The Influence of Socioeconomic Disadvantage and Low Birth Weight on Child Academic Achievement

(Extended Abstract)

While there is a growing literature utilizing longitudinal data to examine the association between birth weight and human capital formation, more research is needed address the relative influence of low birth weight status in addition to risks associated with poverty and economic disadvantage. The poverty literature has established a strong link between economic disadvantage and hardship, family structure and developmental outcomes (Lichter et al. 2005; Duncan and Brooks-Gunn 1997; McLoyd 1998; Korenman et al. 1995). However, few studies utilizing large scale longitudinal data have examined the relative influence of birth weight and economic disadvantage on children's achievement trajectories (Boardman et al. 2002 are a notable exception). We use data from a recent nationally representative sample of children designed to study children's human capital formation to examine the relationship between birth weight, and social risk factors/disadvantage.

The academic performance of LBW children relative to their NBW peers is an important issue for parents, and the educators and doctors who decide the necessity of special medical or educational services (Klebanov et al. 1994a). Studies suggest that lower birth weight children are at greater risk for school-related problems than those born heavier, and the risks appear to increase as birth weight decreases (Reichman 2005; McCormick et al. 1994; Klebanov, Brooks-Gunn, and McCormick 1994a,b; Hack, Klein, and Taylor 1995). Not surprisingly, given the birth weight gradient on cognitive skills, the school achievement and performance of lower birth weight children is inhibited both in childhood (Klebanov, Brooks-Gunn, and McCormick 1994a; Klein, Hack, and Breslau 1989) and adolescence (Boardman et al. 2002). Outcomes in young adulthood are also implicated since sibling birth weight discordance is associated with the likelihood of high school graduation (Conley and Bennett 2000, 2001).

Children by social class and racial/ethnic background are not at equal risk for LBW, with those facing the most detrimental social conditions also more likely to be born prematurely and/or of lower birth weight (Paneth 1995; Cramer 1995; Sastry and Hussey 2003). Gaps in birth weight among social, economic, racial and ethnic groups, and geographic areas have not substantially lessened in recent years despite increased medical care expenditures (Marmot et al 1987; Hahn et al 1995; Pappas et al 1993; in Gortmaker and Wise 1997). Children who grow up in disadvantaged backgrounds are at increased risk of lower achievement and increased developmental problems due to a lack of resources, physical health problems, poor school environments as well as overcrowding and risky environments at home (Duncan and Brooks-Gunn 1997). For families in poverty, parents have a higher prevalence of mental and physical health problems which contribute to potential declines in both employment and the ability to effectively invest in parenting their children's developmental and academic well-being (McLoyd 1998). In addition to objective poverty measured by income, socioeconomic status (or a family's placement in a hierarchy based on access to valued commodities such as wealth and status) is seen as an indicator of economic advantage or disadvantage in families (Duncan et al. 1994; Brooks-Gunn, Klebanov, & Liaw 1995). Parents who have more access to valued commodities may be more likely to provide their children with improved schooling environments, choose to send their children to better schools, live in safer neighborhoods, and have access to health care they may not otherwise be able to afford. While providing these amenities for their children, they may also have the time and ability to invest more in their children in terms of their success in school (i.e. concerted cultivation; Lareau 2003).

Prior research addressing poverty and child development emphasizes the importance of poverty and deprivation in setting children on a trajectory that is not easily remedied. Because children experiencing disadvantage enter school with a deficit, already scoring lower cognitively than their non-poor counterparts (Smith, Brooks-Gunn, and Klebanov 1997; Mayer 1997) they face challenges catching up with their non-poor peers. In addition to familial contextual factors related to poverty influencing children's development, children's health also plays an important role. Birth weight, as noted above, is an important health indicator linked with developmental outcomes and human capital formation. Having a low birth weight child is highly correlated with being in poverty and can have potentially far reaching effects on later educational outcomes in adulthood (Conley and Bennett 2000). While the results using large scale longitudinal data sets is limited, there is evidence that being low birth weight is significantly associated with lower test scores in early and middle childhood (Boardman et al. 2002) especially for children who are considered very low birth weight based on an array studies examining the risk associated with birth weight status.

