# Beyond the “30-Million-Word Gap”

## Children’s Conversational Exposure is Associated with Language-Related Brain Function

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# Socioeconomic Status (SES)

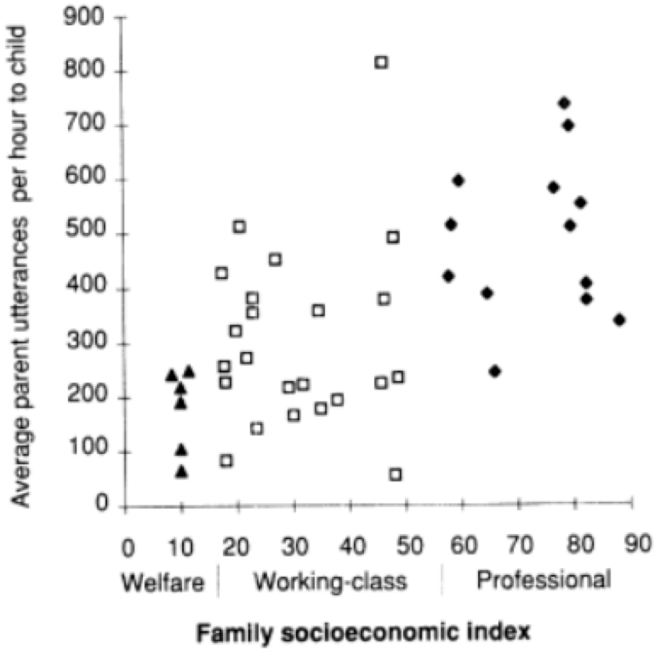
- “An individual's access to economic and social resources, as well as the benefits and social standing that come from these resources.” Brito & Noble 2014
    - “All societies have “worse off” and “better off” individuals.” Farah, 2017

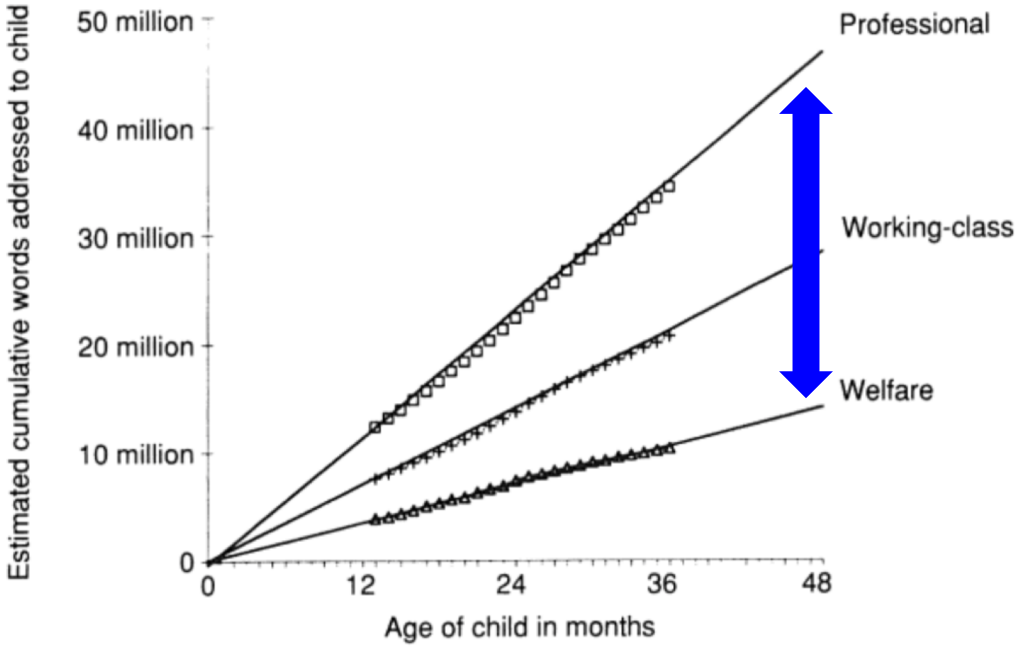
- Common (objective) measures include educational attainment, income, and occupational/social prestige. Ensminger & Fothergill, 2003
    - Though correlated, these factors exert unique influences on development. Duncan & Magnusen 2012

- SES indexes a number of correlated factors:
    - Chronic/toxic stress
    - Violence exposure
    - Nutrition
    - Access to health care
    - Exposure to toxins/pollutants
    - Educational resources
    - Parental/caregiver availability
    - Cognitive stimulation

# The “30 Million Word Gap”

“Time and amount of talking varied systematically with the socioeconomic status of the family… Parents in [higher SES] families devoted twice as much time to interaction and said three times as many words to their children.”

