ED255C
Assignment#7

Assessment of Intervention effect on Reading Achievement using a Multilevel Growth Model

This report aims at examining the effect of intervention on reading achievement by analyzing a nested structure data set of a randomized intervention study. In this study, one pre-intervention reading achievement was observed at the baseline followed by four post-intervention measurements at equidistant times. Since the randomization for the intervention took place at the classroom level in 110 classrooms, 1,000 individuals are nested within different classrooms. Ignoring the multilevel nature of the data can result in standard errors for intervention effect estimates that are misleadingly small and might mask potentially substantial between-classroom heterogeneity in intervention effects. Hence, a multilevel growth model analysis, which can take into account the characteristics of multilevel data, was conducted to assess these intervention effects.

Preliminary analysis

General growth pattern

First, to find the general growth pattern of the data, the means of reading achievement for the intervention group and the control group over time were examined ignoring the nested structure of the data. Figure 1 clearly shows that the intervention group has higher reading achievement over time than the control group. It seems that the reading achievement gap between the intervention group and the control group becomes larger over time. At the end of study, the mean of the reading achievement for intervention group is 2.52 while the mean for the control group is 1.17 (Table 1). Although linear increasing trends are observed for both groups over time, after time point 3, the rate of increase seems to be slower indicating non-linear growth patterns for both groups.

Figure 1 Mean of Reading achievement over time for Intervention versus Control group

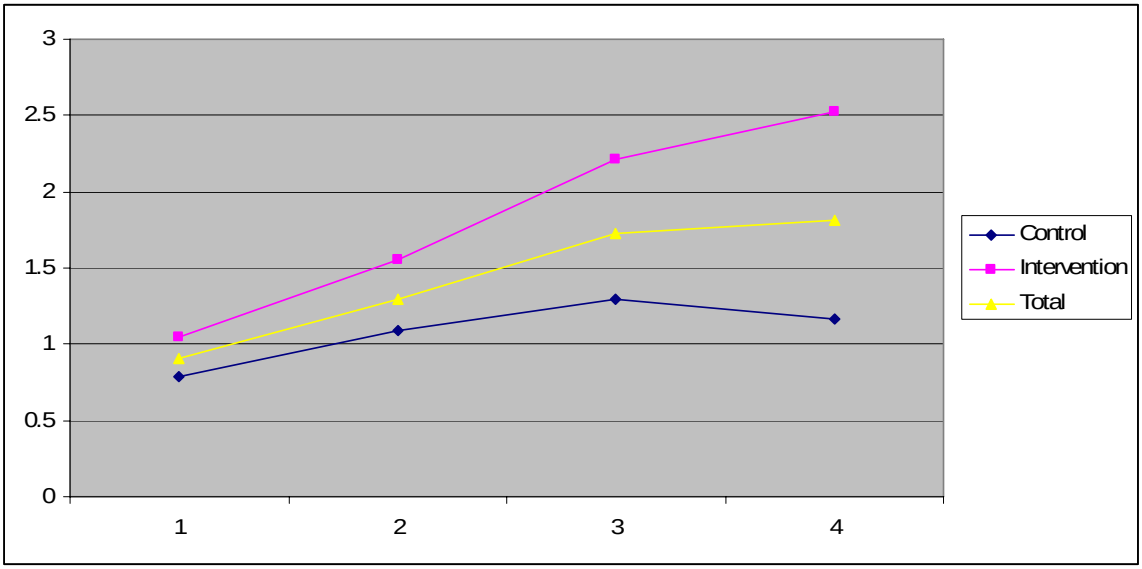

Table 1 Variable Descriptive Statistics

Group	N Obs	Variable	N	Mean	Std Dev	Minimum	Maximum
Control	520	Y1	384	0.79	1.66	-4.59	5.62
		Y2	403	1.09	1.88	-4.88	7.45
		Y3	367	1.29	2.29	-5.60	8.01
		Y4	342	1.17	2.46	-7.08	7.99
Intervention	480	Y1	349	1.05	1.74	-4.08	5.94
		Y2	359	1.55	1.86	-3.87	7.70
		Y3	336	2.21	2.17	-3.79	7.52
		Y4	312	2.52	2.46	-5.27	8.79
Total	1000	Y1	733	0.91	1.71	-4.59	5.94
		Y2	762	1.30	1.88	-4.88	7.70
		Y3	703	1.73	2.28	-5.60	8.01
		Y4	654	1.81	2.55	-7.08	8.79

Design Effect

Since the data is nested within classrooms, the size of the design effect was examined to see if the clustering in the data needed to be taken into account in the growth model. The estimated intra-class correlations for the outcome variables and the design effect (DEFF) are shown in Table 2. The average size of each cluster was 9.09 and the DEFF's for all variables were greater than 2, which indicates that

the nature of the clustering of the data should be considered following Muthen and Satorra's suggestion (1995)[1].

