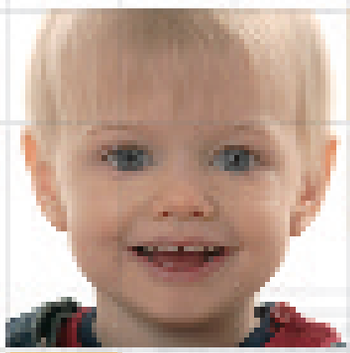
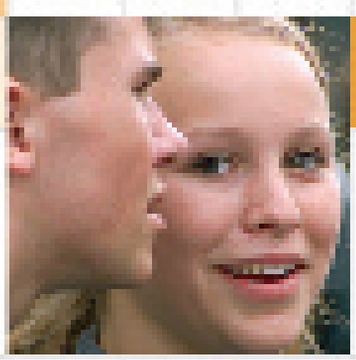




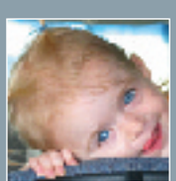
PEDIATRIC ASSESSMENT TOOLS

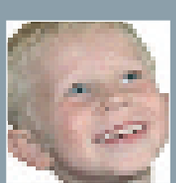
LittlEARS

EARS

TeenEARS

MED EL
MEDICAL ELECTRONICS





MED-EL aims to provide the audiologist, speech-language therapist, teacher-of-the-deaf and rehabilitation professional with a unique battery of tests to assess auditory perception outcomes in children of all ages. The “EARS family” is that tool. The “EARS family” provides a series of tests (both open-set and closed-set), questionnaires and diaries to assess outcomes in children prior to receiving their cochlear implant, as well as afterwards. This unique set allows the professional to monitor the development of a child who receives a cochlear implant over a long period of time. This provides important information on the functioning of the device, progress of the child, and rehabilitation needs and goals. The “EARS family” comprises LittlEARS, developed for children under the age of two; EARS, developed for children aged 2 and older; and TeenEARS, developed for teenagers.

LittlEars

For children aged 2 and younger

In recent years, the age of implantation for children who were born deaf or deafened at early ages has decreased dramatically. This has made it necessary to develop new diagnostic tools to assess early auditory-verbal development, because most diagnostic systems were designed for older children and do not cover specific early preverbal phases of a child's development. The LittlEARS test battery assesses auditory development and early speech production development of hearing impaired children. It includes parent questionnaires as well as tools for selective observations for therapists.

LittlEARS Auditory Questionnaire

The auditory questionnaire is the first module of the LittlEARS battery. It is a parent questionnaire designed to assess the auditory behavior of hearing impaired children who are provided with a CI or a hearing aid prior to their 24th month of life. It records preverbal auditory development during their first two years of hearing in the child's natural environment, considering reception, understanding and adequate response, and vocal-verbal production of acoustic (linguistic) stimuli. The questionnaire consists of 35 age-related sorted questions to be answered with "yes" or "no" by parents.

LittlEARS Diary

The "My LittlEARS diary" is the second module of the LittlEARS battery. It consists of three parts: a parent's manual, a therapist's manual and the LittlEARS diary.

The diary provides a guided documentation and observation of the development of the child over half a year after device fitting. The diary includes specific questions and information for parents, as well as space for notes.

The questionnaires and products included in the LittlEARS test battery are as follows:

Name	Aim	Reference
LittlEARS Auditory Questionnaire (LEAQ)	Assesses auditory development; validated in normal hearing children; for hearing impaired children after CI or hearing aid fitting before 24 month and for follow up analysis after.	Kühn-Inacker, Weichbold, Tsiakpini, Coninx, D'Haese (2003)
LittlEARS Diary	Provides a guided documentation and observation of the development of the child over half a year after device fitting	K. Veekmans and H. Kühn-Inacker (2005)

Results

A validation study in 218 normal hearing children was conducted. The questionnaire is based on item analysis (correlation with age, difficulty index, discrimination index, and selectivity parameter). Scale analysis showed that the parameters of the questionnaire were well chosen. The correlation of the scale was found to be very high (Pearson's: r = 0.91, criterion r > 0.6). The measure is reliable (split-half: r = 0.88, criterion r > 0.7; Guttman's lambda: ˇ= 0.93, criterion ˇ> 0.7) and homogenous (Cronbach's alpha: • = 0.96, criterion • > 0.7). This resulted in the conclusion that the LittlEARS auditory questionnaire is a valid and reliable measure designed to record preverbal-auditory development within the first two years of hearing.

