17.

SQL files: Fit parameters and levels for IFNOISE and UEN17 as well as BBS80 are provided.

trueLOUDNESS gains

Calculated gains to restore normal binaural broadband loudness perception (Oetting et al., 2018; Suck et al., 2020; Zimmer et al., 2024)

The gain values for the input levels G50, G65, G80 dB for left and right ear at six frequencies 250, 500, 1000, 2000, 4000, 6000 Hz, derived from audiogram-based individual narrowband loudness compensation and binaural broadband loudness scaling results.

Original source files: "LVM_BBLS_GOESA_TL".mat file, named "LVM_BBLS_GOESA_TL": A MATLAB data file that includes a MATLAB structure. In this structure, navigate to open the subject's corresponding struct under OLFIT column.

Example: G50_l corresponding to 50 dB input gain at left ear. The vector includes the values in this order: [250,500,1000,2000,4000,6000]. Sample vector: [3,4,12,39,52,45], the value 3 corresponds to 250 Hz, 4 corresponds to 500 Hz and so on. In addition, the struct contains the audiogram and the fit parameters of the IFnoise measurement used for gain calculation.

Summary Excel sheets: In trueLOUDNESS Excel file, gain values are included in gain sheet.

Example: G50_l_250 refers to Gain at 50 dB at Left ear at 250 Hz.

SQL files: Teh gains at different levels are provided.

Goettingen sentence test (Göttinger Satztest GÖSA)

Speech Recognition of Predictable Sentences (Kollmeier and Wesselkamp 1997; Brand and Kollmeier 2002)

Three measurement settings were performed.

1. For all subjects: The unaided condition: measured SRT using headphones without any amplification (S0N90).
2. For all subjects: Aided SRT measurement using headphones with applied trueLOUDNESS amplification (S0N90).
3. Only for aided subjects: Additional measurements were conducted in a free-field condition, presented via loudspeakers (S0N90), while participants wore their own hearing aids.

Headphone measurements were performed in the standard mode, therefore there was a pause between the sentences. Freefield measurements were performed with continuous noise presentation.

Original source files: "LVM_BBLS_GOESA_TL".mat file, named "LVM_BBLS_GOESA_TL": A MATLAB data file that includes a MATLAB structure. In this structure, navigate to open the subject's corresponding struct under Goesa column.

Measurement settings 1 and 2: Under the *result* struct, there are 2 rows and the corresponding SRT values are given under the second column. SRT *Unversorgt* corresponds to unaided measurement (headphone, S0N90). SRT *trueLOUDNESS* corresponds to the case when individual gains for loudness normalization, given in the olfit column of the structure, were applied.

Measurement settings 3: There are 2 structs per subject. One which corresponds to the headphone measurement, as explained above for all other subjects which has two substructures. One more for free field presentation. Under the column "Transducer", it is shown that headphone or free field was applied.

Summary Excel sheets: GOESA_SRT_values: For all subjects, it includes the SRT value for headphone measurements, both unaided and unaided with trueLOUDNESS gains applied. For the aided subjects, it includes the SRT values for free field measurements.

SQL files:

- **SRT_unaided:** It corresponds to unaided measurement with headphones at S0N90 setting.
- **SRT_trueLoudness:** It corresponds to the case when individual gains for loudness normalization from trueLOUDNESS amplification measurements were applied.

  SRT_aided: For aided subjects, two measurement results were provided. One corresponds to the standard headphone measurement, similar to all other subjects, and the second captures free-field sound presentation (also at S0N90) conducted while the subjects were wearing their own hearing aids.

Loudness Validation Method (LVM)

Loudness perception evaluation (Jansen et al., 2020, Exter et al., 2024)

Stores data related to LVM with participants' own hearing aids in place in free field. The presentation category is demonstrated with two words: The First word refers to the frequency range, defined as follows: Low (200-920 Hz), Middle (920-2300 Hz), High (2300-6400 Hz), and Broadband (200-6400 Hz). The second term classifies the sensitivity score into three presentation level categories: Soft, Medium, and Loud, corresponding to equivalent speech levels of 50 dB SPL, 65 dB SPL, and 80 dB SPL, respectively, resulting in an overall of 12 categories. Example: low_loud_sensivity_score, middle_soft_sensivity_class

- Sensitivity score: The average response across the five samples in each presentation category.
- Sensitivity class: Six possibilities which correspond to the colors show up on the LVM map as follows.

class	color	Meaning
1	dark blue	much softer
2	light blue	slightly softer
3	green	Normal
4	orange	Slightly louder
5	red	much louder
6	dark red	extremely loud

Original source files: "LVM_BBLS_GOESA_TL".mat file, named "LVM_BBLS_GOESA_TL": A MATLAB data file that includes a MATLAB structure. In this structure, navigate to open the subject's corresponding struct under LVM column. Under "Results", for each category of frequency and loudness, sensitivity score and class are provided.

Summary Excel sheets: Sensitivity score and class are extracted for each category.

SQL files: For each category, sensitivity score and class are given. Example:
middle_loud_sensivity_score, middle_loud_sensivity_class

HEAR-COMMAND Tool

(Afghah et al., 2022; Afghah et al., 2024)
HEAR-COMMAND Tool is a questionnaire developed to inquire about self-report disability in functioning and hearing.

Original source files: The questionnaire can be found here: https://www.hz-ol.de/en/open-tools-for-science/hear-command-tool/
Response range for questions starting with H: [0 – 8]. Numbers 0 to 4 on Likert scale refer to the response options of “No”, “Mild”, “Moderate”, “Severe”, and “Profound/Complete”. 5: “I don’t know”, 6: “Not applicable”, 7: “Not required”, 8: “Missing data”. References values: [0 – 10]. For example, a score of 0 indicates that the subject reports no difficulty with speech perception, while a score of 10 signifies the subject perceives the maximum level of difficulty in speech perception.

Summary Excel sheets: The responses to all questions asked are provided.

SQL files:
HEAR-COMMAND Tool Questions: Stores the questions used in the Hearing Command tool.

- **Question_ID**: Unique identifier for each question (Primary Key).
- **Question_Code**: Unique code for each question (H01, H02,...).
- **Question_Category**: Category of the question (H: Hearing and functioning, A: Personal Factors).
- **Question_Text**: Text of the question.

HEAR-COMMAND Tool Responses: Stores responses to the HEAR-COMMAND Tool questions.

- **Question_ID**: Foreign key referencing HEAR-COMMAND Tool Questions (Question_ID).
- **Response_Text**: Text of the response.

Tone in noise detection

Tone-in-noise detection thresholds. (Schädler et al. 2020)

It is a measure proposed to assess the suprathreshold, frequency-specific suprathreshold deficits, here performed at 500 and 2000 Hz for both ears.

Original source files: .txt files

Examples: siam-tin-VP03-l-2000,30-1.txt: Threshold at 500 Hz for Right ear for subject 03.

Summary Excel sheets: Four extracted threshold per subject. At 500Hz Left and Right ear / 2000 Hz Left and Right ear.

SQL files: Four extracted threshold per subject. At 500Hz Left ear/ 500 Hz Right ear / 2000 Hz Left ear / 2000 Hz Right ear.

Coupler Measurements

For hearing aid users, the sound pressure output of their own hearing aids was measured via coupler measurements, using ISTS (Holube et al., 2010) for the left and right hearing aids.

Original source files: .GND, XML, and Excel files

Summary Excel sheets: It includes input, output, and the resulting gain, for a wide range of frequencies.

SQL files: Input, Gain, output

Literature

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