DOCUMENT RESUME

ED 452 236 TM 032 522

AUTHOR	Kim, Sooyeon; Murry, Velma McBride; Brody, Gene H.
TITLE	Studying the Relationship between Children's Self-Control and Academic Achievement: An Application of Second-Order Growth Curve Model Analysis.
PUB DATE	2001-04-00
NOTE	45p.; Paper presented at the Annual Meeting of the American Educational Research Association (Seattle, WA, April 10-14, 2001).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150) -- Tests/Questionnaires (160)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	*Academic Achievement; Child Development; Elementary Education; *Elementary School Students; Longitudinal Studies; *Self Control
IDENTIFIERS	Georgia; *Growth Curve Analysis; Latent Growth

ABSTRACT

The functional relationships between developmental change in children's self-control and academic achievement were examined using longitudinal family data. Multivariate latent growth models (LGM) were specified to determine whether the rate of growth in academic achievement changes as a function of developmental change in self-control. Data came from the Rural Georgia Single-Parent Family Study for 140, 127, and 124 families, and 114, 120, and 102 teachers. Self-control and academic achievement were significantly associated as indicated by the significant covariance between the variables' initial status. Children who initially displayed better cognitive and behavioral self-control also initially displayed greater academic achievement. Change in these variables over time, however, was not significantly correlated. Measurement invariance was also assessed for the Children's Self-Control Scale (CSC) (L. Humphrey, 1982) and the Woodcock Johnson test. Restrictive models, based on assumptions of equality across both time and raters, yielded adequate model fit. An appendix contains the CSC. (Contains 4 figures, 7 tables, and 22 references.) (Author/SLD)

ED 452 236

Studying the Relationship Between Children's Self-Control and Academic Achievement: An Application of Second-Order Growth Curve Model Analysis

Sooyeon Kim

Velma McBride Murry

&

Gene H. Brody

The University of Georgia

Center for Family Research

Athens, Georgia

TM032522

Paper presented at the Annual Meeting of the American Educational Research Association, Seattle, Washington, April 10-14, 2001.

Running head: Children's self-control and achievement

E-mail:sykim@arches.uga.edu

Abstract

In the present study the functional relationships between developmental change in children's self-control and academic achievement were examined using longitudinal family data. Multivariate latent growth models (LGM) were specified to determine whether the rate of growth in academic achievement changes as a function of developmental change in self-control. Self-control and academic achievement were significantly associated as indicated by the significant covariance between the variables' initial status. Children who initially displayed better cognitive and behavioral self-control also initially displayed greater academic achievement. Change in these variables over time, however, was not significantly correlated. Measurement invariance was also assessed for the Children's Self-Control (CSC) scale and the Woodcock-Johnson test. Restrictive models, based on assumptions of equality across both time and raters, yielded adequate model fit.

Self-control ability frequently has been cited as necessary for children's successful adjustment at home and in school (Rohrbeck, Azar, & Wagner, 1991). Generally, self-control has been viewed as the ability to manage one's actions, thoughts, and feelings in adaptive and flexible ways across a variety of social and physical contexts. Researchers use a variety of terms to refer to the concept of self-control, such as impulse control, self-regulation, self-management, self-direction, and independence; they also describe its development in very different ways.

Bronson (2000) conceptualized self-regulation in early childhood using two general definitions. The first focused mainly on the control of external behavior, such as the ability to comply with adult requests or to manage behavior and emotions adaptively in specific situations. Because this type of self-control is important both at home and in school, parents and teachers are likely to agree that it is an essential social skill. For instance, when Humphrey and Kirschenbaum (1981) examined the relationship between behavioral measures of self-control in preschool children and teachers' perceptions of the children's social competence, tolerance, but not resistance to temptation, was related to cooperation as a social skill. The second definition focused primarily on the control of cognition, such as the ability to focus attention, to direct and monitor thinking and problem solving, and to engage in independent learning activities. Although the development of cognitive self-control begins very early, it becomes increasingly important as children grow older and are expected to attain particular levels of learning and academic development.

Empirical research indicates that self-control, conceptualized as goal-directedness and emotional stability, is as important as IQ and aptitude for success in school and general adaptation. Kendall, Zupan, and Braswell (1981) found that children who lacked self-control exhibited off-task, disruptive behavior and had deficits in social perspective taking. In addition, children with identified behavioral problems were rated by their teachers as low in self-control and were observed to engage frequently in dysfunctional conduct, such as withdrawn, isolated, physically off-task, out-of-seat, and disruptive behaviors. Flynn (1985) studied the relationship between self-control and achievement among 156 four-year-old Black migrant children. Child self-control accounted for a significant amount of variance in predicting growth in achievement for boys, but not for girls. More recently, Normandeau and Guay (1998) tested a model of school achievement that included children's intellectual abilities, preschool behavior, and cognitive self-control. They found that teacher-rated preschool behavior, such as aggressive, anxious-withdrawn, and prosocial behavior, were associated with cognitive self-control, which in turn predicted school achievement. Children's cognitive self-control may mediate the relation between children's behavioral characteristics and their school performance; however, because this finding emerged from cross-sectional data, its usefulness in detecting a recursive effect between cognitive self-control and school achievement is limited.

The characteristics of self-control vary with age and development. As children mature, their self-control capacity reflects their growing cognitive complexity, exposure to diverse experiences, and opportunities to learn new ways of coping with distressing circumstances. Younger children are most likely to turn to their caregivers to help them regulate their feeling during times of stress. In middle childhood, children are more likely to look to peers for support. Indeed, the comparisons that children make between themselves and others in middle childhood can be highly challenging for previously confident children (Saarni, 1997). Children who cannot conform to age-appropriate expectations for self-control may experience adjustment difficulties and elicit concern from their parents and teachers.

Two general ideas form the basis of the present study. First, the characteristics of self-control vary with age, according to development and adaptation. Second, children's ability to concentrate on a task, to participate in academic routines, and to regulate their behavior helps to determine their school achievement. These ideas will be examined using longitudinal family data.

Applications of Latent Growth Curve Modeling

Longitudinal family data have been used to evaluate the home environment and to understand children's development (Khoo & Muthén, 1998). Such data can be useful for inferring a causal connection between variables and studying individual differences or developmental changes. Two general approaches have been used to study change by analyzing longitudinal data: auto regressive model techniques, which assess the effect of a time 1 measure on the time 2 measure of the same variable (Gollob & Reichardt, 1987); and multivariate latent growth curve model techniques, which portray individual change over time and the relationships between developmental trajectories and individual characteristics (Curran, 1998; Rogosa, Brandt, & Zimowski, 1982; Stoolmiller, 1995).

In developmental research, in which repeated observations are made over time on a group of individuals, latent growth curve modeling can be a useful means of interpreting the repeated measurements. Latent growth modeling (LGM), which is conceptualized within the structural equation modeling (SEM) framework, can describe individuals' behavior in terms of initial levels and developmental trajectories and also determine the variability across individuals in both initial levels and trajectories (Lawrence & Hancock, 1998). Assuming that all individuals' growth follows the same functional form, LGM can detect individual differences using two common growth curve factors, the intercept and slope. The intercept factor, which is a constant for any individual across time, indicates the amount of individual difference represented at the initial measurement point. The slope factor describes the extent to which individuals change in terms of their developmental points and represents the shape of an individual's trajectories as determined by the repeated measures.

A general growth model is specified as a two-level model where the level-1 units are the repeated measurements that are nested within the level-2 individual units. At the first level, the observed outcome at each time point is specified as a function of a set of growth parameters over time with measurement error, assuming systematic growth trajectories. In the model of linear change, as presented by MacCallum and Kim (2000), the outcome variable y is represented as a function of time:

$$y_{it} = \beta_{0i} + \beta_{1i}x_{it} + \varepsilon_{it} \tag{1}$$

where y_{it} represents the measure of the response variable y for individual i at occasion t, x_{it} represents the measure of time for individual i at occasion t, β_{0i} is the intercept for individual i, β_{1i} is the slope for individual i, and ε_{it} is the residual for individual i at occasion t. At the second level, the growth factors that characterize individual trajectories are specified to derive a between-individuals model, representing variations in growth across individuals. The intercept and slope are random variables, with their variation across individuals modeled as follows:

$$\beta_{0i} = \beta_0 + u_{0i} \tag{2}$$

$$\beta_{1i} = \beta_1 + u_{1i} \tag{3}$$

where β_0 and β_1 represent the fixed effects for the intercept and slope, or the means of those values, and u_{0i} and u_{1i} represent individuals' random variation around the mean intercept and slope, respectively. Inserting Equations 2 and 3 into Equation 1 yields the single defining equation for the latent growth model:

$$y_{it} = \beta_0 + \beta_1 x_{it} + u_{0i} + u_{1i} x_{it} + \varepsilon_{it} \quad (4)$$

In fitting this model to data, two fixed effects, the mean intercept β_0 and the mean slope β_1, are estimated; four variance and covariance parameters, such as the residual variance σ^2_e, the intercept variance σ^2_{u0}, the slope variance σ^2_{u1}, and the covariance between the intercept and slope σ_{u0u1}, are estimated. Individual differences are represented by variations in the parameters of these developmental functions; thus, the primary interest is in the variation and covariation among individuals around these mean intercepts and mean slopes.

