Early access to language: Creating an optimal foundation for deaf children's cognitive development

Language Acquisition and Learning in Deaf Children
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Marie Coppola, Ph.D.
University of Connecticut
Assistant Professor
Departments of Psychological Sciences and Linguistics
Director, Language Creation Laboratory
Principal Investigator, Study of Language and Math (SLaM)
Executive Director, Manos Unidas Nicaragua

UCONN
UNIVERSITY OF CONNECTICUT

A little about me…

- Deaf parents; first languages ASL and English
- 1994: MIT, First trip to Nicaragua
- 2002: PhD, Brain & Cognitive Sci., Univ. of Rochester
- 2002: Postdoc, Univ. of Chicago, Developmental Psychology
- 2005: Founded Manos Unidas (Hands Together)
- 2010: Began at UConn; Advisor for *Language for All*
- 2016: NSF Study of Language and Math (SLaM)
- Passionate promoter of access to language

ALL CHILDREN achieve good outcomes when they have:

- CHILD: Early experience with high-quality, accessible language
- FAMILY/PEERS: High sociocommunicative engagement with parents and peers
  - Socially well-adjusted
  - Mentors and role models

- EDUCATION: High-quality educational environment
  - Rich and varied content
  - Good communication with educators
  - High expectations from family and teachers

DEAF CHILDREN achieve good outcomes when they have:

- CHILD: Early exposure to high-quality, accessible language
- FAMILY/PEERS: High sociocommunicative engagement with parents and peers
  - Socially well-adjusted
  - Mentors and role models
- EDUCATION: High-quality environment
  - High-quality content
  - Good communication with educators
  - High expectations from family and teachers

Access to language is the key

- A strong language foundation is key to all of these ingredients
- For most children, access to language can be taken for granted
- Even among hearing children, quantity and quality of language input are important (e.g. Hart & Risley 1975)
  - 30-*million* word gap by age 3 (!)
  - http://www.providencetalks.org

PROVIDENCE TALKS

Learning Objectives

- Accessible language input is necessary to establish neural networks for language
- Acquiring a natural sign language does not impede acquisition of spoken language
- Language is not just for communication
  - Delays in full access to language *increase risk for impulsive behavior and impair other aspects of cognitive development*

The bigger picture

- Cochlear Implants (CIs) are now used by a majority of deaf and hard of hearing (DHH) children
- We cannot accurately predict which children will succeed in acquiring spoken language via CIs
- Spoken language and sign language are BOTH subject to biological constraints (sensitive periods)
- To achieve optimum outcomes, DHH children should be bimodal and bilingual (acquire both English and ASL)

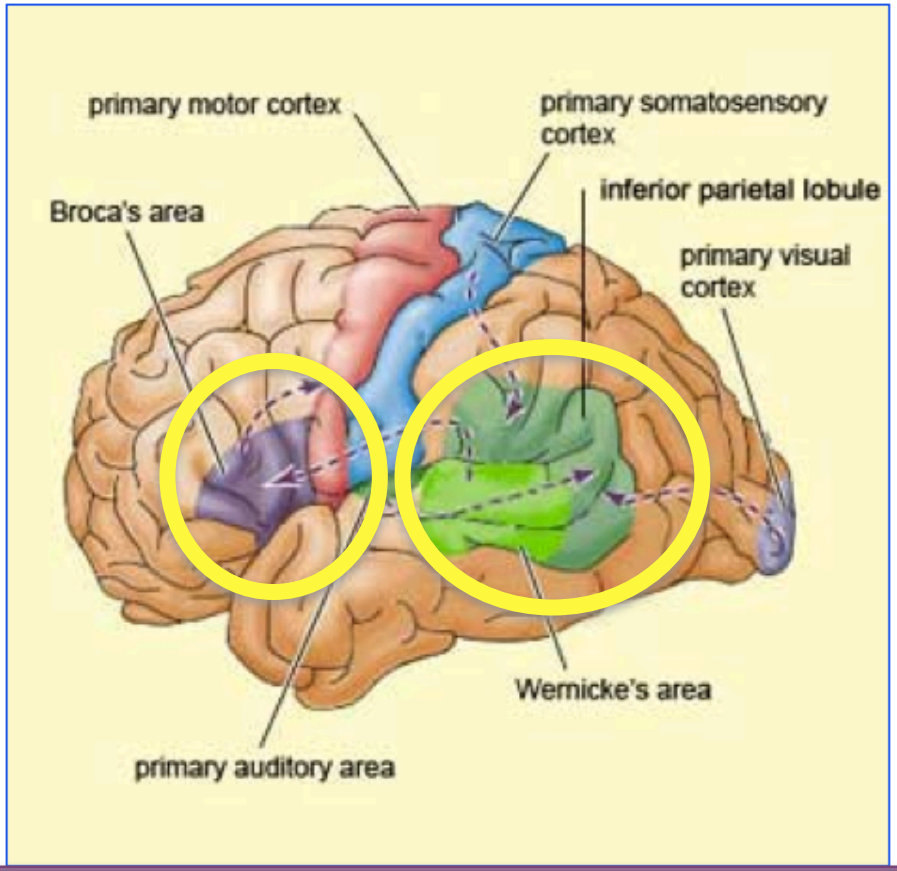
Natural sign languages and spoken languages:

- Are linguistically structured
- Convey an infinite number of concepts
- Rely on similar neural substrates
- Are acquired on the same developmental timetable
- *Must be learned early in development*

What counts as "language?"

ASL = Hands, eyes

English = Mouth, ears



Cortical areas that process English and ASL are highly overlapping, even though they enter via different senses.

Today's plan

- Language, modality, and the brain
- What is language for besides communication?
- Does sign language hinder spoken language development?
- Is early sign language the solution?

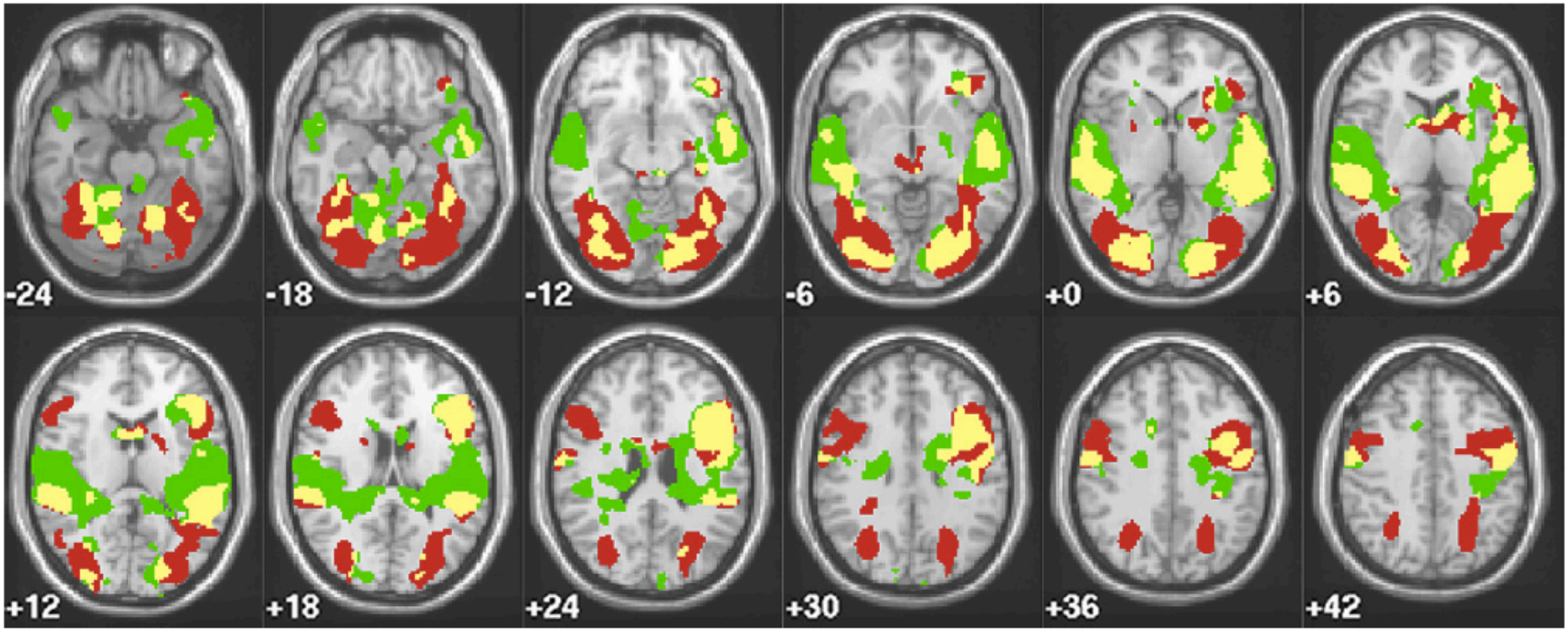
Does the functional neuroanatomy of language depend on the **sensory and motor modalities** used to perceive and produce it?