The risk factors associated with birth weight status as well as with socio-economic disadvantage may lead to increased risks of adverse outcomes for poor children and persist over time. Because parents of higher socioeconomic status have the time and the resources to invest in their children's development (Lareau 2003) and provide support in instances where their children may require it, they are less likely to be as negatively effected by the risk of low birth weight relative to their poorer counterparts. The purpose of this study is to 1) examine relative contributions of birth weight status and socioeconomic disadvantage among a large scale sample of children sharing the same environments (fixed effects) on teacher reported achievement test scores and behavioral assessments.[1] In addition we examine 2) whether initial birth weight disadvantages are due to poverty, background characteristics, and 3) whether these disadvantages persist or accumulate over time. 4) Finally we explore the extent to which being low birth weight exacerbates the impact of social disadvantage on children's outcomes (or vice versa).[2]

Data & Methods

We use four waves of the Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K) to assess the relationship between children's mathematics and reading learning and birth weight. Developed under the sponsorship of the U.S. Department of Education, National Center for Education Statistics (NCES), the ECLS-K is a longitudinal study focusing on children's early school experiences beginning at kindergarten entry. The ECLS-K data were collected using a three-stage stratified sampling procedure. A sample of approximately 23 children from over each of 1,000 public and private schools offering kindergarten programs was selected from a sample of geographic areas consisting of a county or groups of counties. Information was gathered from the children, their families, teachers, and school administrators (see NCES 2000).

The data used are drawn from the fall of kindergarten, spring of kindergarten, the fall of first grade, spring of first grade, and spring of third grade surveys. Table 1 provides the descriptive statistics of the sample (N=12,888) disaggregated by birth weight status. Normal birth weight (NBW) is defined as birth weight ≥ 2500g while low birth weight and very low birth weight are defined as births weighing 1500g <2500g and births weighing <1500g respectively.

Variables

Dependent Variables: Academic achievement is measured using IRT scaled mathematics and reading tests from kindergarten entry through the spring of third grade. *Birth Weight and the Independent Variables.* We divide birth weight in grams by 500 so that coefficient estimates reflect expected 500 gram differences in birth weight. Nonparametric exploratory analyses utilizing lowess curves suggested that the growth parameters from our regression models (below) indicated that the association between birth weight and children's skills at kindergarten entry and subsequent growth were well-approximated by a quadratic curve, so we leave birth weight continuous and also include a quadratic term. In addition, we construct a *parental investment in education* variable based upon Lareau's (2003) observations using indicators reflecting child participation in extra-curricular activities, parent involvement with the

[1] Later versions of this paper will include analyses with interactions as well as more analyses on child internal and external behavior problems.

[2] The final draft will include interactions on poverty and background characteristics and birth weight.

school, and the number of books in the home (for details see Cheadle 2005). In addition to these variables we also control for poverty status, AFDC/TANF receipt, socioeconomic status, race/ethnicity, family structure, whether the child was a premarital birth, whether the child received center- or home-based care, and Head Start participation.

The Model

We model children's mathematics and reading achievement using a multilevel free-loading growth curve model (Bollen and Curran 2006, pgs. 98-103). This model relates children's achievement scores to growth through a random intercept and random slope, while allowing the pattern of change to be nonlinear through the freely estimated time scores relating the temporal slope to the individual items. The factor loadings relating the first and last observations are from to 0 and 1, respectively, to fix the metric of time. The intercept captures the expected scores of children at kindergarten entry, while the slope represents change over the kindergarten through third grade period, while period specific estimates can be derived through the estimated factor loadings for observations 2-4 (λ). The factor loadings capture the proportion of cumulative total growth over the kindergarten year (time 1 – time 2), the summertime (time 2 – time 3), the first grade year (time 3 – time 4), and the second and third grade years (time 4 – time 5). In addition, the solid circles associated with the achievement scores at each wave depicted in Figure 1 represent random intercepts which are used to model a free-loading growth model in the school-level part of the model (per Muthén and Muthén 2006). Thus, the model depicted in Figure 1 is a multilevel latent growth curve model, although this model departs from the normal multilevel growth model by (a) allowing time to be nonlinear through the free estimation of the factor loadings, (b) allowing the within-child residual variances to vary across items, and (c) allowing residual variances in the between schools growth curve.

