Hearing and Balance: Impact and Outcomes of Dual Sensory Impairments in the Pediatric Population With Sharon Cushing – 7 pm ET

CAA webinars count towards CEUs.
Please keep your 'thank you for attending email" as proof of your attendance.

This webinar is being recorded and will be posted to the CAA website within 2 business days (including PPT).
canadianaudiology.ca/webinars/

If you have slow internet we recommend you call in on a land line.

CAA Canadian Academy of Audiology
Heard. Understood.
Academie canadienne d'audiologie ACA
Entendus. Compris.

CAA Webinar

Hearing and Balance: Impact and Outcomes of Dual Sensory Impairments in the Pediatric Population

Sharon L. Cushing MD MSc, FRCSC,
Otolaryngologist, Hospital for Sick Children

Oct 20th, 2020

CAA Canadian Academy of Audiology
Heard. Understood.

Academie canadienne d'audiologie ACA
Entendus. Compris.

Thanks to our Sponsor

Canadian Academy of Audiology is a professional association dedicated to enhancing the role of audiologists as primary hearing health care providers through advocacy, education and research.

Salima Jiwani - Host

Dr. Salima Jiwani is a Past President of CAA, and is the clinical and research Director of Audiology at AudioSense Hearing & Balance, a centre of excellence in Hearing and Balance Healthcare.

Salima earned her Ph.D. in auditory neurophysiology with the Institute of Medical Science at the University of Toronto.

Speaker: Sharon L. Cushing MD MSc

Dr. Sharon Cushing is a full time paediatric otolaryngologist at The Hospital for Sick Children in Toronto, and an Associate Professor and Clinician Investigator at the University of Toronto.

She is the Director of the Cochlear Implant Program at the Hospital for Sick Children. Dr. Cushing has a clinical and surgical interest in disorders of the external, middle and inner ear, including hearing loss and vestibular dysfunction. Her research interest include vestibular and balance function and dysfunction in children, and its association with hearing loss and cochlear implantation.

Hearing and Balance: Impact and Outcomes of Dual Sensory Impairments in the Pediatric Population

Sharon L. Cushing

Disclosures

- Speaker's Bureau
  - Interacoustics, Cochlear Corporation
- Royalties
  - Plural Publishing
    - Editor: Balance Disorders in the Pediatric Population
- Patent Holder:
  - Patents #: 7041-0: Systems And Methods For Balance Stabilization
- Sponsored Research Agreement
  - Cochlear Americas

Cochlear Implant Research Team

DIRECTORS
- Karen Gordon
- Blake Papsin
- Sharon Cushing

RESEARCH COORDINATORS
- Carmen McKnight
- Christina Lavallee

GRADUATE STUDENTS
- Salima Jiwani
- Melissa Polonenko
- Nikolaus Wolter
- Morrison Steel
- Michael Deighton
- Sara Giannantonio
- Josh Gnanasegaram

POST-DOCTORAL FELLOWS
- Vijayalakshmi Easwar
- William Parkes
- Shazia Peer

FUNDING
- CIHR
- SickKids Foundation

COLLABORATORS

Local – Sick Kids
- Bob Harrison
- Susan Blaser
- Adrian James
- Sam Doesburg
- Vicky Papaioannou

Local - External
- Sandra Trehub
- Frank Russo

International
- Robert Cowen
- Richard van Hoesel

Cochlear Implant Team

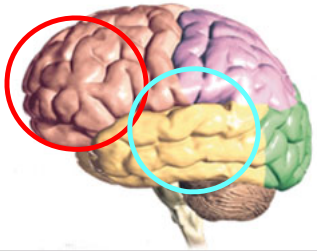
- Blake Papsin
- Vicky Papaioannou
- Karen Gordon
- Sharon Cushing
- Gina Goulding
- Naureen Sohail
- Laurie MacDonald
- Patt Fuller
- Mary Lynn Feness
- Pat Di Santos
- Susan Druker
- Ibtissam Mustaq
- Valerie Simard
- Rebecca Malcomson
- Gillian Lieberman

Making Sense of the World

Making Sense of the World - Perspective

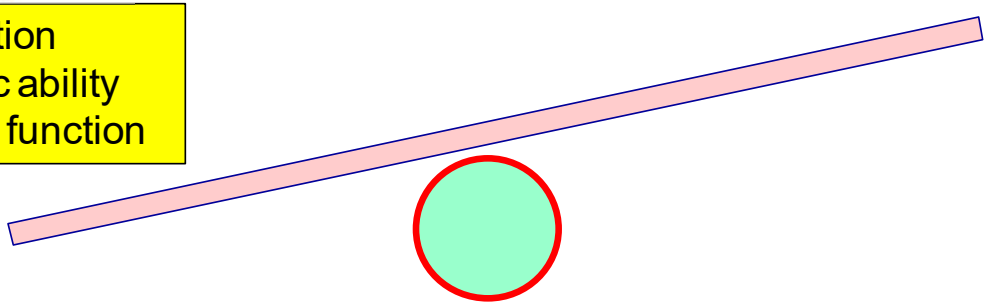
Sensory Interaction / Integration

Human = Language Predators

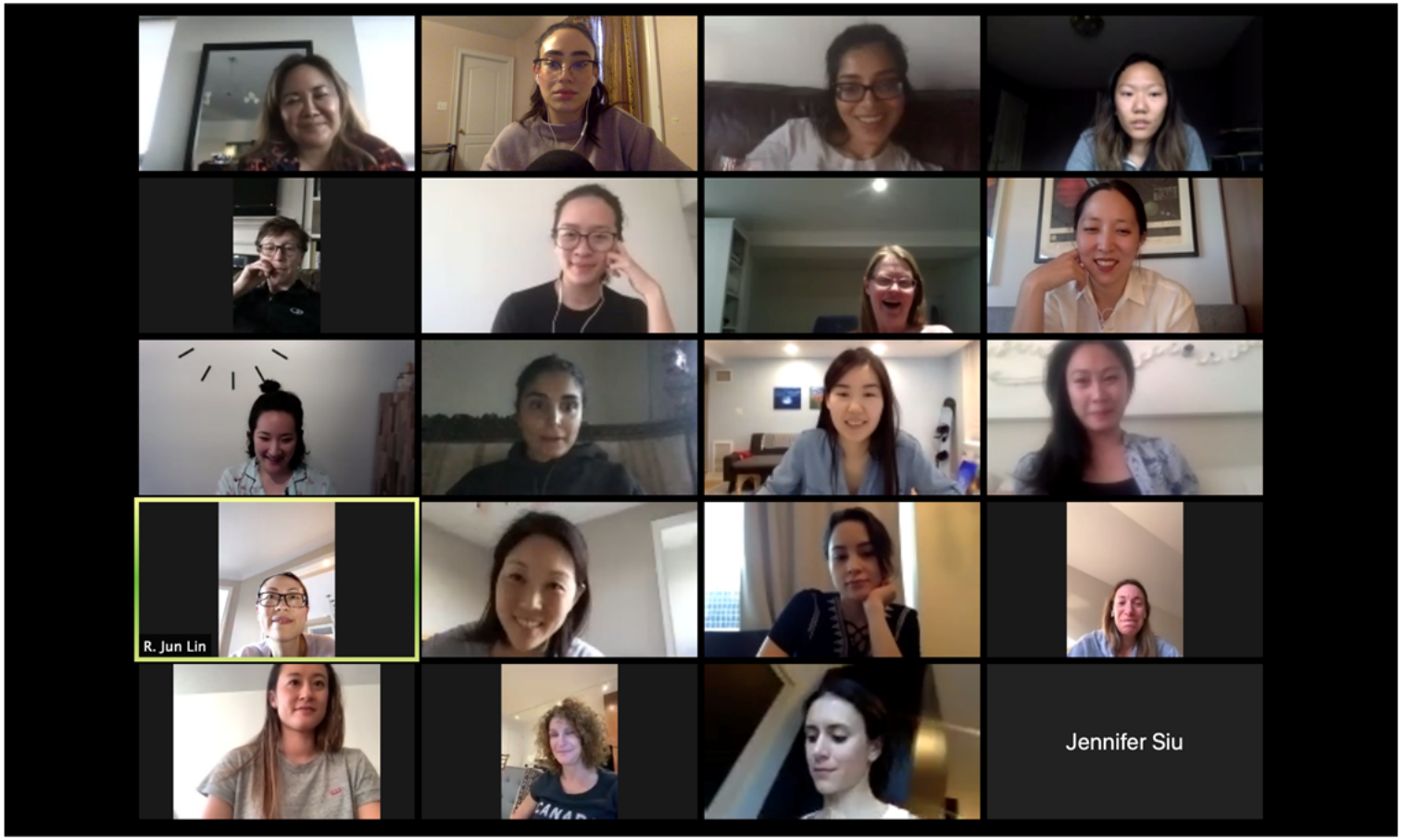


audition
linguistic ability
executive function

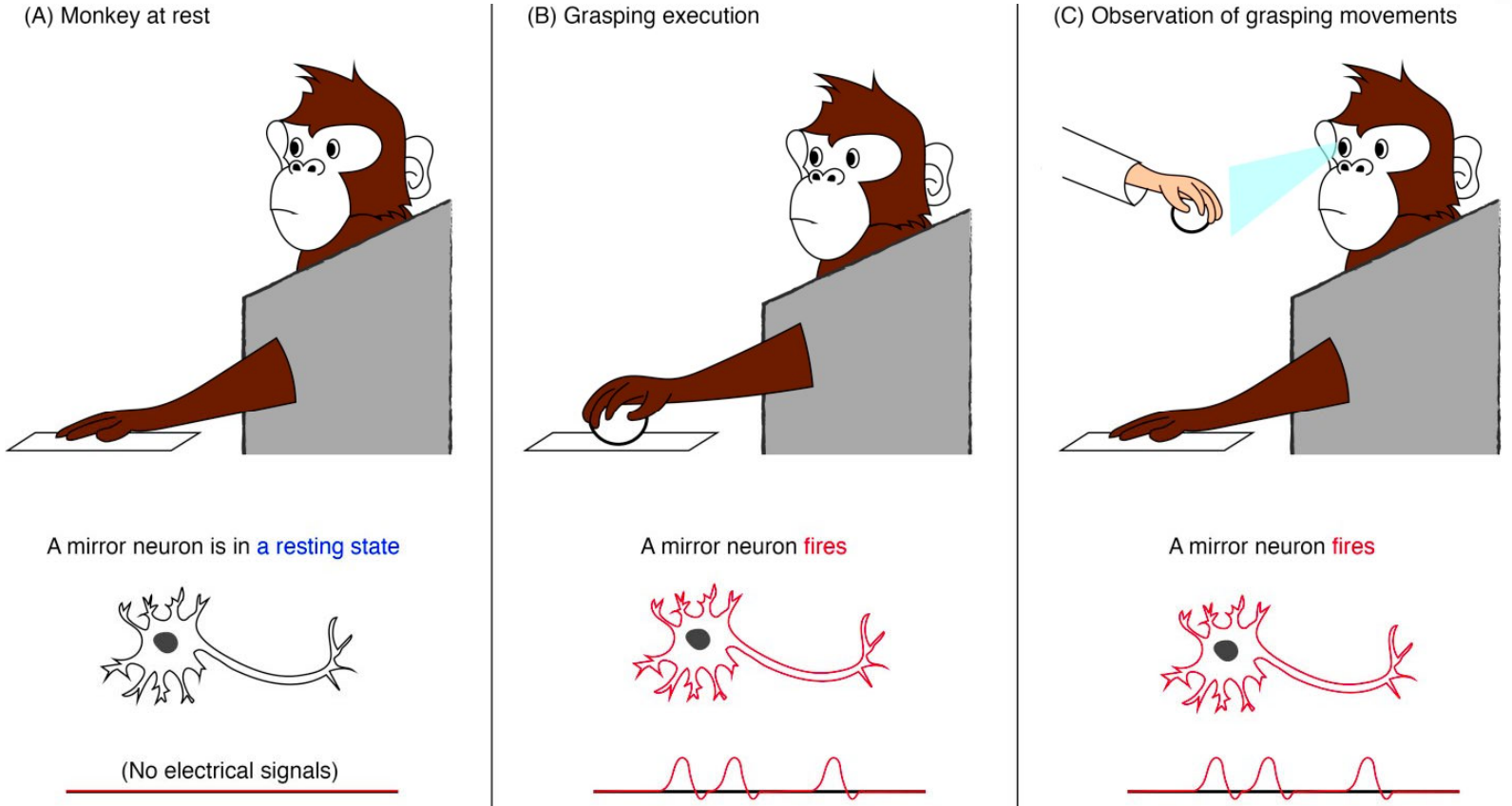
olfaction
vision
motor skill



Connecting During a Pandemic



Wired for Connection – Mirror Neurons

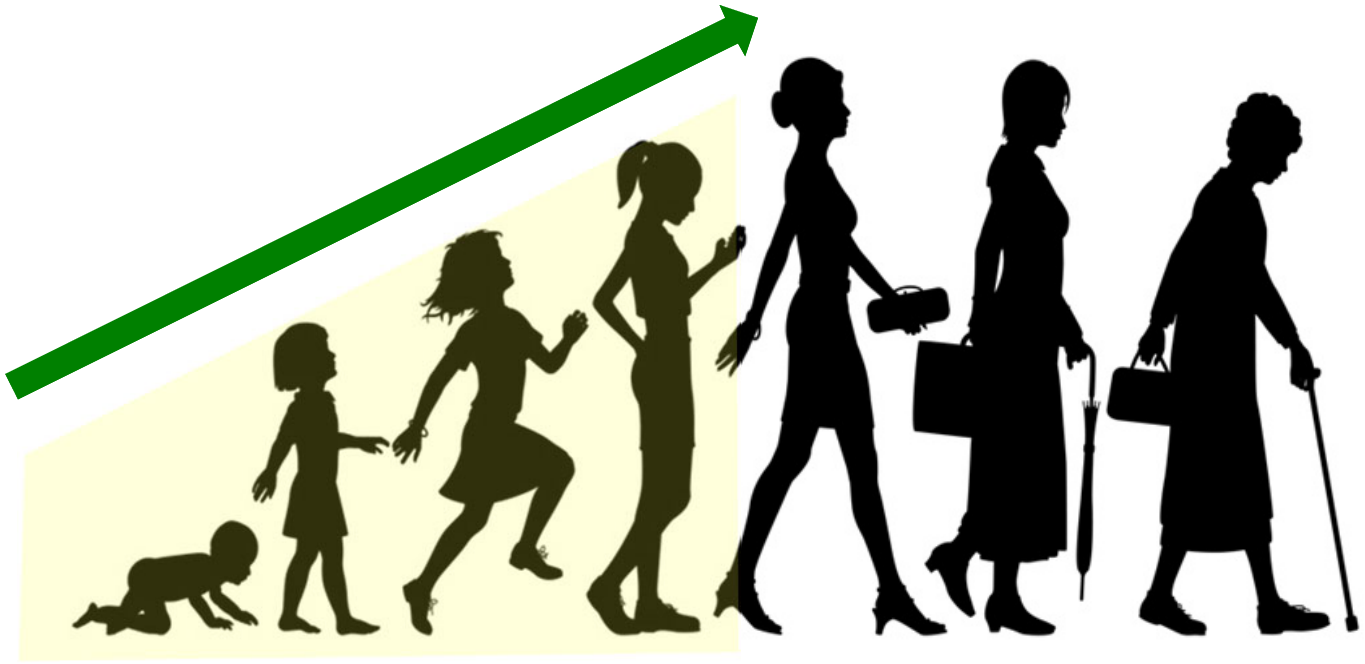


Restoring Connection with Cochlear Implants: What are we missing?

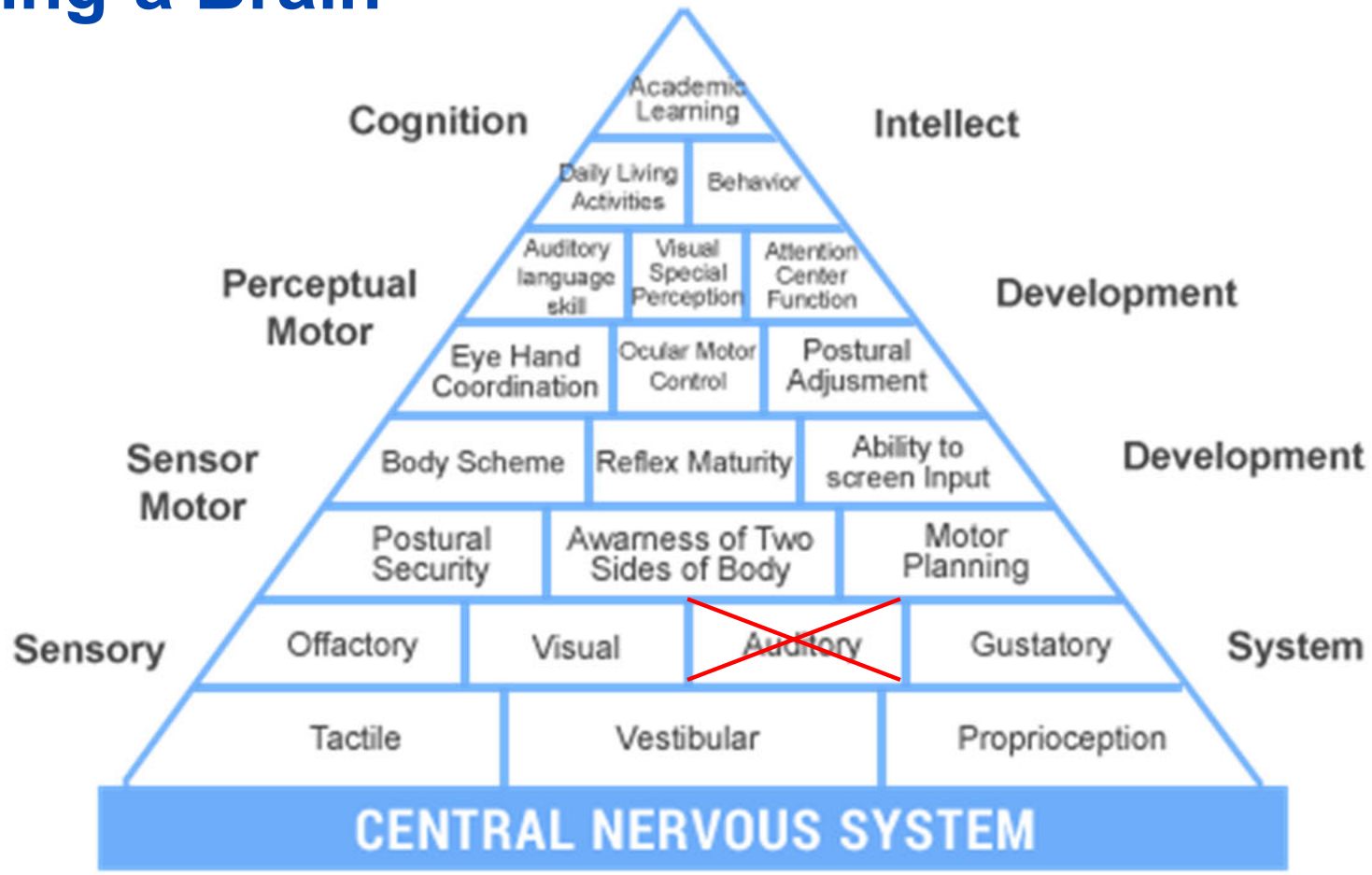
Sharon L. Cushing

Cognitive Decline

Cognitive Incline

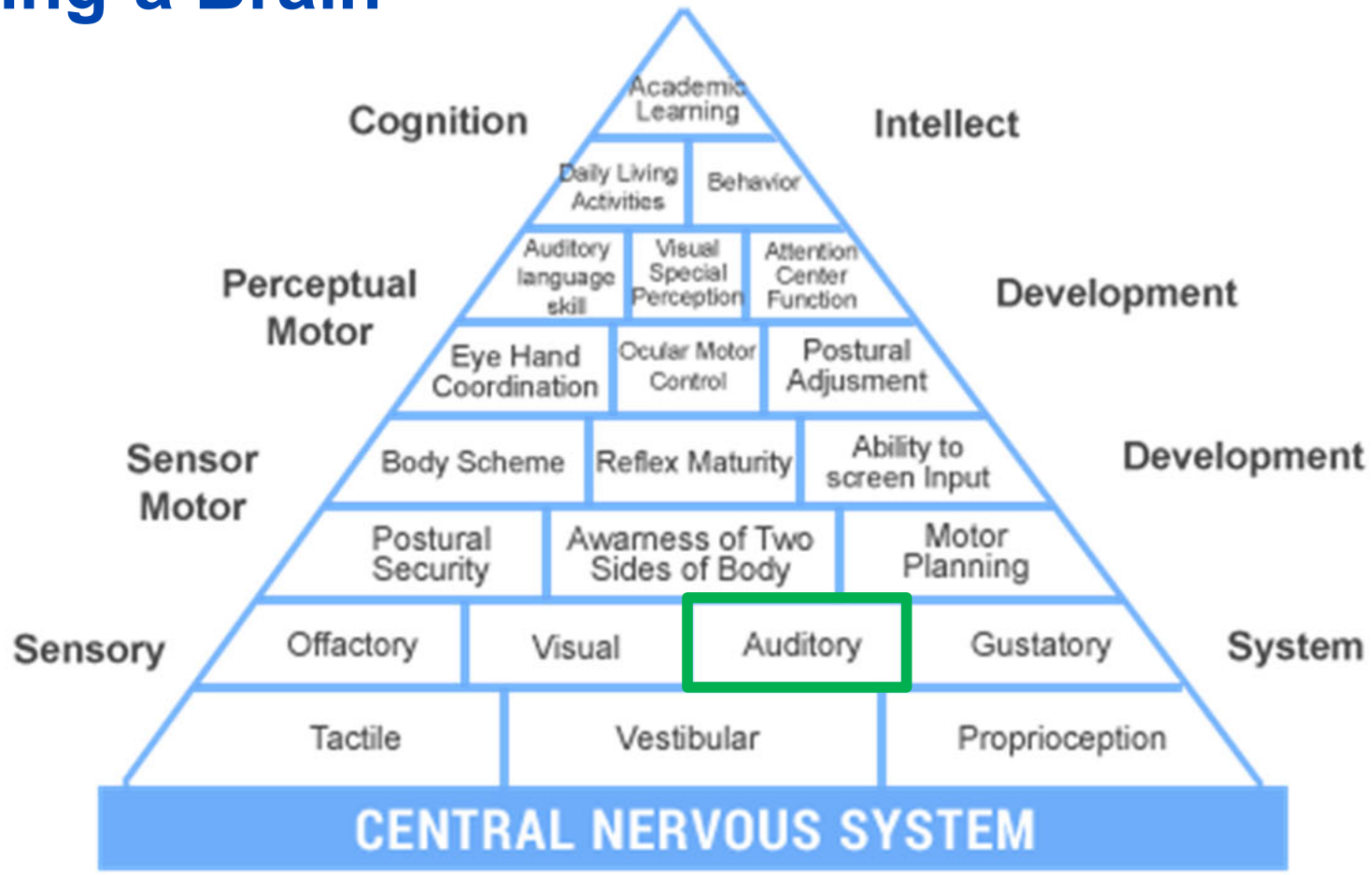


Building a Brain



Pyramid of Learning. (Williams & Shellenbeger,1-4)

