

Environmental influences on language development in children with hearing impairment

Tobias Busch
UiO, SPED 4100
Nov 18, 2020

tobias.busch@isp.uio.no

1. The interactionist view of language development
2. The neuronal basis of language development
3. Environmental influences on language development
4. HL as a risk factor
5. Environment in assessment & intervention

The interactionist view of language development



Linguistic Nativism

Emphasizes the role of innate linguistic knowledge

Interactionism

Emphasizes the role of linguistic experience



Your turn...

- What do children need to learn to master a language?
- How does their language environment assist them with this?



Cracking the speech code

- Children attune themselves to the language
- Cascading development: phonology, lexicon, syntax, ...
- They have innate perceptual biases, learning mechanisms, social skills

Kuhl PK. Early language acquisition: cracking the speech code. *Nature Reviews Neuroscience*. 2004;5(11):831-843. doi:10.1038/nrn1533.

Werker JF & Gervain J (2013). Speech Perception in Infancy. In: The Oxford Handbook of Developmental Psychology, Vol 1: Body

and Mind (ed. Zelazo, PD). Oxford University Press.
<https://doi.org/10.1093/oxfordhb/9780199958450.013.0031>

Saffran JR, Senghas A, Trueswell JC. The acquisition of language by children. *Proceedings of the National Academy of Sciences*. 2001;98(23):12874-12875. doi:10.1073/pnas.231498898.

Phonology - Lexicon - Syntax

- From 600 consonants and 200 vowels to 40 phonemes
- Small acoustical differences, e.g. /b/ to /p/
- Variation across speakers and contexts
- move towards categorical perception around 10 mo.
- stable phonemic representations set the stage for word learning



Johnson EK, White KS. Developmental sociolinguistics: Children's acquisition of language variation. *WIREs Cognitive Science*. 2020;11(1). doi:10.1002/wcs.1515.

Phonology - Lexicon - Syntax

- Linking words to meaning
- Quine's Induction Problem: referential ambiguity ↗
- Variable forms (social & linguistic context, speaker, ...)
- different words for the same thing (nappy/diaper, stroller/pram)
- different meanings for the same word ("tomato sauce")
- No reliable acoustical boundary between words



Samuelson LK, McMurray B. What does it take to learn a word?. *WIREs Cognitive Science*. 2017;8(1-2):e1421.
doi:10.1002/wcs.1421.

Phonology - Lexicon - Syntax

- Structural regularities and non-adjacent dependencies
- classes of words, grammatical roles, morphological markers
- *Linking problem:* Structure not represented directly on the surface of the speech signal



Biases & Bootstrapping Strategies

- Preference for speech over non-speech
- Preference for native language
- Attentional biases (novel objects, things in mom's hands...)
- Limited visual field
- Phonological and prosodic cues
 - Stress - trochaic (weak-strong) vs. iambic (strong-weak)
 - Phonotactics, e.g., /br/ frequent at onset, /nt/ in final position
 - Allophonic differences, e.g, /toot/

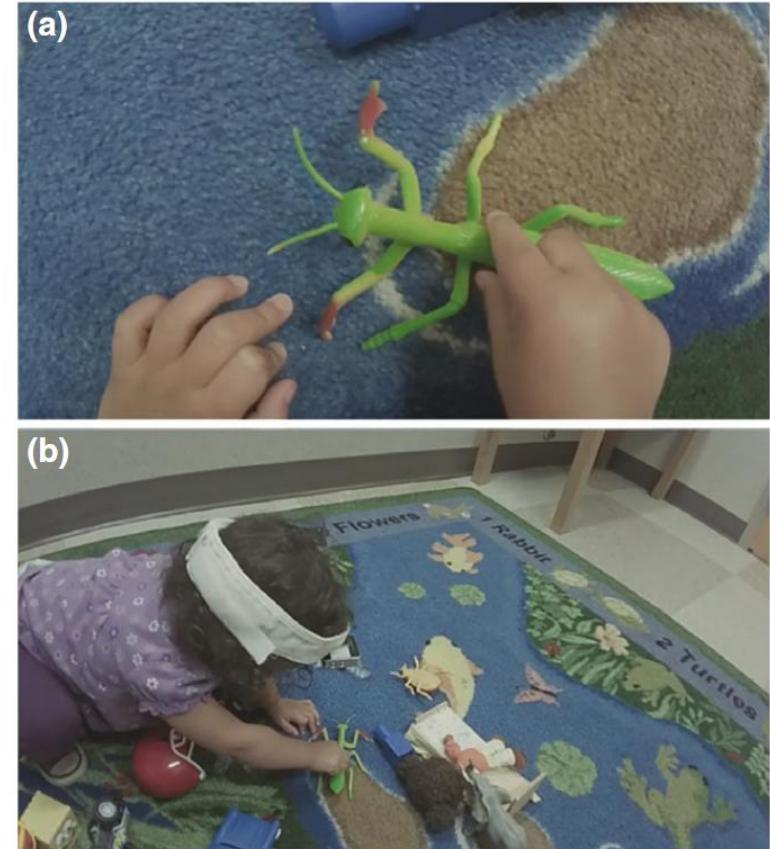
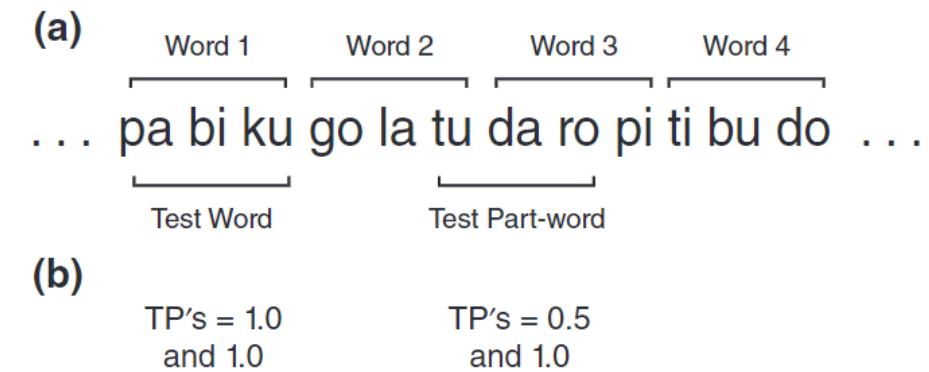


FIGURE 2 | Differences in the number of namable objects in view from the child's (a) and parent's (b) perspective.

Statistical Learning

- Tracking statistical probabilities to detect patterns
- Words:
 - Conditional probabilities (“pret-ty ba-by”)
- Syntax:
 - Certain morphosyntactic constructs (word order, phrase boundary) have phonological and prosodic correlates
 - Infants use the positioning of function words / morphemes, relative to prosodic markers of phrase boundaries



Aslin RN. Statistical learning: a powerful mechanism that operates by mere exposure. *WIREs Cognitive Science*. 2017;8(1-2):e1373. doi:10.1002/wcs.1373.

Saffran JR, Senghas A, Trueswell JC. The acquisition of language by children. *Proceedings of the National Academy of Sciences*. 2001;98(23):12874-12875. doi:10.1073/pnas.231498898.

Romberg AR, Saffran JR. Statistical learning and language acquisition. *WIREs Cognitive Science*. 2010;1(6):906-914. doi:10.1002/wcs.78.

Jusczyk PW. How Infants Adapt Speech-Processing Capacities to Native-Language Structure. *Current Directions in Psychological Science*. 2002;11(1):15-18. doi:10.1111/1467-8721.00159.

Biases are strong

- children can generate utterances of a complexity not available in their input
- rudimentary “homesigns”
- birth of sign language in deaf community in Nicaragua

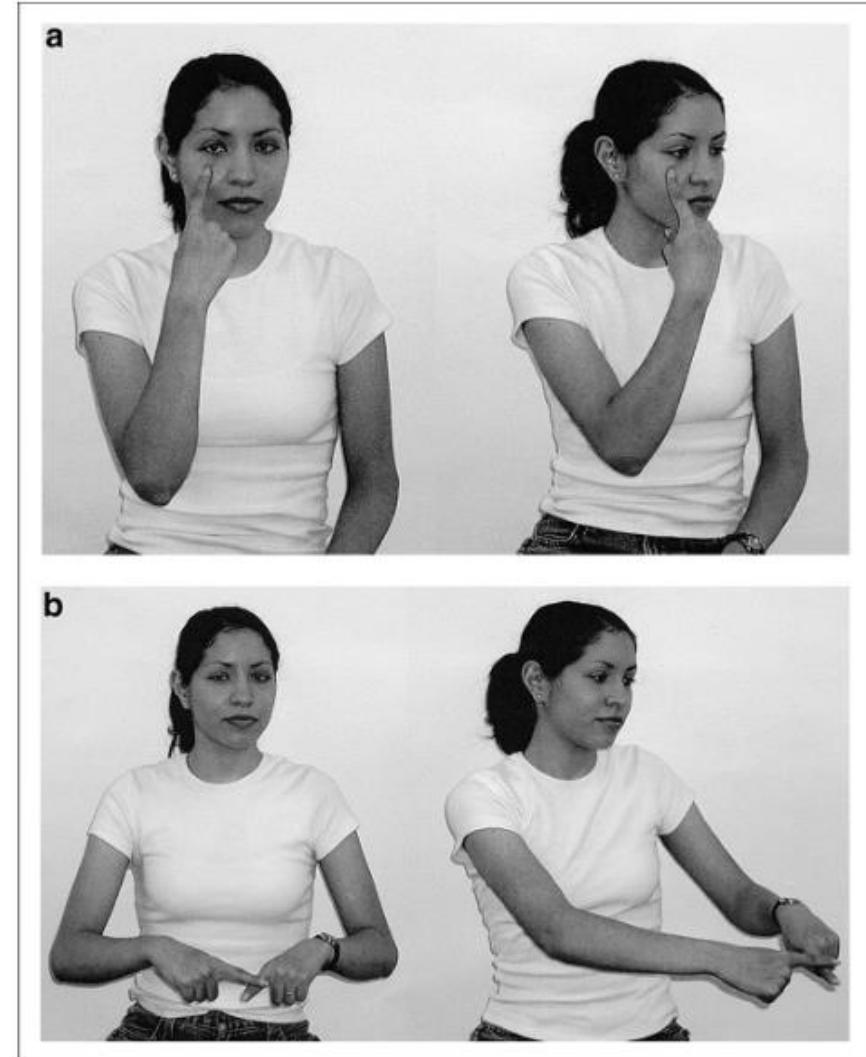


Fig. 1. The Nicaraguan Sign Language signs “see” (a) and “pay” (b), produced in a neutral direction and spatially modulated to the signer’s left.

Senghas A, Coppola M. Children Creating Language: How Nicaraguan Sign Language Acquired a Spatial Grammar. *Psychological Science*. 2001;12(4):323-328.
doi:10.1111/1467-9280.00359.

Your turn...

- Which environmental factors could affect language development?

Child-caregiver interactions

- Language evolved for social communication, and evolution may have forged a link between language and the social brain
- Language learning is grounded in children's appreciation of other's communicative intentions
- Input must be delivered in the context of social interactions (child directed and contingent) and rich in quantity and quality (child appropriate)



Head Zauche L, Darcy Mahoney AE, Thul TA, Zauche MS, Weldon AB, Stapel-Wax JL. The Power of Language Nutrition for Children's Brain Development, Health, and Future Academic Achievement. *Journal of Pediatric Health Care*. 2017;31(4):493-503. doi:10.1016/j.pedhc.2017.01.007.

1. Kuhl PK. Is speech learning 'gated' by the social brain?. *Developmental Science*. 2007;10(1):110-120. doi:10.1111/j.1467-7687.2007.00572.x.

