Language Emergence in Children with Cochlear Implants

Ann E. Geers, Ph.D

Johanna G. Nicholas, Ph.D

Emily A. Tobey, Ph.D

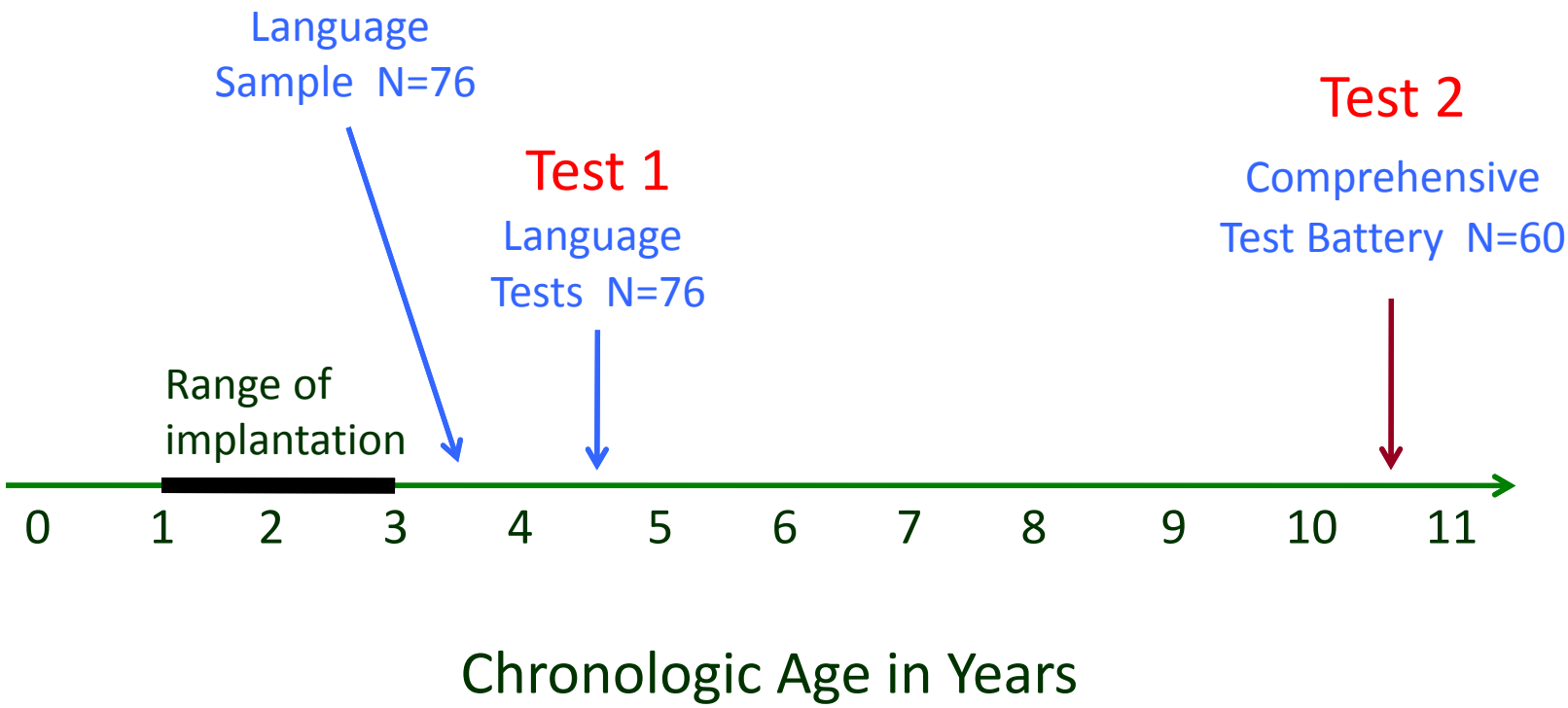
Washington University in St. Louis
School of Medicine

DCIP Dallas Cochlear Implant Program

Disclosure

We have no relevant financial or nonfinancial relationships to disclose.

Longitudinal Design



Participants at Test 2

30 boys / 30 girls

Deaf from birth

Auditory-oral education

Age at first implant: 1;0 – 3;2

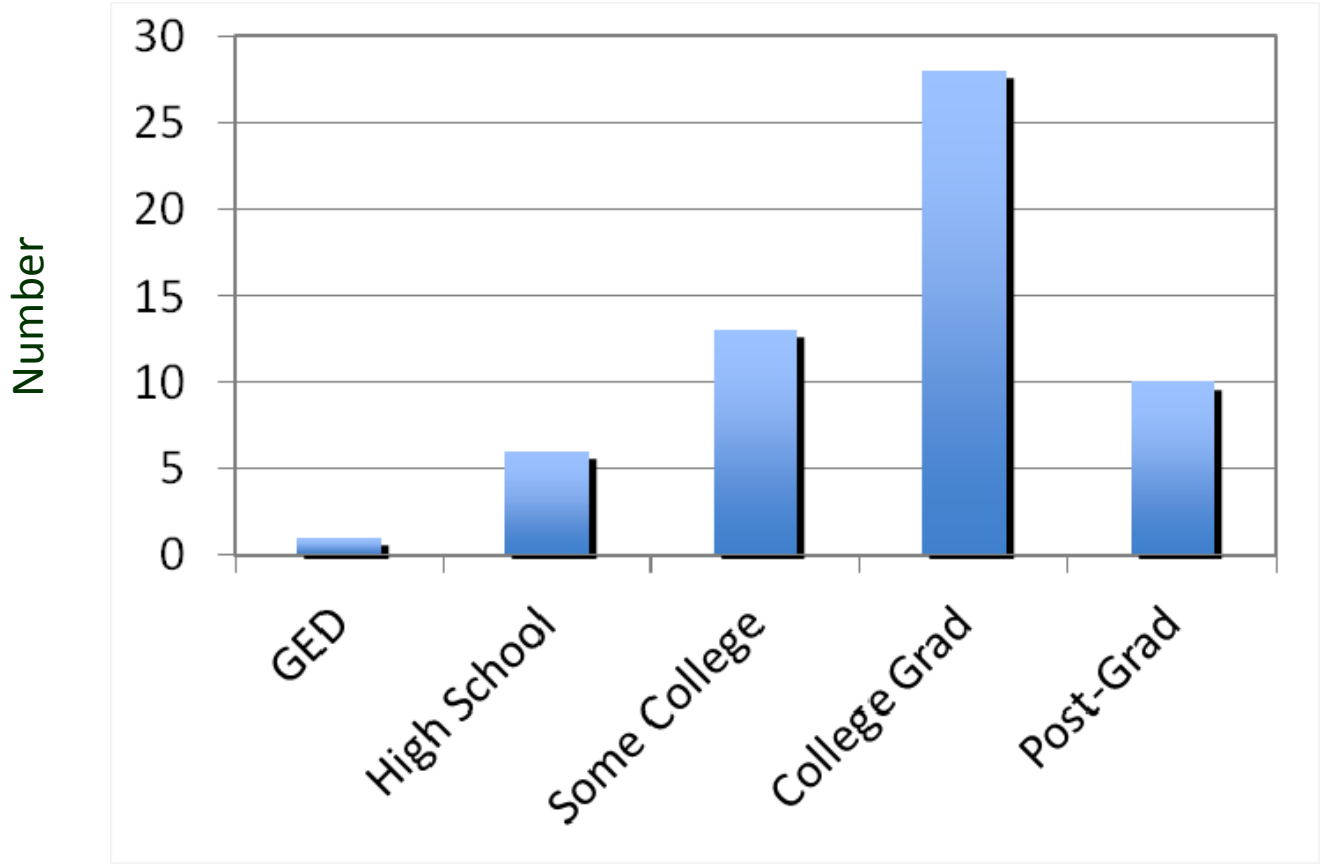
Year of first implant: 1998-2003

Age at second implant: 46- 119 months (N = 29)