Building a Brain

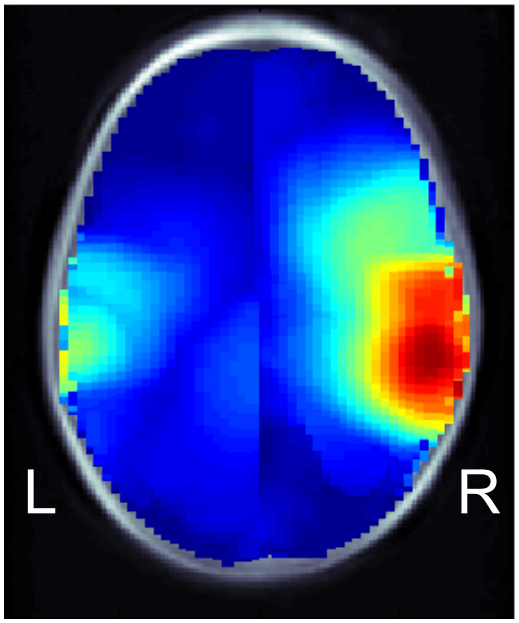


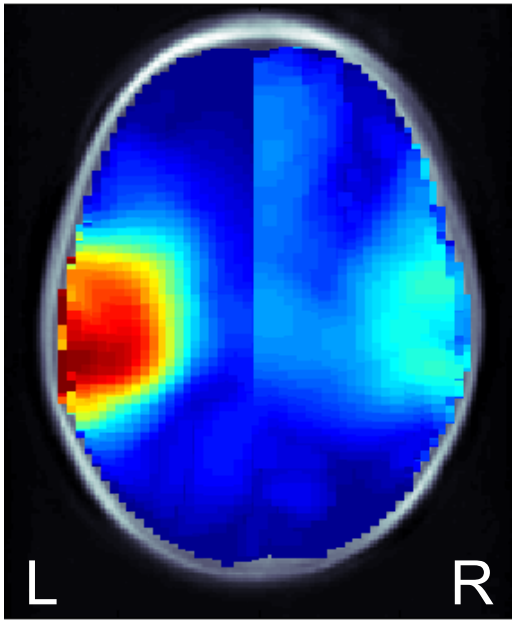
Pyramid of Learning. (Williams & Shellenbeger,1-4)

Normal Aural Preference

Pi

Click
(n=5)

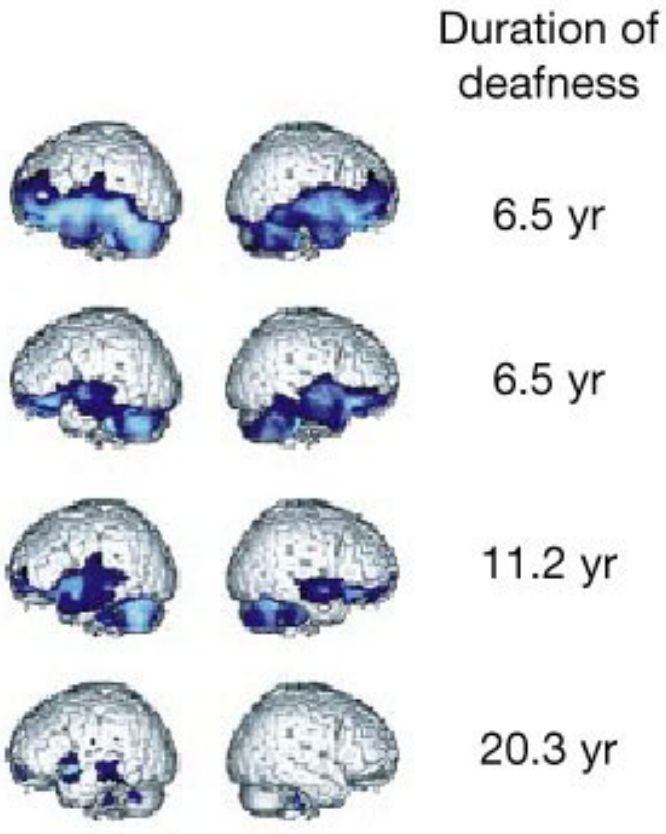




Auditory Deprivation

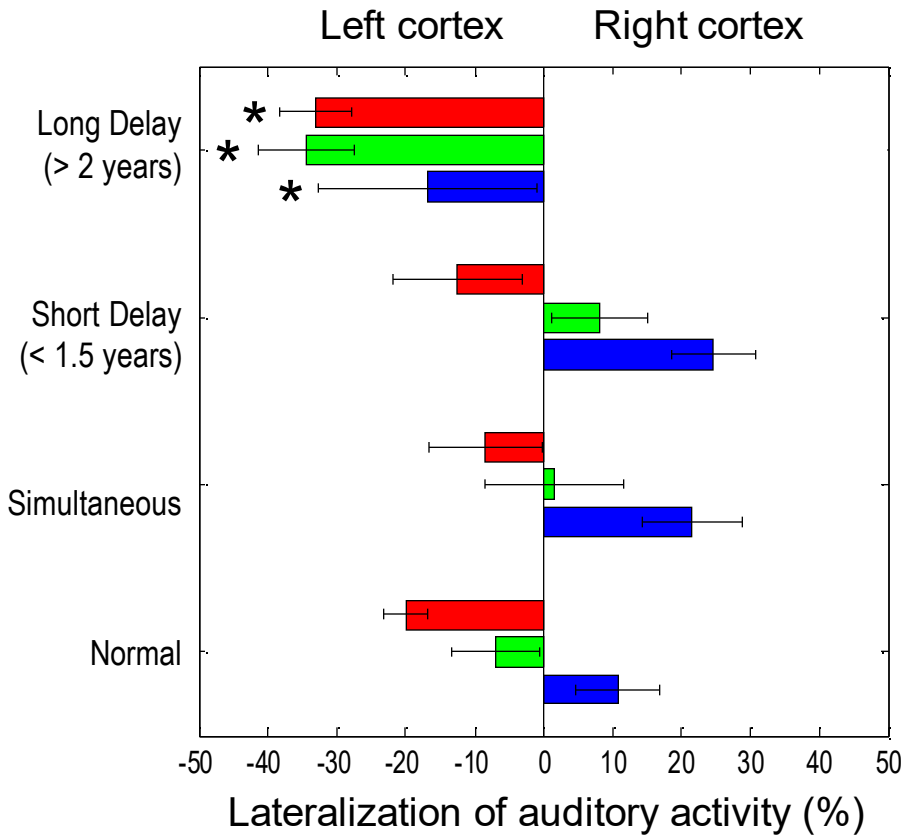
Reduced activity

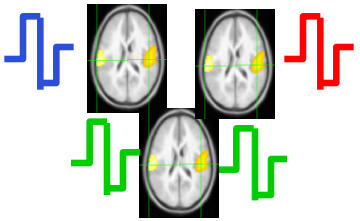
Activity no longer reduced



Lee, et al., Nature, 2001

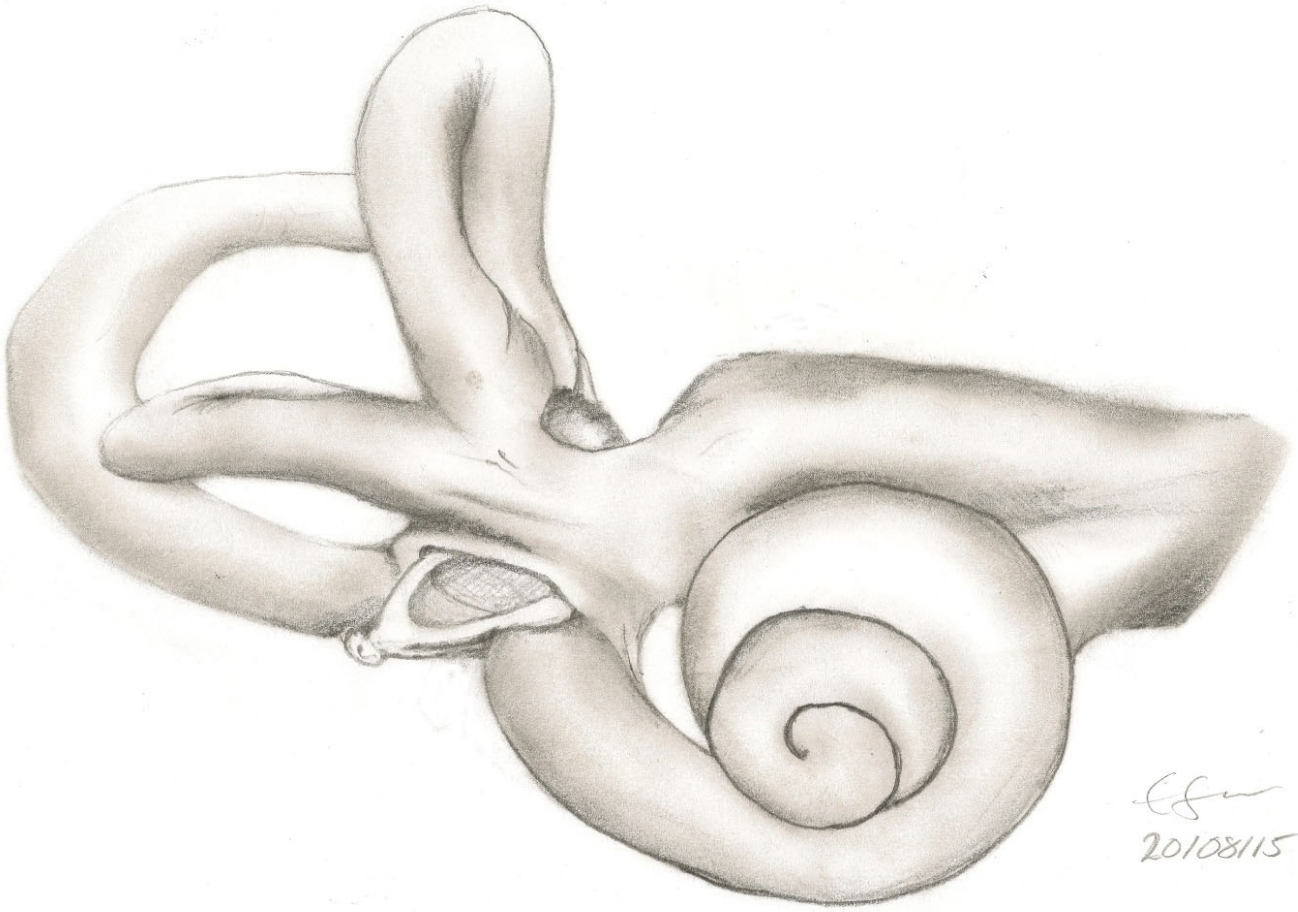
Abnormal Aural Preference



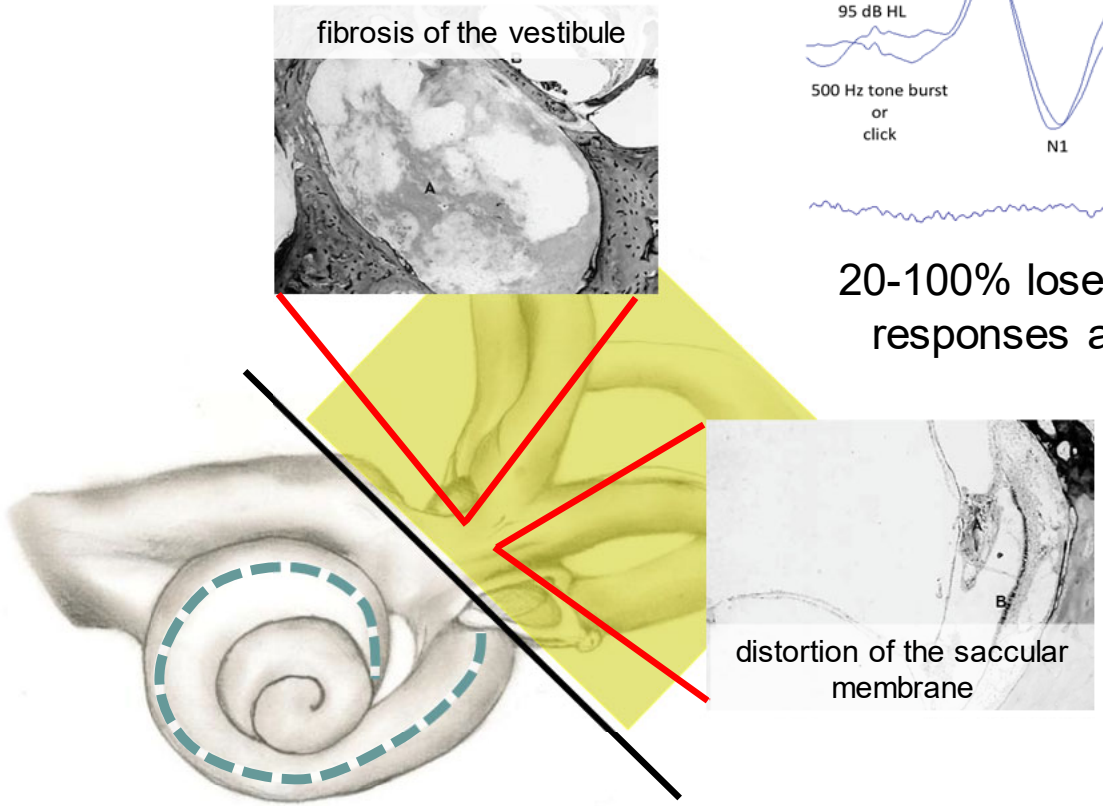


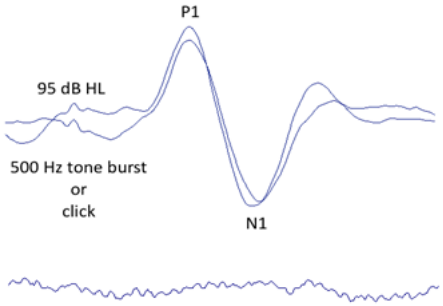
* P<0.05

Brain 2013


20108115

Vestibular Effects of Cochlear Implantation (*negative*)





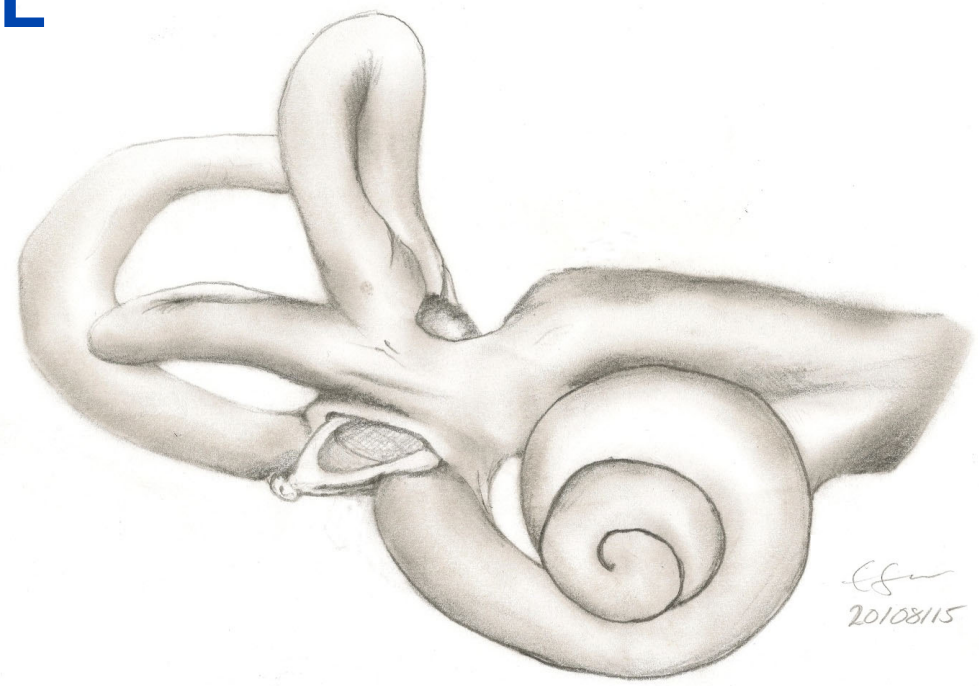
20-100% lose cVEMP responses after CI

Tien et al, 2002

Vestibular Dysfunction is Common in Children with SNHL

70% dysfunction

35-40% complete areflexia



vestibular impairment is the single most common associated feature of SNHL

Otol Neurotol. 2013

Measuring Balance

Bruininks-Oseretsky (BOT2) Balance Subtest

Balance subtest Items		Max. Score
1. Standing with feet apart on a line	Eyes Open	10 sec.
	Eyes Closed	10 sec.
2. Walking forward on a line		6 steps
3. Standing on one leg on a line	Eyes Open	10 sec.
	Eyes Closed	10 sec.
4. Walking forward heel to toe on a line		6 steps
5. Standing on one leg on a balance beam	Eyes Open	10 sec.
	Eyes Closed	10 sec.
6. Standing heel-to-toe on a balance beam		10 sec.

