

# Auditory processing disorder in children

## Nature and assessment

Dave Moore/Lisa Hunter

Communication Sciences Research Center, Cincinnati Children's Hospital  
Department of Otolaryngology, University of Cincinnati College of Medicine

With thanks to:

CSRC: Andrew Dimitrijevic, Molly Grainger, Stephanie Sieswerda, Mike Smith  
MRC IHR: Johanna Barry, Mark Edmondson-Jones, Mel Ferguson, Oliver Zobay



# People often listen in Noisy reverberant environments



# Listening difficulties with 'normal' hearing (aka: Auditory processing disorder - APD)

## **Clinical presentation: No audiometric hearing loss, but**

- Distractibility; impaired attention

“if there is any noise (TV, others talking) she is unaware that she is being spoken to...”

- Academic and communication difficulties

“he has difficulty understanding information and directions”

These reports could equally apply to many learning problems in children that often persist in adults (e.g. SLI, dyslexia, ADD, ASD)

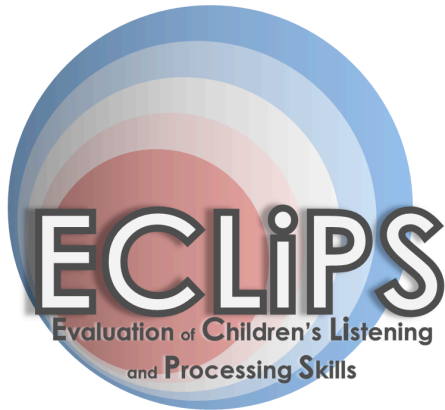
1. What problems do these children have?

2. Are the problems due to undiagnosed/  
subclinical hearing loss or higher level, cognitive  
dysfunction?



(Quotations thanks to Dr Lisa Hunter)

# ECLiPS – Capturing the clinical presentation



- Checklist for parents
- High reliability and validity
- Short (38 items, 5 domains, 5 mins)
- Broad applicability
- Standardized for age and gender

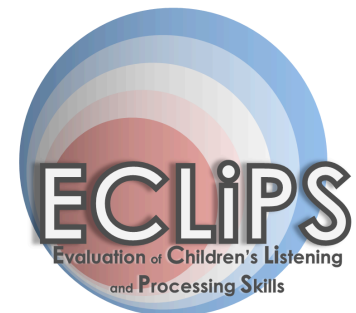
SA Strongly Agree	A Agree	NAD Neither agree nor disagree	D Disagree	SD Strongly Disagree
-------------------------	------------	--------------------------------------	---------------	----------------------------

Statement	SA	A	NAD	D	SD
1. Example statement - Struggles to hear at times		✓			

# ECLiPS – Capturing the clinical presentation

## **Barry, Tomlin, Moore & Dillon (2015) Questionnaires in the assessment of listening difficulties in children. Ear and Hearing, 2015**

- 3 groups of 7-12 y.o.: 1 x 'Typical' (TD), 2 x 'Clinical' (AP-, AP+) groups. All groups given questionnaires and tests of AP and cognition
- The clinical groups (AP+, AP-) did not differ in presenting symptoms. AP- group had higher NVIQ and better attention than AP+ group
- ECLiPS and 3 other questionnaires (Fisher's, TEAP, LIFE) correlated highly
- **ECLiPS was more efficient than AP measures in separating the TD children from the clinical children**
- ECLiPS sub-scales correlated highly with cognitive scores. ECLiPS could be a rapid screen for cognitive difficulties

