Explaining variability in speech and language outcomes for children with bilateral cochlear implants: A longitudinal study

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INTRODUCTION

- Many children who have a bilateral severe to profound hearing loss are now receiving bilateral cochlear implants (BiCIs).

- It has been shown that children with BiCIs develop language skills more comparable to their normal-hearing peers, than children with only one CI.
  - However, speech and language outcomes in children with BiCIs are still extremely variable.

- Despite the variability, the majority of children with BiCIs use primarily auditory-oral modes of communication, and are educated in mainstream environments.

Goal of this study:

To investigate the relationship between speech & language development and multiple *cognitive* and *demographic* factors in children with BiCIs.

Do any of these factors lead to better speech and language outcomes over time?

PARTICIPANTS

- 22 children with BiCIs, ages 4-9 years (12 F, 10 M)
  - Native English speakers
  - Primary mode of communication = oral
  - No diagnosed developmental disabilities
  - **Longitudinal design**:
    Testing was initially conducted within one year of bilateral activation and at 1, 2, or 3 additional visits (time between visits varied for each child)
    - Total number of visits per child: 2 visits (n=5); 3 visits (n=14); 4 visits (n=3)

Table 1. Participant characteristics

	Mean	Min	Max	SD
Chronological Age at CI1 (months)	1;8	0;9	4;9	0;11
Chronological Age at CI2 (yrs;mo)	3;7	1;1	5;5	1;2
Hearing Age at visit 1 (yrs;mo)	3;11	1;5	6;6	1;4
Maternal Ed. (yrs;mo)	17;5	12;0	24;0	2;1

Scores on the Brief-IQ and Memory Screen remained stable across visit

- **Leiter-R** (Roid & Miller, 1997), administered nonverbally
  1) *Brief-IQ* – Composite of four "Visualization & Reasoning" subtests
 2) *Memory Screen (component of executive function)*– Composite of two "Attention & Memory" subtests

Table 2. Group IQ & Memory Screen scores (mean±SD) *note: only 3 children had four visits

	Visit 1 (n=22)	Visit 2 (n=22)	Visit 3 (n=17)	Visit 4 (n=3)
Brief_IQ	111±13	117±19	115±14	119±5
Memory Screen	97±14	113±15	114±11	109±11

Within subject ANOVAs revealed no significant difference in **IQ** [$F_{(3, 6)}$=1.59, p=0.29] or **Memory** [$F_{(3, 60)}$=2.22, p=0.19] between visits.

Evaluation of Speech and Language

- **Test of Language Development-Primary, 4th ed.** (TOLD-P4; Newcomer & Hammill, 2008)
  1) Core Language Composite- 6 subtests (i.e. picture vocab., relational vocab., oral language, syntactic understanding, sentence imitation, morphological completion)
  2) Expressive Language (Speaking) Composite- 2 subtests (i.e. oral vocab., morphological completion)
  3) Receptive Language (Listening) Composite- 2 subtests (i.e. picture vocab., syntactic understanding)

Core Language Composite / Expressive Language Composite / Receptive Language Composite
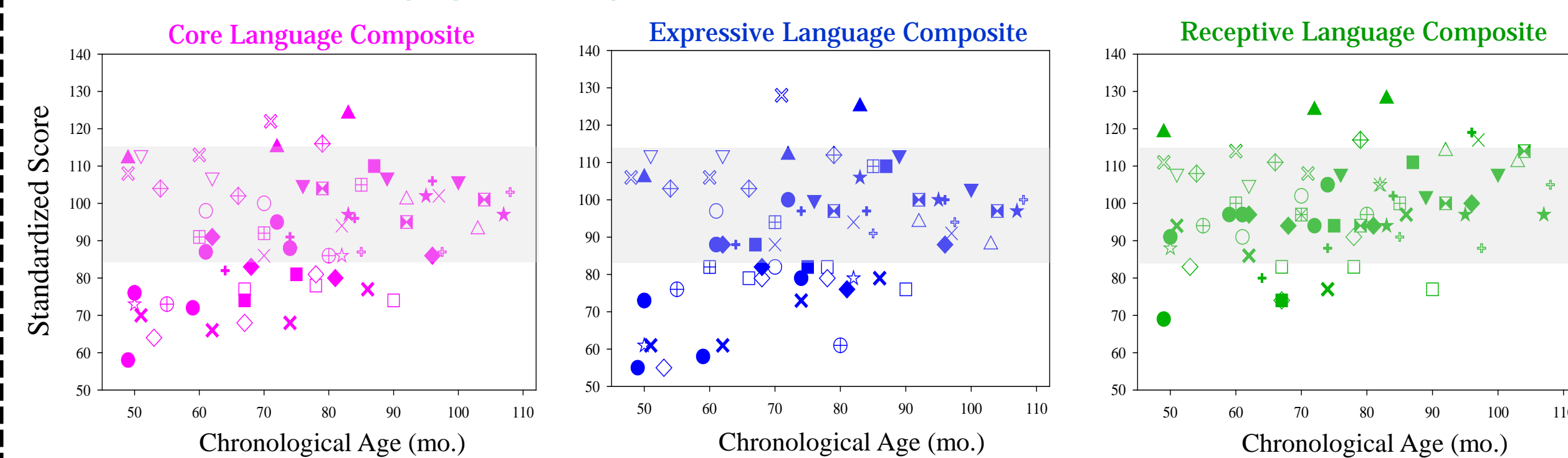
Speech and language scores improved over time for the majority of children.