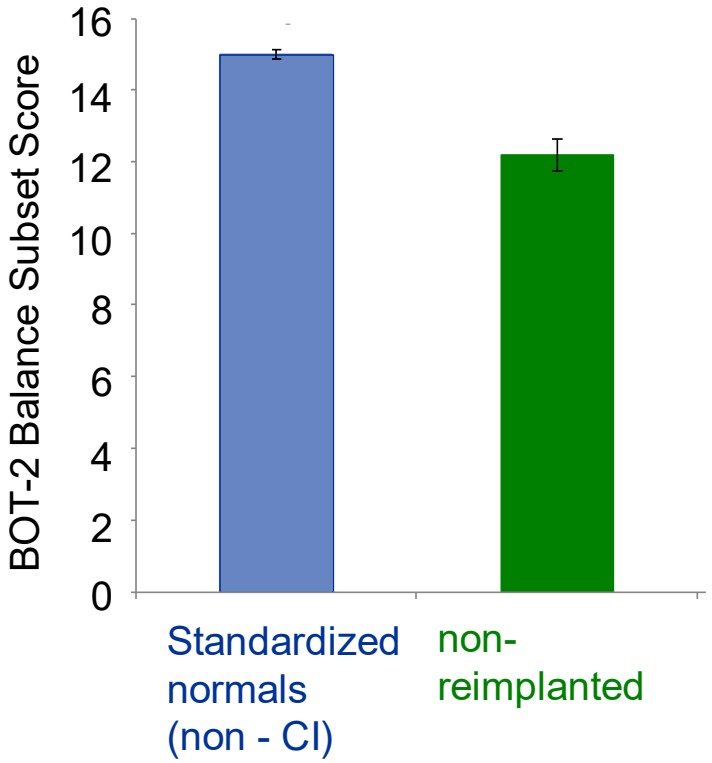
N= 190 children with CI tested

Vestibular Loss Impacts Balance

balance deficits are not always apparent

When Balance is Poor – Implants Fail

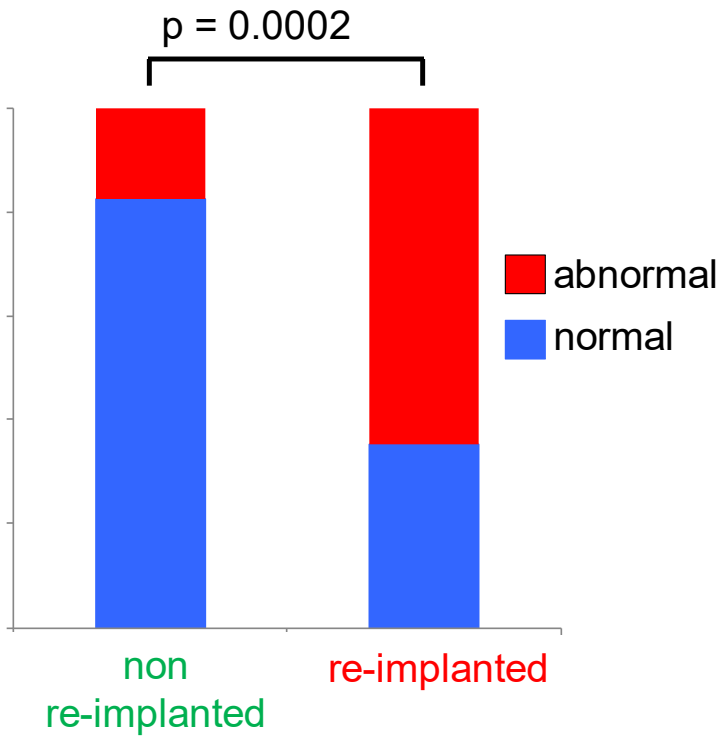
- static and dynamic balance – BOT-2



Otol Neurotol. 2015

When Vestibular Function is Poor – Implants Fail

bilateral areflexia



Otol Neurotol. 2015

When Vestibular Function is Poor – Implants Fail

vestibular & balance dysfunction α risk of CI failure

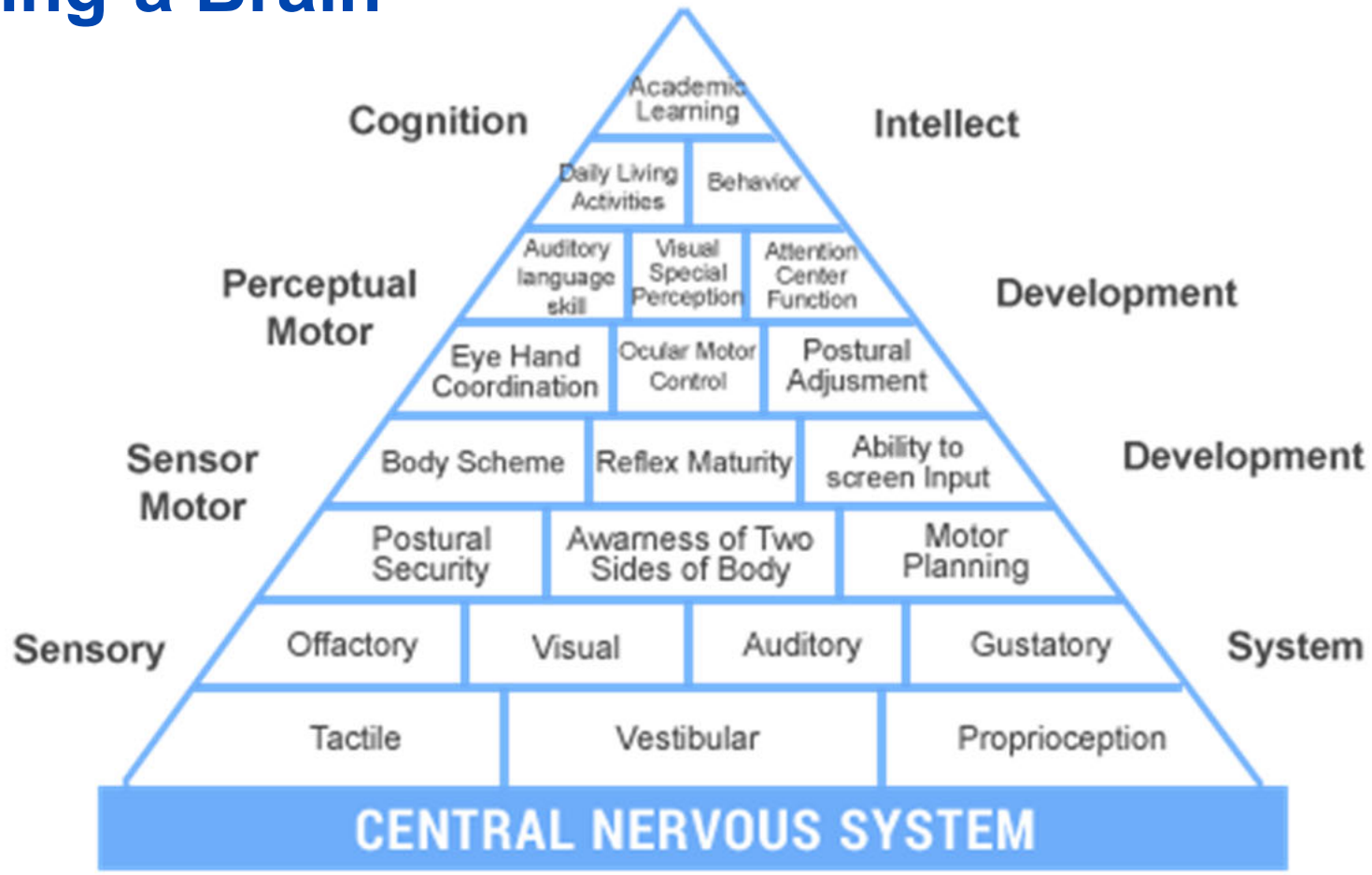
Bilateral Areflexia

Odds ratio: 8.6

Implant failure

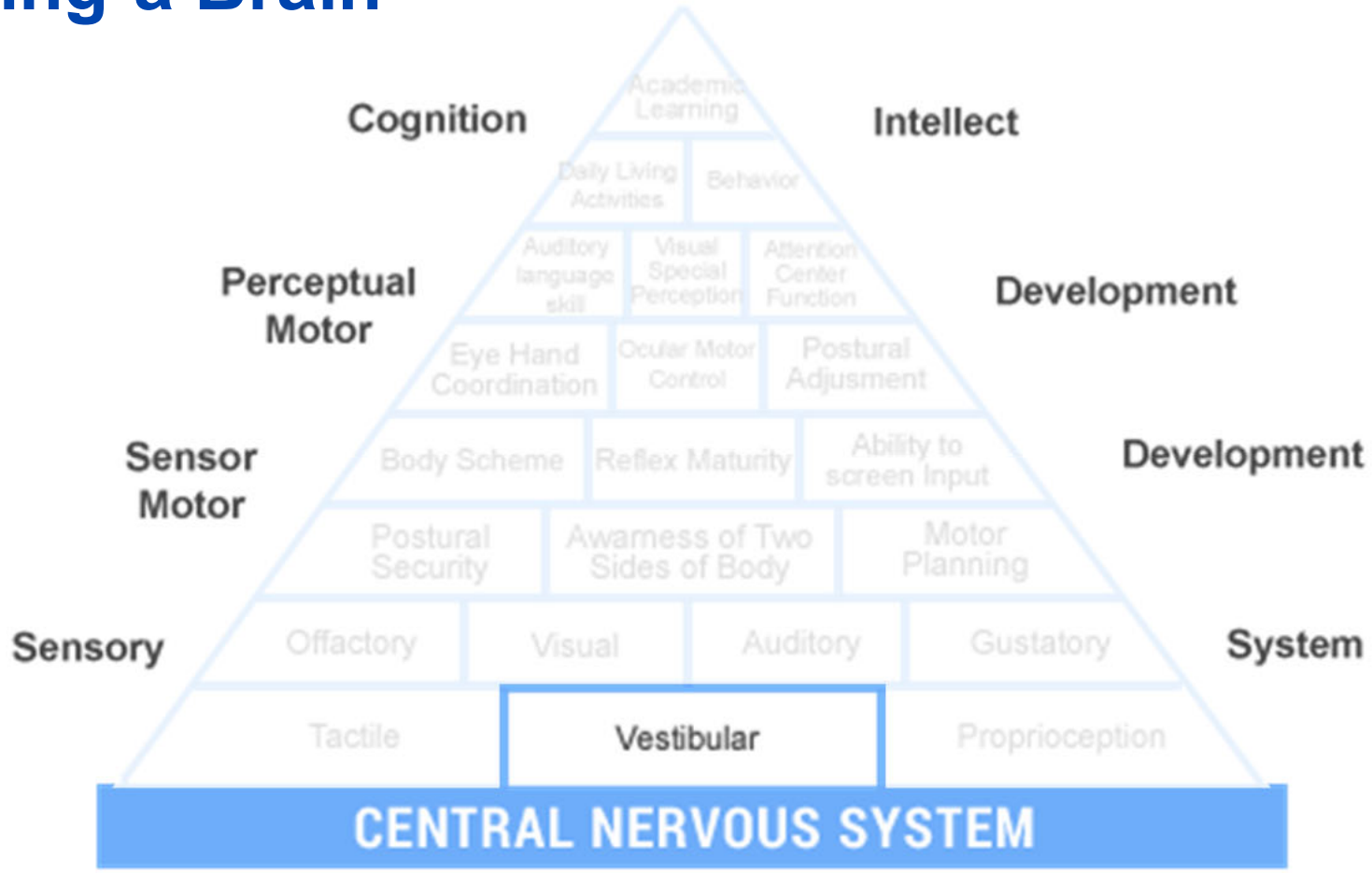
Otol Neurotol. 2015

Building a Brain



Pyramid of Learning. (Williams & Shellenbeger,1-4)

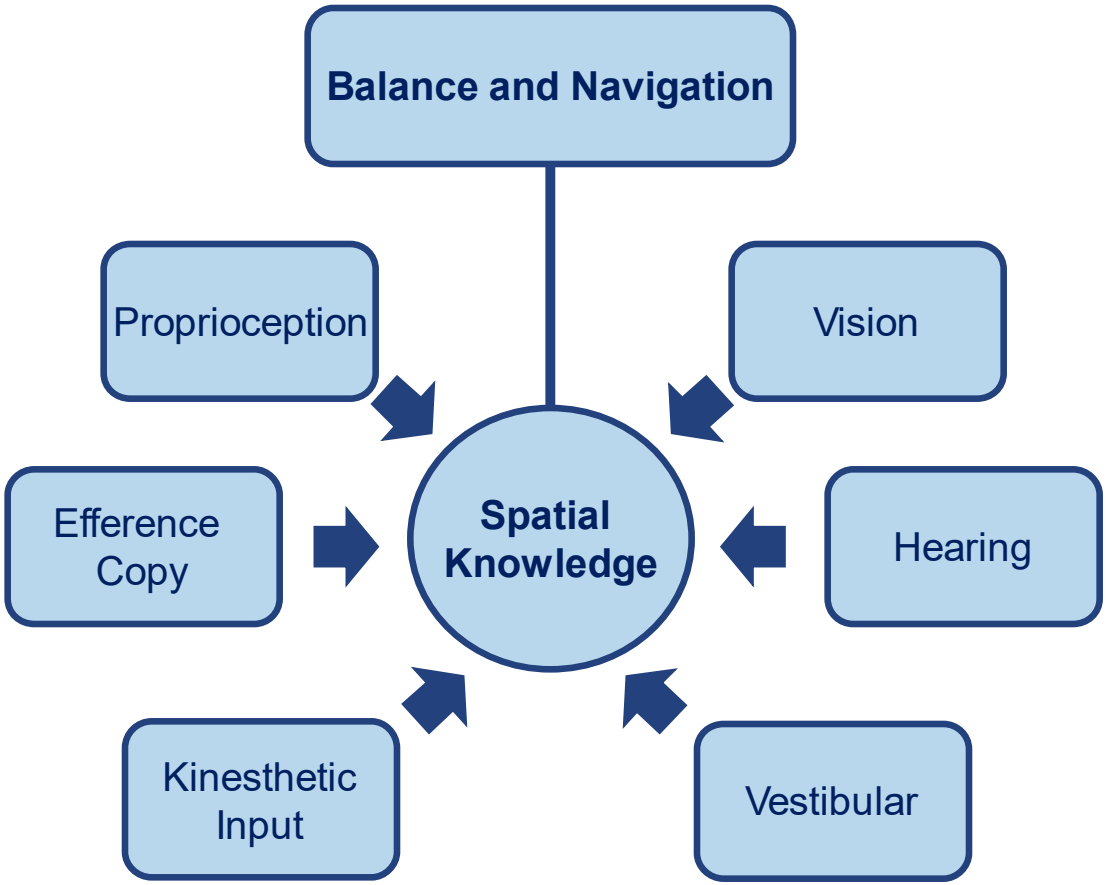
Building a Brain



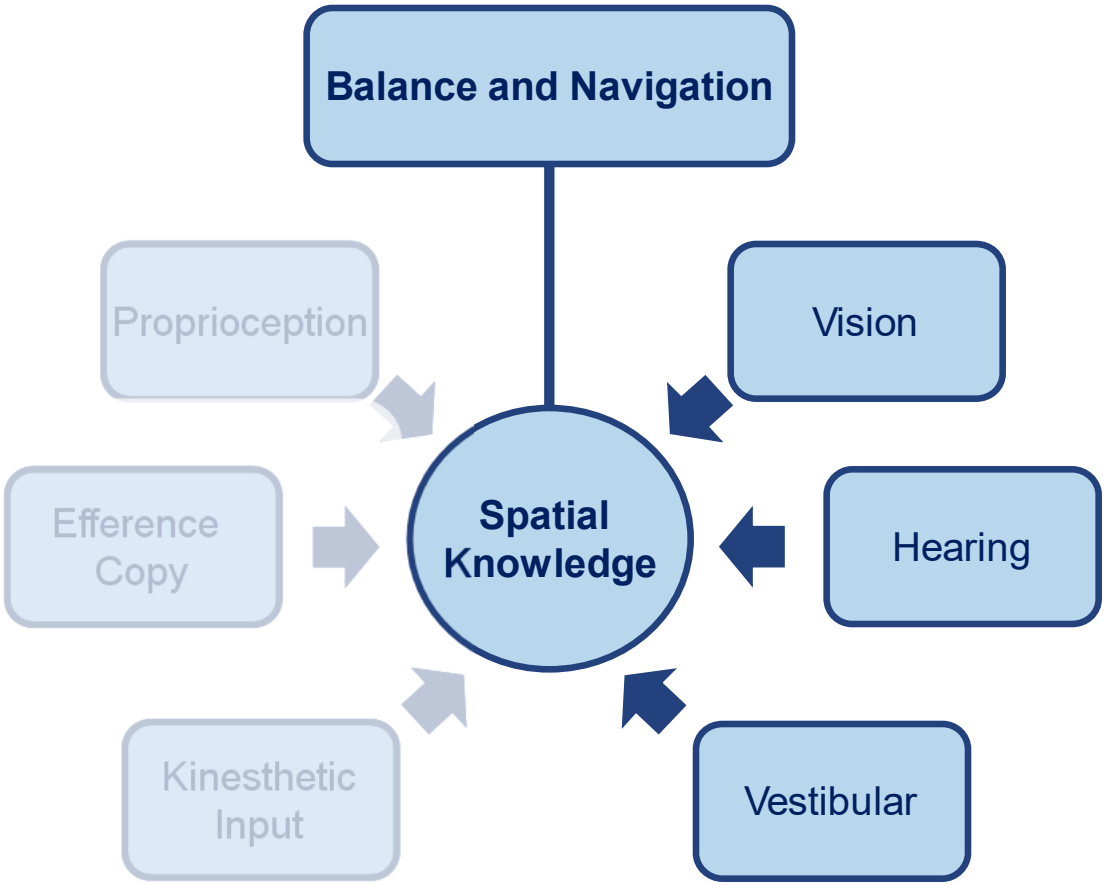
Pyramid of Learning. (Williams & Shellenbeger,1-4)

Balance and Navigation

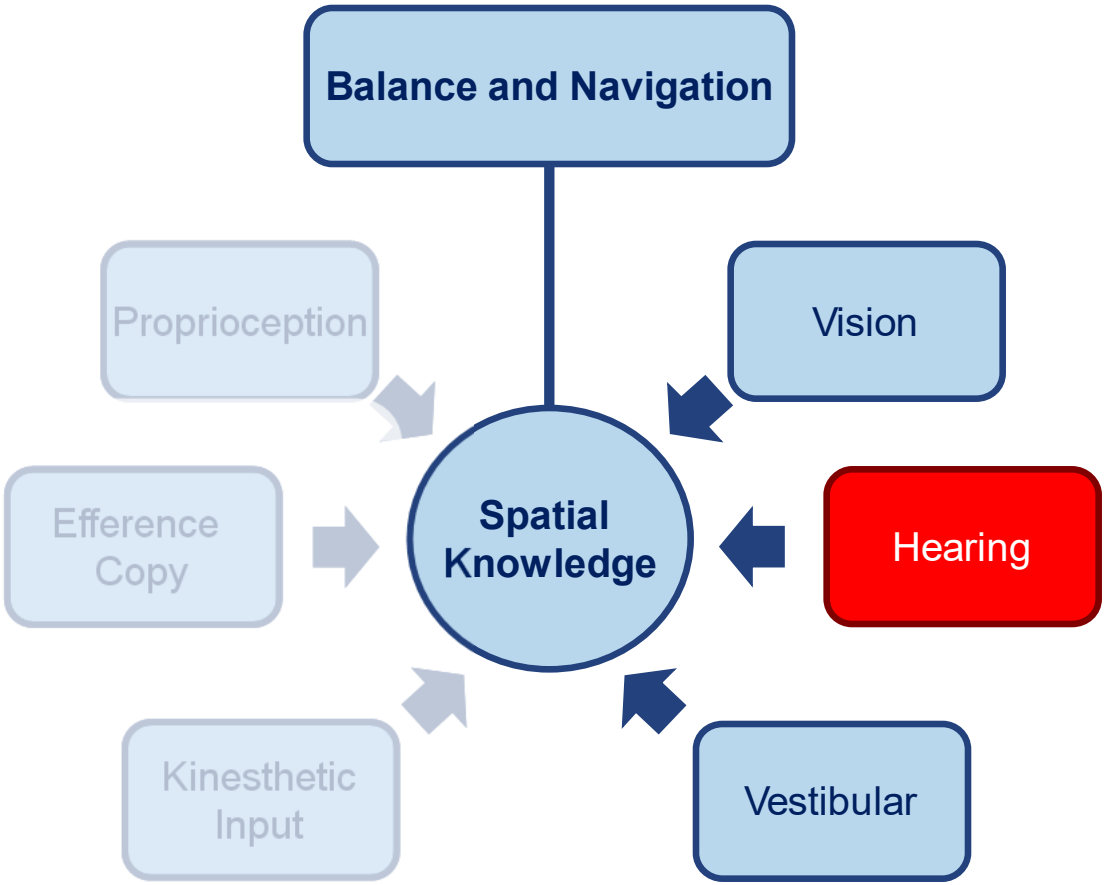
Development of Spatial Knowledge



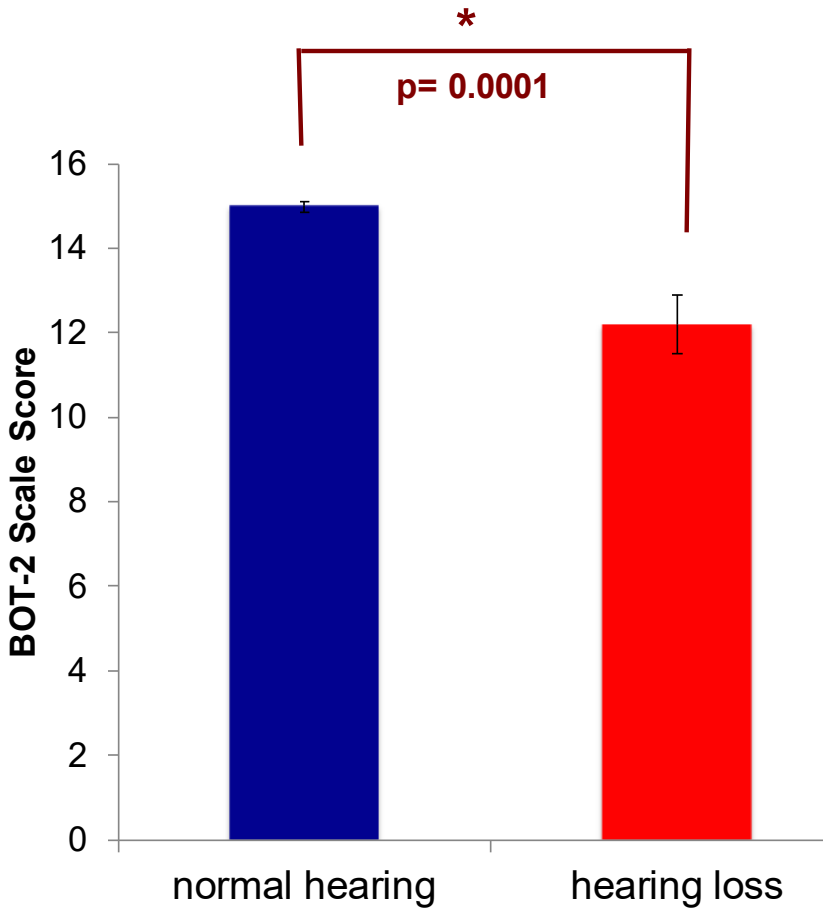
Development of Spatial Knowledge



Development of Spatial Knowledge



Hearing Loss Impacts Balance



Otol Neurotol. 2009


Unilateral
Bilateral

Effects of Poor Spatial Hearing

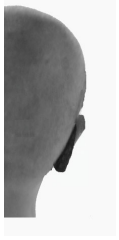
Normal binaural hearing

Normal hearing (n=36)
10.0 ± 3.3 years of age

Abnormal binaural hearing

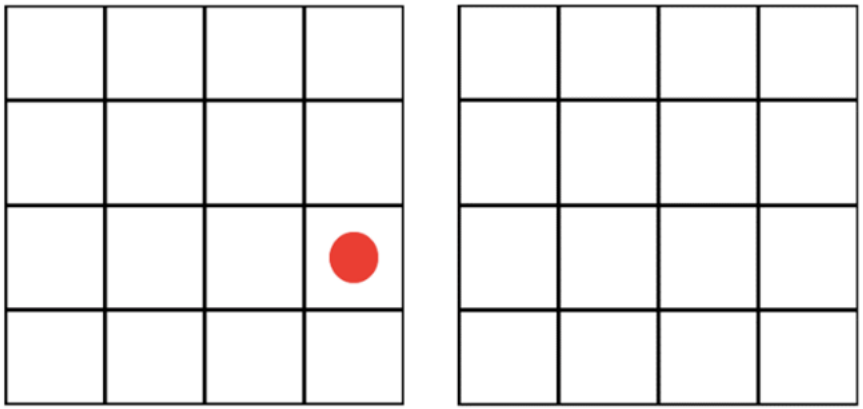
Bilateral CI (n=32)
9.1 ± 3.0 years of age