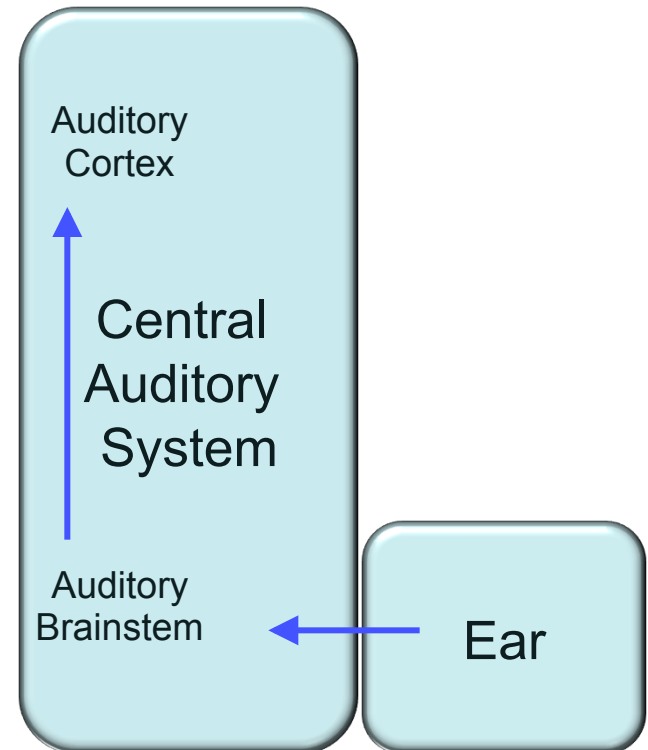


Flyer: <http://www.ihr.mrc.ac.uk/downloads/eclips/ECLiPS.pdf>

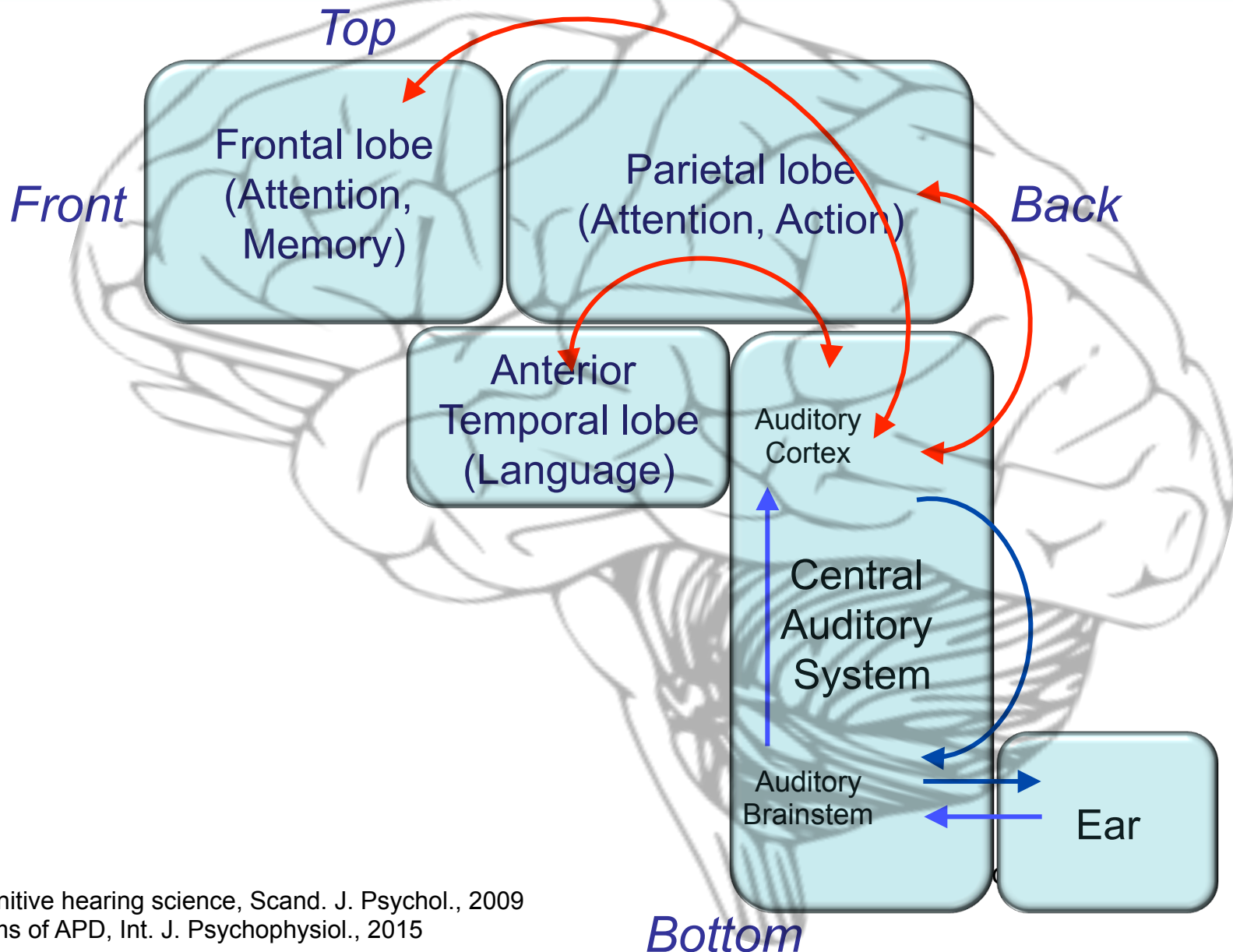
Enquiries: [Johanna@ihr.mrc.ac.uk](mailto:Johanna@ihr.mrc.ac.uk)

(Barry, J.G. and Moore, D.R. Evaluation of Children's Listening and Processing Skills, London: MRC-T, 2014)

# The auditory brain



# The 'real' auditory brain

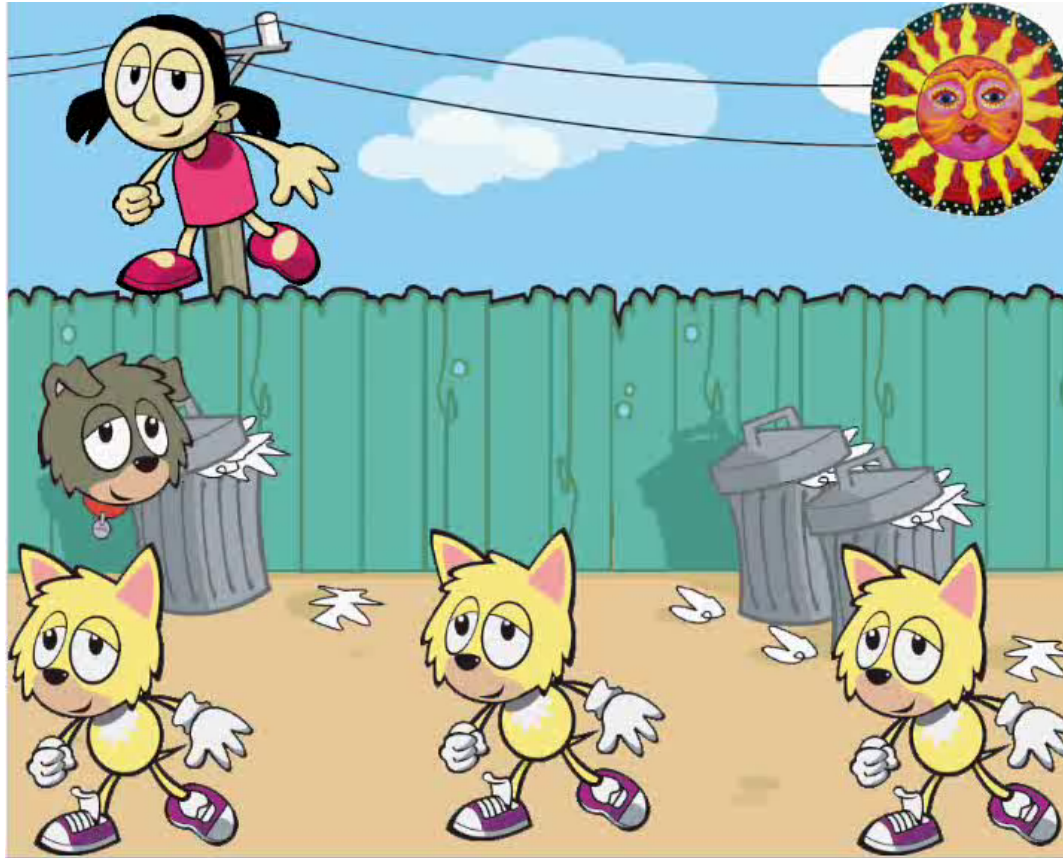


See:

Arlinger et al. Cognitive hearing science, Scand. J. Psychol., 2009

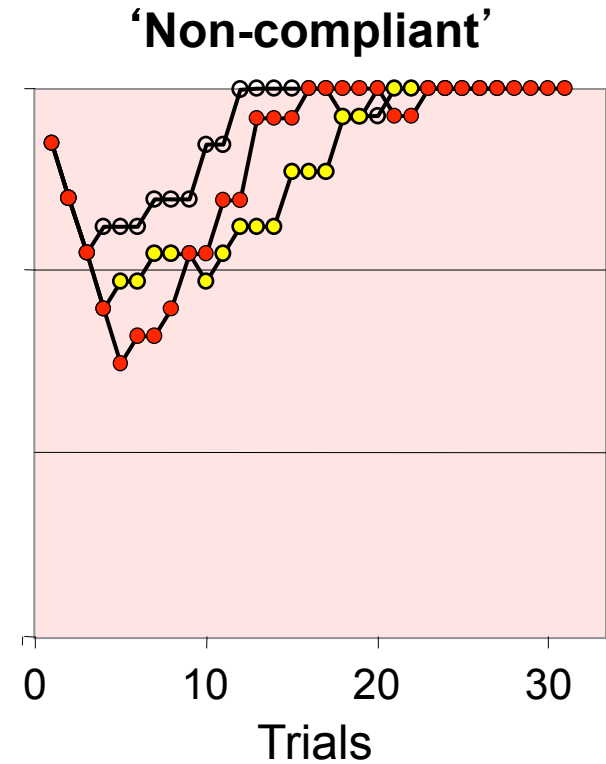
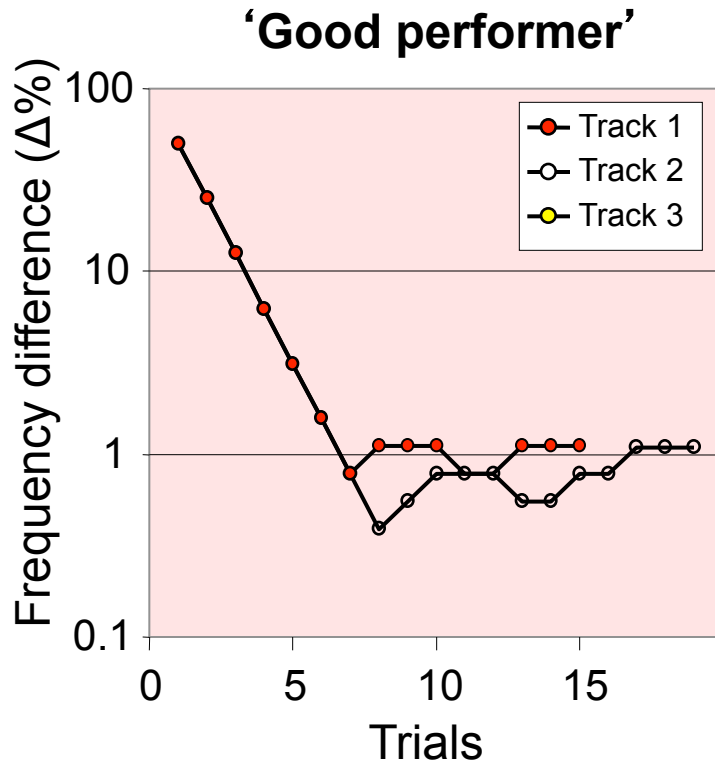
Moore, Mechanisms of APD, Int. J. Psychophysiol., 2015

# Sensory and cognitive contributions to listening



All hearing tasks involve multiple skills including attention, memory, action (mental, motor), and sensory integration

# AP performance



(typical children - 8-9 y.o. - frequency discrimination)

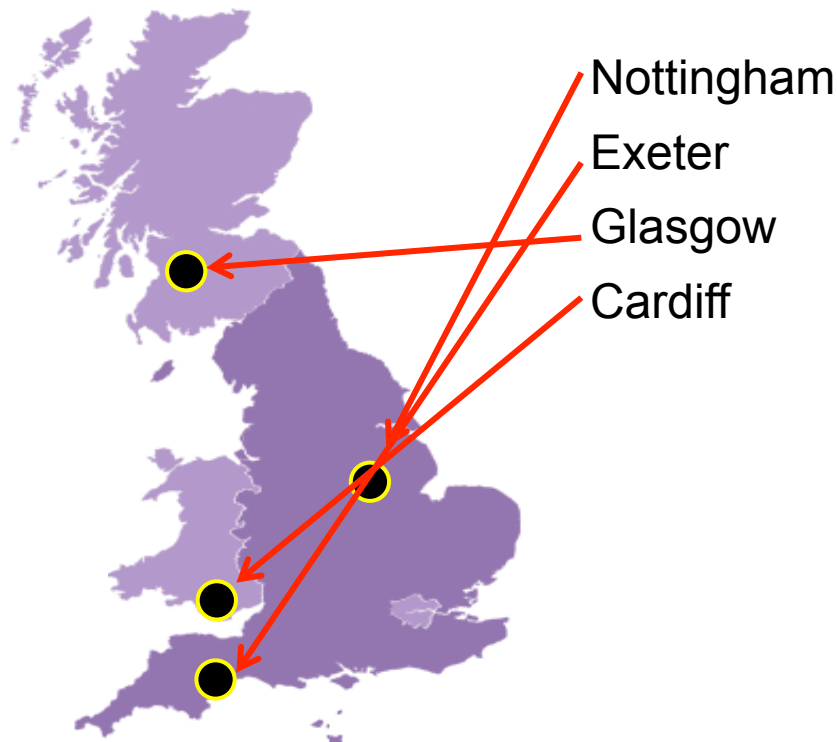
# Auditory processing in children

## The 'IMAP' study

### Are listening difficulties due to poor auditory perception?

n = 1638 unselected children, 6-11 y.o.