Normative data

The following figure visualizes well the correlation between age of hearing and auditory skills. The bold black line describes the expected value, i.e. the total scores children of a certain age group should reach, calculated from the regression by a second order polynomial, explaining 86% of the entire variance. Thus, if a child reaches a value above the 95% confidence interval of the regression as critical lower level, it can be assumed that this child has age-appropriate auditory development. The minimum value of age-specific auditory behavior is marked by a fine orange line in the diagram.

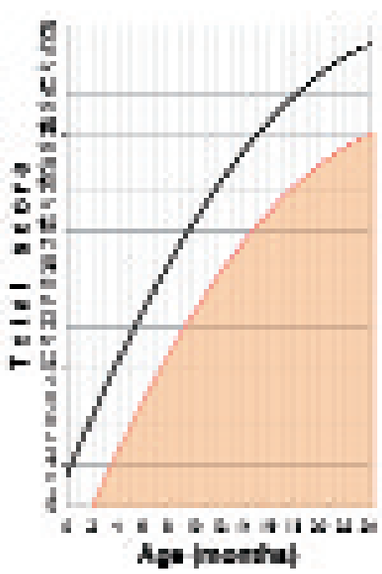


Figure: Norm curve of normal hearing children assessed with the LEAQ

Validation of LEAQ in CI-children:

MED-EL conducted a multi-center study, including 63 children (mean age at implantation: 14.8 months) from Germany and Italy, to assess the validation of the LEAQ in CI-children. The aim was to analyze the extent to which the auditory development of early implanted CI-children is comparable to the development of normal hearing children. Further, the study investigated the appropriateness of the LEAQ as a method for assessment of the auditory development in the first year of hearing.

In the following figure the regression of the CI-children is compared to the regression of normal hearing children.

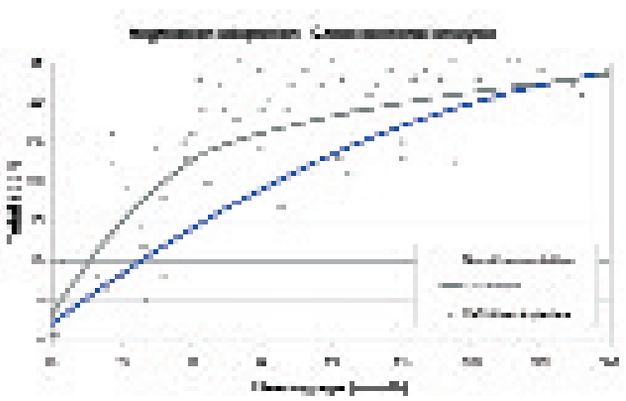


Figure: Regression curve of CI-children assessed with the LEAQ.

Ears

Developed for children aged 2 and older

MED-EL has designed a unique test battery to monitor progress in auditory perception and speech production of CI-children. In 1995 Dr. Dianne Allum-Mecklenburg developed the Evaluation of Auditory Responses to Speech (EARS) test battery in order to support fitting of the processor, to assist in rehabilitation, to assess children's hearing and speech abilities and to allow performance comparisons. Currently, the test is available in 21 languages, and thus performance can be compared within and across languages. EARS constitutes the largest international pediatric study of CI-recipients ever conducted. MED-EL has established an extensive data base, which allows reports to be taken from a large sample of CI-children.

Objectives of EARS

:: Track progress in hearing abilities of CI-children

:: Track progress in speech production and voice control of CI-children

:: Provide support for device fitting

:: Provide support for rehabilitation of CI-children

:: Provide an instrument for long-term assessment of CI-children

:: Provide an instrument for within and across language performance assessment of CI-children

General structure of EARS

Auditory perceptual skills are expected to develop soon after cochlear implantation. As described by Erber (1982) and Ling (1976), the development of auditory perception always seems to follow a certain order. The EARS test battery was designed to follow these levels of emerging auditory skills.