No binaural hearing

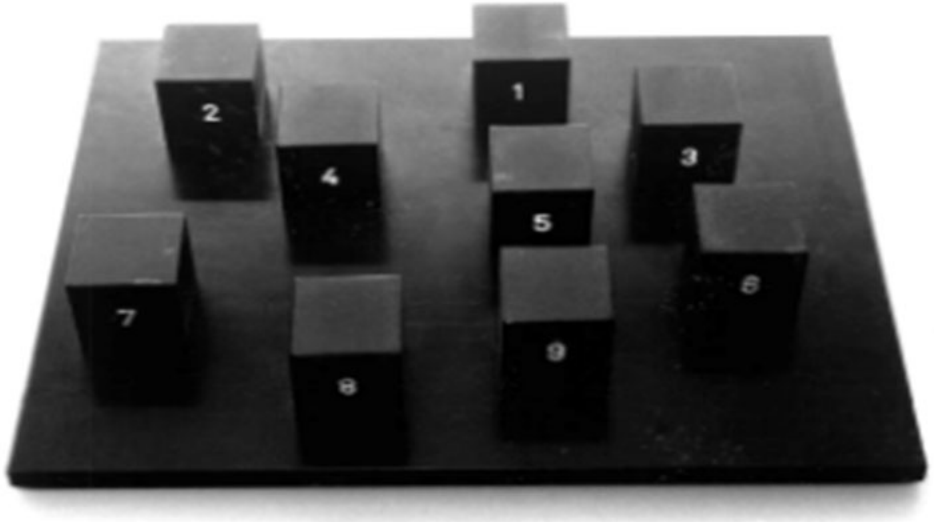


Untreated SSD (n=20)
10.8 ± 4.1 years of age

Memory Deficits are Visuospatial

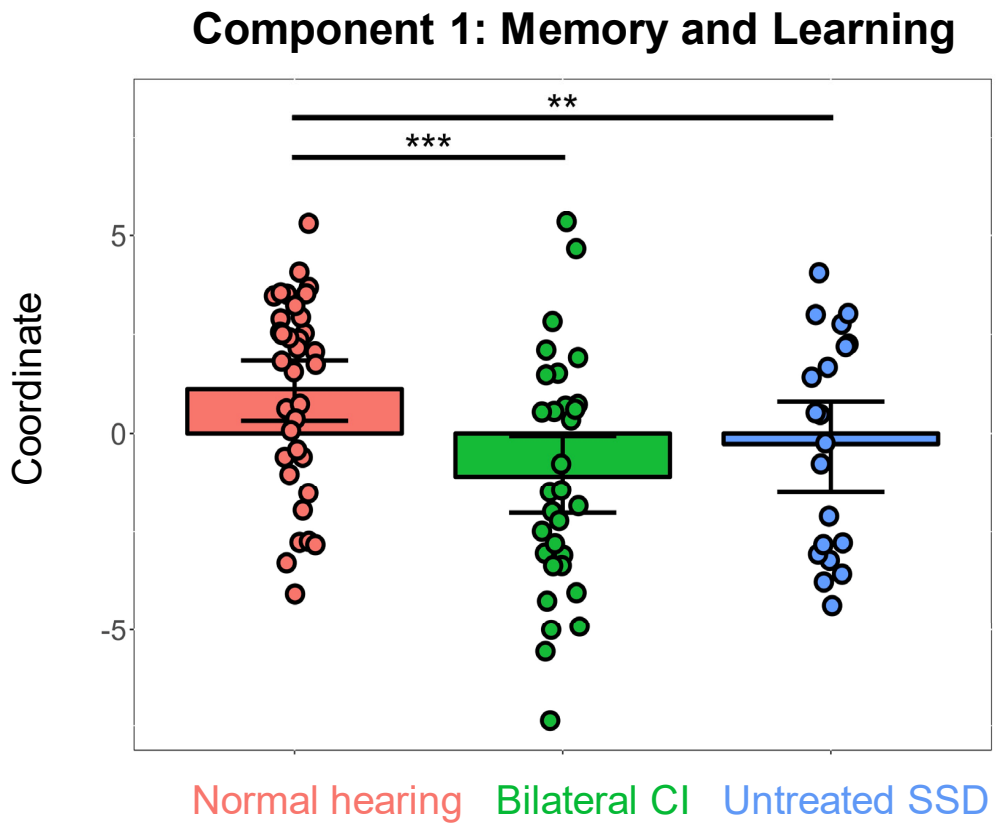


Dot Matrix Test

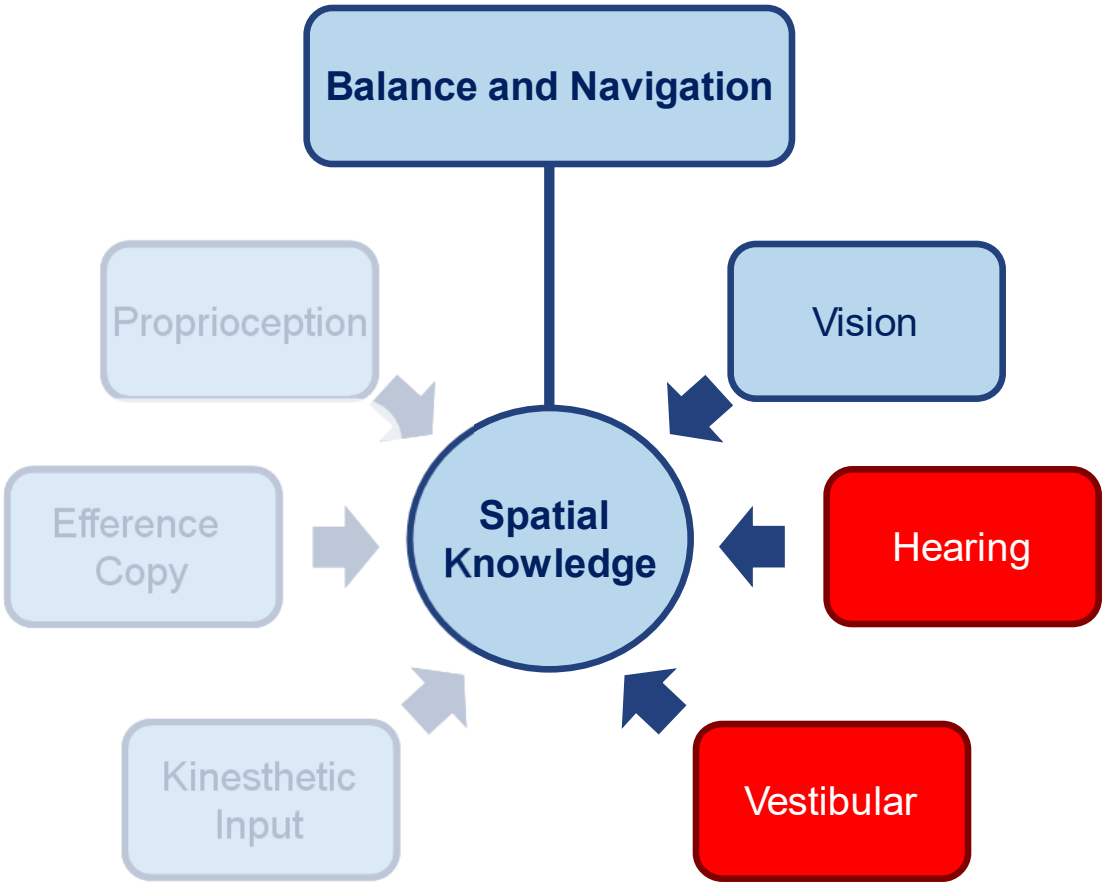


Corsi Block Test

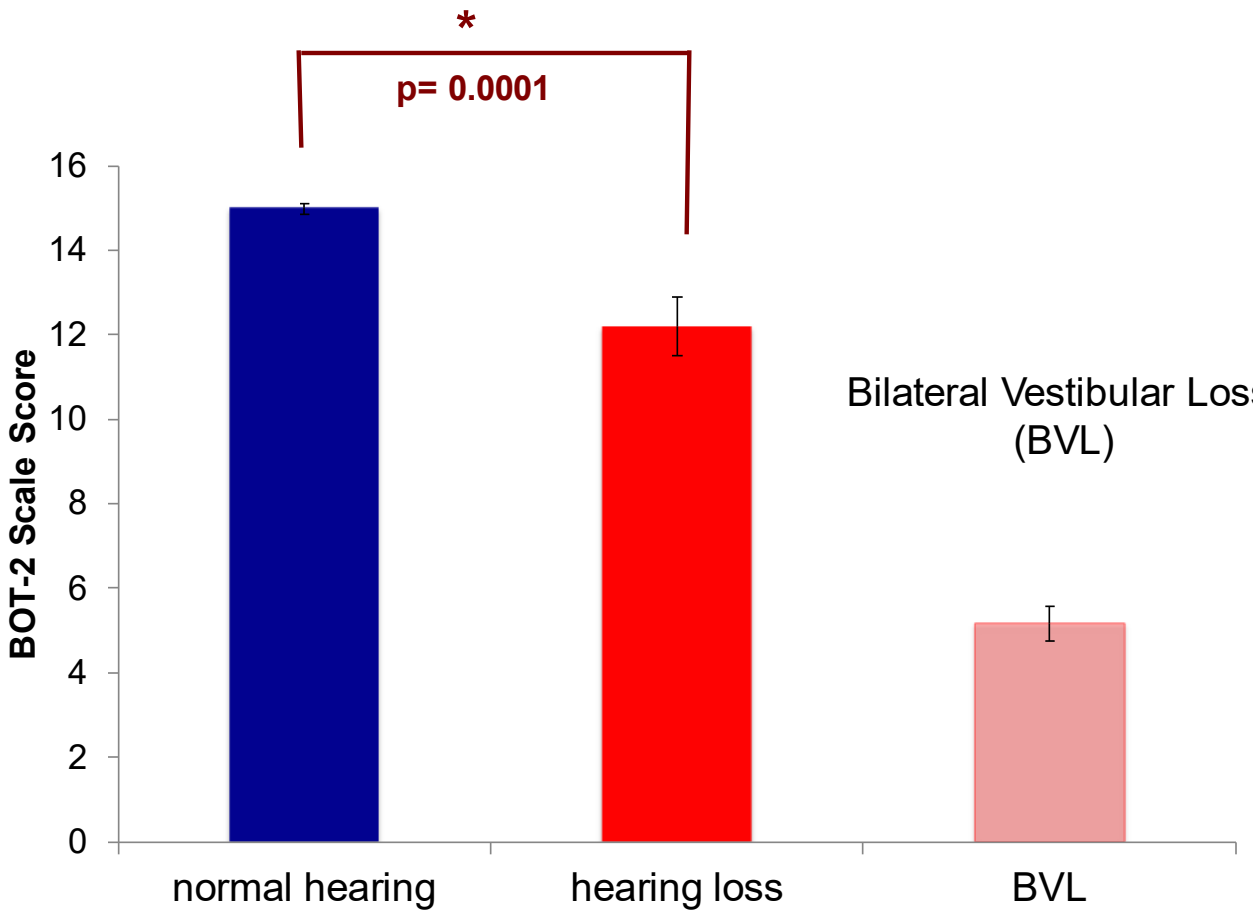
Memory and Learning Deficits



Development of Spatial Knowledge

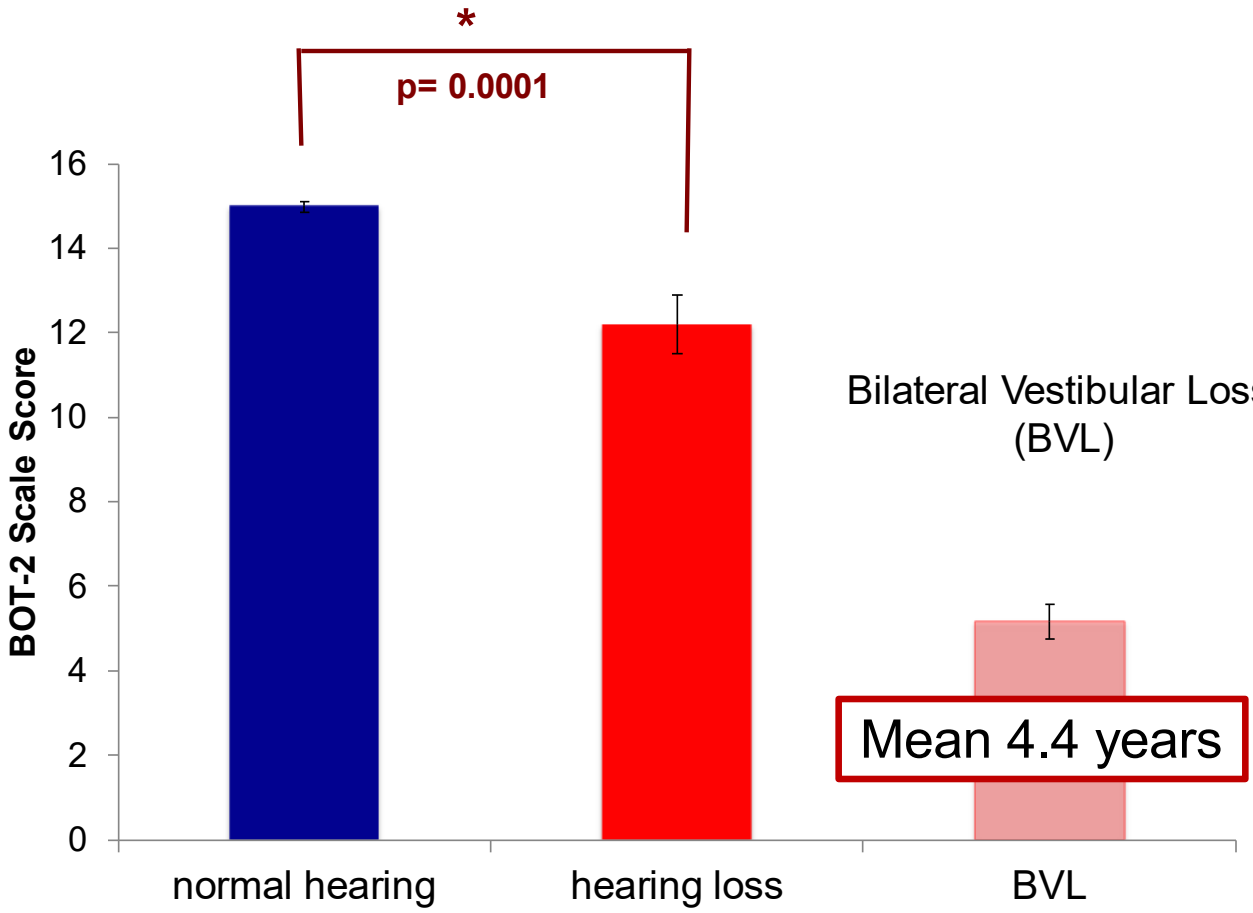


Sensory Loss Impacts Balance



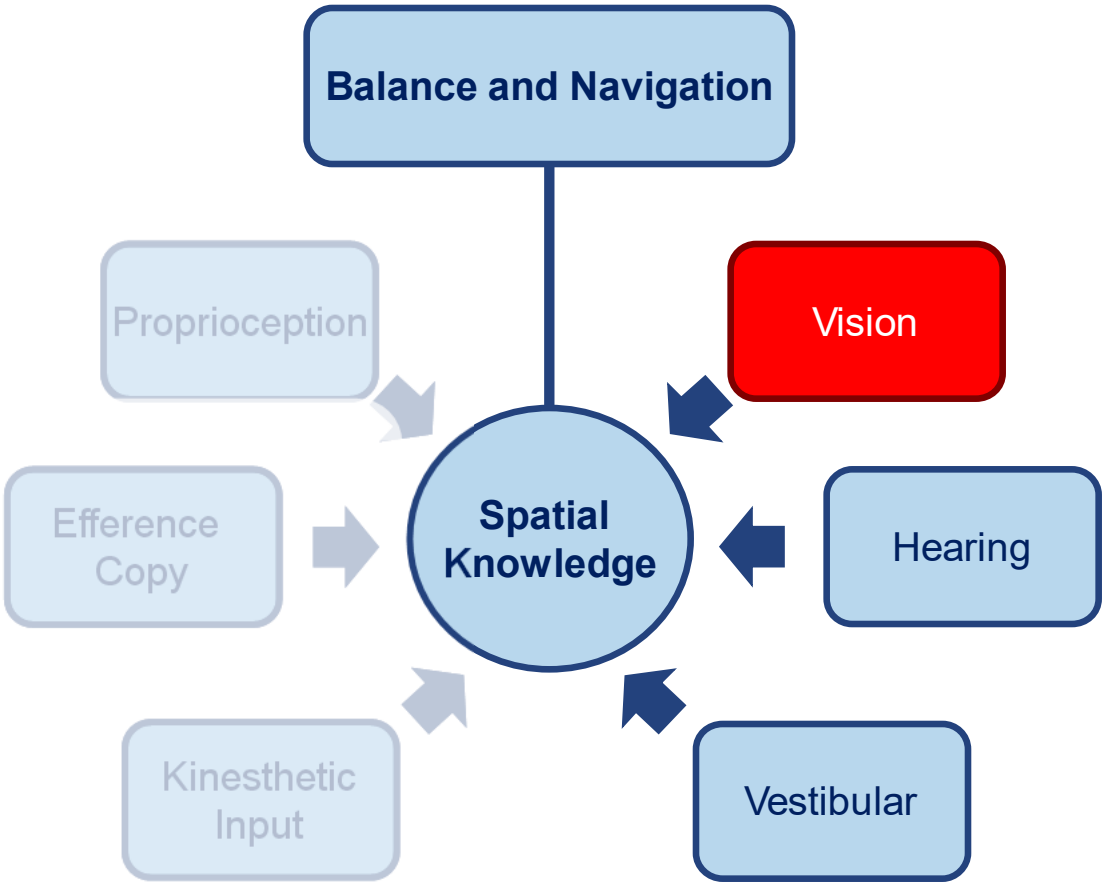
Otol Neurotol. 2009

Sensory Loss Impacts Balance

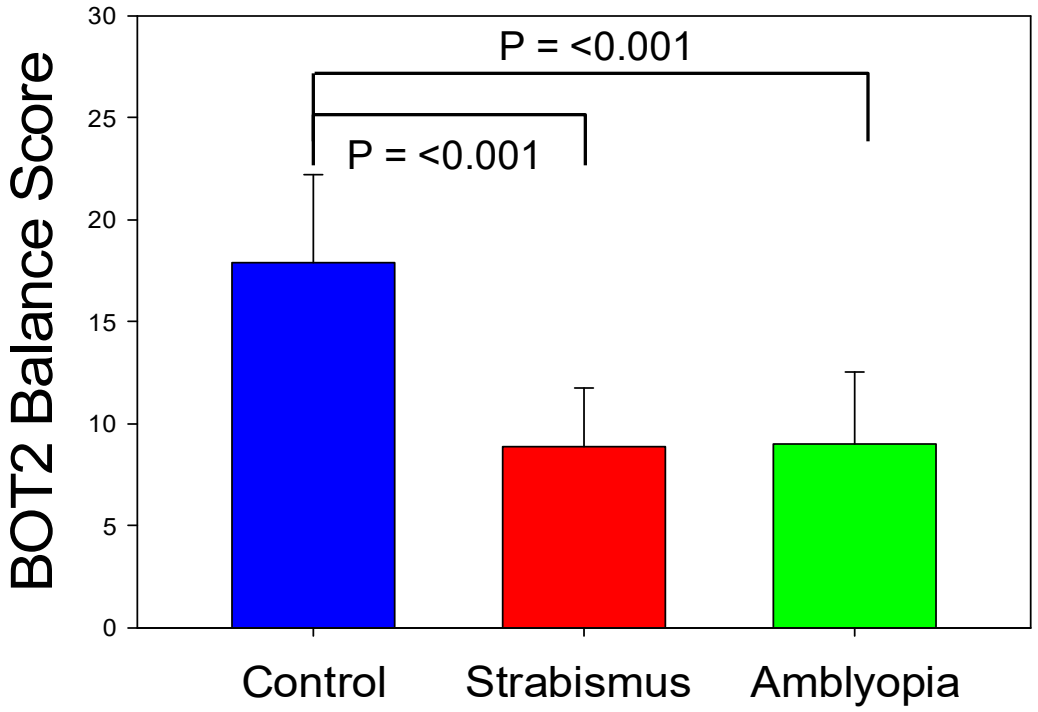


Otol Neurotol. 2009

Development of Spatial Knowledge

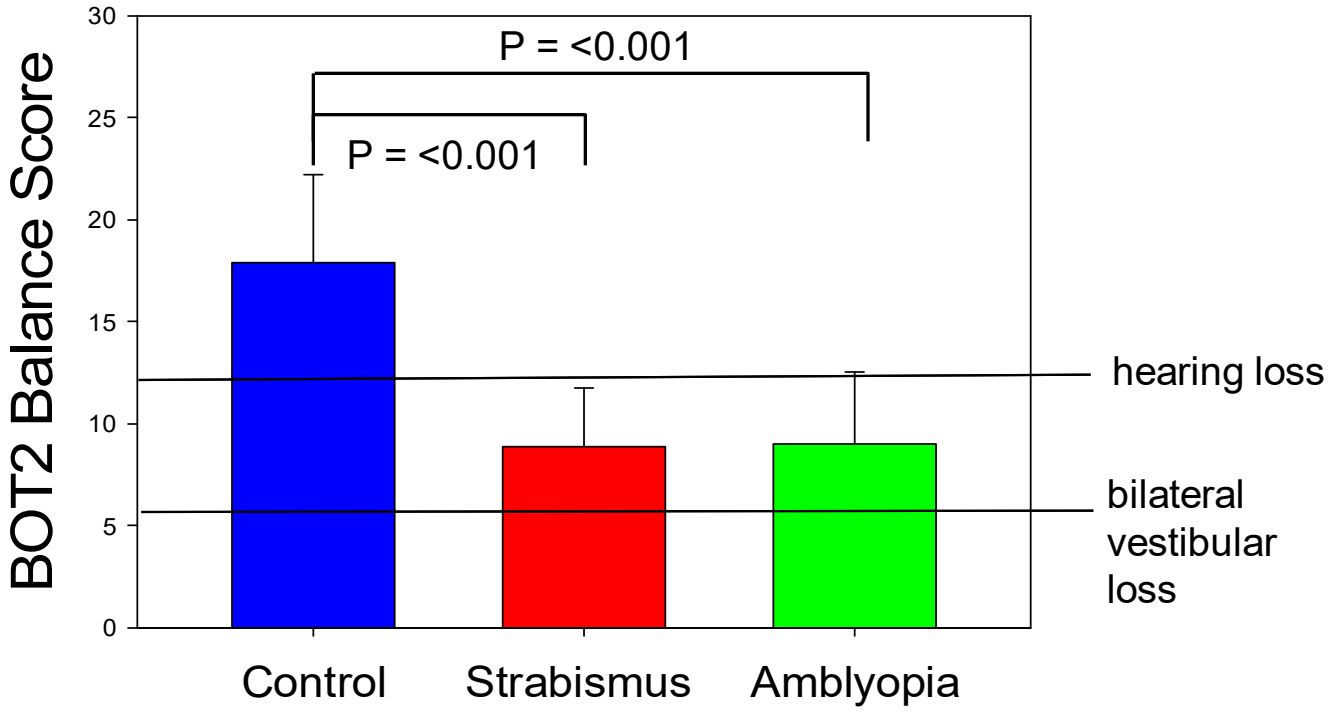


Balance is Impaired in Developmental Visual Anomalies



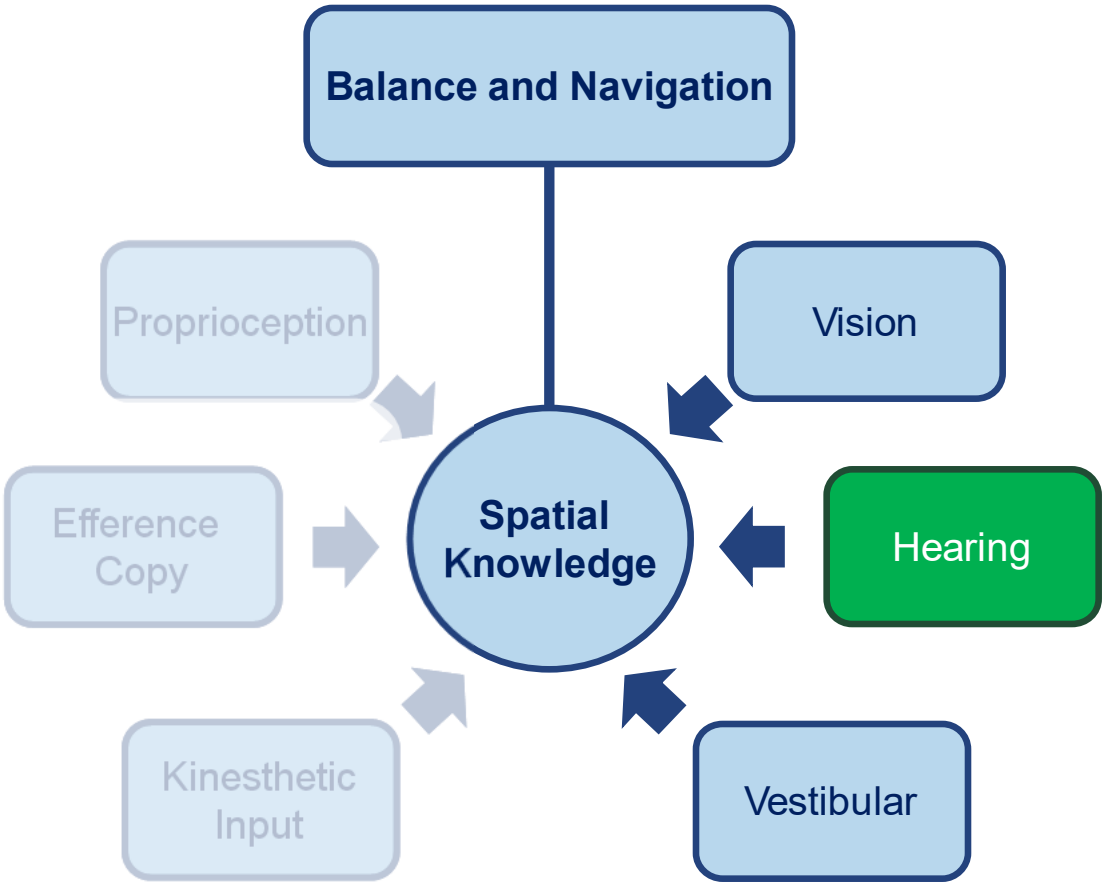
PLoS One. 2018

Balance is Impaired in Developmental Visual Anomalies

