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	Significance
(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.

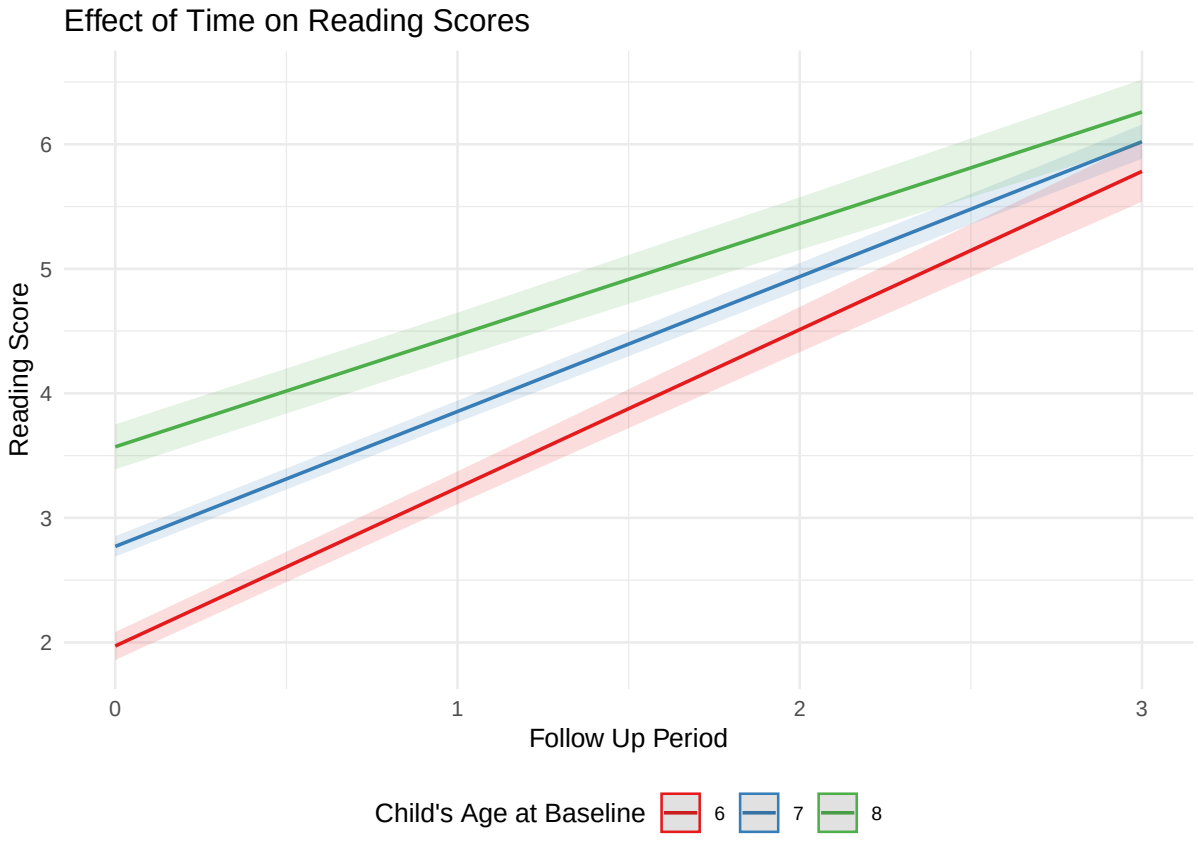

Figure 1: Blank

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.