The Major Focus of the Present Study

The major focus of the present study can be summarized in three parts, which require different LGM specifications. The first is to investigate the developmental trajectories of children's self-control and individual differences in those trajectories. The LGM is specified for analysis of change in self-control as rated by primary caregivers (mostly mothers) and teachers across time. The second purpose is to clarify the functional relationships between developmental changes in children's self-control and their academic achievement. The expanded LGMs, analyzing two outcome variables, will be specified to determine whether the rate of growth in academic achievement changes as a function of developmental change in self-control. The third purpose is to assess the measurement equivalence of the scales and tests used to represent the latent variables of children's self-control and academic achievement in this application. The investigation of measurement invariance is essential, because the implications derived from the LGM analyses are sound only when the measures' meaning is equivalent across time points and raters.

Method

The three waves of data used in the present study were part of a longitudinal project, the Rural Georgia Single-Parent Family Study, in which the links among family processes, parenting, and psychosocial competence were examined for children living in economically stressed families.

Participants

The participants in the present study were African American single-mother-headed families with a child who was 7 to 16 years old. Because the range of children's ages was very wide among these families, only families that included 9- to 14-year-old child at the first wave are considered in this study. Accordingly, a total of 140, 127, and 124 families and a total of 114, 120, and 102 teachers were analyzed at each measurement point, respectively. The children's mean age was 11.21 years (SD = 1.42) at the first wave, 11.87 years (SD = 1.53) at the second wave, and 13.01 years (SD = 1.49) at the third wave. Children and their mothers completed questionnaires in their homes during a home visit by research staff. To collect teacher data, the questionnaires were mailed to the secretary of each school. After the teachers completed the questionnaires, the secretaries mailed the questionnaires to the research center. Data were collected between September 1997 and December 1999, and follow-up assessments were conducted approximately 12 months later. All participants were compensated.

Measures

Children's self-control. The children's Self-Control Scale (CSC; Humphrey, 1982), which reflects a cognitive-behavioral conceptualization of self-control, was used to rate children's self-control. Parallel versions of the CSC scale were rated by mothers (CSC_Mother) and teachers (CSC_Teacher). The instrument includes 15 items presented in a Likert-type format with a five-point response scale (see Appendix). Common factor analysis (Humphrey, 1982) indicated that the 15 items were explained by two common factors. The first 10 items represent personal and cognitive aspect of self-control, such as the ability to concentrate on a task, whereas the last 5 items represent interpersonal and behavioral aspects of self-control, such as annoying or disruptive behaviors. Because the number of items in the subscales differed, adjusted mean scores (subscale score / number of items) were used in analyses; possible scores ranged from 0 to 4. The descriptive statistics and internal consistency coefficients (e.g., Cronbach's alpha) for the CSC subscales are presented in Table 1, separately for mothers and teachers.

Insert Table 1 About Here

As presented in Table 1, the internal consistencies for the CSC subscales ranged from .68 to .81 for the mothers' version and ranged from .91 to .94 for the teachers' version. The teachers' version of the CSC displayed better internal consistency among the items than did the mothers' version. Items 3, 4, 7, and 8 of the cognitive subscale and all five items (11 to 15) of the behavioral subscale were reverse scored, so that the higher scores in both subscales represent greater cognitive and behavioral self-control.

Composite scores derived from the two subscales, personal/cognitive and interpersonal/behavioral, were used to represent the latent self-control construct and treated as the basic unit of analysis. Likert-format items are ordered categorical variables, thus, they are non-normal by definition. For that reason, the use of subscale scores instead of single items may close to statistical assumptions (e.g., continuity and normality of variables) required for the use of common estimation methods (e.g., ML or GLS) in the covariance structure modeling context. To assess the composite scores' unidimensionality, both the conceptual criteria based on item content and empirical indices (e.g., internal consistency, item-level correlation, and factor loadings from the exploratory factor analyses) were considered.

Academic achievement. The Woodcock Johnson Psycho-Educational Battery-Revised (WJ-R) was used to measure children's achievement. The WJ-R is a wide-range, comprehensive set of individually administered tests that measure cognitive abilities, scholastic aptitude, and achievement (Woodcock & Mather, 1989; 1990). The nationally standardized revised test battery is composed of two major parts: the Woodcock-Johnson Tests of Cognitive Ability (WJ-R COG) and the Woodcock-Johnson Tests of Achievement (WJ-R ACH). The letter-word identification and calculation tests from the WJ-R ACH were used in this study. The letter-word identification test, which is related to the reading curriculum, measures a child's ability to match a rebus with an actual picture of the object and to identify isolated letters and words presented in large type. The calculation test, which is related to the mathematics curriculum, includes addition, subtraction, multiplication, division, and a combination of these basic operations, as well as some geometric, trigonometric, logarithmic, and calculus operations.

The WJ-R scores are used to assess changes in individual achievement following a specific time interval. These data were analyzed to measure linear change in children's academic achievement and individual differences in growth rates. In the second-order LGM analysis, raw scores were used instead of standardized scores. The descriptive statistics for the letter-word identification and calculation tests are presented in Table 1.

In sum, a total of 18 composite scores obtained across time and measures were analyzed as the outcome variables in this study. Intercorrelations among them were presented in Table 2.

Insert Table 2 About Here

Procedures: Data Analyses

As mentioned previously, the major purposes of this study are to determine how children's self-control ability changes over time, and how changes in self-control ability are related to developmental trajectories regarding academic achievement. For these purposes, a series of second-order LGMs was specified and tested in terms of the overall model fit to the data and component fits related to the common growth factors.

As an initial step, the second-order LGMs based solely on CSC data were analyzed. The parallel versions of CSC used by different raters were analyzed separately based on the same model specification. The general modeling framework is presented in Figure 1. When specifying the model, equality constraints were imposed on the factor loadings (i.e., b_1), intercepts (i.e., I_1) and uniqueness (i.e., e_1 and e_2) of the cognitive and behavioral variables, to assess the measurement invariance over time. Because the equality constraint was imposed on even time-specific error variances (i.e., e_1 and e_2), fairly restricted and parsimonious LGMs could emerge. In addition, although the linear growth function for the WJ-R raw data may be self-evident, the LGM based solely on WJ-R raw data was analyzed and briefly explained in terms of the functional relationship between the intercept and slope factors. The model framework was identical to the CSC data (see Figure 1).

Insert Figure 1 About Here

When the second-order LGMs for the CSC data and WJ-R data appeared to be plausible in the first step, the expanded second-order LGMs, which analyzed two outcomes simultaneously, were conducted as the next step. As presented in Figure 2, the parameters related to four growth factors, namely CSC_Intercept, CSC_Slope, WJ-R_Intercept, and WJ-R_Slope, and all possible associations among them were estimated to answer the second research question. Equality constraints were imposed on both the CSC subscales and the WJ-R tests to assess their measurement invariance as well.

Insert Figure 2 About Here

At the third step, the second-order LGM was fully expanded to include all data, CSC_Mother, CSC_Teacher, and WJ-R, in a model. The framework of model was presented in Figure 3. Because mothers and teachers, rather than randomly sampled independent groups, rated the same children, the model specification for capturing their dependency may be more adequate than ordinal multi-group comparisons. Accordingly, the associations among the three initial status factors and the three rate of change factors were examined in this analysis. Particularly, measurement invariance for the parallel versions of the CSC scale was assumed across both time points and raters. Generally, when specifying all the LGMs, the residual correlations at the level-1 units caused by method effects and their equality constraints are empirically driven to improve model-data fit as well as to satisfy model parsimony.