Child-caregiver interactions

- Children and caregivers engage in *triadic interactions*
 - Direct attention via cues like visual gaze or pointing
 - Caregivers gaze at things they talk about, infants' follow
 - caregivers talk about what children attend to
- Regulate attention, highlight linguistic structures, facilitates understanding of language as a social tool
- Attention determines what information is analyzed



Contingency

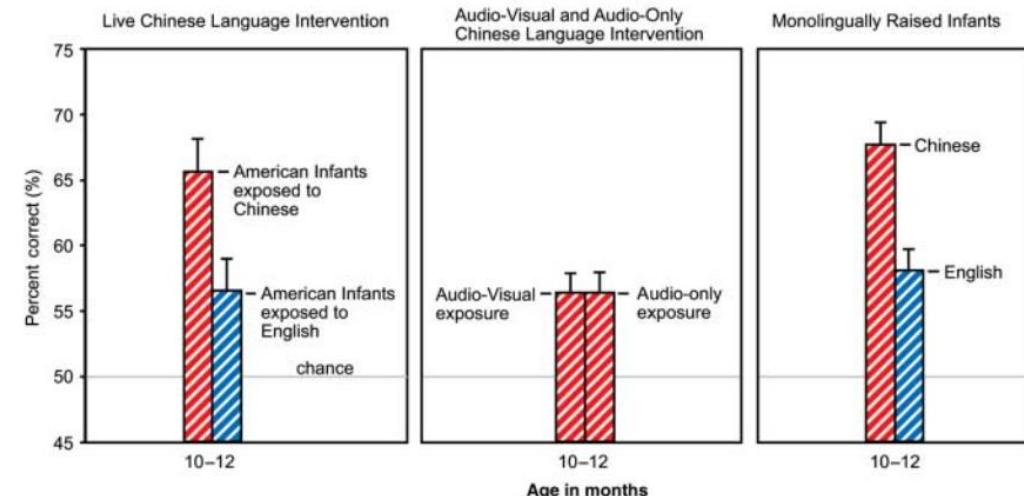
- Benefit of child-caregiver interactions comes from their *contingency*
 - following the child's lead
 - reciprocity, responsiveness,
 - commenting, recasting, expanding
- Contingent interactions provide specific information that fosters learning
- Language development is driven by child directed input rather than overall input

Kuhl PK. Is speech learning 'gated' by the social brain?. *Developmental Science*. 2007;10(1):110-120.
doi:10.1111/j.1467-7687.2007.00572.x.

A Foreign-Language Exposure B Phonetic Perception Test
Live Exposure

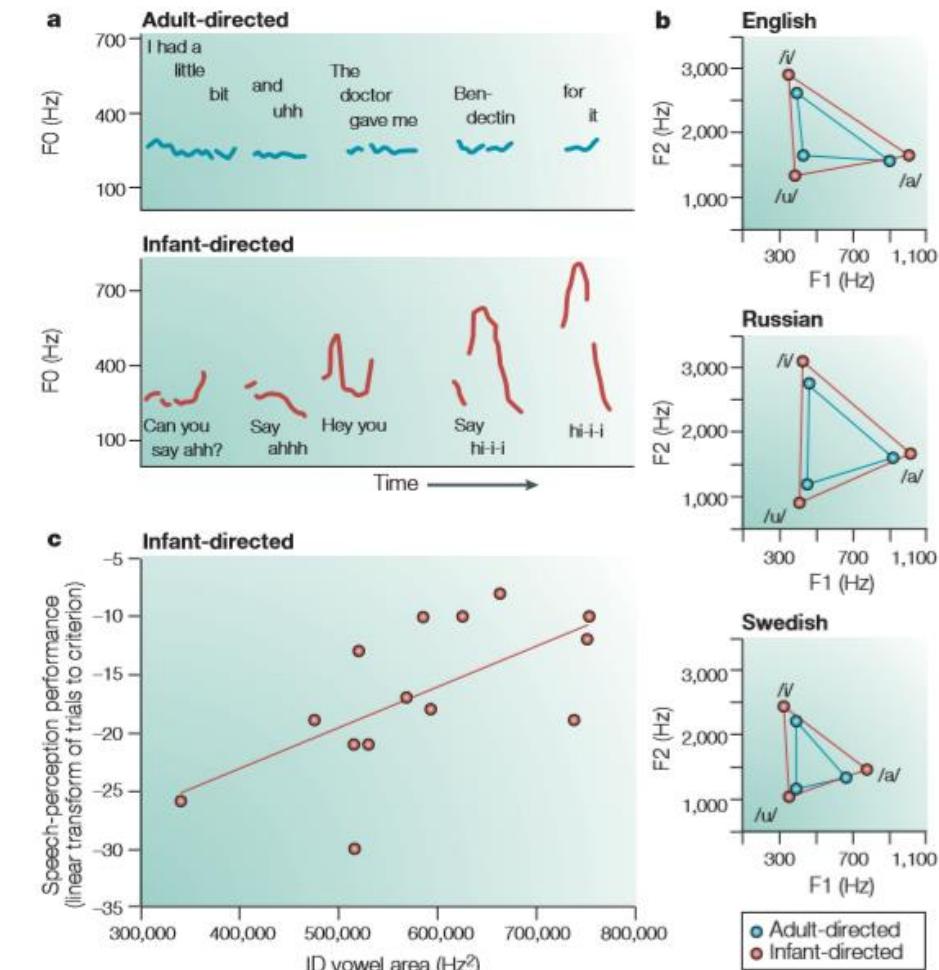


C Mandarin Chinese Phonetic Discrimination



Motherese / Infant-Directed Speech

- Adults adjust speech to the needs of the infant
 - slower speech rate and longer pauses
 - higher average pitch and exaggerated contours
 - repetitive tonal structure
 - more clearly articulated vowels
 - Simplified sentence structure
 - Enhancing visual attributes
 - redundant deictic gestures
- Stimulate attention, sustain interactions, highlight messages, draw attention to relevant aspects of the speech signal
- Related to positive affect: Smiling shortens vocal tract, causing vowel shift, making articulation more accessible



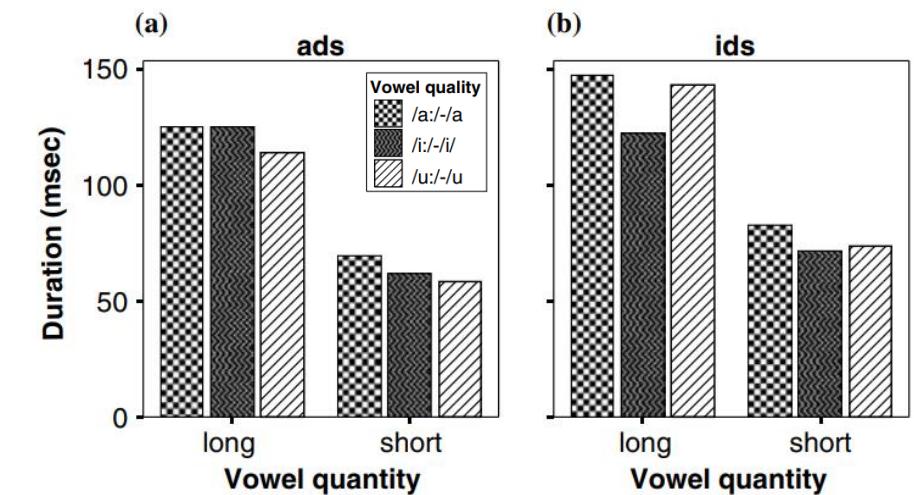
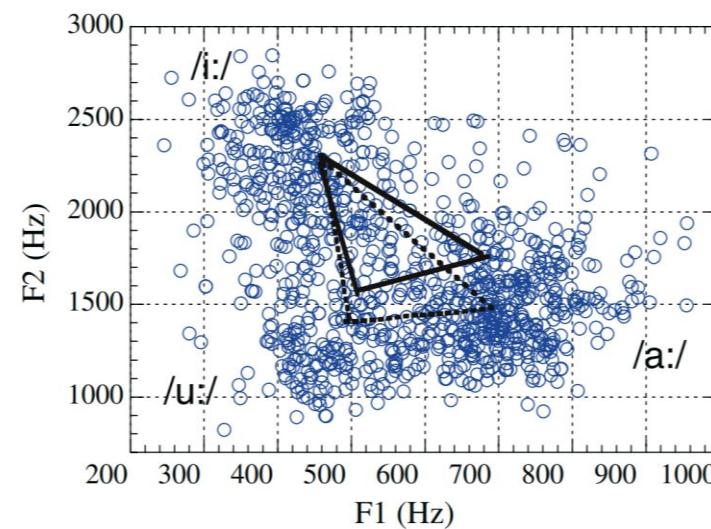
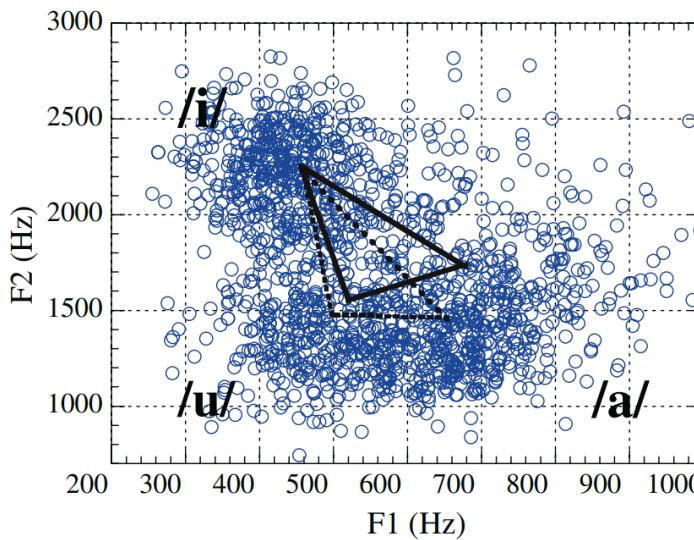
Englund KT, Behne DM. Infant Directed Speech in Natural Interaction—Norwegian Vowel Quantity and Quality. *Journal of Psycholinguistic Research*. 2005;34(3):259-280.
doi:10.1007/s10936-005-3640-7.

Saint-Georges C, Chetouani M, Cassel R, et al.. Motherese in

Interaction: At the Cross-Road of Emotion and Cognition? (A Systematic Review). *PLOS ONE*. 2013;8(10):e78103.
doi:10.1371/journal.pone.0078103.

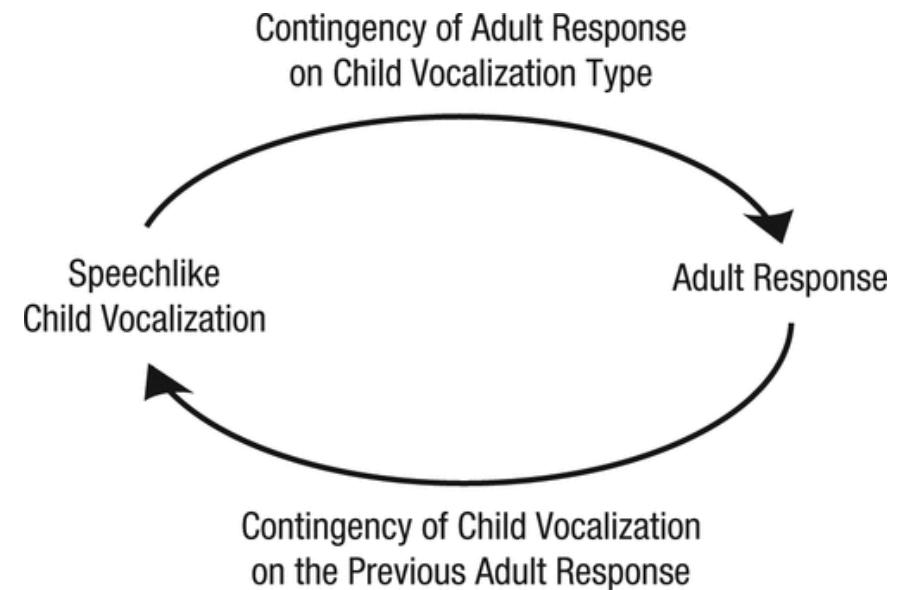
Motherese / Infant-Directed Speech

- Norwegian Motherese: Vowels articulated more frontal, longer (~14ms) and higher (~20Hz, except for /i/, /i:/)



The social feedback loop

- Improves affective engagement, reactivity and attractiveness
- Infant's synchronous response improves motherese
- Facilitates understanding of language as a social tool
- Coordination goes beyond language and affect - touch, arousal, movement, proximity...
- Fosters emotion sharing, adjustment, synchrony, joint attention learning → far-reaching effect on psychosocial development (attachment, self-regulation)



Feldman R. Parent-Infant Synchrony. *Current Directions in Psychological Science*. 2007;16(6):340-345.
doi:10.1111/j.1467-8721.2007.00532.x.

Autism. *Psychological Science*. 2014;25(7):1314-1324.
doi:10.1177/0956797614531023.

