THE OHIO STATE UNIVERSITY

Development of spoken word-learning skills after cochlear implantation: Access to sound is just the beginning

Derek Houston, PhD

hear Indiana Listening & Spoken Language CONFERENCE

February 21, 2020

THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

NATIONWIDE CHILDREN'S

Collaborators & Funding


Irina Castellanos


Esther Chen


Chen Yu


David B. Pisoni


Linda Smith

- Claire Monroy
- Heidi S. Neuburger
- Seth Foster
- Steven Elmlinger
- Sven Bambach
- Sami Gharbi
- Luis Hernandez

Department of PSYCHOLOGICAL & BRAIN SCIENCES

SCHOOL OF INFORMATICS AND COMPUTING

Research Funding

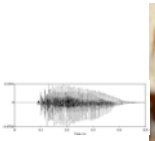
- R01DC006235 (Houston)
- IU Collaborative Research Grant (Houston & Yu)
- T32 DC00012 (Pisoni)

NATIONWIDE CHILDREN'S

THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

Cochlear Implantation in Children

Provides access to sound



20-25% (Davidson et al., 2019)

/dɑg/

NATIONWIDE CHILDREN'S

THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

THE OHIO STATE UNIVERSITY

Real-time mechanisms of word learning during social interaction in young deaf children with cochlear implants

Derek Houston

THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

NATIONWIDE CHILDREN'S

Collaborators & Funding


Irina Castellanos


Esther Chen


Chen Yu


David B. Pisoni


Linda Smith

- Claire Monroy
- Heidi S. Neuburger
- Seth Foster
- Steven Elmlinger
- Sven Bambach
- Sami Gharbi
- Luis Hernandez

Department of PSYCHOLOGICAL & BRAIN SCIENCES

SCHOOL OF INFORMATICS AND COMPUTING

Research Funding
- R01DC006235 (Houston)
- IU Collaborative Research Grant (Houston & Yu)
- T32 DC00012 (Pisoni)

NATIONWIDE CHILDREN'S

THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

Cochlear Implantation in Children

- Permanent hearing loss prevalence rate: 1-3 in 1000 births
- Cochlear implants (CIs) stimulate the surviving spiral ganglion cells of the auditory nerve

NATIONWIDE CHILDREN'S

THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

Cochlear Implantation in Children

- Provide individuals with profound hearing loss access to sound
- Large individual variability in language outcomes after implantation

(Pisoni et al., 2000)

NATIONWIDE CHILDREN'S

THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

Important Demographic Factors

- Age at CI
- Amount of residual hearing
- Duration of deafness
- Length of CI use
- Number of electrodes inserted
- Communication mode
- Amount of speech-language therapy
- Etiology of hearing loss

NATIONWIDE CHILDREN'S

THE OHIO STATE UNIVERSITY WEXNER MEDICAL CENTER

Important Demographic Factors

- Age at CI
- Amount of residual hearing
- Duration of deafness
- Length of CI use
- Number of electrodes inserted
- Communication mode
- Amount of speech-language therapy
- Etiology of hearing loss

Nationwide Children's | The Ohio State University Wexner Medical Center

Question

- What underlying cognitive and linguistic skills does early auditory experience affect?

Nationwide Children's | The Ohio State University Wexner Medical Center

CI < 1 Year vs. 1-2 Years

Better Outcomes for CI<1	No Differences
• Colletti et al., 2005, 2009, 2011	• Holt & Svirsky, 2008
• Dettman et al., 2007	• Horn et al., 2007
• Holman et al., 2013	• Houston & Miyamoto, 2010
• Holt & Svirsky, 2008	• Leigh et al., 2013
• Houston et al., 2003, 2012	• Lesinski-Schiedat et al., 2004
• Houston & Miyamoto, 2010	• Miyamoto et al., 2005
• Leigh et al., 2013	• Schauwers et al., 2004
• Miyamoto et al., 2005	• Phan et al., 2016
• Nicholas & Geers, 2013	
• Schauwers et al., 2004	