Language	Produced	Perceived
Sign	Gestural	Visual
Spoken	Vocal	Auditory
Written	Motor (hands)	Visual

Language, Modality, and the Brain

- Overlap of networks processing spoken language (auditory) and written language (visual)
- Overlap of networks processing spoken language (auditory) and sign language (visual)
- No evidence that Deaf and Hard of Hearing children cannot be BILINGUAL in English and American Sign Language given appropriate exposure

+ Overlap of networks processing spoken (auditory) and written language (visual)



Braze et al., 2010

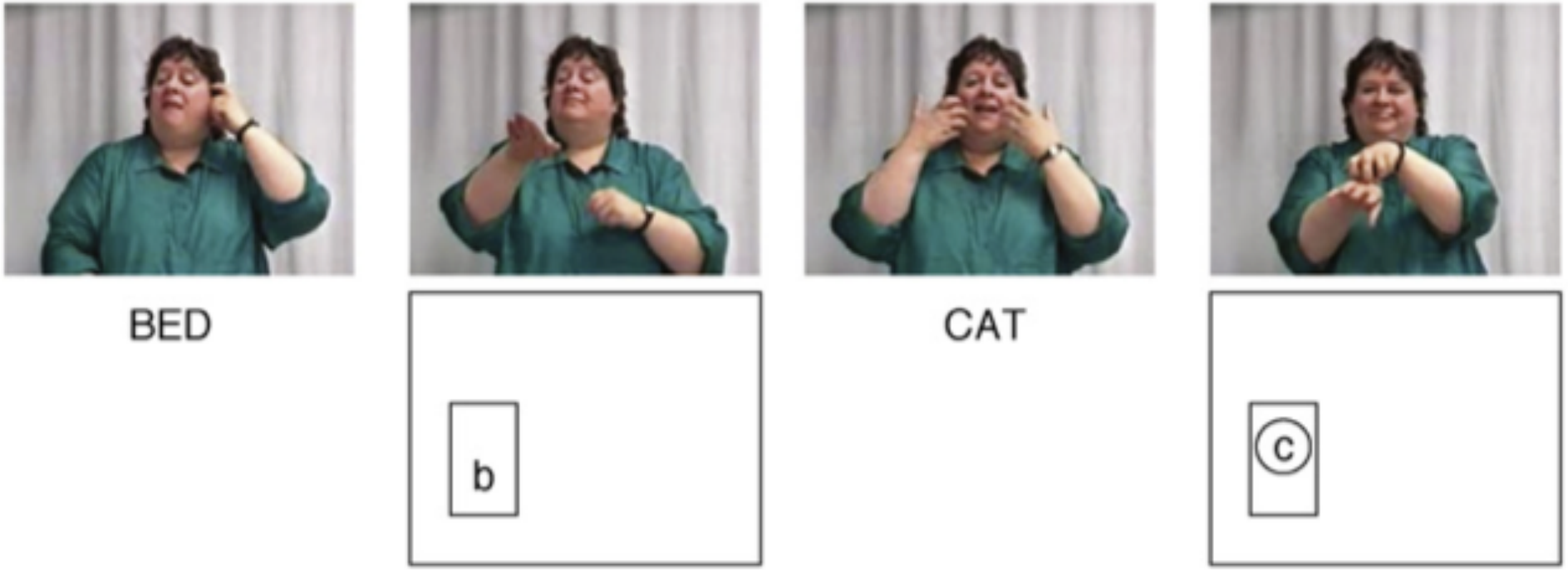
Activated by speech

Activated by print

Activated by both speech and print

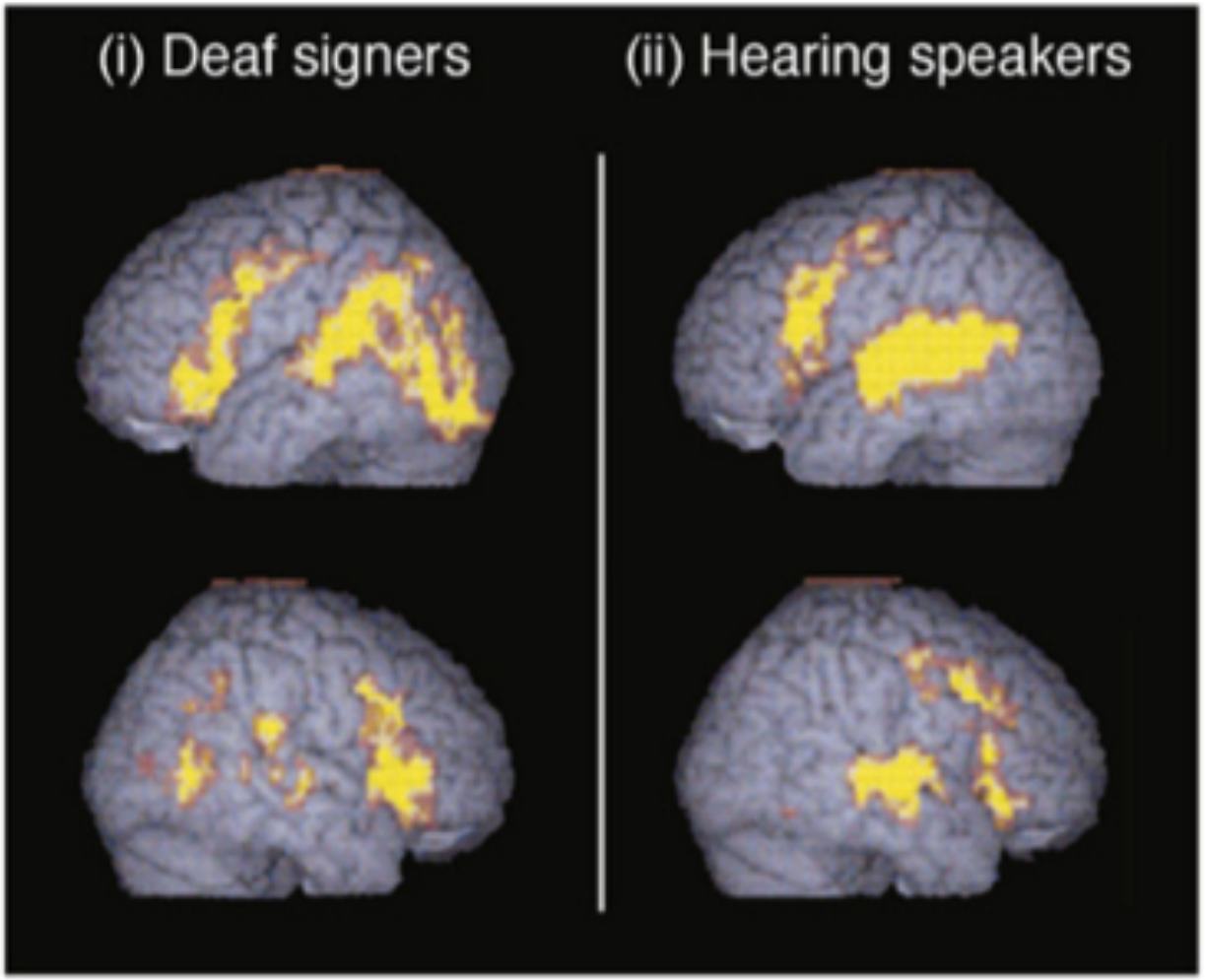
Overlap of networks processing spoken (auditory) and sign language (visual)

English translation: *The cat sat on the bed.*



- Compared the activation observed in British Sign Language (BSL) signers watching BSL sentences and English speakers listening to English sentences (MacSweeney et al. 2002)

Overlap of networks processing spoken (auditory) and sign language (visual)



To control for modality of input:
Language inputs were contrasted with a baseline: perception of the still model and a low-level target detection task (visual for deaf; auditory for hearing).

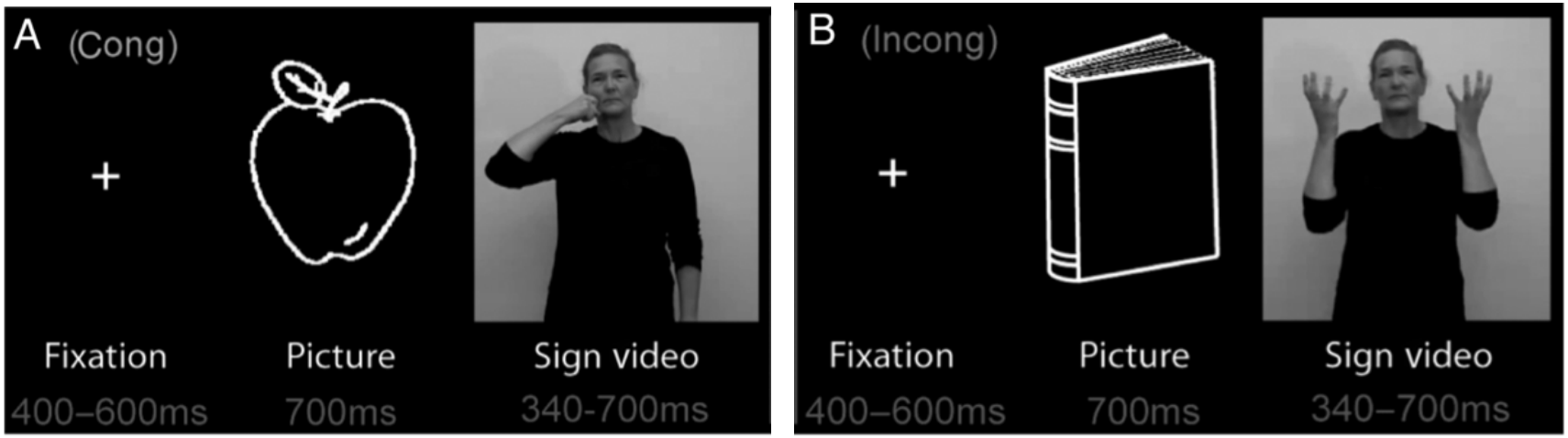
Is the functional neuroanatomy of language influenced by the TIMING of exposure to language?