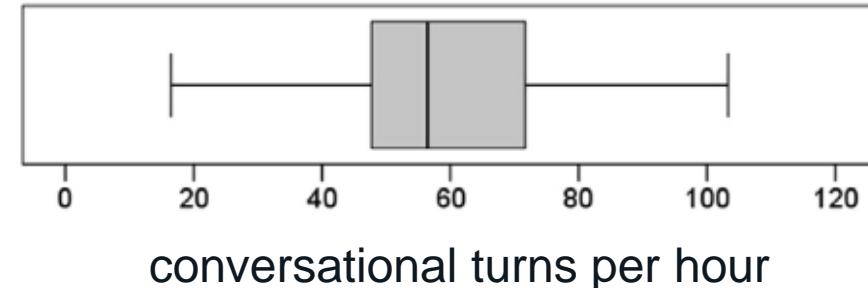
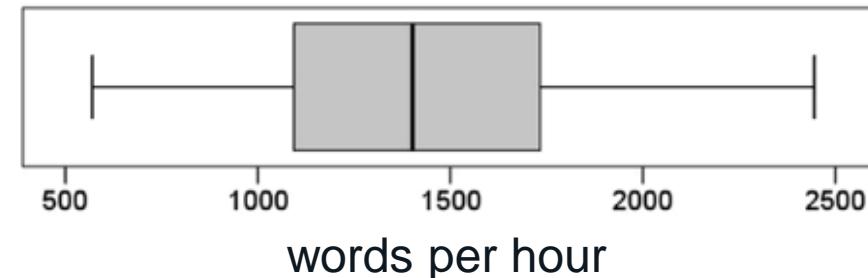
Warlaumont AS, Richards JA, Gilkerson J, Oller DK. A Social Feedback Loop for Speech Development and Its Reduction in

Other important aspects of caregiver language

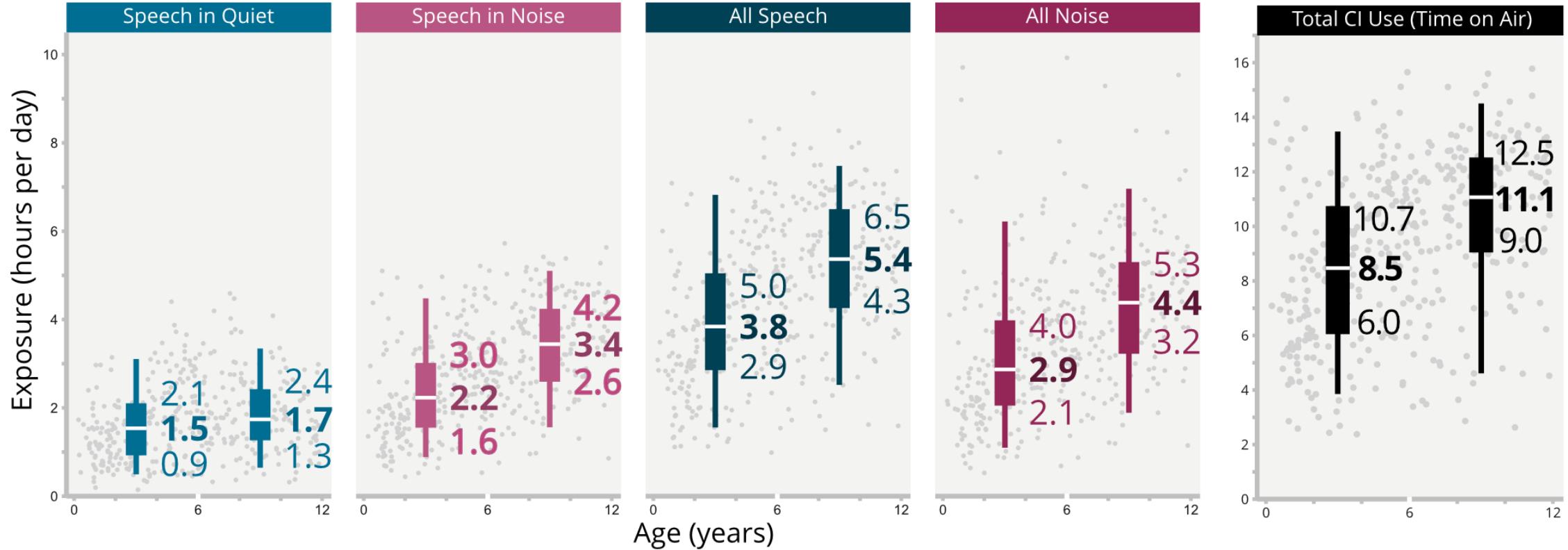
- Directiveness
- Lexical diversity
- Complexity of speech
- Use of gestures
- Parenting/teaching skills & self-efficacy beliefs
- Quantity of language input (difficult to separate from quality)

Large variation in Quality and Quantity

- Hart & Risley (1995):
The 30 million word gap
- Weisleder & Fernald (2013):
670 - 12,000 words per 10 hrs
- Rowe (2012):
360 - 9,200 words per 90 mins
95 - 714 word types
- Also for children with hearing loss
(Ambrose et al., 2014)...



Large variation in Quality and Quantity



Busch, Tobias, Vanpoucke, Filiep, & Van Wieringen, Astrid. (2017). Auditory Environment Across the Life Span of Cochlear Implant Users: Insights From Data Logging. *Journal of Speech, Language, and Hearing Research : JSLHR*, 60(5), 1362-1377.

Similar results by Easwar et al. (2016), Cristofari et al. (2017),

Polonenko et al. (2017), Oberhoffner et al. (2017)

Large variation in Quality and Quantity

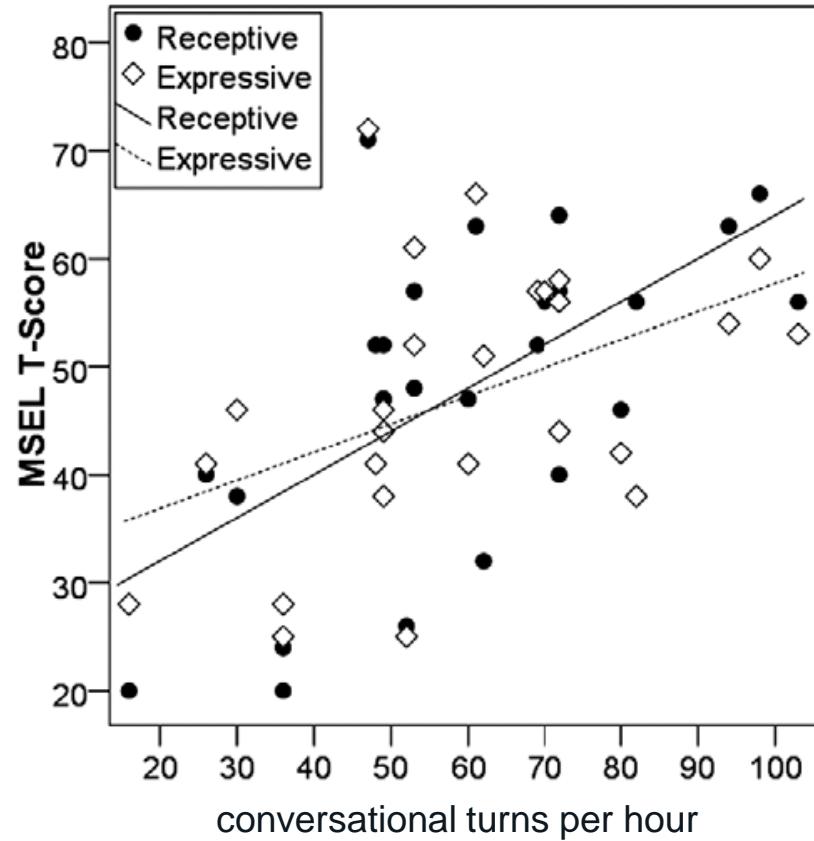
LENA measures at 18-24 mo. explained variance in IQ, verbal comprehension, and vocabulary 10 years later

- Adult word count accounted for 1-9%
- Conversational turn count accounted for 14-27%

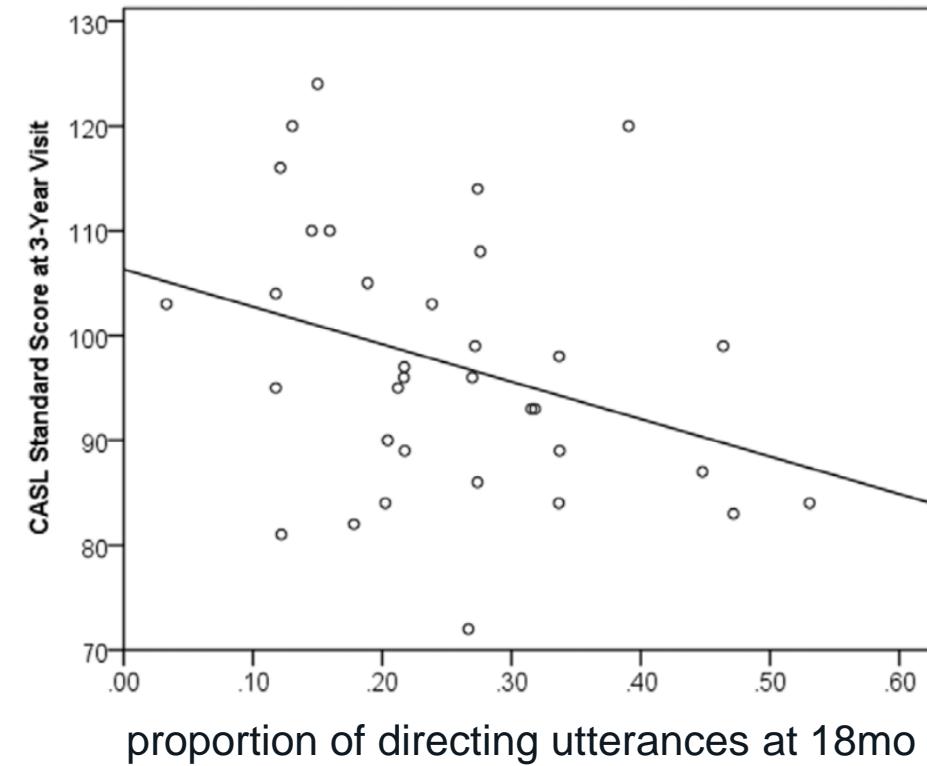


Gilkerson, J., Richards, J.A., Warren, S.F., Oller, D.K., Russo, R., Vohr, B., 2018. Language Experience in the Second Year of Life and Language Outcomes in Late Childhood. *Pediatrics*. doi:10.1542/peds.2017-4276

Differences predict language outcomes

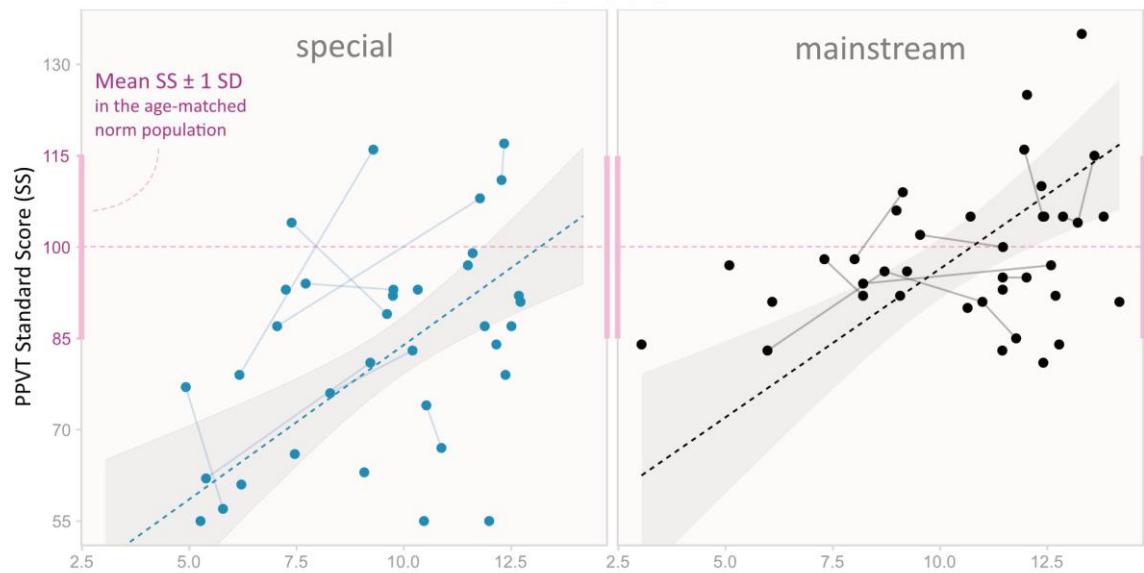


Ambrose et al. (2014, 2015)