Fig 1. Individual standardized scores on each language assessment as a function of chronological age. **The shaded region represents scores within the normal range**. Each child is represented with a different symbol. The number of symbols per child varies (i.e. 2-4 symbols per child) depending on their total number of visits.

Relationship between performance on measures of executive function & speech and language
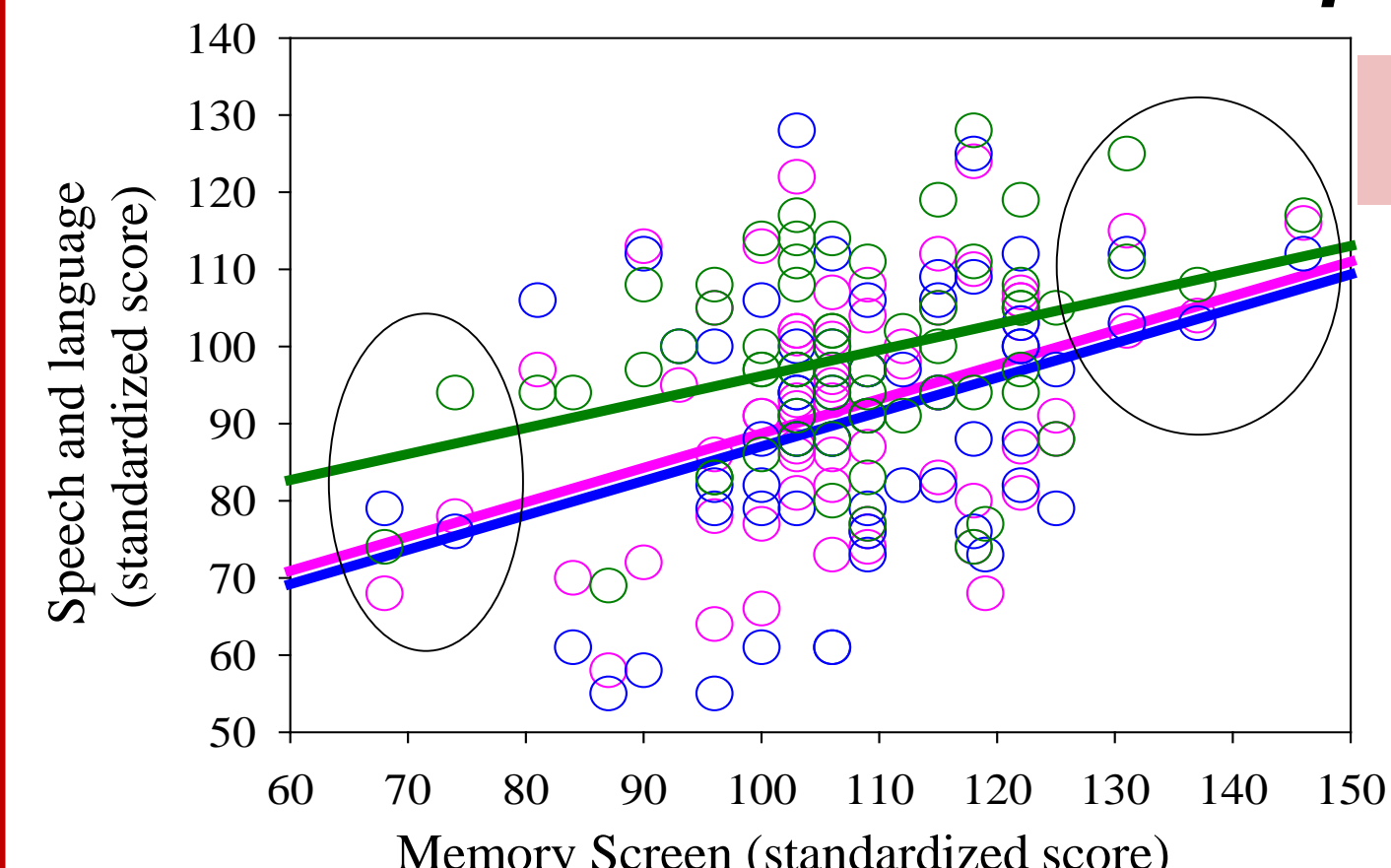
There was a significant relationship between speech & language and performance on the memory screen at one point in time.