Sensitive period: Timing of linguistic input affects proficiency

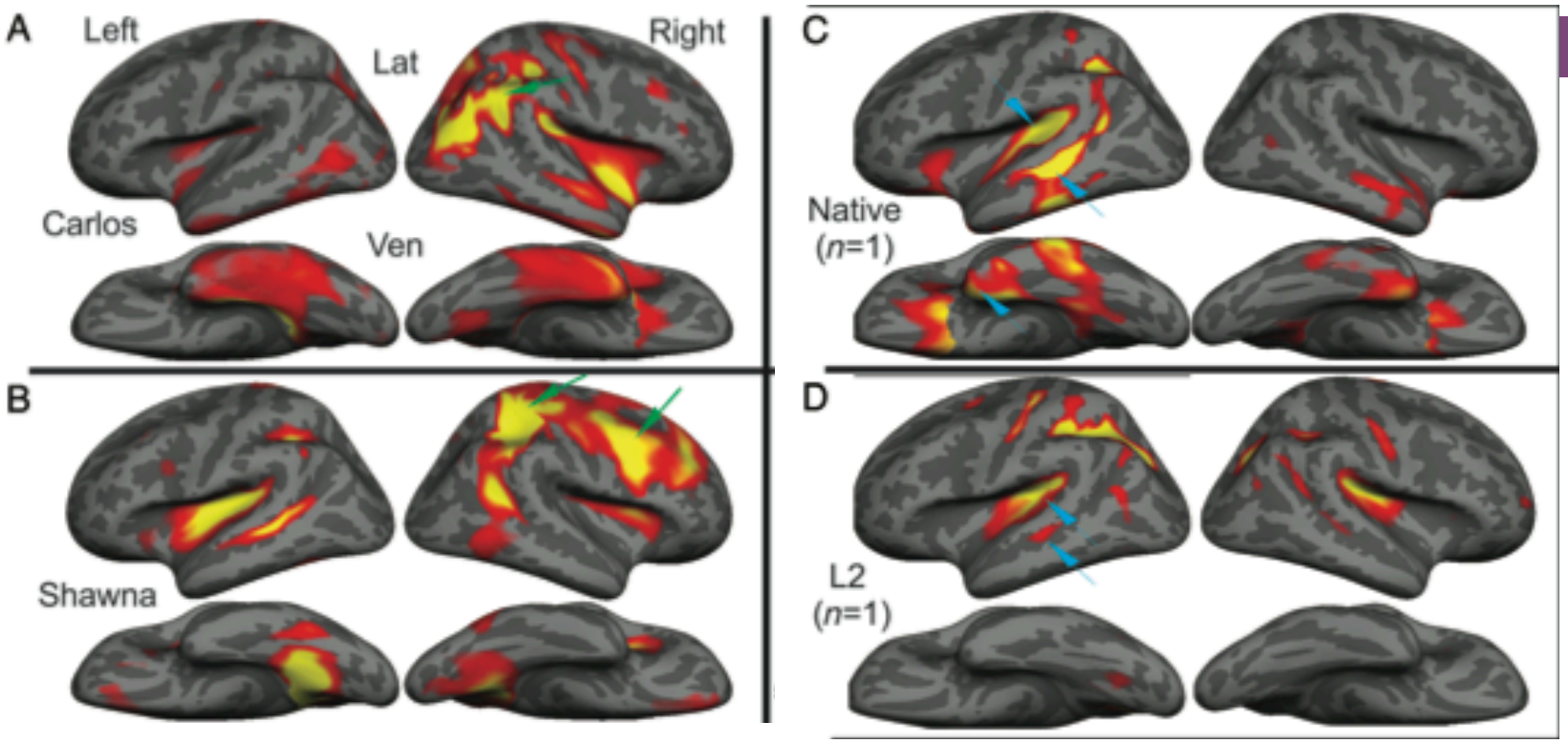
- Effects on Grammar
  - both signed (e.g., Mayberry, 2011; Newport 1990) and spoken (e.g., Johnson & Newport 1989)
  - late exposure to either 1st or 2nd language
- Effects on Language Processing
  - late 1st language users (Mayberry & Eichen 1991)

Timing of linguistic input affects brain structures for language

- Two young adults who were exposed to their first language (ASL) at 13 or 14 years of age were compared to:
  - Deaf signers exposed to ASL from birth (n=12)
  - Hearing signers with ~ 1 year ASL in college (n=11)
- Simple task: decide whether an ASL sign matched an object



Ferjan Ramirez et al. 2013, *Cerebral Cortex*



2 cases with late exposure to ASL (top and bottom)

Deaf ASL signer exposed from birth (top)
Hearing adult second-language learner of ASL (bottom)

Method: anatomically constrained magnetoencephalography (aMEG)

Images of brains show the DIFFERENCE between the areas activated during the incongruent trials and the areas activated during the congruent trials (incongruent MINUS congruent)

Ferjan Ramirez et al. 2013, *Cerebral Cortex*

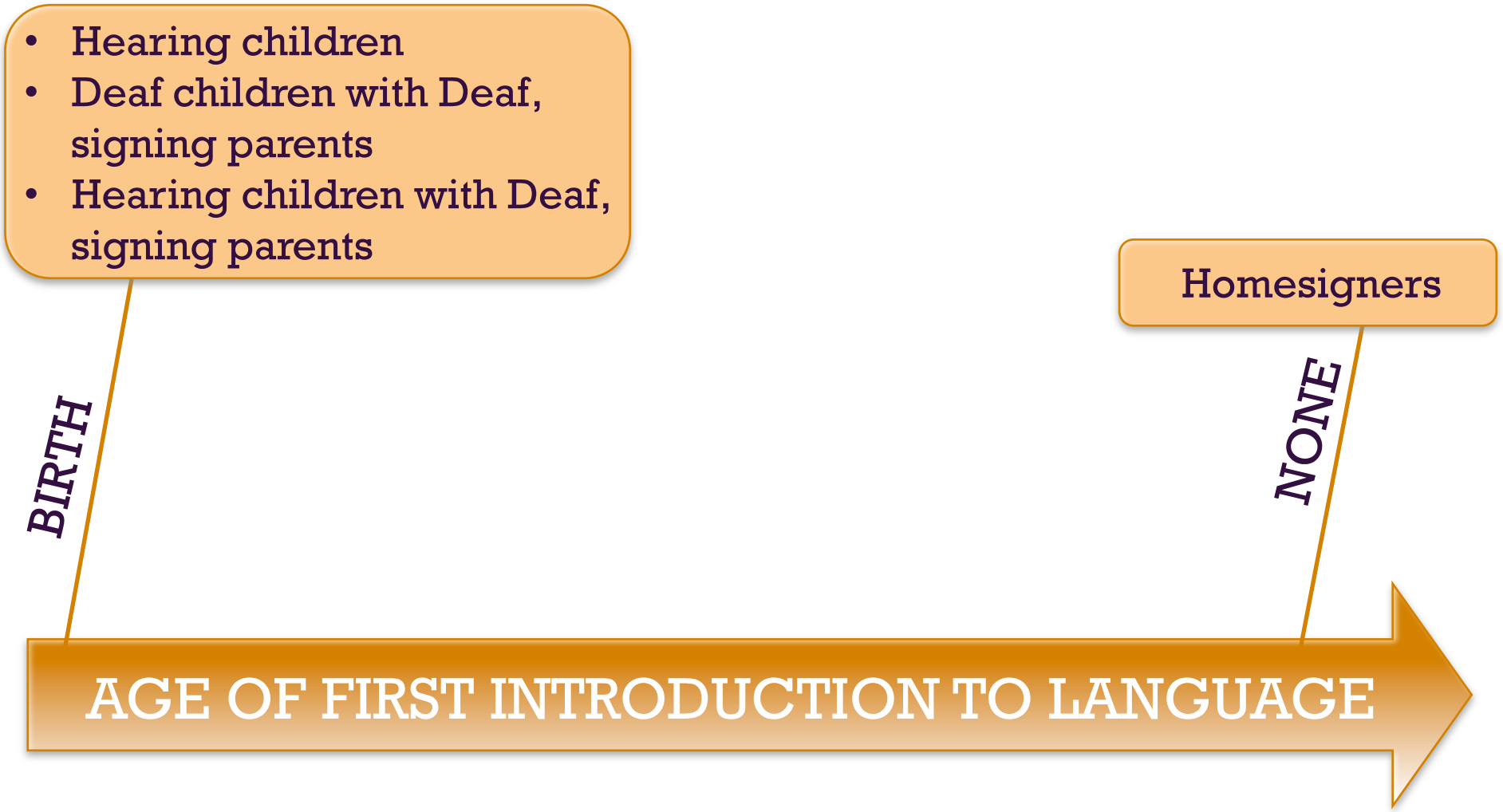
Summary: Language, modality, brain

- The overlap in brain areas specialized for spoken and signed language is ONLY observed when language acquisition begins early.
- Adults who acquired sign language early had more activation in left frontal brain regions
  - Characteristic pattern found in native speakers of spoken languages
- The individuals who began acquiring language as teenagers DID NOT develop typical neural networks for language

Language is not just related to "Communication"…

Number understanding above "3"	• Math achievement • Daily living skills
Understanding others' perspectives, intentions, behavior	• Successful social interactions at work and at home
Ability to self-regulate	• Better: Jobs, mental health, relationships. • Lower: crime, substance abuse

Variation in the age of exposure to language among deaf children: two example extremes



Kids with early access to language develop these things normally:

- Hearing children
- Deaf children with Deaf, signing parents
- Hearing children with Deaf, signing parents