Educational Setting – Change from age 4 to 10

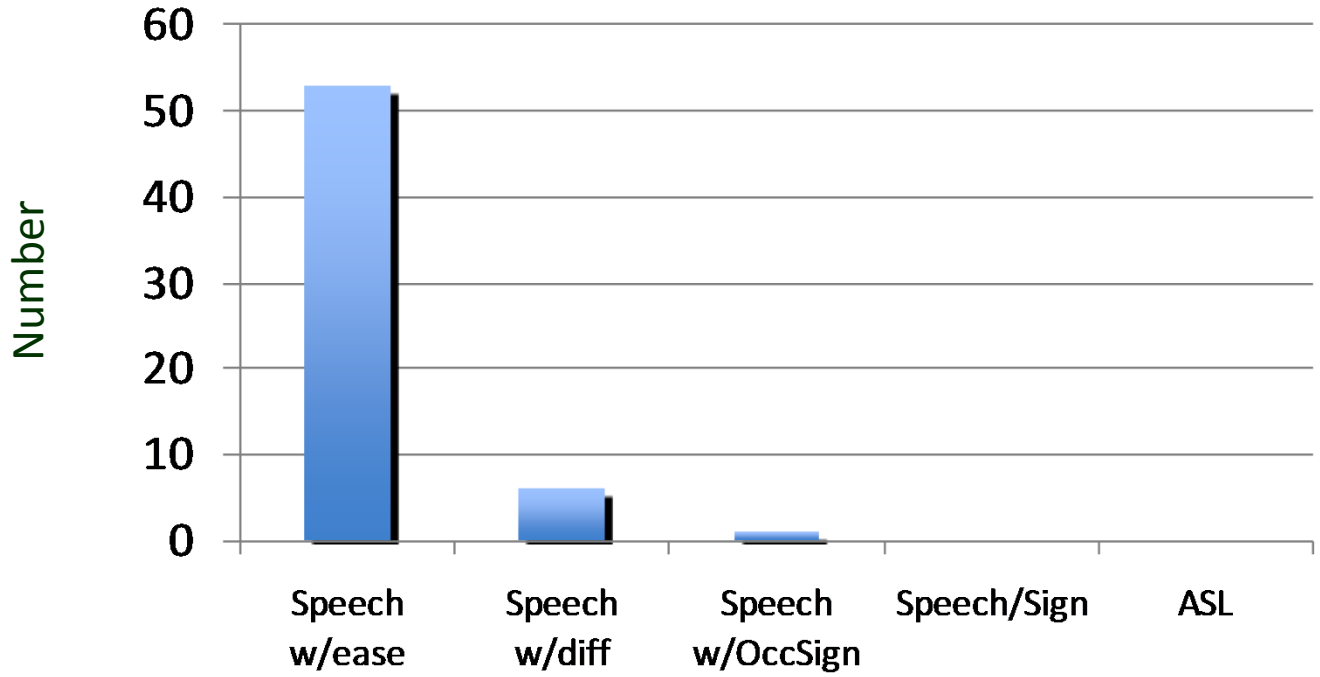
	Age 4	Age 10
Special Education	78%	2%
Full Mainstream	12%	85%
Partial Mainstream	2%	8%
Home School	8%	5%

Mother's Education Level



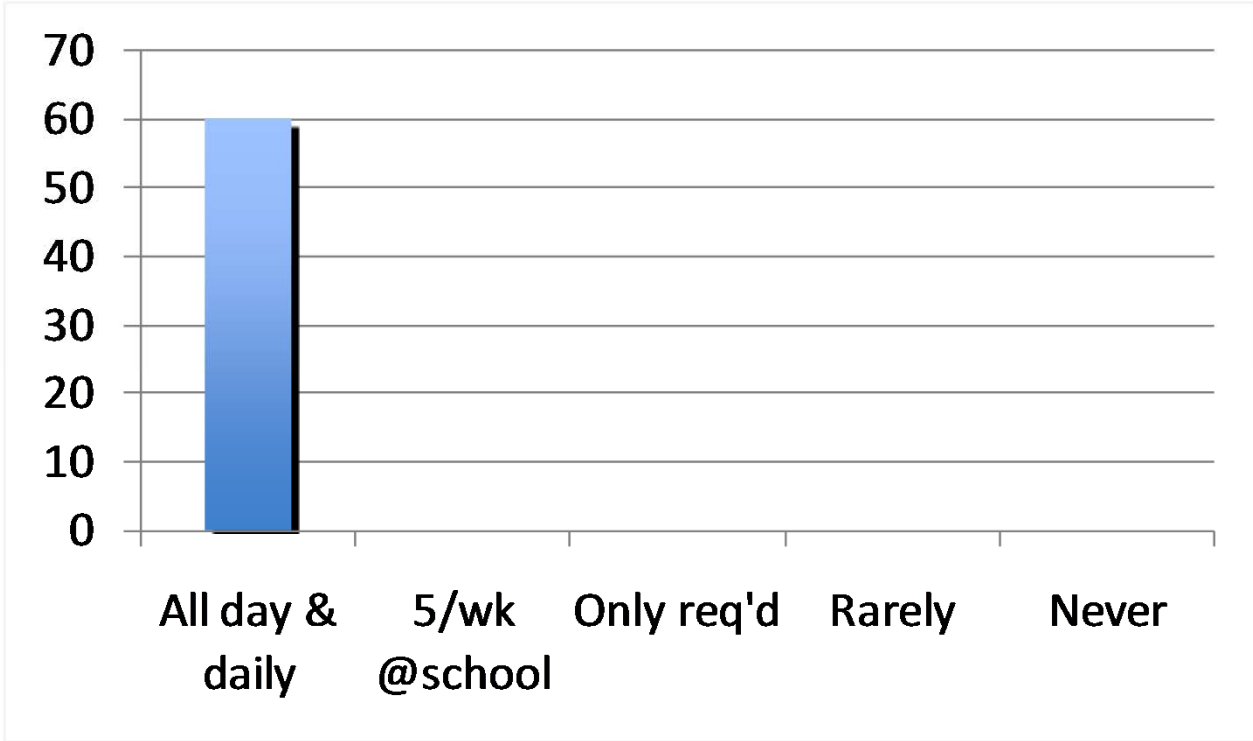
N = 60

Communication Mode



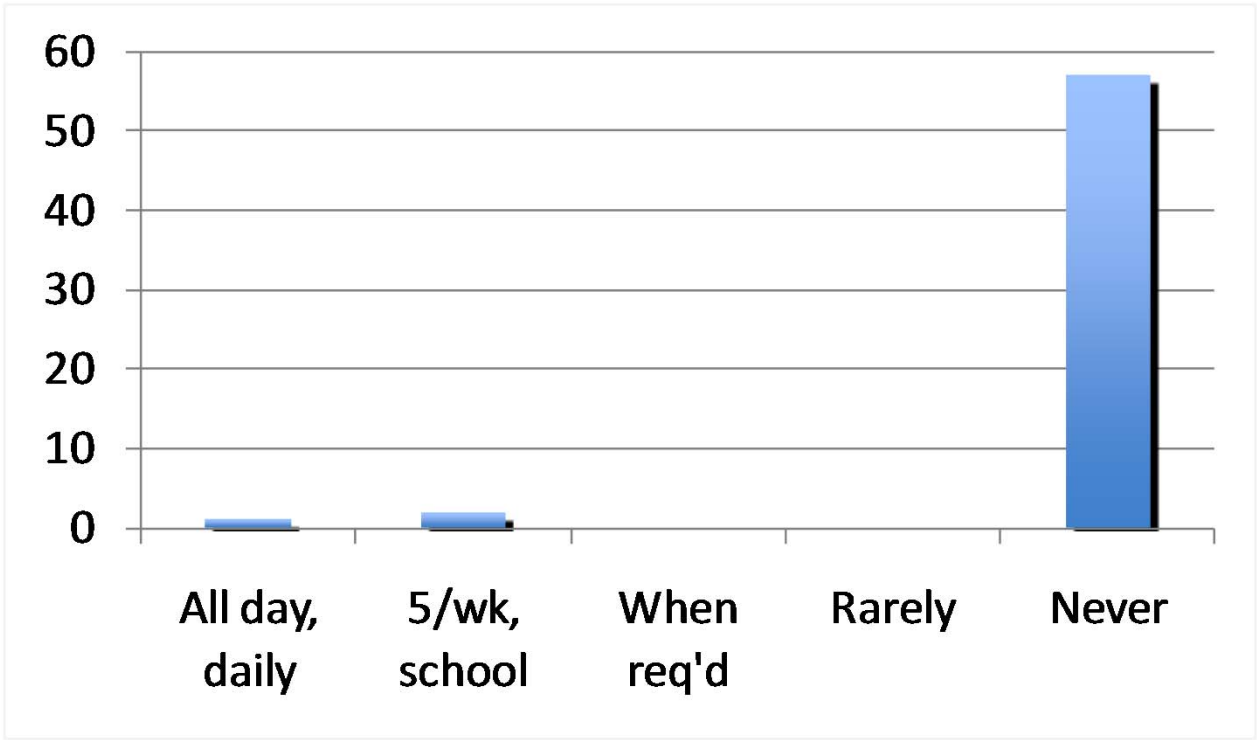
N = 60

How often does student wear implant?