Insert Figure 3 About Here

When examining children's developmental trajectories and individual differences using LGMs, two issues can be addressed. The first issue is related to missing data in the longitudinal study. Generally, data can be missing from longitudinal sets due to both omission and attrition. Although listwise deletion methods take advantage of the balanced nature of the resulting data set to simplify computations, a substantial amount of potentially useful data is discarded in this process. Furthermore, considerable sample bias can be introduced when the assumption that data are missing completely at random is not tenable (Muthén, Kaplan, & Hollis, 1987). Only 80 families remained in the sample when listwise deletion was used. To decrease the limitations that the missing data imposed, model parameters were estimated using the full information maximum likelihood (FIML) estimation method built into the Amos software (Version 4, 1999). FIML estimation with incomplete data has been regarded as more efficient and less biased than listwise and pairwise deletion and mean imputation methods. In the case of missing-at-random (MAR) data, FIML is less biased than listwise deletion and mean imputation methods (Wothke, 2000).

The second issue is related to measurement invariance, which indicates whether or not the meanings of measures are equivalent across different points in time and different raters. Because the observed indicators should measure the latent self-control factor equivalently, and the same items were used at the three time points, equality constraints can be imposed on the indicators' factor loadings, intercepts, and uniqueness (i.e., parallel test assumption) to assess their measurement equivalence. Particularly, in a longitudinal study based on the repeated use of same measures, ensuring psychometric quality of the measures is an essential step that must be taken before further analyses are conducted. The explanations for the latent growth curve factors will be reasonable only if the indicators' measurement properties are sound.

Results

The Second-Order LGMs for Univariate Change

CSC data. The second-order LGMs based solely on CSC data were analyzed to examine changes in children's self-control ability over time. The overall model-data fit indices for the mothers' and teachers' models are presented in the upper part of Table 3, and the component fits related to the growth factors is displayed in Table 4. The model fit the mother-reported data acceptably for both statistical (χ^2 [df = 15] = 10.31, p = .80) and practical (NNFI = 1.00, CFI = 1.00; RMSEA= .00) purposes. The model also fit the teacher-reported data acceptably both statistically (χ^2 [df = 14] = 13.25, p = .51) and practically (NNFI = 1.00, CFI = 1.00, RMSEA=.03). Because different teachers provided data at each time point, teacher effects could influence the model parameters estimated. As a result, the second-order LGM of the mother-reported data yielded a slightly better model fit than did the teacher-reported data. Because the same subscales were used repeatedly, correlated errors appeared, particularly for the behavioral subscale. However, the magnitude of the correlations was constrained to be equal across time. In the CSC_Mother model, the residual for the time 3 self-control construct (i.e., e_5 in Figure 1) was negative (-.02). This inadmissible estimate was not statistically significant from 0; thus, it was fixed at 0 for the analysis under the assumption that the negative variance may be random variation from 0 (J. Arbuckle, personal communication, February 24, 2001; Tisak & Tisak, 2000). Because this residual was no longer a parameter in the CSC_Mother model, the model has one more degree of freedom (15) than does the Teachers' model (14).

Insert Tables 3 and 4 About Here

In the mothers' version, the means for the intercept and slope factors were 2.29 (CR = 40.96) and .07 (CR = 2.87), respectively. This indicated that the estimated mean starting points for children's self-control was 2.29 and the estimated mean rate of self-control change was .07 per wave. Significant variances emerged for the intercept (.10, CR = 2.81) and slope (.02, CR = 2.37) factors, indicating substantial inter-individual variability around both the starting point and rates of change over time. The covariance (.01, CR = .75, [r = .22]) between two growth curve factors was not significant, however, reflecting orthogonality between them. This means that the rate of change was not steeper as a function of initial status.

In the teachers' version, the means for the intercept and slope factors were estimated to be 2.57 (CR = 30.61) and -.08 (CR = -1.78), respectively. This indicated that the estimated mean starting points for children's self-control was 2.57 and the estimated mean rate of true change was -.08 per wave, indicating a slight decrease in self-control. Although the linear growth rate mean was not significantly different from zero, significant variations emerged across individuals for both the starting point (.50, CR = 3.35) and the rate of change (.12, CR = 2.03) factors. This means that some children's rates were still increasing at the first measurement point and that other children's rates were already declining at the first measurement point, with an average decrement of about -.08 in the growth rate varied across children. This indicates individual differences in the self-control trajectories. Although the covariance between the initial status and the rate of change was not statistically significant (CR = -1.86), the children who scored higher initially, tended to display less steep rate of negative change over time ($r = -.55$).

Despite very restricted model specifications, the second-order LGMs based on children's self-control data yielded adequate overall model-data fit, supporting the measurement equivalence of the CSC scale. Equality constraints imposed on the factor loadings, intercepts, and even time-specific error variances of manifest variables yielded neither statistically nor practically inappropriate model fit. The direction of linear growth rate (i.e., slope), however, was reversed across raters. As the descriptives presented in Table 1 indicate, mothers rated their children's self-control ability as increasing with age, whereas teachers' ratings for the same children were fairly inconsistent across time. Teachers' ratings increased from the first ($M_{T1} = 2.48$) to the second ($M_{T2} = 2.53$) measurement point, but their ratings decreased steeply from the second to the third measurement point ($\underline{M}_{T3}$ = 2.29). Although the model cannot explain this result, it might be associated with instability in the CSC ratings caused by teacher effects.

WJ-R data. The second-order LGM based on WJ-R data was analyzed to confirm the linear growth function in academic achievement. As expected, the overall model-data fit was acceptable both statistically (χ^2 [df = 14] = 22.67, $\underline{p}$ = .07) and practically (NNFI = 1.00, CFI = 1.00; RMSEA= .07; see Table 3). Because the same tests were used repeatedly, correlated errors emerged, particularly in the letter-word identifcation test; however, their magnitude was constrained to be equal as in the CSC models.

As presented in Table 4, the latent mean for the intercept was statistically significant (CR = 32.85), and individual differences around the mean intercept were substantial (CR = 7.08). The mean of the slope factor differed statistically from 0 (CR = 13.85), but the variability of the mean slope was negligible (CR = 1.34). This means that children's academic achievement tended to increase at an average of about 2.65 points per wave. The rates of change did not vary significantly across children, indicating stability in the individual trajectories. The functional relationship between the two growth factors was not statistically significant (CR = -1.00). Indeed, the rate of linear change was not steeper as a function of initial academic achievement status.

The Second-Order LGMs for Multivariate Change: CSC and WJ-R Data

When the mothers' and teachers' LGMs were conducted separately to investigate the association between children's self-control and their academic achievement, both the CSC_Mother/WJ-R (χ^2 [df = 61] = 64.25, $\underline{p}$ = .36) and CSC_Teacher/WJ-R (χ^2 [df = 61] = 67.43, $\underline{p}$ = .27) models showed statistically acceptable overall fit to the data (see Table 3). Equality constraints imposed on the factor loadings, intercepts, and error variances did not produce a poor model fit, supporting the measurement equivalence of the CSC scale and the WJ-R test. The residual variances for the time 3 self-control construct in the first model (signified as e_5 in Figure 2) and the time 3 academic achievement construct in the second model (signified as e_{10} in Figure 2) were negative; therefore, they were fixed at 0 in this application. As a result, the number of parameters estimated in the two models was identical.

When compared to univariate LGMs, the results related to each measure's growth curve factors converged in terms of their means and variances (see Table 5). Although many parameters were estimated under these multivariate change models, the primary interest was to examine the functional association between the CSC and WJ-R growth curve factors. Accordingly, when six covariances were estimated in each model, none of them was statistically significant except the covariation between the CSC intercept and the WJ-R intercept factors. This means that, although children with better self-control ability tended to achieve better academic performance, change in these variables may not correspond over time. Particularly for the model based on the CSC_Mother and WJ-R data, both self-control and academic achievement showed a linear increase over time; however, the changes in these variables did not correspond systematically.

Insert Table 5 About Here

Two types of multivariate change models yielded different estimation results for CSC slope mean, CSC slope variance, and WJ-R slope variance. Inconsistent CSC slope factors due to different raters were detected in the univariate change models. The meaning of WJ-R slope factor, however, differed across raters. For instance, in the CSC_Mother/WJ-R model, inter-individual differences in the academic achievement trajectories were statistically negligible (1.81, CR = 1.39), leading to a conclusion consistent with the WJ-R only model (2.37, CR = 1.34; see Table 4). When analyzed using CSC_Teacher data, however, substantial inter-individual differences emerged in the developmental trajectories for academic achievement (1.90, CR = 3.24), casting doubt on stability on the growth trajectories over time. This result implies that teachers may not be as accurate as mothers in evaluating children's self-control ability.

Despite some inconsistencies, the association between children's self-control and academic achievement converged across the multivariate change models. This result may imply that, regardless of the rater, children who were rated high in self-control ability at the starting point tended to show better academic achievement. The functional relationship between self-control and academic performance was still questionable, however, because the rate-of-change factors were not correlated over time.

