Sit long, talk much: The relation between language and sitting for infants with typical or delayed motor development

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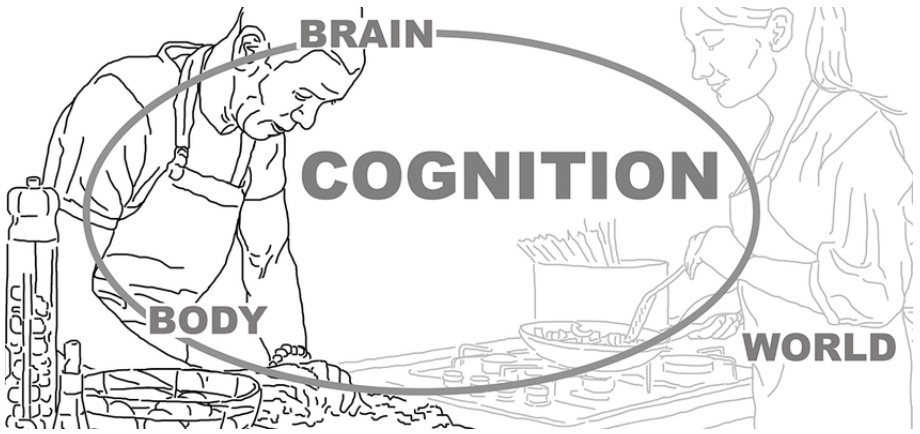
How do infants learn from play?

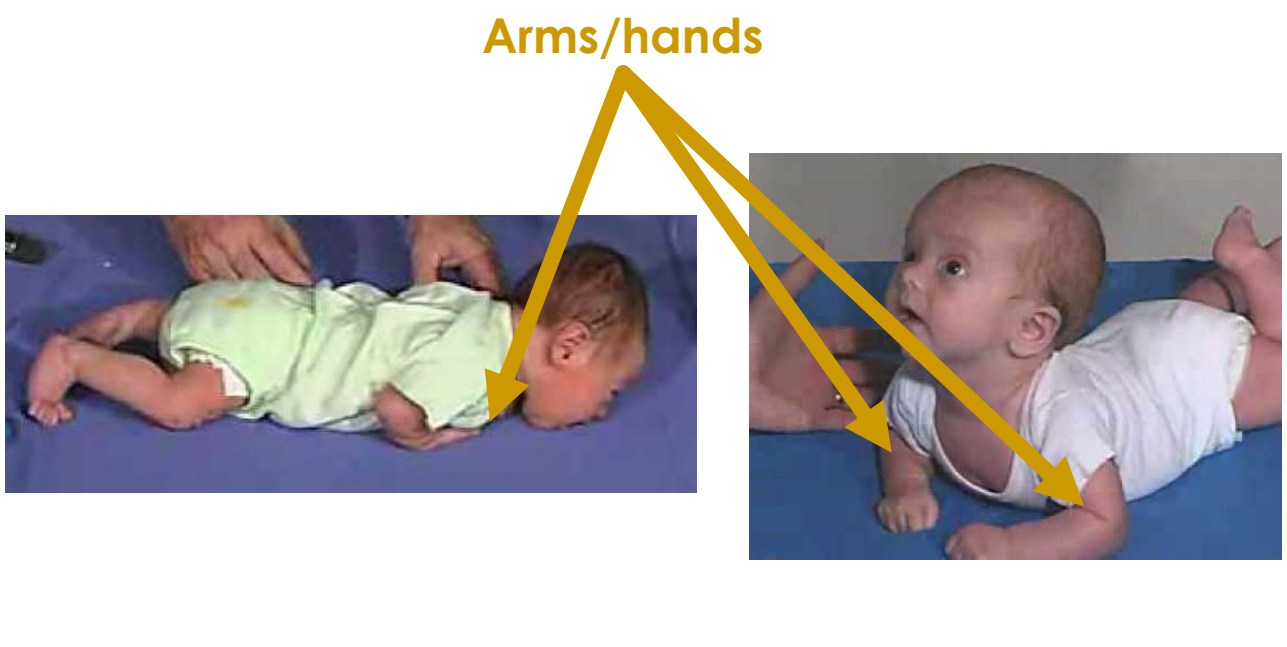
- **Active exploration** of the environment provides sensory information about the properties of the environment
- **Embodied Cognition Theory** – the processes of language, concept formation and use, and abstract reasoning comprise mental simulations of bodily experiences of actions on objects and interactions of the self and others.
- **Motor development** – Greater motor control of the body leads to greater capability to manipulate the environment actively across development
  - Constraints