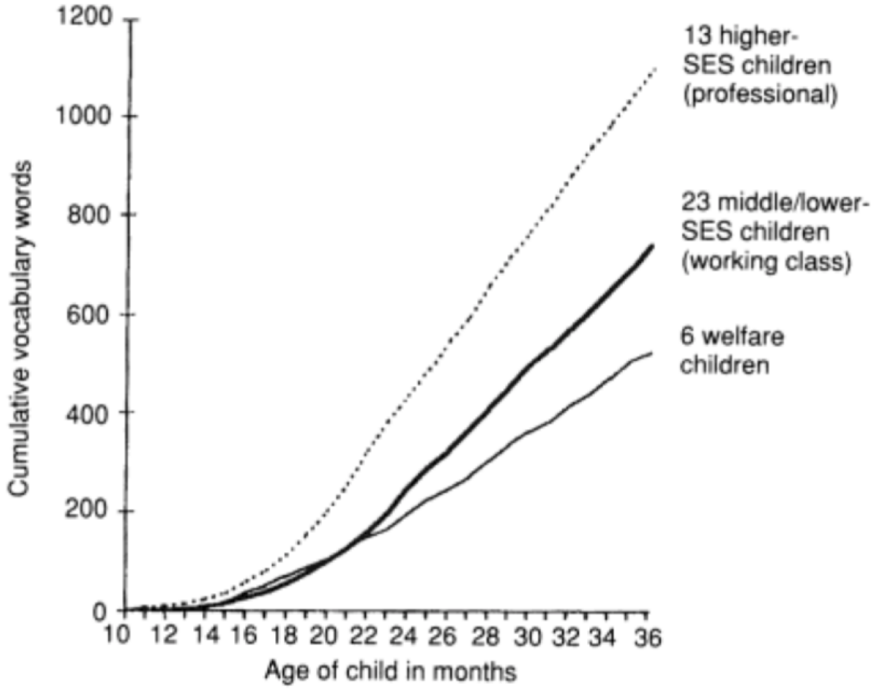



Hart & Risley, *Meaningful Differences in the Everyday Experience of Young American Children*, 1995

# Word Gap ➡ Vocabulary Gap

- "By age 3, some children were as far above the average in vocabulary resources as other children were below; we saw a widening gap beginning as early as age 24 months." Hart & Risley, 1995
- Fernald et al. 2013 found that the widening gap starts even earlier.




Hart & Risley, 1995

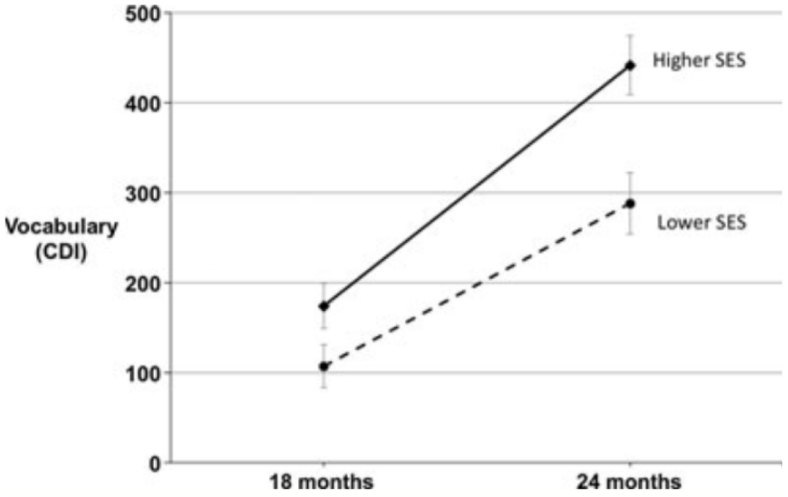
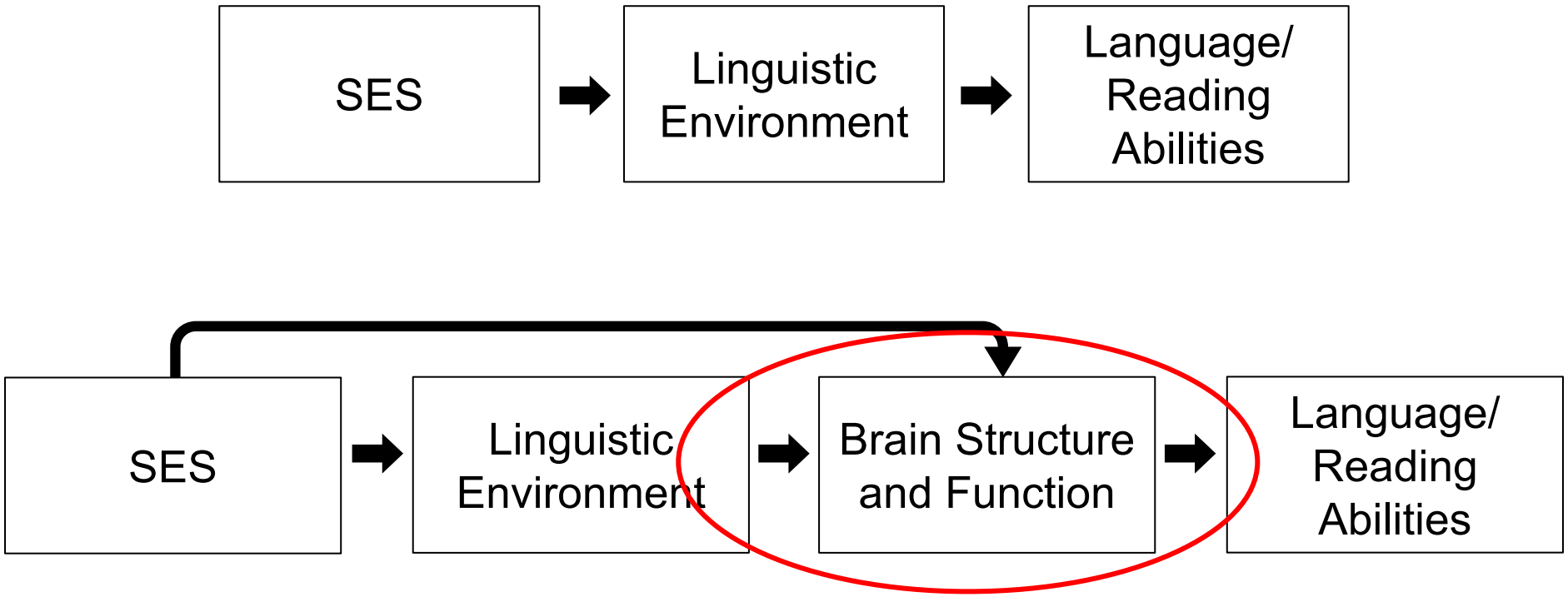