Because multilevel models assume that exogenous covariates are uncorrelated with the random effects, and also to facilitate interpretation, we school-mean center the child and family covariates so that coefficients estimates reflect expected differences between children who attend the school, which are analogous to econometric fixed-effects estimates (Allison 2005). Because birth weight is in grams and is divided by 500, the intercept captures early childhood learning disparities at kindergarten between schoolmates differing by 500g of birth weight, while the relationship between birth weight and the slope parameters represents the accumulation of disadvantage in children's reading and math scores from kindergarten through the third grade between schoolmates differing by a birth weight of 500g.

Results[3]

Results for the preliminary mathematics and reading results are presented in 2, with the mathematics results on the left and the reading on the right, for a restricted specification including birth weight and birth weight squared (Model A), and a model including main-effects for family circumstances (Model B).[4] Standard errors are presented next to the regression parameters and are enclosed in parentheses.

Mathematics Achievement

Children enter school scoring nearly 20 points on the mathematics test, on average, and gain nearly 65 points by the scaled test metric at the spring of the third grade. Approximately 12% of their total growth occurs over the kindergarten year, with most of the mathematics learning occurring over the second and third grade years (100(1.0-.225)=77.5%). Both the linear and quadratic birth weight terms are statistically associated with children's skills at kindergarten entry, and consistent with a cumulative deficit hypothesis, are also associated with children's growth. The relationship between birth weight and skills at kindergarten entry and subsequent growth are displayed graphically in Figure 2. Both panels of Figure 2 suggest that the birth weight effect are driven principally by the lower achievement

[3] Due to space limitations we restrict the discussion principally to the relationship between birth weight and (a) children's academic skills at kindergarten entry and (b) growth over the study period.

[4] In future versions of this paper we plan on exploring the moderating impact of social context on the relationship between birth weight and children's academic outcomes.

and consequent growth by lower birth weight children, which largely conforms to expectations from the prior birth weight literature which used dummy variables for birth weight implying a stepwise function.[5] The gap between a 1500g child and a child of average birth weight (3,365g) in Model B is a sizeable effect of over 2 points or about .36 standard deviations (using the between-child variance[6]). Similarly, the nearly 5 point decrement in accumulated growth is a standardized gap of nearly .43 standard deviations. These gaps, net of a variety of important family context variables, indicate that lower birth weight children (a) enter school performing poorly relative to higher birth weight children (utilizing the comparison above, about 10% of their total average achievement), and (b) lower birth weight children grow more slowly than other children, accumulating learning disadvantages relative to their schoolmates as they age (about 8% of total growth).

Reading Achievement

Children begin their school careers scoring approximately 23 points on the reading achievement test, although there is substantial heterogeneity both between children and schools. Between kindergarten entry and the spring of third grade children on average acquire an additional 85 points although, again, there is a great deal of variation in children's growth between both students and schools. Children learn a substantial portion of their end-of-third grade reading skills, as measure by the test, by the end of the first grade (about 80%). Birth weight, across both Model A and B, shows a significant statistical association with children's reading achievement at kindergarten entry and subsequent growth. In model B a 1500g child enters schools with an expected score of 21.5 points, all else equal, which is a 1.5 point or .2 standard deviation gap. That is, a 1500g child is expected to learn 3.1 points fewer than other children over the subsequent years, which is approximately .32 standard deviations. These gaps, net of a variety of important family context variables, indicate that lower birth weight children (a) enter school performing poorly relative to higher birth weight children, and (b) lower birth weight children grow more slowly than other children, accumulating learning disadvantages relative to their schoolmates as they age. Although the accumulated disadvantage in growth effect size is moderate, however, the disadvantage relative to children's total average knowledge at kindergarten entry is modest (only 6.5%, comparing a 1500g to a 3365g child), while the learning deficit relative to total learning is smaller yet (only 3.6%). Thus, relative to other children, lower birth weight children underperform at kindergarten entry, and grow more slowly, but given the total amount of knowledge gained, on average, the effect sizes are modest to small.