Second-Order LGM Based on CSC_Mother, CSC_Teacher, and WJ-R Data

CSC data obtained from mothers and teachers were analyzed simultaneously in a model to investigate measurement equivalence between raters. After removing the effects of two growth factors, the residual terms signified as e_7 and e_{13} in Figure 3 were negative but not statistically significant; thus, these residuals were fixed at 0 for the analysis. Based on measurement assumptions, equality constraints were imposed on the factor loadings, intercepts, and time-specific item error variances/covariances across time and rater groups in the baseline model. The overall model fit was acceptable both statistically (χ^2 = 169.66 [df=149], p =.12) and practically (CFI = 1.00, RMSEA = .03), despite very restricted model specification (see Table 6). This result indicates that the CSC measure are equivalent across points in time and rater groups.

Based on the measurement equivalence for the CSC indicators across time and rater groups, further comparisons for the latent growth factors were conducted. When equality constraint was imposed on the latent mean of intercept factors (i.e., CSCM_I and CSCI_I), the overall model fit (χ^2= 170.23 [df=150], p = .23) was as good as the fit of the less restricted baseline model. As the nested model comparison indicates (Models 1 versus 2; $\Delta\chi^2_{[\Delta\, df=1]}$ = .57, p = .46), the latent mean difference between mothers (2.39) and teachers (2.45) at the starting point can be attributed to random variation. However, imposing equality constraint on the latent means of slope factors (CSCM_S and CSCI_S) yielded a statistically worse model fit than did Model 2 (Models 2 versus 3; $\Delta\chi^2_{[\Delta\, df=1]}$ = 9.83, p = .00). Based on a series of nested model comparisons, Model 2 assuming the same latent mean for the CSC intercept factors could be the most plausible model.

Insert Table 6 About Here

When the functional associations among six growth factors were investigated simultaneously in a model, their relationships were consistent with the models tested in the second step (see Table 7). Only the three covariances among the three intercept factors were statistically significant ($Cov_{CSCM\_I,\, CSCI\_I}$ = .10, CR = 3.54; $Cov_{CSCM\_I,\, WJ\text{-}R\_I}$ = 1.10, CR = 3.92; $Cov_{CSCI\_I,\, WJ\text{-}R\_I}$ = 1.75, CR = 3.94); however, the associations among the rate of linear change factors (i.e., slopes) were negligible. As in previous analyses, children who were rated high in self-control ability at the starting point tended to show better academic achievement; however, developmental change in self-control ability may not in itself facilitate academic development.

Insert Table 7 About Here

The possibility that a common intercept factor exists (i.e., CSC_I) is strongly supported by the excellent overall model-data fit in Model 2. More specifically, because CSCM_I and CSCT_I were significantly correlated (r = .46) and their latent means were equivalent, intercept factors for CSC data can be estimated as a common factor across raters. The slope factors should be estimated separately, however, because changes in children's self-control differed across raters. When the LGM was analyzed based on five, rather than six, developmental factors (see Figure 4), the overall model-fit was acceptable in practical (χ^2/df = 1.26; NNFI = 1.00; CFI = 1.00; RMSEA= .04 [.02; .06]) but not in statistical (χ^2= 194.57 [df=154], p = .02) terms. In addition, the variation/covariation around the five intercept and slope factors were equivalent to the results derived from Model 2.

Insert Figure 4 About Here

Conclusion

Discussion of Findings

In practice, latent growth modeling can be useful in understanding human development and growth because it can explain inter-individual changes based on longitudinal data sets. Second-order latent growth modeling was used to investigate developmental changes in children's self-control and academic achievement over time. The growth parameters, which described a systematic pattern of individual differences in change over time, were the primary focus of this study. Measurement invariance was also assessed because a longitudinal study based on the repeated use of the same measures requires that the psychometric properties of those measures be sound. If a scale does not display measurement equivalence over time and across rater groups, questions may arise about the meanings of the growth curve factors.

The findings can be summarized in four parts. First, the parallel versions of the CSC scale demonstrated measurement invariance over time and across raters under very restricted model specifications, such as parallel test assumptions. This means that the manifest indicators are supposed to serve equivalently for the latent self-control factor across groups. Accordingly, the latent growth factors based on data from different raters can be compared for further examination.

Second, when the growth factors, intercept and slope, were examined based on univariate change analyses for the two versions of the CSC, consistent results emerged for the initial status factor (i.e., intercept of CSC). This suggested that a common intercept factor operated across rater groups; however, the rate of linear change (i.e., slope) factors differed in direction and magnitude. According to mothers' ratings, self-control changed in a positive direction, indicating increasing function with age; however, the change over time was negative and non-linear when teachers' ratings were used in the analysis. Furthermore, when teachers' CSC data were analyzed simultaneously with WJ-R data, the stability of the slope factor that was detected in the univariate change analysis (WJ-R data only) did not emerge, indicating substantial inter-individual differences in the academic achievement trajectories. These findings lead to questions about the raters' characteristics. The LGMs based on either mothers' or teachers' ratings may differ in terms of their variance components. Rater effects arising from the participation of different teachers at each time constitutes temporal variance, not permanent variance; and furthermore, it may lead to differences in parameter estimation. In addition, mothers and their children are nested within the same family units; thus, their interdependency may influence parameter estimations.

Third, substantial variations existed in both the initial status and the developmental trajectories of children's self-control, casting doubt on the stability of trajectories. Particularly for the mothers' reports, children's self-control increased with age as indicated by a statistically significant mean slope factor. This result can be explained in terms of children's expectations of themselves concerning self-control. A preliminary study in which the significance of age and gender in children's behavioral expectations revealed that older children expected to display greater self-control than did younger children, and that this trend displayed a linear increase with age (Burke, Solotar, Silverman, & Israel, 1987). Unlike children, however, parents do not expect significantly more self-control on the part of older children than on the part of younger children. The general increase in self-control that emerged from mothers' reports may involve children's compliance with adults' expectations.

Finally, the association between self-control and academic achievement that cross-sectional data suggested (e.g., Normandeau & Guay, 1998) was partially supported based on the significant covariance between the variables' initial status. Children who displayed better cognitive and behavioral self-control ability at the first data collection tended to display greater academic achievement. However, it is still questionable that children's self-control ability alone facilitates academic growth.

Study Limitations and Recommendations for Future Studies

This study addresses developmental change in self-control and academic achievement using latent growth curve modeling. However, several limitations restrict the results' generalizability. These methodological and theoretical limitations, as well as recommendations for future studies, are summarized in four parts.

First, the time scale was based on data collection waves, instead of children's ages. More specifically, the LGMs specified in this study were based on the fairly restricted design assumption that children in different age cohorts were from the same population and that no cohort effects existed. This assumption may be unrealistic. Particularly when the children's age range is fairly wide as it was in this sample, estimation of the underlying growth process might be confounded due to age cohort differences. Cohort-sequential design (e.g., Nesselroade & Baltes, 1979), which provides a way to link adjacent segments of limited longitudinal data for different age cohorts, can be used to reducing age cohort effects.

Second, the rate of change for children's self-control did not converge across raters. Due to restriction in the design structure, the sources of this inconsistency cannot be clarified in this study. More than three measurement points will be needed to clarify this finding because the precision of a slope estimate in a linear growth model increases with the number of time points at which data are collected. Given time constraints, concerns about participant attrition, and the cost of multiple assessments, cohort-sequential design can be used as an alternative to evaluate the existence of a common developmental trend for children's self-control. The latent state-trait model framework may be another alternative that can be used to disentangle variance components from rater effects.

Third, the methods used in this study involved fitting models to the data. Consequently, a reasonably large sample was required for precise parameter estimates to be derived and for asymptotic properties to hold adequately. In addition, the calculation of p-values assumes that the parameter estimates are normally distributed, which is possible only with large sample (Arbuckle & Wothke, 1999). In this application, however, the LGMs were tested with less than 200 participants at each time point. Accordingly, questions may arise about estimated standard errors and test results because of the small sample.

Fourth, in this study only non-directional relationships between children's self-control and academic achievement regarding their growth curve factors were considered. Previous studies in which the mediational effect of self-control on the association between children's behavioral characteristics and achievement were investigated (e.g., Normandeau & Guay, 1998) support a directional relationship between self-control and achievement. Directional paths can be introduced from the CSC_Intercept factor to the WJ-R_Intercept and WJ-R_Slope factors, and from the CSC_Slope factor to the WJ-R_Slope factor, instead of computing covariations among them. This alternative was not considered in this study because CSC and WJ-R data were collected simultaneously at each time points; thus their effects may be confounded over time.

