Cochlear Implantation for Pediatric Unilateral Deafness: Lessons Learned and Lingering Questions

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Disclosures

- Salaried employee at Boston Children's Hospital

- Research grant funding from the Hearing Health Foundation

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Researcher

- *pediatric unilateral hearing loss*

SSD + CI

Clinician

- *cochlear implant audiologist*







But my mother would suggest, I've been interested in stereo hearing for quite some time!







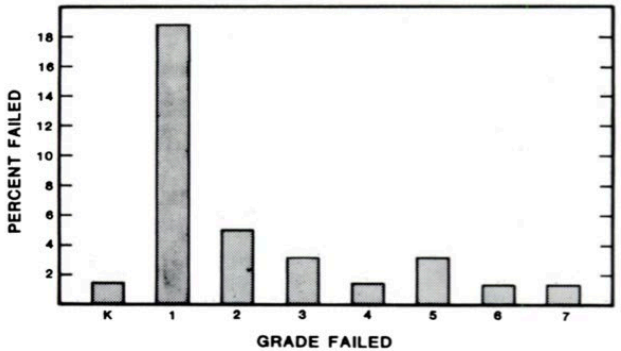


Fig 1. Percentage distribution showing grades failed by children with unilateral sensorineural hearing loss. One child failed two grades..

Bess and Tharpe (1984). Unilateral hearing impairment in children. Pediatrics. 74, 206-16.

Management of the Child with Unilateral Deafness

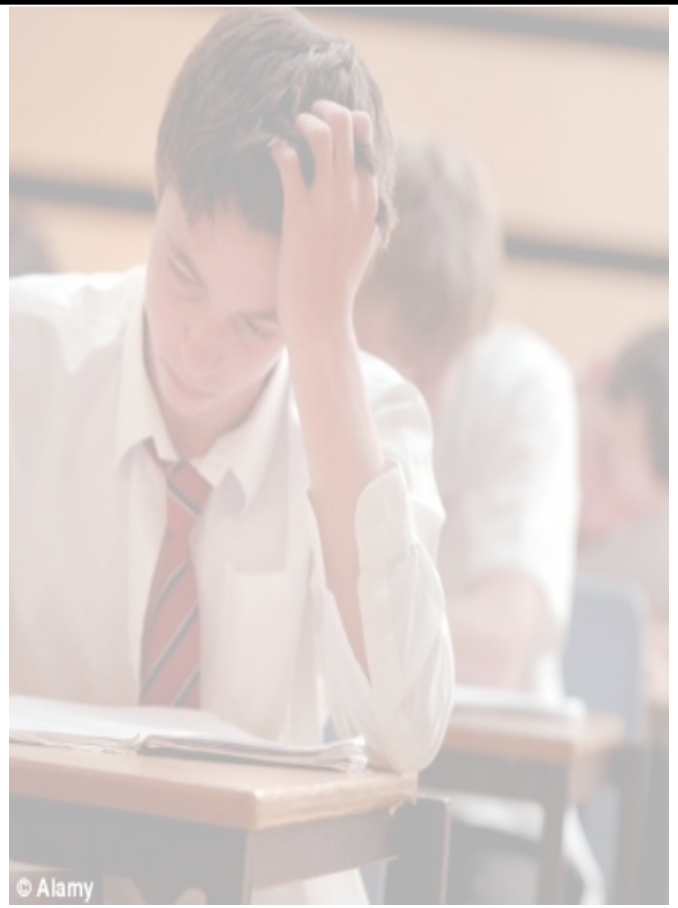
Unilateral deafness has always been common among children, and its prevalence does not appear to be lessening. Chiefly due to mumps, it develops with a suddenness that often baffles both the child and his parents. Audiologists and otolaryngologists are not usually concerned over such deafness, other than to identify its etiology and assure the parents that there will be no handicap. The child is often left bewildered at the mysterious onset and the loss of his "stereo" hearing. Seldom is he able to express his bewilderment, yet the occurrence is more traumatic to him than adults can appreciate. He is infinitely relieved if someone takes the time to explain to him what has happened,

Hearing in Children (1984). Northern and Downs.

We now know that auditory deprivation, *even in just one ear*, can have significant **neurodevelopmental effects**.



We know children with unilateral hearing loss (UHL) are *at risk* for



- **academic underachievement** (Bess & Tharpe, 1984; Culbertson & Gilbert, 1986; Most, 2004)
  - 25-50% experience academic difficulties including grade retention and the need for special education services
- **cognitive weakness** (Purcell et al., 2016; Arras et al., 2025; McSweeny et al., 2021)
- **behavioral and psychosocial problems** (Culbertson & Gilbert, 1986)
  - up to 1/3 demonstrate challenges in the social and behavioral domain, which persist into adulthood
- **speech and language delays** (Lieu et al., 2010; Fischer & Lieu, 2014; Fitzpatrick et al., 2019; Arras et al., 2023)
  - 25-40% are at risk for poorer speech and language skills compared to their peers with normal hearing
- **decreased quality of life** (Umansky et al., 2011; Griffin et al., 2019)



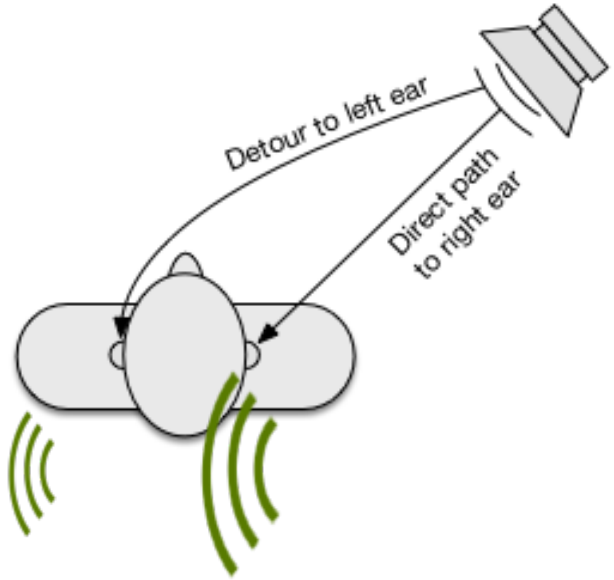
Children with UHL experience deficits on auditory tasks that require binaural access: sound localization and hearing in noise.











(e.g., Humes et al., 1980; Bess & Tharpe, 1984; Bess et al., 1986; Bovo et al., 1988, Jensen et al., 1989; Feuerstein, 1992; Ruscetta et al., 2005; Reeder et al., 2015; Griffin et al., 2019, 2020; Corbin et al., 2021; Park et al., 2023)



SSD + CI may feel new, but “we” have been studying this for over 20 years!

2003
- 1st SSD + CI surgery performed for tinnitus

2005
- 1st SSD + CI surgery performed *without* tinnitus

2008
- 1st paper published on SSD + CI outcomes in adults (Van de Heyning et al., 2008)

2012
- 1st case report (n=3) published on SSD + CI in children

2013
- **MED-EL** receives CE mark for SSD + CI

2019
- **MED-EL** receives FDA approval for SSD + CI

2022
- **Cochlear** receives FDA approval for SSD + CI

2026
- AB receives FDA approval for SSD + CI

Dhanasingh and Hochmair, 2021



Studies have demonstrated measurable benefit from a CI for SSD.

Improved speech understanding	Improved localization	Decreased tinnitus perception	Improved quality of life
• Friedmann et al., 2016 • Sladen et al., 2017 • Thomas et al., 2017 • Buss et al., 2018 • Brown et al., 2022 • Deep et al., 2021 • Ehrmann-Mueller et al., 2020 • Firszt et al., 2018 • Galvin et al., 2019 • Jakob et al., 2021 • Park et al., 2021 • Peter et al., 2019 • Peters et al., 2021 • Távora-Vieira et al., 2019 • Zeitler et al., 2019	• Arndt et al., 2015 • Távora-Vieira & Rajan, 2015 • Dillon et al., 2017 • Buss et al., 2018 • Dillon et al., 2020 • Ehrmann-Mueller et al., 2020 • Firszt et al., 2018 • Jakob et al., 2021 • Kurz et al., 2020 • Peter et al., 2019 • Peters et al. 2021 • Távora-Vieira et al., 2019	• Dillon et al., 2017 • Galvin et al., 2019 • Peter et al., 2019 • Peters et al., 2021	• Dillon et al., 2017 • Firszt et al., 2018 • Galvin et al., 2019 • Marx et al., 2021 • Oh et al., 2023 • Peter et al., 2019 • Peters et al., 2021

Last updated 2023



Kids benefit too

Cochlear Implantation in Children With Congenital Single-Sided Deafness

*Jan Peter Thomas, †Katrin Neumann, *Stefan Dazert, and *Christiane Voelter

*Department of Otolaryngology, Head and Neck Surgery; and †Department of Otolaryngology, Head and Neck Surgery, Divisi
Phoniatrics and Pediatric Audiology, Ruhr University Bochum, St. Elisabeth-Hospital, Bochum, Germany

Objective: To determine audiological and clinical results of cochlear implantation in children with congenital single sided deafness (SSD), with an emphasis on children implanted before and after 6 years of age.
Study Design: Retrospective study.
Setting: Tertiary referral center.
Subjects: Twenty one children with congenital SSD who were implanted aged 10 months to 11;3 years.
Intervention: Unilateral cochlear implantation.
Main Outcome Measures: Speech recognition in noise via the German Oldenburg Sentence Test for Children (OlKiSa), lateralization ability, and subjective evaluation of hearing

Parents had a high overall level of satisfaction with children's cochlear implantation. Subjective benefit verified in all three subscales of the Speech, Spatial, Qualities of Hearing Questionnaire. No significant differ was found between subjects implanted before the age with those implanted later. Three of the five subjects w follow-up of greater than 3 years were limited user nonusers.
Conclusions: Cochlear implant (CI) provision provides dren with congenital SSD with significant audiological subjective benefits which can be seen even in chil implanted after the age of 3;6. The problem of limited

Benefits of Cochlear Implantation in Childhood Unilateral Hearing Loss (CUHL Trial)

Kevin D. Brown, MD, PhD; Margaret T. Dillon, AuD; Lisa R. Park, AuD

Objectives/Hypotheses: Children with unilateral sensory hearing loss (UHL) struggle to locate the origin of sound and have reduced quality of hearing. This clinical trial will determine tation in children with UHL.
Study Design: Prospective clinical trial.
Methods: Twenty children with at least moderate to profound sensory hearing loss and score <30%) in one ear and normal hearing in the contralateral ear participated in a Food and clinical trial. Subjects were evaluated for speech perception in quiet, speech perception in noise, tive benefits after implantation.
Results: CNC word score perception in quiet significantly improved (1% to 50%, $P < .00$ tion. Speech perception in noise by BKB-SIN significantly improved in all three noise configurat tage in head shadow ($P < .0001$), a 1.6 dB advantage in summation ($P = .003$), and a 2.5 dB ad Localization improved by 26° at 9 months ($P < .0001$). Speech, Spatial, and Qualities (SSQ) der

Longitudinal Developmental Outcomes of Children With Prelingual Single-Sided Deafness With and Without a Cochlear Implant and Recommendations for Follow-Up

Tine Arras,[1,2] An Boudewyns,[3,4] Ingeborg Dhooge,[5] Andrzej Zarowski,[6] Birgit Philips,[2] Christian Desloovere,[7] Jan Wouters,[1] and Astrid van Wieringen[1,8]

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JAMA Otolaryngology–Head & Neck Surgery | Original Investigation

Cochlear Implantation in Children With Single-Sided Deafness
A Systematic Review and Meta-analysis

Liliya Benchetrit, MD; Evette A. Ronner, BA; Samantha Anne, MS, MD; Michael S. Cohen, MD

IMPORTANCE In 2019, the US Food and Drug Administration approved cochlear implantation for children with single-sided deafness (SSD). The absence of robust clinical data specific to pediatric patients to guide shared decision-making and to identify potential advantages is a challenge in family counseling.

OBJECTIVE To evaluate the audiological and patient-reported outcomes in children who underwent cochlear implantation for SSD and to assess the association between time of implantation, subjective outcomes, and cochlear implant device use rates.

DATA SOURCE MEDLINE, Embase, Scopus, Cochrane, and PubMed were searched for English-language articles that were published in a peer-reviewed journal from database inception to February 18, 2020.

STUDY SELECTION Inclusion criteria were designed to capture studies that evaluated pediatric patients (1) younger than 18 years, (2) with a diagnosis of SSD for which they underwent a cochlear implantation, and (3) with at least 1 outcome of interest measured numerically: speech perception, sound localization, device use, and patient-reported outcomes. Of the 526 articles reviewed, 12 (2.3%) met the selection criteria.

DATA EXTRACTION AND SYNTHESIS The Meta-analyses Of Observational Studies in Epidemiology (MOOSE) reporting guidelines were followed. Data were pooled using fixed-effect and random-effect models. The following information was obtained from each article: study characteristics, patient characteristics, hearing loss and intervention characteristics, and outcomes.

MAIN OUTCOMES AND MEASURES Outcomes were (1) postoperative changes in speech perception (in quiet was measured as a proportion of correct responses, and in noise was measured as decibel signal to noise ratio for speech reception threshold) and sound localization (measured in degree of localization error), (2) patient-reported audiological outcomes (measured by the speech, spatial, and qualities of hearing scale), and (3) device use rates among children who received cochlear implantation for SSD.

RESULTS Twelve observational studies that evaluated 119 children (mean [SD] age, 6.6 [4.0] years) with SSD who received a cochlear implant were included. Most children showed clinically meaningful improvement in speech perception in noise (39 of 49 children [79.6%]) and in quiet (34 of 42 children [81.0%]). Long duration of deafness (>4 years in congenital SSD and >7 years in perilingual SSD) was the most commonly proposed reason for lack of improvement. Sound localization as measured by degrees of error from true location (mean difference [MD], −24.78°; 95% CI, −34.16° to −15.40°; I^2 = 10%) improved statistically significantly after cochlear implantation. Patients with acquired SSD and shorter duration of deafness compared with those with congenital SSD reported greater improvements in speech (MD, 2.27; 95% CI, 1.89-2.65 vs 1.58; 95% CI, 1.00-2.16) and spatial (MD, 2.95; 95% CI, 2.66-3.24 vs 1.68; 95% CI, 0.96-2.39) hearing qualities. The duration of deafness among device nonusers was statistically significantly longer than the duration of deafness among regular device users (median difference, 6.84; 95% CI, 4.02-9.58).