Policy Relevance

While not all studies report birth weight impacts (Padilla et al. 2002), there is a large medical literature suggesting important developmental consequences (partially noted above; see also Boardman et al. 2002). However, the extent to which the effect is due to correlated social and economic factors remains an important area of inquiry. Since birth weight is an important characteristic of population health, isolating the birth weight effect from social confounders including poverty and familial background characteristics correlated with birth weight provides information both on birth weight, *per se*, and the extent to which birth weight proxies for, or is a pathway through which, social disadvantage operates. In order to effectively implement appropriate policies that target populations in need, it is important to understand the *nature* of the need and the extent to which a characteristic like birth weight represents a meaningful status in its own right, or surrogates for one. Policy makers, when attempting to design treatment for LBW children, particularly those in the normal range and not suffering from severe biological trauma, would benefit from knowing whether or not they need to treat biology or social disadvantage, or the nature and extent of the pairing of these factors.

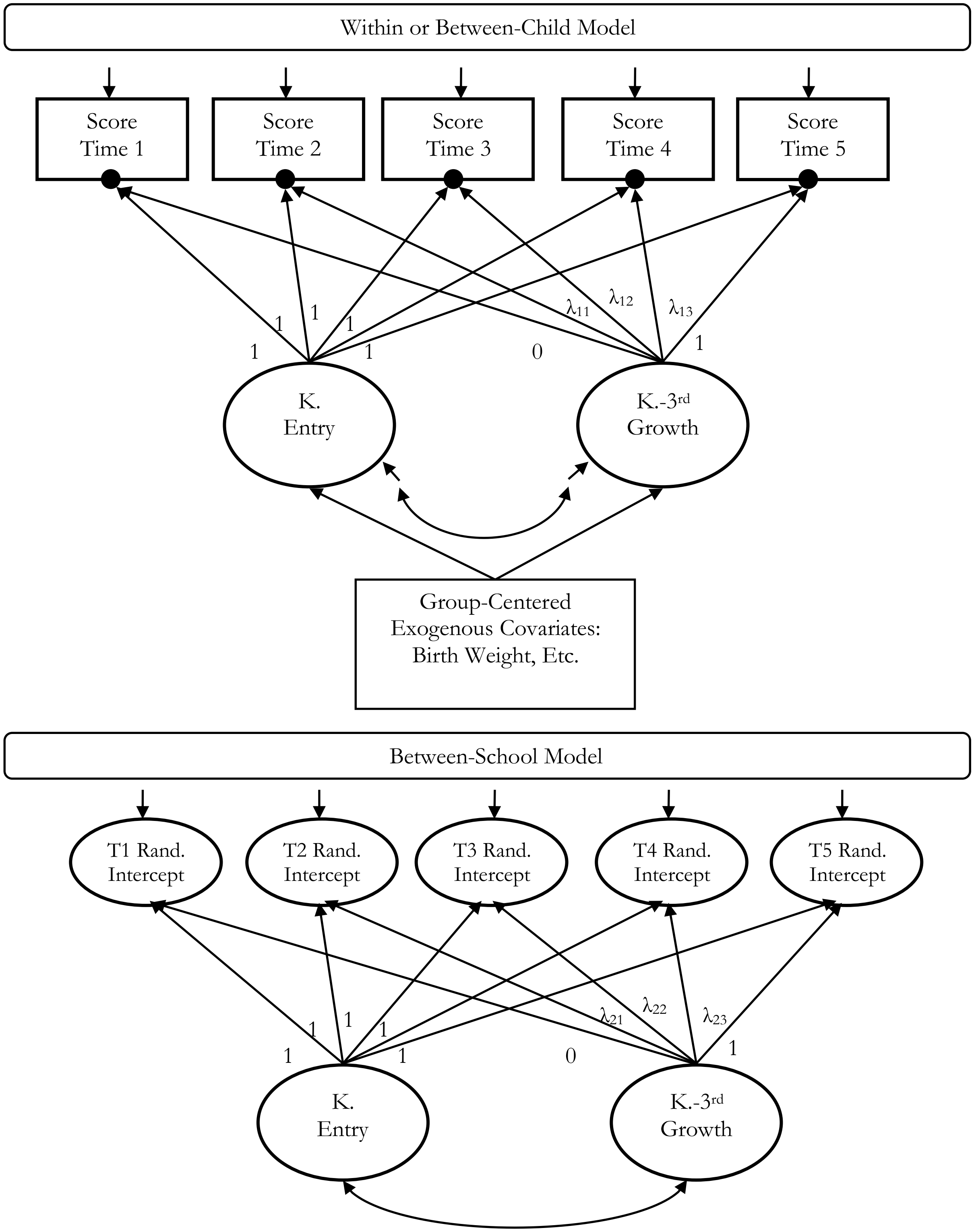
[5] As noted above, exploratory nonparametric analyses suggested that the birth weight associations we describe are well-approximated with a quadratic curve.