Finally, the present study stands focused mainly on measurement. Consequently, any other predictors that influence the growth curve factors for either the CSC or the WJ-R data were not included. Both static and time-varying variables can be included in models as predictors of growth functions. These could include a wide range of theoretically based measures, such as gender, family income, mothers' education level, and parenting practices. The proportion of variance in slopes for which these covariates account could be estimated by comparing estimates of residual slope variations from models with and without them. For instance, based on theory, gender differences might be expected to emerge during certain developmental stages. Gender effects were not considered in the present study because of the small sample. The effects of variables omitted from this study on the functional associations between self-control and academic achievement should be investigated with a large sample and more data collection points.

Despite these limitations, this study is useful from a practical perspective because it demonstrated a sound approach to analyzing longitudinal and multi-group data. Although the data measurement assumptions should be met before testing theories about the relationships among latent constructs, practitioners often ignore this point. In this study we examined the association between children's self-control and their academic achievement after assessing the initial measurement invariance of the CSC scale and the WJ-R data. Consequently, the findings are useful in understanding children's developmental change. In sum, the current findings can be used as guidelines for future studies of causal associations among child developmental variables.

References

Arbuckle, J., & Wothke, W. (1999). Amos 4 user's guide. Smallwaters Cooperation.

Bronson, M. B. (2000). Self-regulation in early childhood: Nature and nurture. New York: A division of Guilford Publications, Inc.

Burke, A. E., Solotar, L C., Silverman, W. K., & Israel, A. C. (1987). Assessing children's and adults' expectations for child self-control. Journal of Clinical Child Psychology, 16, 37-42.

Curran, P. J. (1998). A latent curve framework for the study of developmental trajectories in adolescent substance use. In J. Rose, L. Chassin, C. Presson, & J. Sherman (Eds.), Multivariate applications in substance use research (pp. 1-41). Hillsdale, NJ: Lawrence Erlbaum Association Inc.

Flynn, T. M. (1985). Development of self-concept, delay of gratification and self-control and disadvantaged preschool children's achievement gain. Early Child Development and Care, 22, 65-72.

Gollob, H. F., & Reichardt, C. S. (1987). Taking account of time lags in causal models. Child Development, 58, 80-92.

Humphrey, L. L. (1982). Children's and teachers' perspective on children's self-control: The development of two rating scale. Journal of Consulting and Clinical Psychology, 50, 624-633.

Humphrey, L. L. & Kirschenbaum, D. S. (1981). Self-control and perceived social competence in preschool children. Cognitive Therapy and Research, 5, 373-379.

Kendall, P. C., Zupan, B. A., & Braswell, L. (1981). Self-control in children: Further analyses of the self-control rating scale. Behavior Therapy, 12, 667-681.

Khoo, S. T, & Muthén, B. (1998). Longitudinal data on families: Growth modeling alternatives. In J. Rose, L. Chassin, C. Presson, & J. Sherman (Eds.), Multivariate applications in substance use research (pp. 43-78). Hillsdale, NJ: Lawrence Erlbaum Association Inc.

Lawrence, F. R., & Hancock, G. R. (1998). Assessing change over time using latent growth modeling. Measurement and Evaluation in Counseling and Development, 30, 211-224.

MacCallum, R. C. & Kim, C. (2000). Modeling multivariate change. In T. D. Little, K. U. Schnabel, & J. Baumert (Eds.), Modeling longitudinal and multilevel data: Practical issues, applied approaches, and specific examples (pp. 51 - 68). Mahwah NJ: Lawrence Erlbaum Association Inc.

Muthén, B., Kaplan, D., & Hollis, M. (1987). On structural equation modeling with data that are not missing completely at random. Psychometrika, 52, 431-462.

Nesselroade, J. R., & Baltes, P. B. (1979). Longitudinal research in the study of behavior and development. New York: Academic Press.

Normandeau, S. & Guay, F. (1998). Preschool behavior and first-grade school achievement: The mediational role of cognitive self-control. Journal of Educational Psychology, 90, 111-121.

Rogosa, D., Brandt, D., & Zimowski, M. (1982). A growth curve approach to the measurement of change. Psychological Bulletin, 92, 726-748.

Rohrbeck, C. A., Azar, S. T., & Wagner, P. E. (1991). Child self-control rating scale: Validation of a child self-report. Journal of Clinical Child Psychology, 20, 179-183.

Saarni, C. (1997). Emotional competence and self-regulation in childhood. In P. Salovey & D. J. Sluyter (Eds.) Emotional development and emotional intelligence (pp. 35-66). A Division of HarperCollins Publishers Inc.

Stoolmiller, M. (1995). Using latent growth curve models to study developmental processes. In J. M. Gottman (Ed.), The analysis of change (pp. 103-138). Mahwah, NJ: Lawrence Erlbaum Association Inc.

Tisak, J., & Tisak, M. S. (2000). Permanency and ephemerality of psychological measures with application to organizational commitment. Psychological Methods, 5, 175-198.

Woodcock, R. W., & Mather, N. (1989, 1990). WJ-R Tests of Achievement: Examiner's Manual, In R.W. Woodcock & M.B. Johnson, Woodcock-Johnson Psycho-Educational Battery-Revised. Itasca, IL: Riverside.

Wothke, Werner (2000). Longitudinal and multiple modeling with missing data. In T. D. Little, K. U. Schnabel, & J. Baumert (Eds.), Modeling longitudinal and multilevel data: Practical issues, applied approaches, and specific examples (pp. 219-240). Mahwah NJ: Lawrence Erlbaum Association Inc.

Appendix

Child Self-Control Questionnaire

Please answer the following questions with __________ in mind.

0 = Never
1 = Not Very Often
2 = Sometimes
3 = Usually
4 = Almost Always

1. How often does stick to what he/she is doing, even doing long, unpleasant tasks, until finished?
0-----1-----2-----3-----4

2. How often does work toward a goal?
0-----1-----2-----3-----4

3. How often does fail to complete work when an adult is not watching?
0-----1-----2-----3-----4

4. How often does get frustrated or give up on difficult tasks?
0-----1-----2-----3-----4

5. How often does pay attention to what he/she is doing?
0-----1-----2-----3-----4

6. How often does plan ahead before acting?
0-----1-----2-----3-----4

7. How often does get distracted from work or responsibilities?
0-----1-----2-----3-----4

8. How often does make careless mistakes because he/she rushes through work?
0-----1-----2-----3-----4

9. How often does think ahead of time about the consequences of his/her actions?
0-----1-----2-----3-----4

10. How often does know when he/she is misbehaving without being told?
0-----1-----2-----3-----4

11. How often does have to have things right away?
0-----1-----2-----3-----4

12. How often does get into arguments or fights with other children?
0-----1-----2-----3-----4

13. How often does talk out of turn?
0-----1-----2-----3-----4

14. How often does interrupt others when they are doing things?
0-----1-----2-----3-----4

15. How often does have trouble keeping promises to improve his/her actions?
0-----1-----2-----3-----4

Table 1

Descriptive Statistics and Internal Consistency of CSC Subscales

Descriptives / Time — Measures	1			2			3		
	M	SD	α	M	SD	α	M	SD	α
Mothers' ratings									
	(n = 140)			(n = 127)			(n =124)		
Children's self-control	2.34	.57	.79	2.36	.58	.82	2.49	.60	.85
Cognition	2.36	.52	.68	2.42	.54	.76	2.51	.59	.81
Behavior	2.32	.77	.75	2.29	.79	.74	2.47	.77	.76
Teachers' ratings									
	(n = 114)			(n = 120)			(n =102)		
Children's self-control	2.48	.85	.95	2.53	.87	.95	2.29	.82	.94
Cognition	2.38	.85	.93	2.42	.87	.94	2.20	.79	.93
Behavior	2.58	.98	.91	2.65	.98	.91	2.37	.99	.91
Children's academic achievement (Woodcock Johnson)									
	(n = 135)			(n = 126)			(n= 125)		
Letter-word identification	36.73	8.25	--	39.83	7.79	--	41.97	8.06	--
Calculation	20.28	7.25	--	22.97	7.29	--	25.29	7.49	--

Note. Because total subtest scores rather than responses to single items were included for the WJ-R test, the internal consistencies for these tests were not calculated. Adjusted mean = (Total subscale score / total number of items). However, internal consistency coefficients for the letter-word identification test ranged from .88 to .94 based on the norming samples (9 and 13 years). Internal consistency coefficients for the calculation test were .89 based on the norming samples (9 and 13 years).

