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The UWO PedAMP: An Evidence-Based Outcome Evaluation Guideline for Infants, Toddlers and Preschool Children

Marlene Bagatto, Au.D., Ph.D.
Audiology Online
May 22, 2013

Presentation Outline

- Introduction
- Characteristics of a good outcome measurement tool
- Description of the UWO PedAMP
  - Using the Speech Intelligibility Index (SII)
  - LittLEARS Auditory Questionnaire
  - Parents’ Evaluation of Oral/Aural Performance of Children (PEACH) Questionnaire
- Case Example
- Objective Outcome Measures
- Summary and discussion
Process of Pediatric Hearing Aid Fitting

Audiometric Assessment

Evaluation of Auditory Performance

Prescription and Selection

Hearing Aid Verification

Outcome Evaluation of Hearing Aid Performance

Background and Rationale
Intervention for Childhood Hearing Loss

- Access to early intervention is key
- One component is access to sound through the use of hearing aids
- Supports the development of language and literacy skills
- Improves functional auditory capacity and participation in hearing- and communication-specific situations

Provision of Hearing Aids

- Suitable technology and evidence-based hearing aid fitting protocols support accurate and safe hearing aid fittings for the pediatric population
  - American Academy of Audiology, 2003
  - Australian Protocol; King, 2010
  - British Columbia Early Hearing Program, 2006
  - Modernizing Children’s Hearing Aid Services, 2005
  - Ontario Protocol; Bagatto, Scollie, Hyde & Seewald, 2010
Clinical Need:

Pediatric audiologists who fit young infants with hearing aids need tools to measure the impact of the hearing aid on the child’s auditory development.
Program Need:

Early Hearing Detection and Intervention (EHDI) programs need tools to assess the overall quality of the program.

Use of Outcome Measures

- Program outcomes such as *when* the hearing aids were fitted are often the focus of outcomes studies.

- Process outcomes such as *how well* the hearing aid was fitted should be included as part of the focus.
  - Quality of the hearing aid fitting can impact overall outcome of the child (Joint Committee on Infant Hearing, 2007)
Recent Outcomes Studies

- Amplification details (i.e., process outcomes) were included as part of the study methodology in some recent studies
  - Moeller, et al., 2007
  - Ching, Dillon, Day & Crowe, 2007
  - Sininger, Grimes & Christensen, 2010

- Knowledge of the hearing aid fitting details provides insight about the potential reason for some of the outcomes observed within the EHDI program

Applying Research to Clinic

- The outcomes batteries used in these studies may not be suitable for clinical implementation

- Protocols were designed for research and may have barriers to clinical implementation:
  - Extensive test batteries
  - Impractical to administer and score
  - No norms to compare scores to
  - Many include speech and language measures
Characteristics of a Good Outcome Measure

A Good Outcome Evaluation Tool Should Have...

(Andresen, 2000; Cox et al, 2000; Hyde, 2000)

- Conceptual clarity
  - Covers relevant domains

- Normative data
  - For comparison purposes

- Appropriate measurement model
  - Capture true breadth and detail of group by avoiding floor and ceiling effects
A Good Outcome Evaluation Tool Should Have... (Andresen, 2000; Cox et al, 2000; Hyde, 2000)

- No item / instrument bias
- No respondent or administrative burden
  - Length and content should be acceptable to respondent
  - Tool should be easy to administer, score and interpret by clinician
- Statistically, tool should have good
  - Test-retest reliability
  - Internal consistency
  - Validity
  - Responsivity

Types of Outcome Measures

**Objective**

*Capacity Measure:* What the child can do in the clinic
*Example:* child’s aided ability to detect low level speech sounds

**Subjective**

*Performance Measure:* What the child can do in the real world
*Example:* parent’s observation of child’s performance using a questionnaire
Objective Outcome Measures

Objective

Advantages
• Direct measure of child’s aided hearing
• Most clinics already equipped

Disadvantages
• Specific measurement technique and stimuli needed for different ages and developmental levels
• Difficult to conduct with some children
• Child must be alert
• Specific equipment needed
• Capacity in quiet, low reverb