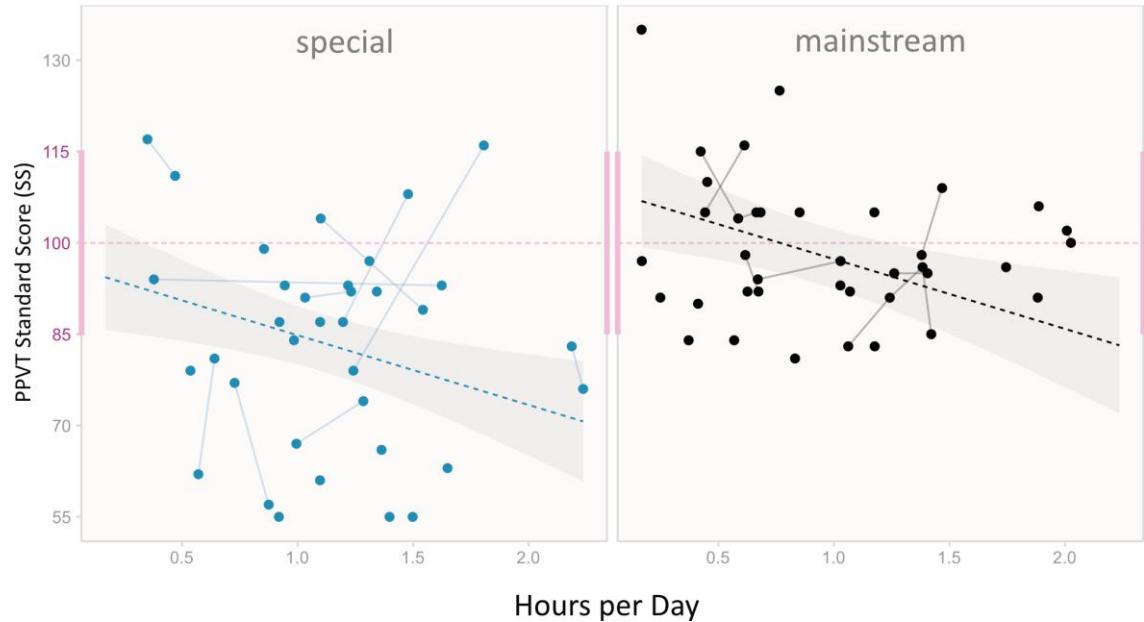


Differences predict language outcomes

CI Use



Music



Differences predict language outcomes

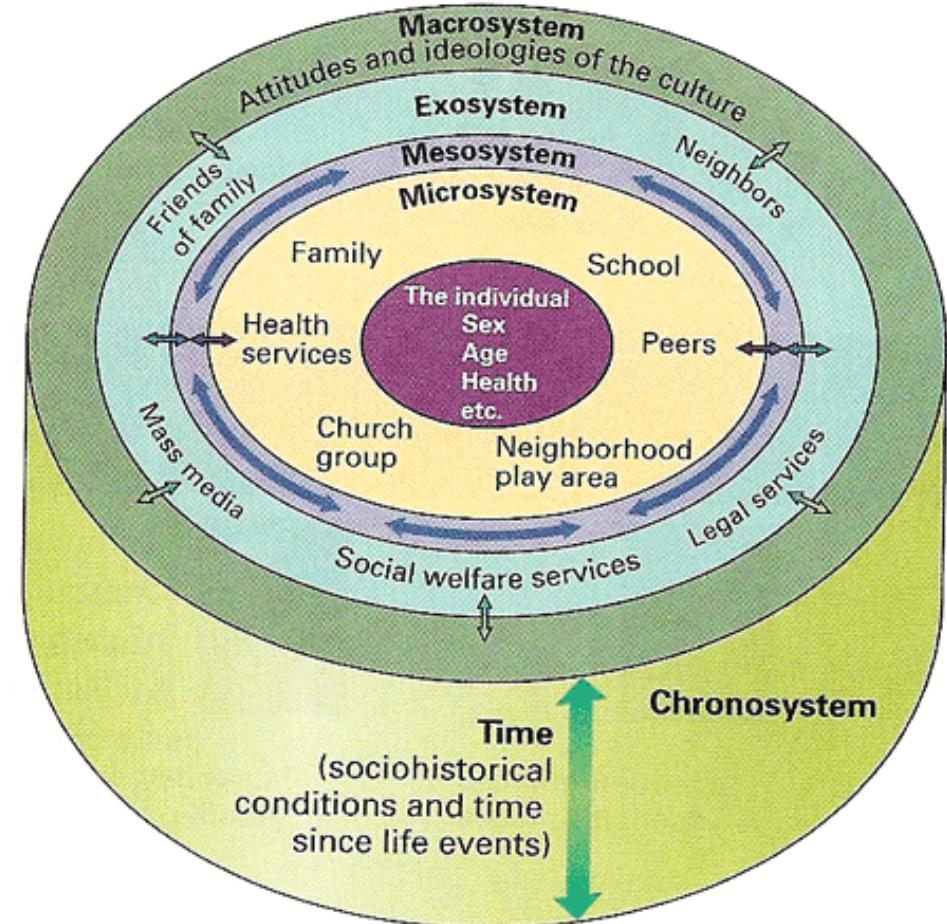
- Better outcomes can be expected for children with HL who
 - receive more speech input
 - experience less noise,
 - use their HA/CI more

Hurtado et al., 2008; Weisleder & Fernald, 201; Klatte et al., 2013; Busch et al., 2020; Tomblin et al., 2015; Walker et al., 2015; Wie et al., 2007

Other environmental factors

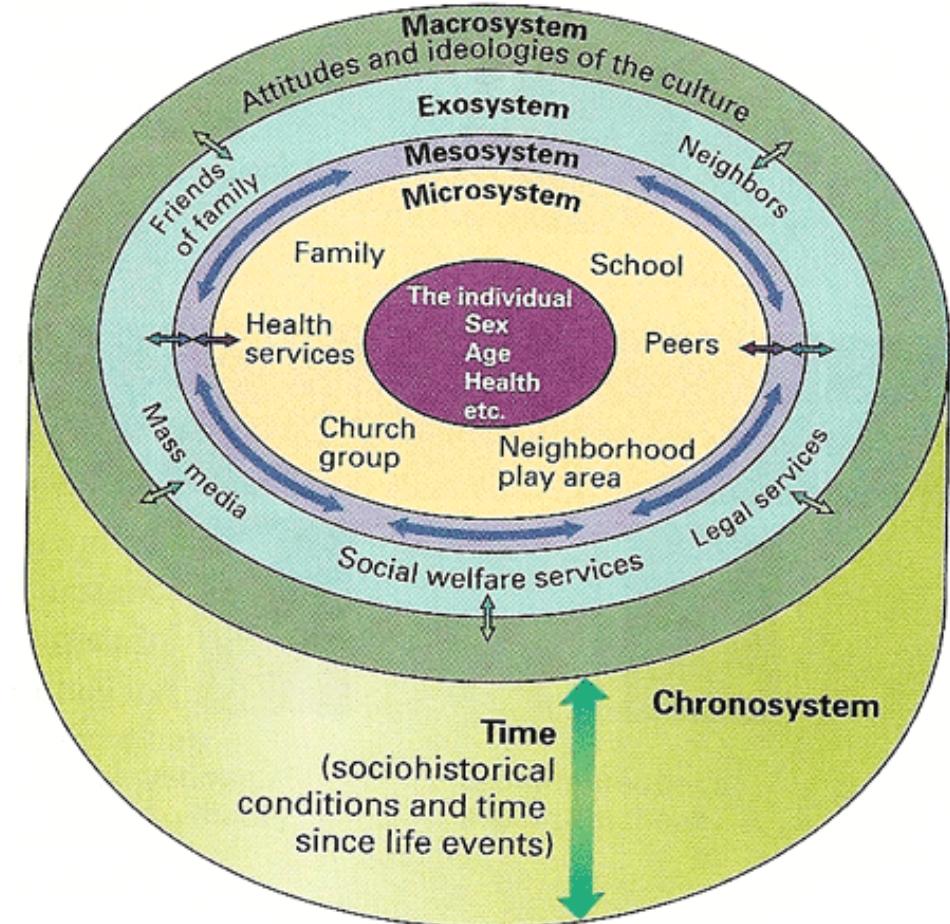
Bronfenbrenner's ecological systems theory

- Microsystem
- Mesosystem
- Exosystem
- Macrosystem



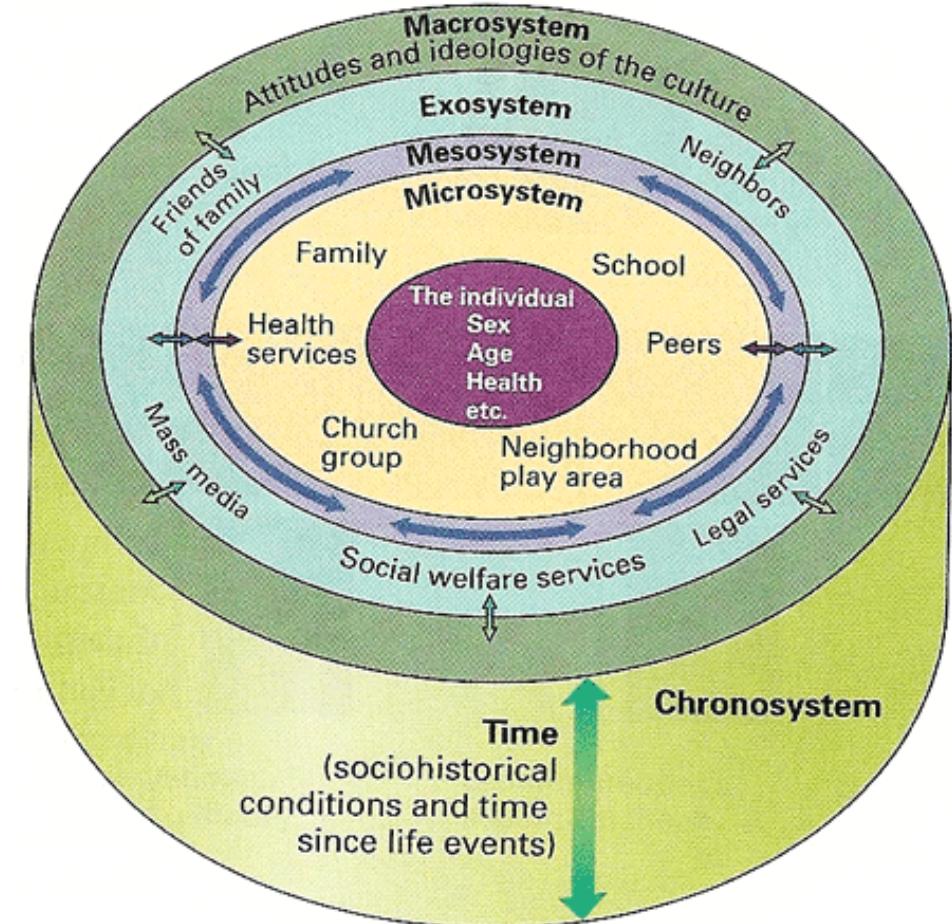
Family Environment

- parenting behavior
 - self-efficacy beliefs
 - knowledge of their role in child's development
 - parental awareness and responsiveness to child's needs
 - parenting style (authoritativeness, consistency)
- parental involvement in education and rehabilitation
- Socio-economic status
- family structure and family size
- physical aspects of the home environment
- Media use



Other environmental factors

- Day care / school factors (e.g. size, structure)
- Parent-teacher cooperation
- Parents place of work, network of friends
- Neighborhood
- Broader social context: Legislation, resources, life-styles, belief-systems, social classes, immigrant and minority groups...
- Aspects of the language



1. Vasanta D. Language cannot be reduced to biology: Perspectives from neuro-developmental disorders affecting language learning. *Journal of Biosciences*. 2005;30(1):129-137. doi:10.1007/bf02705157.

The background is a solid dark blue color. Scattered across it are numerous walnut halves, which are light brown with a textured, wrinkled surface. They are of various sizes and orientations, some pointing upwards and others downwards, creating a natural and organic feel.

The neuronal basis of language
development

The neuronal basis of language development



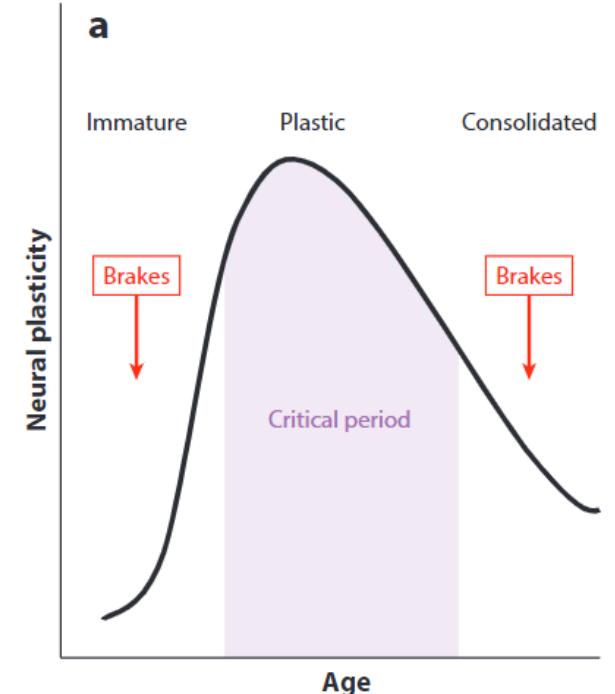
- Experience shapes the brain
- Neural commitment to the regularities of the target language
- Commitment is efficient: Optimal neural representation of the environment to guide action
- Rewiring is expensive and poses limitations

1. Werker JF, Hensch TK. Critical Periods in Speech Perception: New Directions. *Annual Review of Psychology*. 2015;66(1):173-196. doi:10.1146/annurev-psych-010814-015104.
2. Kuhl P, Rivera-Gaxiola M. Neural Substrates of Language

Acquisition. *Annual Review of Neuroscience*.
2008;31(1):511-534.
doi:10.1146/annurev.neuro.30.051606.094321.