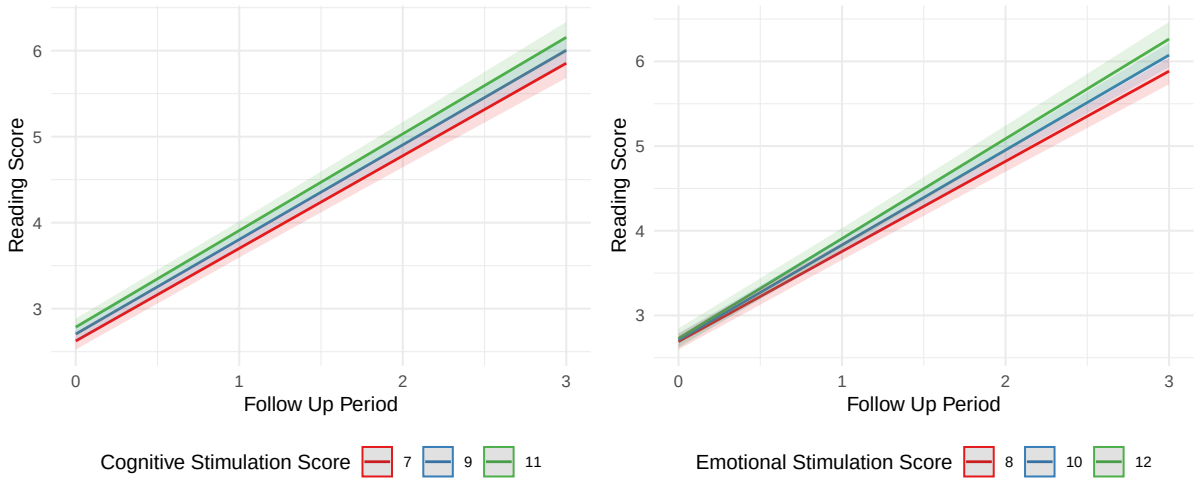

Figure 2: Values of Emotional and Cognitive Scores are chosen at 25th, 50th, and 75th sample percentiles

Antisocial Scores

As a secondary outcome, we assessed the impact of emotional and cognitive stimulation at home at baseline using Gaussian GEE model with exchangeable correlation structure. The results are presented in Table 3. We have found no evidence that change in emotional stimulation scores (P = 0.58), cognitive stimulation (0.89) are statistically related to change in the antisocial

behavior scores. Additionally, there is no evidence that the effect of cognitive scores varies at difference levels of emotional scores (P = 0.36), and vice versa.

Table 3: Gaussian GEE Main Effects on Antisocial Behavioral Score

Model Term	Estimate	95% CI	P-value	Significance
(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

Antisocial behavior scores are a measure on the scale from 0 to 10, with 0 representing the lowest possible score. We found that one unit increase in the emotional stimulation score was associated with an expected decrease of antisocial score by 0.06 point (-0.28 to 015 95% confidence interval), after adjusting for other predictors. We estimate that one unit increase in cognitive scores resulted in 0.02 points (-0.21 to 0.24 95% confidence interval) increase in antisocial scores, after adjusting for other variables. Both estimates show a weak effect of two predictors on the antisocial score, with no statistical evidence of strong association. Table 3 presents other predictors that have stronger effects that help explain variability in the antisocial scores.

Similarly to the reading score analysis, followup time period, age of a child at baseline and their interaction were strong predictors of antisocial behavior change and development. Figure 3 present marginal effects of follow up times on antisocial scores for children with varying baseline ages. It appears that, on average, younger children had lower baseline antisocial scores, which grew at steeper rate over the course of six years. In contrast, oldest children at baseline had approximately 25% higher antisocial scores, which did not change greatly over time.

In particular, for children aged 6 years old at baseline, the average change in antisocial scores at each additional follow up time was 0.26, bounded by (0.12 to 0.39 95% confidence interval). For children aged 7 years old, similar average change was smaller, estimated at 0.12 units change, bounded by the (0.04 to 0.19) confidence interval. For children who were 8 years old at baseline the average change was a slight decrease in antisocial scores, estimated at -0.02,

bounded by (-0.15 to 0.11). This effect was close to zero, which is evident on Figure 3. All marginal effects are estimated after adjusting for other predictors.