Subjective Outcome Measures

Subjective

Advantages
• Can be completed in waiting room or while child is being assessed
• Paper and pencil or computer administered
• Performance of child in real-world environment
• Appropriate for children with complex needs

Disadvantages
• Language and literacy barriers
• Reliability and validity of caregiver report
Subjective Outcome Measures

A Critical Review of Audiological Outcome Measures for Infants and Children

Bagatto, Moodie, Seewald, Bartlett & Scollie, 2011a

Trends in Amplification
Volume 15(1): 23-33
Considerations for Outcome Evaluation

Target Population: Infants & young children who wear hearing aids

Purpose: Measure the impact of the hearing aid fitting

Good Statistical Properties

Clinically Feasible

Administration & Interpretation: By Audiologist

Clinically Meaningful
UWO PedAMP Development

- Avoid tools that:
  - are too lengthy or complicated
  - rely on information or scoring by other professionals
  - (e.g., standard language measures)
  - May be implemented in other parts of the Early Hearing Detection and Intervention (EHDI) program

- Include tools that:
  - have good statistical properties
  - have good clinical feasibility and utility
  - support family-centered practice
  - help you collaborate better with others

- Maximize efficiency and interpretation through:
  - Visual tools to permit rapid scoring
  - Data to support interpretation

Community of Practice (Sheila Moodie)

- Soliciting opinions and experiences from end-users is recommended when developing outcome evaluation tools and clinical practice guidelines
  - (Graham et al, 2000; Andresen, 2000)

- Network of Pediatric Audiologists of Canada
  - Opinions were gathered regarding clinical relevance, quality, feasibility, utility, executability, acceptability, and comparative value of each tool
  - Modifications made where possible
  - Provided information about barriers and facilitators to implementation
Creating a Balance
(modified from Bhattacharyya, O. 2010)

CLINICAL UPTAKE

ACTIONABLE
Clear
Specific

EVIDENCE-BASED
Complex
Rigid

Purpose of the UWO PedAMP

- Intended to be used with children with permanent childhood hearing impairment (PCHI) from birth to 6 years who may or may not wear hearing aids

- Consists of several outcome evaluation tools that aim to measure auditory-related outcomes in infants and young children including the following dimensions:
  - Subjective assessment of early auditory development
  - Subjective ratings of auditory performance in daily life
Contents of the UWO PedAMP

- Ontario Infant Hearing Program (OIHP) Amplification Benefit Questionnaire
- Hearing Aid Fitting Summary
- Aided Speech Intelligibility Index (SII) Normative Values
- LittlEARS Auditory Questionnaire (Tsiakpini et al, 2004)

<table>
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<th>Appointment Type (Aided)</th>
<th>Initial Assessment</th>
<th>Prefitting</th>
<th>Initial Fitting</th>
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<th>3 month Recheck</th>
<th>6 month Recheck</th>
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UWO PedAMP Manual: www.dslio.com
OIHP Amplification Benefit Questionnaire

• 11-item questionnaire jointly developed by the OIHP and Child Amplification Laboratory at UWO
• 5-point rating scale for parents addressing:
  • Acceptance and use of hearing aids
  • Auditory performance for different levels of sound
  • Effectiveness of service delivery
  • Overall satisfaction
  • Final question is open-ended asking about how hearing aid services could be improved

Where to find: www.dslio.com

Administration of the OIHP Amplification Benefit Questionnaire

• Initially completed by the caregiver after the child has worn hearing aids for 3 months or more
  • Gives respondent a chance to become comfortable with child’s hearing aids and services offered

• Re-administered at follow-up visits

• Available in 13 languages


Hearing Aid Fitting Details

Reasons for Tracking Hearing Aid Fitting Details

- Good auditory-related outcomes infer good audibility from hearing aids
  - Important part of outcome evaluation guideline

- Clinician can determine whether individual child's fitting is providing a typical degree of audibility