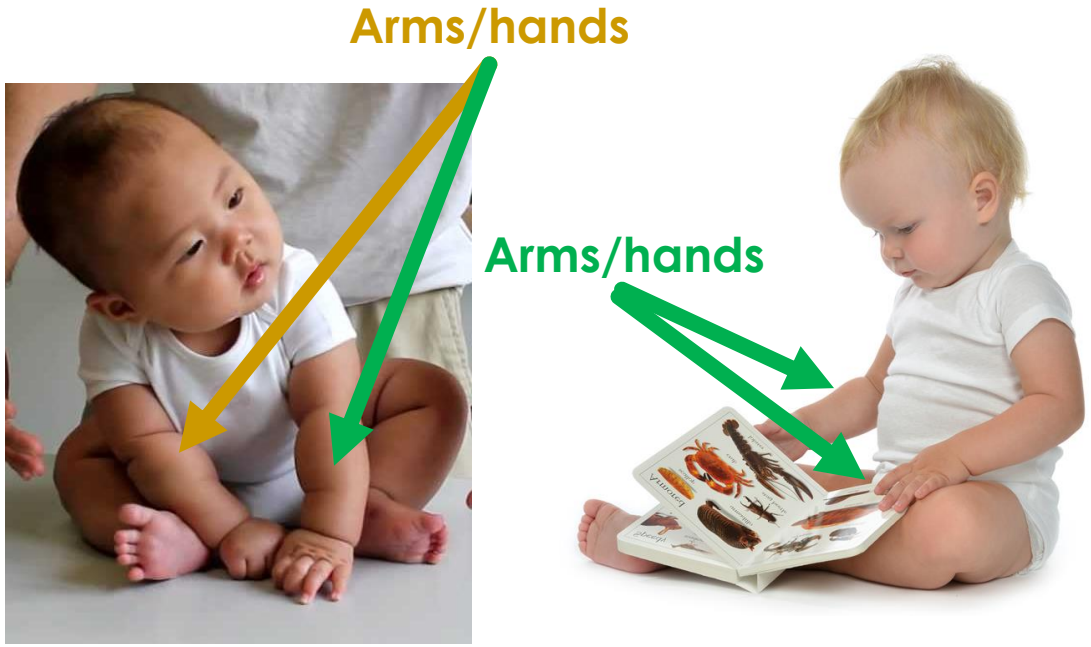


Constraints

a factor which shapes motor activity through affordances or containment

The consequences of the emergence of independent sitting





Independent sitting skill changes…

How a child is capable of exploring objects from the environment

How cognition and language emerges, as a result

Why might sitting important to understanding language?

- **Sitting changes how infants:**
  - Explore objects: Arms-free sitters explore objects at higher frequencies, and visually explore objects for longer, than prop sitters (Marcinowski et al., 2019; Soska & Adolph, 2013; Surkar et al., 2018)
  - Understand object properties: Sitters performed more object rotations and exhibited a greater understanding of 3D object completion, than same-aged non sitters (Soska et al., 2010)

- **Early language is proposed to be encouraged by sitting and object action**
  - Upright sitting does not constrict breathing which may in turn affect babbling production (Yingling, 1981)
  - Infants vocalized more frequently, with more variations, and with a greater likelihood of supraglottal consonants when mouthing objects (Fagan & Iverson, 2007; Iverson, 2010).