Detection:	Ability to respond to the presence or absence of a signal
Discrimination:	Ability to distinguish differences or similarities between two stimuli
Identification:	Ability to choose an item from a known set
Recognition:	Ability to repeat or imitate spoken stimuli
Comprehension:	Ability to demonstrate understanding of spoken language

Therefore, tests for different levels were selected, considering factors such as applicability in different languages, linguistic level, and expenditure of time. The tests are divided into closed-set tests for the assessment of detection, discrimination and identification; and open-set tests for the assessment of recognition and comprehension. Additionally, questionnaires are included to record subjective impressions of parents and therapists as scaled scores, which allows for statistical analysis. They are highly useful in gathering data, especially for younger children who are less likely to cooperate with formal testing. Furthermore, behavior in unstructured, real-life situations can be evaluated.

Incorporating the theoretical background of auditory perception skills, a set of tests and their description was agreed upon at a meeting with interested cochlear implant clinics in Seefeld, Austria (1995), for the assessment of CI-children.

The tests and questionnaires included in the EARS test battery are as follows:

Reference	Aim	Name
CLOSED-SET-TESTS		
Archbold (1996)	Investigates the ability to identify environmental sounds, phonemes, rhythmic features, and number of syllables	LiP (Listening Progress Profile)
Erber (1978)	Measures the ability to identify different syllable patterns; depending on the age of the child, different word-sets are used (3, 6 or 12 items)	MTP (Monosyllabic-Trochee-Polysyllabic Test)
Schneider, Leyrer, Pilkington, and Allum (1995)	Investigates the ability to identify familiar monosyllables; depending on the age of the child, different word-sets are used (4 or 12 items)	Monosyllable Closed-Set Test
Tyler and Holstad (1987)	Measures the ability to identify familiar words in a familiar phonological context; depending on the age of the child, different word-sets are used (2x3, 3x3, 3x4 or 4x4 matrices)	Closed-Set Sentence Test
Plant and Moore (1992)	Assesses the ability of complex closed-set speech perception, auditory memory and auditory-motor integration; depending on the age of the child, different subtests are used	COT (Common Objects Token) Test
OPEN-SET TESTS		
Schneider, Leyrer, Pilkington and Allum (1995)	Measures the ability to identify monosyllables in the consonant-vowel-consonant (CVC) pattern; Number of correct identified phonemes and words can be evaluated	Monosyllable Open-Set Test
Erber (1982)	Measures the ability to understand simple sentences, i.e. ten everyday questions	GASP (Glendonald Auditory Screening Procedure)
QUESTIONNAIRES		
Robbins et al (1991)	Evaluates observable auditory behavior in everyday situations	MAIS (Meaningful Auditory Integration Scale)
Robbins and Osberger (1991)	Assesses the use of language in different everyday situations, referring to voice control, speech production and communication strategy	MUSS (Meaningful Use of Speech Scale)

Results

Data from the EARS test battery have been reported in the following studies:

:: Anderson I, Weichbold V, D'Haese P, Szuchnik J, Sainz M, Martin J, Shehata-Dieler W, and Philips L (2004)

:: Anderson I, Weichbold V, D'Haese P (2004)

:: Baumgartner WD, Pok SM, Egelierler B, Franz P, Gstöttner W, Hamzavi J (2002)

:: Gstöttner WK, Hamzavi J, Egelierler B, Baumgartner WD (2000)

:: Sainz M, Skarzynski H, Allum JHJ, Helms J, Rivas A, Martin J, Zorowka PG, Phillips L, Delaunay J, Brockmeier SJ, Kompris M, Korolewa I, Albegger K, Zwirner P, Van de Heyning P, D'Haese P (2003)

:: Szuchnik J, Skarzynski H, Geremak A, Zawadzki R (2001)

For more information, refer to the "References" section.

The two graphs below demonstrate the usability of the EARS test battery as an assessment tool in pediatric audiology.