- Provides overall reporting information for the Early Hearing Detection and Intervention (EHDI) program as a whole
  - Programs need measurable outcomes
Hearing Aid Fitting Details

- Real-Ear-to-Coupler Difference (RECD)
- Maximum Power Output (MPO)
- Speech Intelligibility Index (SII)
  - Soft = 55 dB SPL
  - Average = 65 dB SPL
  - Proportion of speech above threshold
  - Percentage value
  - Not a speech recognition score

SII Soft = 66%
SII Avg = 78%
Aided SII Normative Data

- Collected through the Network of Pediatric Audiologists of Canada
  - Moodie, 2009
- Fittings from 161 ears of infants and children with a wide range of hearing losses
  - Fit-to-targets assessed
- Main Finding: As hearing loss increases, SII values decrease
  - Level distortion factor applied for speech inputs higher than 62 dB SPL

Data courtesy of S. Moodie and Clinician Network
Using the SII Normative Data

Recommended Fit-to-target Criteria

- For losses ≤ 70 dB PTA:
  - 5 dB from 250 – 2000 Hz
  - 5 to 7 dB at 4000 Hz

- For losses > 70 dB PTA:
  - insufficient data
  - recognize inherent limitations of this fitting

Using the SII Normative Data

PTA = 52 dB HL
SII Avg = 78%
The LittLEARS Auditory Questionnaire

http://www.earfoundation.org.uk/shop/items/98
Other languages direct from MED-EL. Tel: +44 (0) 1226 242 874
LittlEARS (Tsiakpini et al., 2004)

- Goal: to assess auditory development during first 2 years of hearing
  - Receptive auditory behaviour
  - Semantic auditory behaviour
  - Expressive vocal behaviour

- Format: 35 yes/no questions listed in developmental order

LittlEARS

- Scoring: All ‘yes’ answers are added and compared to average and minimum values

- Normative data collected with 218 German-speaking families (Weichbold et al., 2005)
  - Reliable
  - Good internal consistency
  - Good discriminative ability
  - Good correlation of overall score and age of child
  - Validated in 15 languages (Coninx et al., 2009)
External Validation of the LittLEARS® Auditory Questionnaire with English-Speaking Families of Canadian Children with Normal Hearing

Bagatto, Brown, Moodie & Scollie, 2011

*International Journal of Pediatric Otorhinolaryngology*
*Volume 75(6): 815-7*

## Analysis

1) Validation: Normal Hearing Children

<table>
<thead>
<tr>
<th>Quadratic Regression Curves</th>
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<tbody>
<tr>
<td>German Norm Curve: N = 218</td>
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<tr>
<td>Canadian Norm Curve: N = 130</td>
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</tbody>
</table>

- Mean age = 8.11 months
- Age range = 2 to 23 months
- Standard Deviation = 4.93
- Mean score = 18
- Score range = 3 to 35
- Standard Deviation = 7.83

Bagatto et al, 2011

*Int J Ped Otorhinolaryngology*
The University of Western Ontario Pediatric Audiological Monitoring Protocol (UWO PedAMP)

Bagatto, Moodie, Malandrino, Richert, Clench & Scollie 2011b

Trends in Amplification
Volume 15(1): 57-76
Children with Hearing Aids

**Aided* = 116**
PTA = 52.25 dB HL
Range = 21.25 to 117.50 dB HL

Typically Developing = 42 (36.21%)
Comorbidities = 27 (23.48%)
Complex Factors = 47 (40.87%)

* Clinicians followed OIHP hearing aid fitting protocol (Bagatto et al, 2010)

Administration of LittLEARS

76 caregivers; 126 times
Mean age = 26.2 months
Range = 3.6 – 72.7 months

Typically Developing = 30 (39.5%)
Comorbidities = 19 (25.0%)
Complex Factors = 27 (35.5%)
Typically Developing Children