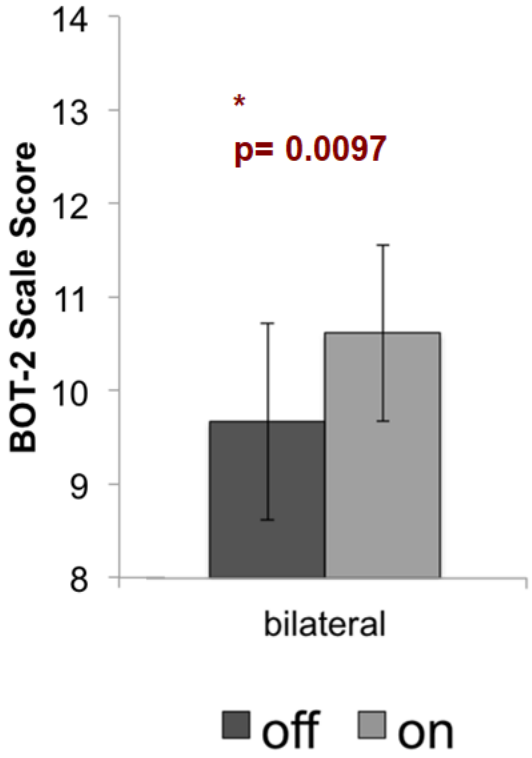


PLoS One. 2018

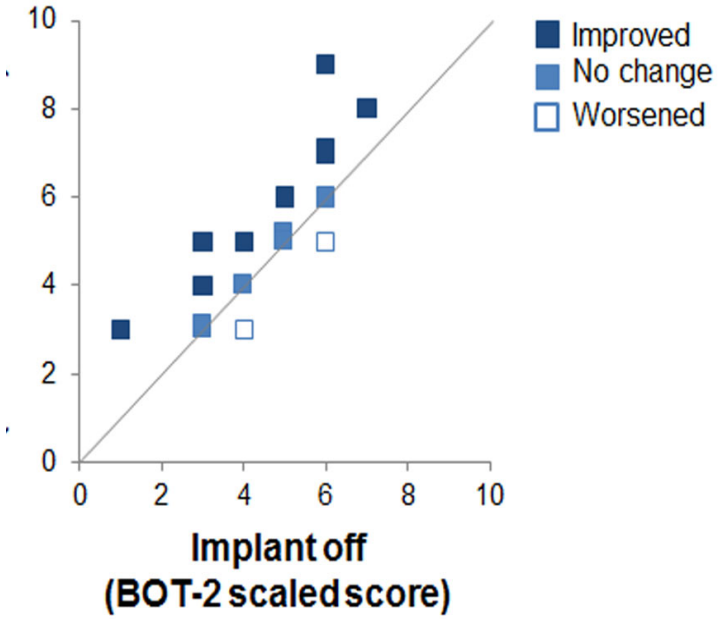
Development of Spatial Knowledge



Vestibular Effects of Cochlear Implantation (*positive*)

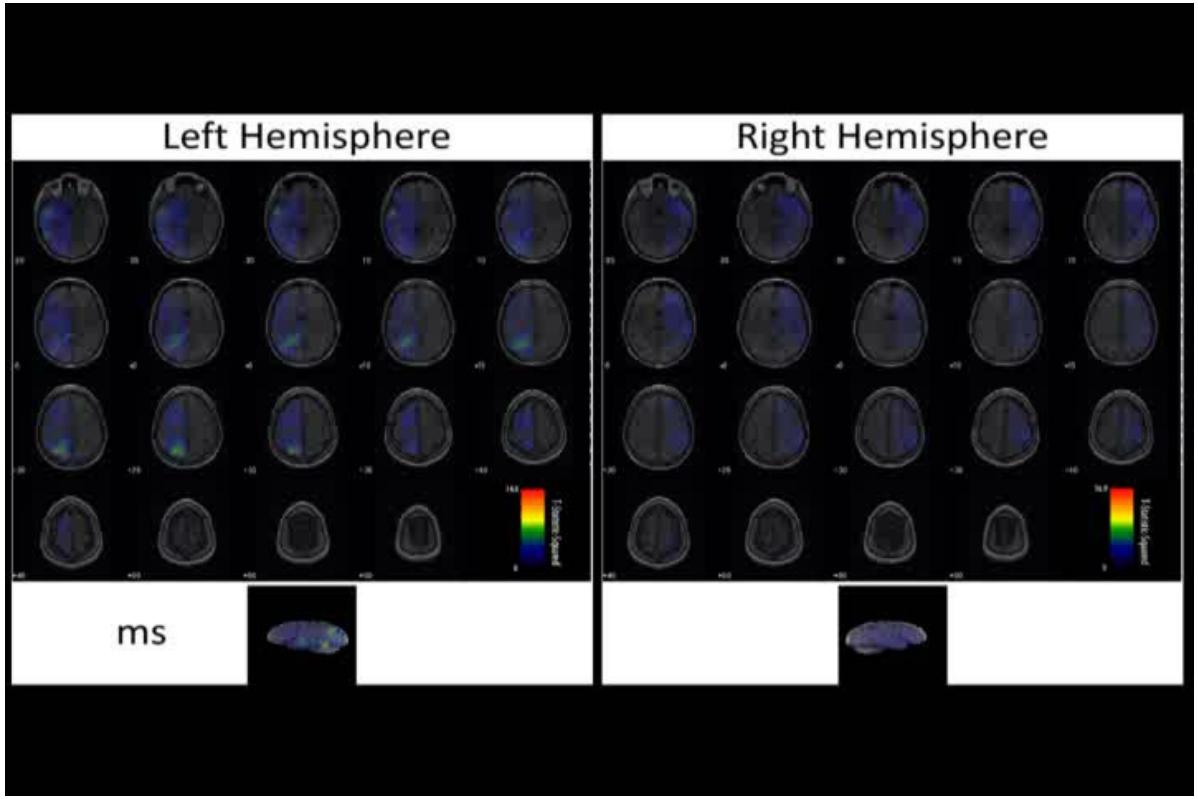


Laryngoscope. 2008



Audiol Neurootol. 2019

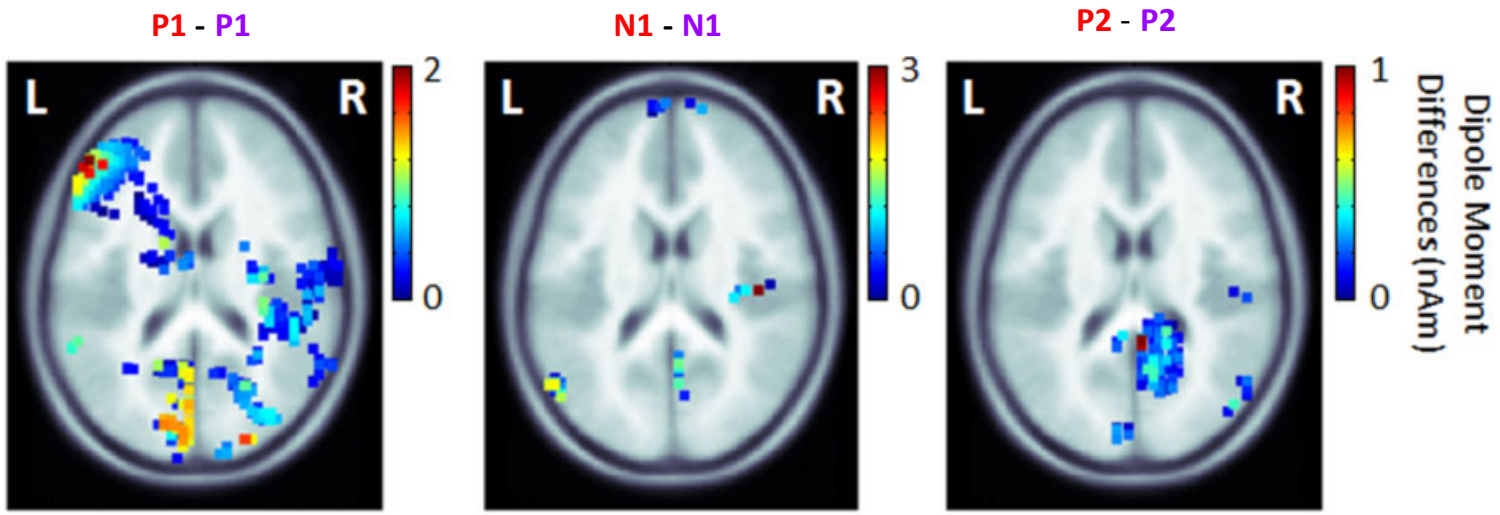
Measuring Plasticity



Plasticity is Required for Listening

Right Stimulation

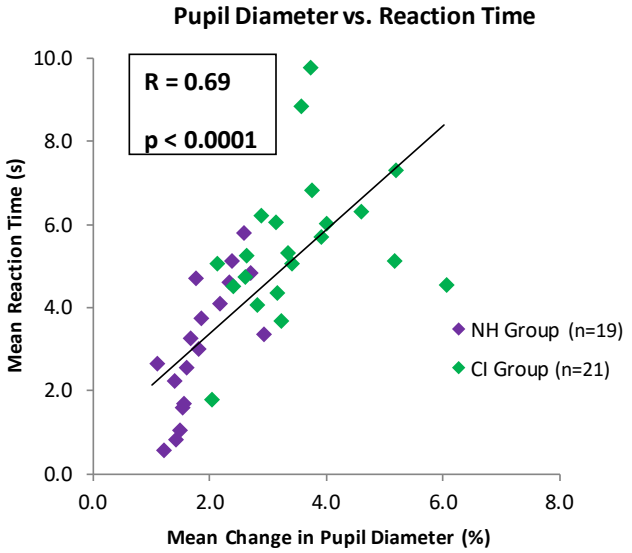
CI Experienced – Normal Hearing Dipole Differences



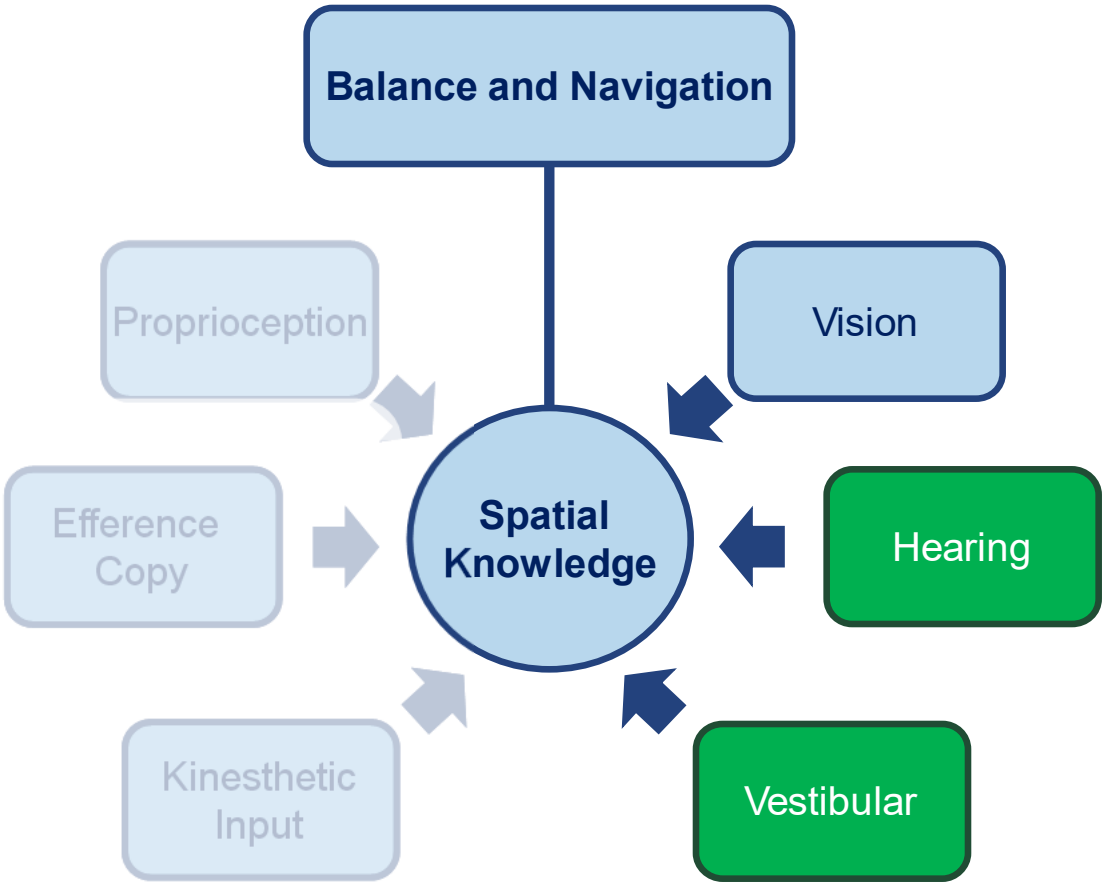
Hum Brain Mapp. 2016

The Effort of Processing

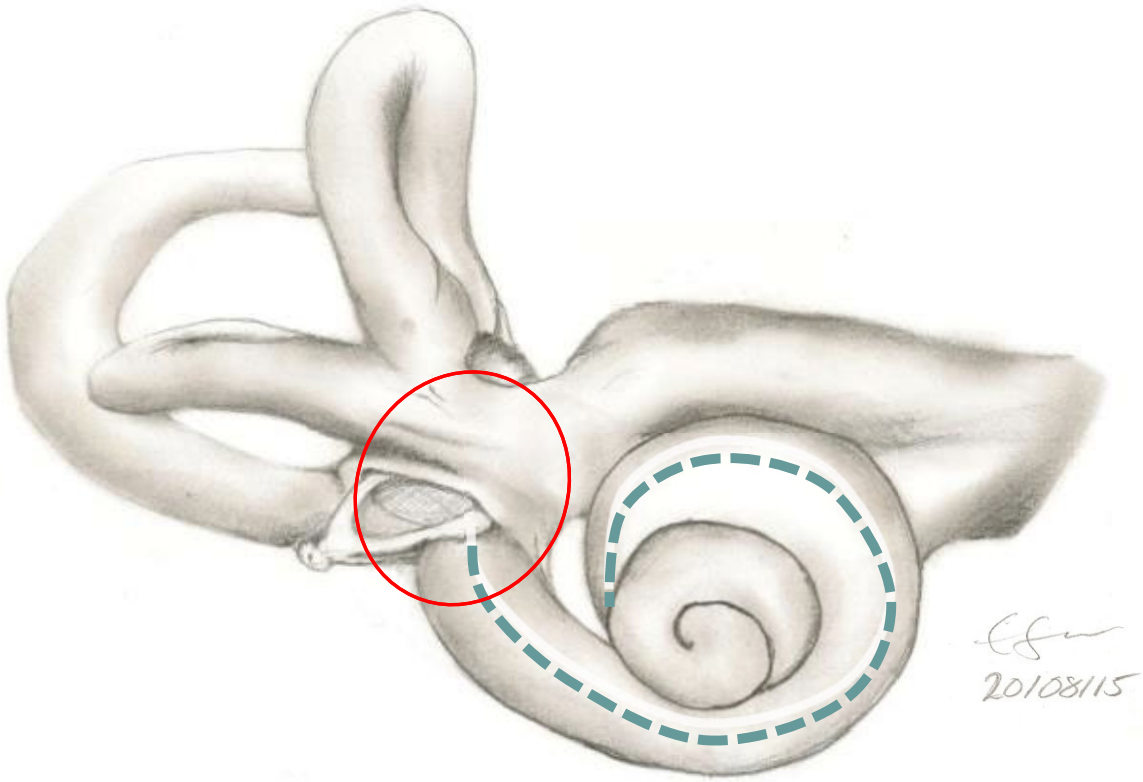
Binaural fusion & listening effort



Development of Spatial Knowledge

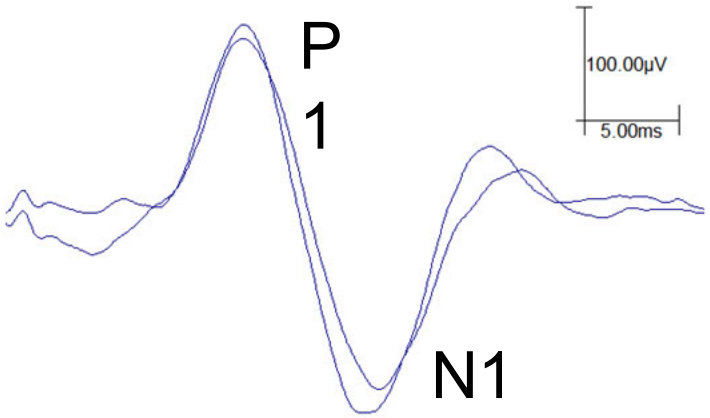


Can Electrical Current from a Cochlear Implant Spread to the Vestibular System ?