Stratified by age, sex and socioeconomic group



**Tests** (in schools, 1 hour):  
Audiometry  
Auditory processing (AP)  
Speech-in-noise  
Cognitive  
Parent questionnaires

MRC

Institute of  
Hearing Research

# Sensory and cognitive contributions to listening



Multiple regression,  $\approx 200$  variables

Proportion of known variance (19-24%)

<u>Test:</u>	Communication (CCC-2 GCC)	Listening (CHAPPS)	Speech-in-noise (VCV)
Cognitive	33%	32%	40%
AP variability	38	42	20
AP threshold	8	5	4
Demographics	21	16	16

**Conclusion: APD is due to poor auditory attention**

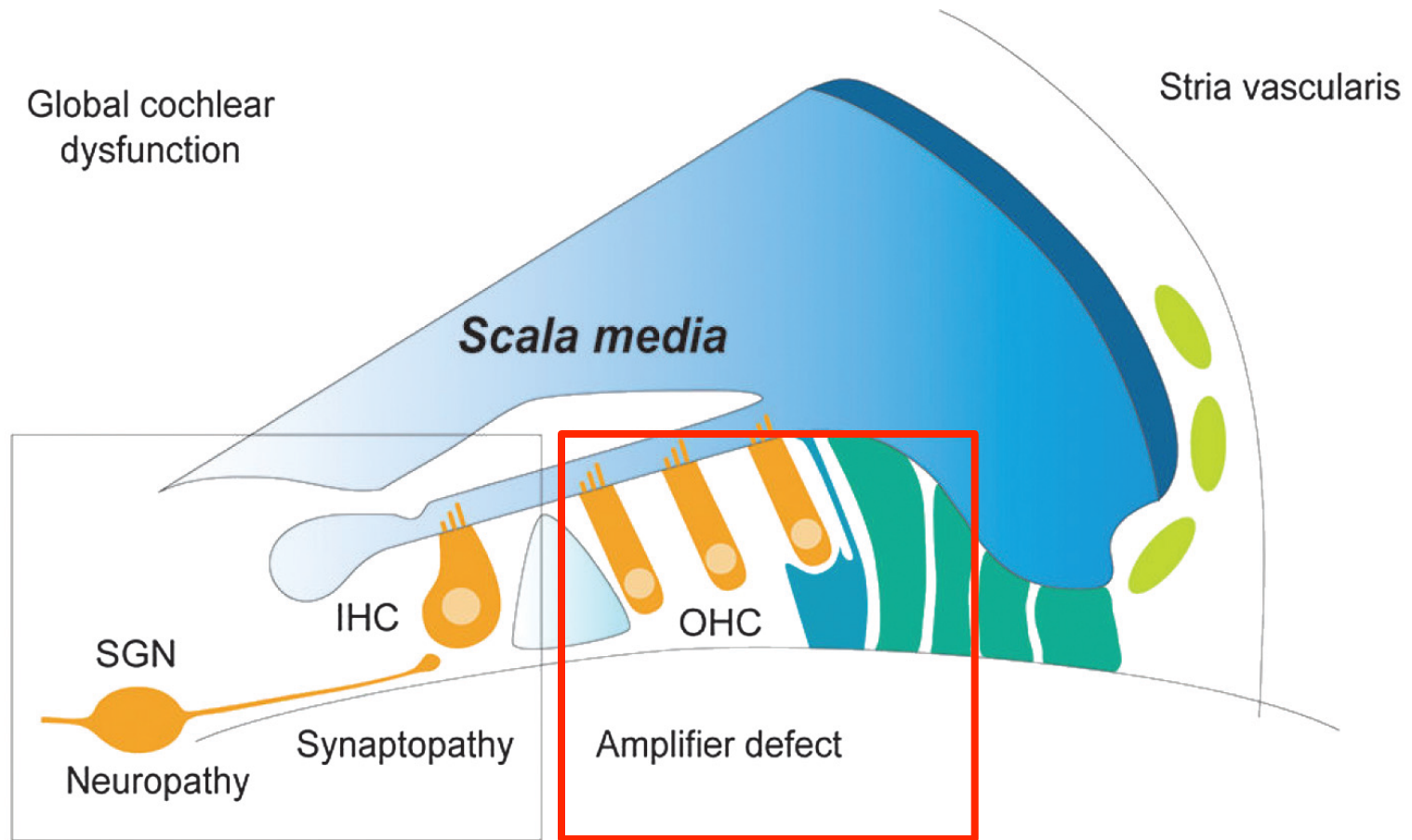
**BUT . . . can we rule out lower  
auditory system involvement?**

MRC

Institute of  
Hearing Research

(adapted from Moore et al., Pediatrics 2010)

# 'Hidden hearing loss' (HHL)



# Otoacoustic emission (OAE) in teenagers

## The Clark Montessori study

n = 382 students, 14-18 y.o., High school in Hyde Park, Cincinnati  
All students had 'Normal' hearing

**Tests:** Questions, Otoscopy, Screen audiogram, Distortion product OAEs (DPOAE; 2-5 kHz), Tympanometry

### Questions

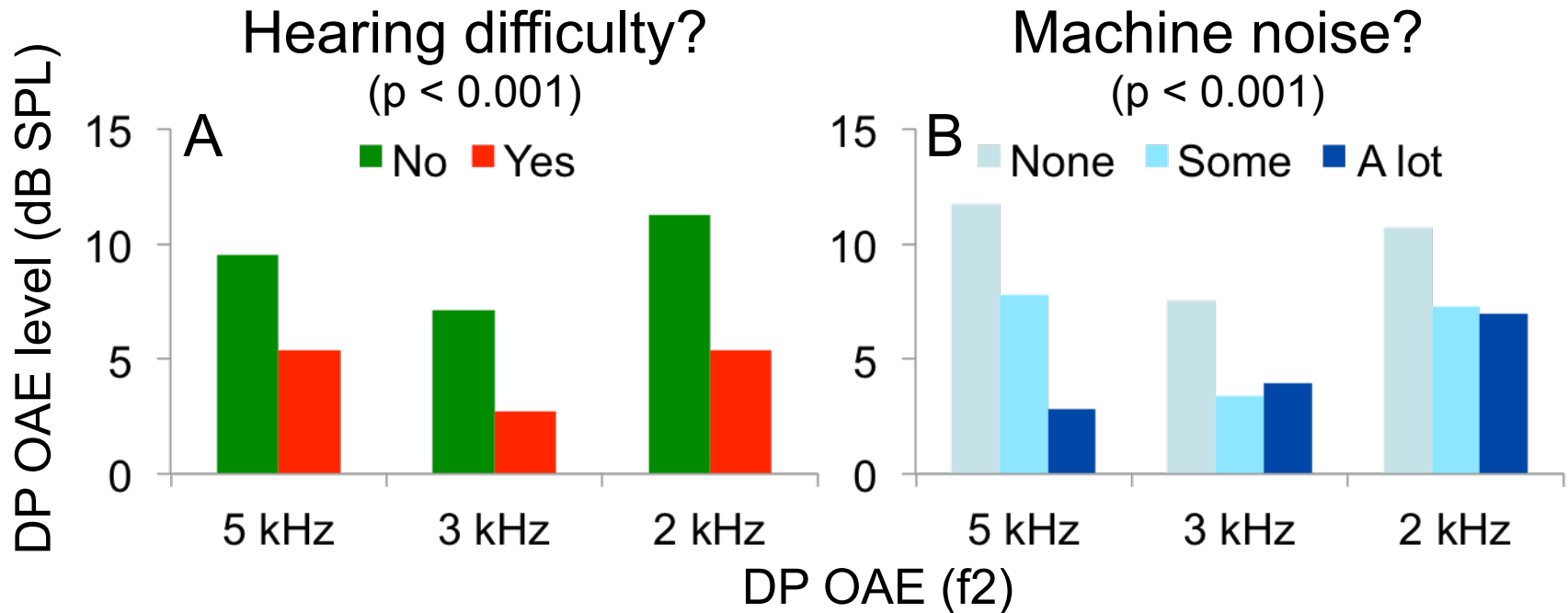
Q12. Do you currently have any difficulty with your hearing? (Yes: 13%)