Table 2

Correlation Matrix for the Study Variables

Measures	CSC_Mother						CSC_Teacher						WJ-R					
	Time 1		Time 2		Time 3		Time 1		Time 2		Time 3		Time 1		Time 2		Time 3	
	CO	BE	CO	BE	CO	BE	CO	BE	CO	BE	CO	BE	LE	CA	LE	CA	LE	CA
CSC_Mother:																		
T1: Cognition	1.00																	
T1: Behavior	.52	1.00																
T2: Cognition	.45	.38	1.00															
T2: Behavior	.31	.52	.53	1.00														
T3: Cognition	.44	.37	.72	.43	1.00													
T3: Behavior	.26	.47	.53	.60	.56	1.00												
CSC_Teacher																		
T1: Cognition	.24	.03	.27	.19	.29	.04	1.00											
T1: Behavior	.26	.02	.18	.10	.12	-.08	.72	1.00										
T2: Cognition	.14	.17	.33	.32	.42	.24	.53	.38	1.00									
T2: Behavior	.19	.28	.38	.37	.41	.31	.45	.50	.79	1.00								
T3: Cognition	.20	.09	.27	.17	.27	.14	.32	.28	.47	.42	1.00							
T3: Behavior	.10	.04	.19	.10	.23	.11	.32	.45	.35	.51	.70	1.00						
WJ-R																		
T1: Letter	.22	.24	.27	.13	.33	.31	.33	.20	.38	.39	.26	.24	1.00					
T1: Calculation	.21	.27	.36	.23	.38	.27	.31	.19	.42	.38	.23	.21	.63	1.00				
T2: Letter	.25	.28	.35	.14	.34	.29	.30	.17	.28	.26	.21	.12	.84	.61	1.00			
T2: Calculation	.21	.29	.37	.25	.30	.28	.26	.16	.34	.32	.15	.13	.56	.87	.64	1.00		
T3: Letter	.15	.16	.33	.12	.28	.20	.28	.20	.30	.29	.28	.22	.76	.59	.87	.59	1.00	
T3: Calculation	.22	.26	.39	.26	.32	.25	.31	.15	.36	.33	.25	.18	.56	.84	.62	.88	.65	1.00

Note. These correlations are based on pairwise deletion.

Table 3

Overall Model-Data Fit Indices in the Second-Order Latent Growth Curve Models

χ^2	df	p	χ^2/df	CFI	NNFI	RMSEA (CI)	AIC
Step 1: Univariate change (see Figure 1)							
CSC only							
Mothers' rating							
10.31	15	.80	.69	1.00	1.00	.00 (.00; .05)	34.31
Teachers' rating							
13.25	14	.51	.95	1.00	.1.00	.03 (.00; .08)	39.25
WJ-R only							
22.67	14	.07	1.62	1.00	1.00	.07 (.00; .12)	48.67
Step 2: Multivariate change (see Figure 2)							
CSC_M and WJ-R							
64.25	61	.36	1.05	1.00	1.00	.02 (.00; .06)	122.25
CSC_T and WJ-R							
67.43	61	.27	1.11	1.00	1.00	.03 (.00; .06)	125.43

Note. CFI = Comparative Fit Index/ NNFI = Non-normed Fit Index

RMSEA= Root Mean Square Error of Approximation (Confidence Interval)

AIC = Akaike Information Criterion

Table 4

Parameter Estimates in the Second-Order Latent Growth Curve Models for Univariate Change

	CSC_Mother			CSC_Teacher			WJ-R		
	Estimate	SE	C.R.	Estimate	SE	C.R.	Estimate	SE	C.R.
Means									
Initial status (I)	2.29	.06	40.96	2.57	.08	30.61	20.18	.61	32.85
Linear growth rate (S)	.07	.02	2.87	-.08	.04	-1.78	2.65	.19	13.85
Variances									
Initial status (I)	.10	.04	2.81	.50	.15	3.35	47.52	6.72	7.08
Linear growth rate (S)	.02	.01	2.37	.12	.06	2.03	2.37	1.77	1.34
Covariance									
Intercept & slope	.01	.01	.75	-.13	.07	-1.86	-2.06	2.15	-1.00

Note. SE = Standard Error. CR = Critical Ratio (Estimate / SE).

Table 5

Parameter Estimates in the Second-Order Latent Growth Curve Models for Multivariate Change

	CSC_Mother and WJ-R			CSC_Teacher and WJ-R		
	Estimate	SE	C.R.	Estimate	SE	C.R.
Means						
Initial status (CSC_I)	2.29	.06	40.77	2.57	.08	30.64
Rate of change (CSC_S)	.07	.02	2.88	-.08	.04	-1.76
Initial status (WJ-R_I)	37.06	.72	51.47	37.06	.72	51.57
Rate of change (WJ-R_S)	2.35	.19	12.08	2.34	.19	12.06
Variances						
Initial status (CSC_I)	.11	.04	2.84	.45	.14	3.26
Rate of change (CSC_S)	.02	.01	2.29	.09	.05	1.62
Initial status (WJ-R_I)	37.20	6.77	5.49	37.23	6.60	5.65
Rate of change (WJ-R_S)	1.81	1.30	1.39	1.90	.59	3.24
Covariance						
CSC_I & CSC_S	.01	.02	.81	-.09	.07	-1.42
WJ-R_I & WJ-R_S	-1.56	1.62	-.96	-1.64	1.26	-1.30
CSC_I & WJ-R_I	.86	.28	3.08	1.67	.51	3.26
CSC_I & WJ-R_S	-.03	.08	-.43	.02	.14	.17
CSC_S & WJ-R_I	.18	.15	1.25	-.05	.27	-.17
CSC_S & WJ-R_S	.01	.04	.14	.02	.08	.30

Table 6

Overall Model-Data Fit Indices in the Second-Order Latent Growth Curve Models for Multivariate Change and Measurement Invariance

χ^2	df	p	χ^2/df	CFI	NNFI	RMSEA (CI)	AIC
Step 3A: Measurement invariance test (see Figure 3)							
Model 1: Equal factor loadings, intercepts, and uniqueness							
169.66	149	.12	1.14	1.00	1.00	.03 (.00; .05)	249.66
Model 2: Equal mean intercept							
170.23	150	.23	1.14	1.00	1.00	.03 (.00; .05)	260.58
Model 3: Equal mean intercept and mean slope							
180.06	151	.05	1.19	1.00	1.00	.04 (.00; .07)	268.10
Step 3B: Alternative model (see Figure 4)							
194.57	154	.02	1.26	.99	.99	.04 (.02; .06)	264.57

Note. CFI = Comparative Fit Index/ NNFI = Non-normed Fit Index

RMSEA= Root Mean Square Error of Approximation (Confidence Interval)

AIC = Akaike Information Criterion

Table 7

Parameter Estimates in the Second-Order Latent Growth Curve Models Based on Both Versions of Children's Self-Control and Academic Achievement Data

Estimated parameters		CSC and WJ-R		
		Estimate	SE	C.R.
Means				
CSC_Mother	Initial status (CSCM_I)	2.40	.05	49.81
	Rate of change (CSCM_S)	.06	.02	2.92
CSC_Teacher	Initial status (CSCI_I)	2.40	.05	49.81
	Rate of change (CSCI_S)	-.05	.04	-1.53
WJ-R	Initial status (WJ-R_I)	20.13	.61	33.00
	Rate of change (WJ-R_S)	2.63	.19	13.73
Variances				
CSC_Mother	Initial status (CSCM_I)	.11	.03	3.47
	Rate of change (CSCM_S)	.02	.01	2.32
CSC_Teacher	Initial status (CSCI_I)	.43	.11	3.72
	Rate of change (CSCI_S)	.09	.05	1.74
WJ-R	Initial status (WJ-R_I)	47.42	6.40	7.41
	Rate of change (WJ-R_S)	2.39	.74	3.25
Covariance				
	CSCM_I & CSCM_S	.01	.01	.55
	CSCI_I & CSCI_S	-.09	.06	-1.57
	WJ-R_I & WJ-R_S	-2.08	1.60	-1.30
	CSCM_I & CSCI_I	.10	.03	3.54
	CSCM_S & CSCI_S	.01	.01	1.33
	CSCM_I & WJ-R_I	1.10	.28	3.92
	CSCM_I & WJ-R_S	-.04	.09	-.42
	CSCM_S & WJ-R_S	.02	.05	.34
	CSCI_I & WJ-R_I	1.75	.44	3.94
	CSCI_I & WJ-R_S	.03	.15	.23
	CSCI_S & WJ-R_S	.03	.09	.29