Table 2 Intraclass Correlations for Outcome Variables and DEFF

Variable	Intraclass Correlations	DEFF
Y1	0.137	2.11
Y2	0.124	2.00
Y3	0.166	2.34
Y4	0.217	2.76

Model Selection

The proposed three-level growth model, which takes into account the characteristics of the nested data, is as follows:

Variables
Time point *t*, individual *i*, cluster *j* Y_{tij} : Individual level outcome variable $W_j \begin{cases} 0 = Control \\ 1 = Intervention \end{cases}$ X_{ij} : SES
Level-1 (Within)
$Y_{tij} = \pi_{0ij} + \pi_{1ij} Time_{tij} + e_{tij}$
Level-2 (Within)
$\pi_{0ij} = \beta_{00j} + \beta_{01j}(X_{ij} - \overline{X}_{..}) + r_{0ij}$ $\pi_{1ij} = \beta_{10j} + \beta_{11j}(X_{ij} - \overline{X}_{..}) + r_{1ij}$
Level-3 (Between)
$\beta_{00j} = \gamma_{000} + \gamma_{001} W_j + \gamma_{002}(\overline{X}_{.j} - \overline{X}_{..}) + u_{00i}$ $\beta_{10j} = \gamma_{100} + \gamma_{101} W_j + \gamma_{102}(\overline{X}_{.j} - \overline{X}_{..}) + u_{10i}$ $\beta_{01j} = \gamma_{010} + u_{01i}$ $\beta_{11j} = \gamma_{110} + u_{101i}$

In Level-1, π_{0ij} and π_{1ij} represents, respectively, the initial status and rate of change for student i in classroom j. Since student socio-economic status (SES) is known to be an important factor affecting

1 Muthen and Satorra (1995). "Complex Sample Data in Structural Equation Modeling ", Sociological Methodology 25, 267-316.

students' reading achievement, a grand mean centered student SES ($X_{ij} - \overline{X}_{..}$) is included in level-2. In addition, a grand mean centered average classroom SES ($\overline{X}_{.j} - \overline{X}_{..}$) was included in the model since classroom-varying SES might influence the impact of the intervention. To evaluate the effect of intervention on reading achievement, the intervention was added in Level-3.

A couple of model modifications were implemented to improve the model fit. Freeing residual variances of the outcome variables in the "Between Level" significantly improved the model ($\chi_4^2 = 130.32$, p<.001, Table3). However, the non-linear model with a freed time score at time point 4 was not significantly better than the linear model ($\chi_4^2 = 130.32$, p<.001, Table3). Therefore, I selected a 3-level growth model with freed outcome variable residual variances as the final model.

Table 3 Model comparison

Model	Loglikelihood	#parameters	BIC	-2*Difference
3-level Growth model with residual variance fixed at zero	-6324.445	18	12773.229	
3-level Growth model with freed between level residual variance	-6259.286	22	12670.543	130.32
3-level Growth model with freed time point 4	-6259.262	23	12677.403	0.048

Results

Table 4 displays the results of the final model. The expected reading achievement at the baseline for the control classes with average reading achievement, controlling for average classroom SES (γ_{000}) was 0.890. The main initial intervention effect (γ_{001}) was 0.105, suggesting that the mean of reading achievement at the baseline for the intervention classes was 0.995. However, the mean difference was not significantly different from zero. This supports the conclusion that the randomization was successful because the intervention did not influence classroom reading achievement at initial status. The expected effect of average classroom SES on reading achievement (γ_{002}) was 0.481 and was significantly different from zero indicating that classes with higher SES had higher reading achievement at initial status.

The focal interest of the growth model is in examining the intervention impact on reading achievement over time. The expected reading achievement gains during these four years for the control classes (γ_{100}) were 0.399. The main intervention effect on achievement growth rate (γ_{101}) was found to be significant when controlling for average classroom SES. The results show that, on average, reading achievement in the intervention classrooms grew faster by 0.377 versus the control classrooms. The variance of the classroom growth rate, 0.071, is significantly different from zero indicating that the level of reading achievement significantly varies across classrooms. Since the intervention significantly influences classroom growth rate, which varies across classroom, the intervention showed contextual effects which have different impacts on classrooms with different levels of reading achievement.

It was found that average student SES within levels had a significant and positive impact on reading achievement at baseline (γ_{010}) as well as on the reading achievement growth rate overall (γ_{110}). This implies that students with high SES already seemed to have a higher level of reading achievement when they entered the study. Students with high SES also seemed to gain more in reading achievement over time. However, in the "Between Level" group, the average classroom SES did not significantly influence the growth rate of reading achievement over time (γ_{110}).

Table 4 Model results

Model for initial Status (π_{0ij})	
Model for classroom mean of initial status (β_{00j})	
Intercept(γ_{000})	0.890***
Intervention(γ_{001})	0.105
MeanSES (γ_{002})	0.481**
Model for within-classroom relationship between SES and initial status (β_{01j})	
Intercept(γ_{010})	0.985***
Model for 4 year growth rate (π_{1ij})	
Model for classroom mean of 4 year growth rate (β_{10j})	
Intercept(γ_{100})	0.399***
Intervention(γ_{101})	0.377***
MeanSES (γ_{102})	0.182
Model for within-classroom relationship between SES and growth rate (β_{11j})	
Intercept (γ_{110})	0.241***

*** p<.001 , ** p<.05

Discussion

This report examined the effect of intervention on reading achievement in a nested structure data set of a randomized intervention study. It was found that the intervention effect on achievement growth was significant when controlling for classroom SES. On average, the intervention classrooms seemed to gain more than the control classrooms in reading achievement over time. In addition, the intervention showed contextual effects which have different impacts on classrooms with different levels of reading achievement.

It is noteworthy that students within classrooms varied in terms of their baseline reading achievement and their SES level at initial status. This variability might lead to different trajectories of reading achievement over time. Therefore, it will be of interest to find out whether or not there are different populations in the sample, how they form their developmental trajectories and how intervention influences the reading achievement of those subpopulations using growth mixture multilevel modeling.