Q18. Have you ever gone to car or motorbike races or used jet skis, snowmobiles, or lawnmowers? (>3 per year: 20%)

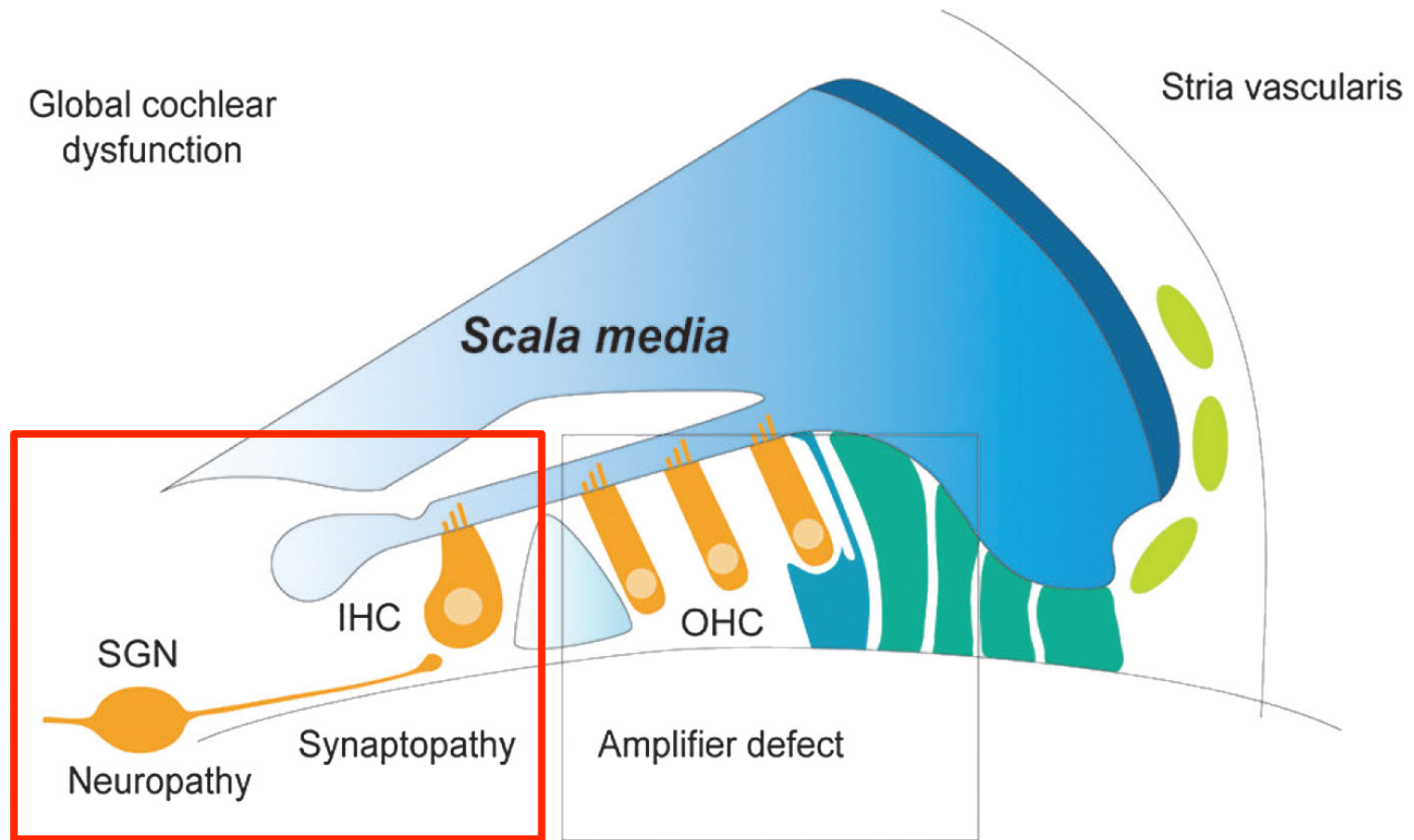
Q16. How often do you get tinnitus (noise in your head or ears) that lasts for more than 5 minutes? (Sometimes, usual, constant: 13%)