Exposed at BIRTH

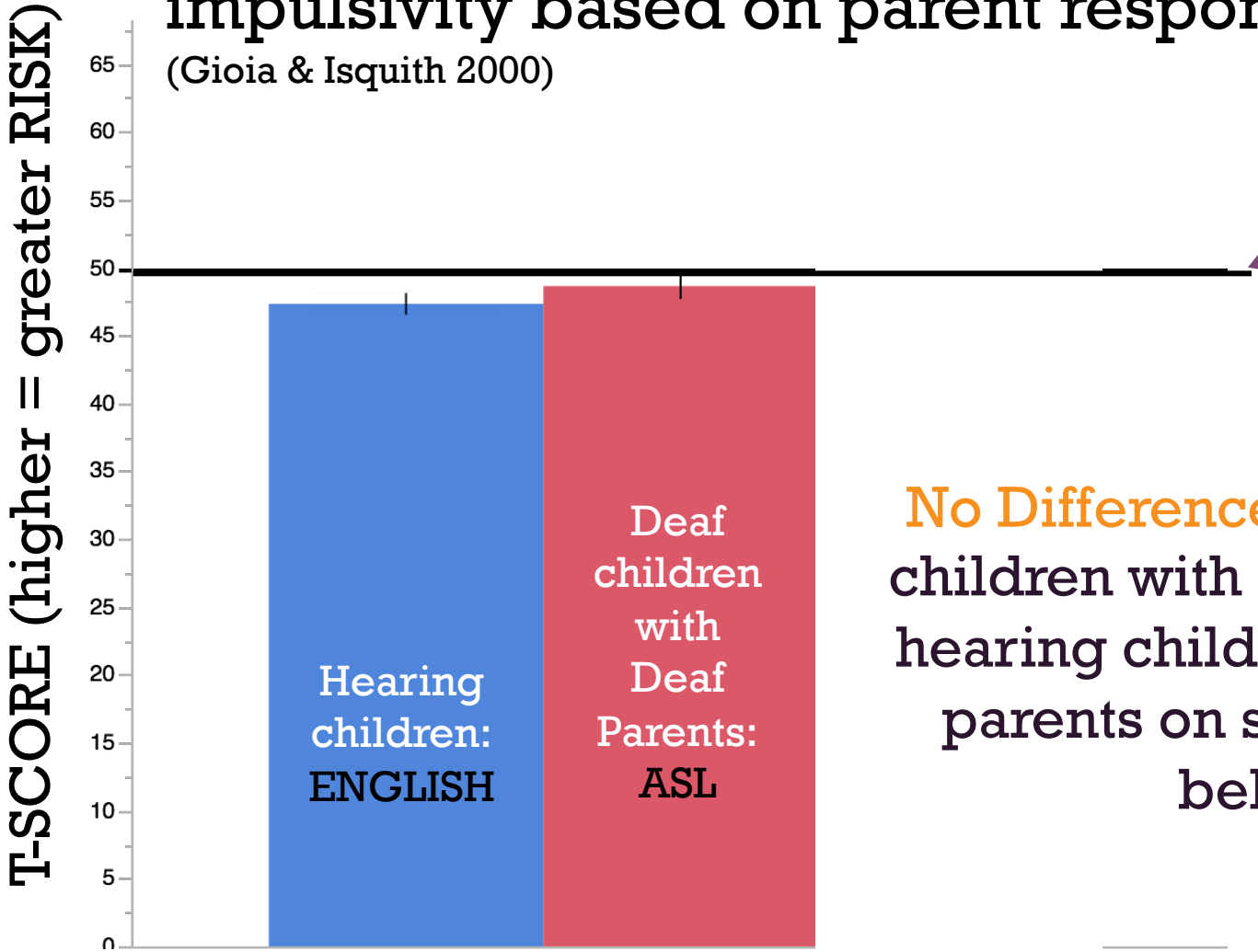
What:

- Number Understanding
- Understanding of others' perspectives
- Self-regulation

All these groups have *early access to language*!

B.R.I.E.F. Questionnaire: measure of child impulsivity based on parent responses

(Gioia & Isquith 2000)



Hall et al. 2015

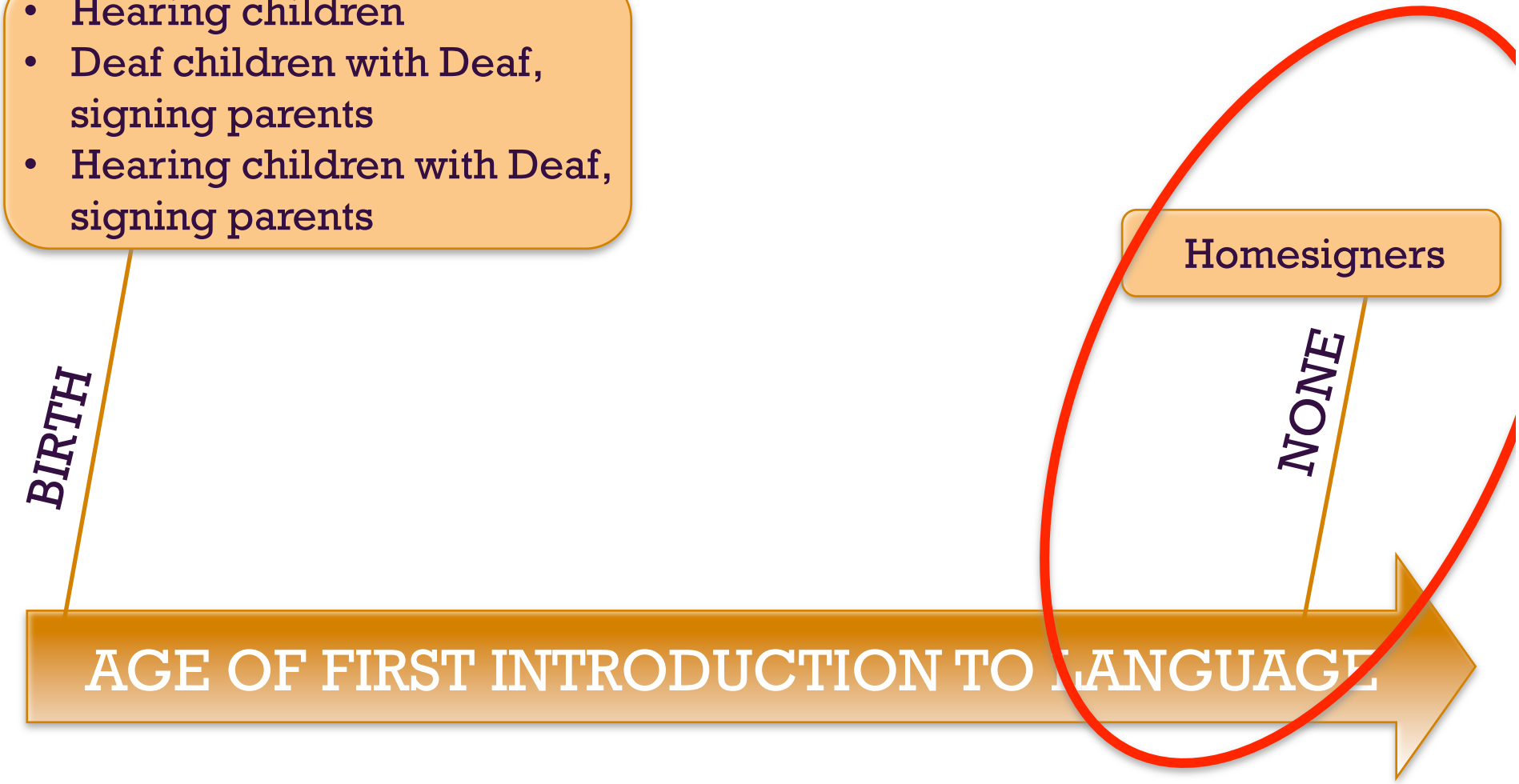
No Differences between deaf children with deaf parents and hearing children with hearing parents on self control and behavior

These outcomes are not linked to hearing level!

Variation in the age of exposure to language among deaf children: two example extremes

- Hearing children
- Deaf children with Deaf, signing parents
- Hearing children with Deaf, signing parents

Homesigners



What is homesign?

- No access to spoken language or sign language input
- "Homemade" gesture system with many similarities to sign languages
- Can express complex ideas
- Can be used throughout a lifetime
- Linguistically but not socially deprived

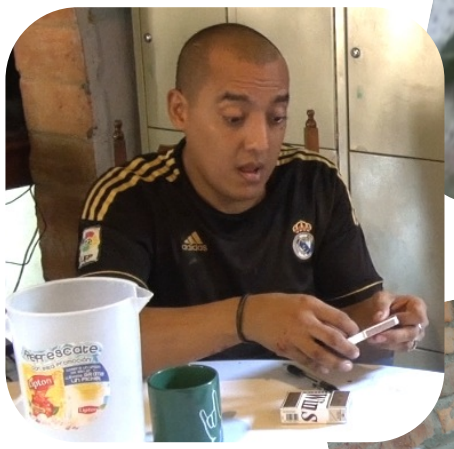
Homesigners: an extreme case of language deprivation

- Deaf people raised in families who do not know sign language:
  - Create their own visual communication systems.
- No opportunity to go to school or learn sign language
- Integrated into family, community, and work– not neglected/abused

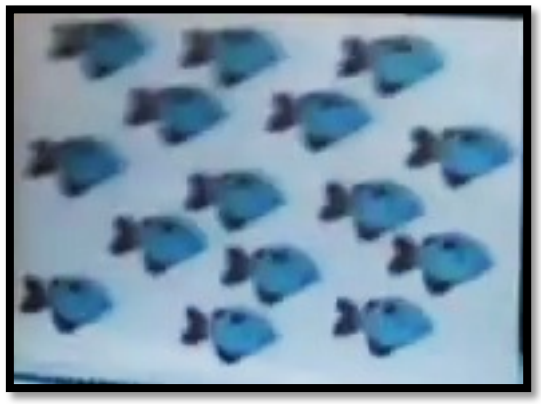
Homesigners don't receive linguistic input but have fairly typical social opportunities.

In spite of "normal" life activities, homesigners struggle with:

- Exactly representing quantities 4 and larger
- Understanding of others' intentions, behavior, perspectives
- Self-regulation / Impulse control



Without language input, life experience is not enough to develop these abilities.