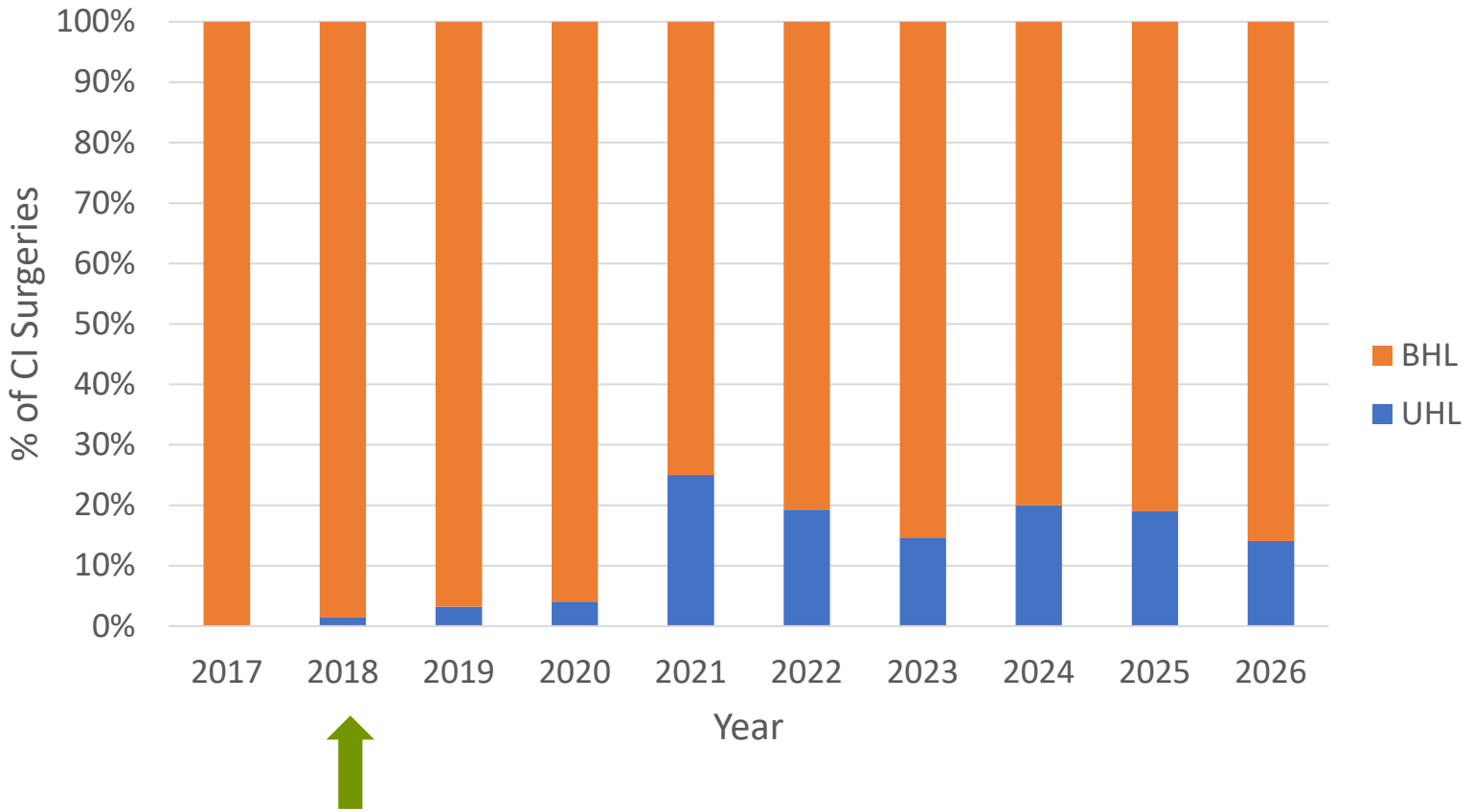
CONCLUSIONS AND RELEVANCE This systematic review and meta-analysis found that cochlear implantation for children with SSD was associated with clinically meaningful improvements in audiological and patient-reported outcomes; shorter duration of deafness may lead to better outcomes. These findings can guide future research efforts, refine cochlear implantation candidacy criteria, and aid in family counseling and shared decision-making.

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Supplemental content

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Corresponding Author: Michael S. Cohen, MD, Department of Otolaryngology–Head and Neck Surgery, Harvard Medical School, Massachusetts Eye and Ear Infirmary, 243 Charles St, Boston, MA 02114 (michael_cohen@meei.harvard.edu).

SSD + CI accounts for ~20% of Boston Children's Hospital's CI surgeries now

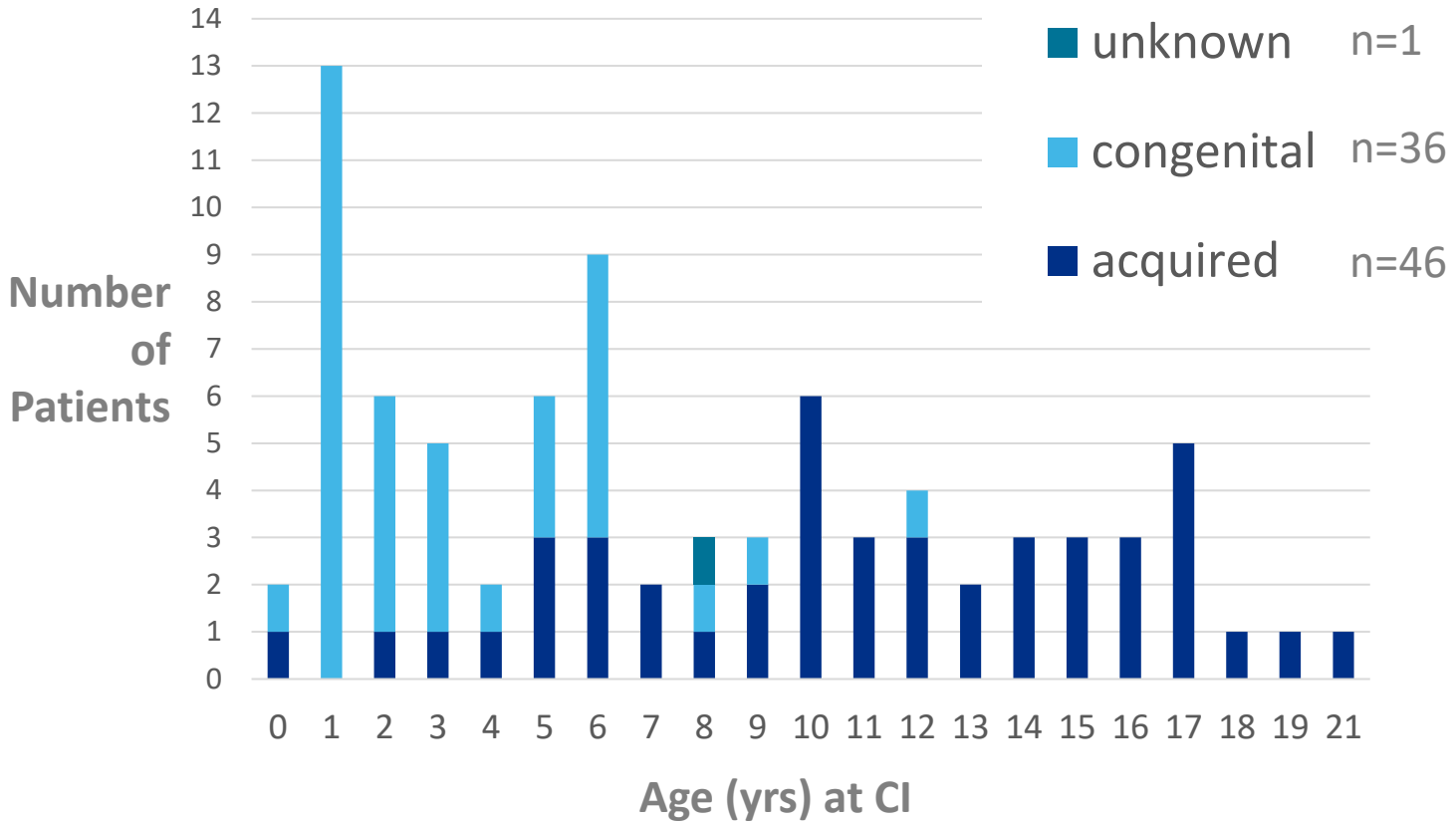


83 SSD+ CI
surgeries to date

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Average age at SSD + CI at Boston Children's Hospital = 8 yrs



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Who is a potential SSD+CI candidate?

A multidisciplinary CI candidacy evaluation is imperative.



Candidacy determination appointments at Boston Children's Hospital



Complete intake questionnaires. Provide outside medical records.



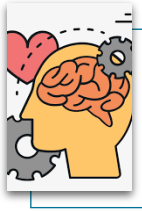
Exam and consult with **ENT** for hearing loss workup.



Evaluation and consult with **CI Audiologist**



Evaluation and consult with **a Speech-Language Pathologist**



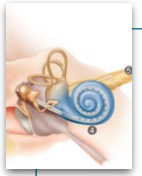
Evaluation with Pediatric (Neuro)**Psychologist**



Consultation with **Social Worker**



Baseline evaluation of **vestibular** (balance) function



Consultation with **CI Surgeon**



Children with SSD arriving to the CI Program appear at increased risk for a comorbid psychological diagnosis, highlighting the importance of a team approach to care.

ASHA American Speech-Language-Hearing Association

AJA

Clinical Focus

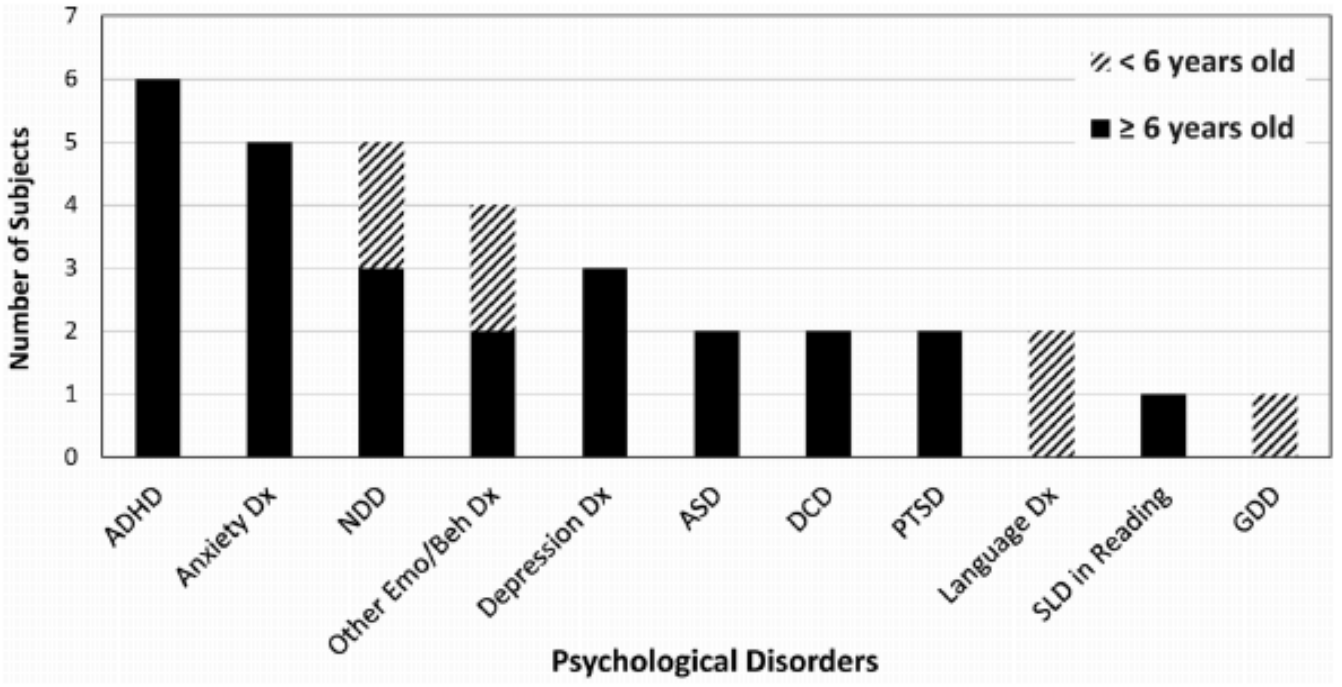
Comorbid Psychological Diagnoses in Children With Single-Sided Deafness Who Received or Are Under Consideration for Cochlear Implantation

Rachel A. Landsman,[a,b] Amanda M. Griffin,[a,c] Michael F. Hoffman,[d] Megan Herlihy,[e] and Greg R. Licameli[a,c]

[a]Department of Otolaryngology and Communication Enhancement, Boston Children's Hospital, MA [b]Department of Psychiatry (Psychology), Harvard Medical School, Boston, MA [c]Department of Otolaryngology—Head and Neck Surgery, Harvard Medical School, Boston, MA [d]Center for Childhood Communication and Department of Child and Adolescent Psychiatry and Behavioral Sciences, Children's Hospital of Philadelphia, University of Pennsylvania [e]Department of Counseling, Human Development and Family Science, University of Vermont, Burlington

- 44% (23/52) had co-morbid psych. condition.
- **55% in kids > 6yrs old**

Co-treatment is essential.



Outcomes with Unilateral Hearing Loss (OWuhL) Study

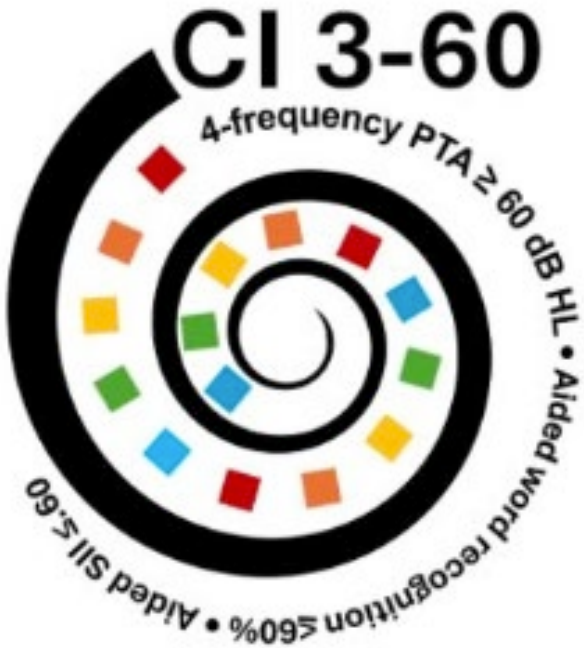
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Q: Audiologically who should be *considered* for a CI evaluation?

A: Use the pediatric CI 3-60 Guideline (Holder, Warner-Czyz, and Park, 2026)

1. 4FreqPTA (.5, 1, 2, 4 kHz) **≥ 60 dB HL** (Leigh et al., 2016)
2. Aided word recognition **< 60%** correct
3. Aided SII < 0.60 (McCreery, 2014)



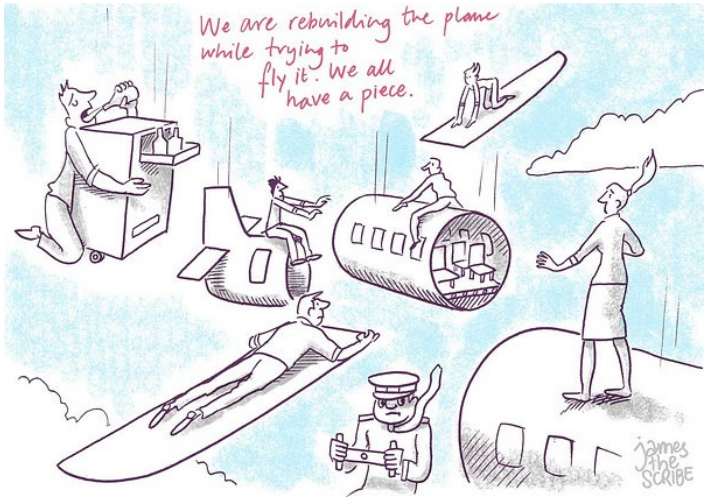
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How’s it going?



Audiological Outcome Measures – The First Year



	Pre-op	Mo. post-activation			
	Unaided/ Pre-CI	1 mo.	3 mo.	6 mo.	12 mo.
Datalogging		X	X	X	X
Audibility		X	X	X	X
Speech-In-Quiet	X	X	X		X
Speech-In-Noise: $SRM_{(Ipsi)}$ 1. CI: T_0 | M_0 2. CI: T_0 | M_{Ipsi}				X	
Speech-In-Noise: 1. Unaided & CI: T_0 | M_0 2. Unaided & CI: T_0 | M_{Ipsi} 3. Unaided & CI: T_0 | M_{Contra}					X
Questionnaires	X				X



Datalogging



Initial research suggested children with SSD + CI used their devices.