Critical windows & Sensitive periods

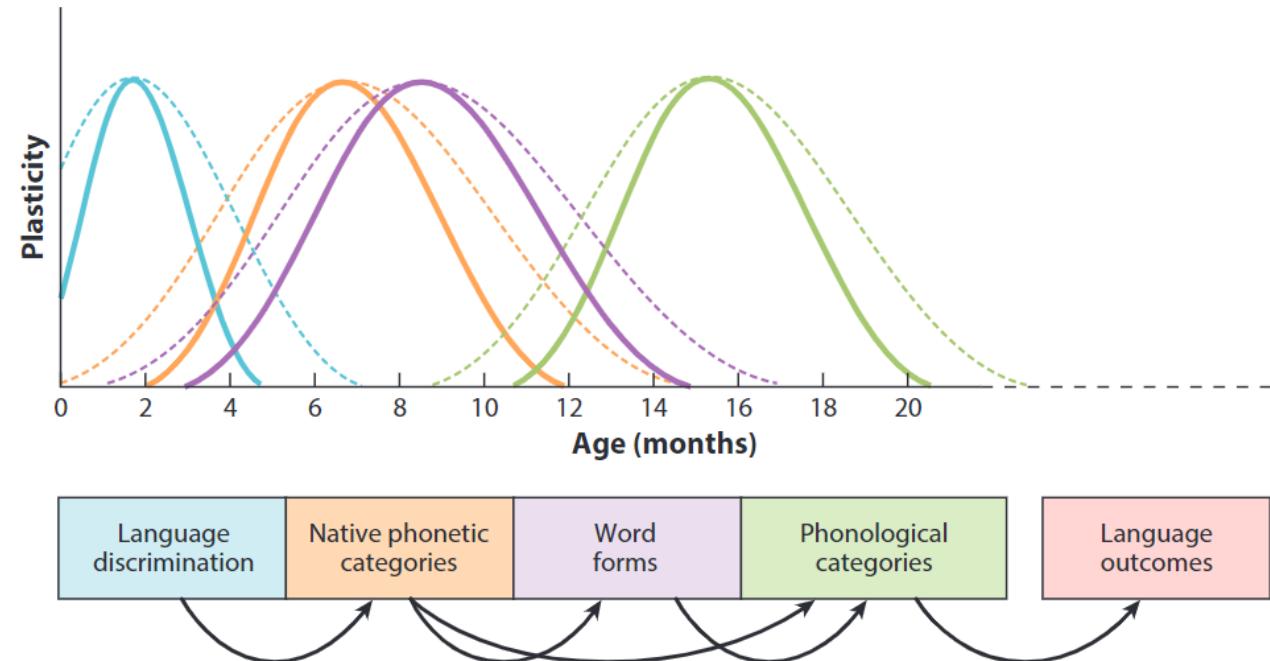
- Maturation of neuronal circuitry (immature → plastic → consolidated)
- Timing determined by molecular brakes, constrained by maturation, triggered by experience
- Timing can be altered through sensory deprivation, environmental enrichment, video games, CI, bilingual experience, drugs, diet, behavioral training...



Critical windows & Sensitive periods



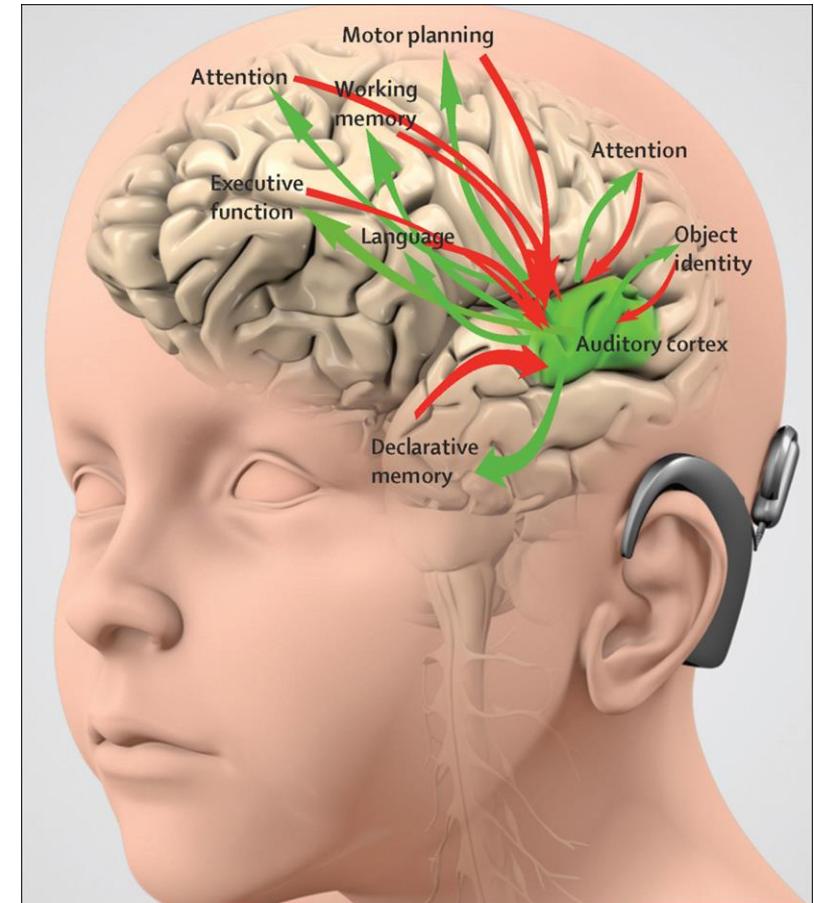
- Multiple critical periods
- Lack of stimulation during one of them can cause a cascade of problems
- Auditory deprivation poses a risk for the development of higher-level cognitive abilities, like executive functions, memory, attention



Kral A, O'Donoghue GM. Profound Deafness in Childhood. *New England Journal of Medicine*. 2010;363(15):1438-1450. doi:10.1056/nejmra0911225.

Critical Periods and HL

- Making a particular developmental step outside of critical period can be difficult
- Auditory system functional at ~26 weeks gestational age
- Children with HL may be forced to take developmental steps after critical period has passed.
- Cross-modal plasticity – repurposing of unused areas by other modality – e.g, audio-visual integration
- Sensory loss has cascading effects beyond the sensory system, incl. higher-order neurocognitive functions



Gordon KA, Wong DDE, Valero J, Jewell SF, Yoo P, Papsin BC. Use It or Lose It? Lessons Learned from the Developing Brains of Children Who are Deaf and Use Cochlear Implants to Hear. *Brain Topography*. 2011;24(3-4):204-219. doi:10.1007/s10548-011-0181-2.

Kral A, Kronenberger WG, Pisoni DB, O'Donoghue GM.

Neurocognitive factors in sensory restoration of early deafness: a connectome model. *The Lancet Neurology*. 2016;15(6):610-621. doi:10.1016/s1474-4422(16)00034-x.

Stevenson RA, Sheffield SW, Butera IM, Gifford RH, Wallace MT. Multisensory Integration in Cochlear Implant Recipients. *Ear &*

Hearing. 2017;38(5):521-538. doi:10.1097/aud.0000000000000435.

Kral A, O'Donoghue GM. Profound Deafness in Childhood. *New England Journal of Medicine*. 2010;363(15):1438-1450. doi:10.1056/nejmra0911225.



Hearing loss as a risk factor

Your turn...

- Given what you know about language development, why do you think hearing loss is a risk factor?



How does HL affect language development?

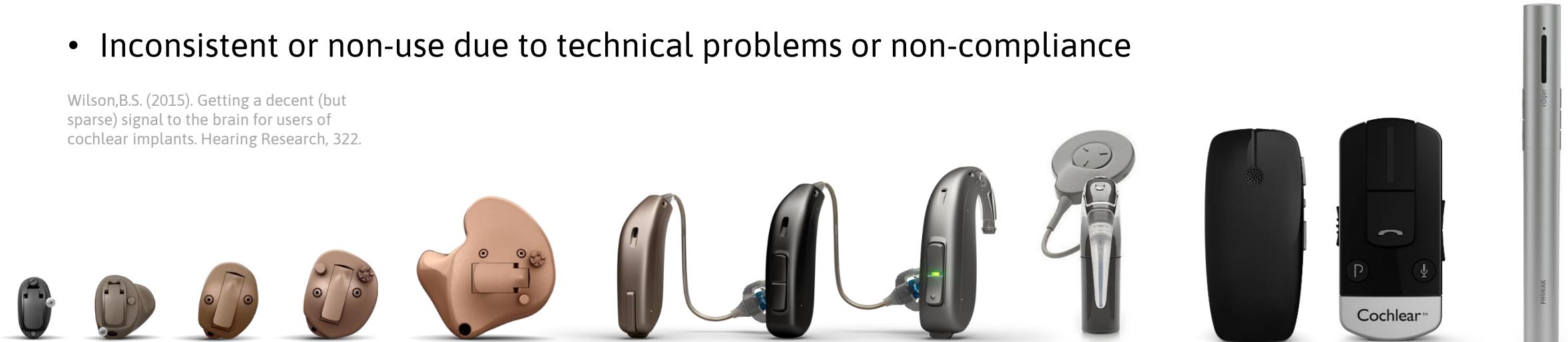
- Problems with noise and difficulty learning from overheard speech due to degraded signal quality
- Technical problems and non-compliance
- Disrupted neurocognitive development as a consequence of early auditory deprivation
- Disrupted Interaction with environment due to HL and resulting speech and language difficulties

Markman TM, Quittner AL, Eisenberg LS, et al.. Language development after cochlear implantation: an epigenetic model. Journal of Neurodevelopmental Disorders. 2011;3(4):388-404.
doi:10.1007/s11689-011-9098-z.

Limits of audiological intervention

- Degraded signal quality due to sensory and technical limitations
→ morphological markers, statistical learning, incidental learning, ...
- Poor representation of fine spectrotemporal detail affects phonological processing → Less stable phonological representations → word learning, verbal working memory, reading, ...
- Poor representation of pitch affects perception/production of prosody → pragmatics, ...
- Performance limited in noise, multitalker conversation, reverberation, distance, low presentation level, ...
- Inconsistent or non-use due to technical problems or non-compliance

Wilson,B.S. (2015). Getting a decent (but sparse) signal to the brain for users of cochlear implants. Hearing Research, 322.