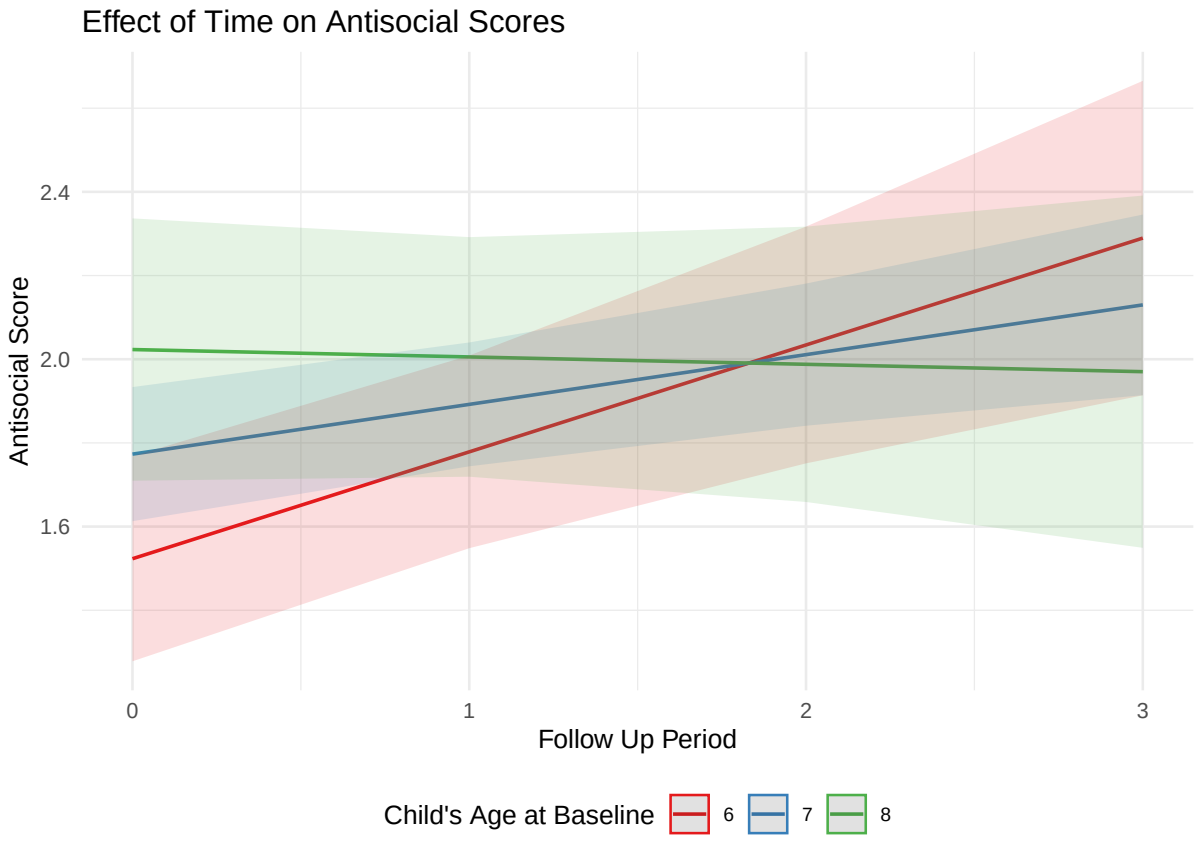

Figure 3: Caption needed

We also found an important effect of sex factor on the antisocial scores. During the model building and variable selection process we did not find significant interactions between sex and other predictors of antisocial scores. We estimated the marginal effect of sex for males at 0.86 (0.58 to 1.14 95% confidence interval) compared to females, after adjusting for other factors. This factor has no interaction with other predictors, we estimated constant differences between males and females in terms of their respective antisocial scores at all time points, while accounting for other variables. There is strong statistical evidence (P <0.001) that the average antisocial behavior score for males at all time is 0.86 points higher when compared to females.

Discussion