Nationwide Children's | The Ohio State University Wexner Medical Center

CI < 1 Year vs. 1-2 Years

Better Outcomes for CI<1	No Differences
• Colletti et al., 2005, 2009, 2011	• Holt & Svirsky, 2008
• Dettman et al., 2007	• Horn et al., 2007
• Holman et al., 2013	• Houston & Miyamoto, 2010
• Holt & Svirsky, 2008	• Leigh et al., 2013
• Houston et al., 2003, 2012	• Lesinski-Schiedat et al., 2004
• Houston & Miyamoto, 2010	• Miyamoto et al., 2005
• Leigh et al., 2013	• Schauwers et al., 2004
• Miyamoto et al., 2005	• Phan et al., 2016
• Nicholas & Geers, 2013	
• Schauwers et al., 2004	

Nationwide Children's | The Ohio State University Wexner Medical Center

CI < 1 Year vs. 1-2 Years

Better Outcomes for CI<1

- Reynell receptive
- PLS receptive and expressive
- RITLS receptive and expressive
- Oral and written language skills
- Peabody Picture Vocabulary Test
- Categories of auditory performance
- Performance IT-MAIS
- Audiovisual association
- Babbling
- DEAP
- Speech intelligibility rating

No Differences

- CNC
- LNT
- Mr. Potato Head Task
- Speech discrimination
- Reynell expressive

Word Learning Experiment

(Houston et al., 2012, *Dev Sci*)

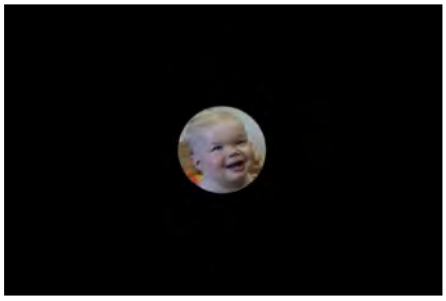
- Does early CI lead to better word learning?
- Early: 6.4–11.8 months
- "Late:" 12.2–15.6 months
- Profound hearing loss
- 1-1.5 years post-CI
- Compared to NH chronologically age-matched – "NHCA"
- Used a variant of the Intermodal Preferential Looking Paradigm

Demographic Variables for Early and Late CI

	Early CI(10)	Late CI(10)	Sig diff?
Age at CI (mos)	9.6 (6.4-11.8)	14.3 (12.2-15.6)	Yes
Pre-CI aided PTA (dB)	87 (82-90)	88 (82-90)	No
Communication Mode	7 OC 3 TC	6 OC 4 TC	No
# Bilateral at test	2	2	No
Hearing age at test (mos)	15.8 (10.8-20.8)	14.8 (10.3-20.3)	No
Maternal Education (yrs)	15.0 (12-20)	13.8 (12-18)	No

Intermodal Preferential Looking Paradigm (IPLP)

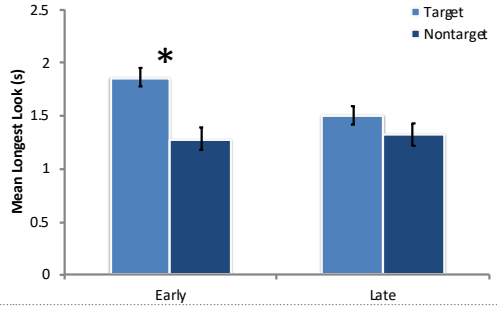
Stimuli



Nationwide Children's

The Ohio State University
Wexner Medical Center

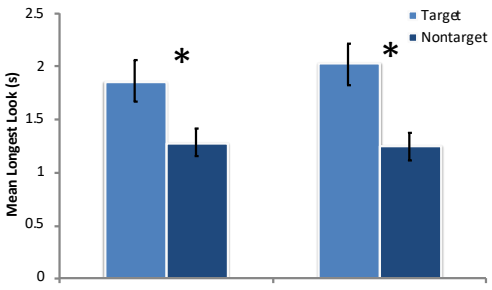
WL Results



Nationwide Children's

The Ohio State University
Wexner Medical Center

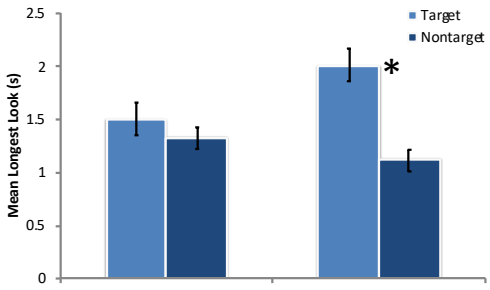
WL Results



Nationwide Children's

The Ohio State University
Wexner Medical Center

WL Results



Nationwide Children's

The Ohio State University
Wexner Medical Center

Partial Correlations

(3-4 years post-CI)