N = 30

Minimum normative values

Significant sigmoid regression curve

76.6% meeting auditory development milestones

Mild to Moderate Comorbidities

N = 9

Significant sigmoid regression curve
Children with Complex Factors

N = 27

All Profiles: Aided PCHI

German-derived norms

Mild/Mod Comorbidities

Typically Developing

Mild/Mod Comorbidities

Complex Factors
LittlEARS Results

• Significant impact of group (i.e., typically developing, comorbidities, complex factors) on LittlEARS scores
  • \( p = 0.001 \)

• Significant impact of overall degree of hearing loss on LittlEARS scores, though not enough data to analyze by subgroup of degree of hearing loss at this time
  • \( p = 0.021 \)

LittlEARS Conclusions

• More data required to further understand special populations (i.e., severe comorbidities, mild/moderate comorbidities, complex factors)

• Majority of typically developing children who have been fitted with hearing aids following an evidence-based protocol are meeting auditory development milestones similar to their normal hearing peers
Interpretation

- Provides information regarding the child’s auditory development in relation to normal hearing peers
  - Monitoring unaided children
  - Assists with follow-up plan (i.e. Sedated ABR)

- With repeated administrations provides a description of the child’s progress
  - In relation to individual and normal hearing peers
  - Can contribute to the overall profile of the child

Tracking Progress Over Time

- This child ‘caught up’
- This child performs parallel to normal but still progressing
- This child demonstrates a lack of progression
Summary: LittLEARS

- Short questionnaire that parents and clinicians find feasible to complete
  - Available in 31 languages
- Norms developed from normal hearing children work well
- Sensitive to medical issues
  - Require more data to characterize different patient profiles
- Useful for monitoring the progression of auditory behaviours in infants and young children
  - Normal hearing
  - PCHI but unaided
  - PCHI and aided

The Parent’s Evaluation of Aural/Oral Performance in Children (PEACH)

Diary:

Rating Scale:
**PEACH** (Ching & Hill, 2005)

- Goal: to evaluate effectiveness of device for infants and children with hearing impairment

- Format: 13 item questionnaire assesses
  - hearing aid use
  - loudness discomfort
  - communication in quiet and noise
  - phone use
  - responsiveness to environmental sounds

---

**PEACH Diary**

- *Administration:* systematic parental observation for 1 week followed by a structured interview with audiologist

- Good internal consistency and test-retest reliability

- Normative data collected with 90 parents of normal hearing children and 90 parents of hearing impaired children (Ching et al, 2007)

- Ching et al, 2008 demonstrated the tool is responsive to evaluating the impact of changes in hearing aid frequency response in severe to profound fittings
PEACH Rating Scale

- 5-point rating scale
- Includes most of the scenarios from the Diary
- Parents think about their child’s behaviour over the past week in relation to each question
  - Can be done in one appointment
  - No follow-up interview by clinician necessary
- Percentage scoring

Validation of PEACH Norms

![Graph showing quadratic regression curves for PEACH Diary and PEACH Rating Scale.](image)

- PEACH Diary
- PEACH Rating Scale

Raw Data:
- Typically Developing

<table>
<thead>
<tr>
<th>Quadratic Regression Curves</th>
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<tr>
<td>PEACH Diary: N = 90</td>
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<tr>
<td>PEACH Rating Scale: N = 59</td>
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</table>

Mean age = 32.17 months
Age range = 2 to 83 months
Mean score = 73.3%
Score range = 0 to 100%

Bagatto & Scollie, 2013
JAAA, vol 24: 121-125
PEACH Scoring

- No score sheet provided with PEACH, therefore, needed to develop one from existing literature and preliminary data

- Ching et al, 2005, 2008, NAL/DSL Study
  - Normal hearing children achieve 90% around age 3 years
  - Hearing impaired children achieve a range
    - Ching et al, 2005 = 62%
    - Ching et al, 2008 = 66%
    - NAL/DSL Study = 80%
      - Ching, Scollie, Dillon, Seewald, et al., 2010
Administration of PEACH

86 caregivers; 188 times
Mean age = 44.0 months
Range = 11.2 – 107.1 months

Removed children younger than 24 months of age: N = 65

Typically Developing = 17 (26.2%)
Comorbidities = 16 (24.6%)
Complex Factors = 32 (49.2%)