- All  $p < 0.01$  negative correlation with DPOAE amplitude

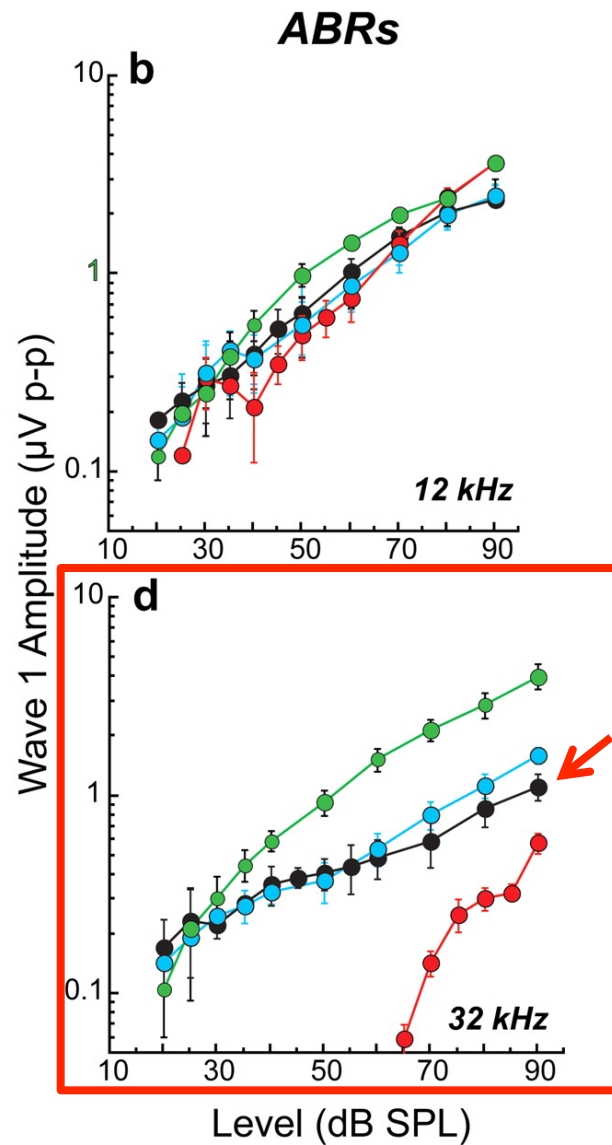
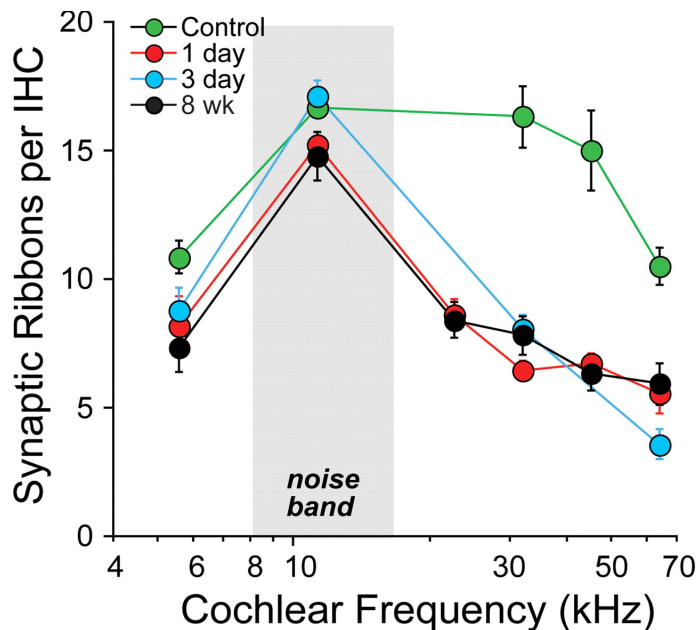
# OAE defects in teenagers with 'normal' hearing



# ‘Hidden hearing loss’ (HHL)?

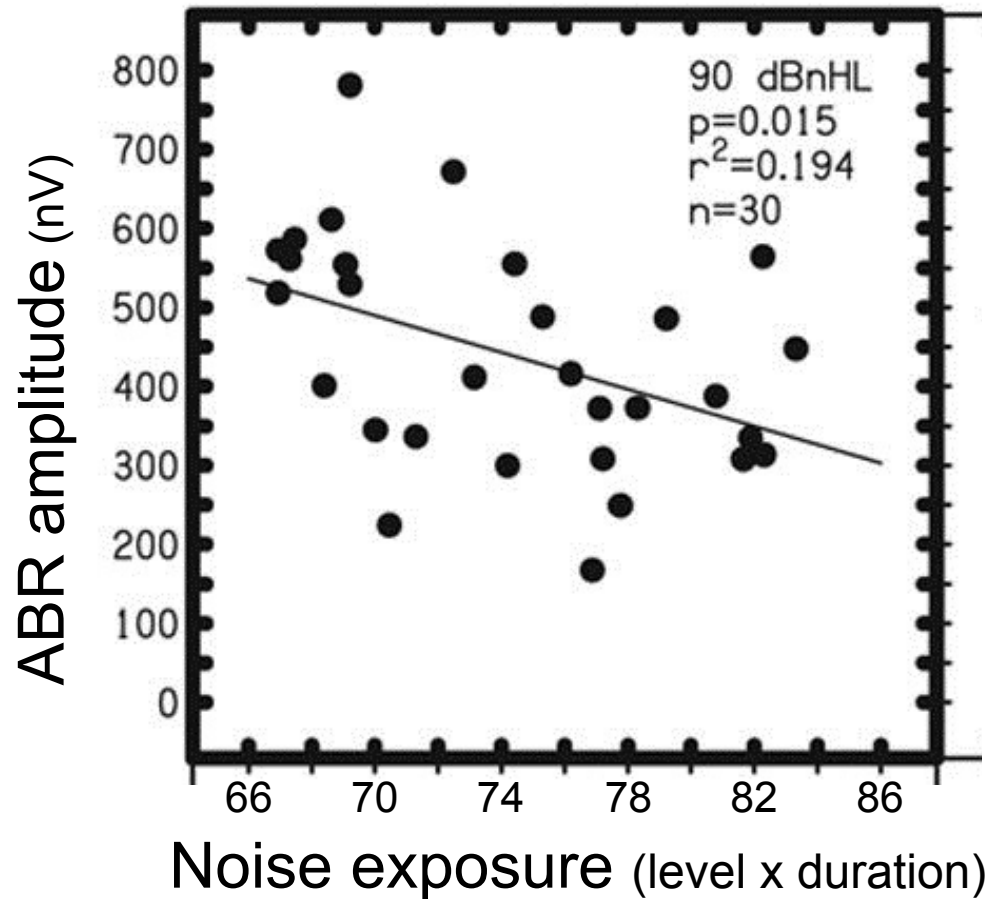


# 'Hidden hearing loss' (HHL)



(from Kujawa and Liberman, J. Neurosci, 2009)