N = 60

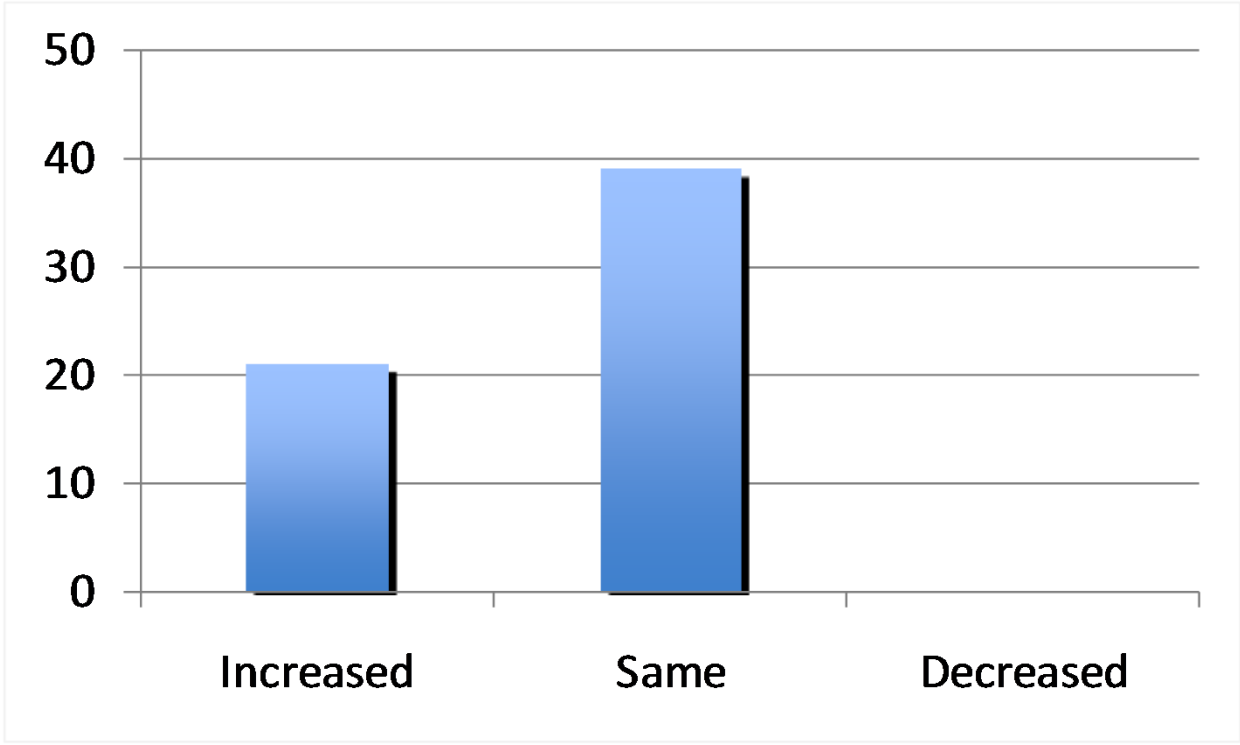
Wears HA in other ear?



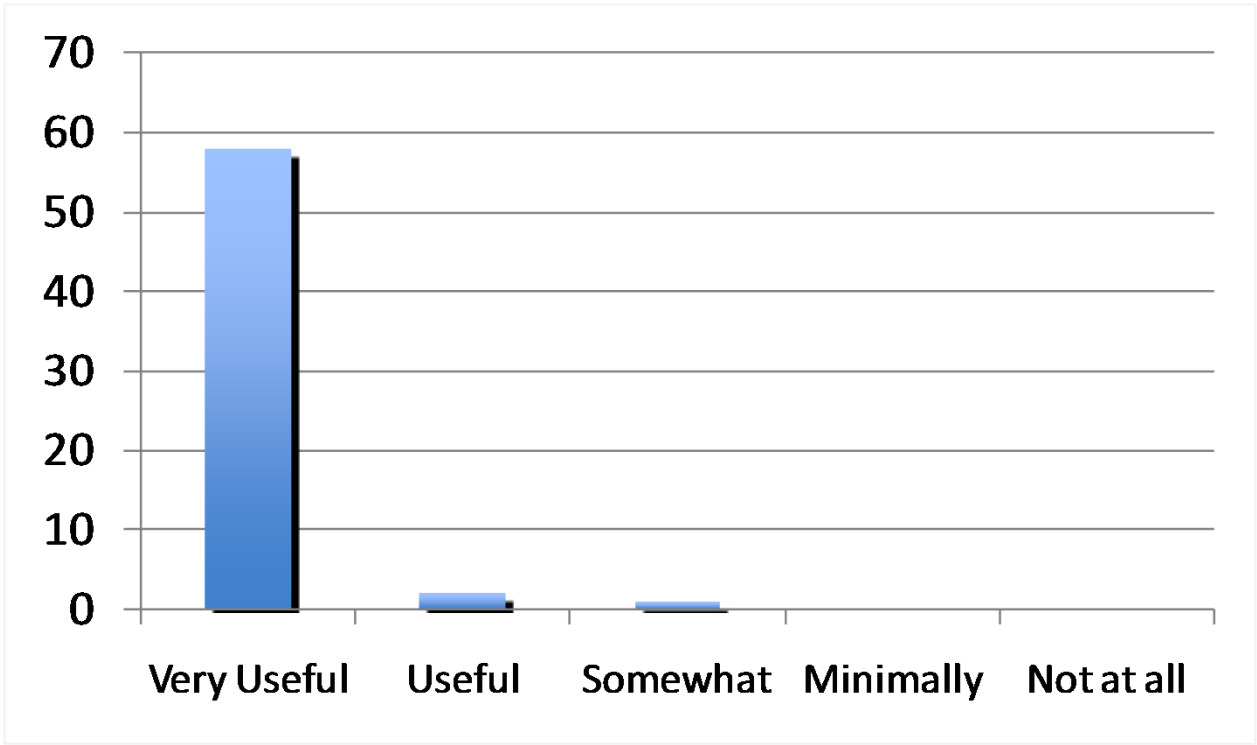
N = 60

Change in Device use over Time

from ages 4 - 10 years



Describe Benefit of Implant



N = 60

Speech Processor Summary

Device	Test Age 3.5 Processor on 1st Implant	Age 10.5 Processor on First Implant	Age 10.5 Processor on 2nd Implant, if applicable	Processor Rating
Nucleus Spectra				1
AB PSP	19	7		1
Med-El Tempo+	1			2
Nucleus Esprit 22	4			2
AB PSP BTE	3	6	2	2
Nucleus Sprint	28			3
Nucleus Esprit 3G	4	5		3
AB Auria BTE	1	3	1	3
Nucleus Freedom		32	20	4
AB Harmony BTE		7	5	4
Nucleus System 5			1	4
N =	60	60	29	

Study 1: Language Emergence

Do early-implanted children reach normal language levels during the preschool years?

Does performance improve, deteriorate or remain constant relative to hearing age mates over time?

What factors contribute to successful outcomes?