[6] Obviously, adding in the between-school standard deviation would result in smaller estimate. The estimate we provide in text captures the standardized difference between children who attend the same schools.

Table 1: Means, Standard Deviations, and Proportions at Kindergarten Entry by Birth Weight Status (ECLS-K).

Variables	Total	NBW	LBW	VLBW
N	12888	11960	815	113
Proportion		0.927	0.063	0.009
African American	0.125	0.117	0.212	0.274
Hispanic	0.166	0.164	0.172	0.222
Asian	0.048	0.047	0.064	0.009
Female	0.492	0.49	0.542	0.557
In Poverty	0.178	0.175	0.221	0.309
AFDC Receipt	0.091	0.088	0.145	0.106
SES (composite score)	0.058	0.07	-0.069	-0.251
(SD)	(.979)	(.977)	(.991)	(.914)
Parental Education Investments	0.087	0.102	-0.094	-0.151
(SD)	(.986)	(.983)	(0.983)	(1.04)
Mother's Age (years)	33.11	33.15	32.55	32.63
(SD)	(5.87)	(5.81)	(6.45)	(7.00)
Premarital Birth	0.259	0.251	0.356	0.407
Single Parent	0.196	0.192	0.267	0.274
Step-parent	0.071	0.069	0.089	0.124
Home-based Care	0.242	0.242	0.255	0.203
Head Start	0.082	0.079	0.11	0.186
Center-Based Care	0.497	0.499	0.467	0.398

Figure 1: Graphic Description of Multilevel Free-Loading Latent Growth Curve Model.



Note: The solid circles in the within model denote random intercepts that are allowed to vary between clusters and are operationalized in the between-school model as latent variables (Muthén and Muthén 2006).

Figure 2: Graphical Depictions of the Relationship between Birth Weight and (a) Children's Mathematics Skills at Kindergarten Entry and (b) Growth over the K-3rd Grade Period.