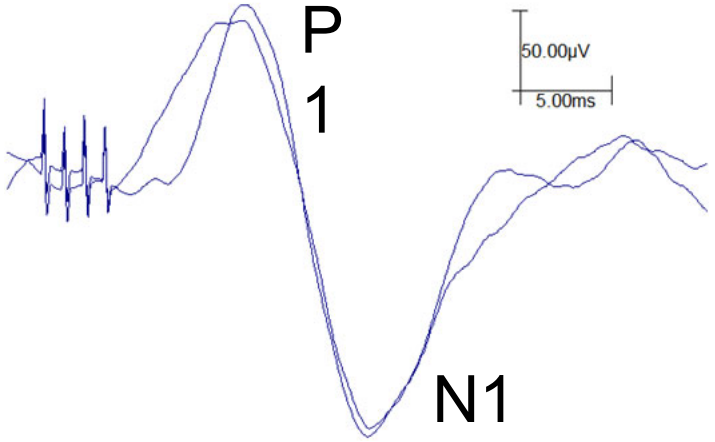


VEMP Waveforms (same ear)

acoustic



electric

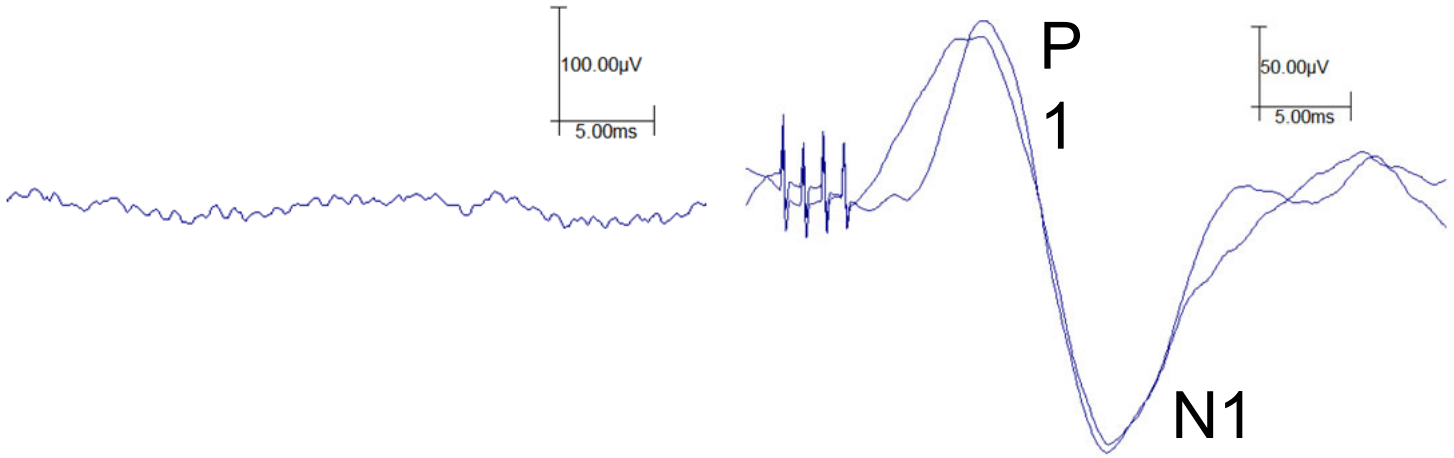


Laryngoscope. 2016

VEMP Waveforms (same ear)

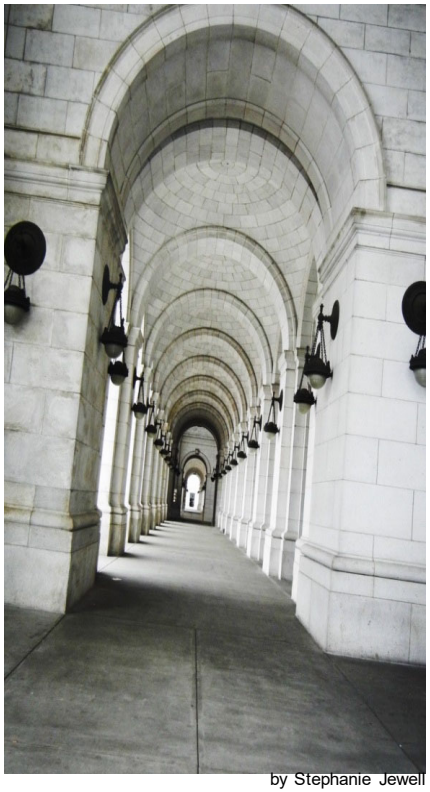
acoustic

electric



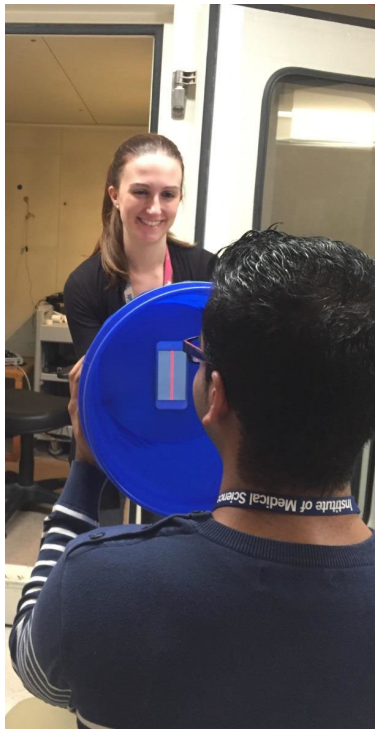
Laryngoscope. 2016

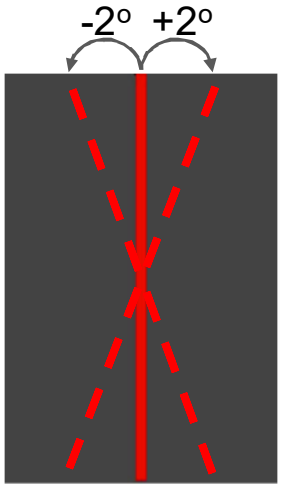
Vestibular Abnormalities Cause Functional Deficits



by Stephanie Jewell

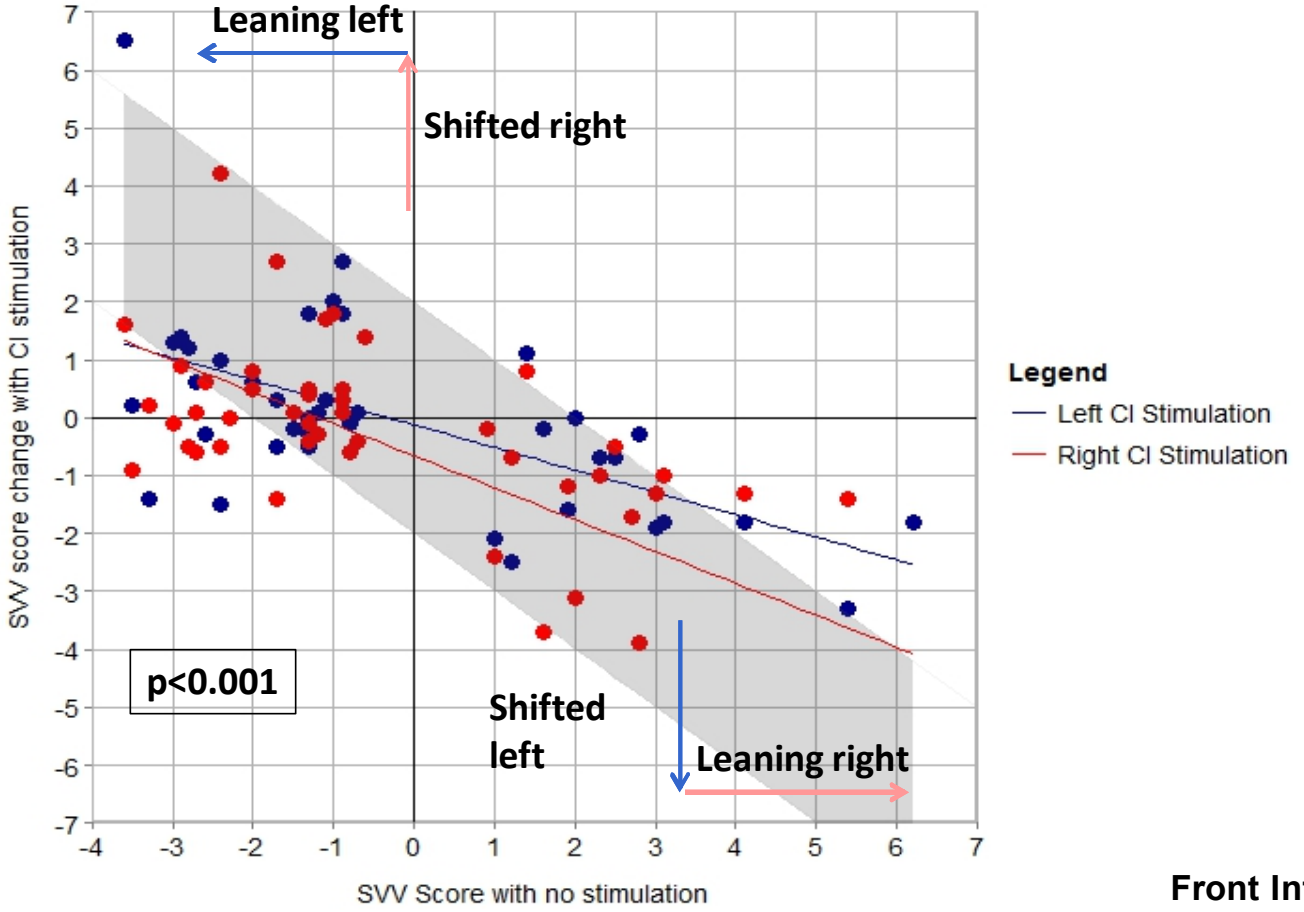
Subjective Visual Vertical (SVV)





- Positive → tilt to the right
- Negative → tilt to the left
- Normal range: ± 2°
  (Brodsky 2015, 2016)
- Bias →initial direction of linear marker
  (Pagarkar 2008; Toupet 2015)

Electrical Stimulation Shifts the Perception of Vertical Back to Center



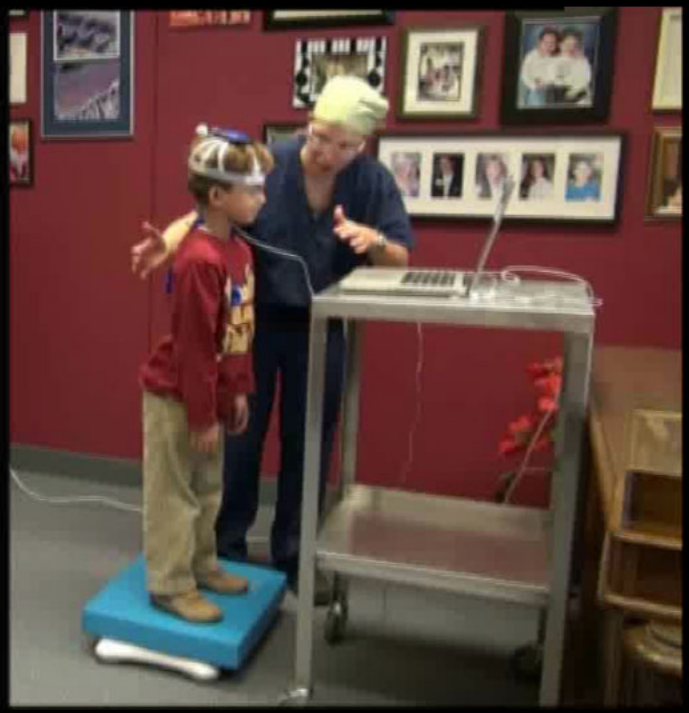
Front Integr Neurosci. 2016

TransCochlear Stabilization of Balance

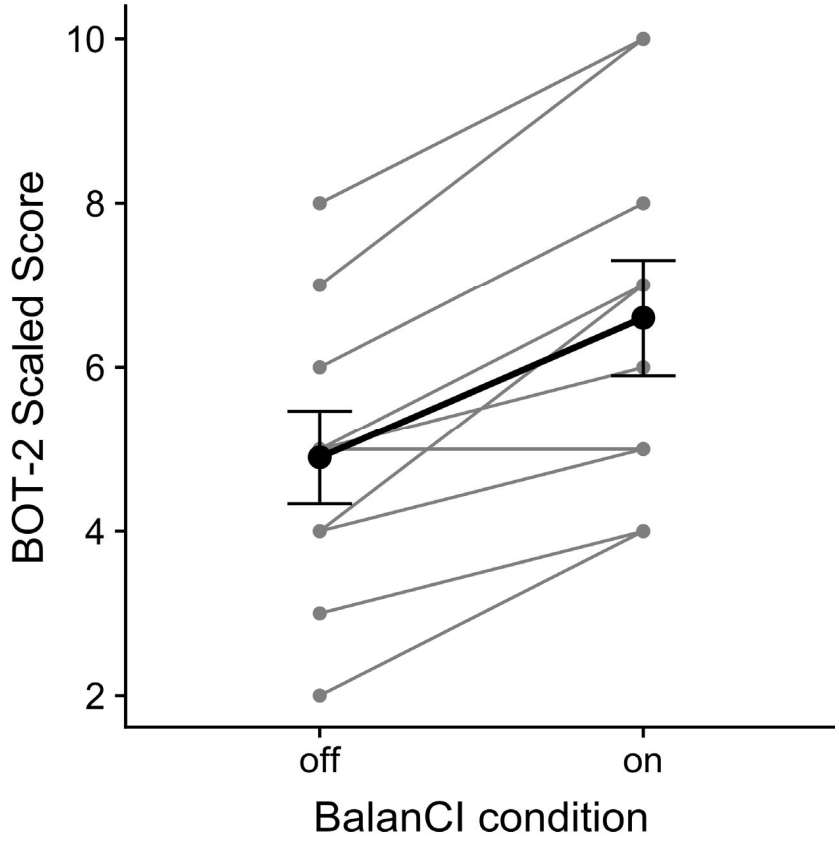
- accelerometer and gyroscopic sensor
- conversion to CI stimulation
  - head referenced
  - deviation signalled
  - transferred electrically to implant
  - 16 patients

OFF

ON

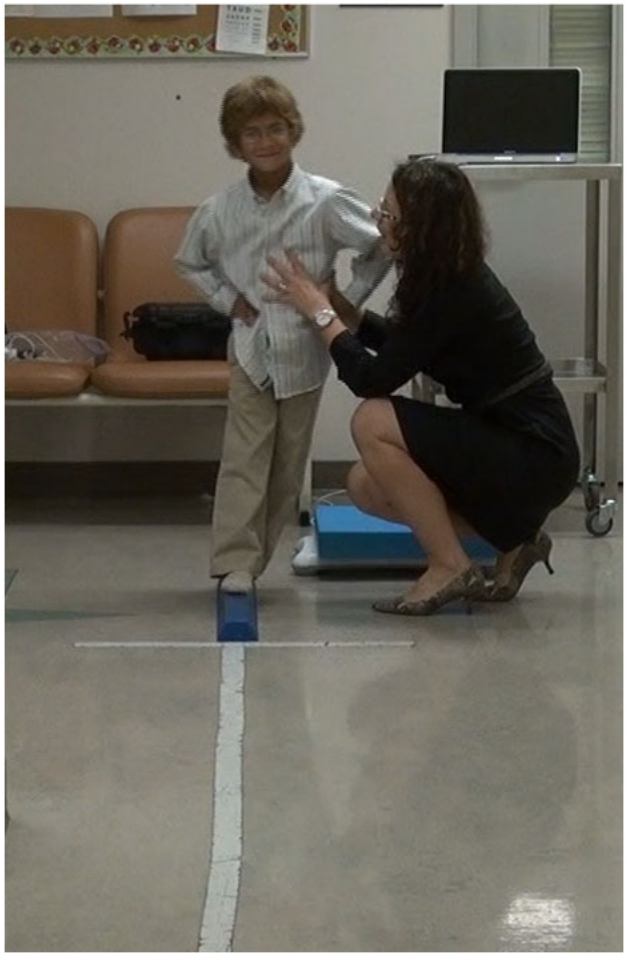


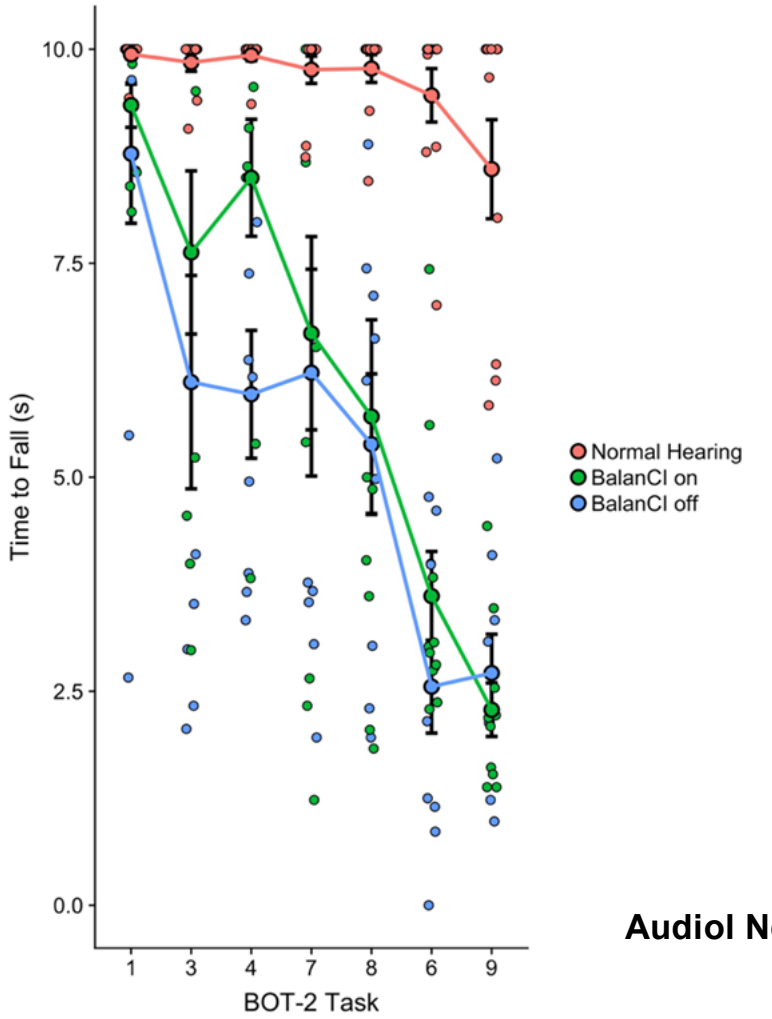
Meaningful Implant Stimulation Improves Balance



Audiol Neurootol. 2019

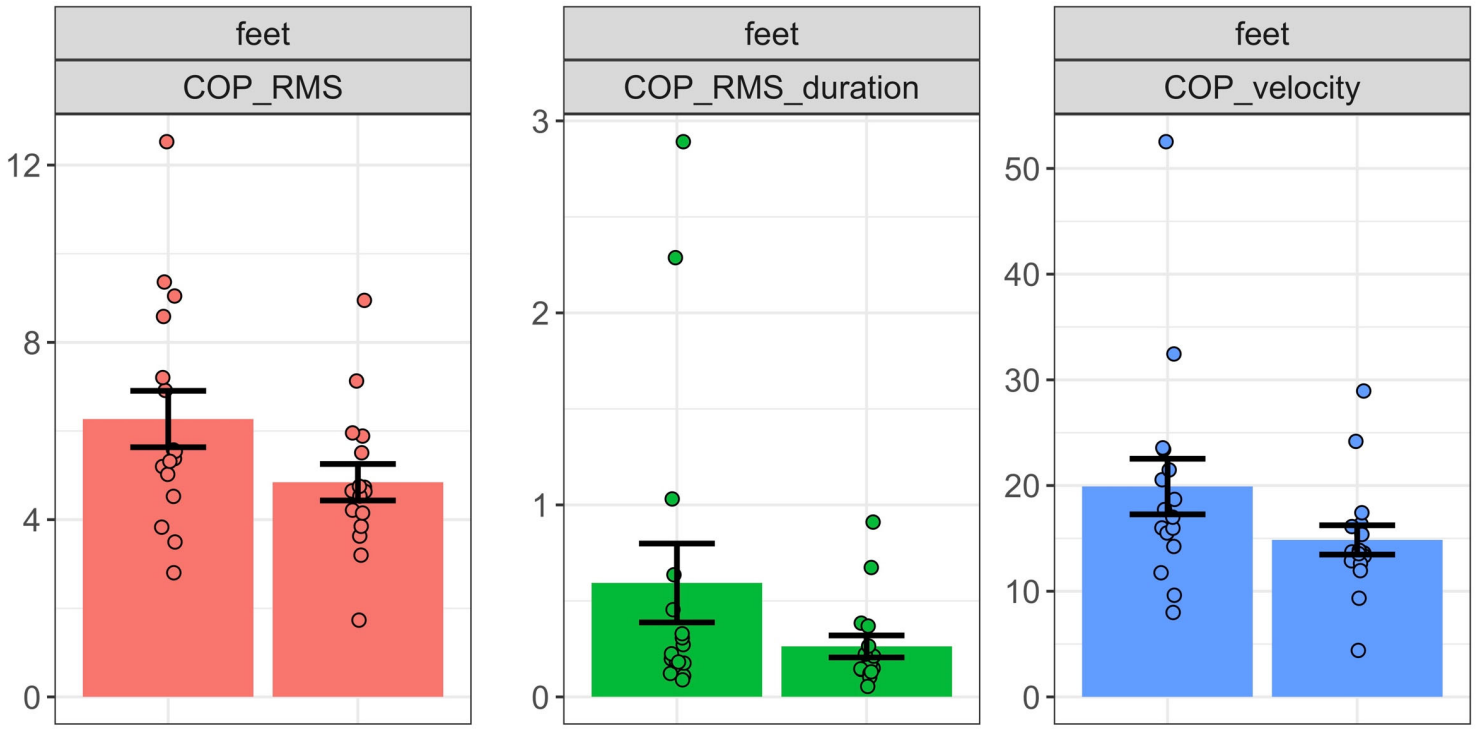
Time to Fall Approaches Normal





Audiol Neurootol. 2019

Postural Stability Improves



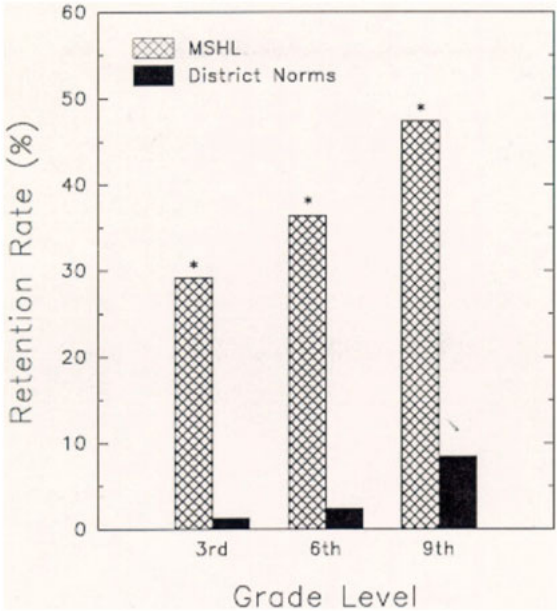
Audiol Neurootol. 2019

Single Sided Deafness in Children

Single Sided Deafness in Children

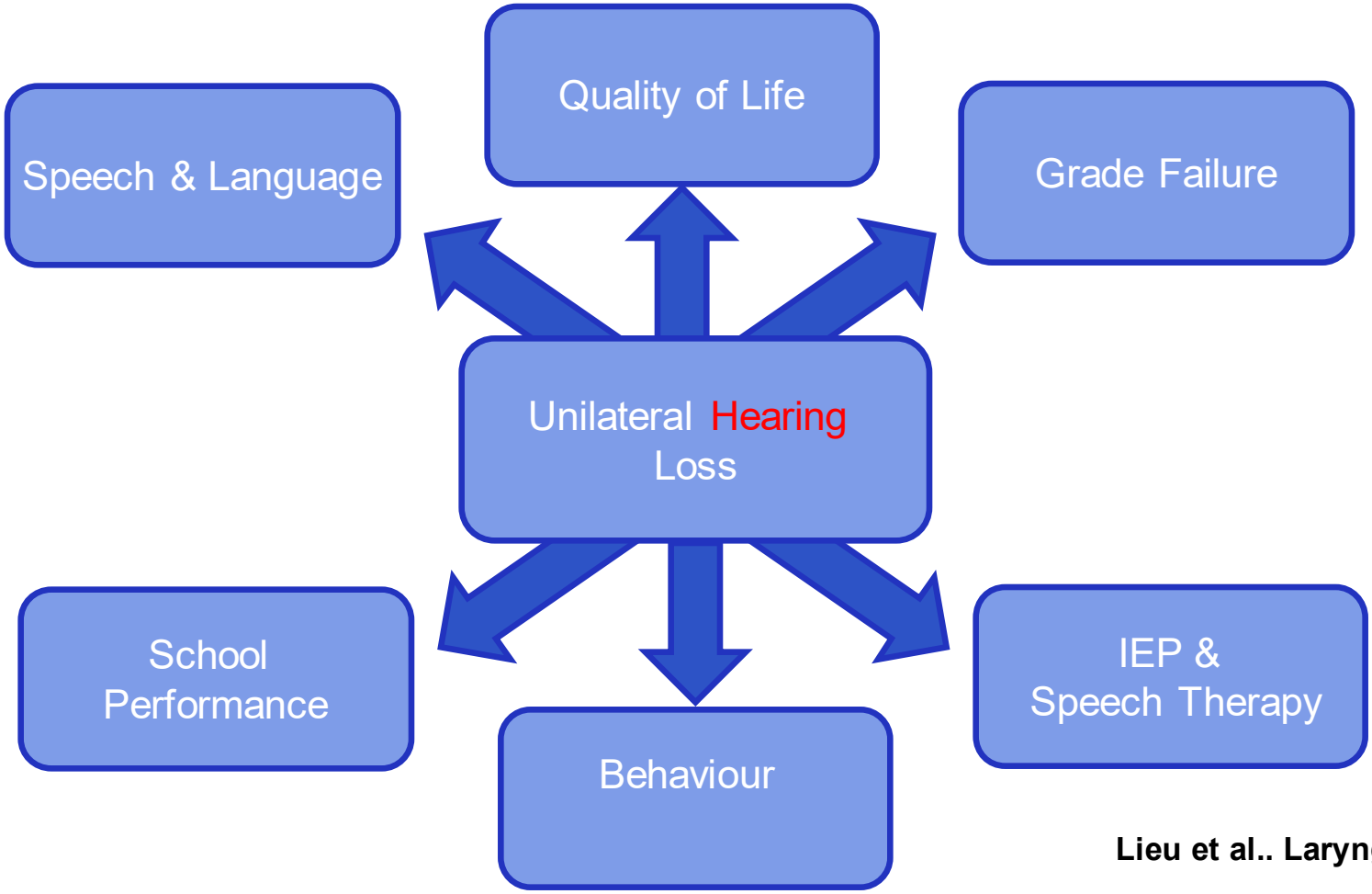
Unilateral Hearing Loss Has Impact

- 1/3 failed at least one grade
- 50% failed a grade or needed additional resources at school