Children with motor delays and language

- **Children with neuromotor disorders exhibit delays globally, including language**

- **Reasons for language delays in children with neuromotor disorders?**
  - Often language delays are conceptualized as "delayed maturation" or "neurological soft signs" in children with motor delays.
  - Co-occurring developmental mechanisms: delays in motor control impair object exploration/environmental manipulation, which impairs subsequent cognitive and language

- **Even changes or delays in early emerging developmental skills may have cascading effects in development, which extend beyond the motor domain**

(Iverson, 2010; Thelen, 2004)

Does sitting skill relate to receptive and expressive language for infants 6 months following the onset of independent sitting?

Prediction 1: Greater sitting skill is expected to predict greater receptive and expressive language in young children with motor delays, when controlling for cognitive ability.

Prediction 2: Greater sitting skill is expected to predict increased frequencies of word understanding and production in young children with typical or delayed motor development.

METHODS

Methods: Participants

- **64 Infants with Motor Delays (28 females)**
  - Control group for a national clinical trial (Virginia, Washington, Delaware, Pennsylvania)
  - Age: 7-17 months adjusted age
  - Severity of Involvement: Mild (n=32), Moderate (n=17), Severe (n=15)
  - Exclusion: Structural abnormalities (e.g., clubfoot), certain genetic disorders (e.g., Trisomy 21), no active arm movements, or not capable of safe floor play

- **36 Infants with Typical Development (18 females)**
  - Typical sample recruited at the Virginia site for the national clinical trial
  - Age: <7 months age
  - Exclusion: Complications during gestation or birth, diagnoses known to affect motor or language, language or gross motor delay on BSID

- **Recruited at Sitting Emergence:** Prop sitting for 3+ seconds through arms-free sitting without position change

Methods: Study Schedule

- **Visit schedule for all infants:**
  - Baseline, +3 months later, +6 months later
  - All assessments were performed by 2 researchers: 1 performed the assessments, 1 video-recorded the infant

- **Assessments**
  - Sitting: Gross motor function assessment sitting scale (GMFM)
  - Language: Bayley Scales of Infant and Toddler Assessment (BSID) Receptive and Expressive sub-scales, Communication and Development Inventory
  - Cognition: Bayley Scales of Infant and Toddler Assessment (BSID) Cognitive sub-scale

Methods: Sitting Assessment

Sitting Assessment (Independent variable)

- Gross Motor Function Measure 88: Sitting Sub-scale (GMFM Sitting) – standard gross motor assessment designed for young children at risk for motor disorders/delays for different dimensions of functioning
- Scoring: Video-recorded and scores were marked by a second coder from video
- Sample: Completed for both infants with typical and delays

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SCORING KEY

0 = does not initiate
1 = initiates
2 = partially completes
3 = completes

Methods: Language Measures

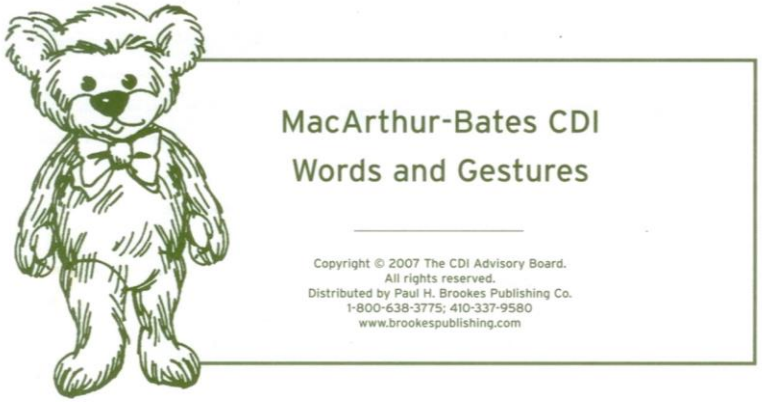
Language Assessments (Dependent variables)