HL & Noise

- Limited access to speech in challenging listening conditions
- *Listening effort* – HA/CI users spend more cognitive resources on listening in noise, leaving less for other tasks and causing fatigue
- Exacerbated by neurodevelopmental problems, e.g. a lack of audio-visual integration and cognitive deficits
- Problems learning from overheard speech (incidental learning)
- Classrooms provide complex learning and social interactions, but also some of the most challenging acoustics
 - Ambient noise levels of 60 dBA and poor SNR (-7 to +5 dB)



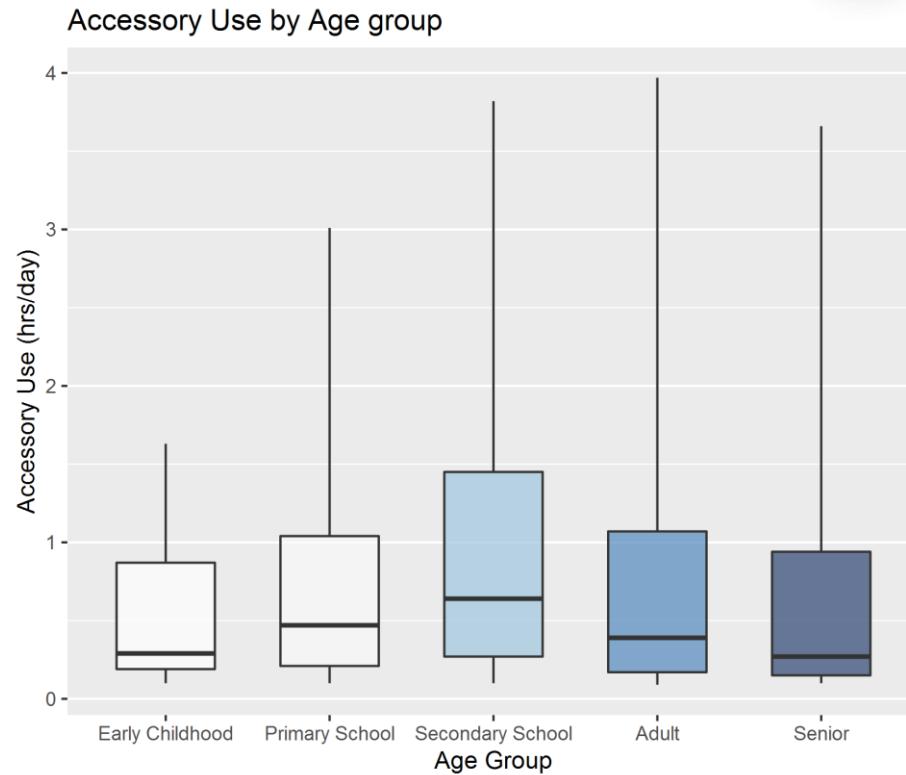
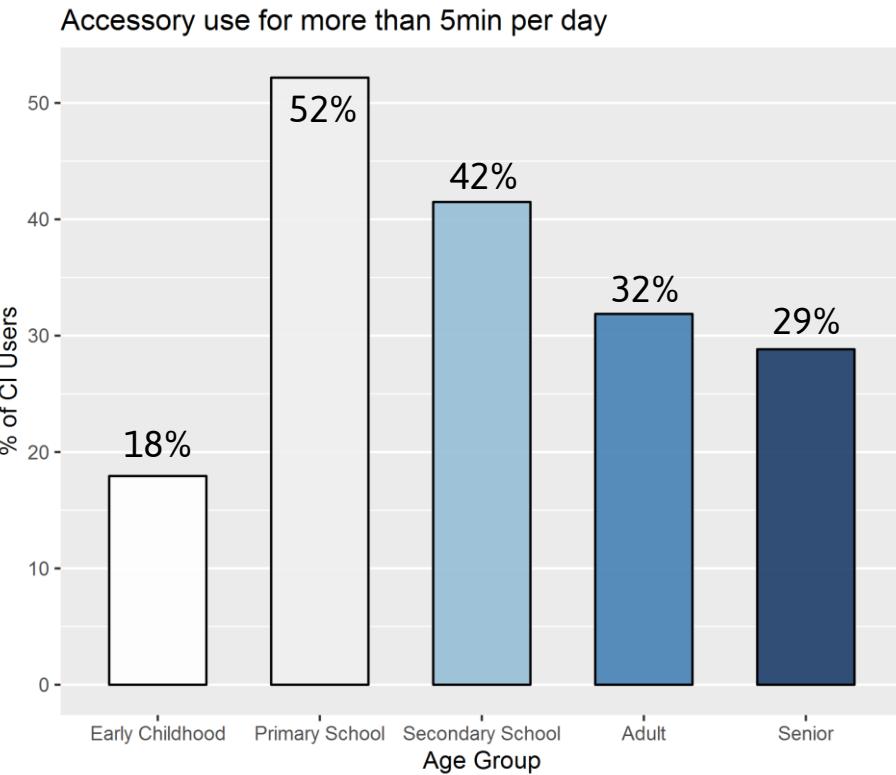
Rönnberg J, Lunner T, Zekveld A, et al.. The Ease of Language Understanding (ELU) model: theoretical, empirical, and clinical advances. *Frontiers in Systems Neuroscience*. 2013;7. doi:10.3389/fnsys.2013.00031.

Pichora-Fuller MK, Kramer SE, Eckert MA, et al.. Hearing Impairment and

Cognitive Energy. *Ear & Hearing*. 2016;37:SS-27S. doi:10.1097/aud.0000000000000312.

Klatte M, Bergström K, Lachmann T. Does noise affect learning? A short review on noise effects on cognitive performance in children. *Frontiers in Psychology*. 2013;4. doi:10.3389/fpsyg.2013.00578.

Lots of noise, yet little accessory use...



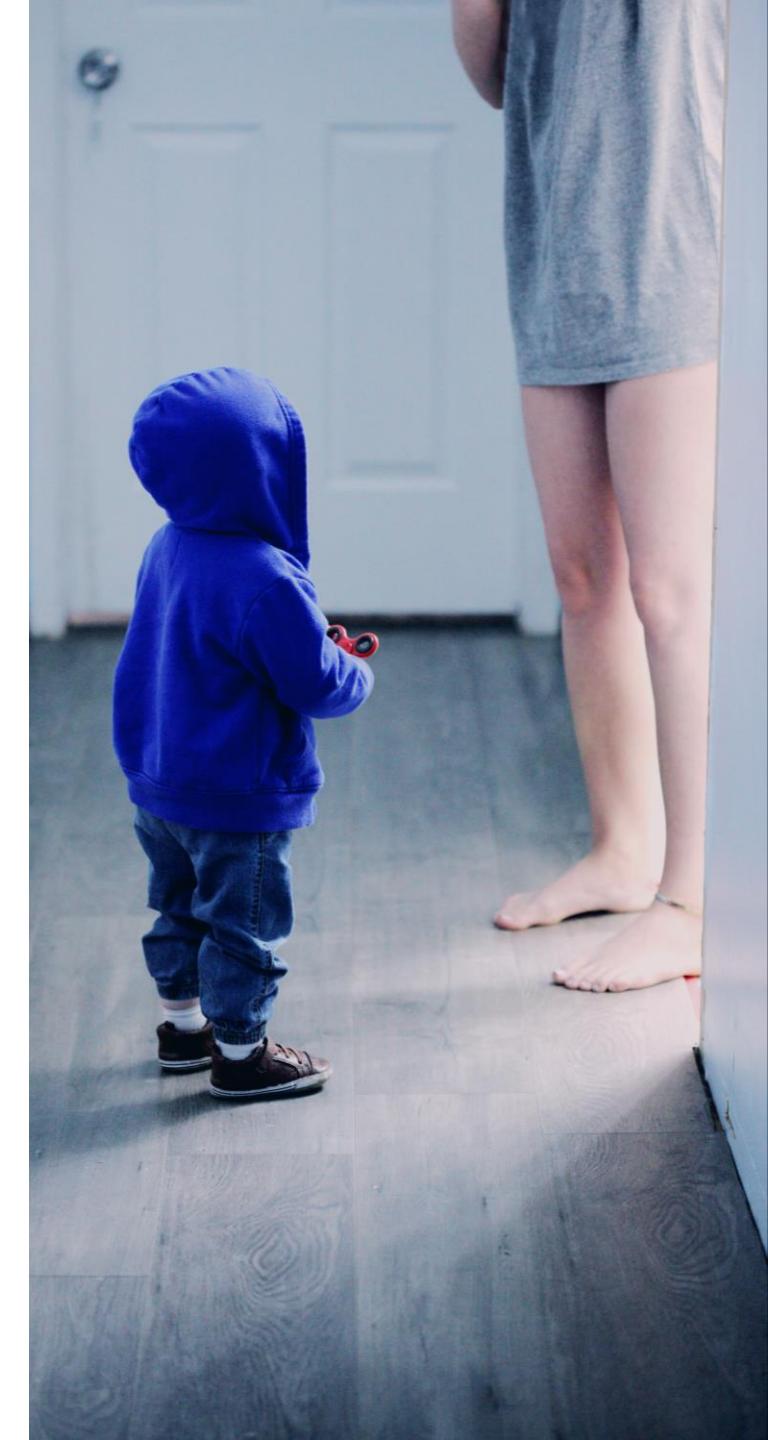
HL disrupts social interactions

- 96% of children with HL are born into hearing families
- Most hearing parents lack experience with HL or signing and lack strategies to facilitate interaction
- difficulties providing meaningful interactions (e.g., eliciting joint attention) and risk of harmful communication patterns
- Communication with children with HL tends to be lower in quality
 - Less positive affect, spontaneity, responsiveness, mutual engagement, playfulness
 - Less synchronicity of vocal interactions
 - More direct, controlling, directive and intrusive
 - Fewer different words, fewer high-level utterances

Tasker SL, Nowakowski ME, Schmidt LA. Joint Attention and Social Competence in Deaf Children with Cochlear Implants. *Journal of Developmental and Physical Disabilities*. 2010;22(5):509-532.
doi:10.1007/s10882-010-9189-x.

Fagan MK, Bergeson TR, Morris KJ. Synchrony, complexity and

directiveness in mothers' interactions with infants pre- and post-cochlear implantation. *Infant Behavior and Development*. 2014;37(3):249-257. doi:10.1016/j.infbeh.2014.04.001.

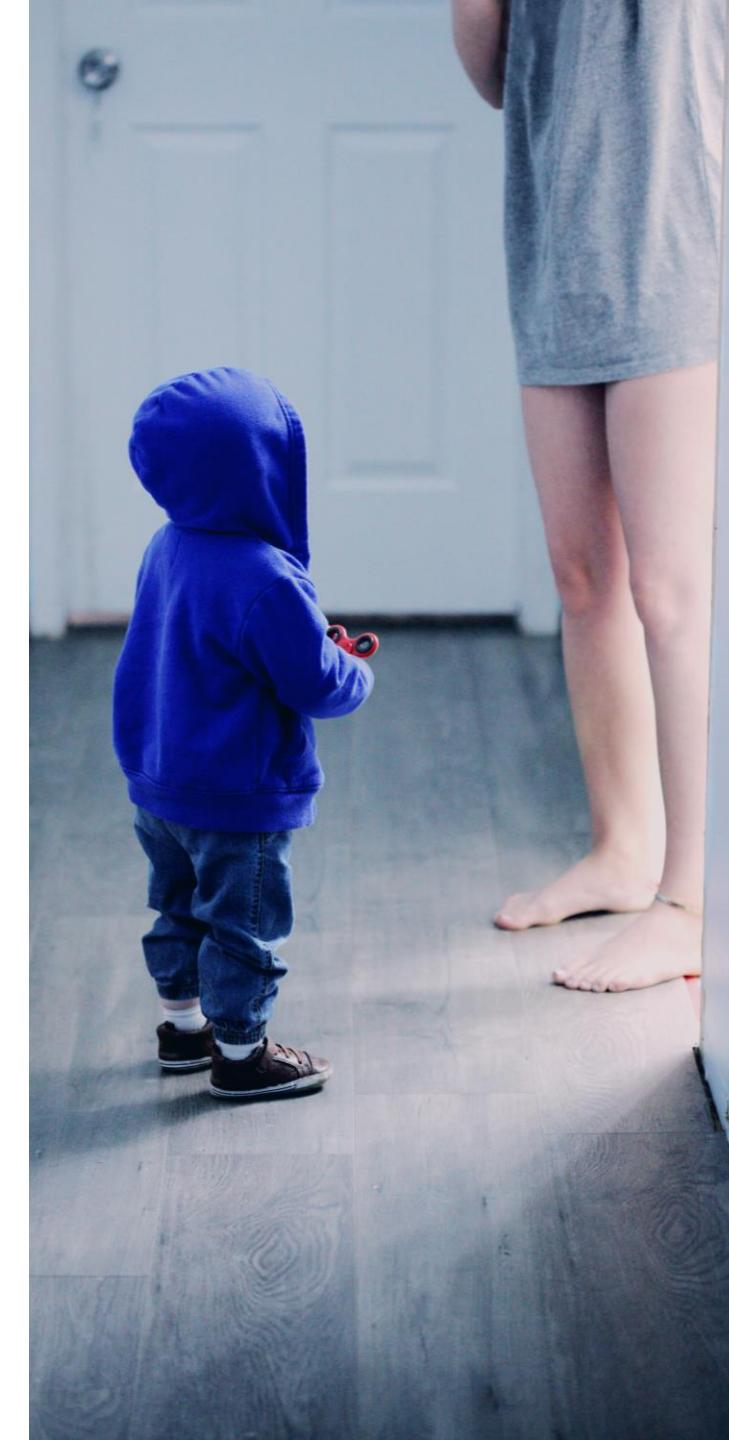


HL disrupts social interactions

- Disrupted communication and social-affective processes affect child behavior and increase parental stress
- parents overwhelmed: dealing with hearing devices, medical services, worries about future, uncertainty regarding their role in the rehabilitation, ...
- Increased stress affects interactions and aggravates problems