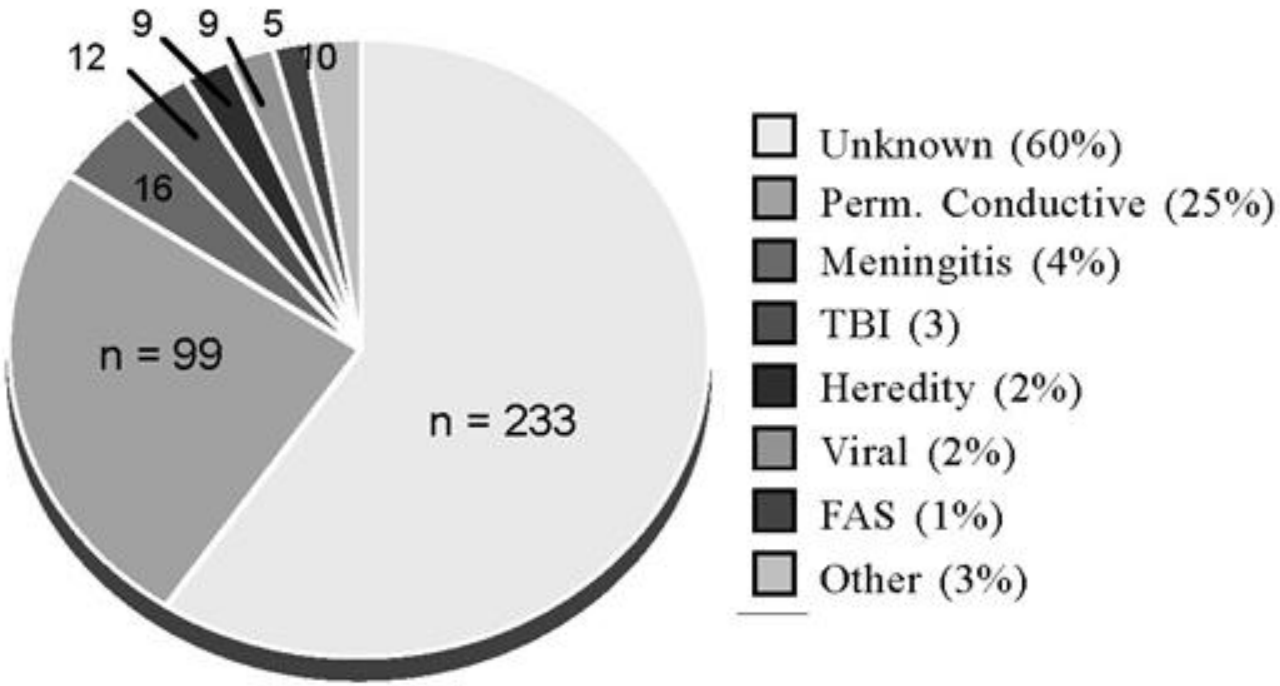
Bess and Tharpe, Int J Pediatr Otorhinolaryngol. 1991

Consequences of SSD in Children



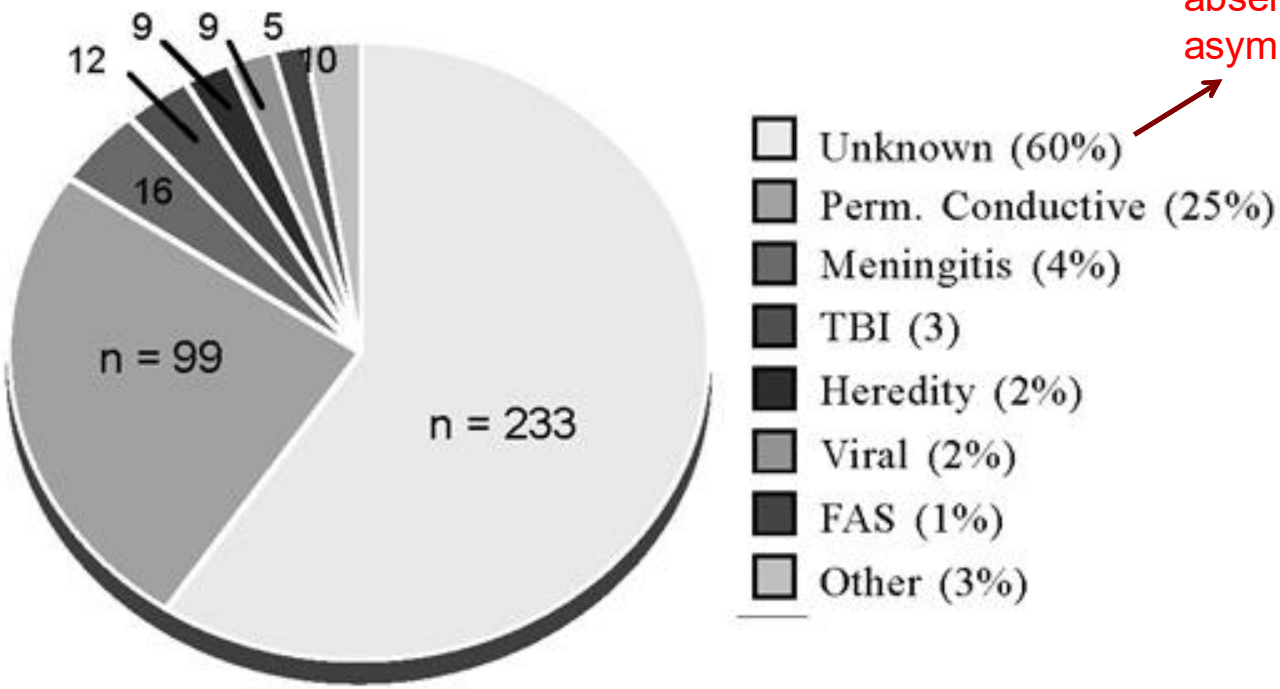
Lieu et al.. Laryngoscope. 2012

Etiology of SSD circa 1990



English et al, LSHSS 1999

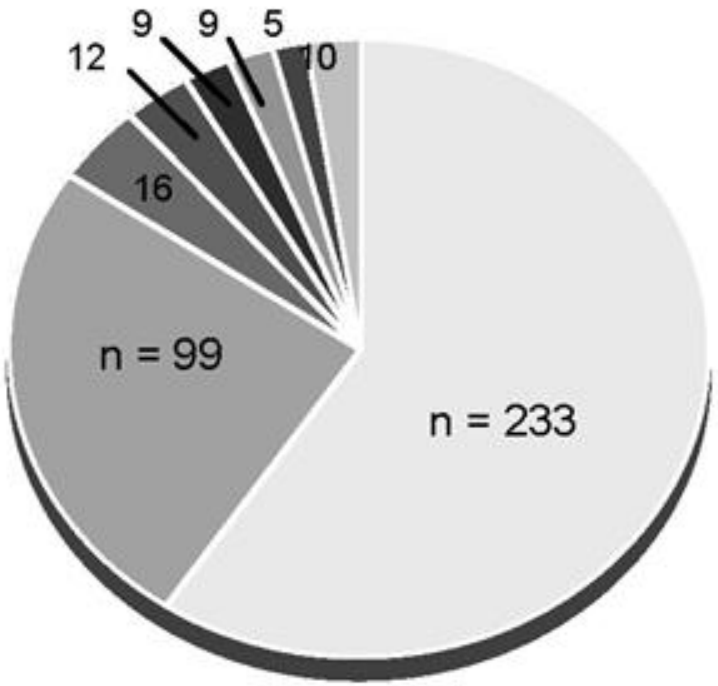
Etiology of SSD circa 1990



absent cochlear nerve
asymptomatic cCMV

English et al, LSHSS 1999

Etiology of SSD circa 1990



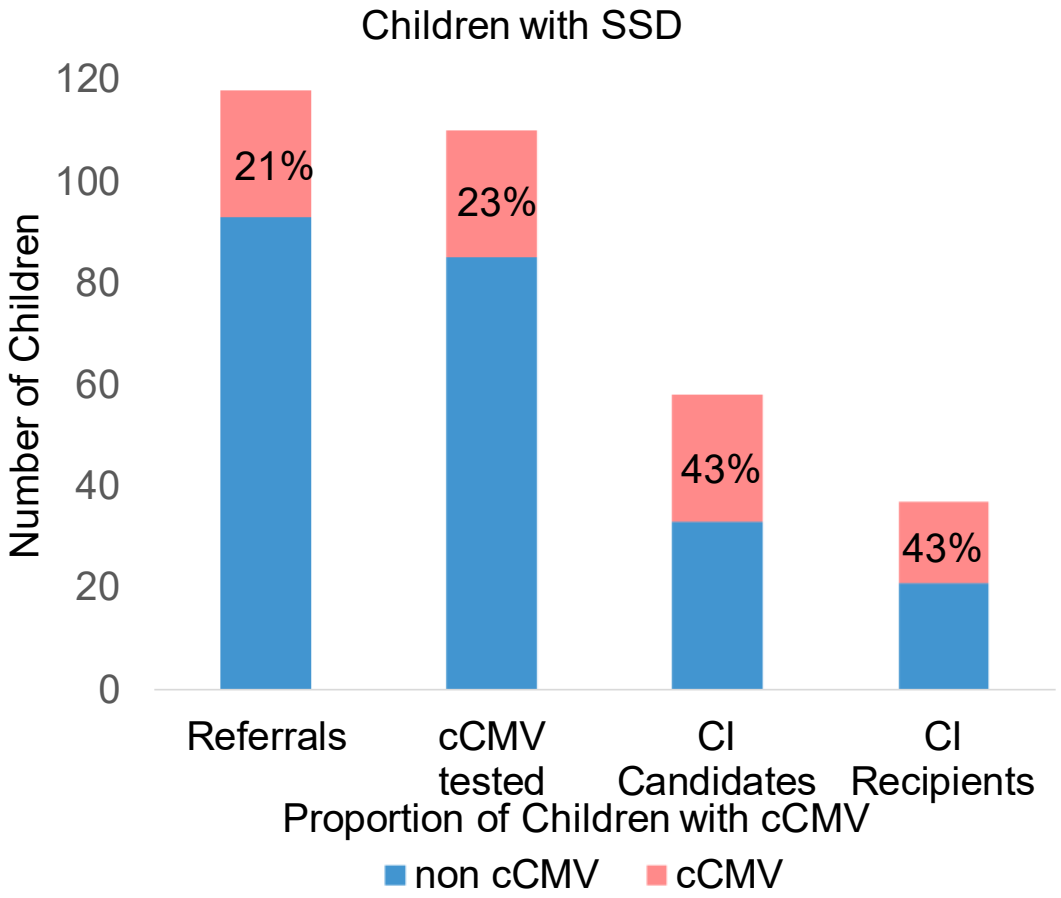
Unknown (60%)
Perm. Conductive (25%)
Meningitis (4%)
TBI (3)
Heredity (2%)
Viral (2%)
FAS (1%)
Other (3%)