Children With Single-Sided Deafness Use Their Cochlear Implant

Melissa Jane Polonenko,[1,2,3,4] Blake Croll Papsin,[1,3,5,6] and Karen Ann Gordon[1,2,3,6]

Objectives: To assess acceptance of a cochlear implant (CI) by children with single-sided deafness (SSD) as measured by duration of CI use across daily listening environments.

Design: Datalogs for 7 children aged 1.1 to 14.5 years (mean ± SD: 5.9 ± 5.9 years old), who had SSD and were implanted in their deaf ear, were anonymized and extracted from their CI processors. Data for all available follow-up clinical appointments were included, ranging from two to six visits. Measures calculated from each datalog included frequency and duration of time the coil disconnected from the internal device, average daily CI use, and both duration (hr/day) and percentage of CI use (% daily use) in different intensity ranges and environment types. Linear mixed effects regression analyses were used to evaluate the relationship
offs, and durati
used to evaluat

Results: Childr
children used th
Longitudinal da
tion. Frequency
icantly contribu
in environments
as containing s
in quiet but more time in music than infants/toddlers and adolescents.

Conclusions: Children with SSD consistently use their CI upon activation in a variety of environments commonly experienced by children. CI use in children with SSD resembles reported bilateral hearing aid use in children but is longer than reported hearing aid use in children with less severe unilateral hearing loss, suggesting that (1) the normal-hearing ear did not detract from consistent CI use; and (2) a greater asymmetry between ears presents a significant impairment that may facilitate device use to access bilateral sound.

Key words: Bimodal experience, Cochlear implant, Cochlear implant experience, Coil-off, Device use, Electroacoustic hearing, Hearing experience, Intensity, SCAN, Noise, Nucleus 6 speech processor, Quiet, Sensorineural hearing loss, Single-sided deafness, Speech, Speech in noise, Unilateral hearing loss.

(Ear & Hearing 2017;38;681–689)

include children with residual hearing in the contralateral ear, or asymmetric hearing loss (Cadieux et al. 2013; Gratacap et al. 2015; Polonenko et al. 2015) to avoid effects of deprivation of sound to one ear in children. These effects include reorganization of auditory brainstem (Gordon et al. 2007a, b, c) and cortical (Gordon et al. 2013; Kral et al. 2013a, b; Jiwani et al. 2016) pathways, as well as development of abnormal brain networks (Schmithorst et al. 2005; Tibbetts et al. 2011; Burton et al. 2012; Rachakonda et al. 2014; Wang et al. 2014; Yang et al. 2014; Zhang et al. 2015). Functionally, children with unilateral deprivation exhibit poor binaural/spatial hearing and defi-
on (Lieu et
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s. Children
with SSD may have unique challenges because they have both a normal-hearing ear and an ear with severe to profound hearing loss and, because of the degree and asymmetry of their hearing, might use CIs inconsistently. In children with permanent bilateral hearing loss, CI and hearing aid use can be affected by a complex interaction of age (Walker et al. 2013, 2015; Muñoz et al. 2014; Marnane & Ching 2015), degree of hearing loss (Marnane & Ching 2015; Devocht et al. 2015; Walker et al. 2013, 2015), age of device fitting (Fitzgerald et al. 2013; Contrera et al. 2014; Marnane & Ching 2015; Easwar et al. 2016), duration of device use (Moeller et al. 2009; Marnane & Ching 2015; Walker et al. 2015; Easwar et al. 2016), listening context (Moeller et al. 2009; Walker et al. 2013), maternal education (Marnane & Ching 2015; Walker et al. 2013, 2015), socioeconomic status (Marnane & Ching 2015), family issues (Archbold et al. 2009; Moeller et al. 2009; Galvin & Hughes 2012), child state (Moeller et al. 2009; Galvin & Hughes 2012; Walker et al. 2013), social

Mean =7.4 hrs/day

Range = 3.5 to 11.2

Cochlear Implant Use Remains Consistent Over Time in Children With Single-Sided Deafness

Hillary V. Ganek,[1] Sharon L. Cushing,[1–4] Blake C. Papsin,[1–4] and Karen A. Gordon[1–5]

Objectives: To measure the acceptance of a cochlear implant by children with single-sided deafness (SSD) using datalogging technology in the cochlear implant processor.

Design: Datalogs from follow-up clinical audiology appointments for 23 children with SSD were extracted from their cochlear implant processors ranging from 1 to 8 visits (M = 3.74, SD = 1.79). The number of hours the cochlear implant was in use per day, the number of times the coil disconnected from the internal device, and the percentage of daily cochlear implant use in
from the datalogs. Line
lyze the relationship bet
use, and coil-offs per da
uate cochlear implant u

Results: Children with
= 2.81; range = 0.0004
cant change in cochlear
or gained more hearing
the number of coil-offs per day was reduced. Preschoolers spent more time in "music" and "speech" and less time in "noise" and "quiet" than older and younger children while older children spent more time in "speech-in-noise."

Conclusions: Children with SSD consistently wear their cochlear implants. However, the auditory environments to which they are exposed vary over time. Regular cochlear implant use by this population suggests that it does not detract from a normal-hearing ear and that children with SSD appreciate access to bilateral input.

Key Words: Children, Cochlear implant, Sensorineural Hearing Loss, Single-sided deafness, Unilateral.

(Ear & Hearing 2020;41;678–685)

access to sound as the auditory system reorganizes to strengthen input from the hearing ear and weaken pathways from the deaf ear (Wang et al. 2014; Yang et al. 2014; Gordon et al. 2015). In addition, language and academic skills are affected by poor access to sound in one ear (Lieu et al. 2013).

Even though the negative implication of SSD is clear, children with SSD often experience a delay between diagnosis and intervention compared with their peers with bilateral sensori-
diagnoses
the hear-
formation
treatment
impact of
l decision
y difficult
compared
with the poor speech and language outcomes associated with untreated bilateral hearing loss. Children with SSD respond to sounds via their better ear and, although language development may be delayed (Lieu et al. 2013), they often effectively communicate in some situations.

In the past, treatment options for children and adults with SSD were contralateral routing of sound through contralateral routing of signal (CROS) amplification or bone-anchored hearing aids (Kenworthy et al. 1990; Christensen et al. 2010; Finbow et al. 2015; Snapp et al. 2017). These options, however, do not help to provide interaural cues which are needed for localization of sound and hearing in noise. Using bone-anchored hearing aids in the management of SSD may also come with the burden of surgery and care along with a high risk of soft tissue complications. Cochlear implantation in children and adults with SSD

Mean = 6.2 hrs/day

Range = 0 to 15

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However, recently published research reports low daily use rates

Original Study

Cochlear Implantation for Single-Sided Deafness in Pediatric Patients: A Critical Assessment of Usage Rate

*Robert J. Macielak, †Celine Richard, ‡Prashant S. Malhotra, *‡Oliver F. Adunka, and ‡Ursula M. Findlen

*Department of Otolaryngology–Head and Neck Surgery, The Ohio State University Wexner Medical Center, Columbus, Ohio; †Division of Otolaryngology–Head and Neck Surgery, Le Bonheur Children's Hospital, Memphis, Tennessee; ‡Department of Pediatric Otolaryngology, Nationwide Children's Hospital, Columbus, Ohio

Objective: To assess the usage rate of pediatric patients undergoing cochlear implantation (CI) for single-sided deafness (SSD).
Study Design: Retrospective cohort study.
Setting: Tertiary care pediatric referral center

these 54 patients (19%) were designated as users (≥6 h per day), and 13 patients (24%) were designated as limited users (>2 but <6 h per day). Of patients capable of performing speech-in-noise testing (n = 13), 11 patients (85%) showed improvement on

most common known cause (17 patients, 26%). Hearing loss was prelingual in 38 patients (58%). Post-implantation, 12 patients (18%) were identified as lost to follow-up. For the remaining 54 patients, the median length of audiometric follow-up was 1.4 years (interquartile range, 0.9–2.2 yr). At last evaluation, only 10 of

critical assessment to ensure appropriate resource allocation.
Key Words: Cochlear implantation—Pediatric—Single-sided deafness—SSD.

Otol Neurotol **45:**1122–1127, 2024.

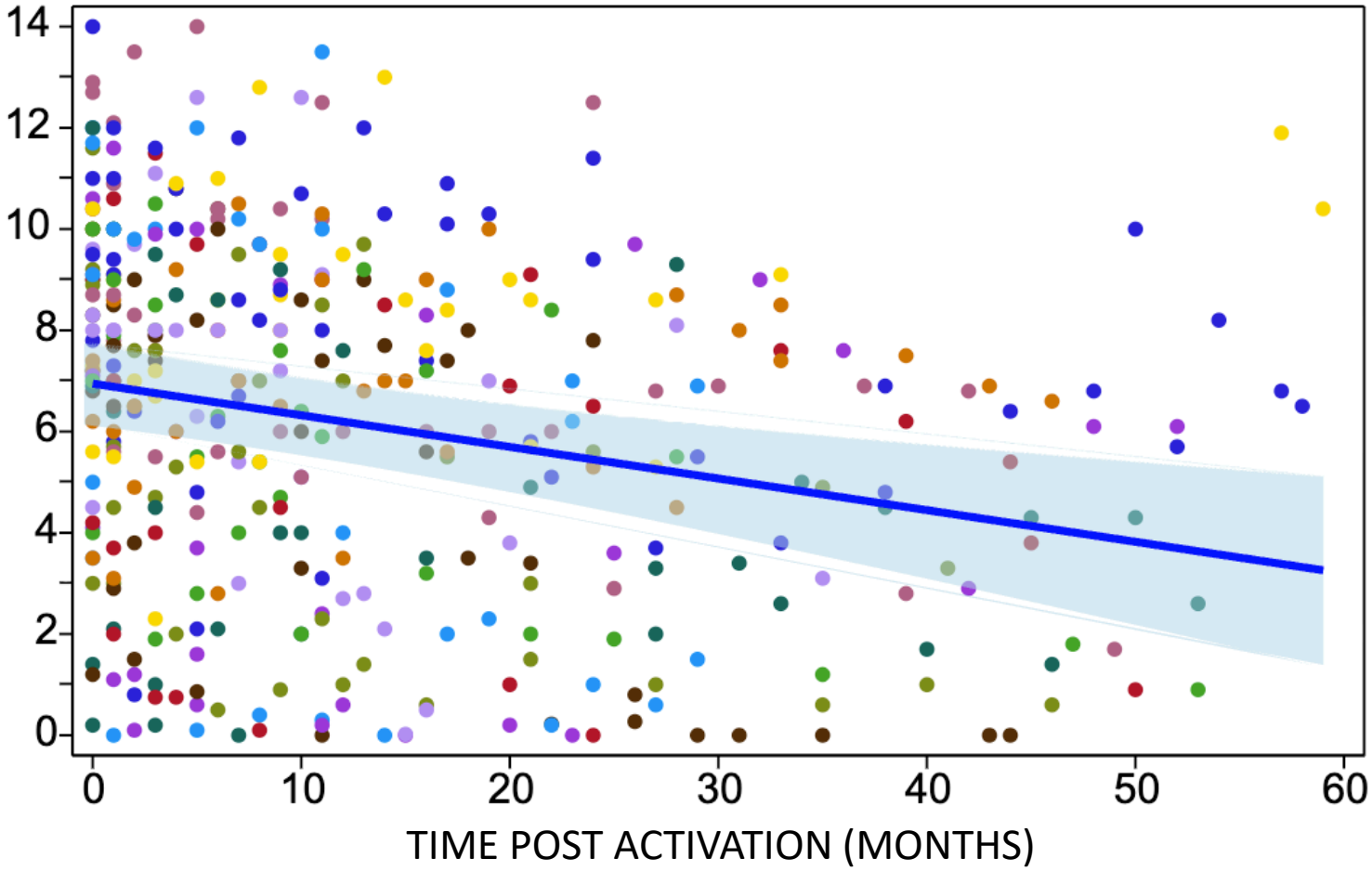
Only 19% (10/54) were using their CI ≥ 6 hours/day

And others…
Spitzer et al., 2024
Gao et al., 2025
Weng et al., 2026

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At Boston Children's we're seeing CI use decrease over time.



12/83 patients currently lost to follow-up.

Higgins, Kim, and Griffin (2026)

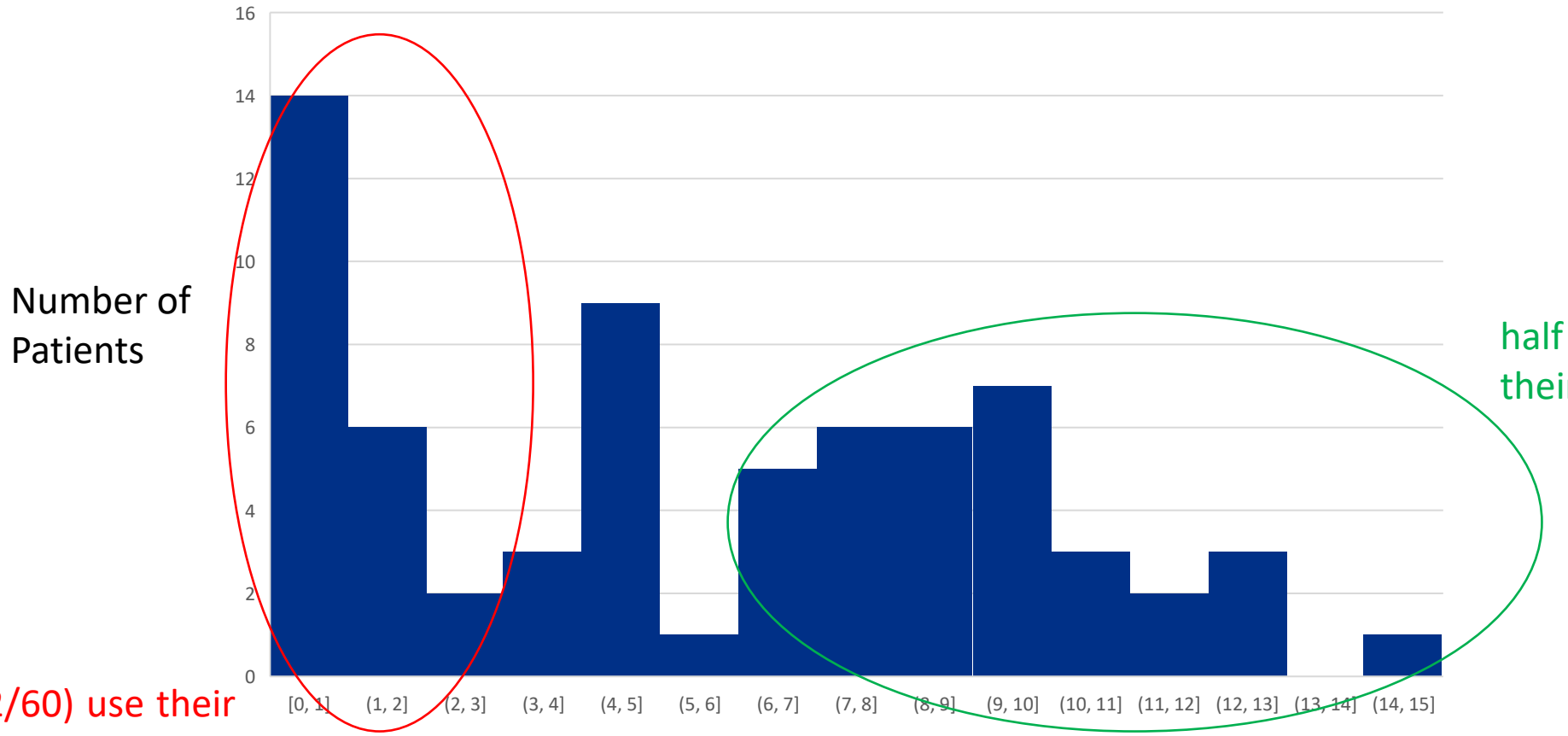
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Most recent datalogging values for those using their CI >6 months

Adapted from Higgins, Kim, and Griffin (2026)



About 1/3 (22/60) use their device less than 3 hours

half (25/49) wearing their CI ≥6 hours/day.

