Analysis

Statistical Analysis

Results

Study Population

Table 1: Population summary at each follow up time point

	Overall	Baseline	First Follow Up	Second Follow Up	Third Follow Up
N	**1393**	405	387	301	300
Reading Score (SD)	**4.14 (1.64)**	2.52 (0.92)	4.08 (1.08)	5.01 (1.16)	5.77 (1.25)
Antisocial Score (SD)	**1.88 (1.93)**	1.66 (1.66)	2.03 (2.04)	1.83 (1.90)	2.06 (2.15)
Child Age (SD)	**6.92 (0.63)**	6.93 (0.64)	6.93 (0.64)	6.90 (0.63)	6.89 (0.62)
% Male	**711 (51.0)**	203 (50.1)	195 (50.4)	157 (52.2)	156 (52.0)
Mom's Age	**28.26 (2.92)**	25.53 (1.88)	27.55 (1.87)	29.55 (1.85)	31.55 (1.89)
Congitive Stimulation (SD)	**8.91 (2.56)**	8.89 (2.58)	8.93 (2.54)	8.88 (2.60)	8.95 (2.56)
Emotional Stimulation (SD)	**9.21 (2.31)**	9.20 (2.31)	9.23 (2.31)	9.20 (2.33)	9.19 (2.31)

Cognitive and Emotional Stimulation Measures

Reading Comprehension Scores

Table 2 displays the main and interaction effects of at-home emotional and cognitive stimulation scores on reading comprehension scores, as well as estimates for other predictors from the Gaussian GEE model with an exchangeable correlation structure. We observed variation in the impact of emotional and cognitive scores at each follow-up time point. The effect modification per additional follow-up for cognitive scores was 0.01 (95% CI: 0 to 0.03) after adjusting for other predictors, indicating that as children aged, the influence of cognitive stimulation on reading scores intensified, albeit not significantly (P=0.16). Comparatively, the role of

emotional stimulation escalated more prominently over time, with an effect modification of 0.03 (95% CI: 0.01 to 0.05) after adjusting for other predictors, denoting that the emotional stimulation score amplified with each extra follow-up (P<0.001).

The main effects of emotional and cognitive stimulation quantify the baseline association between these scores and reading proficiency. A one-unit increase in the cognitive score corresponded to a 0.08 (-0.01 to 0.18 95% CI) uptick in reading ability after adjusting for other predictors, hinting at some effect of cognitive scores on literacy skills, though not conclusively (P=0.08). The emotional stimulation score's baseline impact on reading comprehension was 0.05; every added emotional stimulation unit yielded a 0.05 (-0.03 to 0.13 95% CI) rise in scores after adjusting for other predictors, an influence not strongly linked to variation in reading outcomes (P=0.24). This suggests other modeled predictors better elucidate reading score variability.

The estimated interaction between emotional and cognitive scores at baseline was 0.00 (-0.01 to 0.01 95% CI) after adjusting for other predictors, offering no evidence that one predictor's effect changes across levels of the other (P=0.38).

Table 2: Gaussian GEE Main Effects on Reading Comprehension Score

Model Term	Estimate	95% CI	P-value
(Intercept)	-3.61	(-4.69, -2.54)	0.00
Sex Male	-0.08	(-0.25, 0.09)	0.34
Cog. Score	0.08	(-0.01, 0.18)	0.08
Emo. Score	0.05	(-0.03, 0.13)	0.24
Age	0.80	(0.67, 0.93)	0.00
Follow Up Period	2.03	(1.55, 2.5)	0.00
Cog. Score * Follow Up Period	0.01	(0, 0.03)	0.16
Emo. Score * Follow Up Period	0.03	(0.01, 0.05)	0.00
Age * Follow Up Period	-0.19	(-0.25, -0.12)	0.00
Cog. Score * Emo. Score	0.00	(-0.01, 0.01)	0.38

[a] Terms with '*' denote interactions
[a] Cog. Score = Cognitive Stimulation at Home Score
[a] Emo. Score = Emotional Stimulation at Home Score

Reading score variability was largely explained by the follow-up period and child age at baseline. On average, reading scores rose by 2.03 (95% CI: 1.55 to 2.50) points per follow-up interval after adjusting for other predictors, affirming that literacy skills statistically improved with age over time (P<0.001). Additionally, older children initially showed markedly higher reading

achievement (P<0.001); an extra baseline year corresponded with a 0.80 (95% CI: 0.67 to 0.93) increase in scores after adjusting for other predictors.