# Evidence for HHL in 'normal hearing' adults

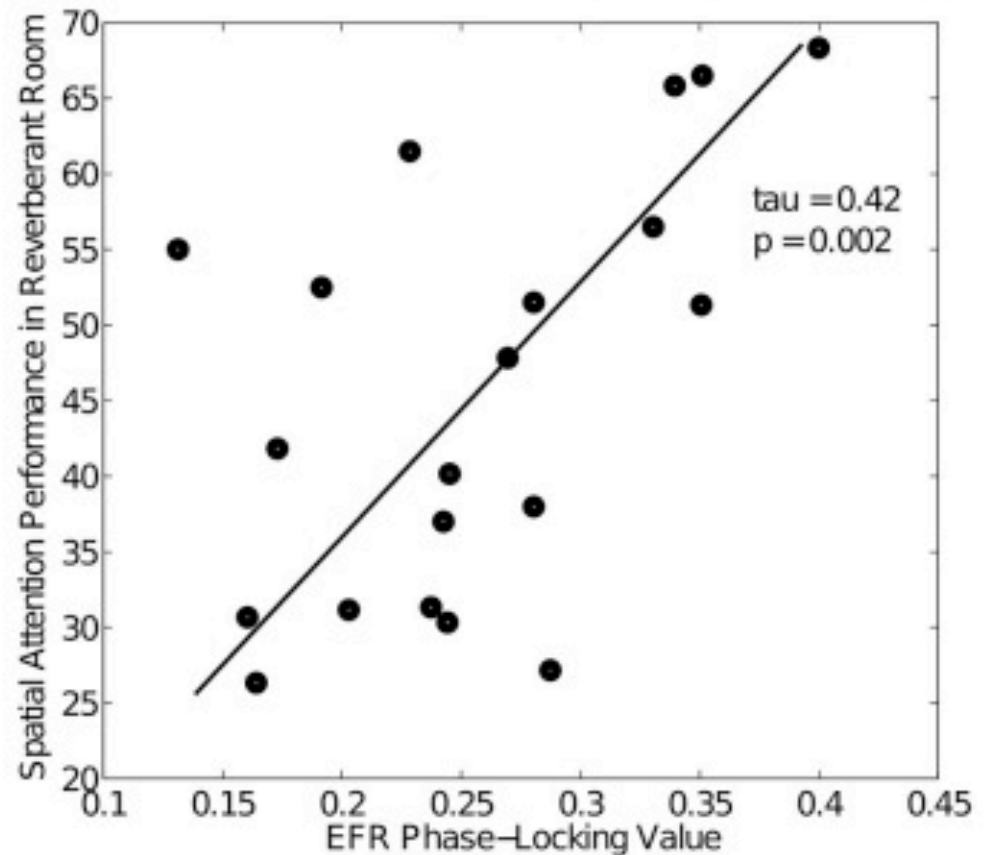
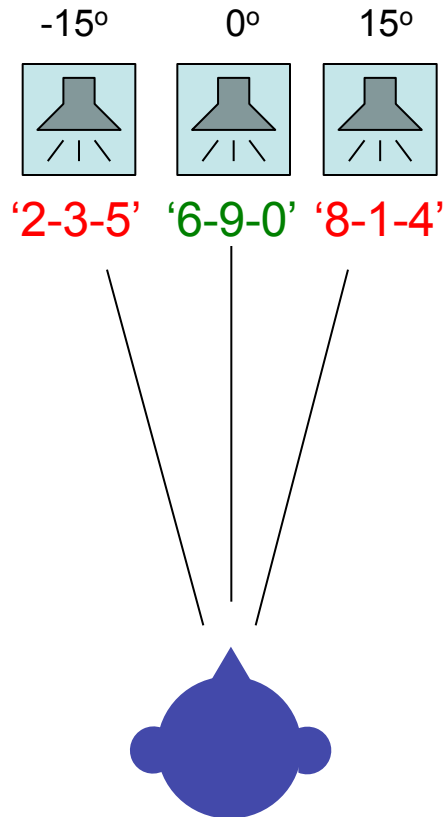


Auditory brainstem response (ABR) reduced after noise exposure

(from Stamper and Johnson, Ear Hear., 2015)