- Bayley Scales of Infant and Toddler Development, III: Language Sub-scales – standardized language assessment with 2 sub-scales: expressive and receptive
- Scoring: Video-recorded and scores were marked by a second coder from video
- Sample: Only for infants with delays sample

Methods: Language Measures

Language Assessments (Dependent variables)

- Communication Development Inventory (CDI) – a parent-report survey with an inventory of common child words
- Mark whether the child "understands" or "understands and says" the words on the inventory
- Scoring: Completed electronically by parent at each visit
- Sample: Completed for both infants with typical and delays



Methods: Cognitive Measure

Cognitive Assessment (Controlling)

- Bayley Scales of Infant and Toddler Development, III: Cognitive Scale – standardized cognitive assessment
- Scoring: Video-recorded and scores were marked by a second coder from video
- Sample: Only for infants with delays sample

Methods: Analytic Plan for BSID Language Scores

- **Raw scores for BSID sub-scales were modeled.**
  - Multilevel longitudinal models
  - Model reduction technique (Singer & Willett, 2003)

- **Prediction Models: Bayley Receptive and Expressive Language**
  - Level 1/Time sensitive: Months since baseline, GMFM sitting skill, Bayley Cognitive Scores
  - Level 2/Time stable: Age at enrollment (intercept)
  - Dependent variables: Receptive (BSID), Expressive (BSID)
  - Adjusted age at baseline was tested for its effect on the intercept for all models.

- **Only infants with motor delays included**

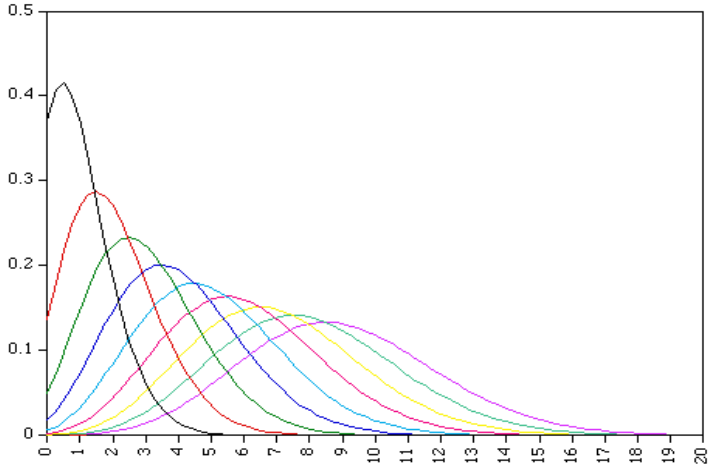
Methods: Analytic Plan for CDI

- **Frequencies of parent-endorsed words were modeled.**
  - CDI variables were both Poisson-distributed and underdispersed
  - Multilevel Poisson longitudinal models
  - Model reduction technique (Singer & Willett, 2003)

- **<u>Prediction Models</u>: CDI Understands & Understands and Says variables**
  - <u>Level 1/Time sensitive</u>: Months since baseline, GMFM sitting skill, Bayley Cognitive Scores
  - <u>Level 2/Time stable</u>: Age at enrollment (intercept), Severity level (intercept, slopes)
  - <u>Dependent variables</u>: Understands, Understands/Says
  - Adjusted age at baseline was tested for its effect on the intercept for all models.

- **<u>Both samples included</u>: infants with typical or delayed motor development**
  - Sample with delays only: control for BSID Cognitive
  - Both sample analyses: do not control for BSID Cognitive

Sample Poisson Distribution



Results: Infants with Delay
BSID Scores

BSID <u>Receptive</u> Language Scores

Months since baseline (β_2=0.14, *t*(64)=1.96, *p*=0.04) and Cognitive scores (β_2=0.15, *t*(32)=5.69, *p*<0.01) positively predicted **<u>receptive</u>** language *<u>trajectories</u>*; however, GMFM sitting skill only <u>approached</u> significance criteria (β_2=0.03, *t*(32)=1.79, *p*=0.07).