**Figure 2** *Mean number of spoken words reported on the MacArthur/Bates CDI by age and SES (HI). Error bars represent SE of the mean over participants.*

Fernald, Marchman, & Weisleder, 2013

# Hypothesized Mechanisms



# Methods

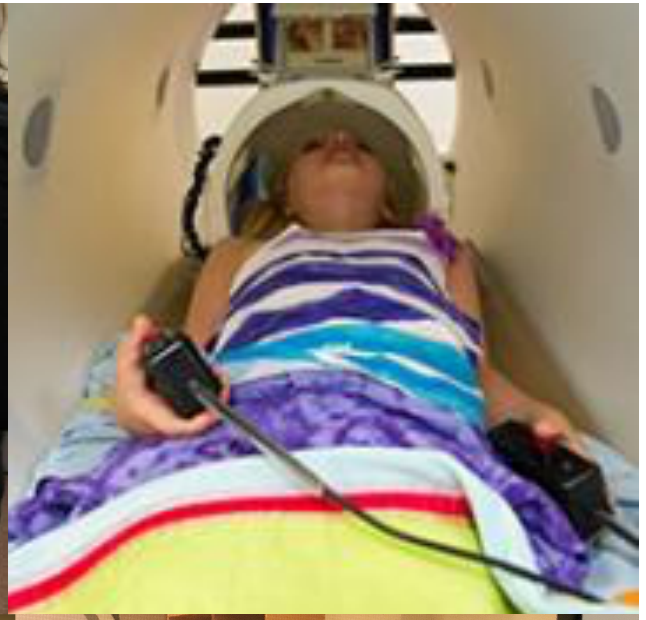
- n = 63 children of varying SES (Parent Edu + family total income)
  - Ages 4-6 years (in pre-K or K grades)
  - Native English, no developmental delay/history of language impairment

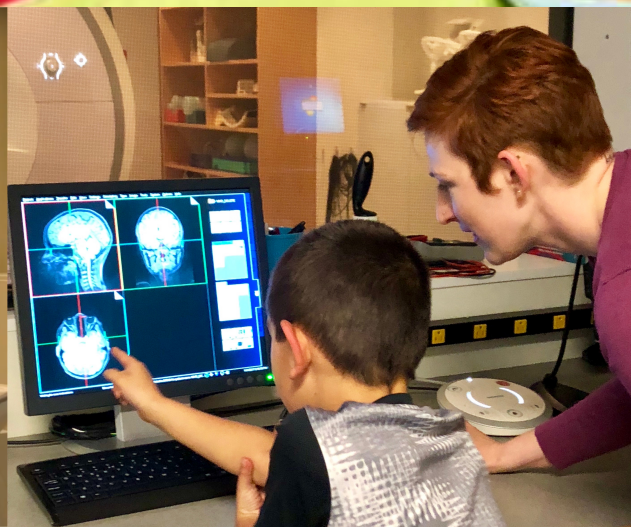
- Standardized language/cognition assessments
  - Verbal composite: Receptive & expressive language via PPVT-4 and CELF-5
  - Non-verbal composite: Fluid reasoning, working memory, processing speed via WPPSI-IV

- Functional Magnetic Resonance Imaging (fMRI)
  - First a 5-min. structural MRI, followed by 6-min. language listening task
  - 11 did not complete, 3 fell asleep, 7 moved too much

- Home Language Recording
  - 2 complete weekend days of LENA
  - Sampled everyone's "best hour" – the one hour with the most speech
  - 6 did not complete (final n = 36)