PEACH Scores for Children with Hearing Aids

88.2% of typically developing children demonstrate typical auditory performance
### PEACH Results

- **Significant effect of age on PEACH scores** ($p = 0.026$)
  - Supports administration guideline to administer LittlEARS until ceiling score reached and child is >24 months of age

- **Degree of hearing loss impacts PEACH scores**
  - As hearing loss increases, PEACH scores decrease
  - Group effect by hearing loss level yet to be determined

- **No effect of group on PEACH scores yet**
  - $p > 0.05$
PEACH Conclusions

- Majority of typically developing children who are fitted with hearing aids following an evidence-based protocol show typical auditory performance

- Children with comorbidities and complex factors have lower scores than typically developing children
  - Further data collection required to characterize scores for these subgroups

Case Example

- Bilateral moderately-severe hearing loss
- Aided at 4.5 yrs of age
- Late fitting due to lack of follow-up
- Typically developing
Summary: PEACH

- Assesses functional auditory performance in quiet and noisy situations
  - Can compare to hearing impaired children who wear hearing aids using score sheet
  - Available in 15 languages

- Can identify whether child is or is not performing typical auditory behaviours

- For example:
  - If noise score is poor, can discuss noise options

Case Example
Case History

- Born full term without complications and no family history of PCHI

- Identified at 4 months of age

- Mild sloping to moderately-severe PCHI
  - PTA right = 43.3 dB HL; PTA left = 46.6 dB HL

- Fitted with hearing aids at 5 months of age

Outcomes Obtained

- Unaided and repeated aided LittIEARS

- Hearing aid fitting details including SII

- PEACH
10/21/17

Unaided 30 day recheck 3 month recheck

SII Values: Average Speech

Right = 86%
Left = 82%
UWO PedAMP

- A guideline consisting of several outcome evaluation tools that aim to measure auditory-related outcomes in infants and young children
  - Visual tools to permit rapid scoring
  - Preliminary data to support interpretation

- The UWO PedAMP will evolve through clinical implementation
  - Community of practice is important for success
Objective Outcome Measures

Speech Tests

Some Examples

- Ling 6 Detection Task
- Plurals Task
- Adapted BKB-SIN for children who wear hearing aids
The Ling 6 Test

- /m/, /u/, /a/, /i/, /ʃ/, and /s/
  - These span the speech frequencies
- Originally proposed for live voice use by therapists: (see Ling, 1989 for more detail)
  - Probe whether the child can detect all sounds
  - Probe whether they can discriminate the sounds
  - Do these prior to every therapy session. Protects against running a therapy session during a period of hearing aid malfunction, etc.

In current practice

- Some audiologists like to use the Ling 6 sounds as a rapid validation measure (Cox, Mendel, & Bell, 2011; Smiley, Martin, & Lance, 2004)
  - By live voice as an informal tool
  - Used with an audiometer to measure aided detection thresholds
- Smiley et al discuss its uses:
  - Detection, Discrimination, Identification are all different purposes
In current practice

- Suggested use 1: For young infants who are (early) hearing aid users, an aided detection task may be a helpful outcome measure
  - Confirm reception of sound, demonstrate efficacy to parents. This does not assess speech sound discrimination or identification.
- Suggested use 2: For determining if hearing aid bandwidth/dsp provides access to all 6 sounds. (Glista et al., 2009; Wolfe et al., 2010; Wolfe et al., 2011)
- Suggested use 3: For fittings that cannot be verified using real ear measurement, aided detection thresholds provide some information about device function. CI, BAHA, etc. (Bass-Ringdahl, 2010; Davidson, et al., 2009; Tharpe, Fino-Szurmski, & Bess, 2004; Hodgetts, Hakansson, Hagler, & Soli, 2010)

A specific tool: Ling 6 (HL) (Scollie et al, 2012)

- Pre-recorded female utterances of each sound
- Norms for detection in dB HL in sound field
- Scoring corrections, a score sheet, and a CD

- Normally hearing listeners:
  - Detect the sounds between –10 and 10 dB HL
  - Have average test-retest reliability of 1 – 2 dB and a range of test re-test of one to two step sizes

continued
Score sheet:

Normal range

Plot (un)aided thresholds as you would on an audiogram.

