ANALYSIS OF THE CHANGE IN READING ABILITY OF CHILDREN OVER TIME

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ABSTRACT

The initial report of a fictitious research project on the effects of the change in reading ability over time in elementary school children is presented.

Keywords: growth models, multi-level analysis, research methods, hierarchical linear modeling

I. INTRODUCTION

Increasing the reading ability of children is of national interest, and the motivation for our research. Our research builds upon prior work in this area (Foorman et. al., 1998; Kamps et al., 2003). As reading is a fundamental part of education, the United States must constantly improve its teaching methods to remain competitive on a global stage. For this purpose grant monies have been given to conduct research in this area. As required by the stipulations of the grant, research results must be analyzed and reported. This paper is a report of the initial findings of this research.

HIERARCHICAL LINEAR GROWTH MODELING

Hierarchical Linear Models, also known as multi-level models, are a statistical tool used for analyzing the variance of outcome variables in a nested structure. Examples of such nested data include, students nested within schools, or students' responses to test items nested within students. Generally, within the domain of growth modeling, each person in the study in measured on a certain outcome variable across multiple time points (Raudenbush & Bryk, 2002). These measurements across time (first-level) form a nested structure when combined with student level variables (second-level).

In the case of measuring reading ability over time, each person may be measured on an outcome variable which consists of performance on a standardized reading test at multiple instances. This creates a multi-level structure where each measurement is nested within a person. In the case of this research, a student's reading ability

measured at three points in time is nested within the each individual student. This yields a level-1 equation of:

$Reading_{ti} = \pi_{0i} + \pi_{1i} \cdot Time_{ti} + e_{ti}$

Thus this equation represents the predicted reading ability score of a student *i* at a time *t*, across different time periods as measured by the variable TIME. e_{ti} represents the residual for a person *i* at time *t*.

DESCRIPTION OF DATA

150 school children were tested on a standardized reading ability test three consecutive times, at the start of third, fourth, and fifth grades. The test was scored on the range of 0 to 100. At the beginning of third grade, the students were tested on spelling ability. To fit the models and hypotheses developed for this study, we created two data sets; the first was a person-period data set in which each student had one record for every year they were observed. The second was a student level dataset which included the student's gender, and the score they received on the spelling test at the start of the third grade. The models and their corresponding coefficients are presented below.

Fixed Effects	Coefficient Value
b_{00}	40.0
b_{01}	4.0
b_{02}	2.0
b_{10}	10.0
b_{11}	1.50
b_{12}	0.75
Random Effects	
τ_{00}	50.0
τ_{11}	1.0

LEVEL-1 MODEL

$Reading_{ti} = \pi_{0i} + \pi_{1i} \cdot Time_{ti} + e_{ti}$

LEVEL-2 MODEL

$\pi_{0i} = b_{00} + b_{01} \cdot Sex_i + b_{02} \cdot Spelling_i + \tau_{0i}$

$\pi_{1i} = b_{10} + b_{11} \cdot Sex_i + b_{12} \cdot Spelling_i + \tau_{1i}$

COMBINED MODEL

$$Reading_{ti} = (b_{00} + b_{01}\cdot Sex_i + b_{02}\cdot Spelling_i + \tau_{0i)0i} + (b_{10} + b_{11}\cdot Sex_i + b_{12}\cdot Spelling_i + \tau_{1i)1i} Time_{ti} + e_{ti}$$

II. INTERPRETATION OF MODEL COEFFICIENTS

First we will interpret the three beta coefficients of the level-1 equation. These three betas significantly affect the reading score at time 0 (the first test score). The coefficient $\mathbf{b_{00}}$ = 40 represents a student's score when SEX and SPELLING are zero. We can interpret this as the initial score (intercept) for a male with an average spelling score. In other words, a male student at time 0 (the start of the third grade) with average spelling ability would have a predicted test score of 40. The coefficient $\mathbf{b_{01}}$ = 4 represents the average change in the level-1 intercept when SEX increases by one unit. In other words, it represents the change in level-1 intercept for females (as compared to males), holding all other predictors constant. Thus, the average female will score 4 points higher than the average male on the reading test, all other predictors being held constant. The coefficient $\mathbf{b_{10}}$ = 2 represents the average change in the level-1 intercept per unit increase in spelling test score, holding all other predictors constant. In other words, it represents the change in the initial reading test score for every point increase on the initial spelling test, for any student. Thus, all else being held constant, a student's initial reading test score will be 2 points higher for a point increase on the spelling test. A male student with a spelling ability score which is 1 point above the mean would have an initial predicted test score of 42, holding all else constant.