- "What's on this Card" (1-20 items)

  As much time as he needed to count

Target	15	2
Response	12	2

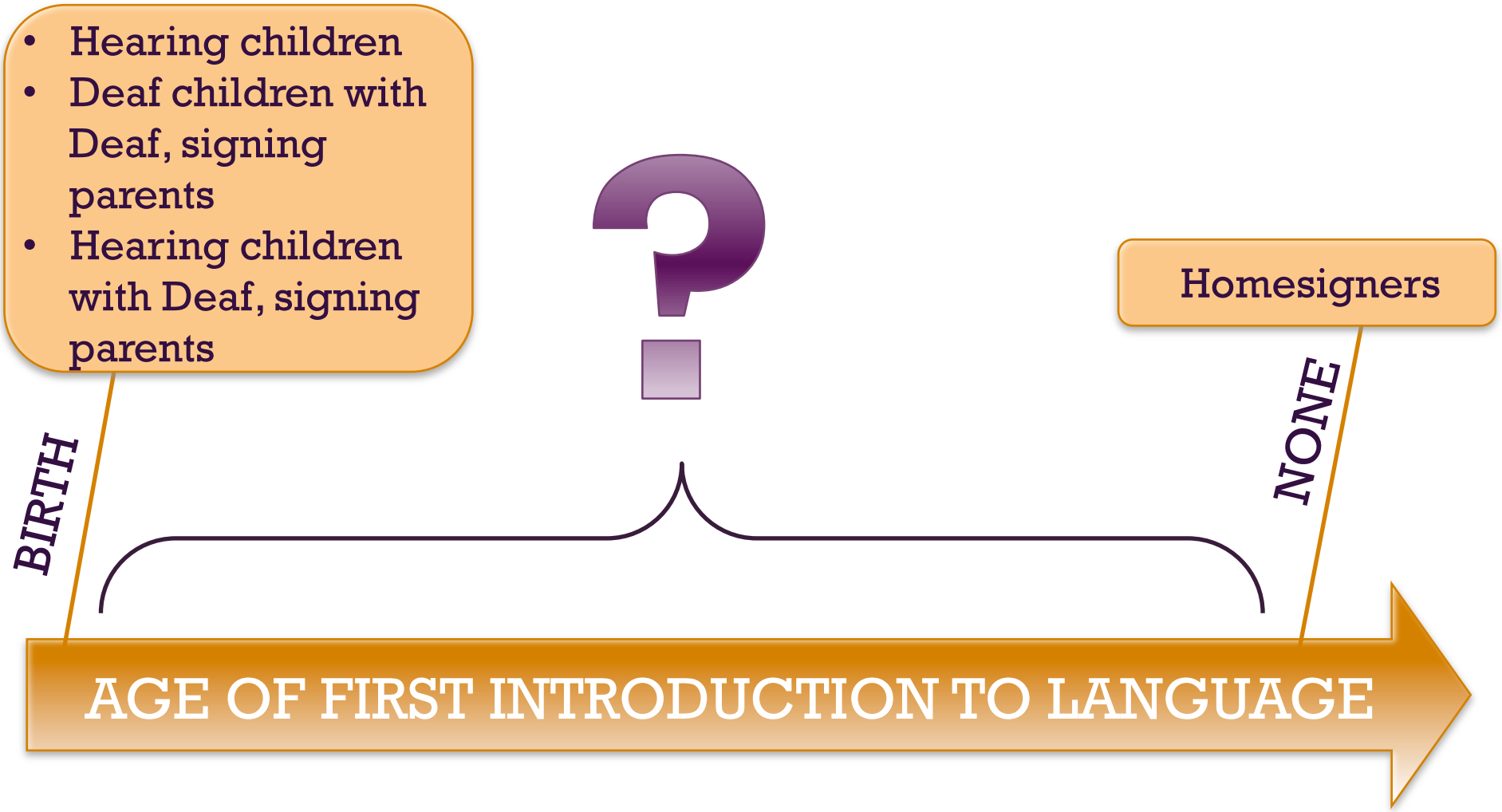
http://youtu.be/VIjAwn8X3Qc

Knock Matching Task

Target	4	1
Response	5	1

https://youtu.be/aK5wvEufWUw

Most deaf children fall between these extremes



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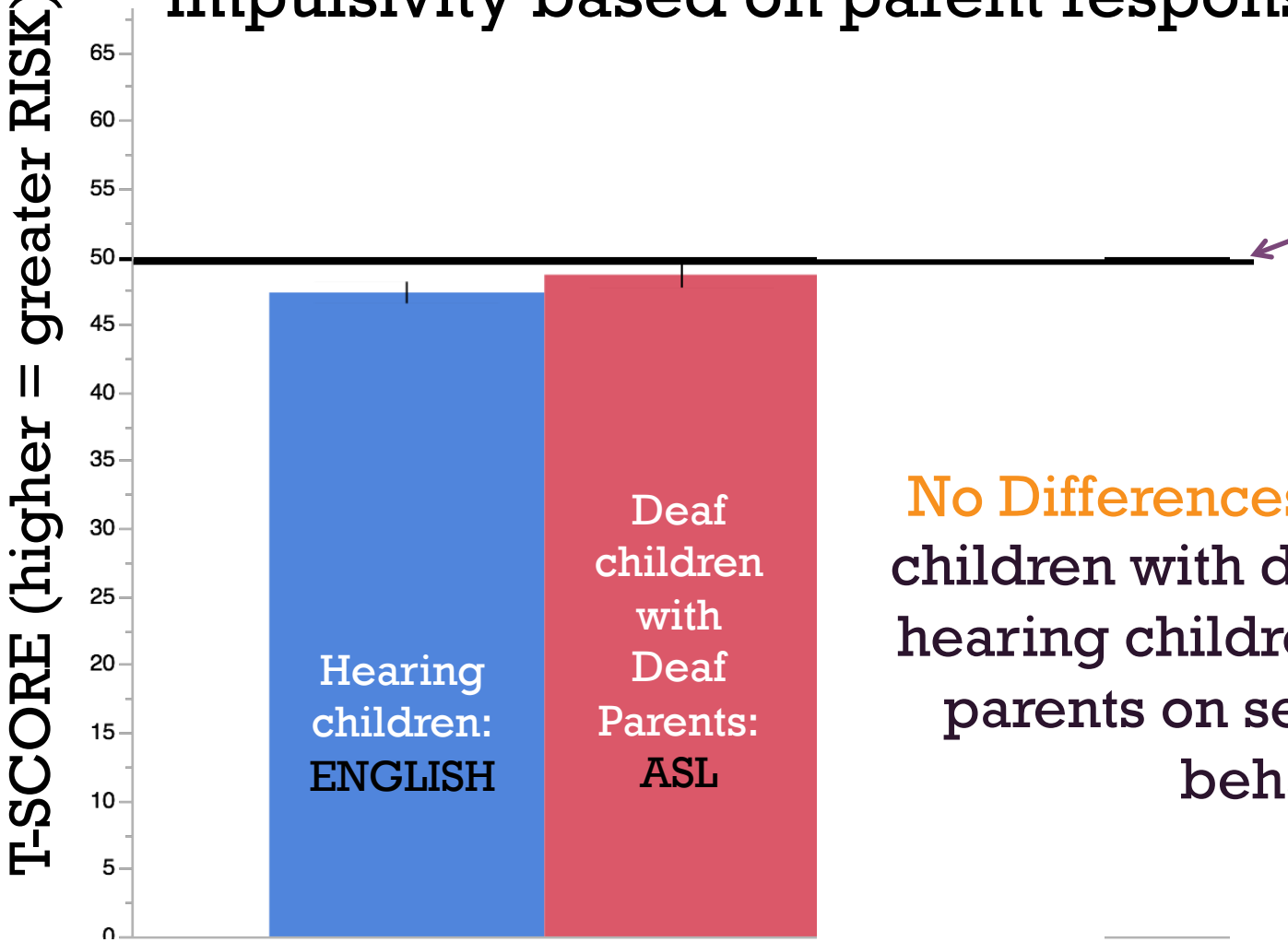

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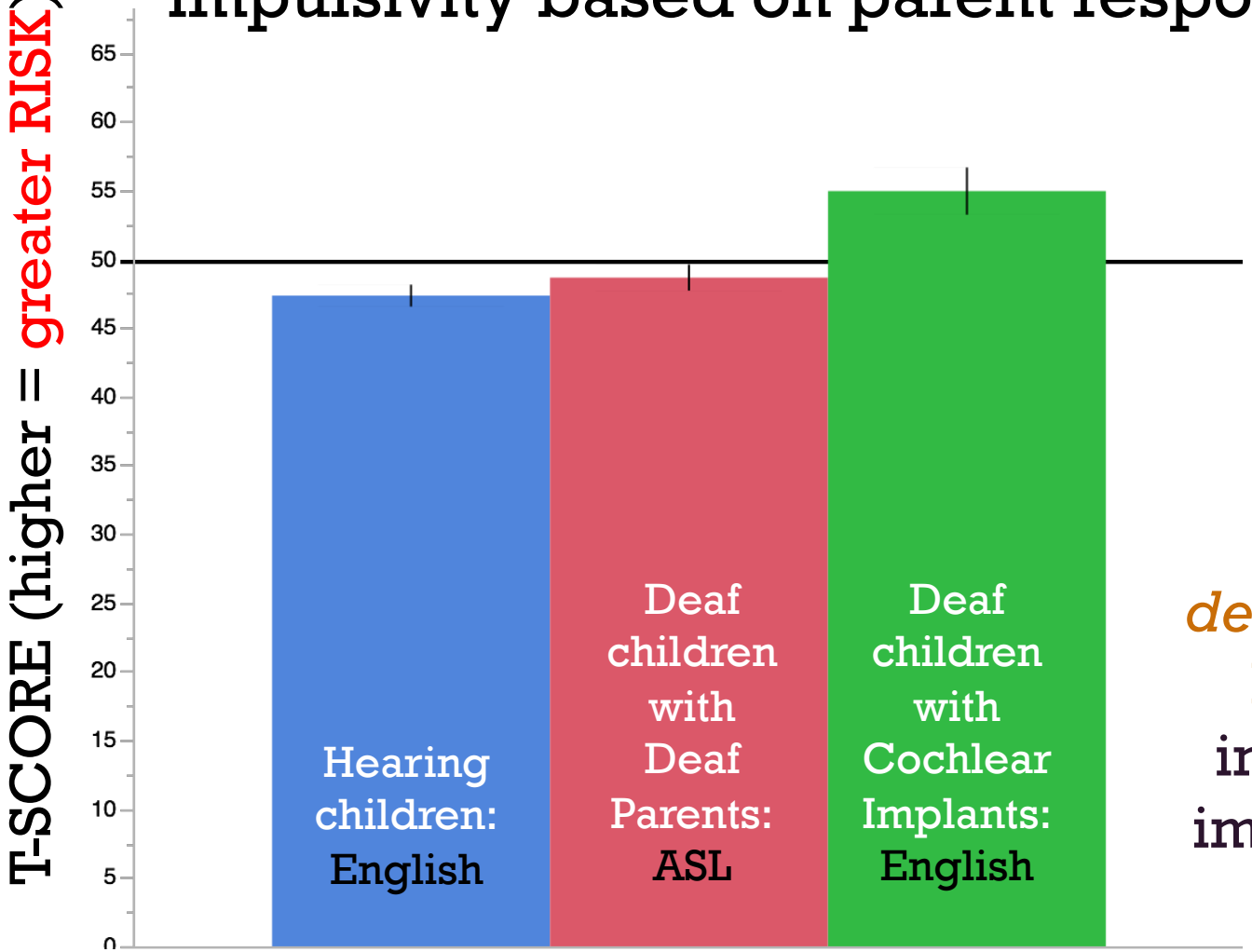