However, the influence of age diminished at each successive follow-up. We estimate a 0.19 (95% CI: -0.25 to -0.12) decrease in the age effect at every additional follow-up after adjusting for other predictors, denoting strong evidence (P<0.001) that initial reading score differences across ages 6 to 8 years vanished in later assessments during early adolescence.

We further investigated the main and interaction effects of age, time, emotional, and cognitive scores using regression effect plots. Figure Figure 1 presents estimated reading score trajectories over time for children of varying baseline ages, selected per study inclusion criteria. The learning effect curves were obtained via Gaussian GEE with an exchangeable correlation structure. The graph highlights that the greatest difference in mean reading scores occurs at baseline, with the youngest children displaying the steepest growth in reading skills on average. By the third follow-up roughly 6 years after baseline measurements, children across all starting ages converge to more similar average reading score levels.

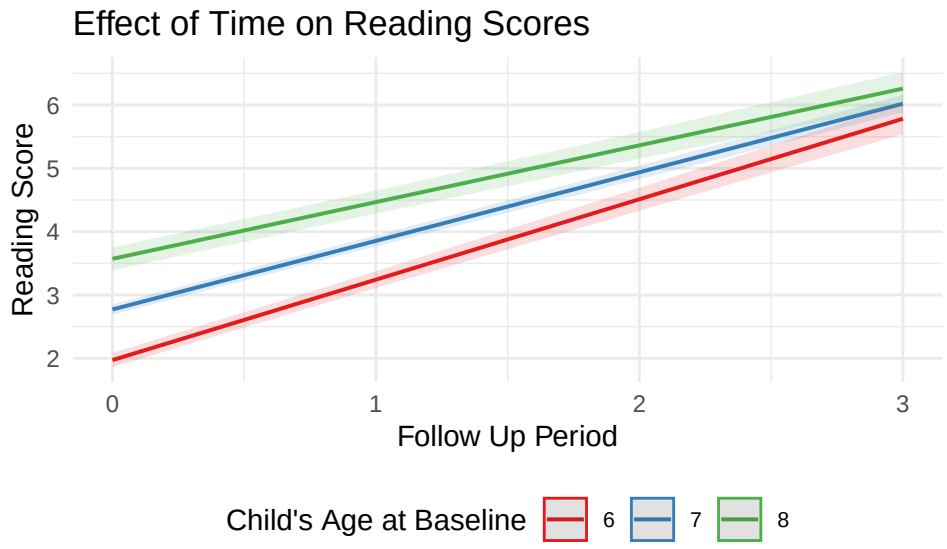

Figure 1: Blank

Figure 2 shows interactions between stimulation scores and reading skill growth rates over time. We chose sample 25^{th}, 50^{th}, and 75^{th} quantiles of cognitive and emotional stimulation scores to display the effect of baseline scores on learning rates.

For an average child with a baseline cognitive score at the 25^{th} percentile (score of 7), the expected two-year change in reading scores was 2.11 (95% CI 1.63 to 2.59). In comparison, the rate of change for an average child with a baseline score of 9 was 2.13 (95% CI 1.65 to 2.62). An average child with a cognitive score of 11 had an average reading score change of 2.15 (95% CI 1.66 to 2.65). All estimates are marginal effects after adjusting for other variables. These

results suggest that higher cognitive stimulation at baseline may improve children reading skill development rates, though more research and data are needed to make definitive conclusions.

Similarly, we adjust the effect of time on reading scores using 25^{th}, 50^{th}, and 75^{th} percentiles of emotional scores in the study population. the marginal effect of one additional follow up period on reading literacy for a child with a baseline emotional stimulation score of 8 is 2.25, bounded by the (1.8 to 2.71) 95% confidence interval. The rate of reading scores change for children with emotional scores of 10 and 12 are 2.31 and 2.37, bounded by (1.86 to 2.77) and (1.91) to (2.83) respectively. All estimates are marginal and summarize the data while adjusting for other predictors in the model.