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CI use matters for unilateral listeners too

Factors that influence outcomes and device use for pediatric cochlear implant recipients with unilateral hearing loss

Lisa R. Park*, Erika B. Gagnon and Margaret T. Dillon

Department of Otolaryngology/Head and Neck Surgery, The University of North Carolina, Chapel Hill, Chapel Hill, NC, United States

97 children with SSD + CI
- Age at activation: 6 months to 17.7 years
- Time since activation: 2 weeks to 6.7 years
- Duration of deafness: 2 months to 14 years

The following factors were correlated with better **word scores:**

1. Increased wear time
2. Longer time since activation
3. Shorter duration of deafness

The following factor was correlated with better **Spatial Release from Masking (SRM):**

1. Increased wear time

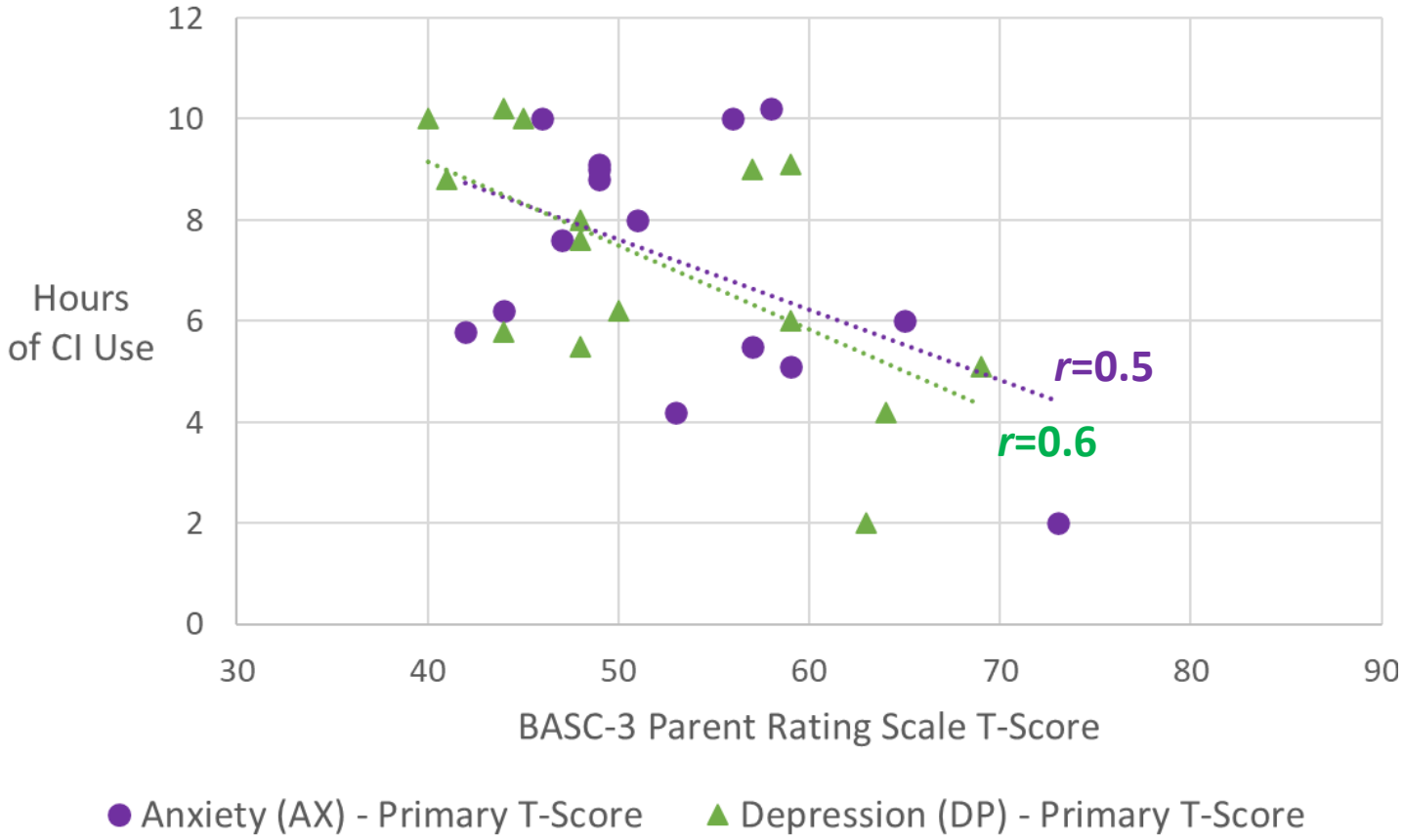
Park et al., 2023

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Psychosocial factors appear related to wear time.



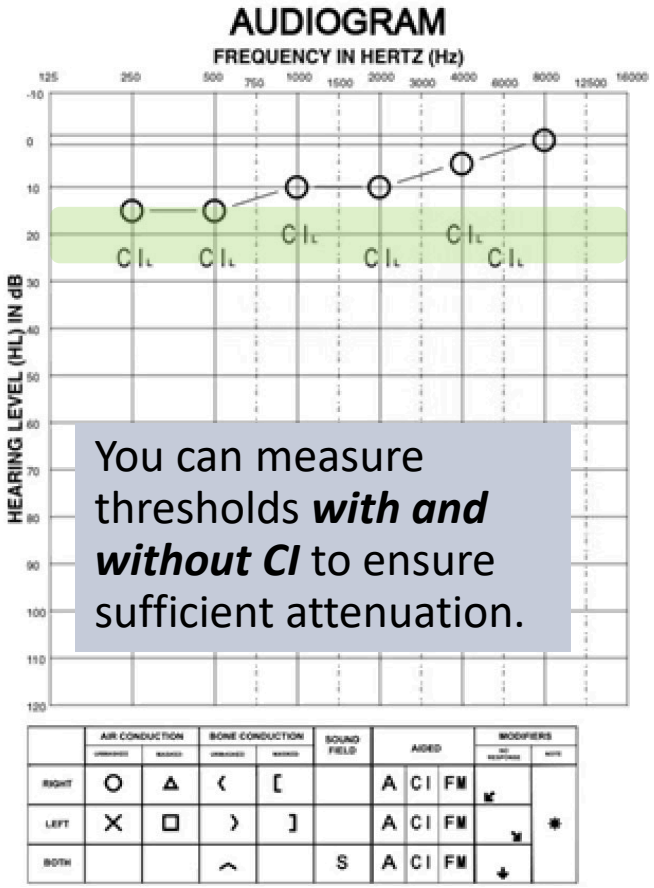
data collection ongoing



Audibility



Confirm appropriate audibility through the CI via 1) plug and muff



You can measure thresholds ***with and without CI*** to ensure sufficient attenuation.



+

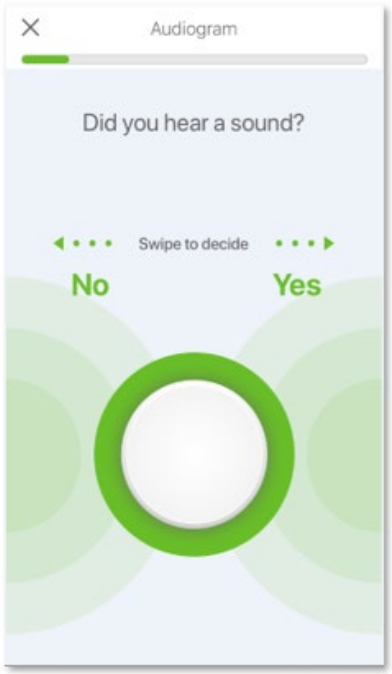


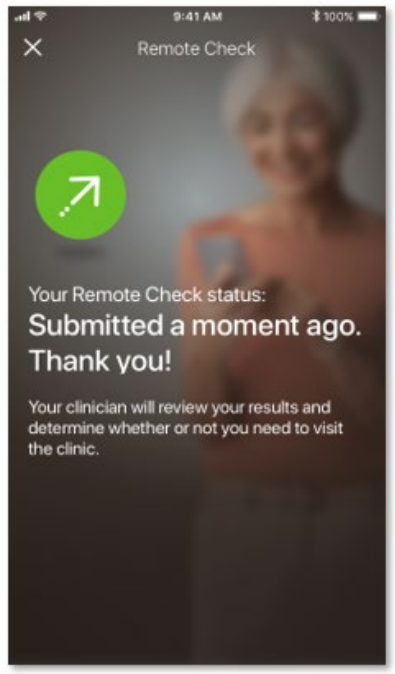


Or 2) DAI?

Aided Threshold Test (ATT) in Cochlear's Remote Check





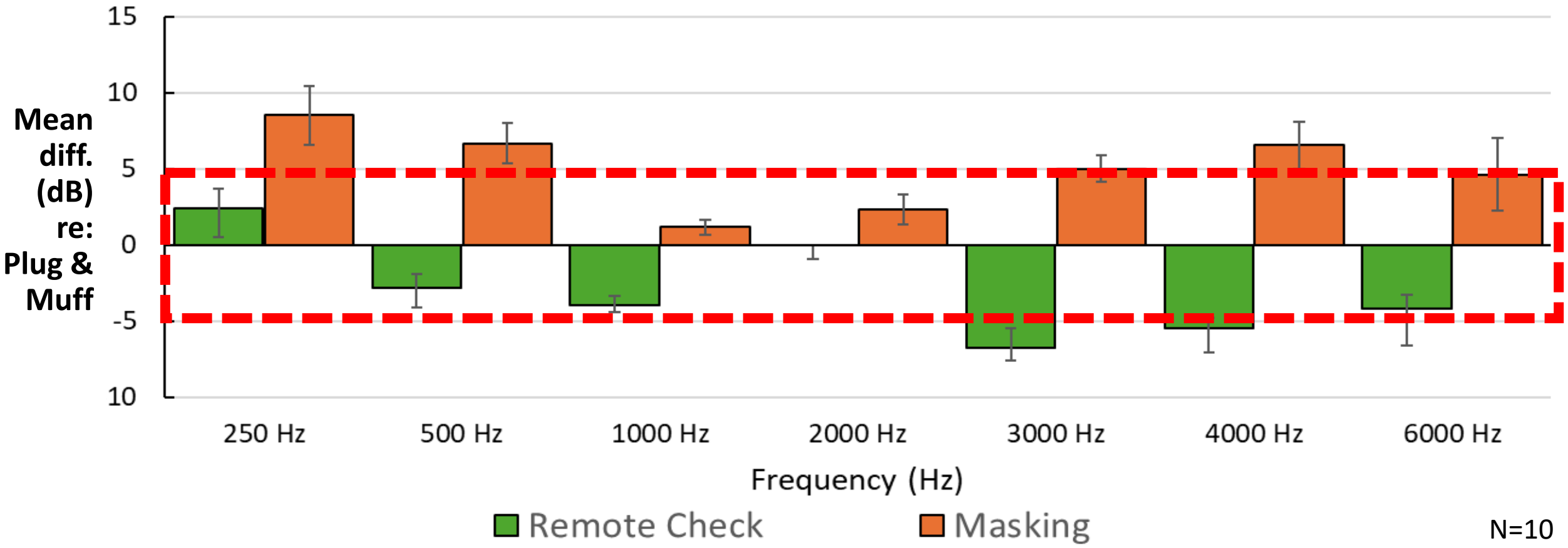


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Preliminary data suggest lower/better thresholds via ATT, yet largely within 5 dB of the plug & muff technique

data collection ongoing; complete dataset to be shared at ACIA



N=10

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Speech perception

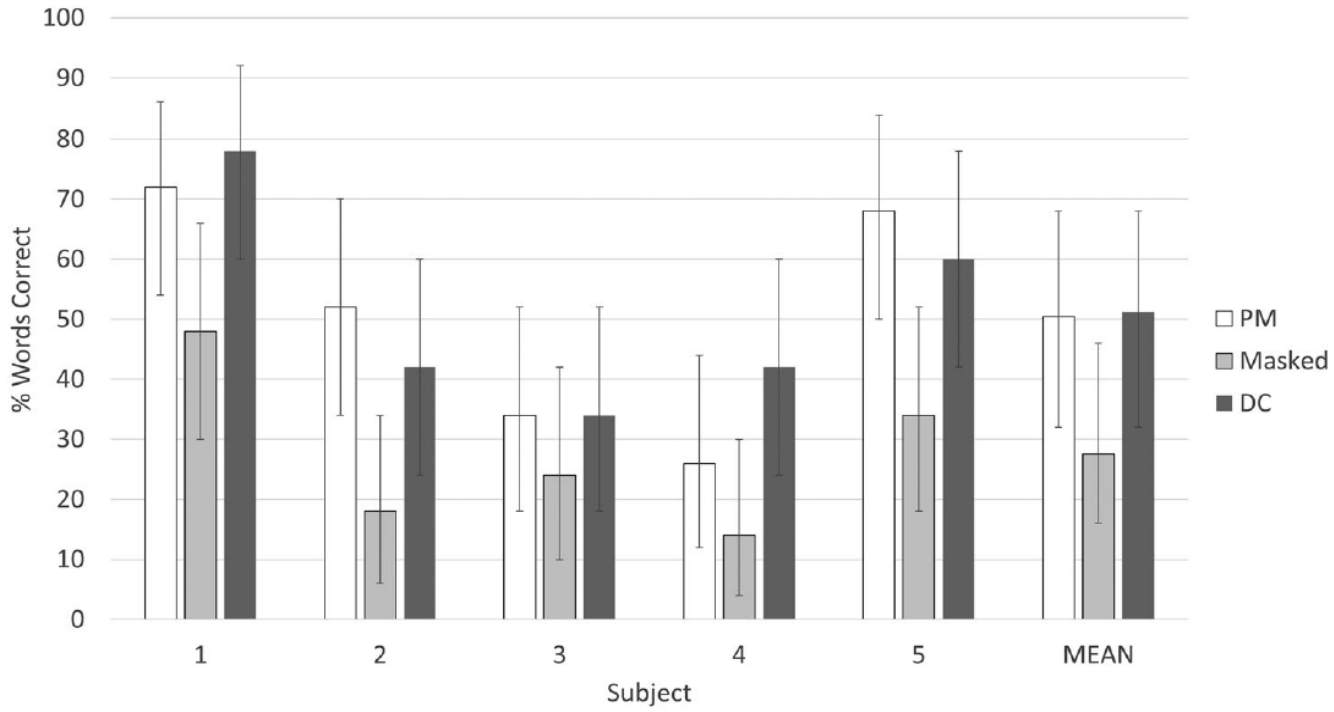
(in quiet)

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Measure speech perception with CI alone via direct audio input *for children*.