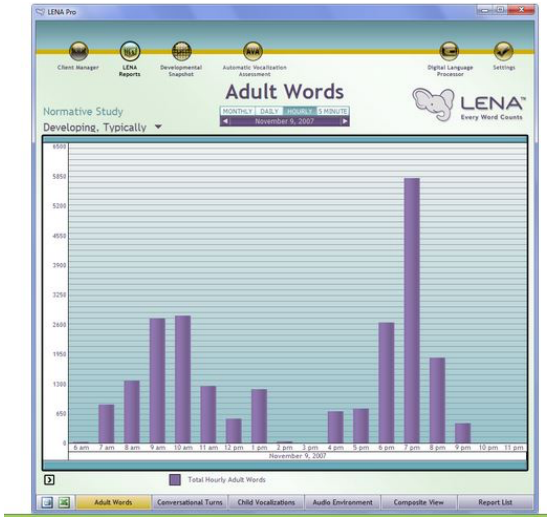
# Pediatric Neuroimaging

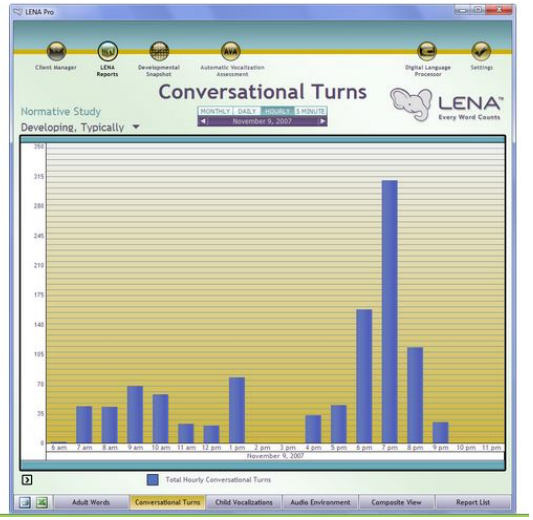


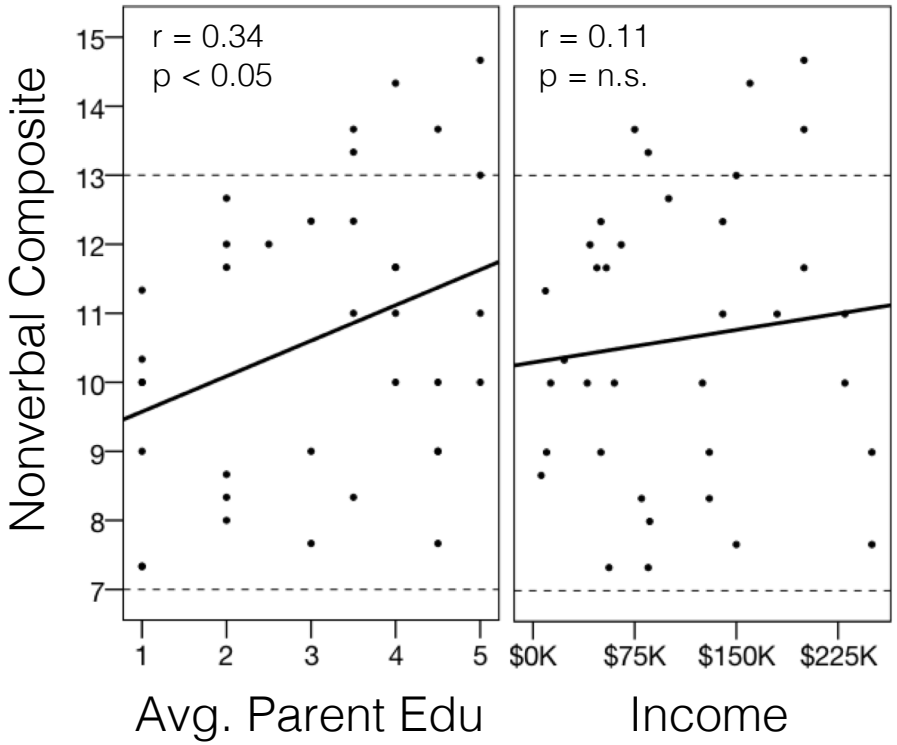
# Language ENvironment Analysis (LENA)

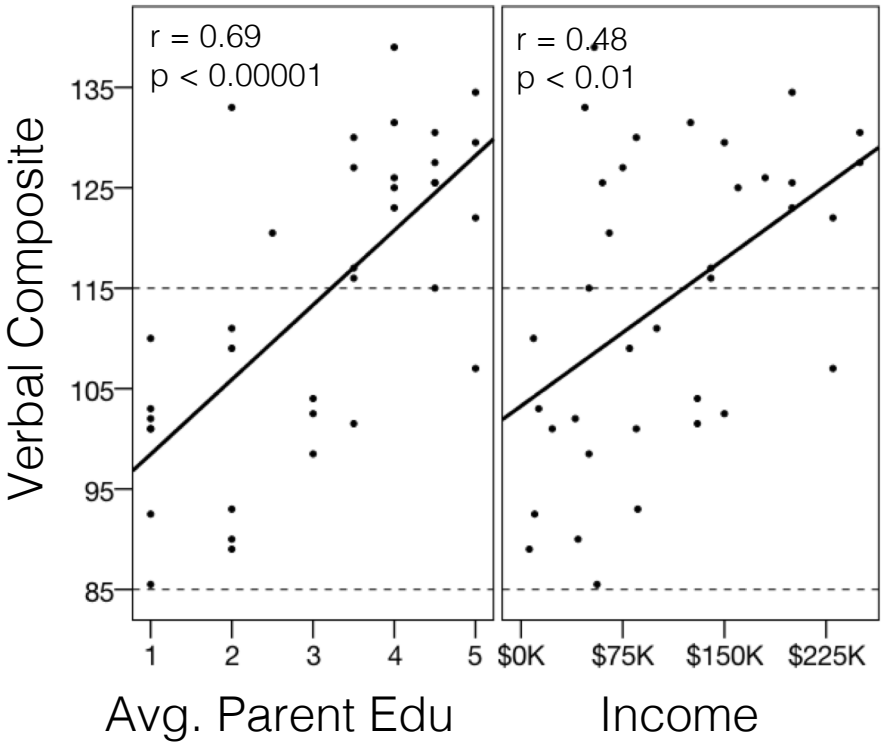
- Small, child-worn recorder than can hold a whole day's worth of audio (16 hrs)
- Software automatically analyzes recordings and determines:
  - How many "adult words" the child heard
  - How many "child vocalizations" the child said
  - How many "conversational turns" occurred between the child and any adult