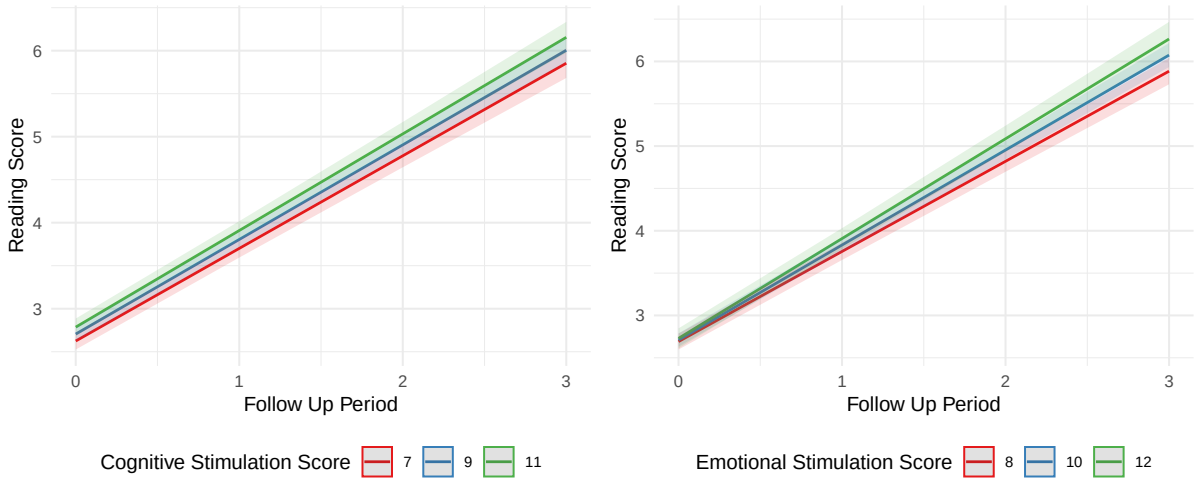

Figure 2: Values of Emotional and Cognitive Scores are chosen at 25th, 50th, and 75th sample percentiles

Antisocial Scores

Table 3: Gaussian GEE Main Effects on Antisocial Behavioral Score

Model Term	Estimate	95% CI	P-value
(Intercept)	0.90	(-1.57, 3.36)	0.48
Sex Male	0.86	(0.58, 1.14)	0.00
Age	0.25	(0.02, 0.48)	0.03
Cog. Score	0.02	(-0.21, 0.24)	0.89
Emo. Score	-0.06	(-0.28, 0.15)	0.58
Follow Up Period	1.07	(0.26, 1.89)	0.01
Follow Up Period * Age	-0.14	(-0.25, -0.02)	0.02
Cog. Score * Emo. Score	-0.01	(-0.03, 0.01)	0.36

[a] Terms with '*' denote interactions
[a] Cog. Score = Cognitive Stimulation at Home Score
[a] Emo. Score = Emotional Stimulation at Home Score