BSID <u>Expressive</u> Language Scores

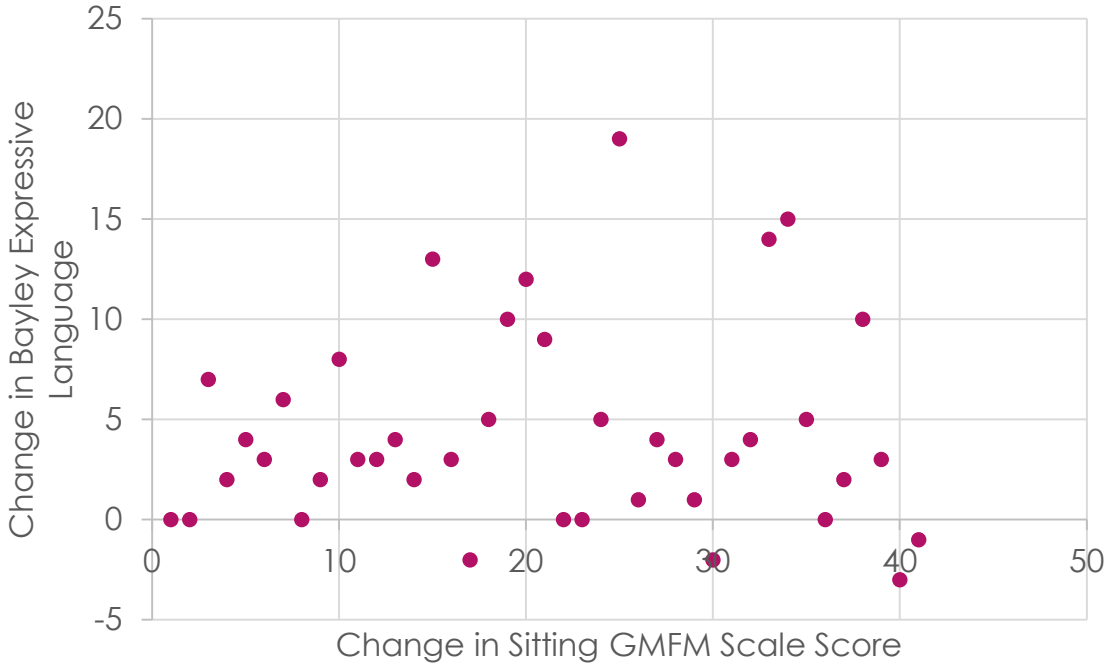
- Months since baseline (Beta2=0.03, *t*(64)=3.39, *p*<0.01) and Cognitive scores (β_3=0.02, *t*(32)=4.74, *p*<0.01) positively predicted **<u>expressive</u>** language *<u>trajectories</u>*; however, GMFM sitting skill did not (β_2=0.01, *t*(32)=1.03, *p*=0.31).

IVs: GMFM sitting, BSID Cognitive Score, Months since baseline
DVs: BSID Receptive, BSID Expressive