Hall et al. 2015

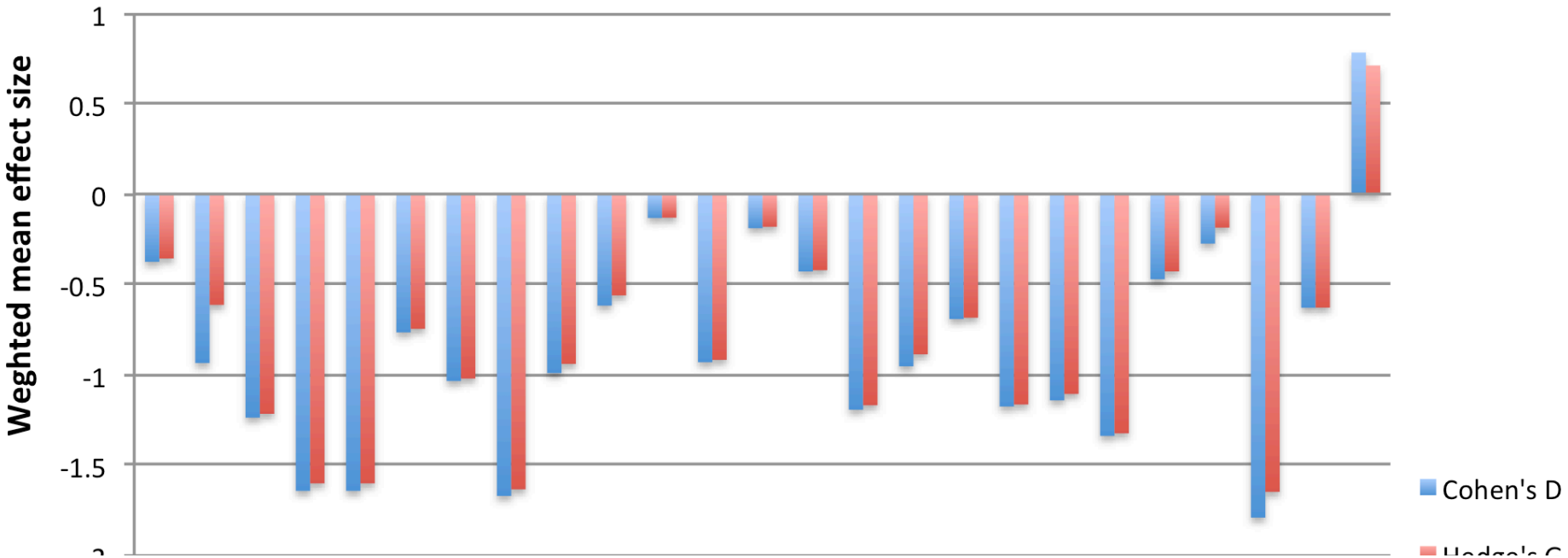
Children with *delayed exposure* to language show increased risk for impulsive behavior

This is a result of a delay in first language exposure!!

Turning to another domain: NUMBER and MATH development

The math gap: A meta-analysis

Normally hearing children outperform Deaf/HH children in 24/25 studies where they are directly



Miller & Coppola, 2016; Coppola et al. in prep; Gottardis et al. 2015

THE IMPACT OF LANGUAGE EXPERIENCE ON NUMBER REPRESENTATIONS IN DEAF, HARD OF HEARING, AND HEARING CHILDREN

NSF CAREER award 2016-2021 (Education & Human Resources, Linguistics):

Sensitive period effects??

Early-Language

Early-Sign: Deaf/hard of hearing (DHH) children with signing Deaf parents (ASL)

Early-Speech: Hearing children with hearing parents (English)

Approach: Compare children who differ in

TIMING of language exposure and TYPE of language

Later-Language

Later-Sign: DHH children with non-signing hearing parents (ASL)

Later-Speech: DHH children with Cochlear Implants/Hearing Aids (English via LSL)

Study of Language and Math

1. Project 1: Developmental trajectory
2. Project 2: Computational fluency with number symbols
3. Project 3: Training study to establish causality

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Study of Language and Math

Elicited Counting

Can you count for me? (*"one"*, *"two"*, *"three"*, etc….)

Elicited Counting with Objects

Can you count these fish for me?

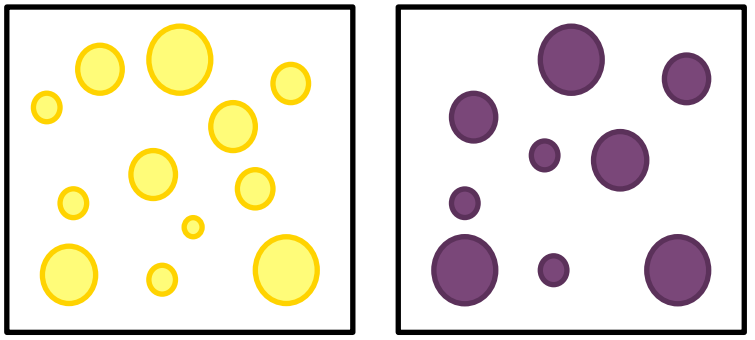
SLaM
Study of Language and Math

Give-N Objects (verbal)

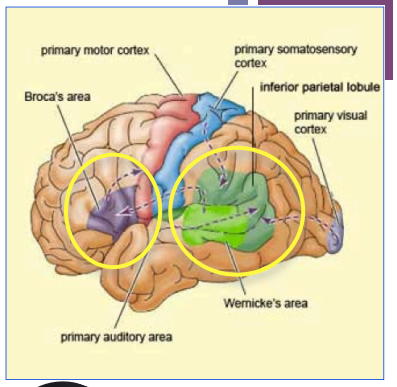
Put N fish in the bowl

Approximate Number System Acuity (non-verbal)

Point to the side that has more dots



Deaf children's language experiences



- Sign languages and spoken languages are acquired the same way– the earlier the better!
  - NOT just about speech and hearing!
- We can't predict which children will succeed with auditory/verbal/aural interventions
- Average age of entry in several signing Deaf schools is about 12-14 years old. (Bravin, Colin McEnroe show, 3/17/16: http://wnpr.org/post/endangered-language-how-technology-may-replace-braille-and-sign#stream/0)

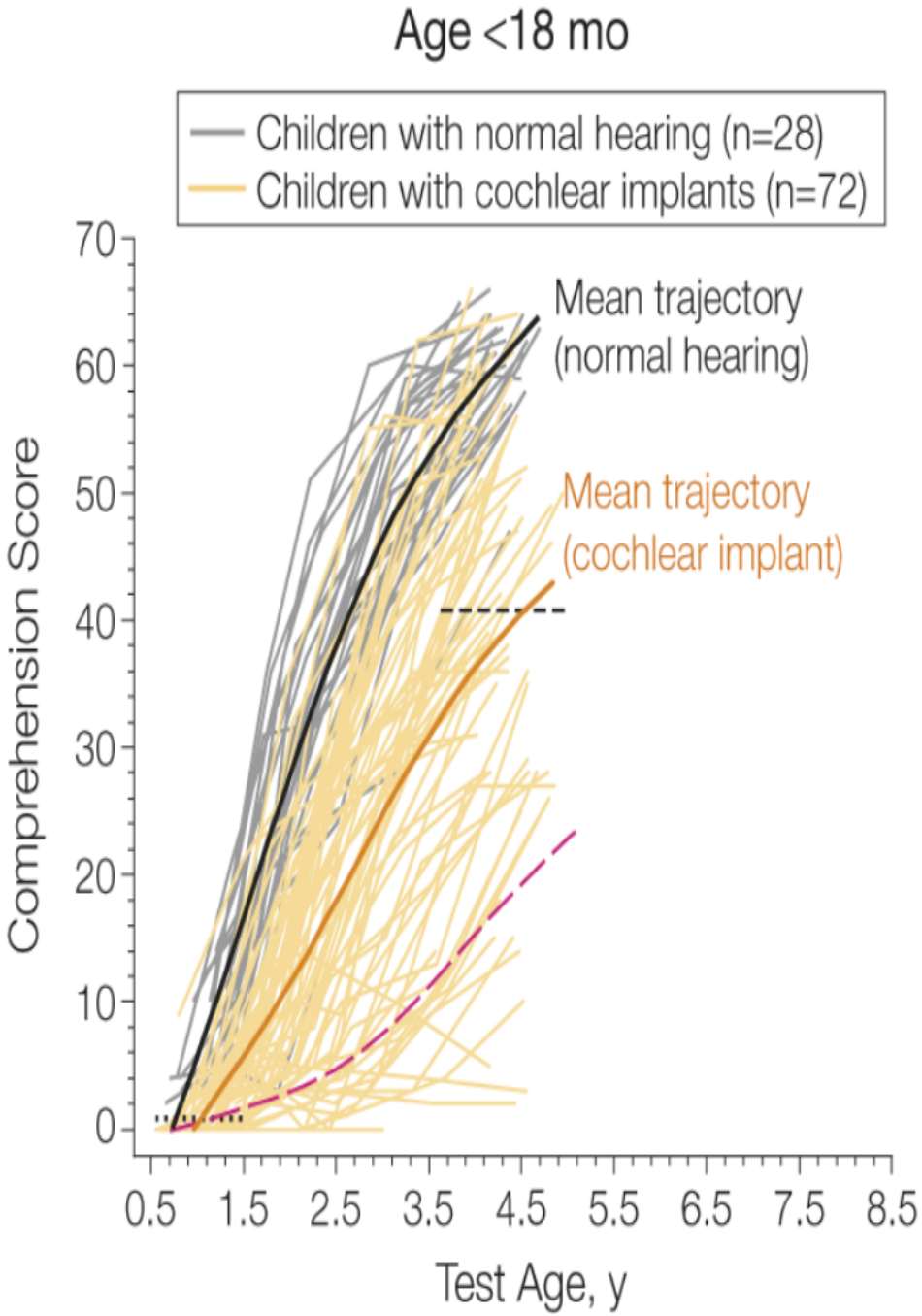
These children did not succeed with speech alone, and have also missed the window of opportunity for optimum learning of <u>any</u> language, signed or not.