absent cochlear nerve
asymptomatic cCMV

symptomatic CMV

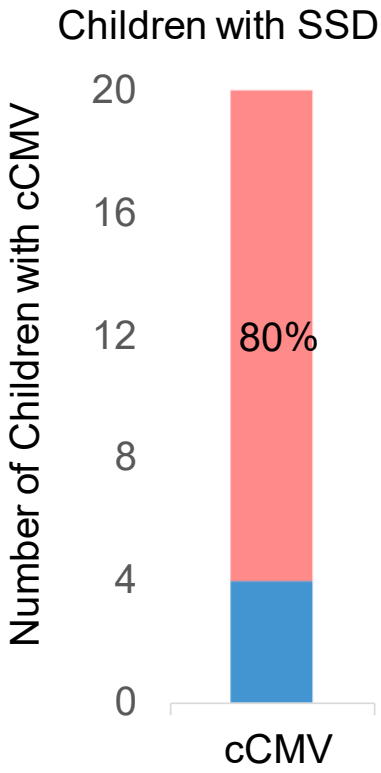
English et al, LSHSS 1999

cCMV is Common in SSD



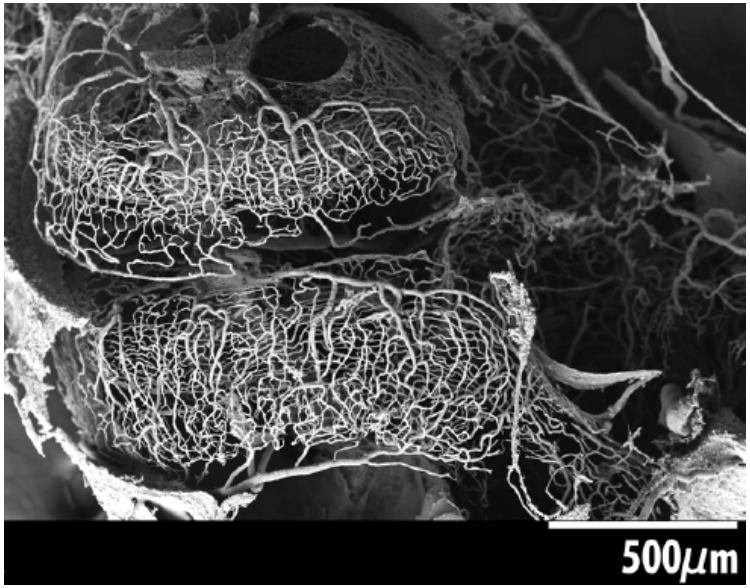
HNO. 2019

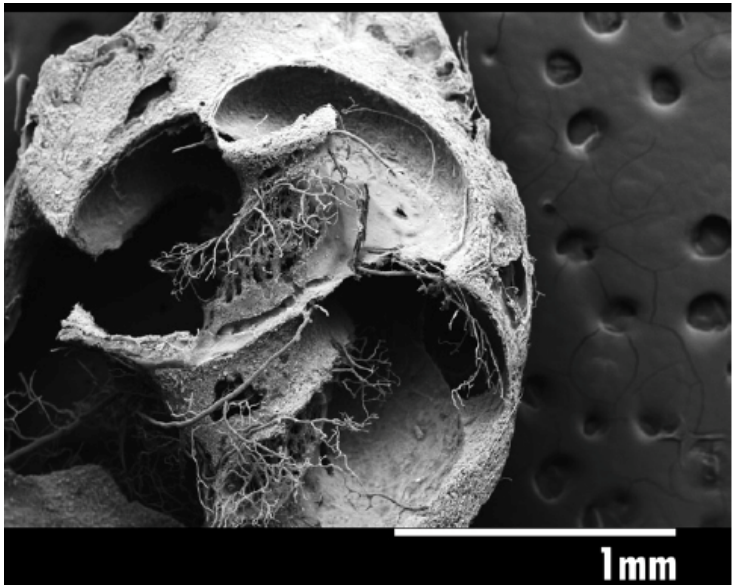
Children with cCMV Proceed to Implant



HNO. 2019

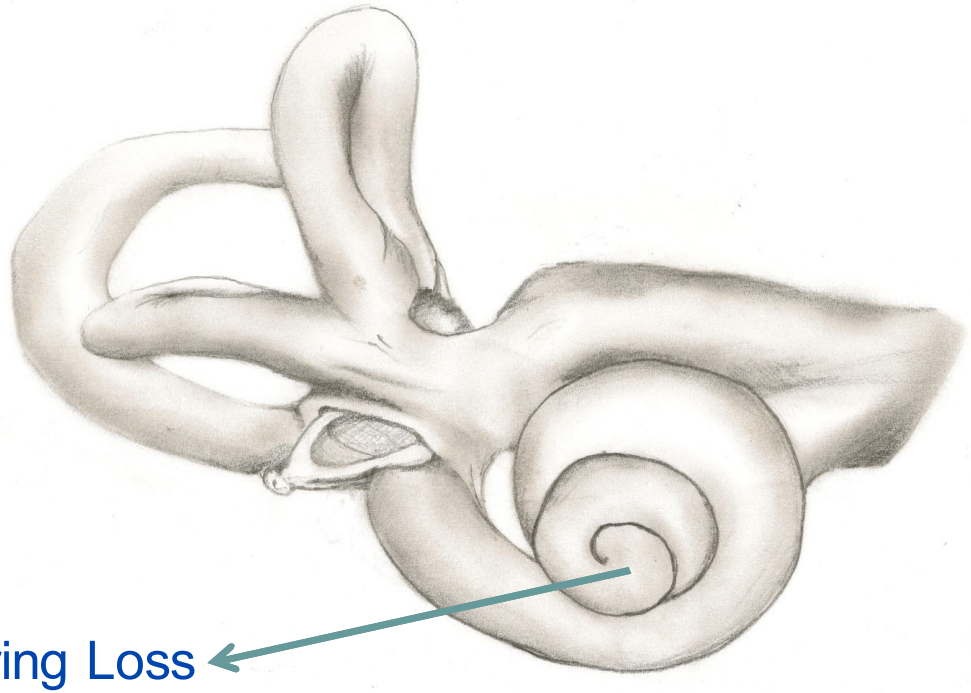
Congenital Cytomegalovirus





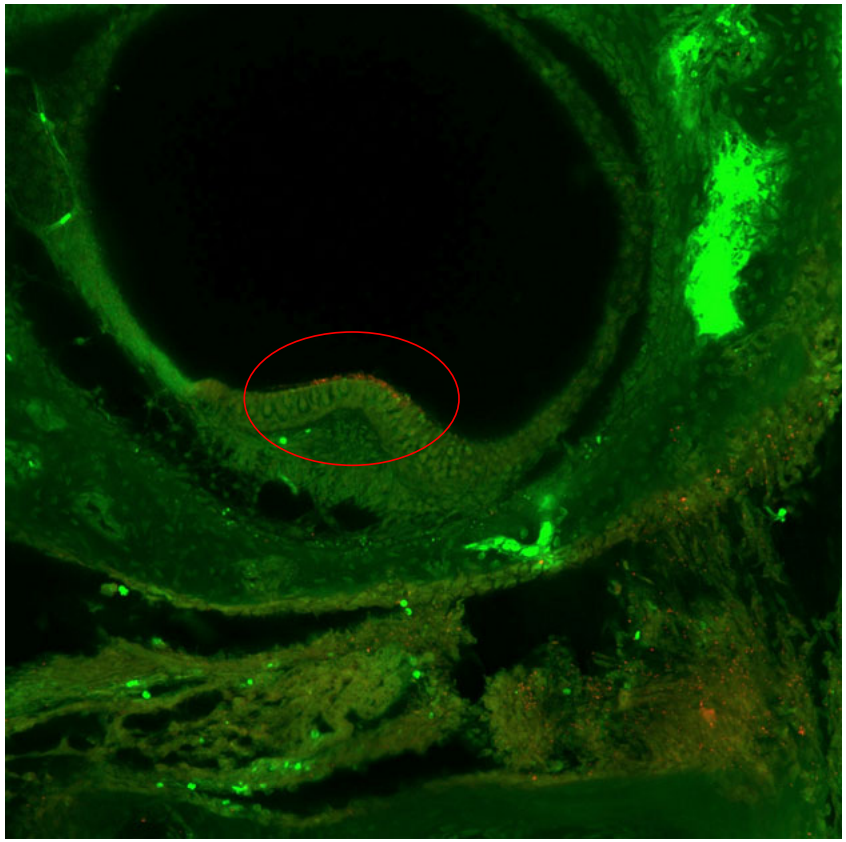
photos courtesy of Dr. Robert Harrison

Congenital Cytomegalovirus



20-50% Sensorineural Hearing Loss

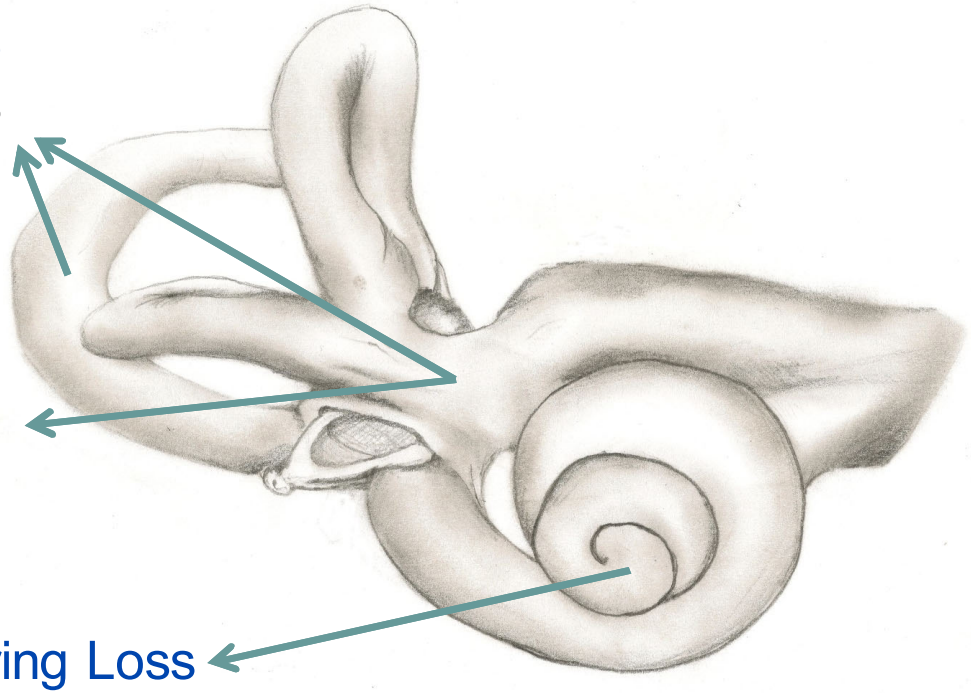
Congenital Cytomegalovirus



photos courtesy of Dr. Robert Harrison

Congenital Cytomegalovirus

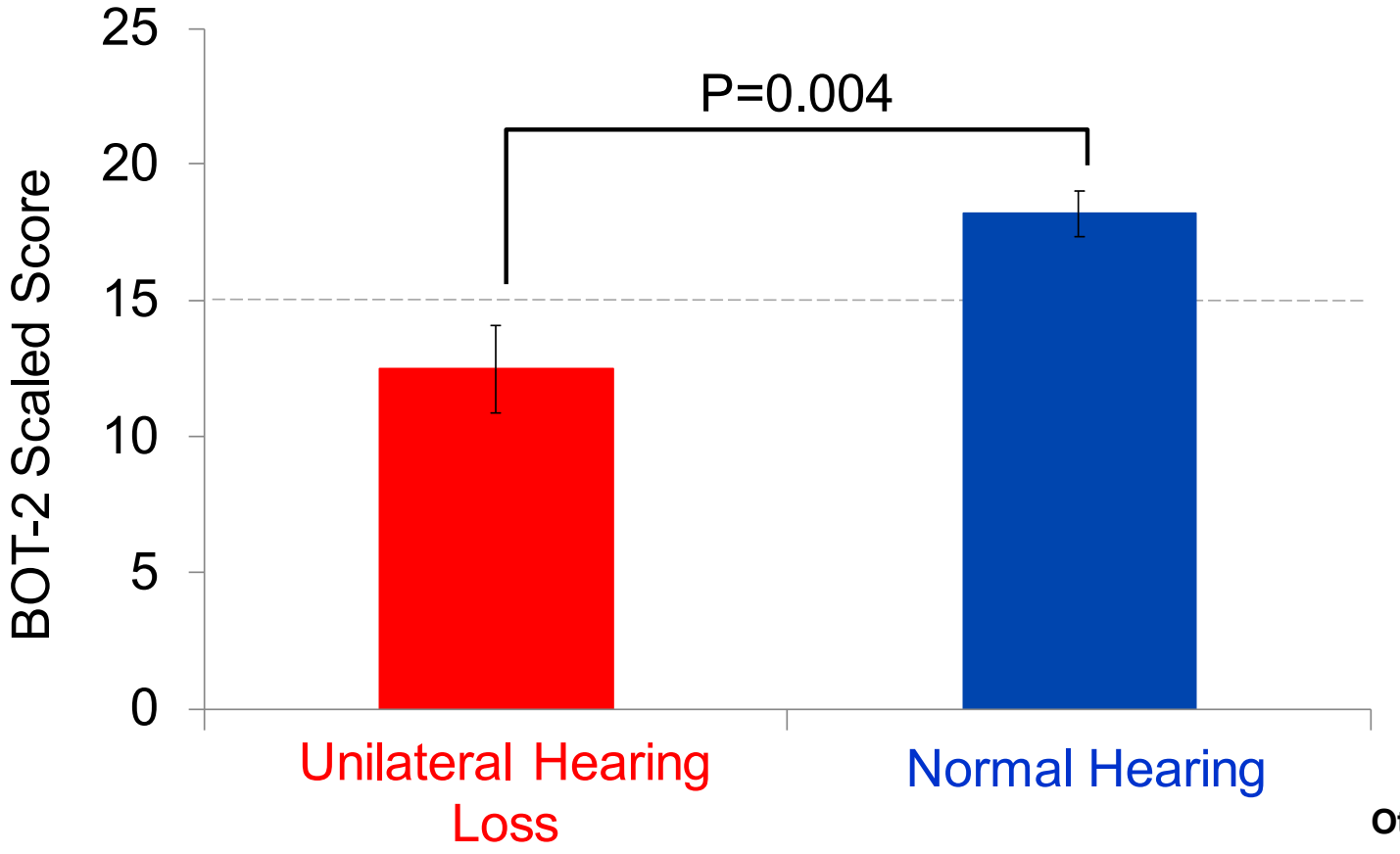
92% Vestibular end-organ Dysfunction
33% Complete Bilateral Loss
50% Progressive
Bernard et al. Pediatrics. 2015



50% Otolithic Dysfunction
cVemp
Maes, Ear & Hearing. 2016

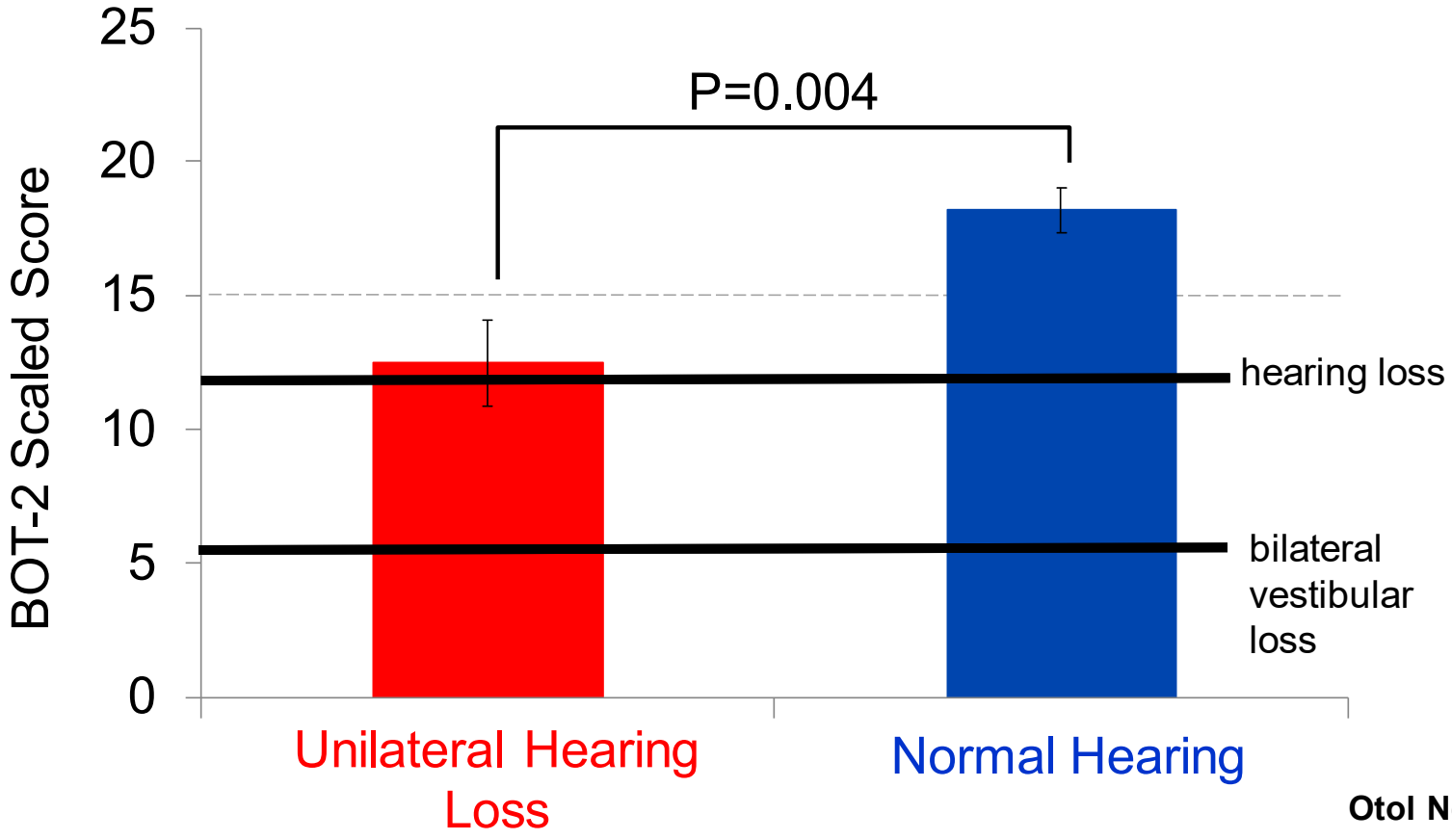
20-50% Sensorineural Hearing Loss

Balance is Impaired in SSD



Otol Neurotol. 2016

Balance is Impaired in SSD

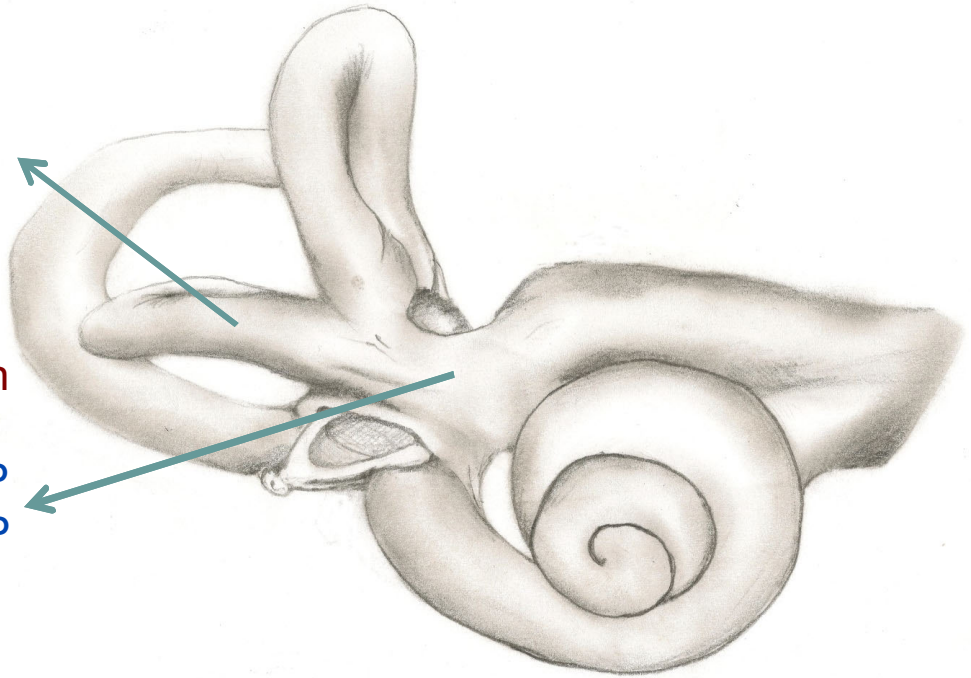


Otol Neurotol. 2016

Vestibular Dysfunction in SSD

Horizontal Canal Dysfunction
48% Caloric Reduction
50% VOR loss vHIT

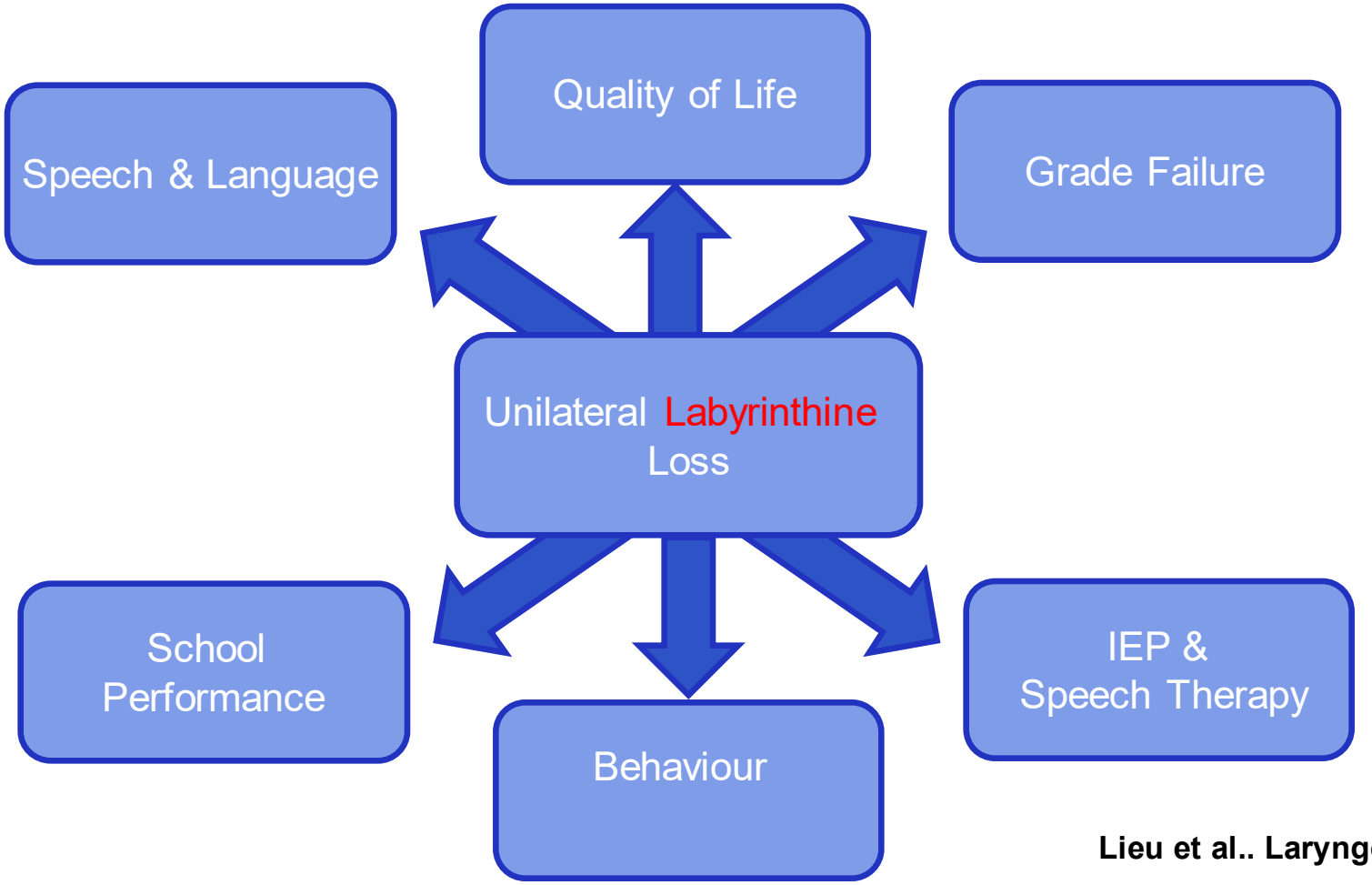
Otolithic Dysfunction
62.5%
Utricular 42% oVEMP
Saccular 25% cVEMP



N = 20

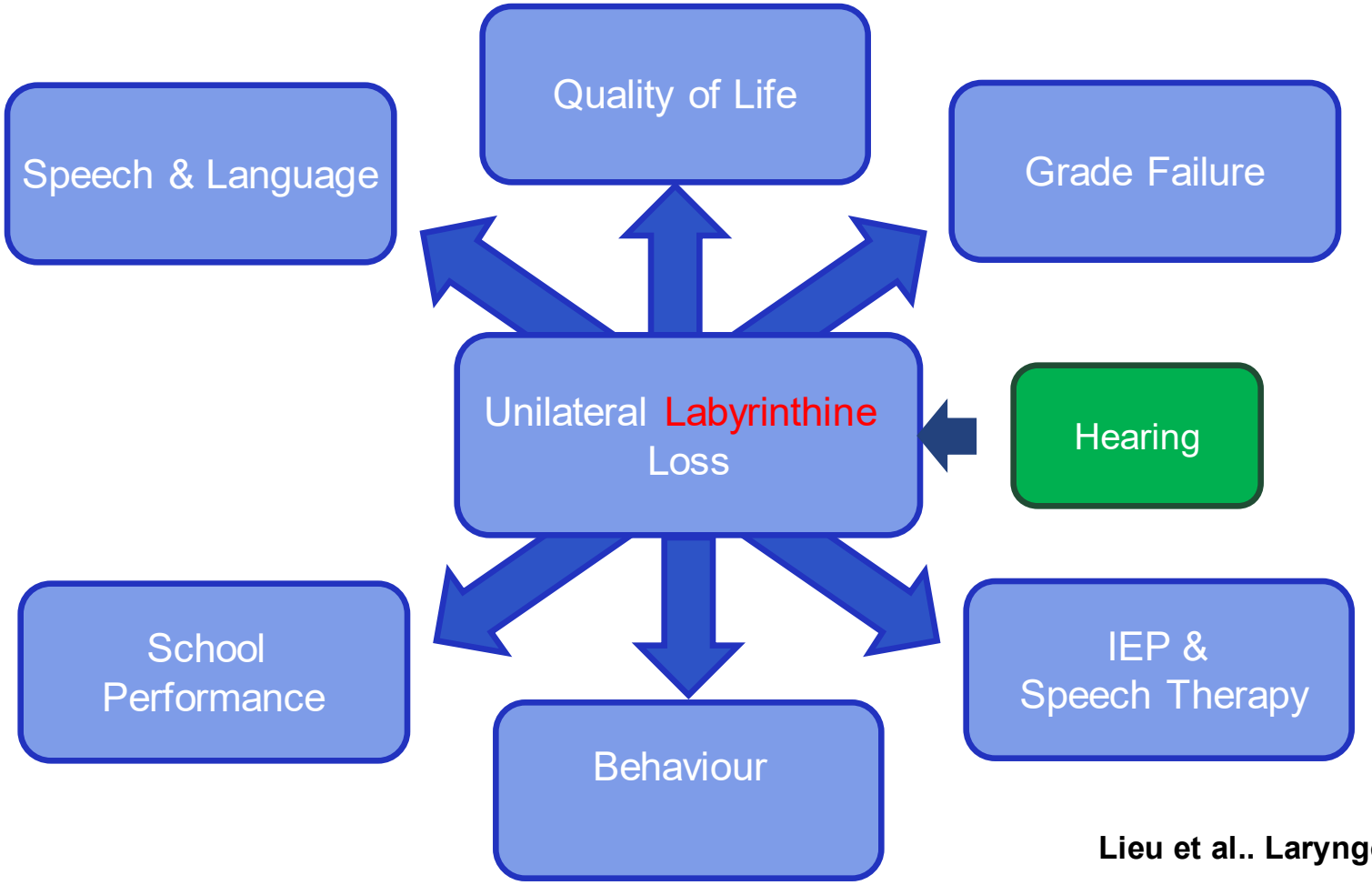
Hear Res. 2018

Consequences of SSD in Children



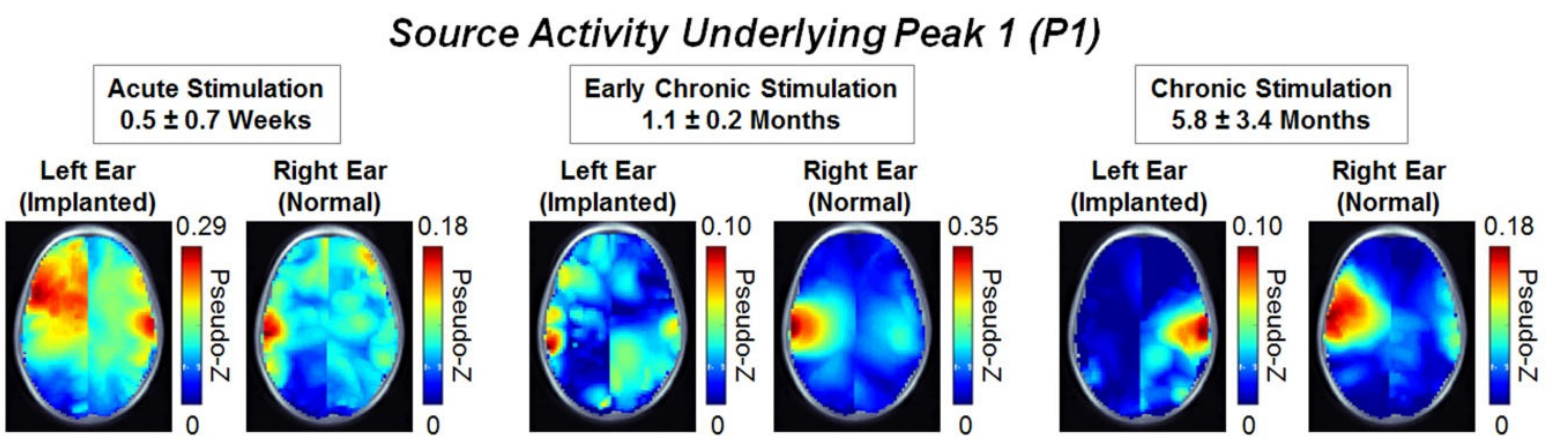
Lieu et al.. Laryngoscope. 2012

Consequences of SSD in Children



Lieu et al.. Laryngoscope. 2012

Aural Preference Restored



Sci Rep. 2017

Summary

- sensory deficits lead to impairment
  - performance and development
- implants restore sensation
  - limits
  - compensation with effort
  - cross-modal?
- outcomes are complicated
  - extend beyond hearing & language
  - many gaps in knowledge exist

What Drives Plasticity in Children?

What Drives Plasticity in Children?

CAA Conference 2021

Delta Grand Marriott Hotel, Kelowna, B.C.

Save the date: October 13-16, 2021 in Kelowna, B.C.

Upcoming and On Demand Webinars

canadianaudiology.ca/webinars/

- Therapeutic Techniques for Counseling Complex Patients with Hearing Challenges and Their Families with Michael Hoffman - Nov 12
- Measuring and Understanding Tinnitus - including patients views on the 'Meaning of Life' with Richard S.Tyler Nov 19th
- Adult amplification and Aural Rehabilitation with Gurjit Singh - Nov 24th
- Audibility-based Hearing aid Candidacy for Children with Ryan McCreery Nov 10th

CAA Canadian Academy of Audiology
Heard. Understood.

Academie canadienne d'audiologie ACA
Entendus. Compris.

Thank you