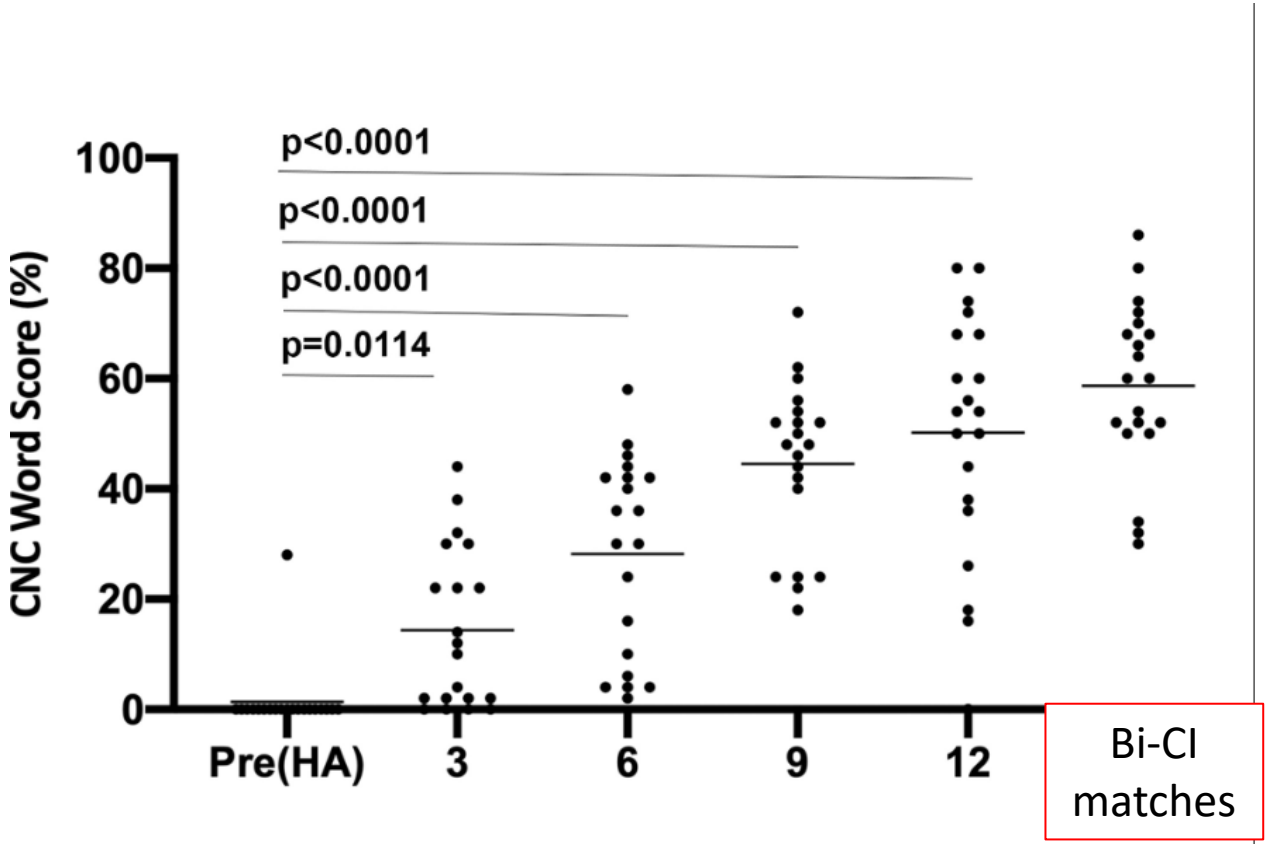
Poorest performance with masking (Masked).
Similar performance with plug & muff (PM) and direct connect (DC)

(Park et al., 2021)

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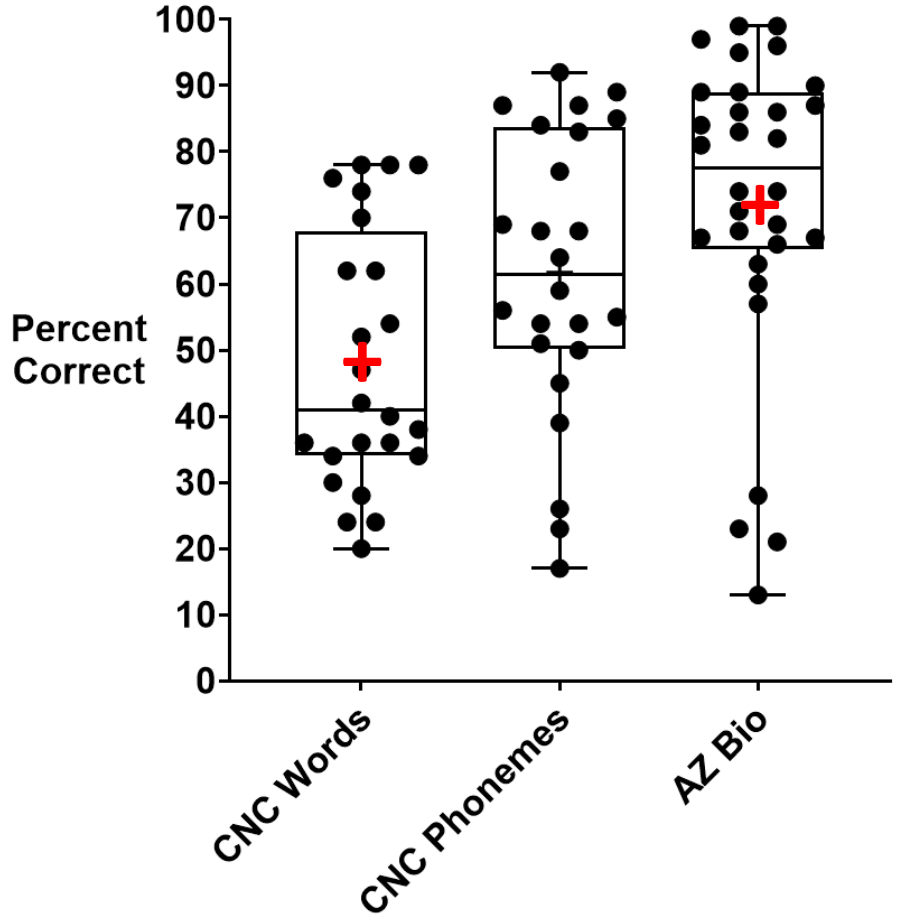
CNC scores improve over the first year of use



Brown et al., 2021



While variable word recognition scores are observed, sentence recognition scores are generally strong with the CI alone.



Months post-activation = 1 - 53

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Speech perception

(in noise)

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There is a growing effort to expand the clinical audiological test battery for children with SSD to accurately capture the specific hearing deficits experienced in this population.

American Cochlear Implant Alliance Task Force Guidelines for Clinical Assessment and Management of Cochlear Implantation in Children With Single-Sided Deafness

Lisa R. Park,[1] Amanda M. Griffin,[2,3] Douglas P. Sladen,[4] Sara Neumann,[5] and Nancy M. Young[6,7,8]

More children with single-sided deafness (SSD) are receiving cochlear implants (CIs) due to the expansion of CI indications. This unique group of pediatric patients has different needs than the typical recipient with bilateral deafness and requires special consideration and care. The goal of cochlear implantation in these children is to provide bilateral input to encourage the development of binaural hearing. Considerations for candidacy and follow-up care should reflect and measure these goals. The purpose of this document is to review the current evidence and provide guidance for CI candidacy, evaluation, and management in children with SSD.

Key words: Candidacy, Children, Cochlear implant, Guidelines, Single-sided deafness, Test battery, Unilateral hearing loss.

(Ear & Hearing 2022;43;255–267)

considerable challenge as so much of the groundwork for evaluation of CI patients has been laid by working with patients who have bilateral hearing loss. Children who seek cochlear implantation for unilateral hearing loss (UHL) or single-sided deafness (SSD) are seeking implantation not solely for better speech understanding, but in the hopes of achieving binaural hearing. Candidacy considerations, counseling, habilitation, and evaluation postactivation must look beyond simple speech perception and move toward evaluation that encompasses tasks associated with binaural hearing. The aim of this review is to summarize the current literature regarding CI outcomes for children with SSD and provide guidance for candidacy, outcome measures, and mapping of children

American Cochlear Implant Alliance Task Force Guidelines for Determining Cochlear Implant Candidacy in Children with Single-Sided Deafness

Course: #37479 | Level: Intermediate | 1 Hour

Wed, Mar 23, 2022 at 12:00 pm EDT

This course will introduce participants to the ACI Alliance Guidelines for cochlear implantation in children with single sided deafness (SSD). Instructors will use case studies to guide attendees through highlights of the document including candidacy, evaluation, and programming recommendations.

ACIA | Cochlear Implants | Hearing and Hearing Loss | Hearing Evaluation - Children | Pediatrics

Presented By

Lisa Park
AuD CCC-A



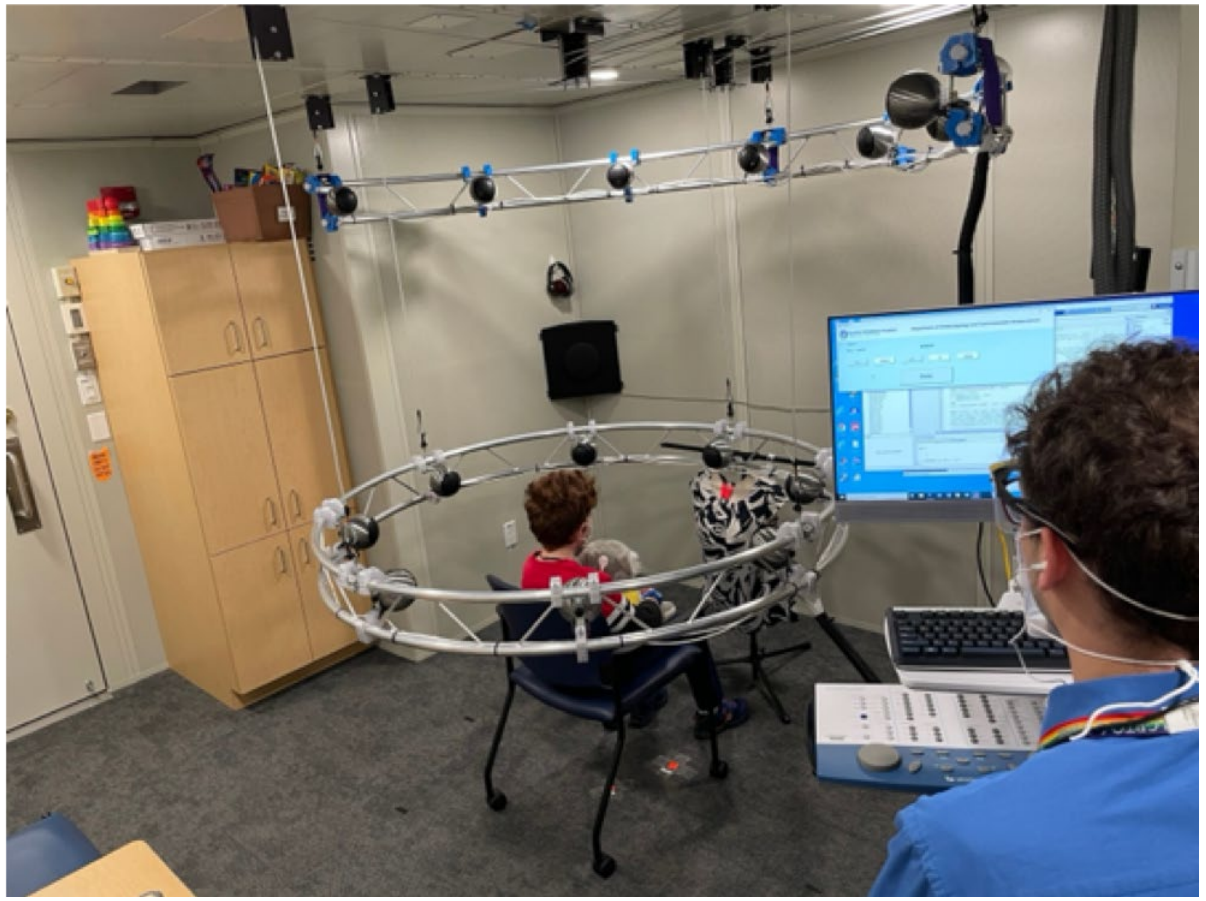
Dr. Park is an Assistant Professor in the Department of Otolaryngology/Head and Neck Surgery at the University of North Carolina at Chapel Hill. She

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How we test hearing-in-noise performance in the lab…



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What a typical audiological sound booth looks like…



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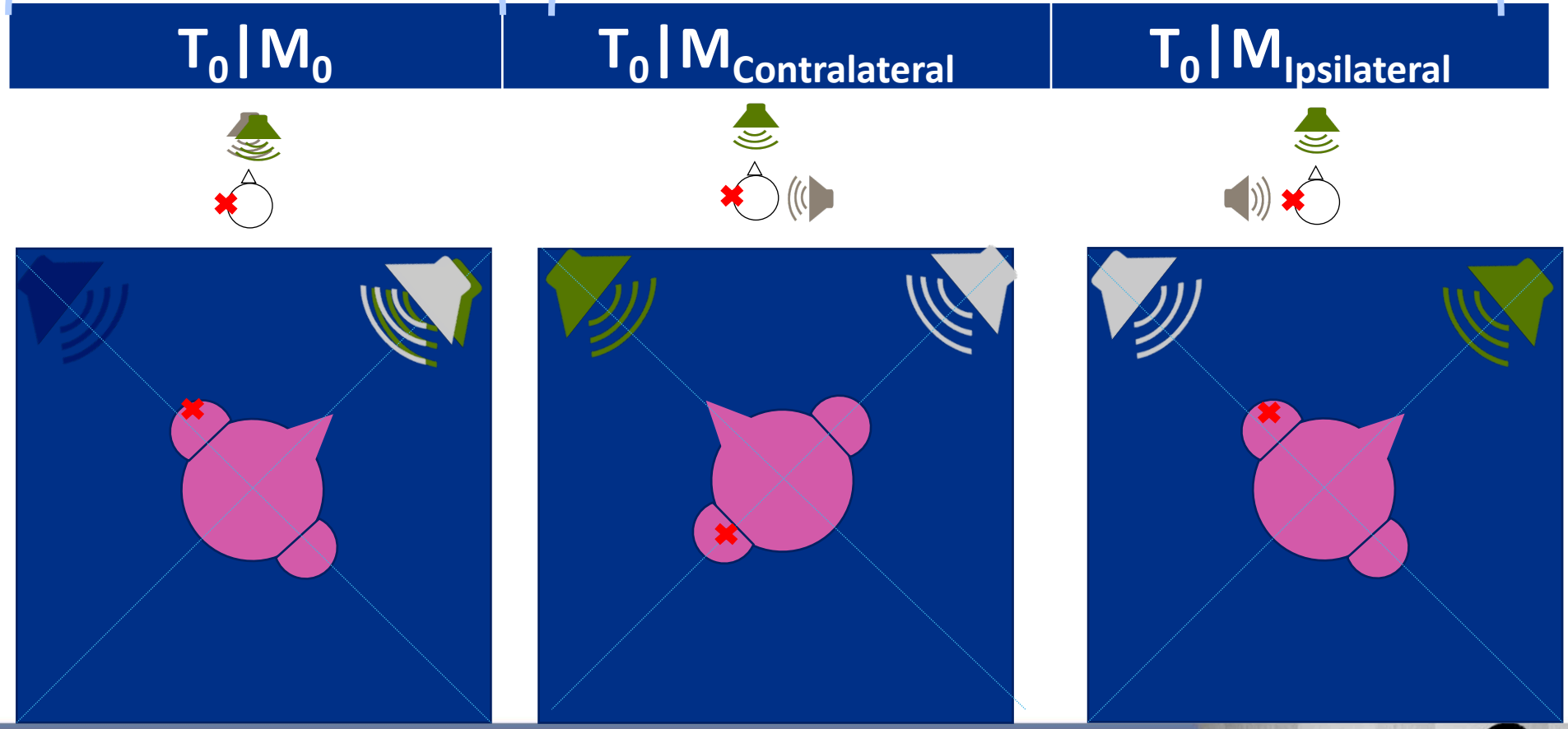
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Target|Masker Spatial Configurations