The UWO Plurals Test (Glista et al, 2012)

- Developed to be similar to a research task used in evaluating hearing aid bandwidth at BTNRH (Stelmachowicz, Pittman, Hoover, & Lewis, 2002).
- Nouns in singular & plural form at a high SNR
  - The task is to hear the word-final fricative
  - Sensitive to high frequency audibility
- UWO version uses 15 nouns: ant, balloon, book, butterfly, crab, crayon, cup, dog, fly, flower, frog, pig, skunk, sock and shoe
  - Pre-recorded, calibrated, available on a CD with scoring and interpretation guidelines
Presentation

- Present at an overall level of about 55 dB(A)
  - This represents speech at a slightly soft level
- A background noise is built-in
  - Ten randomized lists are provided
- Use picture flip cards to administer using a pointing response
  - This is helpful if the child’s own productions of the word would be unclear
  - Tip: pre-sort the cards into the correct random order for the list(s) you will use

Scoring & critical differences

Aided test #1: 64% correct
Aided test #2, after re-adjusting: 79% correct
Scoring & critical differences

- The plotted score falls outside the shaded region and is therefore significantly better.
- The re-adjustments improved the score significantly.
- Note that this test does not assess correct speech sound identification.

Adapted BKB-SIN (Ng et al., 2011)

- BKB-SIN is a test of recognition of words in sentences in noise (Etymotic Research, Inc., 2005)
- Originally developed for unaided testing and therefore uses a high presentation level
- Ng, Meston, Scollie & Seewald (2011) adapted for use as an aided outcome measure
  - Present speech at conversational level and competing babble from 4 surrounding speakers
- Speech in noise tests have utility in assessing benefit or outcomes of hearing technology intervention
Strategies Examined in the Study

- Directional microphones
- Digital noise reduction

- Participants:
  - 14 adults with normal hearing (22-28 yrs)
  - 15 children with normal hearing (6-18 yrs)
  - 14 children who wear hearing aids (9-16 yrs)

Results

**Figure 1.** Performance intensity functions for each group of participants. Data points represent mean percent correct of keywords per sentence, presented at the corresponding SNR.
Results

Figure 3. Performance intensity functions for children who use hearing aids in each of the three aided listening conditions. Data points represent mean percent correct of keywords per sentence, presented at the corresponding SNR.

Conclusions

- Adapted BKB-SIN test was reliable for all groups
- It was sensitive to differences between participant groups
- Sensitive to improved speech recognition abilities with the use of directional microphones
- Uses child-appropriate and realistic materials, therefore it provides an option for the clinical evaluation of the efficacy of hearing aid technology in children
Summary and Wrap-up

UWO PedAMP within an EHDI Program

- Implemented with children who may or may not wear hearing aids

- Consists of:
  - OIHP Amplification Benefit Questionnaire (aided only)
  - Hearing Aid Fitting Summary (aided only)
  - LittLEARS Auditory Questionnaire
    - OR
  - PEACH Rating Scale
Importance of Outcome Evaluation

- Patients
  - Track and monitor
  - Involve parents – result: good observers
  - Shared language

- Audiologists
  - Way to measure impact of hearing aid fitting
  - Improve efficiency and effectiveness of service delivery
  - Improve communication with families and professionals

- EHDI
  - Measure how program is doing
  - Helps describe patterns that affect children within the program

Summary

- Validation is an important stage of the hearing aid fitting process that is often overlooked

- Provides information for caregivers, audiologists and EHDI program stakeholders

- Evaluating outcomes in various ways provides a variety of information that supports the previous stages of the hearing aid fitting process in children
Thank you!!

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May Webinar from the National Centre for Audiology, Western University

Susan Scollie, Ph.D.