FUNCTIONAL HEARING QUALITY IN PRESCHOOL-AGED CHILDREN WITH COCHLEAR IMPLANTS

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ABSTRACT

Objective: This study aimed to develop a parent-report measure of functional hearing quality (the Quality of Hearing Scale, QHS) for preschool-aged children, in order to better characterize auditory outcomes following cochlear implantation. **Design:** 26 children with normal-hearing (NH) and 20 children with cochlear implants (CIs) between ages 3 and 6 years were administered the Quality of Hearing Scale (QHS), a new 21-item parent-report questionnaire of child functional hearing quality. Children also completed measures of speech perception, language, and nonverbal intelligence. Hearing history and audiological exam results were obtained from chart review. **Results:** QHS scores showed adequate to strong internal consistency for 4 subscales (Speech, Localize, Sounds, and Effort) and one composite (Hearing Quality). Children with CIs scored lower than NH peers on QHS Speech, Localize, Sounds, and Hearing Quality subscales (reflecting poorer functional everyday hearing) and higher than NH peers on the QHS Effort subscale (reflecting more effort in everyday hearing), but raw scores suggested adequate to good everyday hearing in the CI sample. Implantation at earlier ages was associated with better QHS Hearing Quality and lower QHS Effort. QHS scores were significantly associated with speech perception and language outcomes. **Conclusions:** The QHS is a reliable and valid measure of functional everyday hearing quality in preschool-aged children with CIs. Functional hearing quality measured with the QHS was associated with hearing history, speech perception, and language skills, demonstrating that QHS-assessed hearing outcomes are associated with downstream speech and language functioning.

INTRODUCTION

- Considerable variability in speech, language, and neurocognitive outcomes is seen in preschool-aged children after cochlear implantation
- Conventional audiological measures (e.g., pure-tone audiological assessment or hearing history) are critical for evaluating the efficacy of CIs
  - However, they do not fully capture and explain hearing and downstream speech and language outcomes
- Functional real-world hearing after implantation may be an important audiological outcome to assess and may help to explain speech and language outcomes
  - Some adult measures assess self-reported hearing quality (e.g., Speech Spatial and Qualities of Hearing Scale [SSQ; Noble & Gatehouse, 2006] and Profile of Hearing Aid Benefit [PHAB/APHAB; Cox & Alexander, 1995])
  - Few measures specifically focus on functional hearing in preschool-aged children (e.g., Infant-Toddler Meaningful Auditory Integration Scale [IT-MAIS; Zimmerman-Phillips et al., 2000]; Parent's Abbreviated Profile of Hearing Aid Performance [PA-PHAP; Kopun & Stelmachowicz, 1998])
- This project aimed to develop a functional hearing measure for preschool-aged children with CIs and to investigate associations of that measure with speech and language outcomes

METHOD

- **Participants**
  - 20 children with CIs (12 male, 8 female; age 3-6 years, *M*=5.3, SD=1.2)
    - Onset of deafness (*M*=2.5 months, SD=6.7) and cochlear implantation (*M*=21.5, SD=9.8) by 36 months; implant use 6+ months (*M*=41.6, SD=17.7); nonverbal IQ scaled score 7 or greater (*M*=11.2, SD=2.1)
    - Pre-implant best ear PTA=98.4, SD=13.1; most recent aided best ear PTA=25.6 (SD=5.0)
  - 26 NH (normal hearing) peers (8 male, 18 female, age 3-6 years, *M*=4.9, SD=1.1)
    - Hearing within normal limits (<= 20 dB HL); nonverbal IQ scaled score 7 or greater (mean=12.2, SD=2.1)
  - No sample differences on age (p=0.28), gender (p=0.07), IQ (p=0.11)
    - Both samples: Absence of any developmental, cognitive, or neurologic diagnoses; monolingual spoken English home environment
- **Measures**
  - Quality of Hearing Scale (QHS) (Figure 1):
    - 21 items developed to assess four domains (Speech, Sounds, Localize, Effort) based on SSQ, APHAB, IT-MAIS, other literature
    - Global Hearing Quality Score consisting of Speech + Sounds items
  - Nonverbal Intelligence (IQ): Leiter-3 Classification and Analogies Scaled Score (Roid et al., 2013)
  - Speech Perception:
    - Lexical Neighborhood Test (LNT) (Kirk, Pisoni, & Osberger, 1995): monosyllabic words
    - Children's Test of Non-word Repetition (CNREP)(Gathercole & Baddeley, 1996): nonwords
    - Multimodal Lexical Sentences Test for Children: meaningful spoken sentences in quiet or noise (Kirk et al., 2012)
  - Language:
    - Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn & Dunn, 2007): receptive vocabulary
    - NEPSY-II Comprehension of Instructions (Korkman et al., 2007): listening comprehension

RESULTS/CONCLUSIONS

- **Results**
  - QHS subscales and composites had adequate to strong internal consistency (Table 1)
  - QHS scores were consistently poorer in the CI sample than in the NH sample, although in the adequate-to-good range based on mean raw scores (Table 1)
  - Younger age at implantation was associated with better QHS Hearing Quality and less QHS Hearing Effort; aided post-implantation PTA was not associated with QHS scores (Figure 2)
  - QHS scores were associated with speech and language outcomes across combined CI and NH samples (Table 2)
- **Conclusions**
  - The QHS is a reliable and valid measure of hearing quality that is associated with hearing history, speech perception, and language outcomes in preschool-aged children and is not redundant with audiological assessment based on PTA
- **Clinical Implications of Results**
  - QHS scores provide additional important information about hearing outcomes for preschool-aged children with CIs
  - A revised version of the QHS (QHS-R) is currently under development based on empirical results and clinical feedback

Figure 1: Quality of Hearing Scale

0 Not at all 1 2 A little 3 4 Some 5 6 Pretty Much 7 8 Very Much 9 10 A Lot; Completely

How Well Does Your Child Understand What is Being Said in These Situations?