Co-located condition

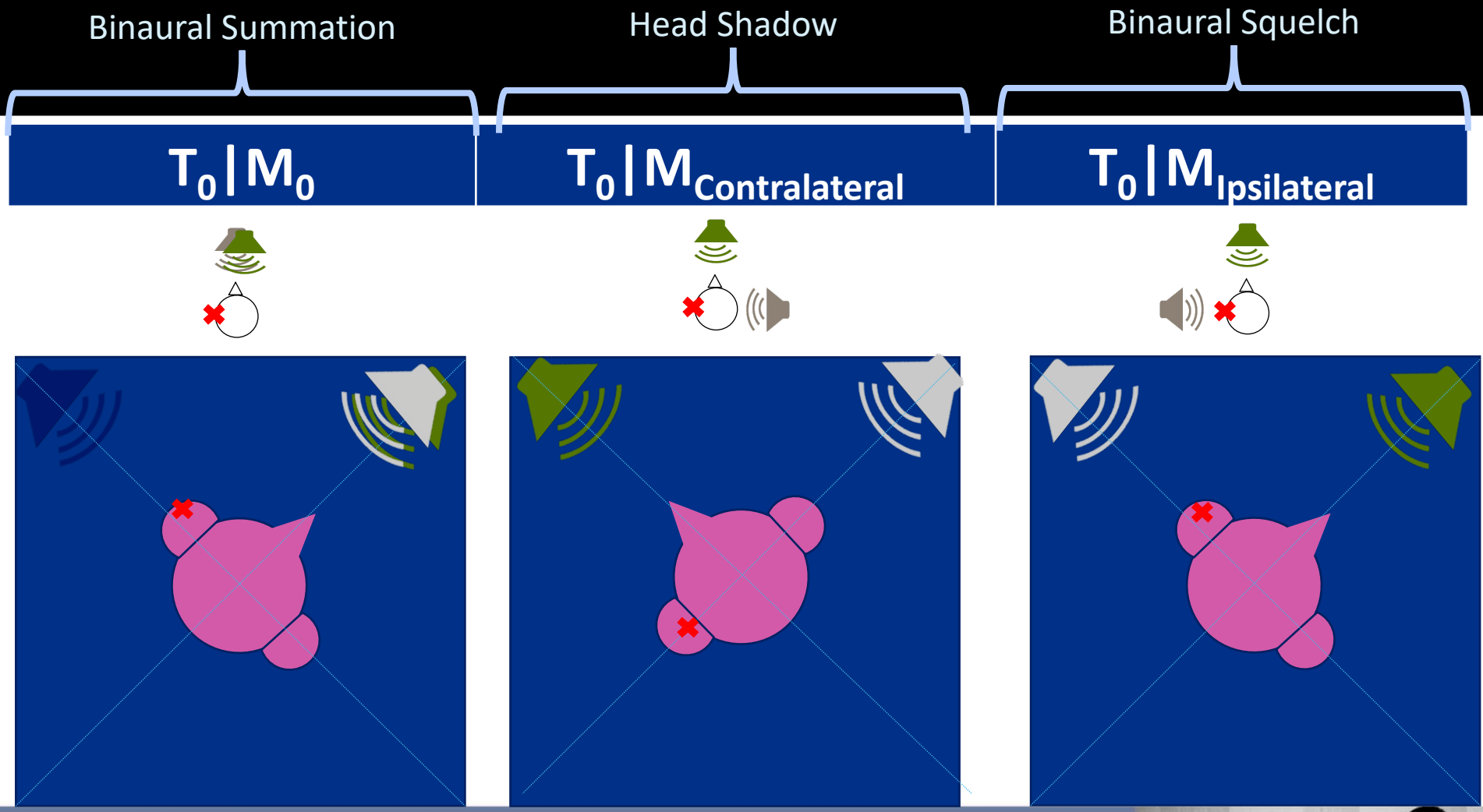
Spatially separated conditions



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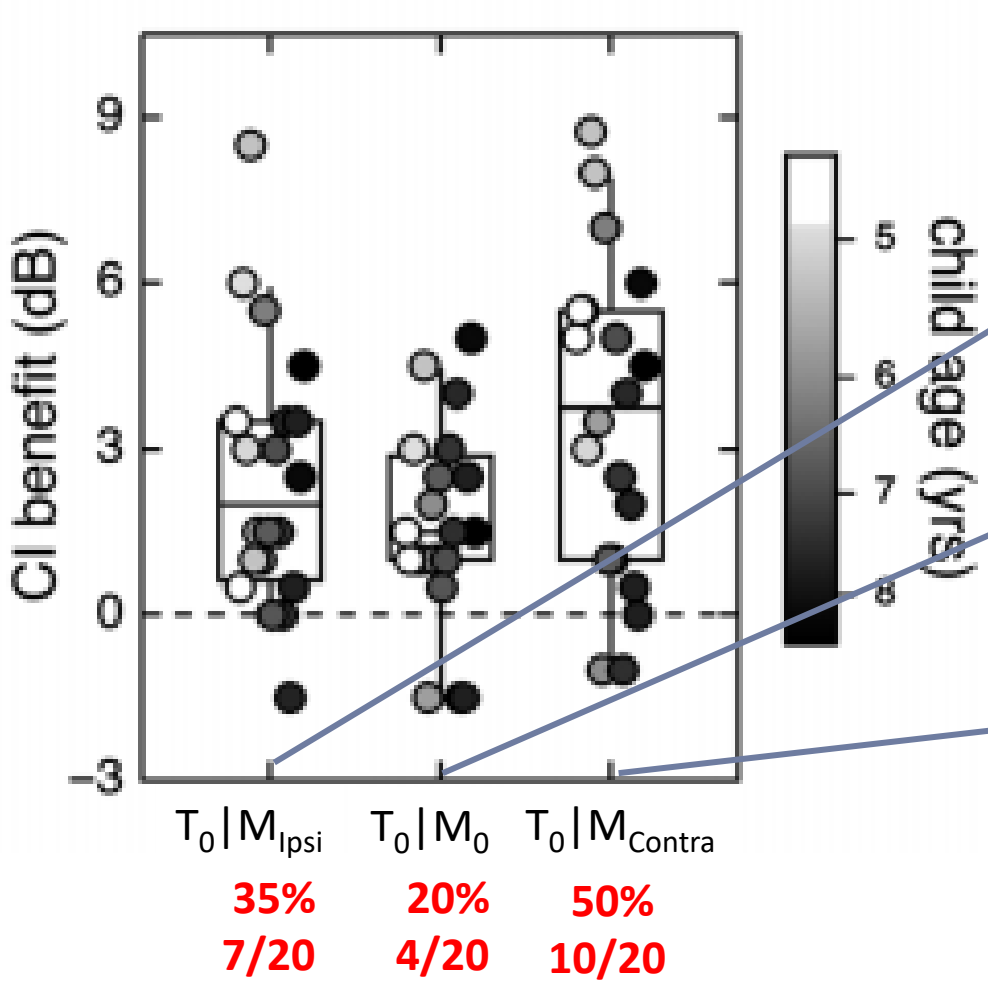




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Comparing SIN (BKB-SIN) scores in the unaided vs. CI condition allows you to estimate binaural benefits.

Positive number indicates binaural benefit.



Binaural Squelch = 2.5

Binaural Summation = 1.6

Head Shadow = 3.5

Park et al., 2021

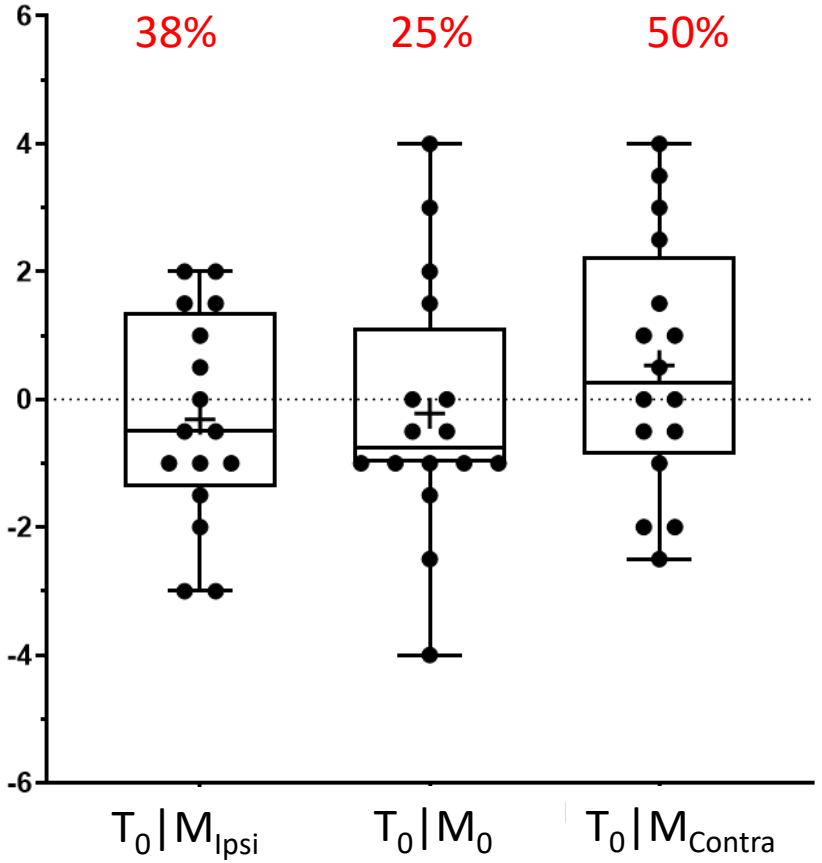
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Similar trends in binaural benefits are seen on the BKB-SIN Test at Boston Children's Hospital

Positive number indicates benefit with CI.



data collection ongoing



Outcomes with Unilateral Hearing Loss (OWuhL) Study

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CONDITIONS PRIORITIZED

Preserve data **quality** vs. quantity!

MOST LIKELY TO SEE BENEFIT

1. Spatial Release from Masking
   - AIDED $(T_0|M_0)$
   - AIDED $(T_0|M_{Contra})$
2. Spatial Release from Masking
   - AIDED $(T_0|M_{Ipsi})$
3. Head Shadow
   - UNAIDED $(T_0|M_{Contra})$
5. Binaural Squelch
   - UNAIDED $(T_0|M_{Ipsi})$
4. Binaural Summation
   - UNAIDED $(T_0|M_0)$

LESS LIKELY TO SEE BENEFIT



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How does the CI group compare to kids with unaided SSD and NH?

Hearing Health Foundation
Prevention | Research | Cure

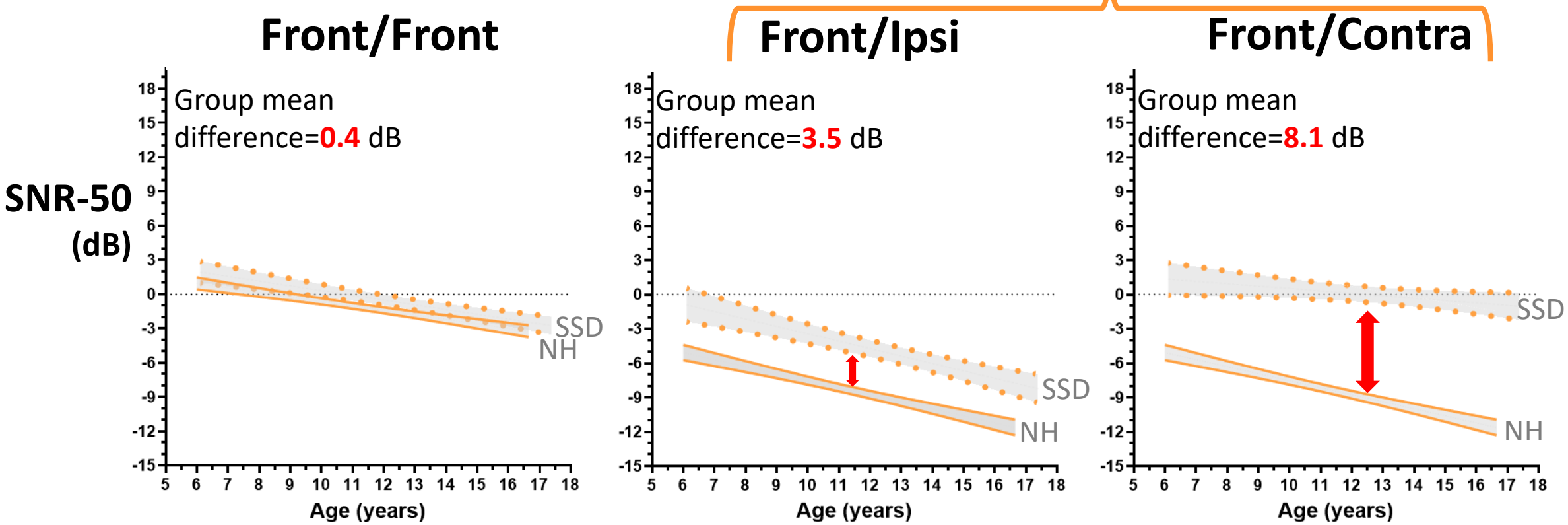
Outcomes with Unilateral Hearing Loss (OWuhL) Study	Single-Sided Deafness + Cochlear Implant (SSD + CI)	Unaided Single-Sided Deafness (SSD)	Normal Hearing (NH)
n	**16**	**39**	**85**
Mean Datalogging (hours per day)	**6.9**	-	-
Mean duration of CI use (months)	**27**	**-**	-
Onset of hearing loss % Congenital	**64%**	**41%** (2 unknown)	-

recruitment is ongoing

data collection ongoing

We're building spatial norms for the BKB-SIN

Spatially separated conditions



Outcomes with Unilateral Hearing Loss (OWuhL) Study

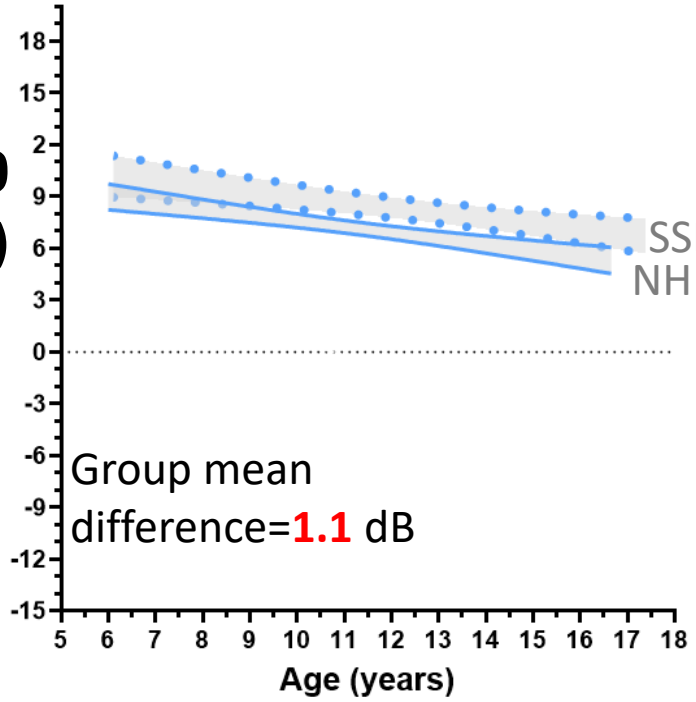
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data collection ongoing