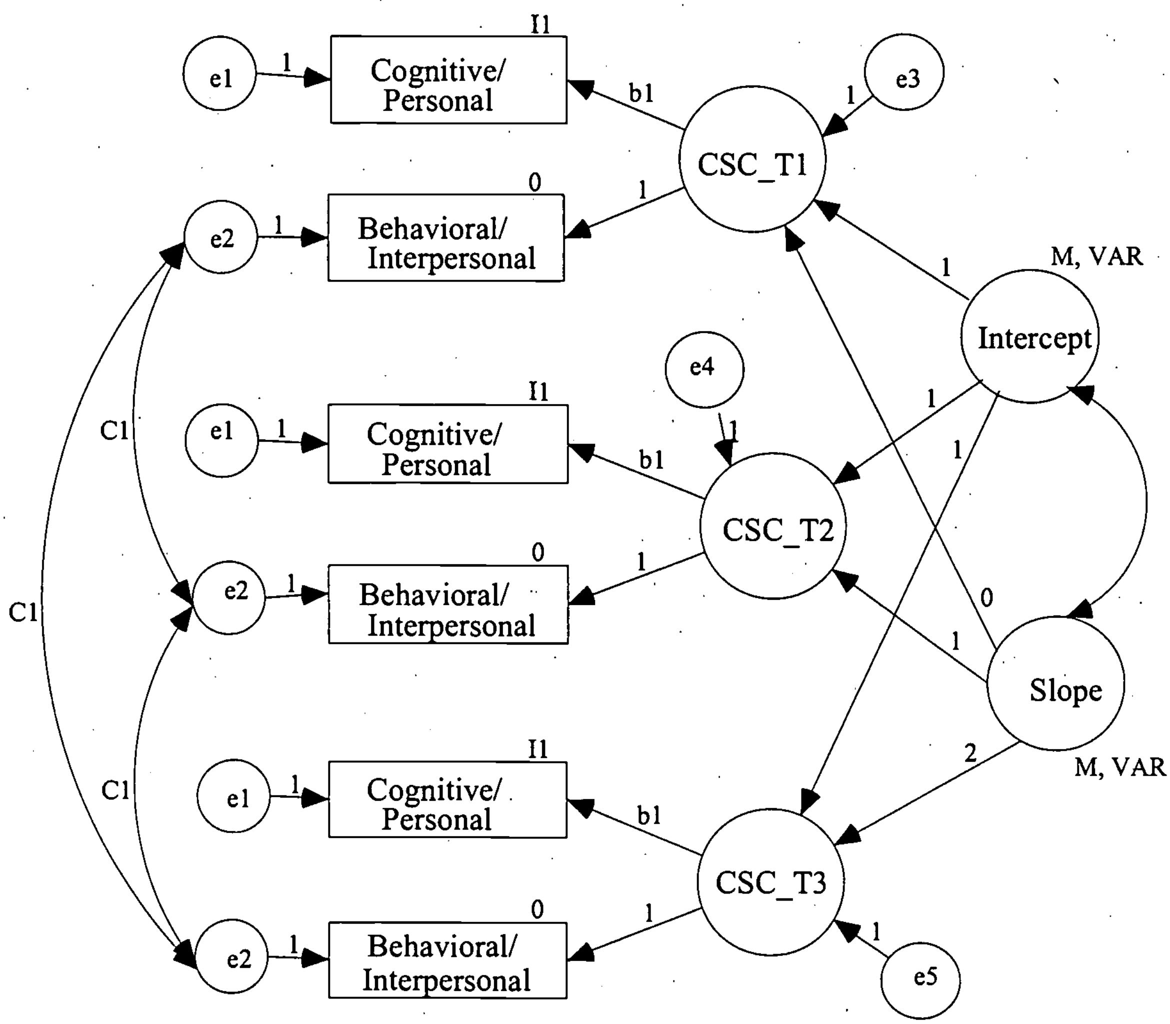

Figure 1. The second-order latent growth curve model for univariate change: CSC data

Note. When analyzing WJ-R data, cognitive indicators are replaced with letter-word identification, and behavioral indicators are replaced with calculation.