DCIP Dallas Cochlear Implant Program

Washington University in St. Louis

Language Tests

Test 1: Age 4.5

- Preschool Language Scale (PLS)

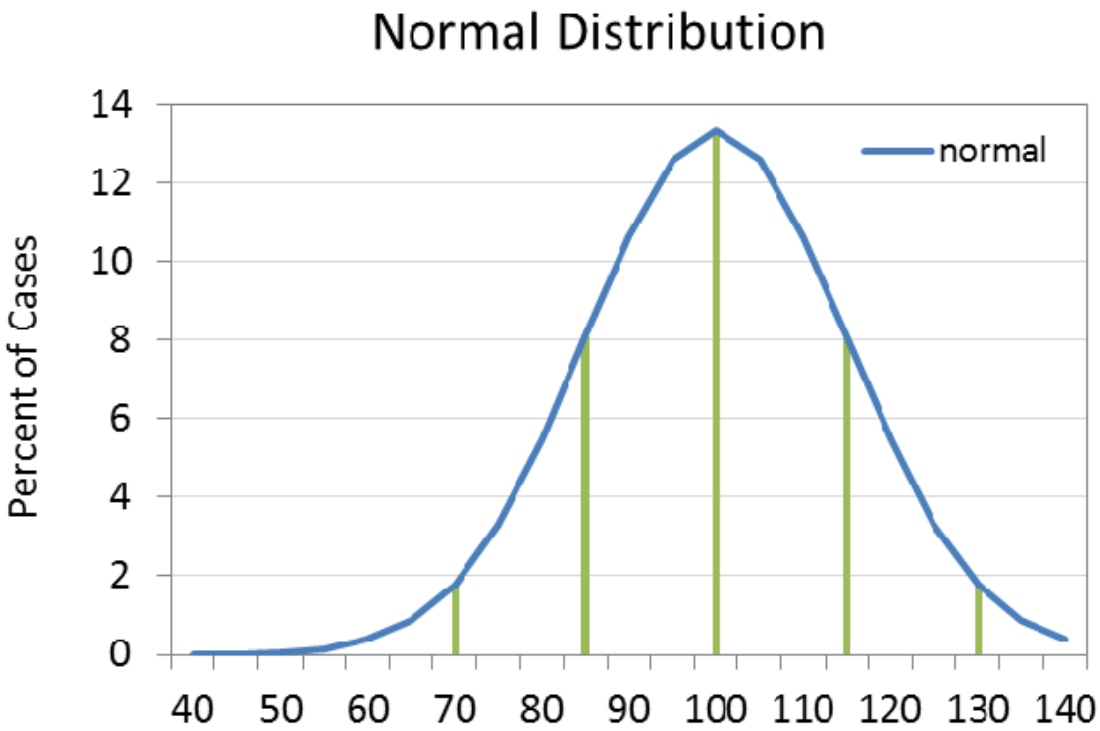
Test 2: Age 10.5

- Clinical Evaluation of Language Fundamentals (CELF)

Dallas Cochlear Implant Program

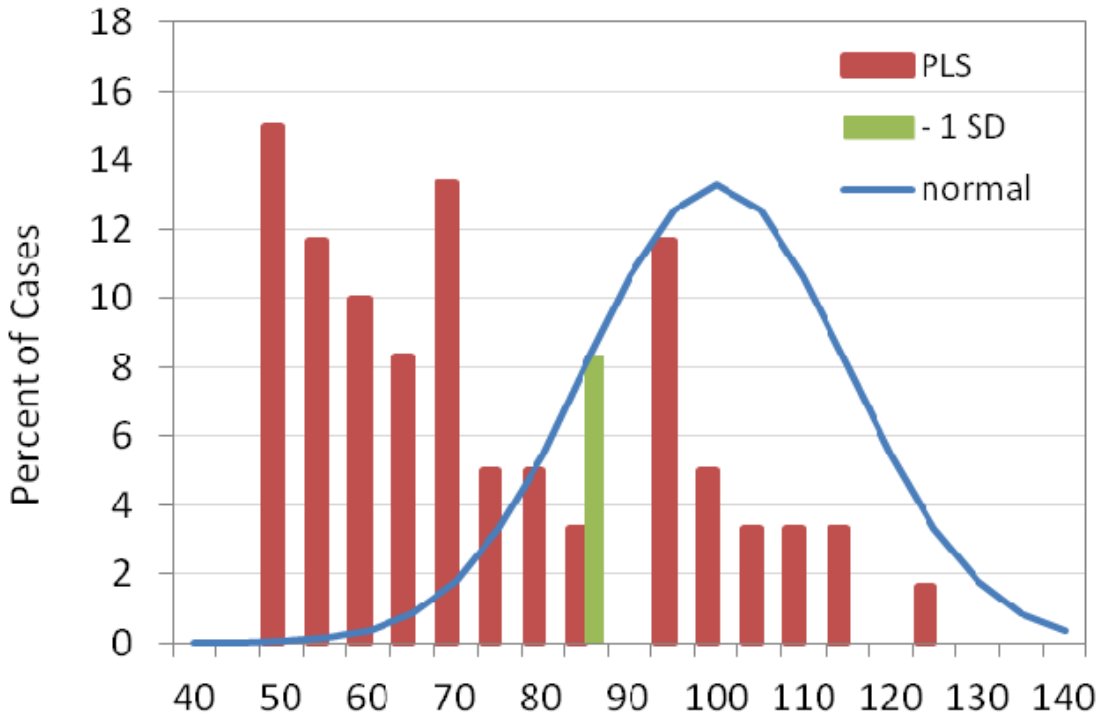
Washington University in St. Louis

Standard Score Distribution



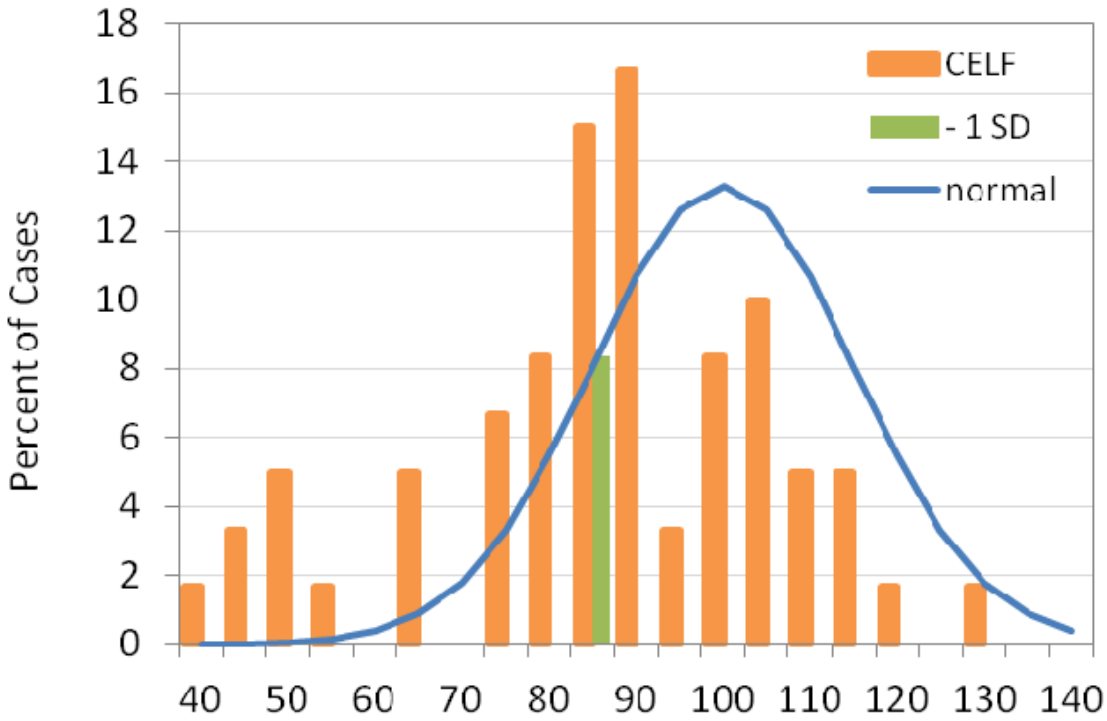
This is a normal distribution of scores with a mean of 100 and a SD of 15.