The last three coefficients significantly represent the rate of change of a student's score over time. The coefficient $\mathbf{b_{10}}$ = 10 represents the predicted level-1 slope for when SEX and SPELLING are zero. In other words, this represents the slope or rate of change for males' with an average spelling ability. Thus, the average male will increase their reading test score by 10 points each time period. The predicted score for this student would be 40 at the start of the third grade and 50 at the start of the fourth grade, and 60 at the start of the fifth grade. The coefficient $\mathbf{b_{11}}$ = 1.5 represents the average change in the change in reading ability per unit increase in time for each unit increase in SEX, holding all other predictors constant. In other words, it represents the change in the change of reading scores for females. Thus, a female student's score will increase by 1.5 points more each year than males. Thus the predicted score for a female student with average spelling ability would be 44 at the start of the third grade, and their average yearly change in test score would be 11.50 (10 + 1.5), holding all other predictors constant. The coefficient $\mathbf{b_{12}}$ = .75 represents the average change in the change in reading ability per unit increase in time per unit increase in spelling test score, holding all other predictors constant. In other words, it represents the average change in the change over each measurement period of a student's reading test score for every unit increase on the initial spelling test score. Thus, a male student who has a spelling ability 1 point above the mean would have an average rate of change in reading test score per unit change in time of 10.75 (10 + .75) holding all other predictors constant.

The HLM software (Raudenbush et. al., 2004) reports the variance components of the two equations. These variance components give us a representation of the variance of the two error terms (τ_{0i} and τ_{1i}). These error terms represent the random individual

effect for level-1 intercept and slope. The variance component τ_{00} indicates the amount of variance among the test scores. The variance component τ_{11} indicates the amount of variance in growth rates. Since both of these values are significant we can conclude that there is significant variance among the test scores and growth rates for each student, and conclude that our model is useful in explaining a portion of that variance.

II. CONCLUSION

Our research finds an interesting relationship between spelling ability and reading ability. Perhaps this relationship can be explored in further detail in subsequent studies. From such studies, recommendations of how teachers can teach both subject areas more effectively will hopefully arise.

Using HLM analysis to study individual change over time is a very useful practice. It allows us to understand what factors lead to increased student abilities, and how those factors change over time. This is especially important in creating innovative curriculum that can be used to increase the level of education in our communities and nation. Recent research has called for Educators to increase move away from descriptive to prescriptive research (Christensen et. al., 2008). This research, and the research which will follow from this grant, is a step in that direction.

References:

Christensen, C. M., Johnson, C., & Horn, M. (2008). *Disrupting Class: How Disruptive Innovation Will Change the Way the World Learns* (p. 288). McGraw-Hill.

Foorman, B. R., Francis, D. J., Fletcher, J. M., Schatschneider, C., & Mehta, P. (1998). The role of instruction in learning to read: Preventing reading failure in at-risk children. *Journal of Educational Psychology*, *90*, 37-55.

Kamps, D. M., Wills, H. P., Greenwood, C. R., Thorne, S., Lazo, J. F., Crockett, J. L., et al. (2003). Curriculum Influences on Growth in Early Reading Fluency for Students with Academic and Behavioral Risks: A Descriptive Study. *Journal of Emotional and Behavioral Disorders*, *11*(4), 211-224. doi: 10.1177/10634266030110040301.

Raudenbush, S., Bryk, A., & Congdon, R. (2004). *HLM for Windows*. Version 6.06.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods*. Sage Publications Inc.