_____ 1. In a room that is quiet, when your child is talking face-to-face with one person.
_____ 2. In a room that has a TV or radio on, when your child is talking face-to-face with one person.
_____ 3. In a room when 4 or 5 other people are talking, when your child is talking face-to-face with one person.
_____ 4. In a noisy room, when your child is talking face-to-face with one person.
_____ 5. In a quiet room, when 4 or 5 people are talking around a table and your child can see all their faces.
_____ 6. In a noisy room, when 4 or 5 people are talking around a table and your child can see all their faces.

How Well Can Your Child Tell Where the Sound is Coming From or its Distance From Your Child in These Situations?

_____ 7. When your child is sitting with a group of people and someone (whom your child can't see) starts talking.
_____ 8. When your child is in a quiet place and a sound (like footsteps) comes from one part of the room.
_____ 9. When your child is outside and he or she hears a motor sound from a car, leaf blower, or lawn mower.
_____ 10. When your child is in a noisy place, and a loud sound like a slamming door comes from one part of the room.
_____ 11. When your child hears a bus or truck, can he/she tell how far away it is?
_____ 12. When your child hears a bus or truck, can he/she tell whether it's coming towards him/her or going away?

How Well Can Your Child Recognize or Understand These Sounds?

_____ 13. Being able to listen and understand one person when several people are talking at the same time.
_____ 14. Being able to listen to music when there are several other sounds in the room (such as talking, knocking, footsteps, etc.).
_____ 15. Recognizing a song that your child likes when he/she hears it on the radio in a quiet room.
_____ 16. Telling the difference between the sound of a car motor and a lawn mower when they can't be seen.
_____ 17. Judging a person's mood from the sound of their voice.

How Much Effort Does Your Child Have to Use to Understand What is Being Said in These Situations?

_____ 18. In a room that is quiet, when he or she is talking face-to-face with one person.
_____ 19. In a room that has a TV or radio on, when he or she is talking face-to-face with one person.
_____ 20. In a room when 4 or 5 other people are talking, when he or she is talking face-to-face with one person.
_____ 21. In a noisy room, when he or she is talking face-to-face with one person.

Table 1: QHS Scores by Sample

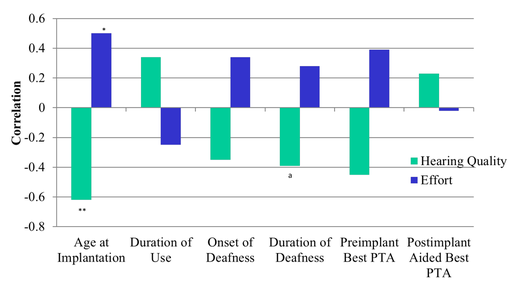
Subscale (Items)	CI (N=20)	NH (N=26)	t (p), df=44	alpha
Speech (1-6)	6.8 (2.1)	8.4 (1.4)	3.1 (0.003)	0.94
Localize (7-12)	7.2 (1.4)	8.5 (1.2)	3.5 (0.001)	0.84
Sounds (13-17)	7.3 (1.4)	8.5 (1.0)	3.6 (0.001)	0.68
Effort (18-21)	3.8 (2.2)	1.9 (1.6)	3.2 (0.002)	0.86
Hearing Quality (1-6, 13-17)	7.0 (1.7)	8.4 (1.1)	3.4 (0.001)	0.92

Table 2: QHS, Demographics, Nonverbal IQ, Speech, and Language

	Hearing Quality	Effort	Speech	Sounds	Localize
Age	-0.14	0.19	-0.12	-0.14	-0.21
Family Income	0.41**	-0.24	0.45**	0.30*	0.37*
Gender	0.13	-0.20	0.13	0.11	-0.06
Nonverbal IQ	0.20	-0.30*	0.15	0.25	0.11
Lexical Neighborhood Test	0.40**	-0.37*	0.40**	0.34*	0.30*
Nonword Repetition	0.35*	-0.29a	0.38**	0.26a	0.35*
MLST-C in Quiet	0.42**	-0.25	0.43**	0.35*	0.31*
MLST-C in Noise	0.44**	-0.39*	0.46**	0.36*	0.36*
PPVT-4	0.43**	-0.36*	0.45**	0.34*	0.47***
NEPSY Comprehension of Instructions	0.41**	-0.32*	0.43**	0.33*	0.37*

Values are Pearson r for combined CI and NH samples; family income on a 1 (under $20K/year) to 8 (over $150K/year) scale; nonverbal IQ is Leiter-3 Classification and Analogies scaled score; MLST-C=Multimodal Lexical Sentences Test for Children; PPVT=Peabody Picture Vocabulary Test; a p<0.10; * p<0.05; ** p<0.01 ; *** p<0.001

Figure 2: QHS and Hearing History



Note: Values are Pearson correlations for CI sample only; PTA=Pure Tone Average

a p<0.10
* p<0.05
** p<0.01

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