Distribution of Language Scores: Preschool



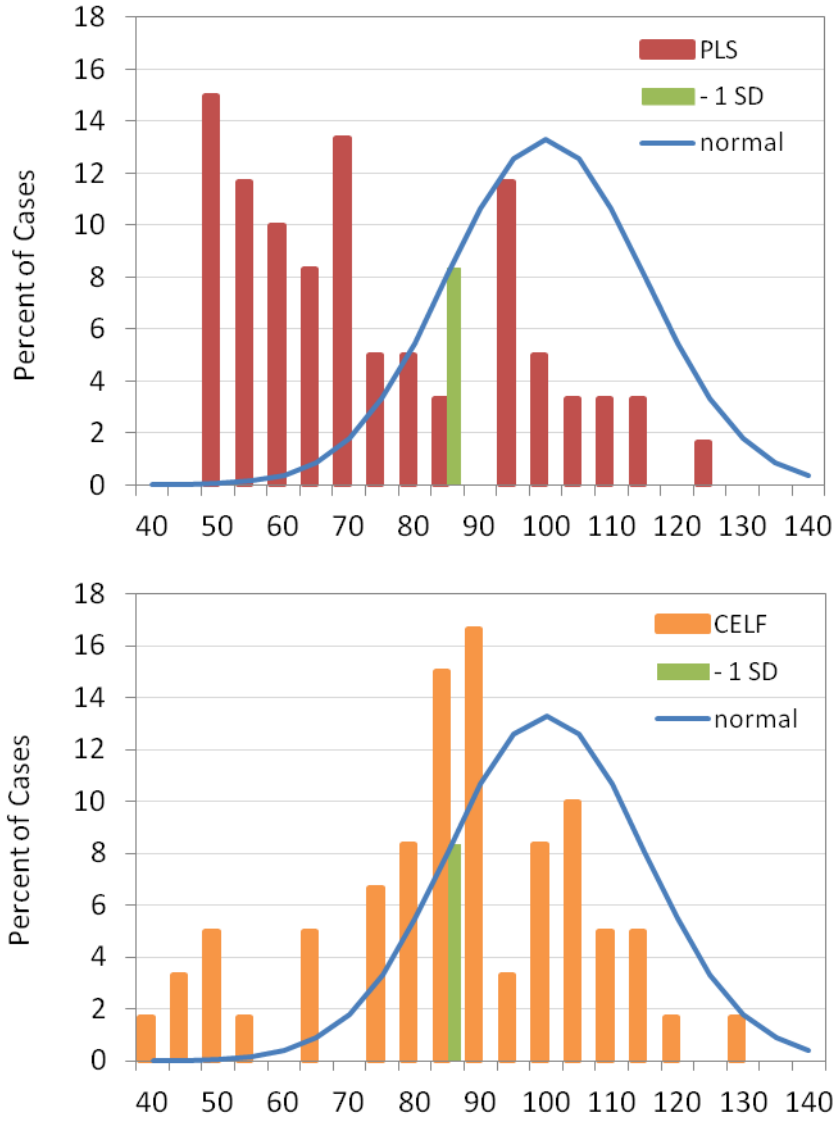
Language scores at age 4.5 are delayed, with 68% of cases > 1 SD below the mean. Only 16% of cases are at this level in the normal distribution, shown in blue.

Distribution of Language Scores: Elementary School



Language scores at age 10 are not as delayed, 32% of cases are > 1 SD below the mean. Only 16% of cases are at this level in the normal distribution, shown in blue.

Distribution of Language Scores

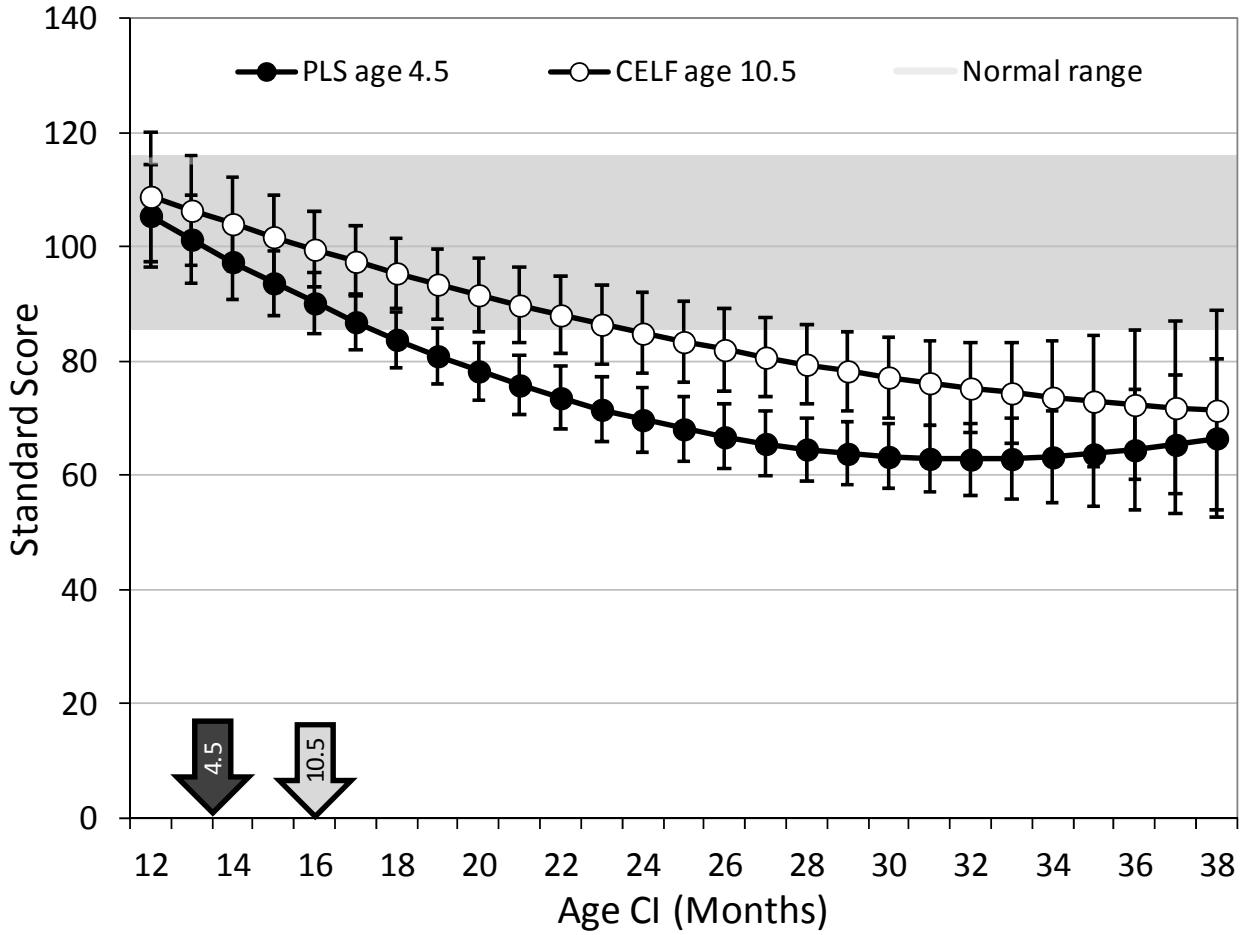


Regression Analysis
Predicting Language Score at Age 10.5

	p
Age CI	.003
Nonverbal IQ	.008
Pre-Implant Aided PTA	.013
Explained Variance	**38%**

Predicted Language by Age CI

Pre-implant hearing set at sample mean



Conclusions

Children implanted at 1-2 years of age can be expected to complete elementary grades in a mainstream setting and achieve language skills that are within one SD of their hearing age-mates by the time they are in the mid-elementary school years.

The advantage of early implantation was maintained over time. Children with the earliest ages of implantation ultimately achieved the highest levels of spoken language skill.

DCIP Dallas Cochlear Implant Program

Washington University in St. Louis

Study 2: Language Delay

- What proportion of preschool language delays persist and what proportion resolve over time?