(Controlling for age at CI and residual hearing)

	Vocab (PPVT)	Rec Lang (PLS-aud)	Exp Lang (PLS-exp)	Speech Perc (LNT-words)
Word Learning				
Pearson's r	.60*	.70***	.59*	.21
N	18	16	16	18

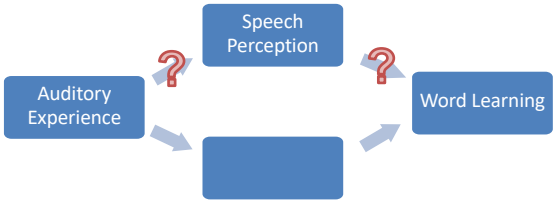
*p<.05; ***p<.01

Conclusions

- No evidence so far that CI <1 year leads to better hearing or speech perception than CI 1–2 years
- CI <1 year leads to better novel word-learning skills
- Early word-learning skills are important for language outcomes

What leads to better word-learning skills?

How does auditory experience affect word-learning skills?



Interaction and Language

- Joint attention associated with vocabulary
  - Tomasello & Todd, 1983; Morales et al.,. 2000; Beuker et al., 2013; Cejas et al., 2014
- Following attention better than directing attention
  - Dunham et al, 1993; Tomasello & Farrar, 1986; Yu & Smith, 2012
- Parent responsivity positively associated with language
  - Bornstein et al., 1999; Tamis-LeMonda et al., 2001; Pressman et al, 1999; Quittner et al., 2013

Effects of Hearing Experience on Parent-Child Interactions

- NH-D/HH differences in joint attention, turn-taking, overlapping speech, parents' referential cues
  - Fagan et al., 2014; Lund & Schuele, 2015; Morgan et al., 2014; Tasker et al., 2010

Limitations of current work on interactions with D/HH children

- Most focus on parent rather than bi-directional interaction
- Little work on micro-level, real-time properties specific to word learning

Three Studies/Analyses

1. Object-related utterances by parents and child attention to objects
   - Attention and object learning (e.g., Macroy-Higgins & Montemarano, 2016)
2. Synchrony of parent naming and child attention
   - Synchrony and word learning (e.g., Yu & Smith, 2012)
3. Joint attention
   - JA and vocabulary (e.g., Tomasello & Todd, 1983)

Dyad Play Session

In-Hand and Eye Tracking

Infants' egocentric view

Parents' egocentric view

Nationwide Children's

The Ohio State University
Wexner Medical Center

Set 1

Ballee

Dooga

Teeva

Set 2

Foma

Mobit

Kooka

Nationwide Children's

The Ohio State University
Wexner Medical Center

35 mos old; 15 mos CI use

Nationwide Children's

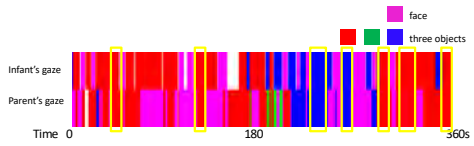
The Ohio State University
Wexner Medical Center

Preferential Looking Paradigm (PLP)

Nationwide Children's

The Ohio State University
Wexner Medical Center

Examples of Infant's and Parent's Gaze Data Stream



Participants

Older NH ↓ NH-CA Younger NH ↓ NH-HA

HI					NH-CA	NH-HA
Device	Chronological Age	Hearing Age	Etiology	Gender	Age	Age
CI	37	12	LVA	M	36	13
HA	36	25	Unknown	F	36	24
CI	34	14	Unknown	F	35	14
CI	30	10	Unknown	F	28	12
HA	27	22	Unknown	M	25	23
M	**32.8**	**16.6**			**32**	**17.2**