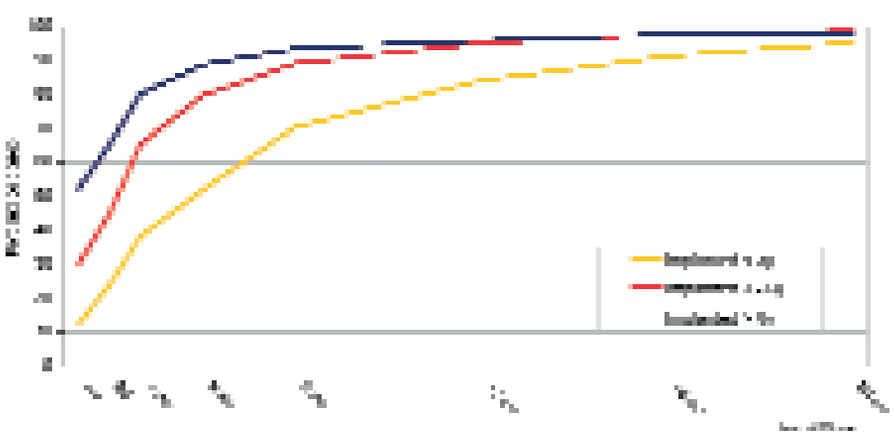


Figure: LIP – mean score of different age groups

This graph shows the results of 340 LiP scores, analyzed in a 3x8-ANOVA with time of measurement (preoperative, 2 days, 1 month, 3 months, 6 months, 1 year, 18 months and 2 years) as a within-subjects factor and with age of implantation (under 3 years [n=61], between 3 and 6 years [n=137] and 6 years and later [n=142]) as a between-subjects factor.

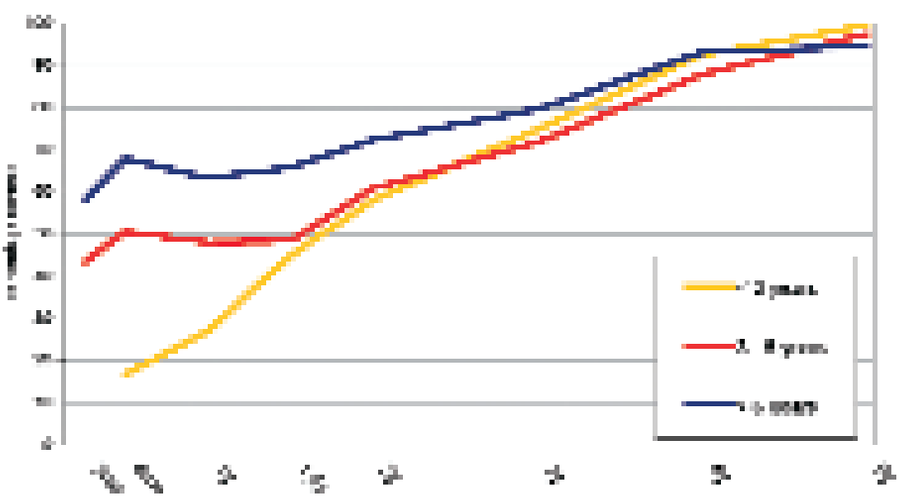


Figure: Open-set sentences (GASP) - mean scores of different age groups

This graph displays the result of 49 GASP scores, analyzed in a 2x6-ANOVA with time of measurement (1 year to 5 years) as a within-subjects factor and with age of implantation (between 3 and 6 years [n=16], and 6 years and later [n=33]) as a between-subjects factor.

These results demonstrate the coherence between the period of CI experience and the auditory reception skills of children implanted at different ages. Improvement over time can be noticed clearly in both figures. Additionally, a difference between age groups becomes apparent. Due to their pre-implant language skills, older children preformed at a higher level than the children in the younger group immediately after implantation. But early implanted children show significant, quicker improvement over time and it appears that they catch up and even surpass the older implanted group at 3 years of CI-use. These results show the benefit of cochlear implantation at an early age.