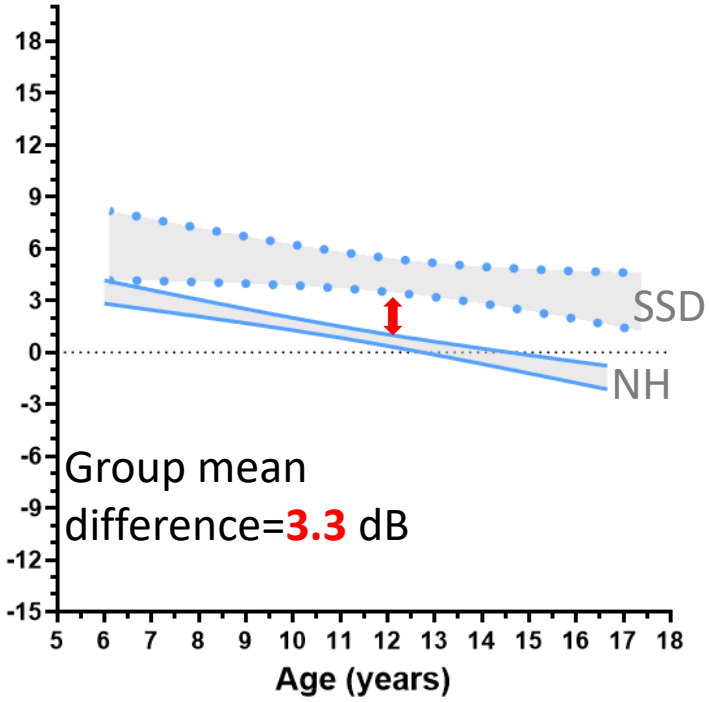
and the WIN

Spatially separated conditions

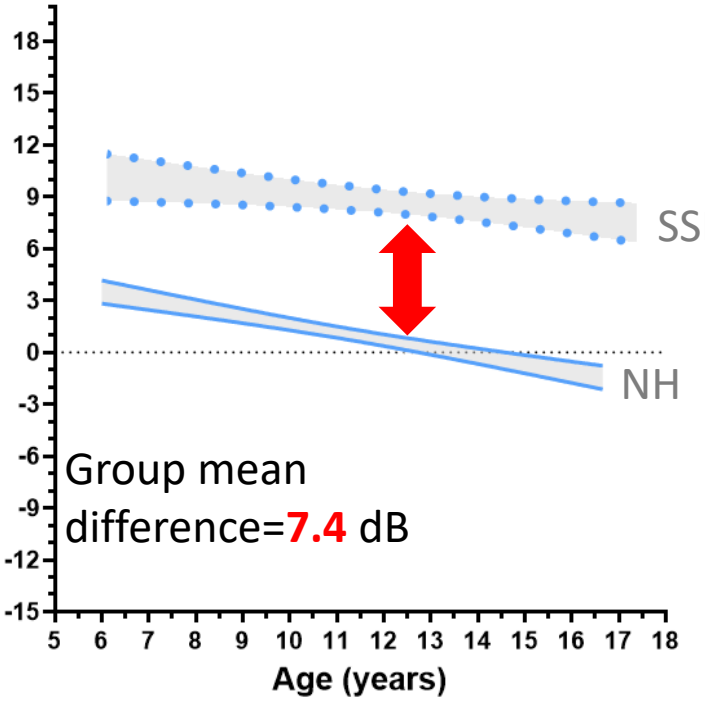
Front/Front



Front/Ipsi



Front/Contra

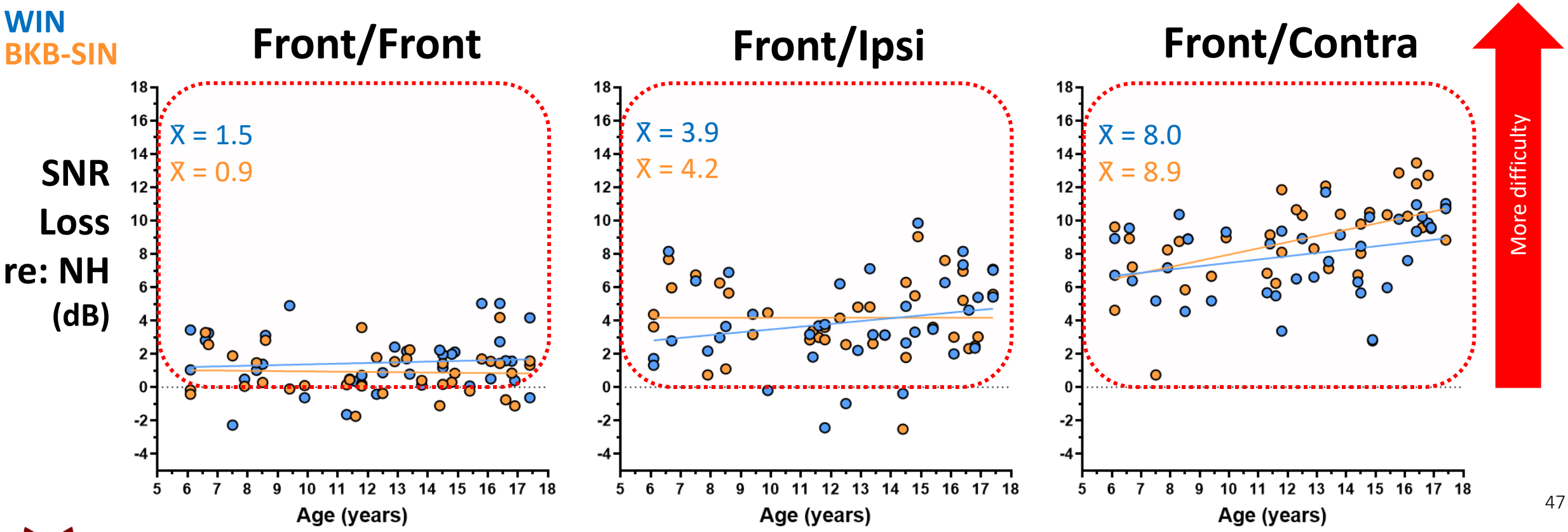


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data collection ongoing

Now that we know how children with NH perform as a function of age, we can calculate **SNR loss** for kids with unaided SSD, by condition



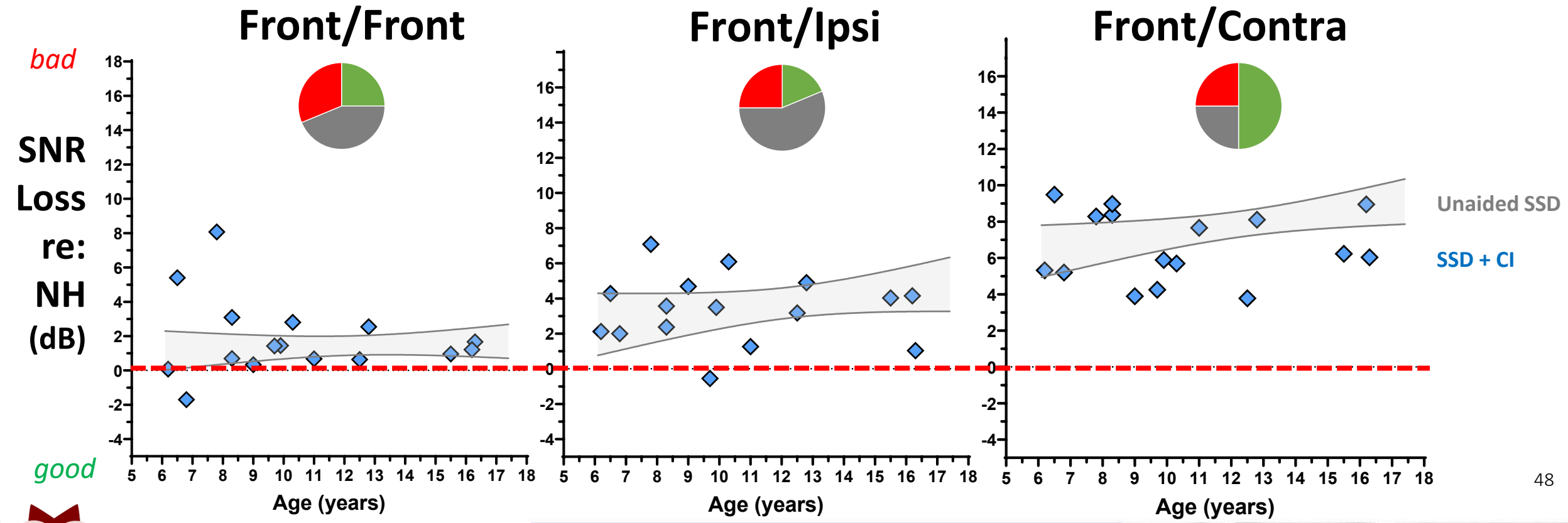
Outcomes with Unilateral Hearing Loss (OWuhL) Study

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data collection ongoing

Now we ask how 16 SSD + CI listeners compare on the WIN.



Outcomes with Unilateral Hearing Loss (OWuhL) Study

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We see familiar developmental trends and group differences across *similar* Target|Masker Spatial Conditions

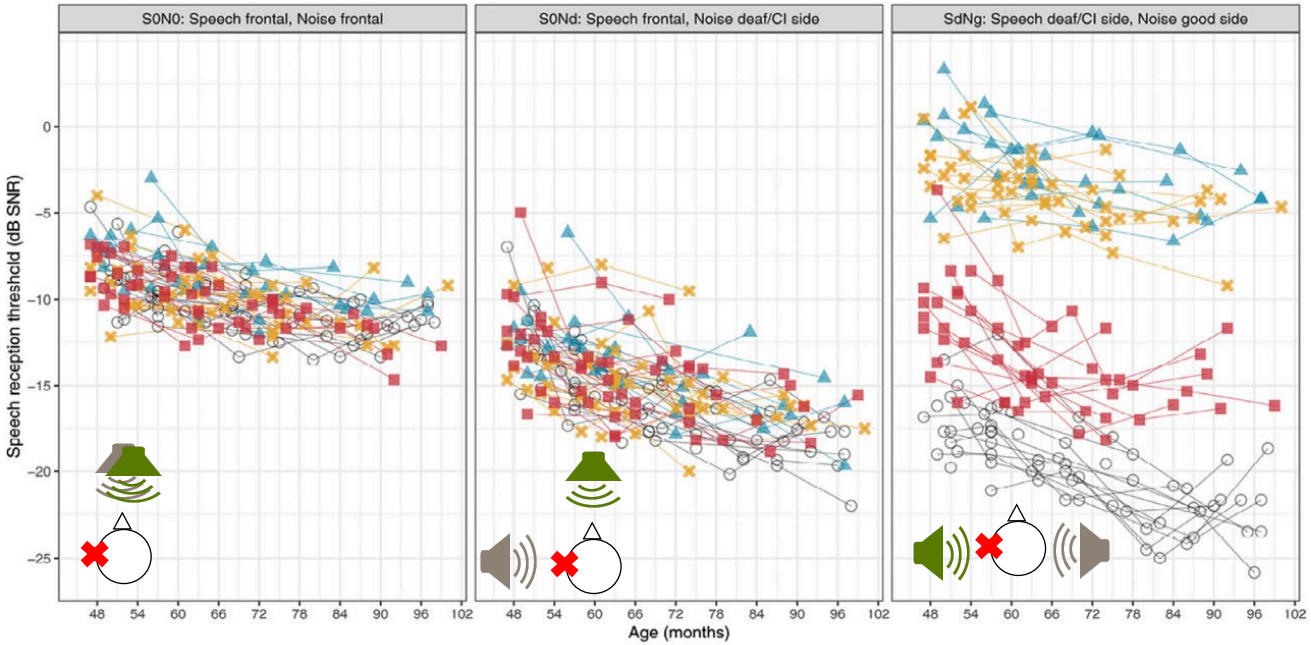


Fig. 2. Individual averaged speech reception thresholds (in dB SNR) for the three spatial conditions as a function of age. SSD + CI (aided) = red squares; SSD + CI (unaided) = yellow crosses; SSD-noCI = blue triangles; NH = gray circles. NH indicates normal hearing; S0N0, speech and noise at 0° azimuth; S0Nd, speech at 0° azimuth, noise at side of deaf ear (90°); SdNg, speech at side of deaf ear (90°), noise at side of good ear (90°); SSD + CI, single-sided deaf with cochlear implant.

-17 SSD

-18 SSD+CI (CI OFF)

-18 SSD+CI (CI ON)

-33 NH

Arras et al., 2016

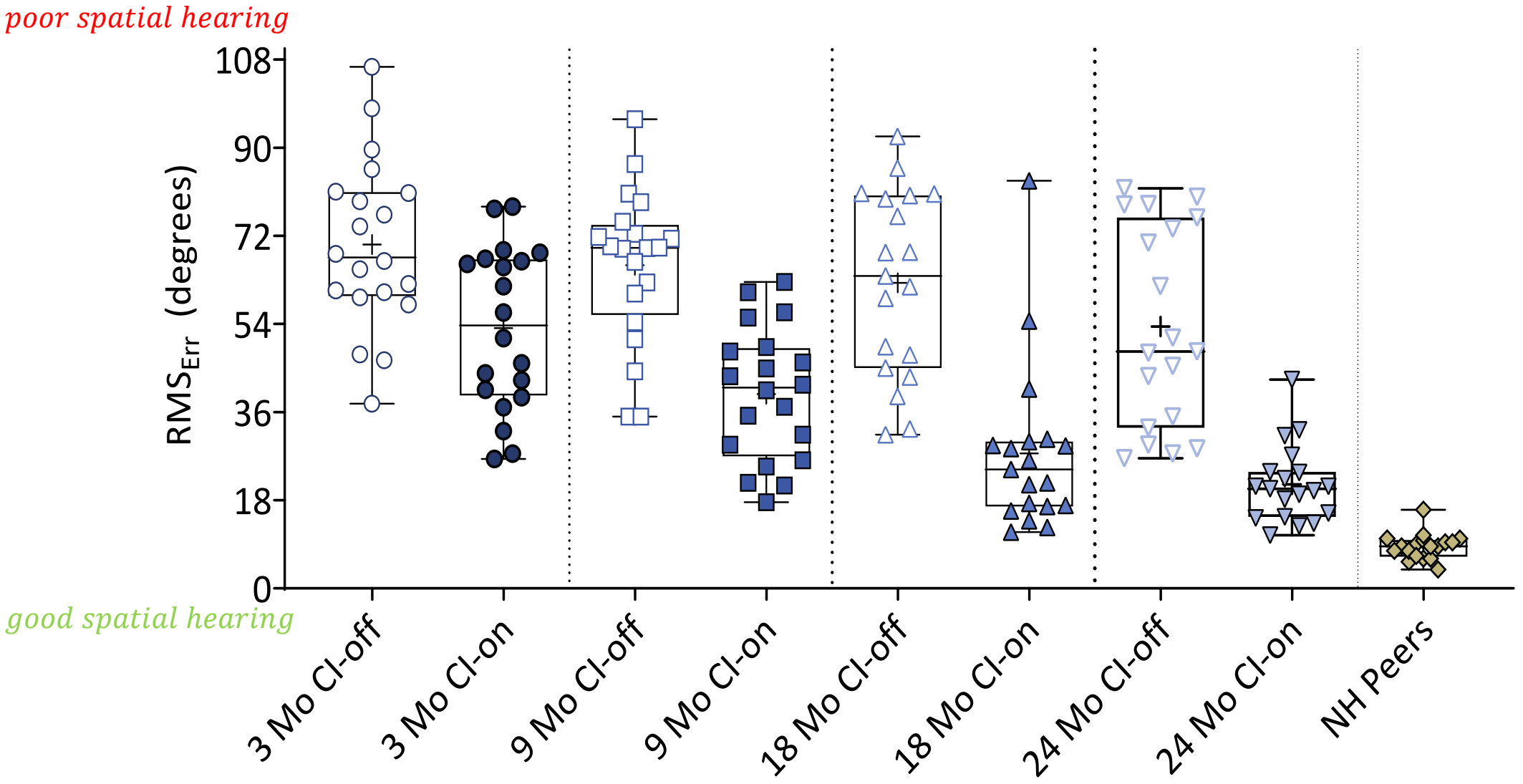
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Sound Localization