Three Studies/Analyses

1. Object-related utterances by parents and child attention to objects
2. Synchrony of parent naming and child attention
3. Joint attention

Three Studies/Analyses

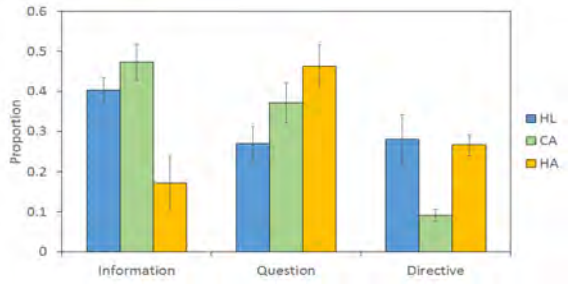
1. **Object-related utterances by parents and child attention to objects**
2. Synchrony of parent naming and child attention
3. Joint attention

Utterances and Attention

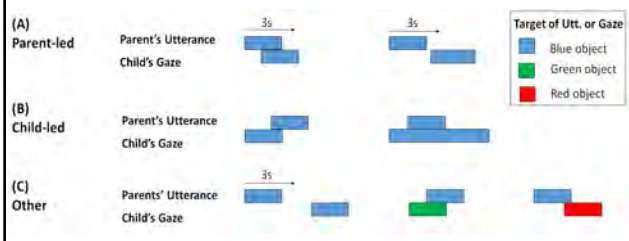
(Chen, Castillanos, Yu, Houston, 2019, *Infancy*)

Type	Description	Example
Information	Providing information, such as label, features, or actions, about the toy object	"That's a wawa." "Wawa is green." "It goes round, round, round."
Question	Asking a question about the toy object	"Why do you like this one?" "Oh, is that a hammer?"
Directive	Telling or directing child to do something	"Spin it." "Show me the wawa."
Other	Utterances that do not fit in the above-mentioned types	"I like this one." "Oh, well, that one."

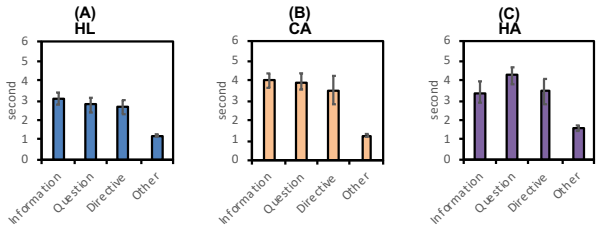
Utterances and Attention



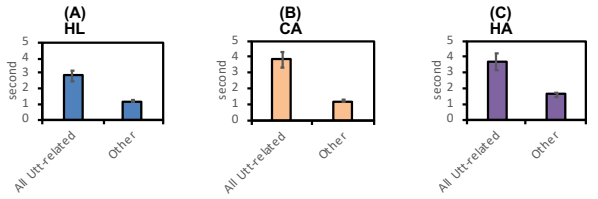
Utterances and Attention



Utterances and Attention



Utterances and Attention



Three Studies/Analyses

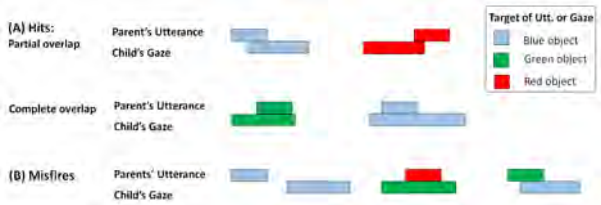
1. **Object-related utterances by parents and child attention to objects**
   - Less effect on children with HL
2. Synchrony of parent naming and child attention
3. Joint attention

Three Studies/Analyses

1. Object-related utterances by parents and child attention to objects
   - Less effect on children with HL
2. **Synchrony of parent naming and child attention**
3. Joint attention

Naming Synchrony

(Chen, Castillanos, Yu, Houston, 2019, *IBaD*)



Naming Synchrony

Group	Hits			Misfires
	Partial overlap	Complete overlap	Total Hits	
HL	0.11	0.16	0.27	0.73
CA	0.14	0.32	0.46	0.54
HA	0.13	0.27	0.40	0.60

Table 2. Proportion of Parents' Utterances Categorized as Hits and Misfires.