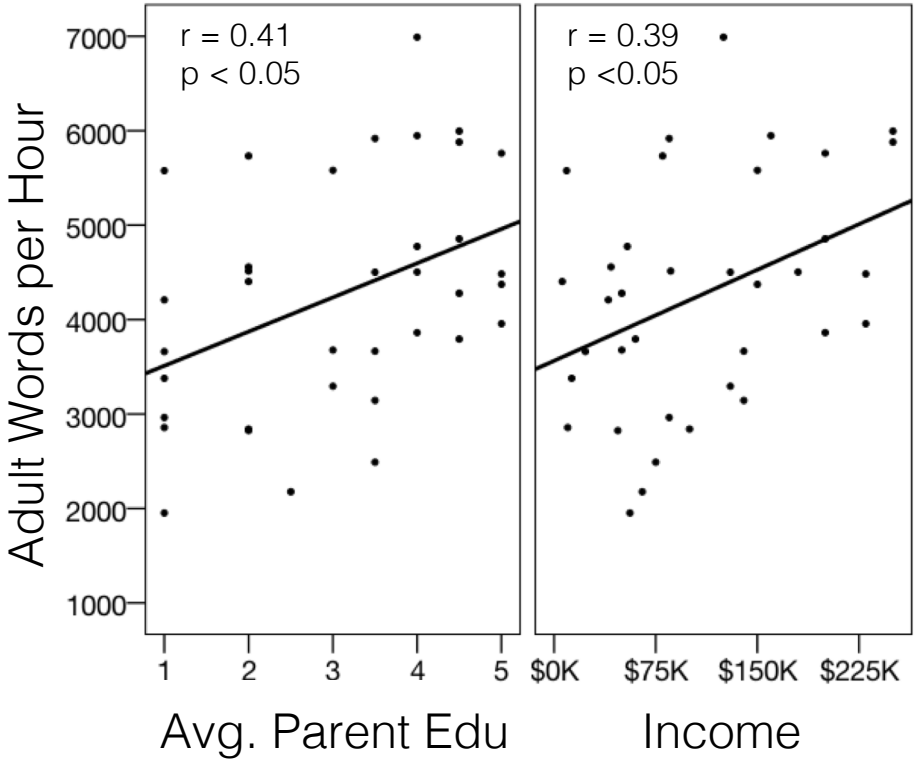



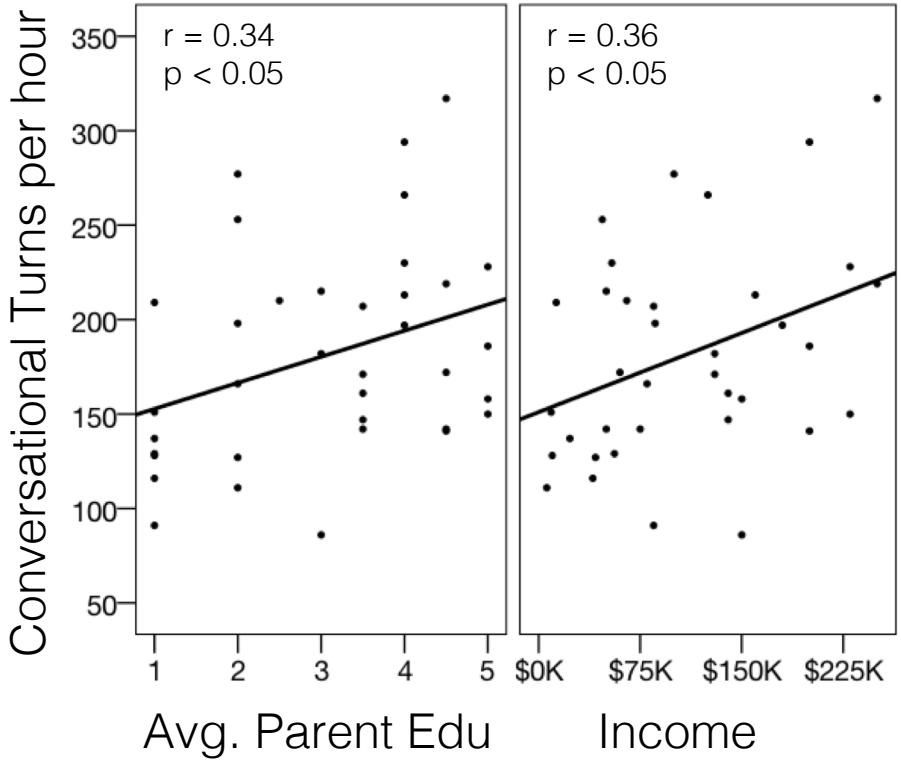
# Behavioral results part 1:
# SES is correlated with Cognitive Scores



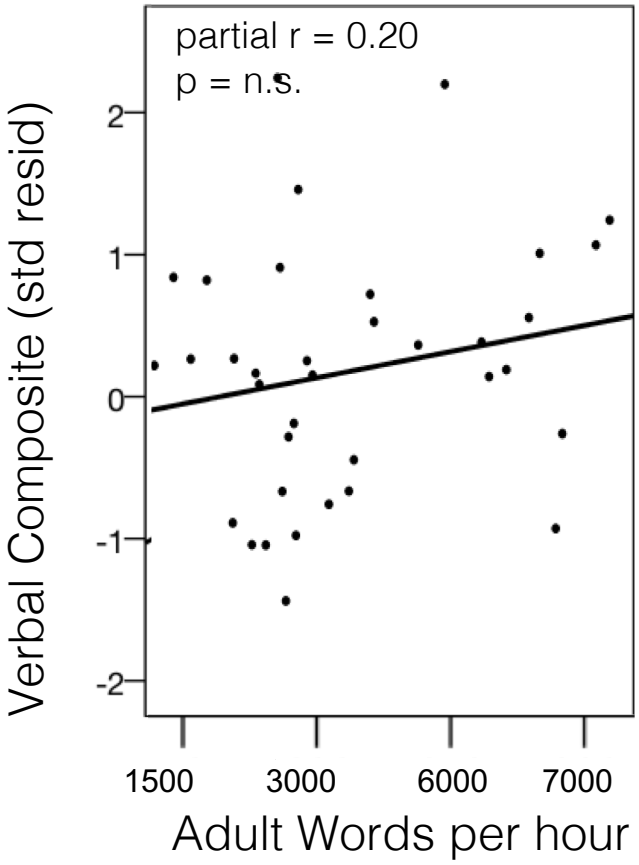
# Behavioral results part 2:
# SES is correlated with Language Exposure

