Brain Maturation and Language Development in 6- to 13-Year-Old Late Preterm and Full Term Children

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Introduction

- Late preterm (LPT) births, which occur between 34 and 36 weeks of gestation, represent nearly two-thirds of all preterm deliveries in the United States.
- LPT children exhibit distinct developmental trajectories compared to full-term peers (≥ 37 weeks of gestation), particularly in language development—over 30% of LPT children demonstrate communication impairments by 36 months.
- Questions remain regarding the mechanisms that underlie variability in language acquisition among LPT children.
- Cortical thickness and surface area are neural markers that offer insights into regional brain maturation and processes critical for language development.

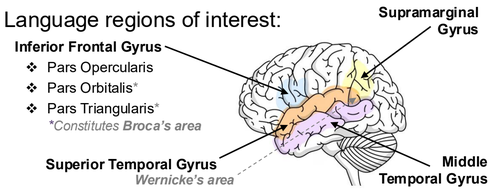
Objectives

To investigate whether canonical language regions differ between LPT and full term (FT) children in the following ways:

- **Aim 1:** Age-related changes in cortical thickness
- **Aim 2:** Association between language skills and (a) cortical thickness and (b) surface area

Methodology

- Secondary analysis of prospectively collected data at the University of Iowa on 6- to 13-year-old former LPT (n=52) and FT (n=74) children born between 1996 and 2006.
- Structural MRI was acquired using a Siemens 3T TIM Trio scanner, and T1- and T2-weighted images were analyzed with FreeSurfer 7.2.
- Language regions of interest:



- Children completed the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV) Vocabulary and Similarities subtests:
  - **Vocabulary**: Participants are asked to verbally express the definitions of several words; Words increase in difficulty.
  - **Similarities**: Participants are asked to explain the similarity between two stated words; Word pairs increase in difficulty.

Results

Table 1. Demographics, Socioeconomic Status, and Language

	Gestational Age		
	Late Preterm (n=52)	Full-Term (n=74)	P value
Birth Weight, *kg*	2.70 ± 4.91	3.59 ± 4.30	< 0.001
Sex: Male, *n (%)*	29 (56)	37 (50)	0.65
Age, *years*	9.43 ± 1.89	10.0 ± 2.21	0.12
Socioeconomic Status	2.25 ± 0.49	2.26 ± 0.44	0.91
School Grade	3.74 ± 1.99	3.94 ± 2.19	0.61
Vocabulary, *Scaled Score*	11.63 ± 3.50	11.64 ± 2.65	1.00
Similarities, *Scaled Score*	11.52 ± 3.17	11.88 ± 2.60	0.50

Note. Socioeconomic status is based on the Hollingshead Four-Factor Index, which considers education, occupation, sex, and marital status. Higher values indicate lower status.

Aim 1

Table 2. Multiple Linear Regression Models Examining the Association Between Chronological Age, Gestational Age, and Cortical Thickness in Bilateral Canonical Language Regions

	Left Hemisphere		Right Hemisphere	
	B (SE)	95% CI	B (SE)	95% CI
Pars Opercularis				
Intercept	3.05 (0.08)#	2.89, 3.20	3.02 (0.07)#	2.87, 3.16
Age	0.00 (0.01)†	-0.02, 0.01	0.00 (0.01)†	-0.02, 0.01
LPT Birth	0.01 (0.13)†	-0.25, 0.26	-0.03 (0.12)†	-0.27, 0.21
Age x LPT Birth	0.00 (0.01)†	-0.03, 0.03	0.00 (0.01)†	-0.02, 0.03
Pars Orbitalis				
Intercept	3.31 (0.12)#	3.07, 3.55	3.38 (0.12)#	3.14, 3.63
Age	-0.01 (0.01)†	-0.04, 0.01	**-0.04 (0.01)^**	**-0.06, -0.01**
LPT Birth	-0.27 (0.20)†	-0.68, 0.13	-0.22 (0.20)†	-0.62, 0.19
Age x LPT Birth	0.02 (0.02)†	-0.02, 0.06	0.02 (0.02)†	-0.02, 0.06
Pars Triangularis				
Intercept	3.18 (0.08)#	3.02, 3.34	3.01 (0.08)#	2.85, 3.16
Age	**-0.03 (0.01)#**	**-0.04, -0.01**	**-0.02 (0.01)***	**-0.03, 0.00**
LPT Birth	-0.08 (0.14)†	-0.35, 0.19	-0.02 (0.13)†	-0.28, 0.24
Age x LPT Birth	0.01 (0.01)†	-0.02, 0.04	0.00 (0.01)†	-0.02, 0.03
Superior Temporal Gyrus				
Intercept	3.11 (0.09)#	2.93, 3.29	3.25 (0.08)#	3.09, 3.41
Age	0.00 (0.01)†	-0.02, 0.02	-0.01 (0.01)†	-0.02, 0.01
LPT Birth	-0.14 (0.15)†	-0.44, 0.15	-0.13 (0.13)†	-0.40, 0.14
Age x LPT Birth	0.02 (0.02)†	-0.01, 0.05	0.01 (0.01)†	-0.01, 0.04
Middle Temporal Gyrus				
Intercept	3.29 (0.08)#	3.13, 3.44	3.39 (0.07)#	3.24, 3.53
Age	-0.01 (0.01)†	-0.03, 0.00	**-0.02 (0.01)***	**-0.03, 0.00**
LPT Birth	-0.04 (0.13)†	-0.29, 0.21	-0.08 (0.12)†	-0.32, 0.16
Age x LPT Birth	0.01 (0.01)†	-0.02, 0.03	0.01 (0.01)†	-0.02, 0.03
Supramarginal Gyrus				
Intercept	2.97 (0.08)#	2.80, 3.13	3.17 (0.06)#	3.04, 3.30
Age	-0.01 (0.01)†	-0.02, 0.01	**-0.02 (0.01)#**	**-0.04, -0.01**
LPT Birth	0.00 (0.14)†	-0.27, 0.28	-0.08 (0.11)†	-0.29, 0.13
Age x LPT Birth	0.00 (0.01)†	-0.03, 0.03	0.01 (0.01)†	-0.01, 0.03