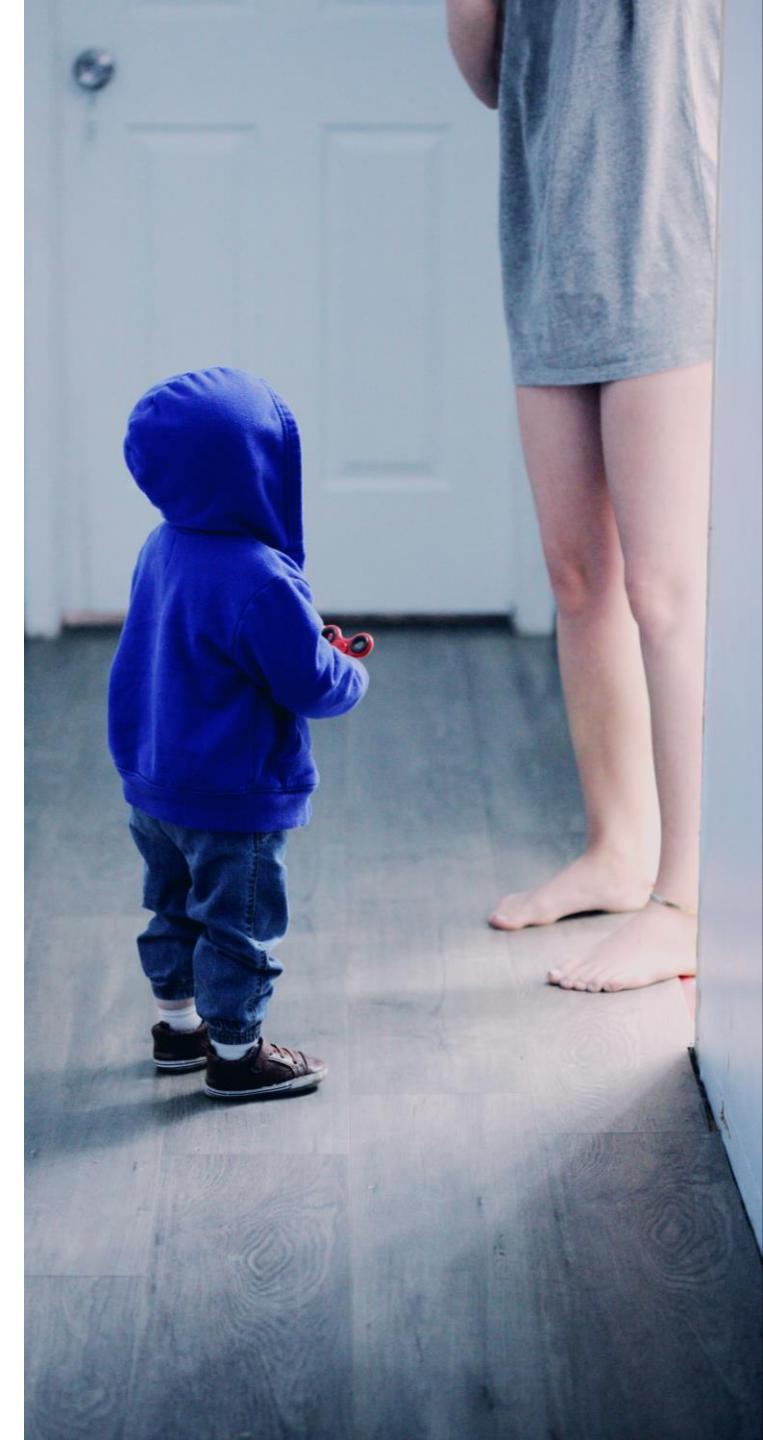
Quittner AL, Barker DH, Cruz I, et al.. Parenting Stress Among Parents of Deaf and Hearing Children: Associations with Language Delays and Behavior Problems. *Parenting*. 2010;10(2):136-155. doi:10.1080/15295190903212851.
Ketelaar, Lizet^{1,2}; Wiefferink, Carin H.¹; Frijns, Johan H. M.^{3,4}; Rieffe, Carolien^{1,2,5}
Children With Cochlear Implants and Their Parents: Relations Between Parenting Style
and Children's Social-Emotional Functioning. *Ear and Hearing*: May/June 2017 -
Volume 38 - Issue 3 - p 321-331

doi: 10.1097/AUD.0000000000000387
DesJardin, Jean L.; Eisenberg, Laurie S. Maternal Contributions: Supporting Language
Development in Young Children with Cochlear Implants. *Ear and Hearing*: August 2007
- Volume 28 - Issue 4 - p 456-469 doi: 10.1097/AUD.0b013e31806dc1ab



HL disrupts social interactions

- Poor representation of pitch
 - Limited perception of prosodic cues
 - Social interactions (emotions, questions vs. statements)
 - Pragmatic language development
 - Social Emotional & behavioral development
 - Theory of Mind
- Social participation



Assessment & Intervention

Your turn...

- How could the environment be assessed in intervention?
- How could the environment be addressed in intervention?

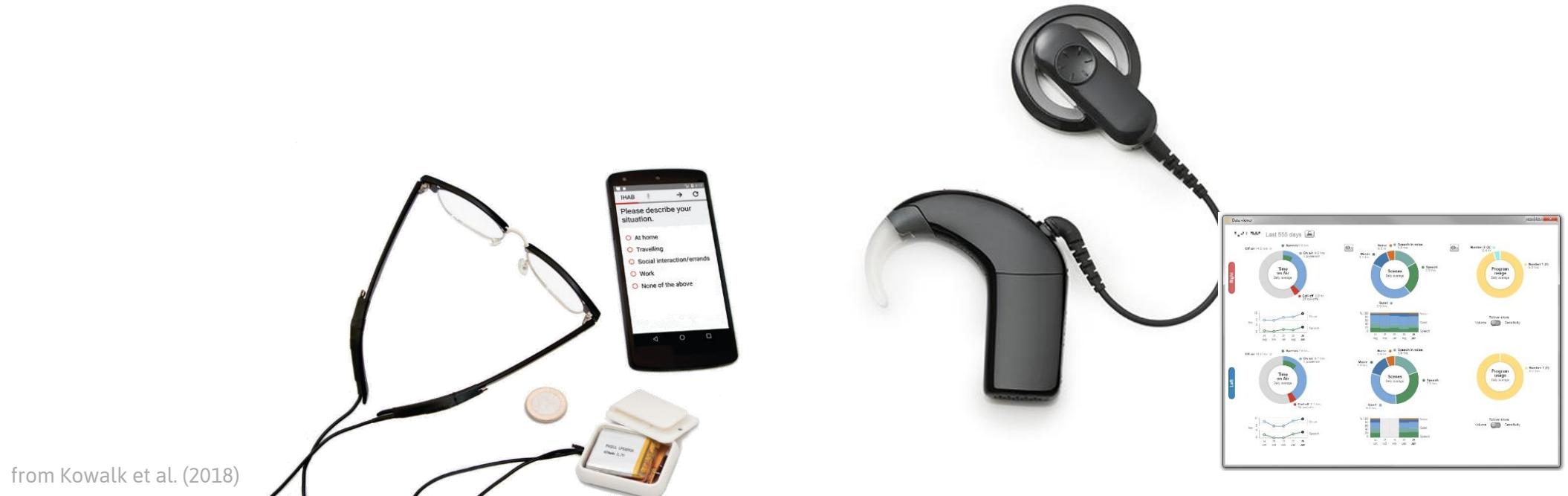
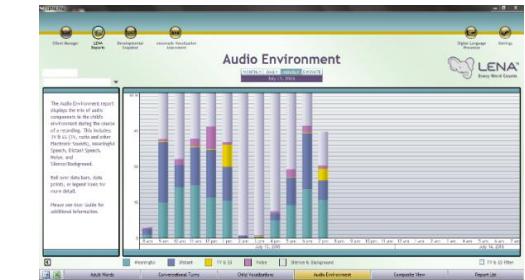
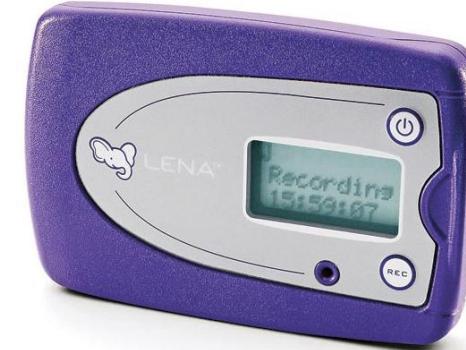
Why include the environment in intervention in audiolinguistic intervention?

- Understand risk factors and challenges in everyday life
- Discriminate disorders from delays – is the deficit/delay (un)surprising and (un)important?
- Optimize support and rehabilitation
- Setting goals and strategies

Problem: How to account for language/hearing history? differences in communication mode and auditory deprivation?

Audiopedagogical Intervention

- Parent-directed intervention
- Automatically Capturing the Auditory Environment
 - LENA
 - Data logging



from Kowalk et al. (2018)

Parent-directed Interventions

- Parent-child interactions are influenced by self-efficacy beliefs and knowledge
- Quantity and quality can be improved through parent-directed interventions
- Based on concepts of self-determination theory - relatedness, competency, autonomy

Linguistic behavior change through...

- *Knowledge Transfer* - knowledge about child development and parents' role, effective communication strategies
- *Behaviour Change Techniques* - feedback + home visits, parent groups, ...

Knowledge Transfer: Key Messages

- “*You drive child development*”
- “*Language Input is important, Interactivity is important*”
- Early Language Learning determines academic success (thus: act now!)
- Follow child’s lead, be interested in what child is interested in
- be engaging and attentive
- Leave pauses for child to respond,
- Use scaffolding, supportive language techniques (Praise, model, respond, repeat, rephrase...)
- Turn everyday situations into fun educational activities, (How to) read a book with your child, Turn off the TV, Establish rituals and consistency, ...

Cochlear's DiaLog



How can I encourage conversations?

The more conversations you have and the longer your shared conversations are, the more opportunities your child has to learn.

Use these techniques to encourage your child to join in with a conversation, but if they don't choose to, you can continue the conversation without pressuring them. They will gradually hear different ways of responding and in time conversations will grow.

TECHNIQUES TO GENERATE AND EXTEND CONVERSATIONS

Remember the balance in conversations –
At first the adult will be supporting the conversations.
Gradually there will be a more equal exchange.

Always accept your child's attempts at conversation –
Never correct when trying to support longer conversations.
Remember your mind reading and try and respond to them.

Prompt your child to take their turn –
If you have made a comment or a sister has answered the same question, prompt your child to take their turn.

Ask the same question to different family members –
Let your child hear others' responses and then they can have a try.
Set up scenarios where each child takes their turn.

Give your child a choice –
Suggest two or three items to choose from.
E.g. When practising the weekly spellings
'Shall we use a pen or a pencil?' (pause for around 5 seconds, if no response)
'Here, I've found a pencil.' **Ask yourself questions (rhetorical questions)**
E.g. I wonder what we should have for dinner tonight?
E.g. What shall we do if it rains today?

Ask Wh- questions

Behaviour Change Techniques

Behavior change can be achieved by a combination of factors:

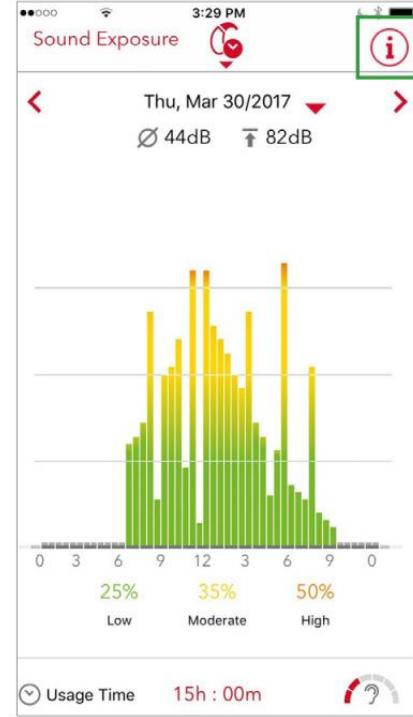
- Quantitative Linguistic Feedback
- Goal-Setting, achievements
- High frequency follow ups (weekly)
- Sense of achievement: Completing/Graduating the intervention program
- Maintenance: Win parents as ambassadors for the program
- Combination with education sessions: Introduce new concepts/goals, let parents implement them, discuss quantitative linguistic feedback as measure of success.