Dallas Cochlear Implant Program

Washington University in St. Louis

Language Groups Diagram

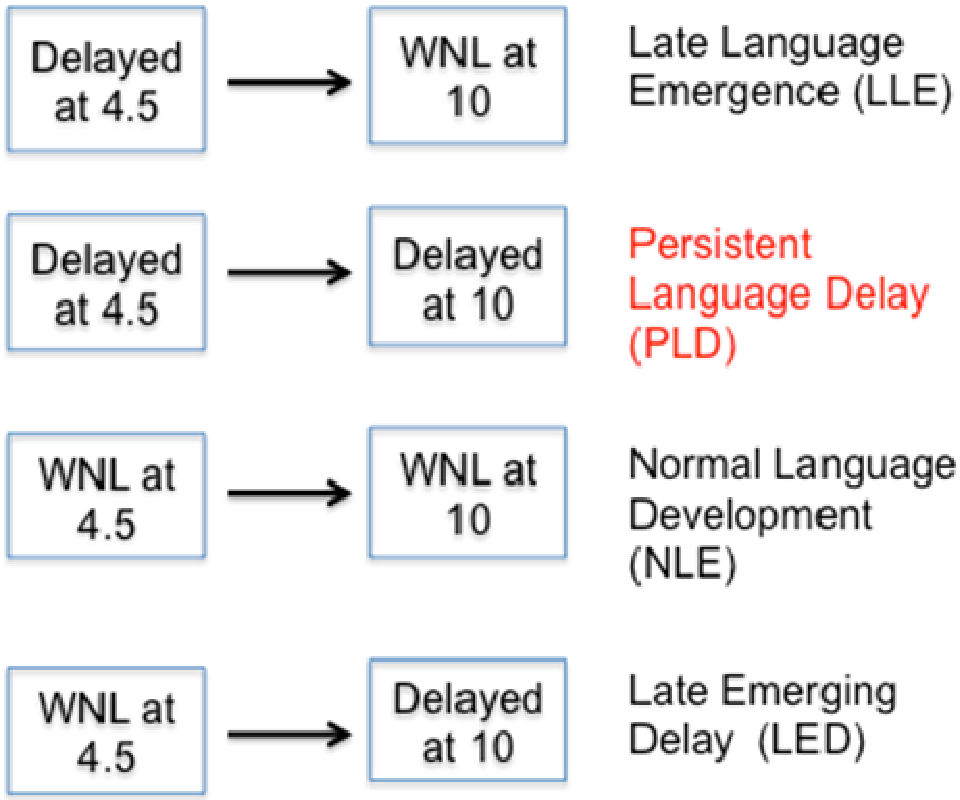
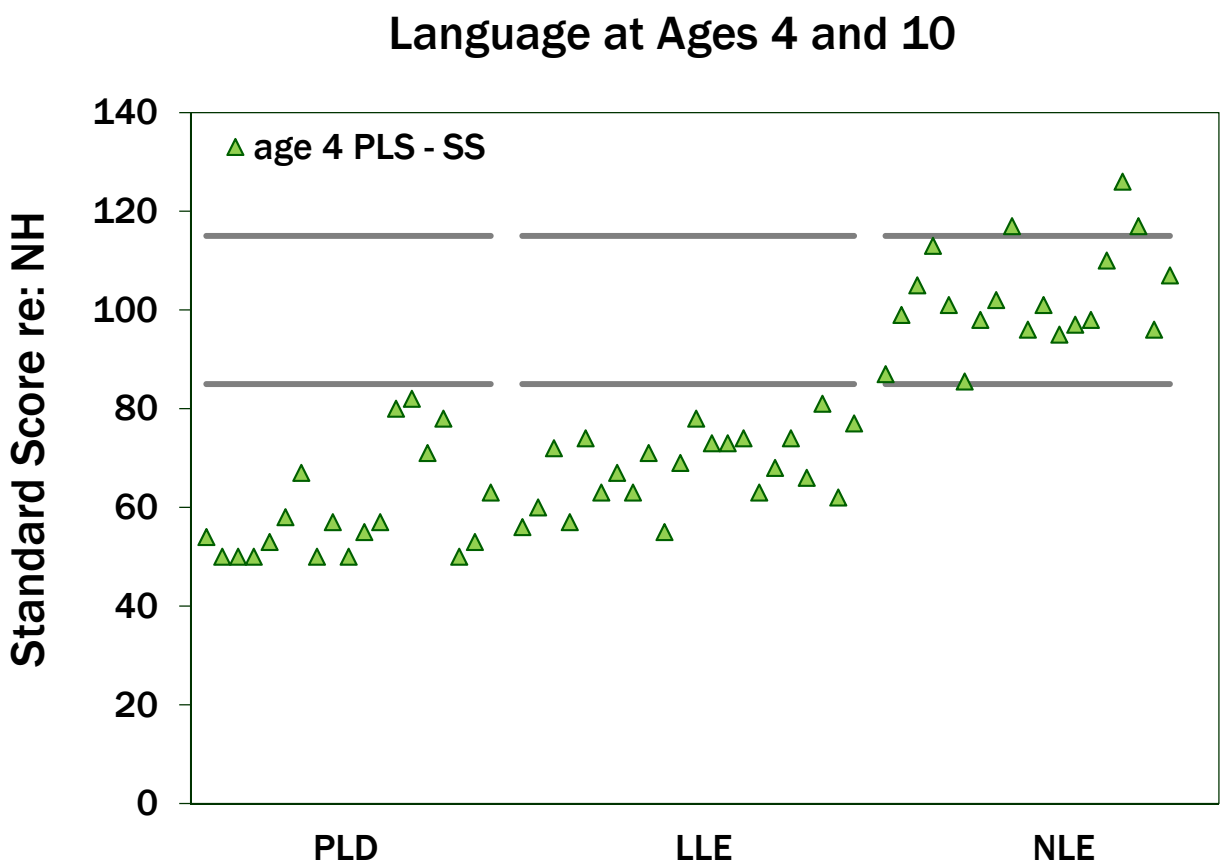


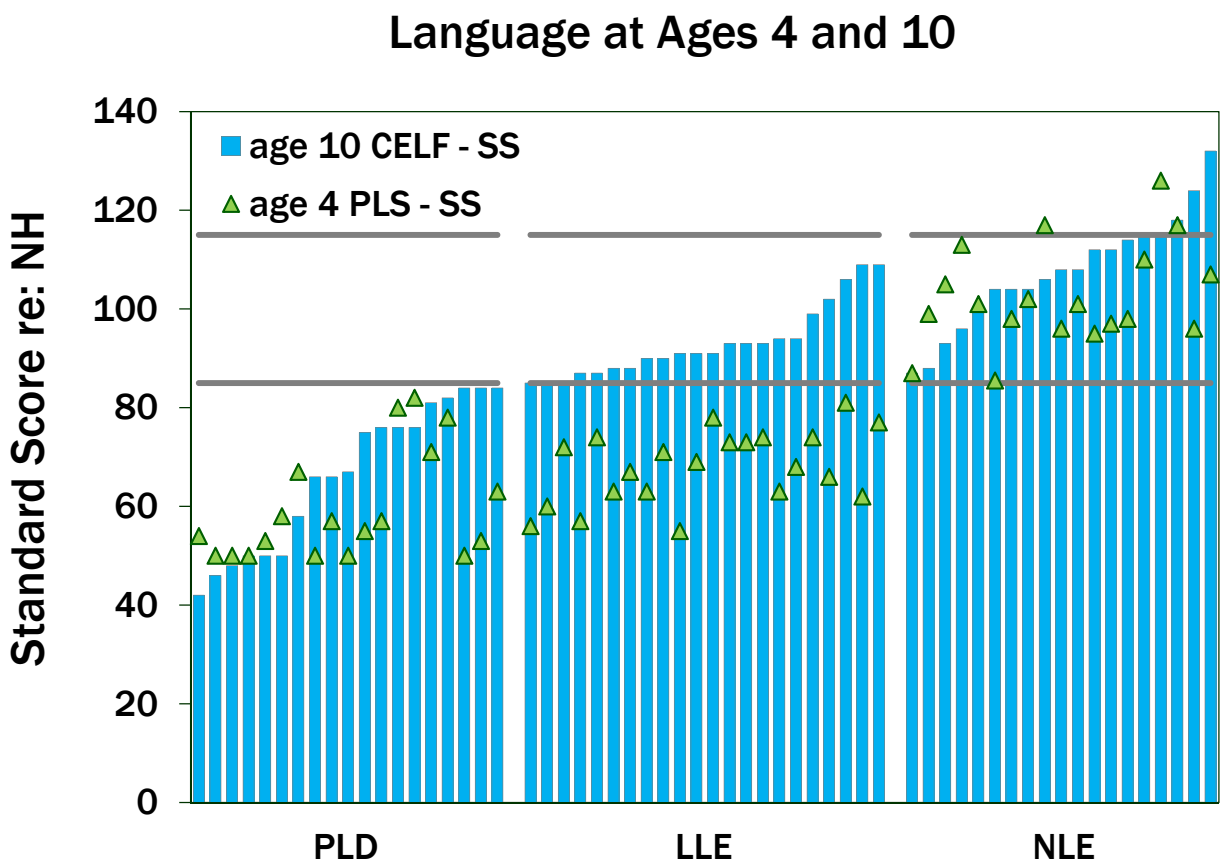
Figure 1. Definitions and relationships among progress groups.