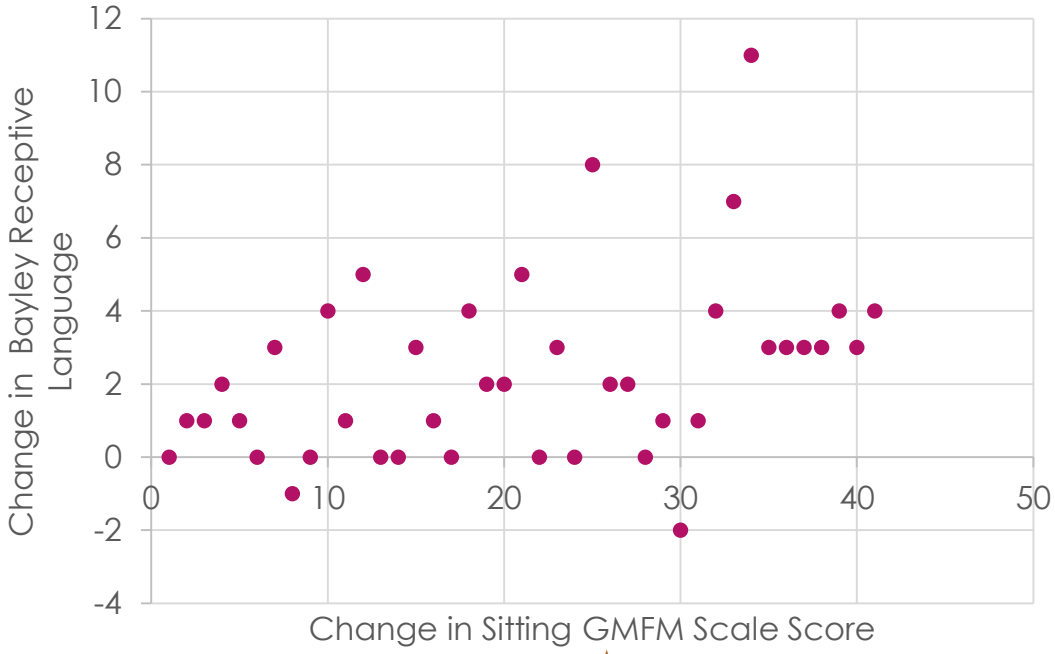
Results: Infants with Delayed Motor Development BSID Scores

Figure 1. Scatter plots of GMFM Sitting Score and BSID Language Difference Scores (6 months-Baseline)

Expressive Language
6 months and baseline difference Scores



Receptive Language
6 months and baseline difference Scores



?

p=0.07

Results: Infants with Delayed Motor Development
CDI Survey Scores

Understands

CDI Word Understanding

- GMFM sitting skill positively predicted CDI Understanding across time (β_2=0.09, $t(64)$=3.30, p<0.01); however, months since baseline (β_2=-0.13, $t(64)$=-1.45, p=0.15) and Cognitive scores (β_3=-0.02, $t(64)$=-1.20, p=0.23) did not.

Understands and Says

CDI Word Understanding/Says

- GMFM sitting skill positively predicted CDI Understand/Say across time (β_2=0.05, $t(64)$=4.58, p<0.01); however, months since baseline (β_2=0.04, $t(64)$=0.50, p=0.62) and Cognitive scores (β_3=0.04, $t(64)$=1.6, p=0.13) did not.

IVs: GMFM sitting, BSID Cognitive Score, Months since baseline
DVs: CDI Understands, CDI Understands & Says

Results: Infants with Typical & Delayed Motor Development CDI Survey Scores

Understands

CDI Word Understanding

- GMFM sitting skill positively predicted CDI Understanding across time across all severity groups (Beta2=0.04, $t(99)=2.92$, $p<0.01$).
- All infant severity groups exhibited significantly different trajectories for understands across Months from Baseline (Betas 0.02-0.41, *ps* <0.03).