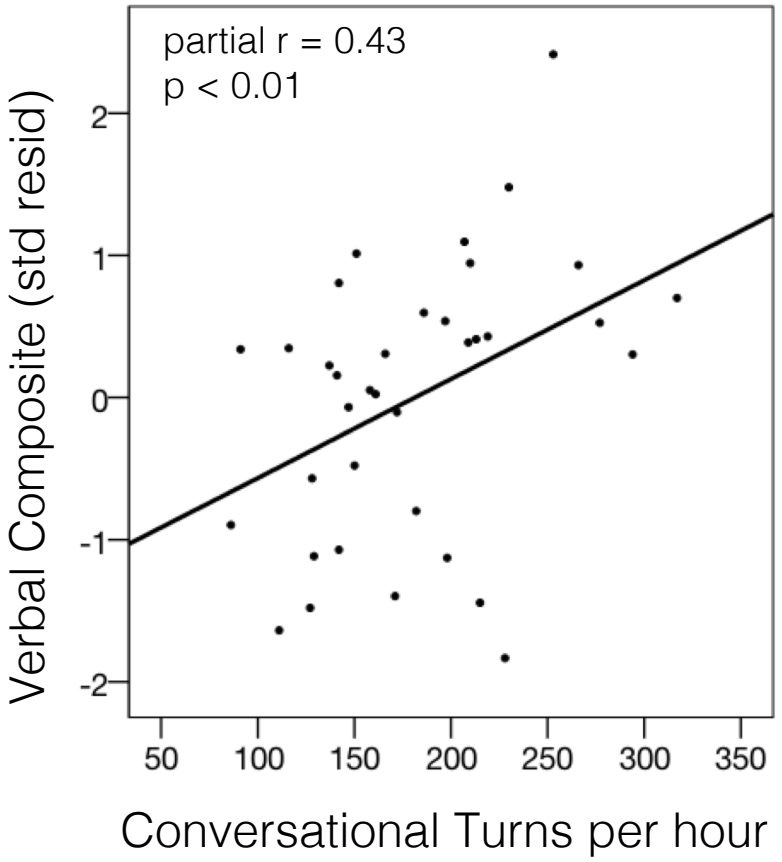


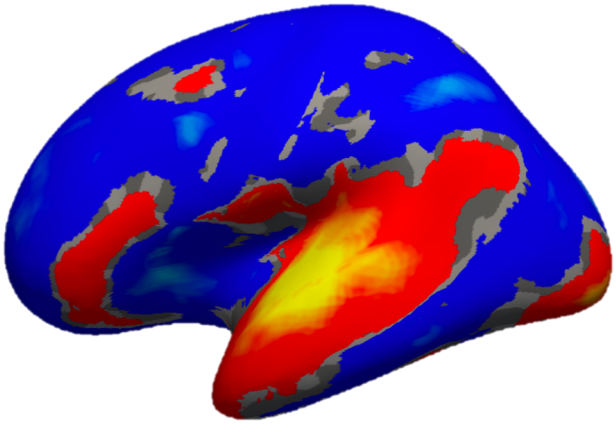

SES not correlated with Child Utterances

# Behavioral results part 3: Number of Conversational Turns explains Verbal Scores, independent of SES



# fMRI Task



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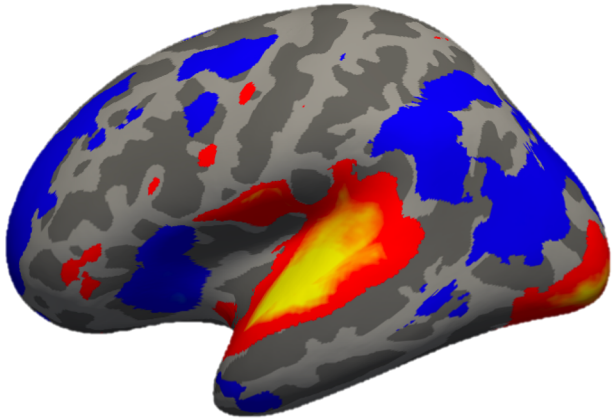

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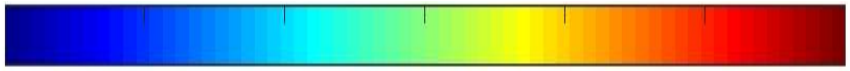
Forward
Speech
task condition