Language Emergence Groups



Note that the horizontal lines indicates 1 SD above and below the mean re: NH

Language Emergence Groups



Note that the horizontal lines indicates 1 SD above and below the mean re: NH

Study 2: Language Delay

- What factors differentiate groups of children with normal language emergence, late language emergence and persistent language delay?

Dallas Cochlear Implant Program

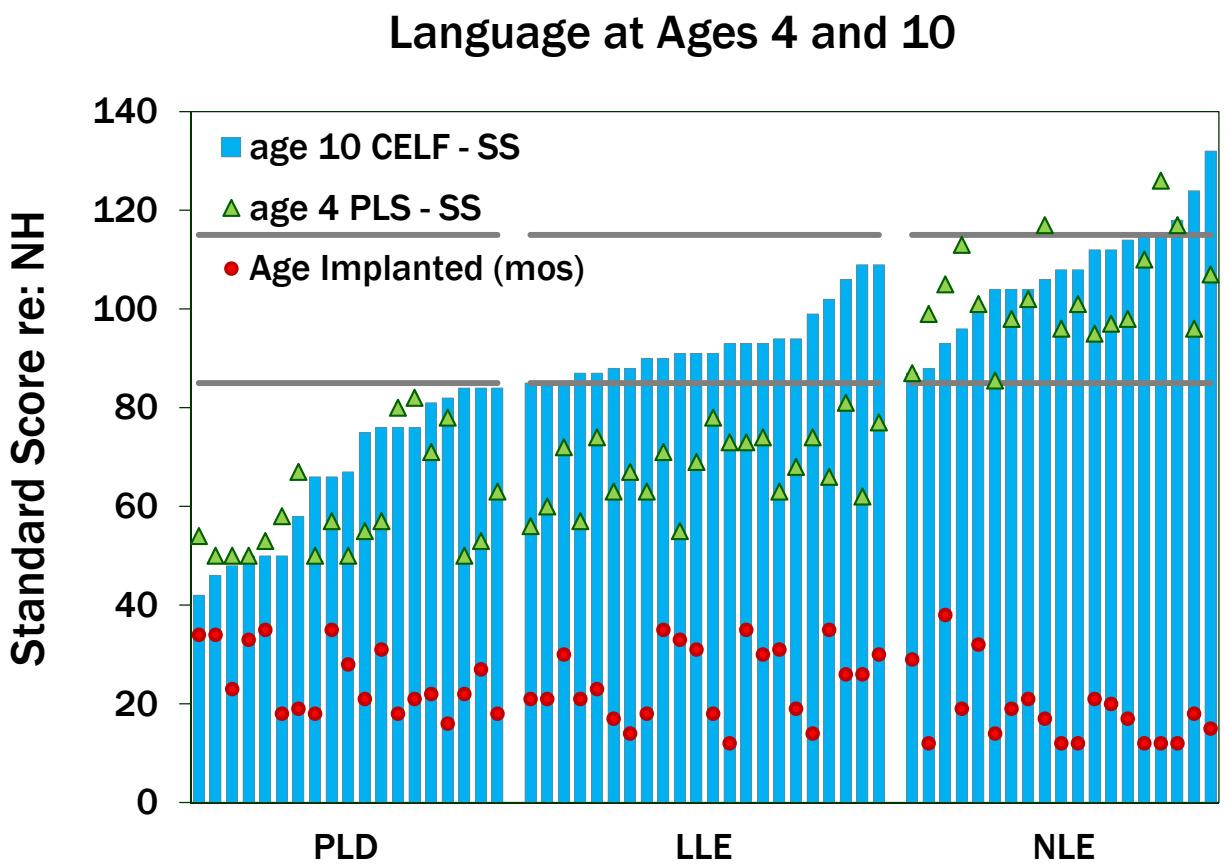
Washington University in St. Louis

Characteristics of Children with Normal Language Emergence (NLE), Late Language Emergence (LLE) and Persistent Language Delay (PLD)

Characteristic	Score	NLE	*SD*	LLE	*SD*	PLD	*SD*	F (2,57)	p
Demographics									
Age 1st HA	Months	7.8	*6.6*	12.1	*8.9*	13.7	*6.7*	2.97	.05
Age 1st Implant*	Months	18.5	*7.4*	24.5	*7.5*	24.9	*6.8*	4.74	.01*
% Left Ear 1st CI	Percent	21.1		13.6		47.4		x^2=6.38	.04
Mother's Education	Years	15.9	*1.7*	15.3	*2.0*	14.8	*2.0*	1.45	NS
Aided PTA Pre-CI	dB HL	64.4	*15.2*	63.5	*17.0*	67.3	*12.9*	0.34	NS
Grade 1st MS^	Grade (0=K)	0 (K)	*0.5*	1	*1.5*	2	*2.5*	8.31	.001^
Gender	Percent Female	42	-	45	-	63	-	x^2=1.97	NS

*NLE younger AOI than other 2 groups, ^NLE sooner in MS than PLD group

Language Emergence Groups



Note that the horizontal lines indicates 1 SD above and below the mean re: NH

Early speech/language measures
Age 3.5

Parent-Child Conversational Interaction

- **30-minute session**
- **video recorded**
- **standardized transcription of language and speech**

MacArthur-Bates Communicative Development Inventories **(MB-CDI) (Fenson et al, 1993)**

DCIP Dallas Cochlear Implant Program

Washington University in St. Louis

Computer-Assisted Language Analysis (CLAN) from CHILDES (McWhinney, 2000)

1. # Different Root Words
2. Mean Length of Utterance (Words)
3. # Bound Morphemes
4. # Different Bound Morphemes

DCIP Dallas Cochlear Implant Program

Washington University in St. Louis

Computer-Aided Speech-Language Analysis (CASALA) (Blamey, et al 2001)

1. # Different Vowel Sounds Correct
2. # Different Consonant Sounds Correct
3. Weighted Developmental Score

Dallas Cochlear Implant Program

Washington University in St. Louis

Communicative Development Inventory

- Vocabulary (number of words)
- Irregular Words
- Sentence Complexity

DCIP Dallas Cochlear Implant Program

Washington University in St. Louis

Characteristics of Children by Language Emergence Group: **Age 3.5**

Characteristic	Score	NLE	*SD*	LLE	*SD*	PLD	*SD*	F (2,57)	p
Early Grammar*	# Diff Root Words	150.9	*37.3*	100.8	*33.7*	76.1	*46.6*	17.96	.001
	Utterance Length	2.5	*0.7*	1.6	*0.4*	1.4	*0.3*	25.64	.001
	# Bound Morphs	48.0	*30.3*	21.6	*22.1*	10.4	*15.9*	12.93	.001
	# Diff Bound Morphs	7.7	*2.4*	4.0	*2.6*	2.5	*2.2*	23.36	.001
Early Speech^	# Diff Vowels	12.2	*1.9*	10.9	*2.1*	8.8	*3.8*	7.69	.001
	# Diff Consonants	15.6	*3.2*	12.8	*4.2*	8.8	*4.9*	12.76	.001
	Weighted Dev Score	64.3	*11.9*	54.6	*13.2*	42.1	*19.3*	10.38	.001
CDI^	Vocabulary	551.1	*103*	308.9	*132*	238.1	*138*	32.20	.001
(Parent Rating)	Irregular Words	12.9	*8.0*	4.8	*4.7*	2.9	*3.3*	16.41	.001
	Sentence Complexity	26.1	*9.6*	8.5	*7.9*	6.9	*7.9*	29.96	.001