Data Logging in CI/HA

- becoming more common and more sophisticated
- changing the role of audiologists, SLPs, and patients
- Support the user
 - adapt sound processing, self-fitting/trainable HA
 - Feedback / motivation
- Support the clinician
 - programming, counselling
 - Are devices used as intended? Are settings ok? Are assistive devices needed?
 - Data logs as conversation starters
 - Integration into Telemedicine / mHealth

Mueller, H. Gustav Data logging: It's popular, but how can this feature be used to help patients?, *The Hearing Journal*: October 2007 - Volume 60 - Issue 10 - p 19,26
doi: 10.1097/01.HJ.0000295442.16133.d7

Dillon, H. et al. (2006) *The trainable hearing aid: What will it do for clients and clinicians?* *The Hearing Journal*



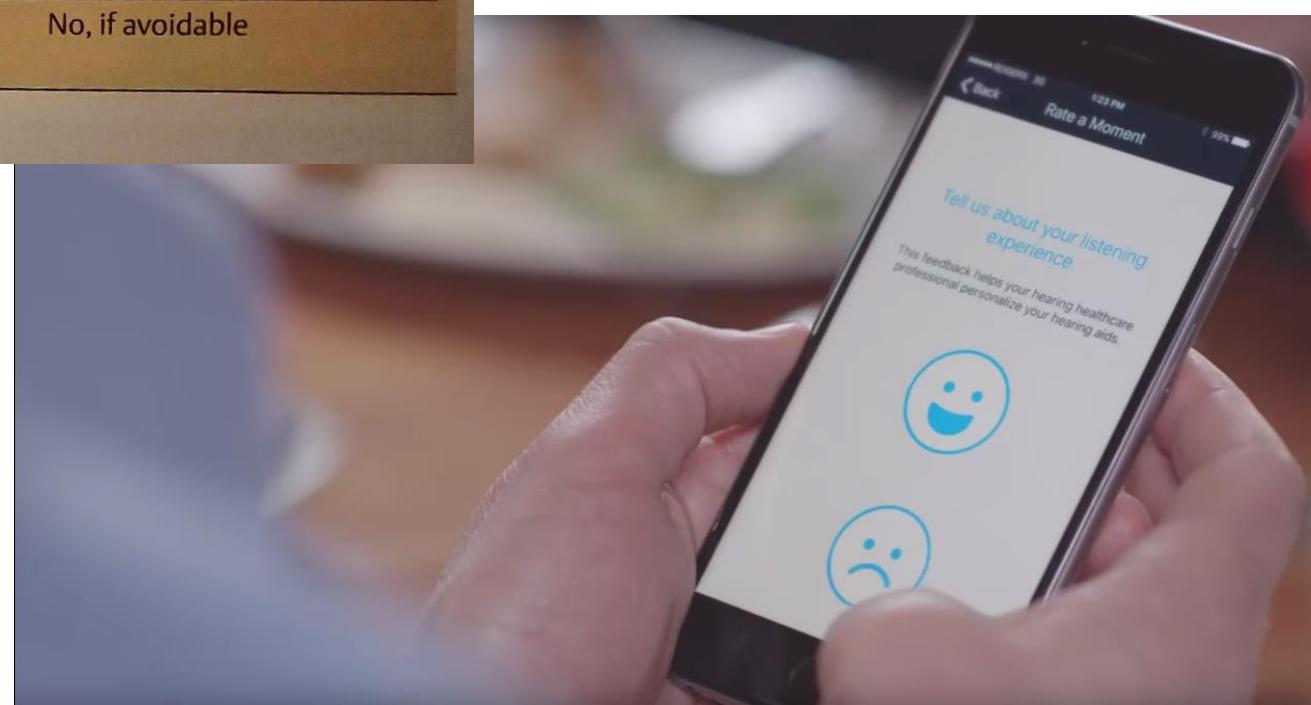
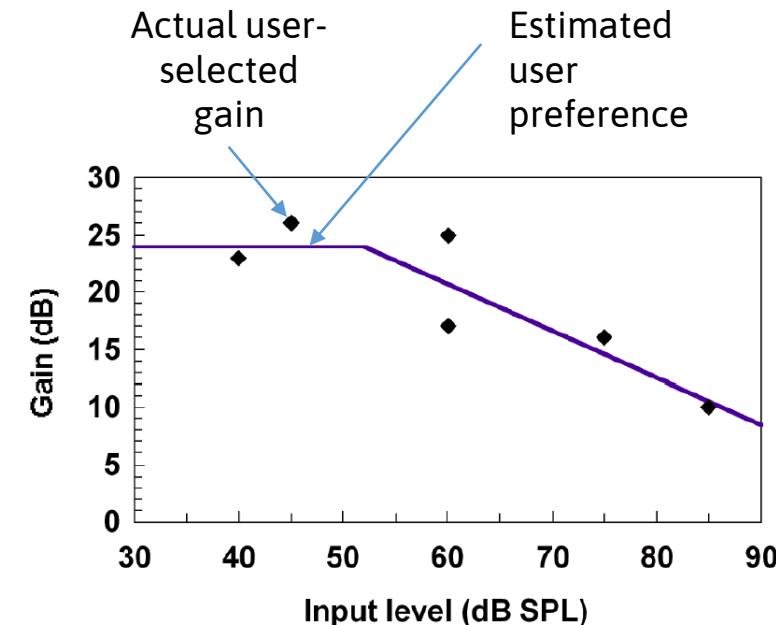
Data Logging in CI/HA

Table 10–1 Sensible Settings for Various Listening Situations

	Acoustic Directionality	Noise Reduction	WDRC	Feedback Cancellation
Speech	Yes, if speech is from the front	Not normally	Maximize intelligibility	Yes, if the amplification requires it
Music	Not normally, except in a reverberant room	No	Broadband amplification	No, if avoidable
Noise	Not normally	Yes, especially in case of loud noise	Depends on situation	No, if avoidable

Abbreviation: WDRC, wide dynamic range compression.

Table from Schaub, Arthur, *Digital Hearing Aids*, p 110



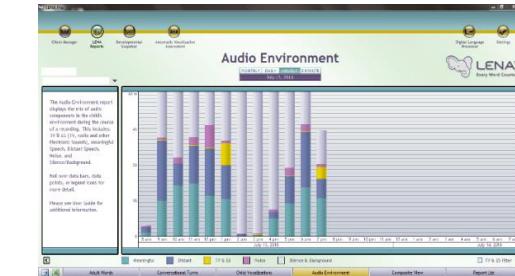
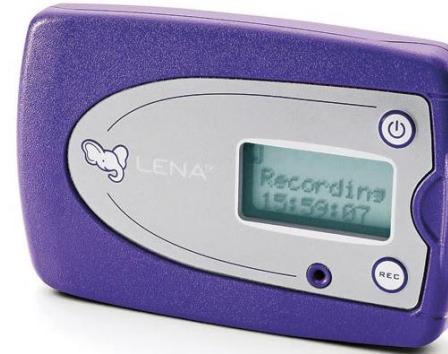
Data Logging in CI/HA

- Captures time between clinic visits
- counts duration of CI use, exposure to speech, speech in noise, noise, music, quiet,
- accessory use
- device diagnostics
- Short and long term logs
- Apps for Clinicians and apps for users



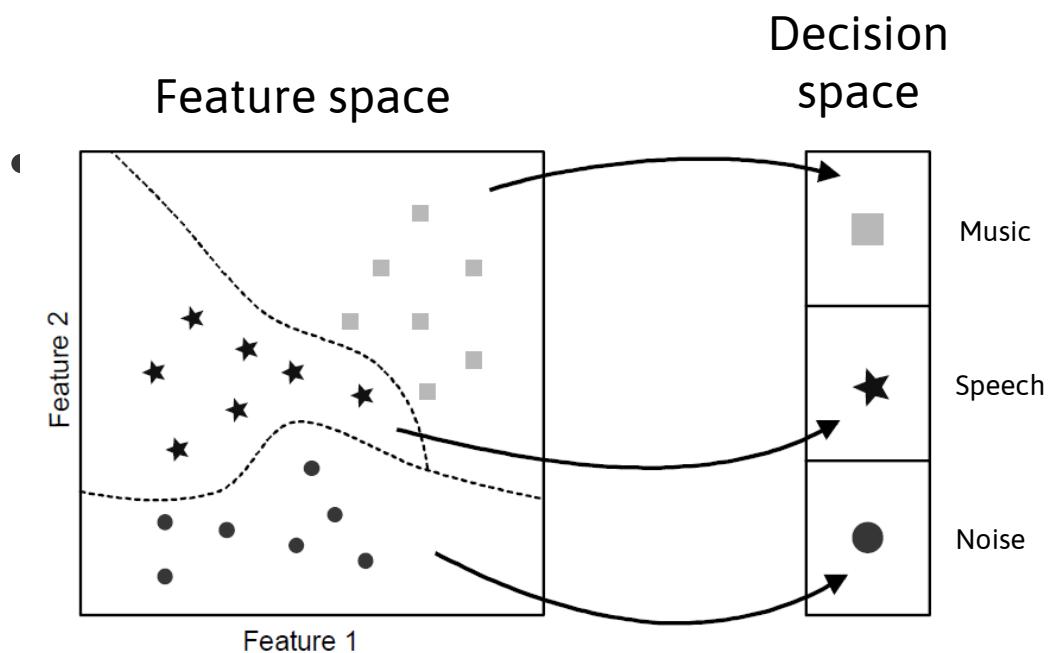
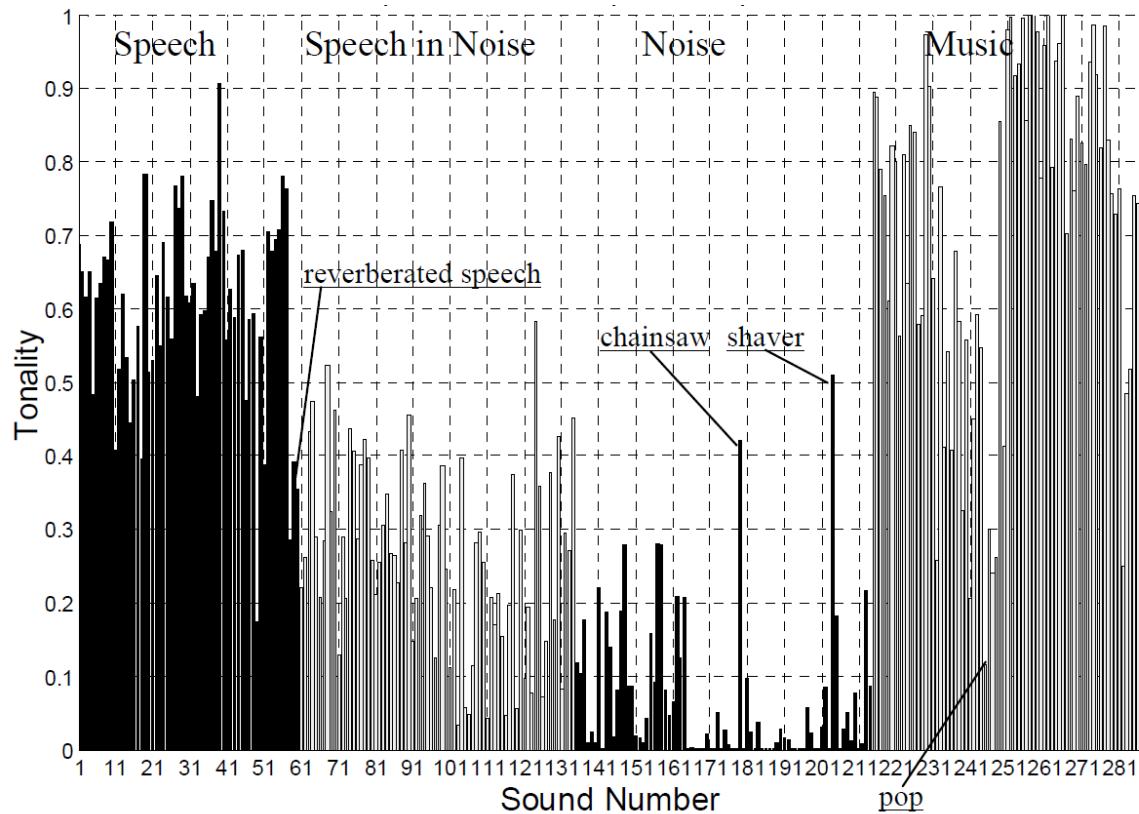
LENA

- Records audio for one day
- estimates adult word count, child vocalization, conversational turns, ...
- Research Themes
 - individual differences
 - cross-linguistic issues
 - population differences
 - context differences
 - word gap intervention research
 - Validity
- Costly license and can be logistically challenging



Greenwood, C. R., Schnitz, A. G., Irvin, D., Tsai, S. F., & Carta, J. J. (2018). Automated Language Environment Analysis: A Research Synthesis. *American journal of speech-language pathology*, 27(2), 853–867.
https://doi.org/10.1044/2017_AJSLP-17-0033

How does automatic scene classification work?



Key points

- The brain reorganizes in response to early language input.
- HL reduces access to language, which causes cascading effects on language, cognition, social-emotional development, and more.
- Child and environment are interconnected
- Important aspects of family environment.
- Children with HL have problems in Noise.
- The environment must be taken into account in assessment and intervention
- LENA or data logging can be useful tools in parent-directed intervention