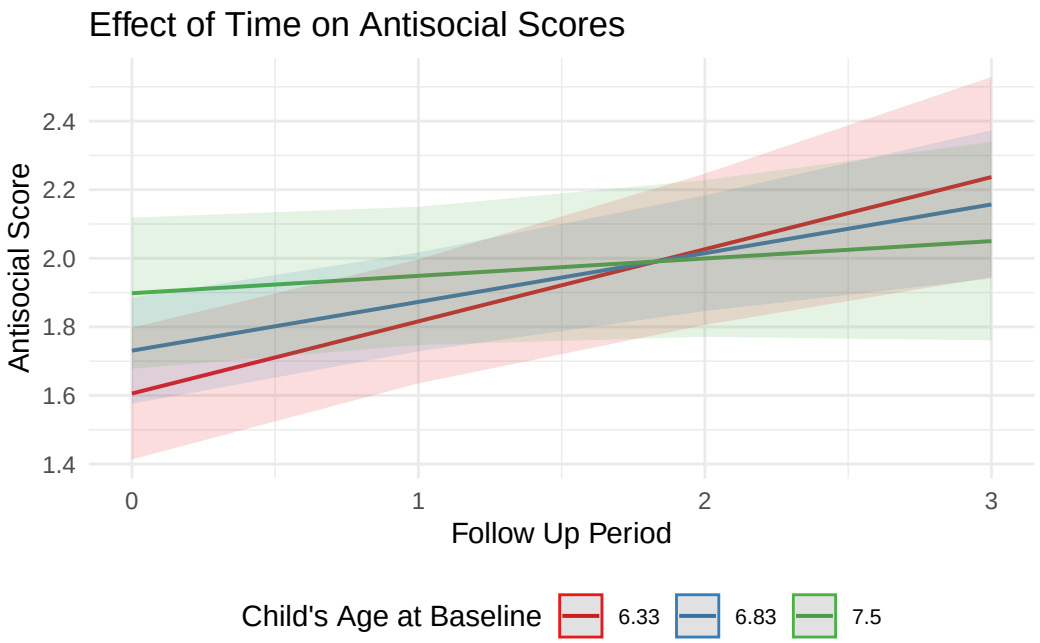

Figure 3: 25th Percentile: 6.3 Years old. 50h Percentile: 6.8 Years old. 75th Percentile: 7.5 Years old.

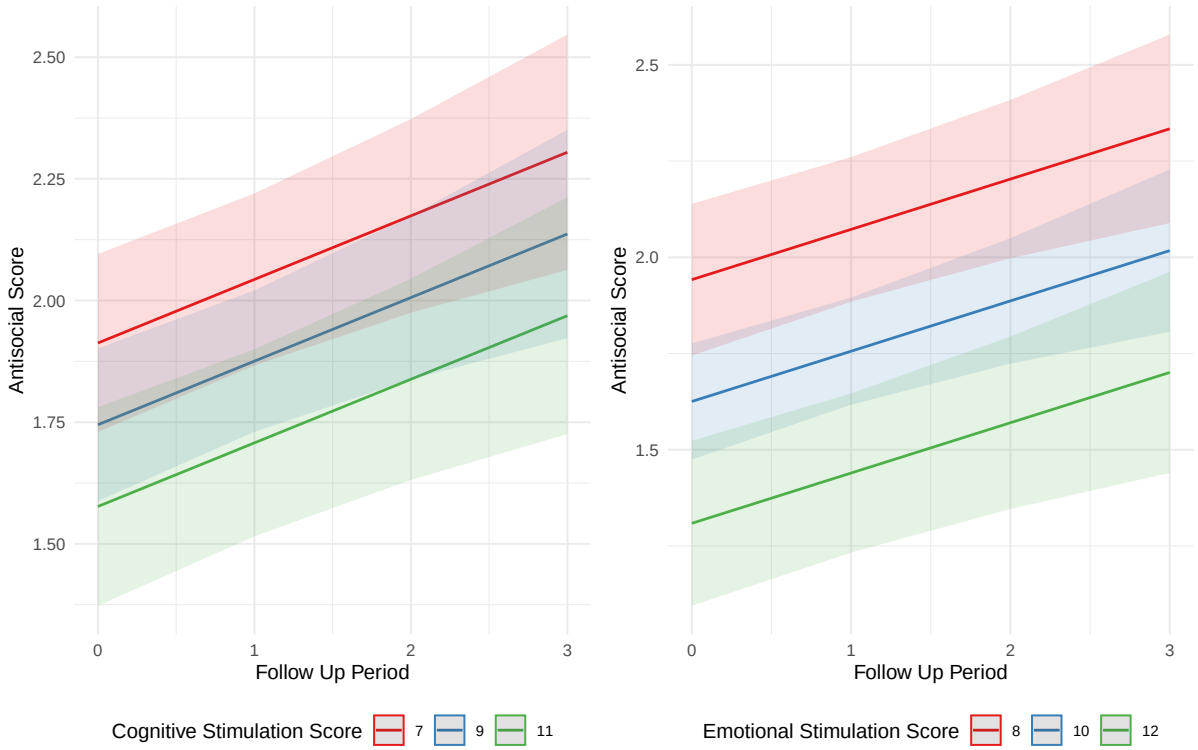

Figure 4: Values of Emotional and Cognitive Scores are chosen at 25th, 50th, and 75th sample percentiles

Discussion