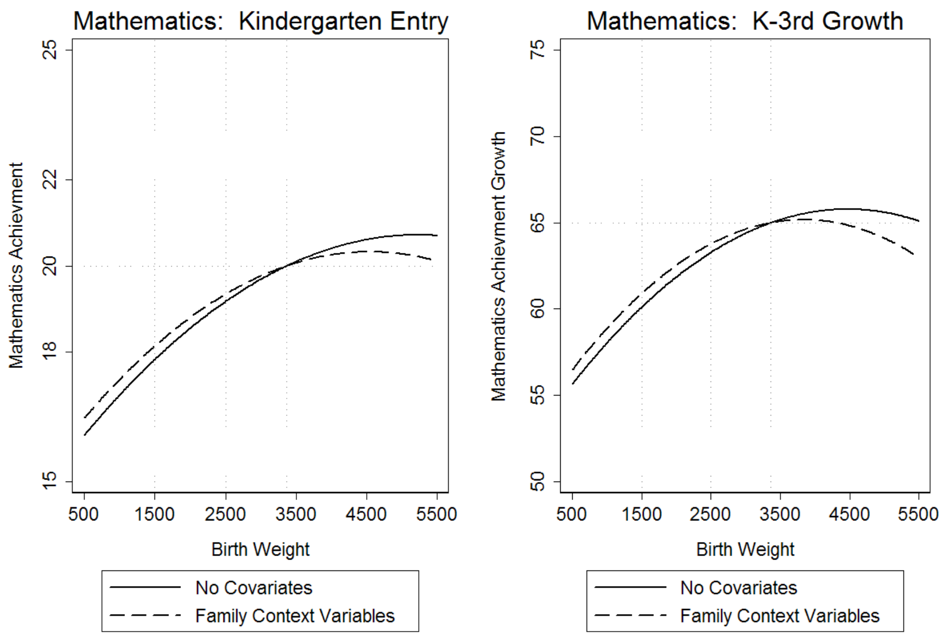


Figure 3: Figure 4: Graphical Depictions of the Relationship between Birth Weight and (a) Children's Reading Skills at Kindergarten Entry and (b) Growth over the K-3rd Grade Period.

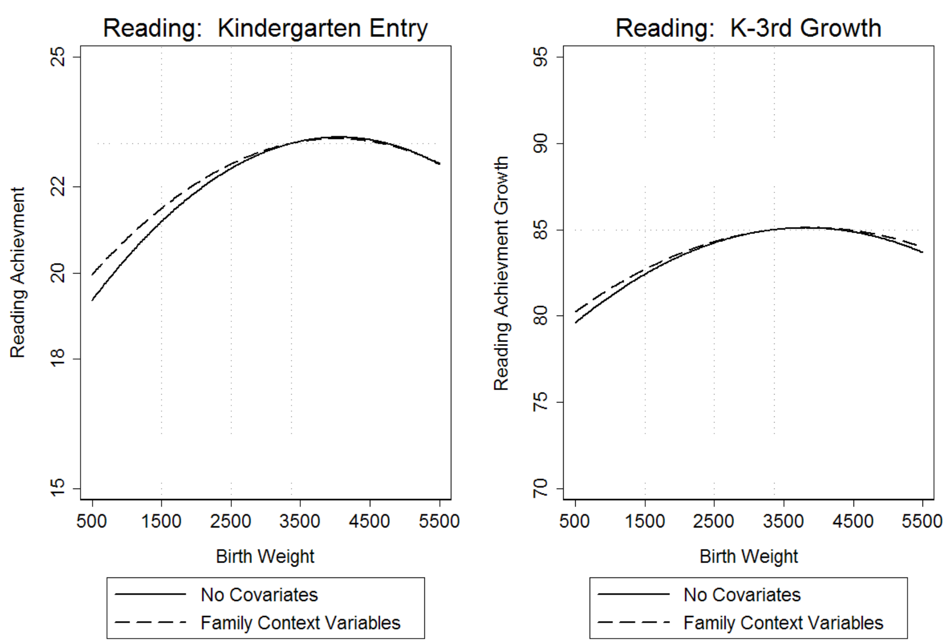


Table 2: Preliminary Multilevel Mathematics and Reading Growth Models with Estimated Time Scores, Including Group-Mean Centered Child and Family Covariates.