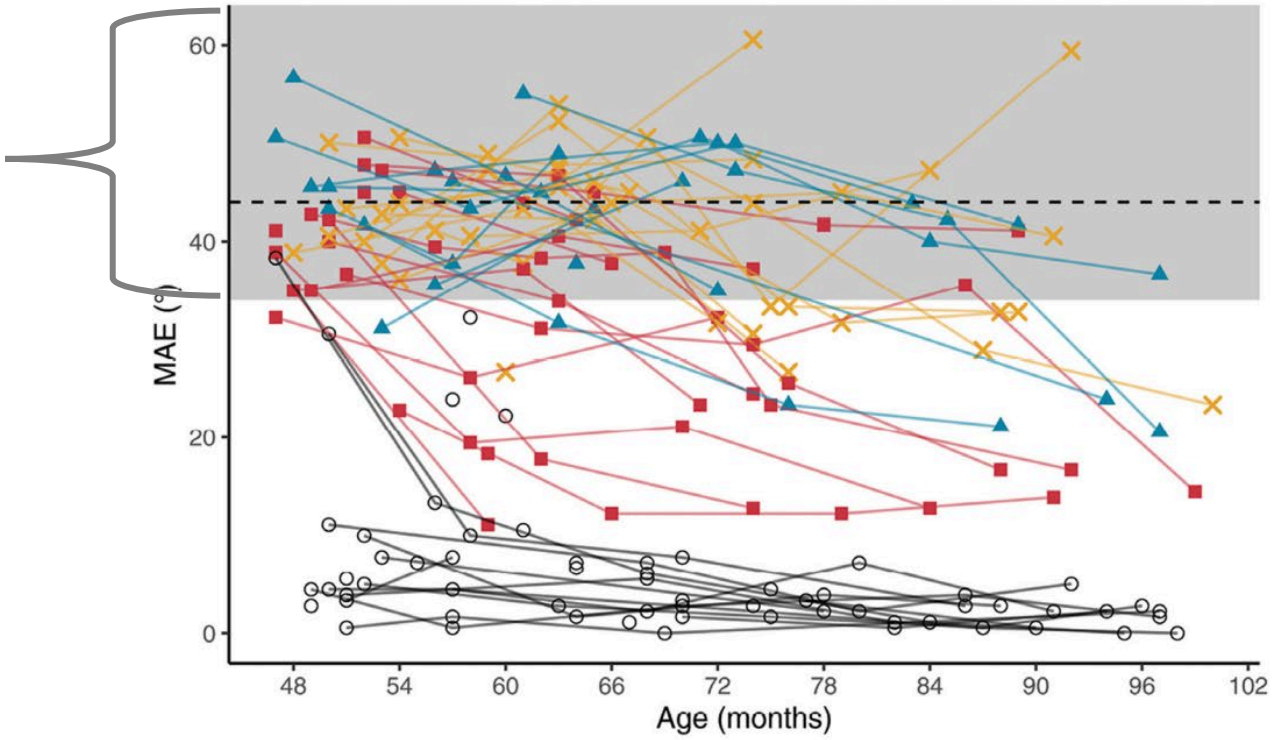
Improvement in spatial hearing is often the first reported benefit following CI for SSD



adapted from Park et al., 2023

Sound localization abilities improve over time; some SSD+CI listeners remain quite impaired.

Chance level performance



-17 SSD, $\bar{x}$=41.3°

-18 SSD+CI (CI OFF), $\bar{x}$=41.7

-18 SSD+CI (CI ON), $\bar{x}$=31.8°

-33 NH, $\bar{x}$=5.9°

Fig. 3. Individual MAEs (in degrees) as a function of age. SSD + CI (aided) = red squares; SSD + CI (unaided) = yellow crosses; SSD-noCI = blue triangles; NH = gray circles. The dotted line at 44° corresponds to chance-level performance; scores below the gray area are significantly better than chance. MAE indicates mean absolute error; SSD + CI, single-sided deaf with cochlear implant.

Arras et al., 2016





But what if you don't have a fancy sound localization speaker array?

A: Questionnaires



Use the SSQ to measure hearing function in everyday listening environments.

The Speech, Spatial, Qualities (SSQ) of Hearing Scale

3 pediatric versions (Galvin & Noble, 2013):

- **Parents** of Children with Hearing Impairment (age 5+ yrs)
- **Teachers** of the Deaf (age 5+ yrs)
- **Children** with Hearing Impairment (age 11+ yrs)

Sample Questions

Speech

- *You are talking with your parent and there is a TV on in the same room. Without turning the TV down, can you understand what your parent is saying to you?*

Spatial Hearing

- *You are at home and it is quiet. Your parent calls you from another room. Will you know where they are without having to look?*

Qualities of Hearing

- *Is it easy for you to ignore other sounds when trying to listen to something?*



Kids demonstrate improvement on all SSQ domains following SSD + CI, but the largest gains are seen on the Spatial subscale.

Benefits of Cochlear Implantation in Childhood Unilateral Hearing Loss (CUHL Trial)

Kevin D. Brown, MD, PhD; Margaret T. Dillon, AuD; Lisa R. Park, AuD

Objectives/Hypotheses: Children with unilateral sensory hearing loss (UHL) struggle to understand speech in noise and locate the origin of sound and have reduced quality of hearing. This clinical trial will determine the benefits of cochlear implantation in children with UHL.

Study Design: Prospective clinical trial.

Methods: Twenty children with at least moderate to profound sensory hearing loss and poor speech perception (word score <30%) in one ear and normal hearing in the contralateral ear participated in a Food and Drug Administration-approved clinical trial. Subjects were evaluated for speech perception in quiet, speech perception in noise, sound localization, and subjective benefits after implantation.

Results: CNC word score perception in quiet significantly improved (1% to 50%, $P < .0001$) by 12 months after activation. Speech perception in noise by BKB-SIN significantly improved in all three noise configurations; there was a 3.6 dB advantage in head shadow ($P < .0001$), a 1.6 dB advantage in summation ($P = .003$), and a 2.5 dB advantage in squelch ($P = .0001$). Localization improved by 26° at 9 months ($P < .0001$). Speech, Spatial, and Qualities (SSQ) demonstrated significant improvements in speech (5.2 to 7.4, $P = .0012$), qualities of hearing (5.9 to 7.5, $P = .0056$), and spatial hearing (2.7 to 6.6, $P < .0001$). SSQ subscales associated with binaural hearing were significantly improved, as was listening effort ($P = .0082$). Subjects demonstrated a non-significant improvement in fatigue.

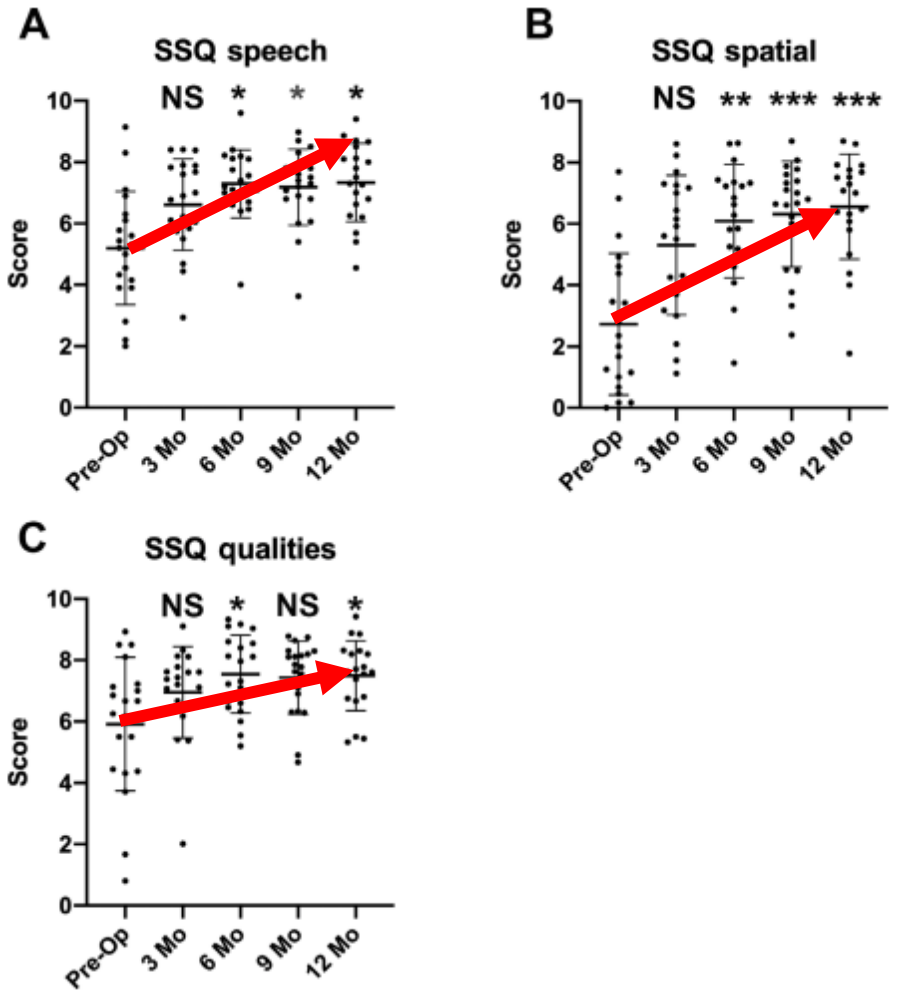
Conclusions: This study demonstrates that children with UHL significantly benefit from cochlear implantation.

Key Words: Unilateral hearing loss, single sided deafness, pediatrics, cochlear implantation.

Level of Evidence: Level 3

Laryngoscope, 00:1–18, 2021

Brown et al., 2022



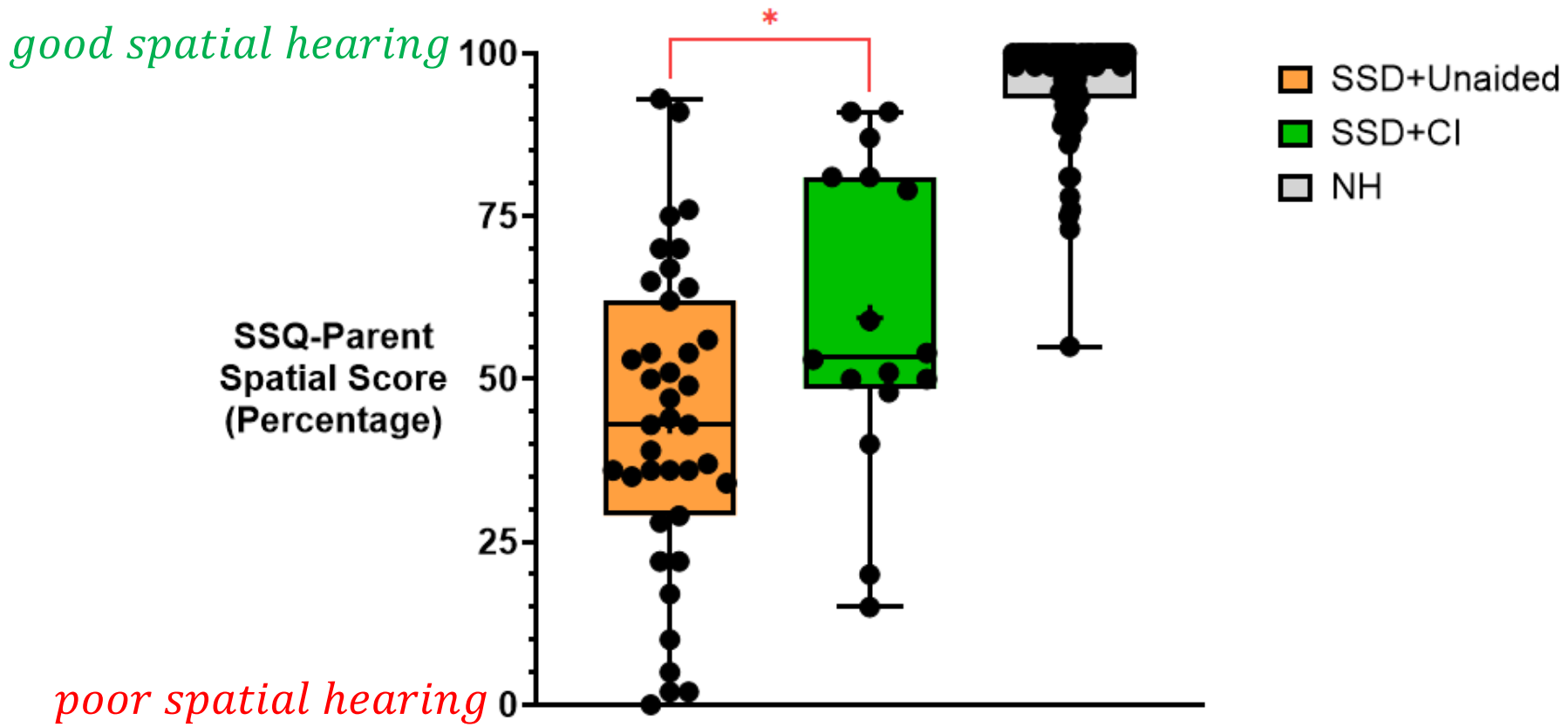
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Parents of kids with SSD+CI report better spatial hearing than those of kids with unaided SSD.

data collection ongoing



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LESSONS LEARNED along the way

1. A trial with a rerouting device is an unnecessary detour to binaural hearing.
2. Measuring objective and subjective benefit does not mean patients will use their CI long-term.
3. While some will *really* benefit from a CI for SSD, *not everyone* will.
4. Comorbid psychological conditions warrant screening, evaluation, and co-tx in this population.
5. Toddlers and teenagers …
6. Not all kids enjoy plug & muff for detection testing - DAI may serve as an alternative method.
7. Altering the FAT may improve initial acceptance of CI.



LINGERING QUESTIONS/NEEDS

1. We need more data and tools to predict SSD+CI benefits!
2. We need normative datasets to accurately interpret spatial hearing benefits or lack thereof from SSD+CI.
3. We need better tools to quantify the impact of SSD in kids <6 yrs old.
4. How do you do RM HAT in school?
5. How will this group use their CI long-term?

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It takes a village: the Boston Children's Cochlear Implant Team

Otolaryngology
- Jacob Brodsky, MD
- Margaret Kenna, MD, MPH *Dir., Clinical Research*
- Greg Licameli, MD, *Dir., Cochlear Implant Program*
- Dennis Poe, MD, PhD
- Aaron Remenschneider, MD, MPH
- Elliot Shearer, MD, PhD

Audiology
- Meg Anderson, *Audiology Assistant*
- Elizabeth Erickson O'Neill, AuD
- Susan Gibbons, AuD
- Amanda Griffin, AuD, PhD, *Dir. Audiology Research*
- Jennifer Harris, AuD, *Cochlear Implant Program Manager*
- Ashleigh Lewkowitz, AuD
- Rebekah Tozer, AuD

Speech-Language Pathology
- Elsa Bucaj, MSc
- Hena Kazmi, MS
- Nicole Salamy, MS
- Serena Yuré, MA

Psychiatry
- Sanjay Gulati, MD

(Neuro)Psychology
- Kerri Bolivar, BA, MRes
- Amber Graham, PhD
- Rachel Landsman, PsyD
- Holly Miller, PsyD

Social Work
- Kathryn Manfield, LCSW

Administrative Coordinators
- Nicole Fahey, *Deaf and Hard of Hearing Program Coordinator*
- Nichole Germain, *Hearing Technology Coordinator*
- Kelly Hanson
- Sarah Thomas, MHA, *Cochlear Implant Program Coordinator*

Research Assistants
- David Faller, BA
- Stella Austin, BS



"Minimal is not inconsequential."

Fred Bess, 2004