Note. B = Unstandardized B (SE), 95% CI. Statistically significant effects are in **boldface**.
†p = NS; *p < .05; ^p < .01; #p < .001

Aim 2

No significant interactions between cortical thickness and gestational age group, or between surface area and gestational age group, were found for WISC-IV vocabulary and similarities scaled scores.

Aim 1

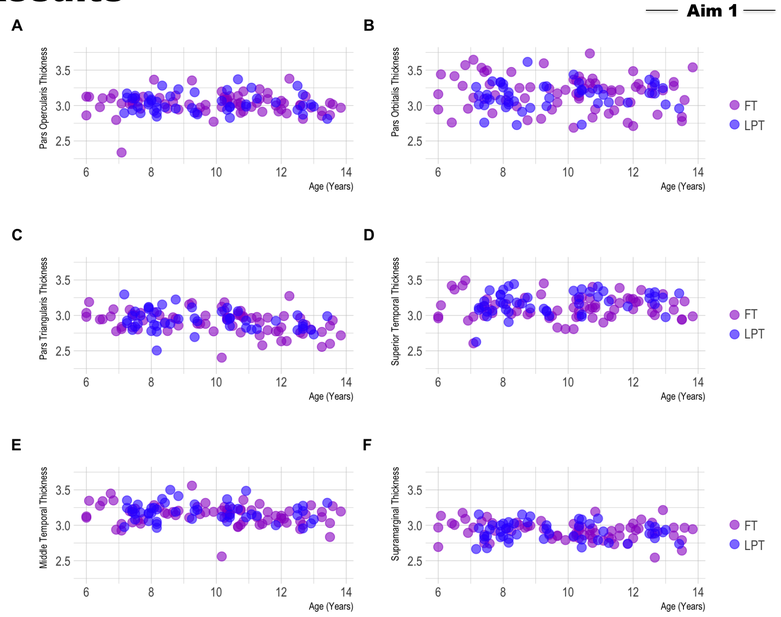


Figure 1. Interactions between age and gestational age on cortical thickness (mm) in **left hemisphere** language regions. Panels show the following regions: (A) Pars opercularis, (B) Pars orbitalis, (C) Pars triangularis, (D) Superior temporal gyrus, (E) Middle temporal gyrus, (F) Supramarginal gyrus. **Results were non-significant.**

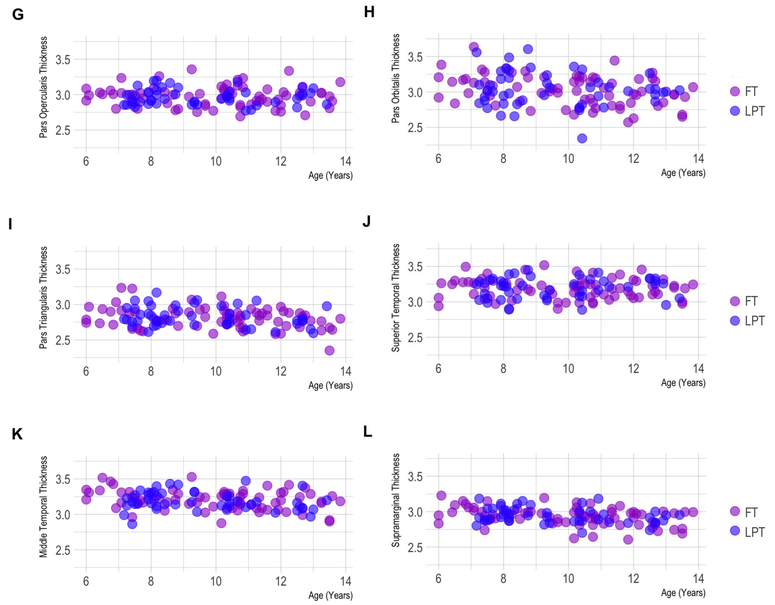


Figure 2. Interactions between age and gestational age on cortical thickness (mm) in **right hemisphere** language regions. Panels show the following regions: (G) Pars opercularis, (H) Pars orbitalis, (I) Pars triangularis, (J) Superior temporal gyrus, (K) Middle temporal gyrus, (L) Supramarginal gyrus. **Results were non-significant.**

Summary

- **Aim 1:** Brain maturation in canonical language regions did not differ between LPT and FT children.
- **Aim 2:** Relations between cortical thickness or surface area and language skills did not vary between LPT and FT children.
- These findings *differ* from prior studies suggesting that LPT children are at *moderate risk* for language difficulties compared to their FT counterparts.

Limitations

- Lack of detailed gestational ages and medical morbidities
- Non-linear statistical methods may provide a better fit for the dataset

Future Directions

- A broader pathogenic model is needed to better capture the developmental language trajectories of LPT children, taking into account:
  - Neonatal morbidities, interventions (e.g., nutrition)
  - Early/longitudinal structural, diffusion, and functional MRIs (e.g., myelination quantification)

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