# Evidence for HHL in 'normal hearing' adults

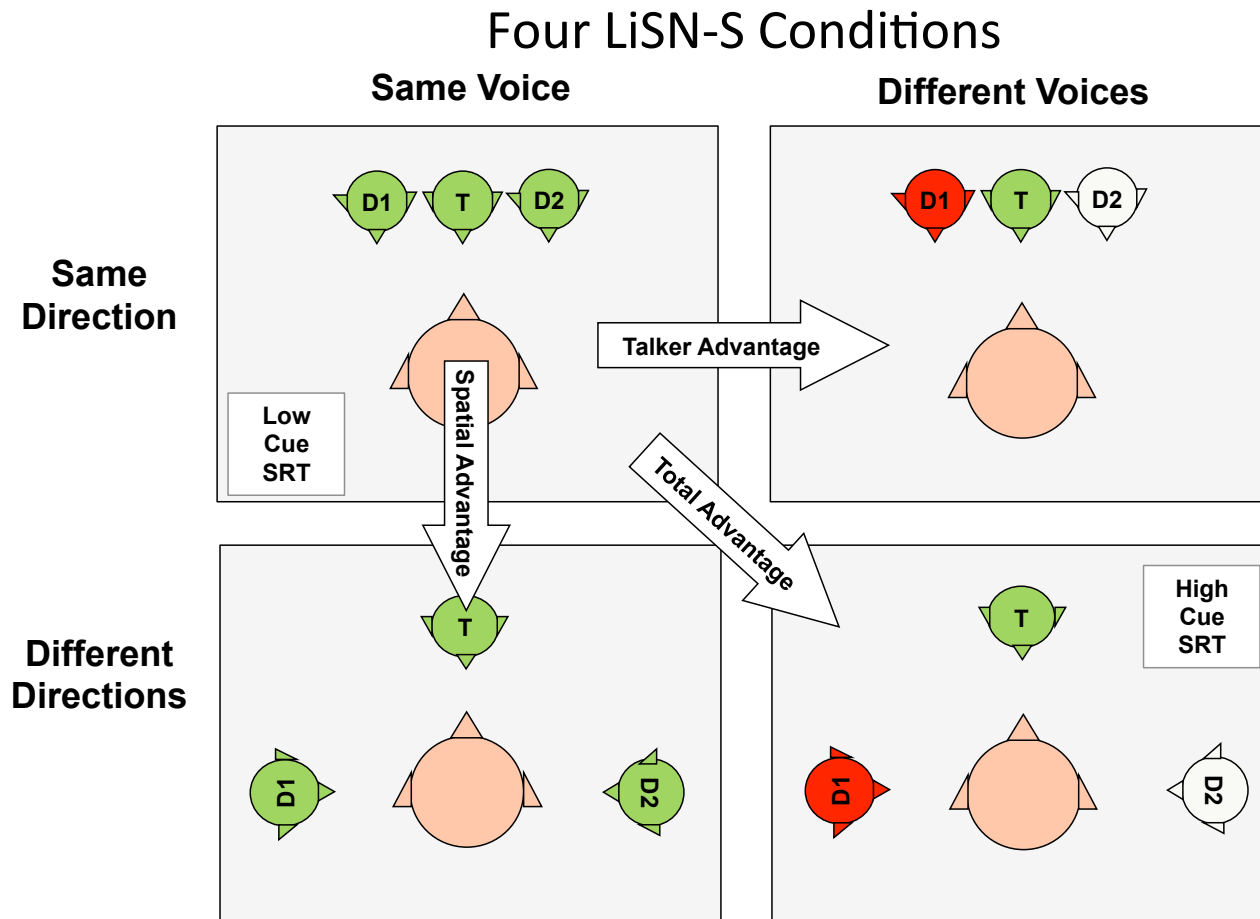
## Spatial attention task



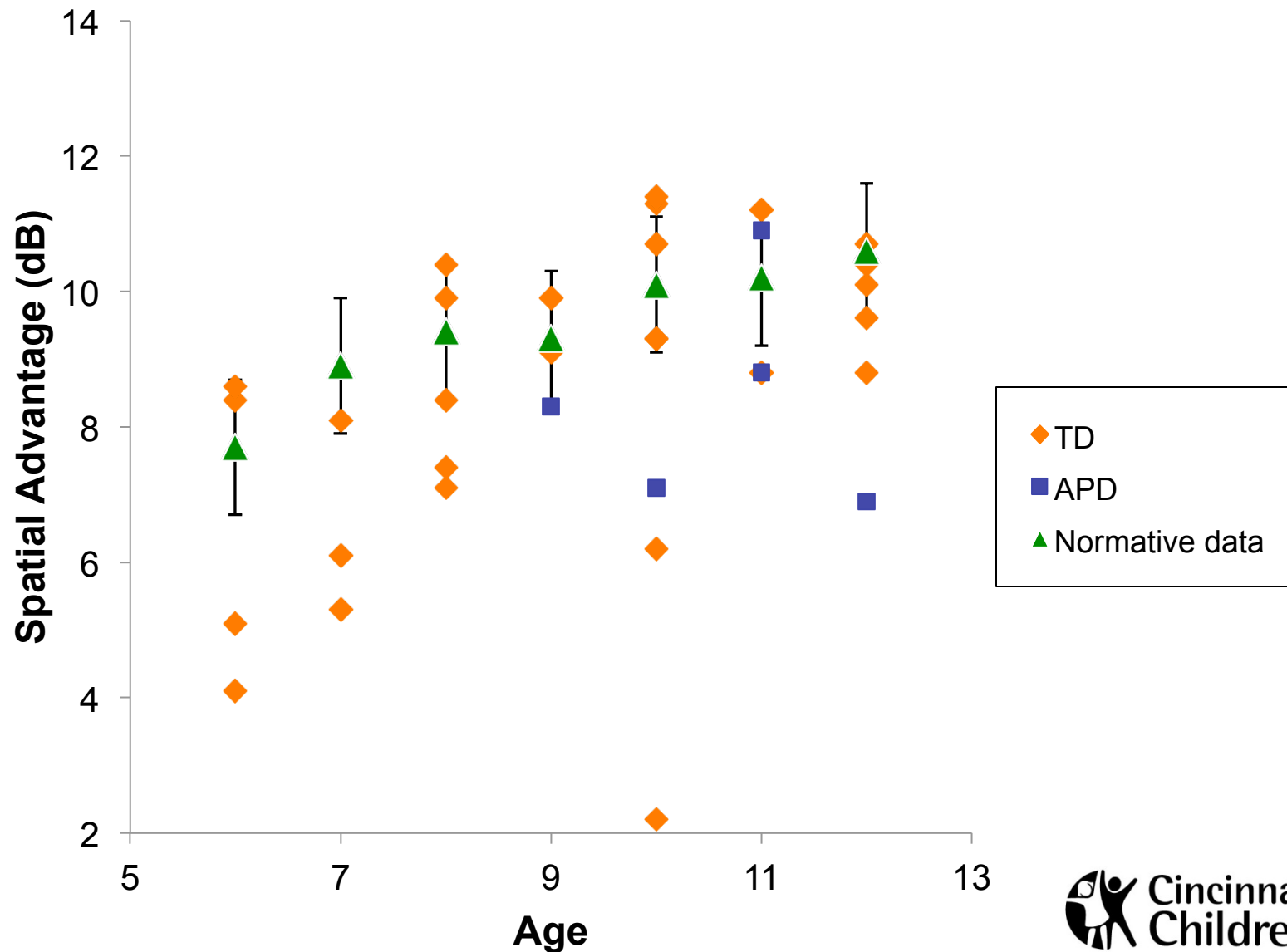
Spatial attention related to brainstem envelope following response (EFR)

(from Bharadwaj et al., Front. Neurosci. 2014)

# Speech hearing in noise: LiSN-S



# Speech hearing in noise: LiSN-S



# Summary

- People with normal audiograms may have listening difficulties and poor performance on tests of auditory perception
- Listening difficulties may be bottom-up (e.g. HHL), but in most cases appears to be due to a top-down cognitive deficit
- New tests of brainstem physiology and speech-in-noise hearing may identify targets for specific prevention or other interventions
- These same issues and strategies may be relevant to listening difficulties found in other disorders (SLI, ADHD, ASD)

# Evaluating statements about APD

What is the evidence?

Is that evidence relevant to hearing/listening?