Core language (r^2=0.17, $F_{(1,63)}$=12.49, p=0.001)
Expressive language (r^2=0.14, $F_{(1,63)}$=10.26, p=0.002)
Receptive language (r^2=0.14, $F_{(1,63)}$=10.02, p=0.002)

Fig 2. Individual simple linear regressions between each measure of speech and language and performance on the assessment of executive function (all visits combined).

Preliminary Results & Future Directions: Development of Speech and Language

An exploratory analysis was used to examine variables that best predict speech and language outcomes at baseline and over time. Preliminary results are shown below.

No variables were found to significantly predict receptive language.

Variables of interest: *(1) maternal education*, (2) chronological age at activation CI1 & CI2; (3) hearing age at first visit; (4) chronological age at first visit, (5) BiCI ex. at first visit, (6) first CI prior to 18 mo., (7) side of first CI, (8) sex

At the first visit, females showed better **expressive** (estimate=-12.1, SE=5.12, *p<0.05) & **core language** (estimate=-13.48, SE=5.58, *p<0.05) abilities than males.

Years of maternal education was related to growth over time in
(1) Expressive language
(2) Core language

(1) Expressive language composite

The children who had better scores at the first time point are the children who tended to improve the least over time.
(estimate=0.07, SE=0.02, *p<0.05)

(2) Core language composite

At the last time point, the majority of the children performed within the normal range.
(estimate=0.07, SE=0.02, *p<0.05)

Upper 25% (19-24 yrs)
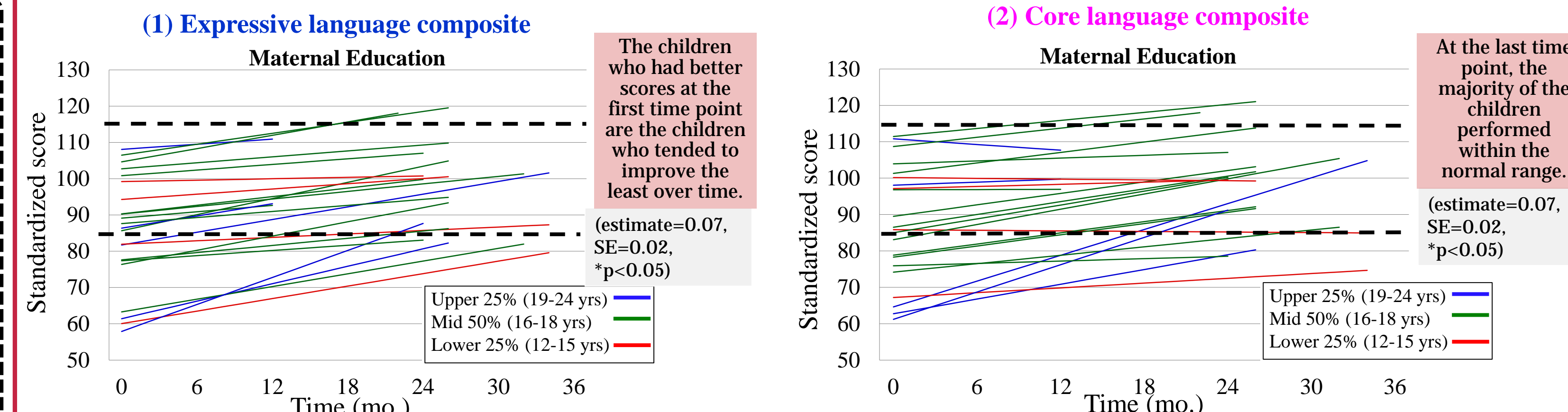Mid 50% (16-18 yrs)
Lower 25% (12-15 yrs)

Fig. 3. Standardized scores on (1) expressive language & (2) core language over time. Each line represents longitudinal data from one child. The colored lines indicate level of maternal education.

Discussion

- Performance on the memory screen assessment was related to speech and language outcomes, suggesting that neurocognitive skills should be assessed in children with CIs– this could help to identify a subset of children who may be more at risk for speech and language delays.

- Children whose mothers had more years of education showed more growth in expressive and core language abilities over time.
  - Mothers education level, a predictor of socioeconomic status, has been shown to correlate with higher development and growth of skills in various fields.

- There was no significant relationship between IQ and speech & language acquisition for children in this study.
  - However, the majority of children in this study had above average IQs.

- Our *preliminary analyses reveals* that there are some non-CI related factors (i.e. executive function and maternal education) that can help to explain some of the variability in speech and language outcomes for children with BiCIs.
  - In order to promote successful development in mainstreamed environments, these factors must be considered when counseling parents and providing clinical care to this population.

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