*NLE better than other 2 groups, ^NLE & LLE better than PLD group

Characteristics: Age 10.5

Nonverbal Intelligence: WISC Perceptual Reasoning

Duration of CI Use

CI Technology

Bilateral Device Use (N=29)

CI-Aided PTA Threshold

Speech perception (Lexical Neighborhood Test)

DCIP Dallas Cochlear Implant Program

Washington University in St. Louis

Characteristics of Children with Normal Language Emergence (NLE), Late Language Emergence (LLE) and Persistent Language Delay (PLD) : **School Age (10)**

Characteristic	Score	NLE	*SD*	LLE	*SD*	PLD	*SD*	F (2,57)	p
WISC – PRQ	Quotient	110	*10*	104	*12*	102	*15*	2.19	NS
Duration of CI use	Years	8.8	*1.0*	8.6	*1.0*	8.3	*0.9*	*1.08*	NS
Most Recent Tech	% Yes	89.5		77.3		42.1		x^2= 12.5	.05
Bilateral Devices	% Yes	63%		45%		37%		x^2= 2.7	NS
CI Aided PTA^	dB HL	18.0	*5.6*	20.1	*5.0*	26.6	*8.5*	9.22	.000
LNT Phonemes ^	% Correct	94.0	*4.9*	90.4	*6.3*	78.4	*21.6*	15.98	.000

^NLE & LLE better than PLD group

Normal vs Late Language Emergence

- Younger age at implant
- Better early grammar
- Earlier mainstream placement
- More recent technology

Dallas Cochlear Implant Program

Washington University in St. Louis

Persistent Delay vs Late Emergence

- Left-ear implantation
- Less audibility for speech
- Poorer speech perception
- Immature early speech production

Dallas Cochlear Implant Program

Washington University in St. Louis

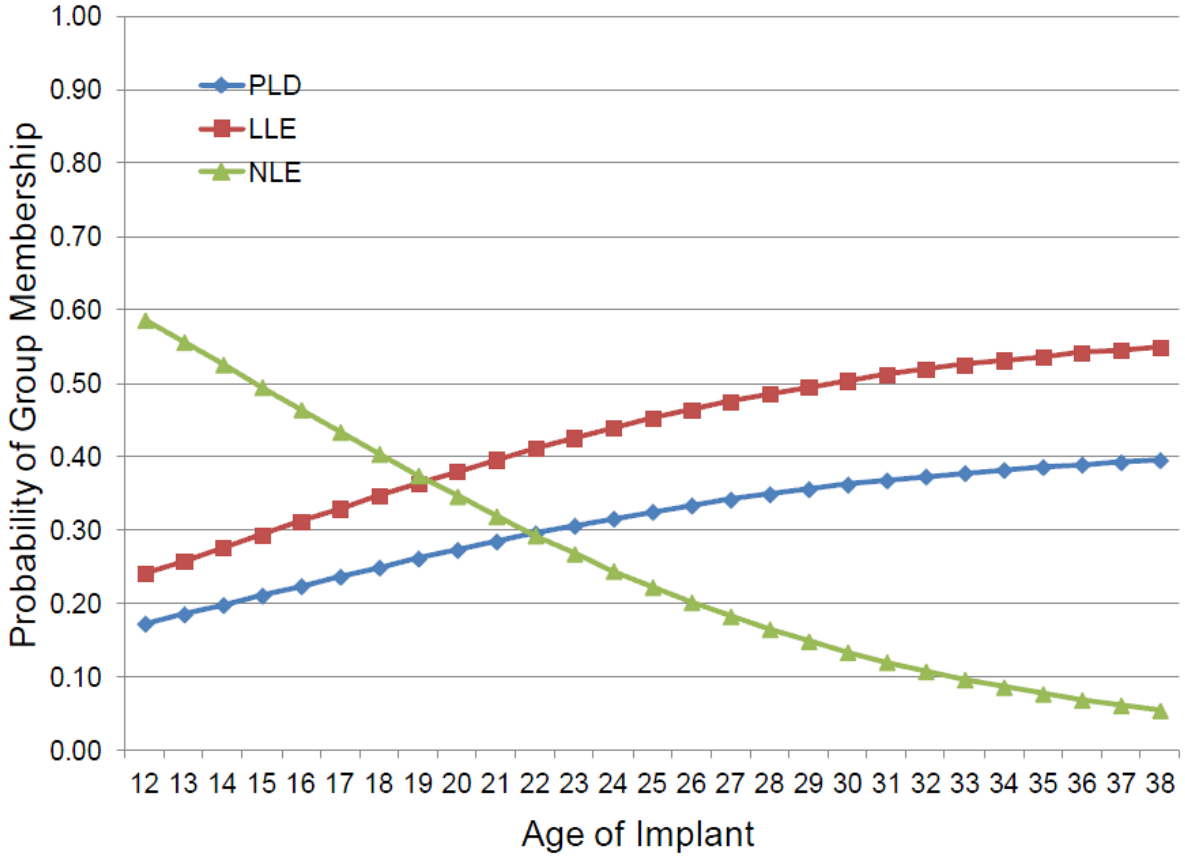
Multinomial Regression

- Predictor Variables
  - Age at first CI
  - Bilateral CIs (Y or N)
  - Most recent technology (Y or N)
  - Ear first CI (R or L)
  - Nonverbal IQ (WISC Perceptual Reasoning)
  - Language at age 3.5 (PC Score)
  - Speech at age 3.5 (PC Score)

Logistic Regression (LLE ref group)

Predictor	NLE	PLD
Intercept	NS	NS
Age of first CI	.057	NS
Bilateral	NS	NS
Most Recent Tech	NS	NS
Ear First CI	NS	.008
Nonverbal Intelligence	NS	NS
Language PC Age 3	.013	NS
Speech PC Age 3	NS	.010

Group membership by Age at implant



Classification of cases relative to actual group membership

Classification

Observed	Predicted			
	NLE	LLE	PLD	Percent Correct
NLE	16	3	0	84.2%
LLE	2	16	4	72.7%
PLD	0	5	13	72.2%
Overall Percentage	30.5%	40.7%	28.8%	76.3%

Study 2: Language Delay

- What are the academic consequences of persistent language delay?

DCIP Dallas Cochlear Implant Program

Washington University in St. Louis

Academic Outcomes

How close is verbal reasoning ability to reaching the child's nonverbal learning potential?

Are phonological decoding skills at age-appropriate levels?

Are reading comprehension skills at age-appropriate levels?

Dallas Cochlear Implant Program

Washington University in St. Louis

Age 10.5 Academic Battery

Wechsler Intelligence Scale

IQ gap = Perceptual Reasoning – Verbal Reasoning

Woodcock Reading Mastery Test

Basic Skills

Word identification

Word attack

Reading Comprehension

Word comprehension

Passage comprehension

Characteristics of Children with Normal Language Emergence (NLE), Late Language Emergence (LLE) and Persistent Language Delay (PLD) : **School Age (10)**

Characteristic	Score	NLE	*SD*	LLE	*SD*	PLD	*SD*	F (2,57)	p
Cognition									
WISC – PRQ	Quotient	110	*10*	104	*12*	102	*15*	2.19	NS
WISC – VRQ**	Quotient	109	*11*	99	*14*	78	*15*	27.16	.000
WISC Gap^	PRQ – VRQ	1	*9.8*	5	*17.4*	24	*13.0*	15.55	.000
Reading									
Basic Skills*	Quotient	122.9	*22.7*	100.4	*14.3*	90.5	*17.7*	15.73	.000
Comprehension**	Quotient	121.4	*20.1*	101.6	*13.1*	84.1	*13.0*	27.12	.000

^NLE & LLE better than PLD group, **All groups differ, *NLE better than other 2 groups

Future Study

- Will more PLD children close the language gap as they gain experience?
- Does specific language impairment (SLI) underlie PLD in some children? Can we distinguish SLI from auditory deprivation?
- Can speech production assessment be used for early diagnosis of PLD?