Three Studies/Analyses

1. Object-related utterances by parents and child attention to objects
   - Less effect on children with HL
2. **Synchrony of parent naming and child attention**
   - Less synchrony
3. Joint attention

Three Studies/Analyses

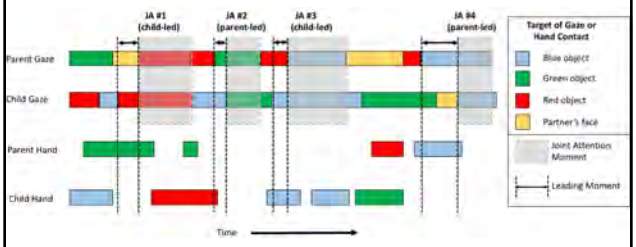
1. Object-related utterances by parents and child attention to objects
   - Less effect on children with HL
2. Synchrony of parent naming and child attention
   - Less synchrony
3. **Joint attention**

Joint Attention

(Chen, Castillanos, Yu, Houston, in press, *DevSci*)

	HL							CA	HA
Participant #	Chronological Age	Hearing age	Sex	Degree of Hearing Loss		Hearing Device		Age	Age
				Left	Right	Left	Right		
1	24	15	F	profound		Cochlear implant	Cochlear implant	24	15
2	27	22	M	severe		Hearing aid	Hearing aid	25	23
3	28	12	F	profound		Cochlear implant	Cochlear implant	26	12
4	30	10	F	Severe to profound		Cochlear implant	Cochlear implant	28	12
5	34	14	F	severe			Cochlear implant	35	14
6	36	25	F	profound	Mild-moderate		Hearing aid	36	24
7	37	12	M	profound	severe	Cochlear implant	Hearing aid	36	13
Mean age	30.9	15.7						30.0	16.1

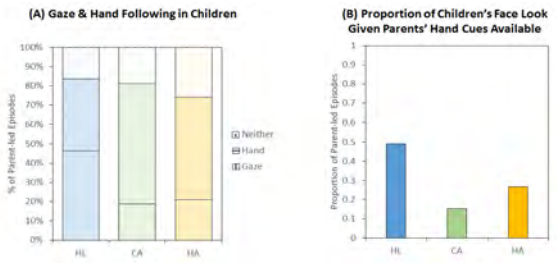
Joint Attention



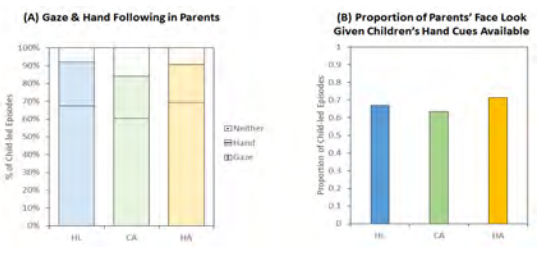
Joint Attention - Results

- No group differences:
  - Number or mean duration of JA episodes
  - % child-led vs parent-led
  - Amount of face looking by parents or children

Parent-Led Joint Attention



Child-Led Joint Attention



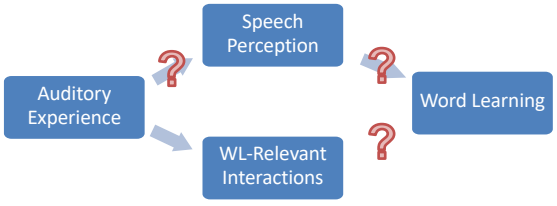
Three Studies/Analyses

1. Object-related utterances by parents and child attention to objects
   - Less effect on children with HL
2. Synchrony of parent naming and child attention
   - Less synchrony
3. **Joint attention**
   - More use of face looks by children

Summary and Conclusions

- The coordination of parents labeling objects when children attend to those objects may be a challenge
- What can be done?
  - General awareness of coordination challenges
  - Things to keep in mind:
    - Talking about objects may be less effective for maintaining children's attention to objects
    - Children may shift attention away from the object the parent is holding to look at the parent's fact.
- But findings are preliminary!

Next Steps



Future Directions

- Parent-child interactions → Word learning
- Malleability of parent-child interactions
- Does parent-child interaction training lead to better word learning?