Spoken language outcomes with CI are highly variable (e.g. Niparko et al., 2010)

- CI users scoring 86 on a standardized measure, fall within the average range; as a group, they would also be significantly delayed (expected mean 100).
- **Scoring "within the average range" is not the same as age-appropriate language development.**
- **Given the importance of a language foundation for cognitive dev't, it is imperative that ALL children succeed with at least one language**

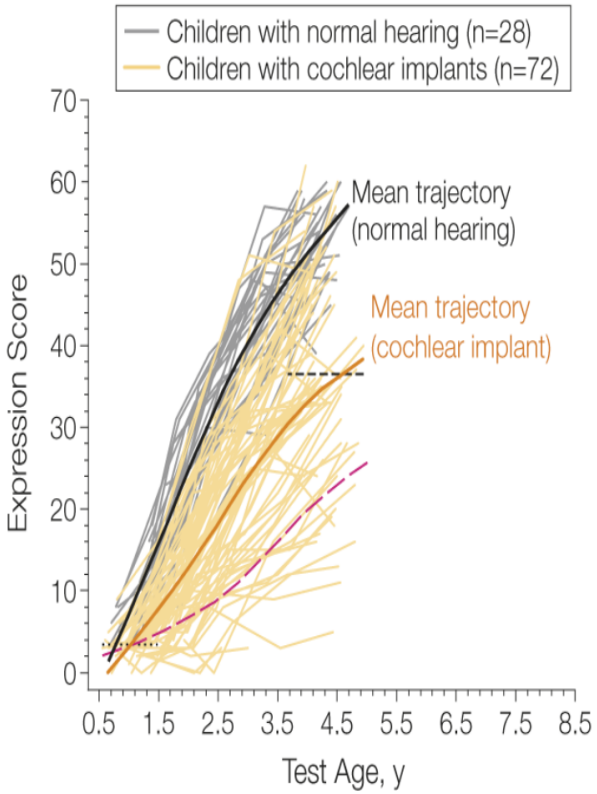
Spoken language outcomes with CI are highly variable