Understands and Says

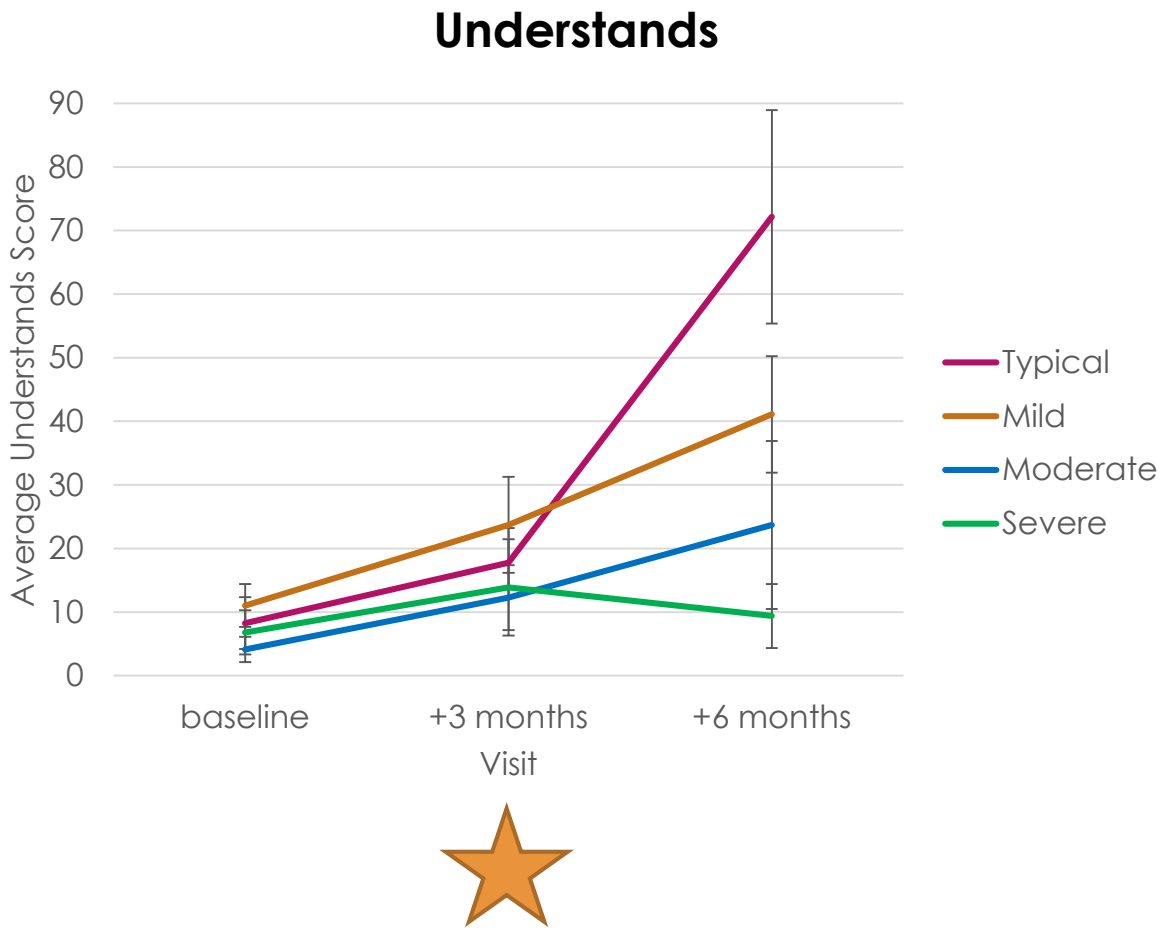
CDI Word Understanding/Says

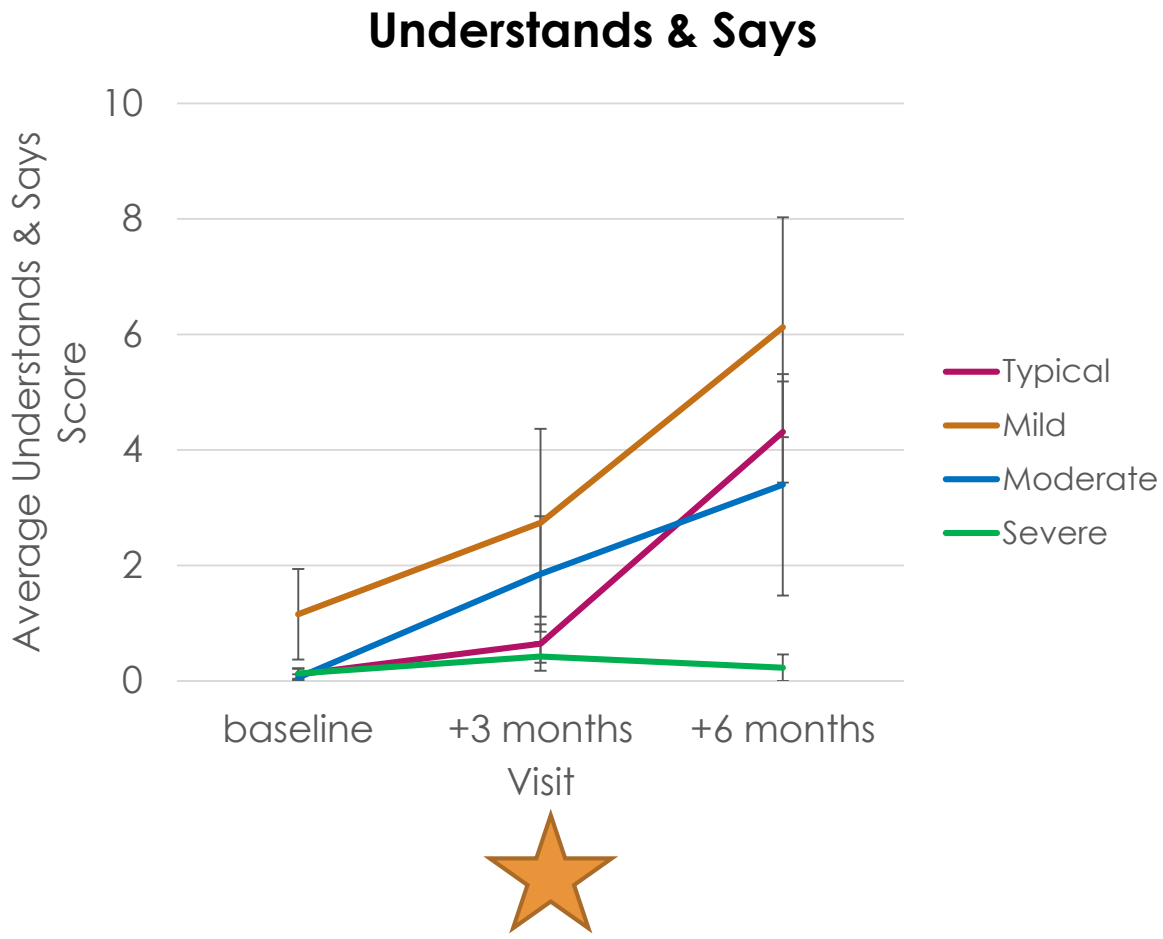
- GMFM sitting skill positively predicted CDI Understand/Say across time for infants in the Moderate category (Beta2=0.24, $t(96)=2.94$, $p<0.01$).
- All infant severity groups exhibited significantly different trajectories for Understands/says across Months from Baseline (Betas -0.45-1.17, *ps* <0.03)

IVs: GMFM sitting, Months since baseline
DVs: CDI Understands, CDI Understands & Says

Results: Infants with Typical & Delayed Motor Development CDI Survey Scores

Figure 2. Scatter plots of GMFM Sitting Score and CDI Survey Trajectories by Severity Group





Study conclusions

- **Prediction 1: Greater sitting skill is expected to predict greater receptive and expressive language in young children with motor delays, when controlling for cognitive ability.**
  - Not conclusive

- **Prediction 2: Greater sitting skill is expected to predict increased frequencies of word understanding and production in young children with typical or delayed motor development.**
  - Evidence found of sitting skill progression positively → trajectories of word understanding and production for both samples.

Future Directions of Research

- **What is the developmental mechanism between sitting and language development?**
  - Fagan and Iverson: Upright sitting → More mouthing → More advanced language/consonant production?
  - Other co-occurring motor factors (e.g., locomotion onset?)
  - Limitation: No babbling specific information in current language data, where a lot of theorized relations are

- **Infants with neuromotor disorders likely develop language differently than infants with typical development, as a function of differences in <u>developmental timing</u>.**
  - Sitting/mouthing = sufficient, but not necessary to language development
  - Sitting may be relevant to language development only within a certain window of time.

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START-Play Sitting Together & Reaching to Play

CHILDREN'S HOSPITAL OF RICHMOND AT VCU