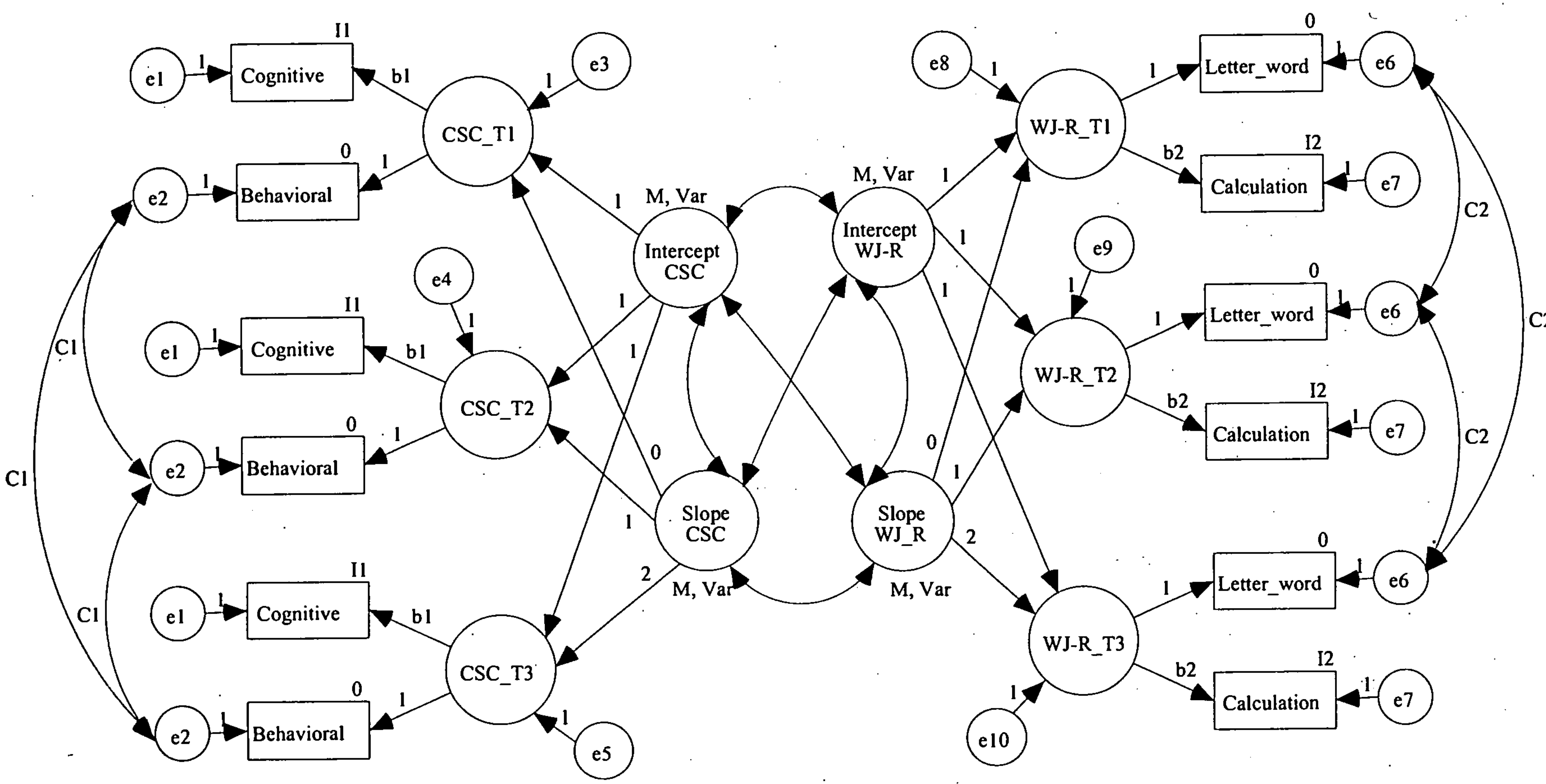

Figure 2. The second-order growth curve model for multivariate change

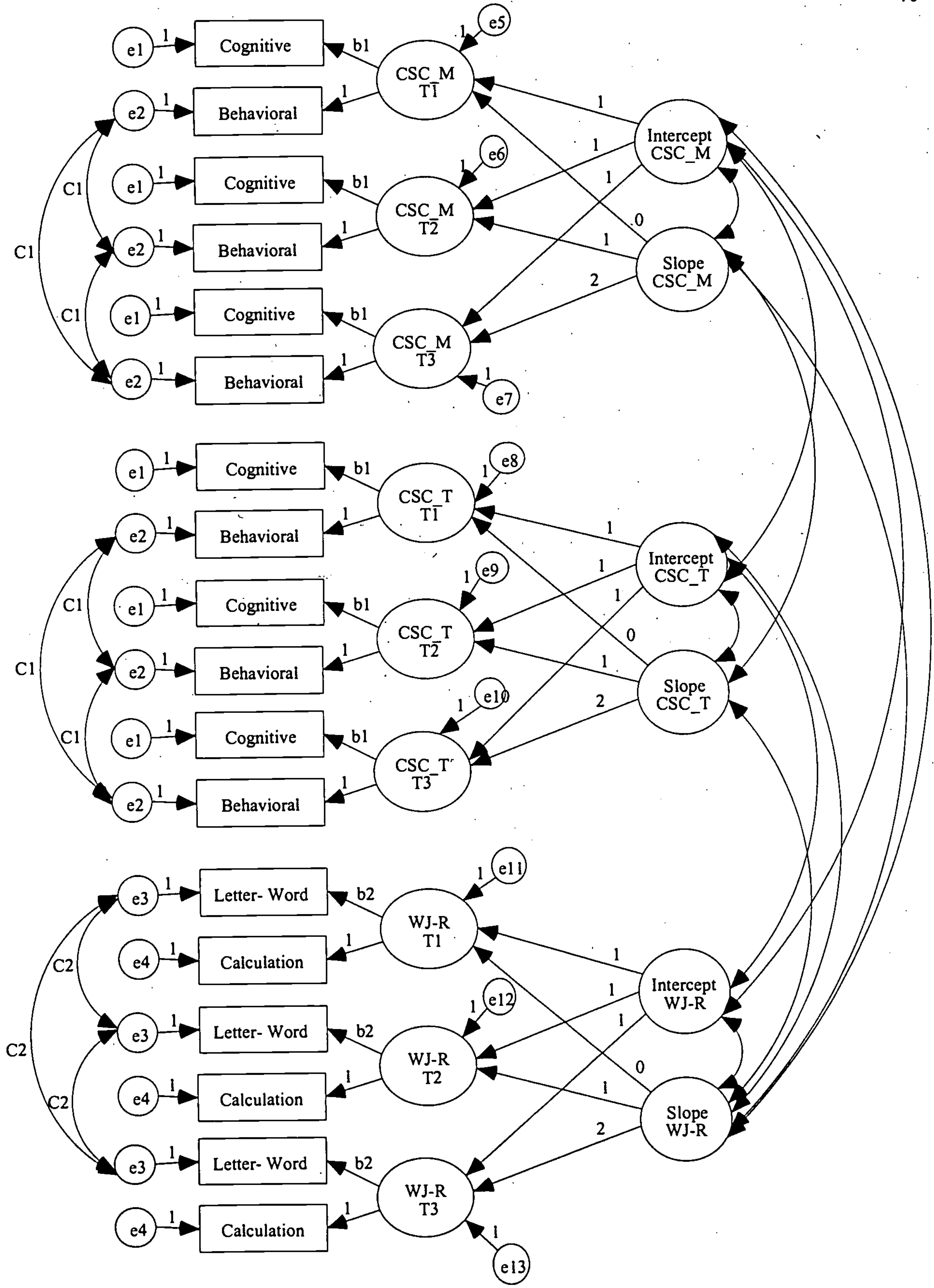

Figure 3. The second-order growth curve model for testing measurement invariance: Parallel versions of the Children's Self-Control Scale and Woodcock Johnson Measures

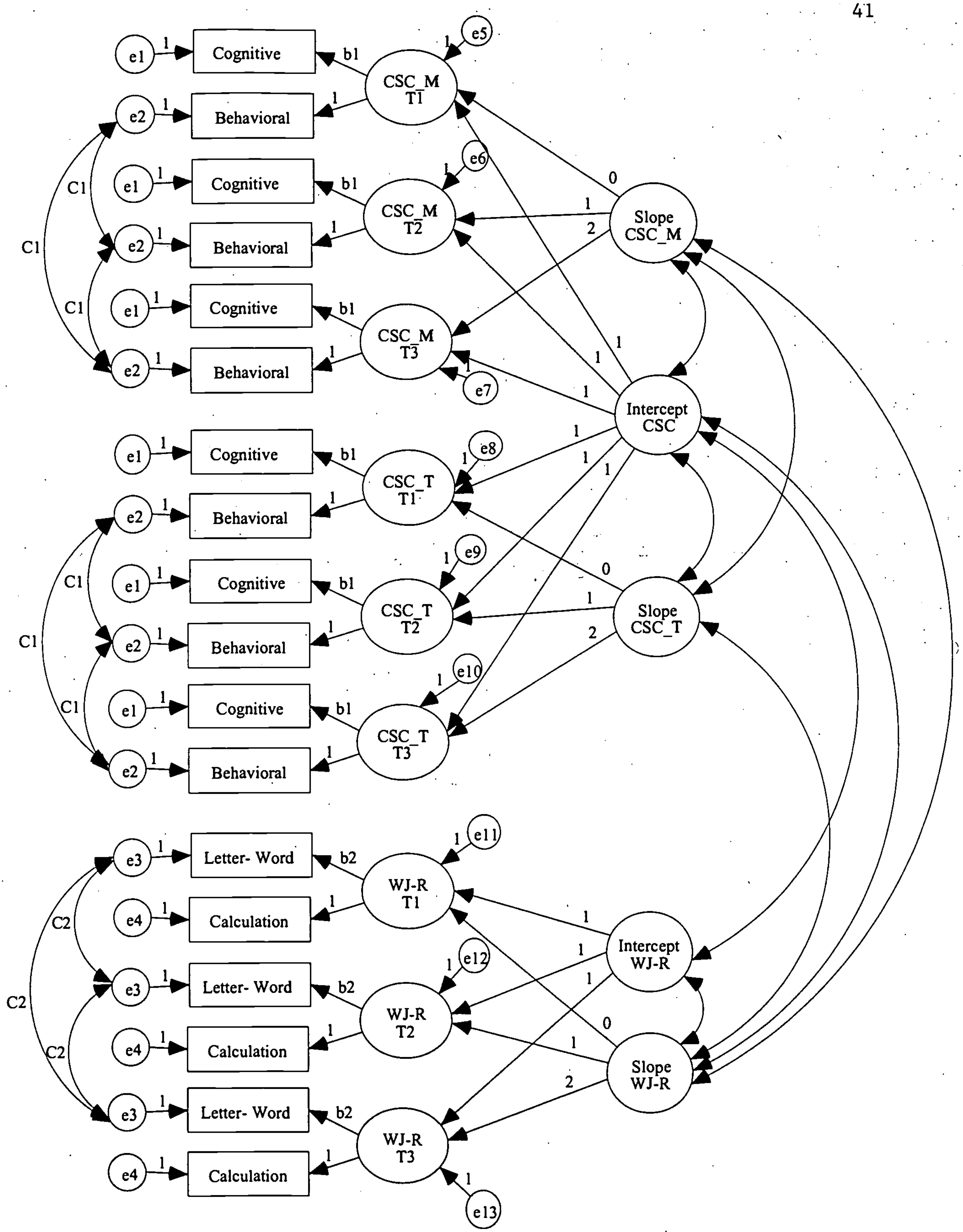

Figure 4. The second-order growth curve model based on common intercept factor for the CSC data

Reproduction Release

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Studying the relationship between children's self-control and academic achievement:

Author(s): Sooyeon Kim, Velma M. Murry, & Gene H. Brody

Corporate Source:

Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, Resources in Education (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign in the indicated space following.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY SAMPLE TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY SAMPLE TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY SAMPLE TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
Level 1	Level 2A	Level 2B
✔	☐	☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g. electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche, or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Signature: Ki, Sooyeon	Printed Name/Position/Title: Sooyeon Kim (Management information specialist)	
Organization/Address: Center for family research, University of Georgia, 1095 College Station Rd, Athens GA 30602-4527	Telephone: 706-425-2977	Fax: 706-425-2985
	E-mail Address: sykim@arches.uga.edu	Date: April 4, 2001

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, or, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:	
ERIC Clearinghouse on Assessment and Evaluation **1129 Shriver Laboratory (Bldg 075)** **College Park, Maryland 20742**	**Telephone: 301-405-7449** **Toll Free: 800-464-3742** **Fax: 301-405-8134** **ericae@ericae.net** **http://ericae.net**

EFF-088 (Rev. 9/97)