Backward
Speech
task condition

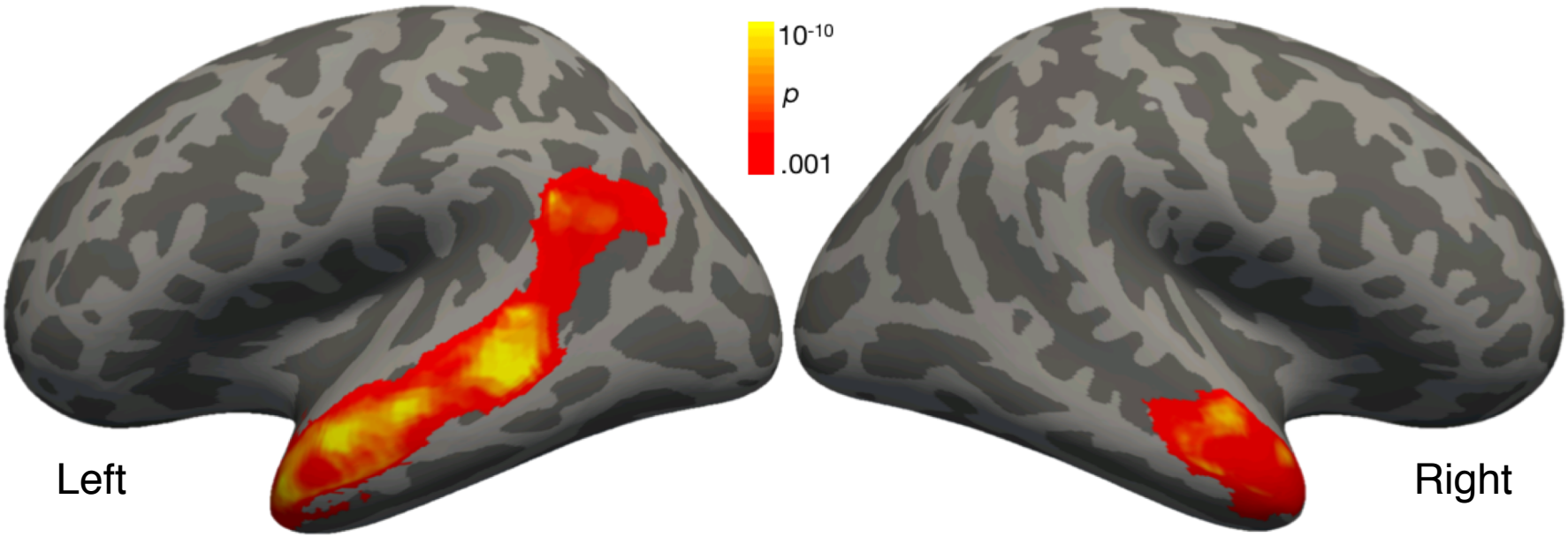


Less Active

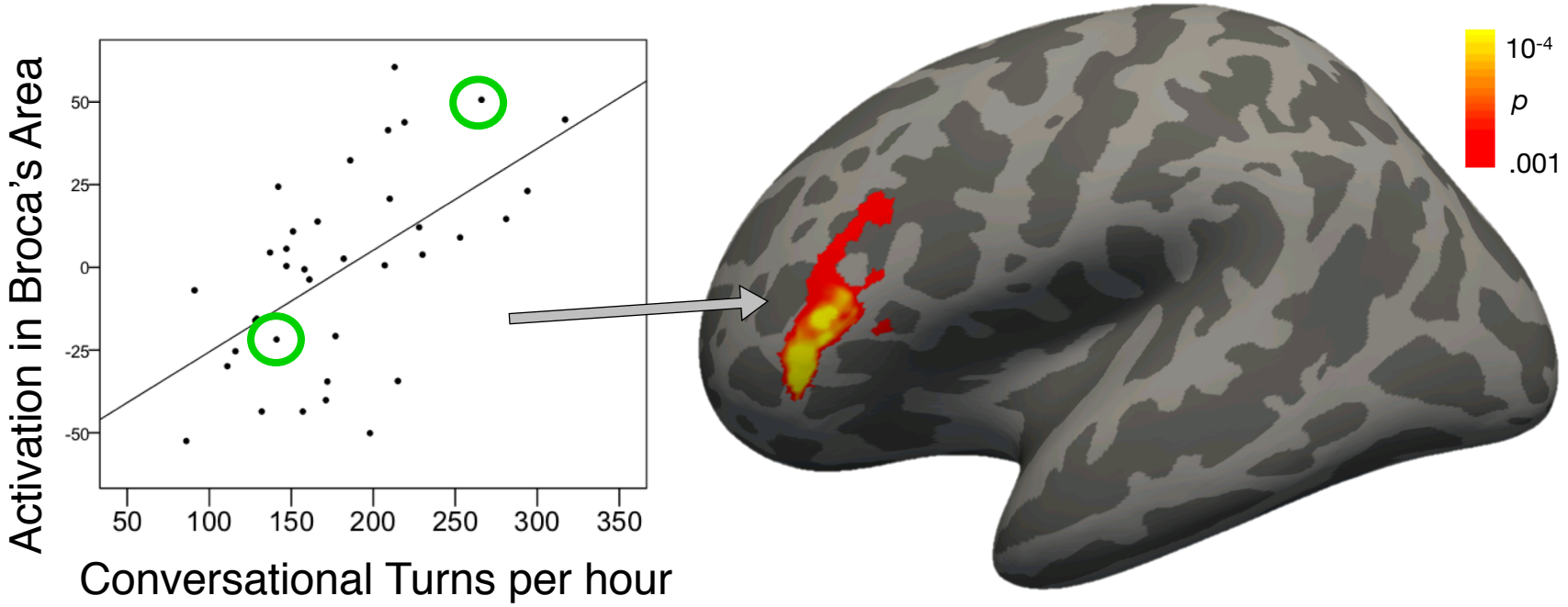
More active

# All participants use receptive language areas during language processing

Group Mean
Forward > Backward



# Greater Broca's Area activation in children who experienced more Conversational Turns

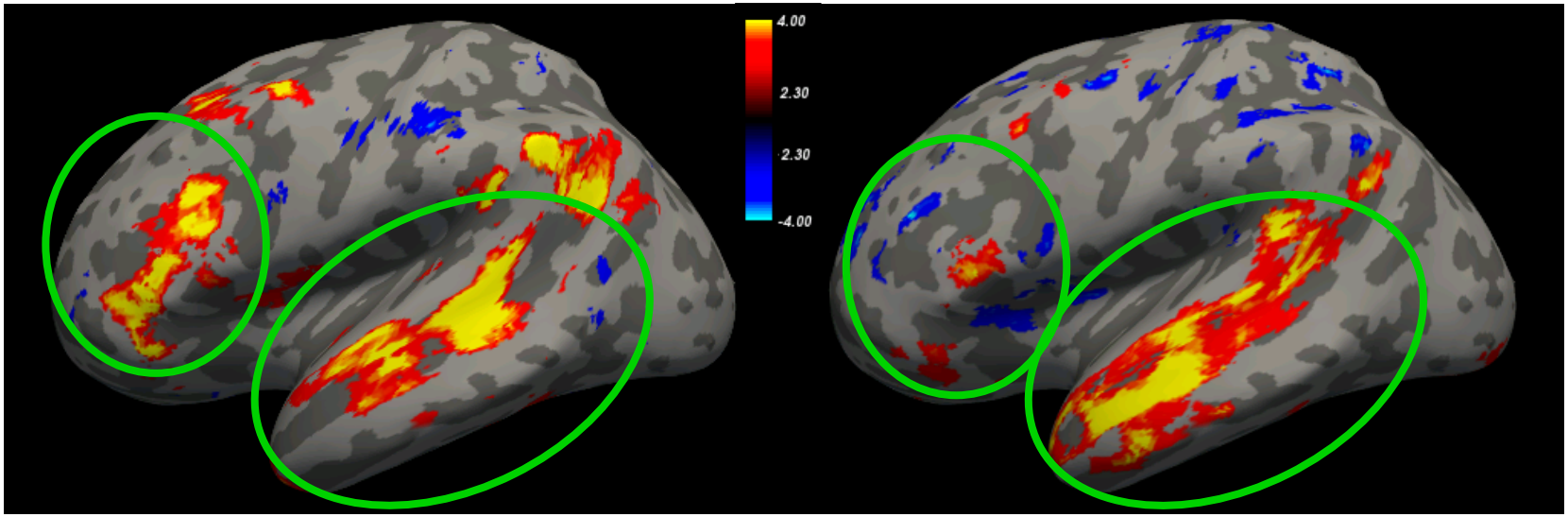


# A Tale of Two Brains

Two lower SES girls (high school edu + $50K total family income)

1,220 turns per day
Verbal score = 121

580 turns per day
Verbal score = 90

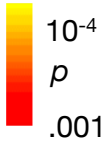


# Correlation independent of SES, IQ, EF, and adult/child speech alone

Correlation with # conversational turns, controlled for:

SES

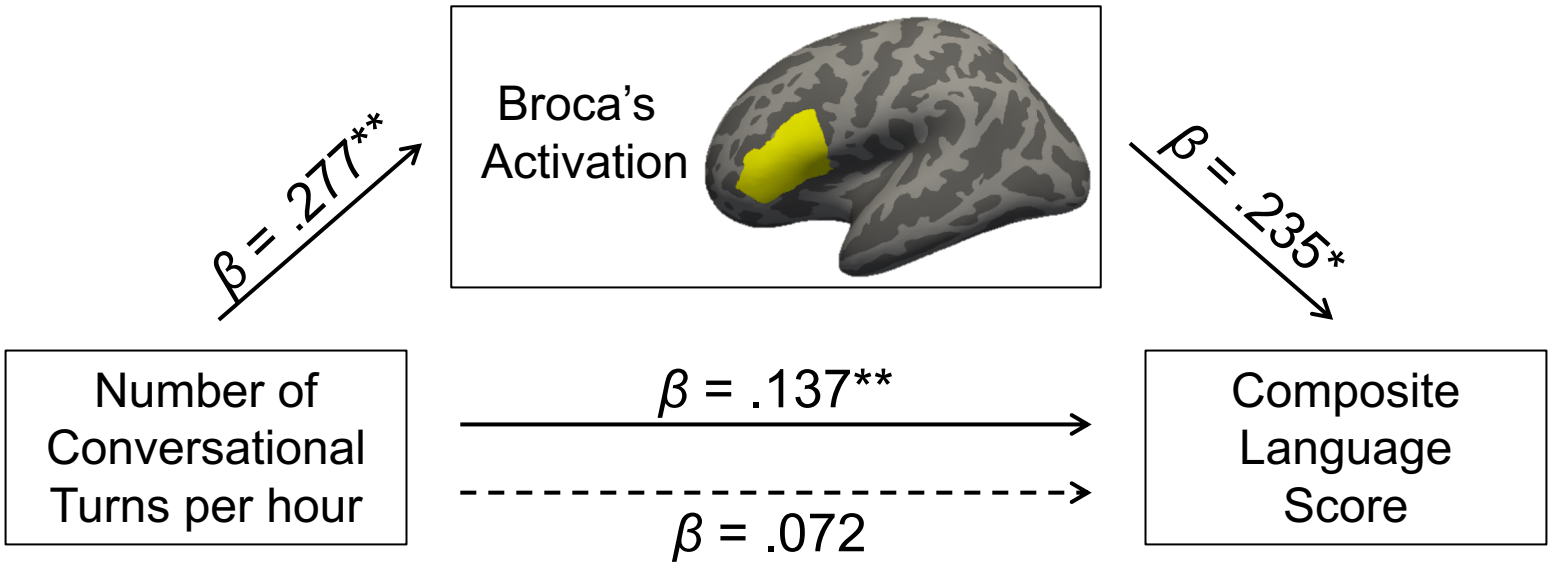
Verbal and nonverbal scores




Executive functioning

Adult words & child utterances

# Broca's activation explains relation between conversational turns and language scores




Additionally, Broca's activation + conversational turns together explain 23% of the total SES gap in children's language skills.

*$p < .01$, **$p < .001$

# Summary and Discussion

- "Conversational turns (but not adult words alone) are associated with Broca's area activation during language processing.
  - These measures mediate the achievement gap in language skills.

- Why Broca's Area?
  - Convergence zone" of smaller elements of language (e.g., phonemes, words) are unified into a coherent whole (Hagoort, 2014)
  - Task (natural language processing) requires integration across phonological, semantic, and syntactic units
  - Greater activation = "deeper engagement" with language?

- Why conversational turns?
  - Incorporates exposure *quality* as well as *quantity*
  - Language development relies on social interaction (Kuhl, 2007)
  - Increased opportunity for language "practice"

# Future Directions

- Can we demonstrate long-term malleability of parent language? If so, can parental interventions cause lasting pediatric neuroplasticity & behavioral outcomes?

- Are there specific populations – such as children at genetic/familial risk for language disabilities – who are more sensitive to their language environments?

- Are there other qualitative aspects of language exposure that predict neural and cognitive development better than conversational turns?

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