TeenEars

Developed for teenagers

With recent advances in cochlear implant technology producing better than expected results, candidacy criteria have been modified to allow implantation in children with more residual low frequency hearing, progressive hearing loss and longer duration of deafness. Thus, teenagers are being seen more frequently at CI centers for cochlear implantation.

The population of teenagers who have graduated from a pediatric cochlear implant program and have had many years of CI experience is also increasing.

The TeenEARS test battery was developed to provide appropriate assessment tools for teenagers. TeenEARS considers the wide range of outcomes expected and also looks at primary and secondary benefits of cochlear implantation.

The TeenEARS test battery consists of the following rating scales, questionnaires and tests:

Reference	Aim	Name
RATING SCALES		
Archbold et al (1995)	Assesses auditory skills in a natural context	CAP (Categories of Auditory Performance)
Allen et al (1998)	Assesses speech production skills in a natural context	SIR (Speech Intelligibility Rating)
Tait et al (2001)	Assesses a wide range of telephone use skills in a natural context	PTP (Pediatric Telephone Profile)
OPEN-SET TESTS		
YCIS & MCIP (1997)	Assesses syllable and pattern perception skills, perception of common sentences and closed-set sentences	Listening Skills Screening
Robbins et al (1998)	Assesses open-set auditory perception of everyday phrases	Common Phrases Test
University College Hospital CI Program (1990)	Assesses identification abilities of common environmental sounds	UCH 1990 Environmental Sounds Test
Plant (2002)	Assesses synthetic conversational listening skills	TesTrax
QUESTIONNAIRES		
Manchester Cochlear Implant Program	Assesses teenagers' expectations of cochlear implantation pre- and postoperatively, covering issues such as safety, communication, education, recreation, confidence, and lifestyle	Manchester Teens Questionnaire

Validation:

TeenEARS was piloted using six tests, three rating scales and two questionnaires. Results were presented at the ESPCI 2004, Geneva, Switzerland, 2-5 May 2004 (Anderson I. et al). Significant correlation was found between cochlear implant experiences and the PTP (Pearson's r = 0.55) and the Common Phrases sentence test (Pearson's r = 0.5). Other tests have been included in the battery to provide tools for determining teenagers' needs and expectations. Although the CAP and the SIR showed no improvement over time, they are useful tools for reporting to team meetings, parents and educational authorities. The 1990 UCH Environmental Sound Test is a more challenging test for experienced children, and the Manchester Teens Questionnaire provides valuable counseling and rehabilitation information, especially in adolescents seeking an implant for the first time. The TeenEARS test battery was based on the outcomes of this study and on input from professionals working with teenagers.

Languages

One important aim of the "EARS family" is to be an international tool, available in as many languages as possible. Due to the nature of language and the need for accurate assessment, direct translations are usually not possible. Instead, the tests are adapted for use in other languages and cultures.

MED-EL has joined forces with professionals around the world to ensure reliable and accurate adaptation of the test batteries into other languages. These professionals are native language speakers who have experience with cochlear implants and working with children.

The adaptation process involves a number of steps, the first of which concerns the language involved. Here, the person responsible for the adaptation consults with other professionals involved with hearing impaired children to ensure the appropriateness of vocabulary and suitable sentence construction. A linguist may also be involved to ensure that correct phonemic constructions and language rules are used. Linguistic challenges can occur, for example, because some languages do not use meaningful monosyllables, some require different word order or morphemic structures, and some do not consider gender.

The adaptation is then back-translated into the original language to ensure as close a representation of the original text as possible. Finally, adjustments are made before the tests are piloted on hearing children and children with hearing loss and/or cochlear implants.

LittlEARS

Bulgarian
Dutch
English
Finnish
French
German
Hungarian
Italian
Norwegian
Polish
Romanian
Serbian
Slovakian
Slovenian
Spanish
Turkish

EARS

Arabic
Bulgarian
Croatian
Dutch
English
Finnish
French
German
Greek
Hungarian
Italian
Korean
Malay
Polish
Romanian
Russian
Slovakian
Spanish
Swedish
Tagalog
Turkish

TeenEARS

German
English

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