Niparko et al., 2010

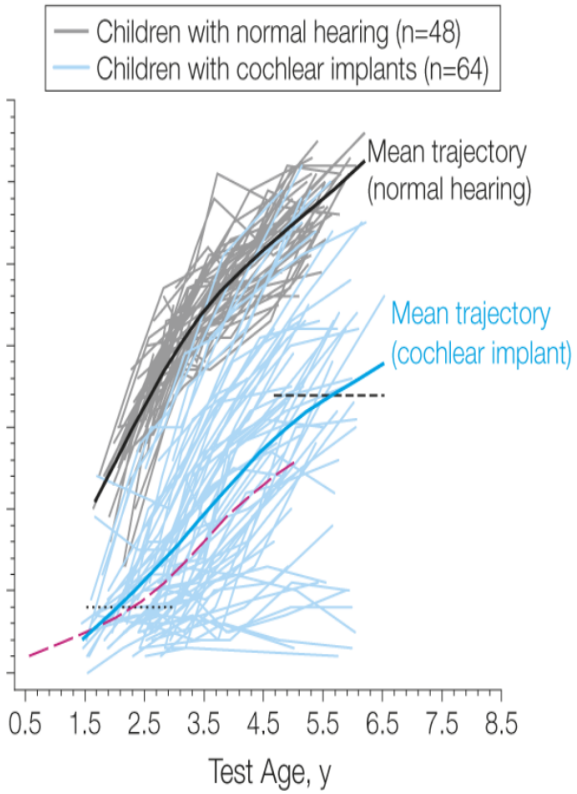


Production of spoken English based on age of implantation

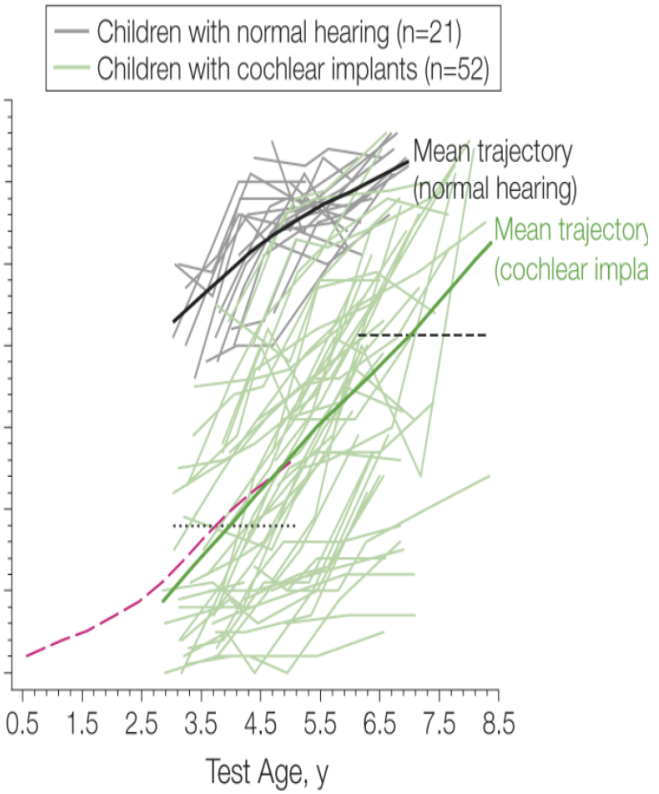
< 18 mo



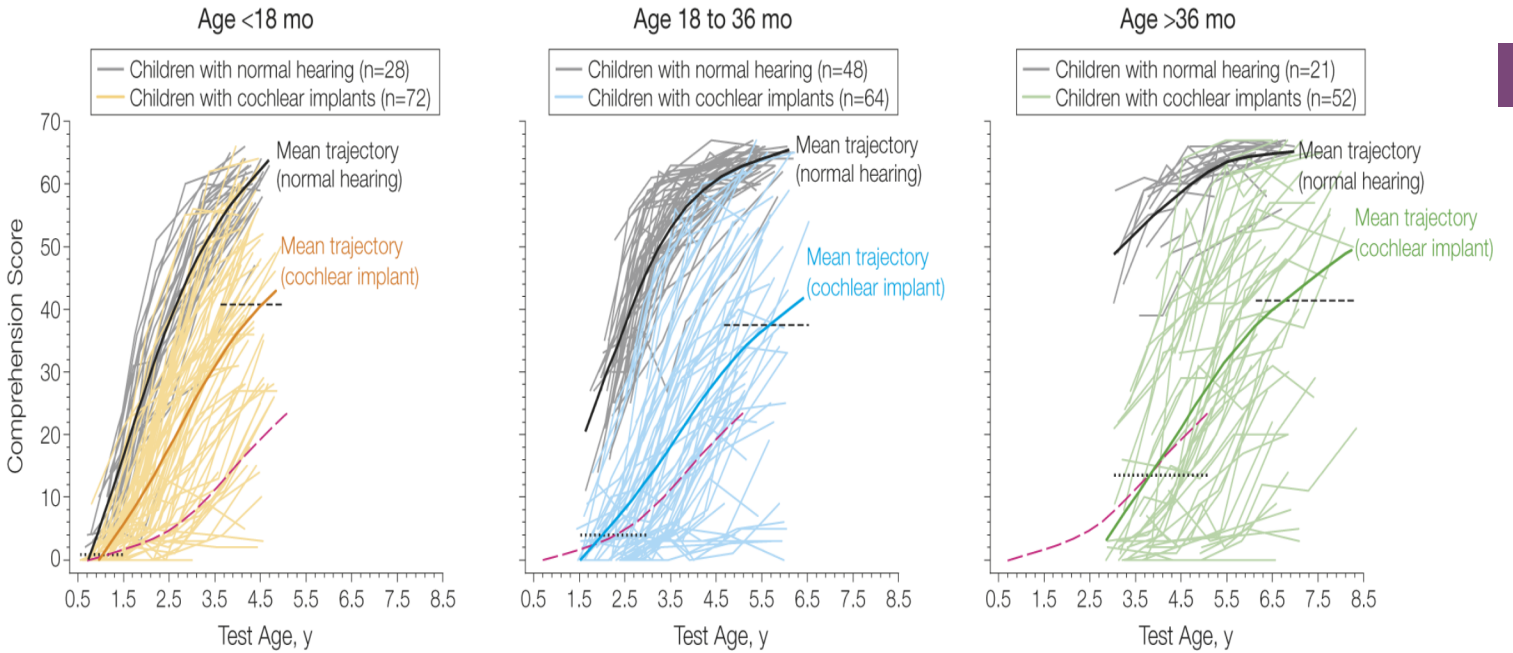
18-36 mo



> 36 mo

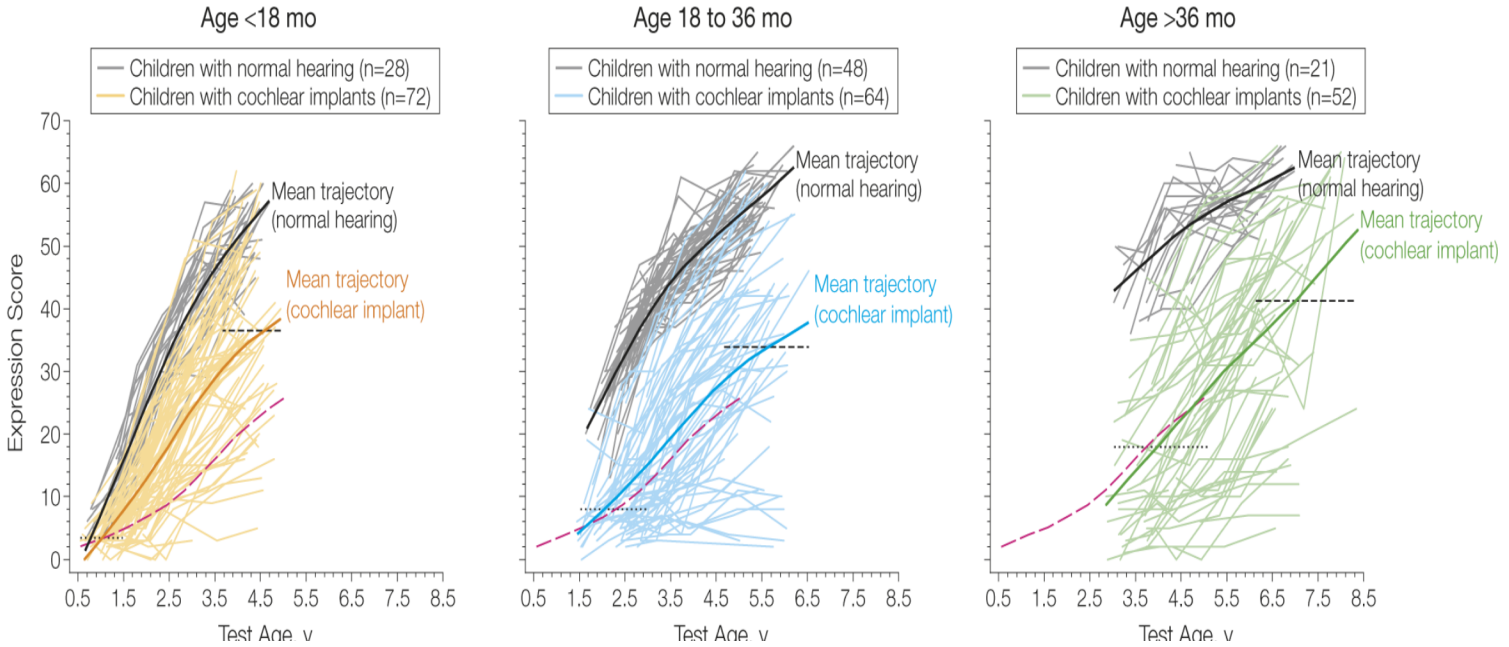


Comprehension



Production

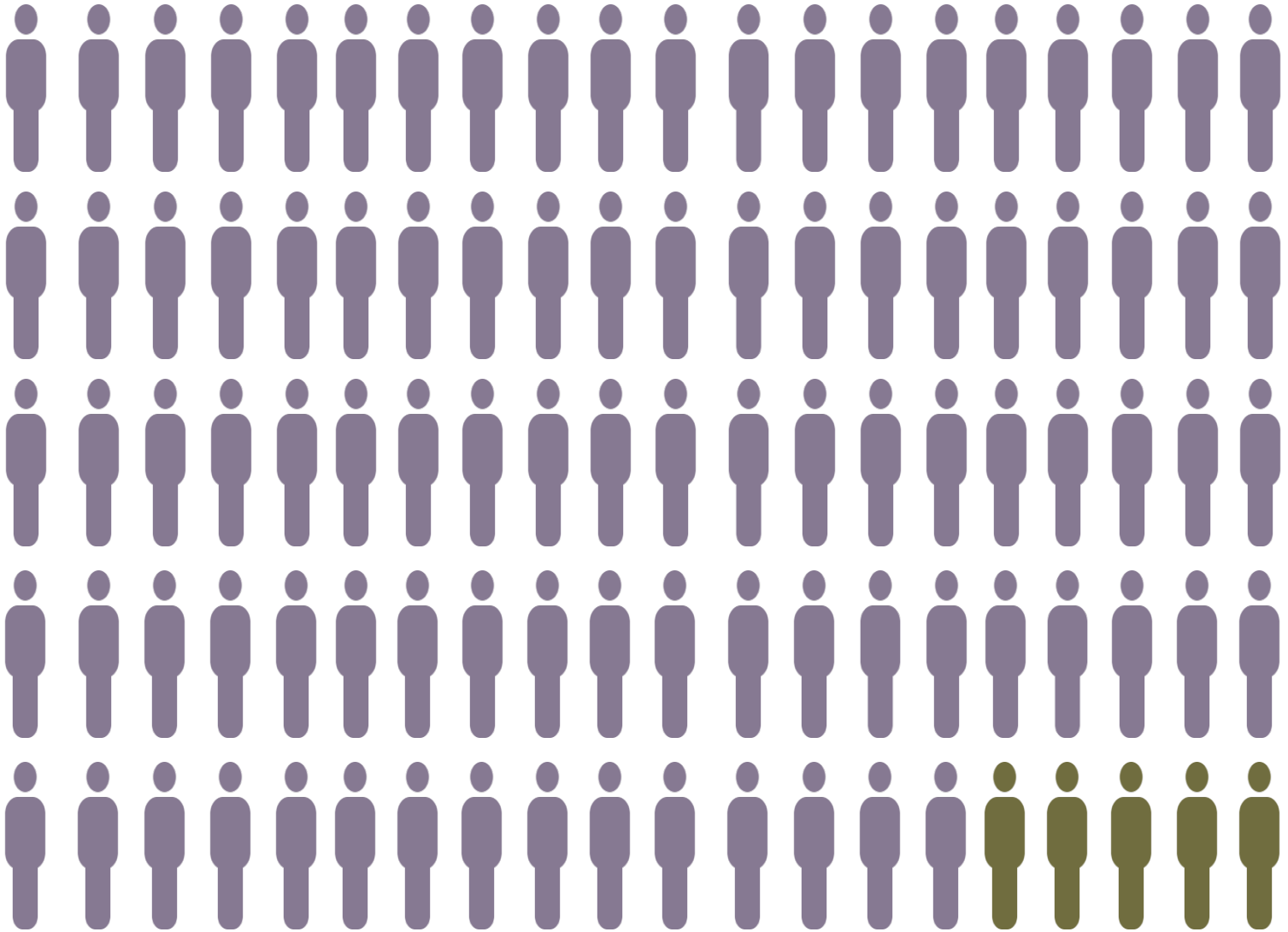
Expression scores



Why aren't all DHH children bilingual in a sign and spoken lg?

- Widespread belief that exposure to sign language hinders development of spoken language
- Parents' difficulty acquiring a new language as adults
  - Lack of motivation, resources, opportunity
- Misunderstandings regarding bilingualism

Deaf infants in the US whose parents know ASL



Does sign language hinder spoken language development?

Deaf children who have Cochlear Implants and who have Deaf Parents using ASL (n=5)

=

Hearing children (KODAs) who have Deaf Parents using ASL (n=20)

Davidson et al. 2013, Hassanzadeh 2012

Tests of spoken ENGLISH:
Auditory/expressive communication, vocabulary, articulation, literacy, syntax

Both groups use ASL at home and English at school.

Sign & speech/English

- Bilingualism is often misunderstood
  - Not a contest; all languages can play well together
  - A large percentage of the world's children know more than one language

Reading OR Speaking,
it doesn't matter!

ASL + English = BILINGUAL!!

Signing doesn't hurt speech, and speech doesn't hurt signing

Is early sign language and bimodal bilingualism the solution?

- Deaf children born into signing Deaf families constitute only about 5% of all deaf children (Mitchell & Karchmer 2004)
- Hard to know: Most studies of DHH children (signing, with CI) fail to include relevant comparison groups

Speech is not the only important outcome!

- Measure spoken language, **but also cognitive, academic, and social-emotional development**
- Development in other domains must be discussed along with spoken language outcomes when training clinicians and when counseling parents
- The greatest risk is not a lack of hearing, but a lack of **language**. Given variability in speech outcomes with CI only, it's risky to rely **exclusively on spoken language**

Conclusions

- Language, modality, and the brain
  - Biological constraints on both sign and spoken languages
- What is language for besides communication?
  - Language is the foundation for cognitive development
- Does sign language hinder spoken language development? **NO!!**
- Is early sign language the solution?
  - Let's find out! Recommended research designs

Improved research designs (Hall 2016) & Accountability

- **Prospective, longitudinal** (vs. retrospective or cross-sectional)
- **Inclusion criteria** designed to distinguish competing theories (vs. expedience)
- **Distinctions** between approaches
  - Listening & Spoken Language (excluding manual communication)
  - Total Communication (sign-supported speech, speech-based sign systems)
  - Bimodal Bilingual (including natural sign languages like ASL)
- ACCOUNTABILITY! E.g., **LEAD-K legislation establishing language benchmarks for children**

SHAMELESS PLUG!
SLAM INTERNSHIPS AVAILABLE

We are looking for motivated, enthusiastic, and skilled students who want research experience.

Minimum qualifications:

- Fluency in ASL
- Strong work ethic

Preferred qualifications:

- Previous research experience
- Background in psychology, development, education, or a related field
- Experience with children

To apply, send these things to Jessica.Contreras@uconn.edu

1. resume or CV
2. contact information for 3 references
3. brief cover letter explaining why you would be a good fit for our team

Thank you! Questions?

- marie.coppola@uconn.edu
- Voice: 860-486-4907
  VP by appointment: 860-288-5332

- www.slam.uconn.edu www.languagecreationlab.uconn.edu
- www.manos-unidas.org

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  - Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation

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