	Mathematics						Reading					
Variables/Parameters	A	(se)		B	(se)		A	(se)		B	(se)	
Kindergarten Entry	19.979	(0.131)	*	19.971	(0.131)	*	23.054	(0.154)	*	23.015	(0.155)	*
Birth Weight[a]	1.086	(0.264)	*	1.071	(0.257)	*	1.215	(0.347)	*	1.026	(0.333)	*
Birth Weight^2	-0.052	(0.021)	*	-0.059	(0.020)	*	-0.075	(0.027)	*	-0.064	(0.026)	*
Age at K. Entry	0.391	(0.016)	*	0.372	(0.015)	*	0.290	(0.020)	*	0.279	(0.020)	*
Black				-0.908	(0.230)	*				-0.280	(0.292)	
Hispanic				-1.070	(0.199)	*				-0.944	(0.263)	*
Asian				1.729	(0.331)	*				3.167	(0.538)	*
Female				-0.093	(0.054)					0.532	(0.072)	*
Poverty				-0.029	(0.158)					0.051	(0.200)	
AFDC Receipt				-0.324	(0.180)					-0.450	(0.232)	
SES				1.268	(0.090)	*				1.789	(0.125)	*
P. Ed. Investments				1.344	(0.075)	*				1.405	(0.099)	*
Mother's Age				0.041	(0.010)	*				0.021	(0.014)	
Premarital Birth				-0.195	(0.138)					-0.153	(0.184)	
Sinble Parent				-0.138	(0.142)					-0.344	(0.193)	
Step Parent				-0.068	(0.211)					-0.317	(0.261)	
Home-Based Care				0.414	(0.162)	*				0.303	(0.218)	
Head Start				-0.062	(0.221)					-0.216	(0.264)	
Center-Based Care				0.962	(0.154)	*				1.257	(0.205)	*
K-3rd Growth	64.993	(0.222)	*	64.970	(0.222)	*	84.745	(0.282)	*	84.760	(0.281)	*
Birth Weight	2.876	(0.673)	*	3.003	(0.651)	*	1.906	(0.568)	*	1.656	(0.582)	*
Birth Weight^2	-0.161	(0.051)	*	-0.196	(0.049)	*	-0.125	(0.043)	*	-0.107	(0.044)	*
Age at K. Entry	0.065	(0.032)	*	0.026	(0.031)		0.115	(0.028)	*	0.120	(0.028)	*
Black				-4.995	(0.630)	*				-1.164	(0.511)	*
Hispanic				-0.104	(0.485)					0.331	(0.409)	
Asian				2.028	(0.652)	*				1.662	(0.627)	*
Female				-1.581	(0.124)	*				0.870	(0.114)	*
Poverty				-1.033	(0.462)	*				-1.526	(0.397)	*
AFDC Receipt				-0.469	(0.553)					-1.130	(0.433)	*
SES				2.279	(0.175)	*				1.176	(0.169)	*
P. Ed. Investments				1.289	(0.183)	*				0.834	(0.157)	*
Mother's Age				-0.025	(0.025)					-0.035	(0.021)	
Premarital Birth				-1.220	(0.364)	*				-0.767	(0.307)	*
Sinble Parent				0.351	(0.393)					-0.029	(0.334)	
Step Parent				-0.350	(0.534)					0.020	(0.450)	
Home-Based Care				0.314	(0.404)					0.140	(0.334)	
Head Start				-1.439	(0.612)	*				-1.591	(0.494)	*
Center-Based Care				0.760	(0.360)	*				-0.266	(0.319)	
Variances												
Child: K. Entry	30.566	(0.713)		26.784	(0.625)	*	61.012	(2.239)	*	54.936	(2.055)	*
Child: K-3rd Growth	135.534	(4.898)		128.118	(4.768)	*	94.664	(3.810)	*	92.106	(3.553)	*
School: K. Entry	10.899	(0.707)	*	11.313	(0.714)	*	16.606	(1.247)	*	17.512	(1.279)	*
School: K-3rd Growth	14.598	(2.099)	*	15.283	(2.124)	*	36.216	(3.695)	*	36.173	(3.682)	*
RMSEA	0.068			0.041			0.067			0.043		

Time Scores	Within	Between	Within	Between	Within	Between	Within	Between
Time 1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Time 2	0.125	0.125	0.120	0.126	0.341	0.120	0.337	0.120
Time 3	0.190	0.203	0.181	0.203	0.570	0.185	0.564	0.185
Time 4	0.225	0.363	0.218	0.363	0.809	0.388	0.797	0.389
Time 5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

* $p<.05$

Notes: [a] Birthweight = (birthweight in g)/(500g)

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