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Behavior problems at ages 6 and 11 and high school academic achievement: Longitudinal latent variable modeling

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A R T I C L E I N F O

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A B S T R A C T

Previous studies documented long-run effects of behavior problems at the start of school on academic achievement. However, these studies did not examine whether the observed effects of early behavior problems are explained by more proximate behavior problems, given the tendency of children's behavior problems to persist. Latent variable modeling was applied to estimate the effects of behavior problems at ages 6 and 11 on academic achievement at age 17, using data from a longitudinal study ($n = 823$). Behavior problems at ages 6 and 11, each stage independently of the other, predicted lower math and reading test scores at age 17, controlling for intelligence quotient (IQ), birth weight, maternal characteristics, family and community environment, and taking into account behavior problems at age 17. Behavior problems at the start of school, independent of later behavior problems, exert lingering effects on achievement by impeding the acquisition of cognitive skills that are the foundation for later academic progress.

1. Introduction

Behavior problems during the early school years curtail educational attainment, adversely influencing long-term social and economic outcomes (McLeod and Kaiser, 2004; Groot and van den Brink, 2007; Breslau et al., 2008). One-way in which behavior problems influence academic attainment is by impeding the acquisition of academic skills and the successful progression in school. Duncan et al. (2007) have documented the longitudinal association of children's attention problems at school entry with academic achievement at the end of primary school, based on data from six studies (Duncan et al., 2007). The evidence on the longitudinal association between attention and academic achievement has been subsequently extended up to the conclusion of high school (HS) (Breslau et al., 2009). In these studies, children's attention problems were correlated with externalizing (disruptive) and internalizing (emotional) problems and all three types of problems predicted subsequent academic achievement. However, regression-adjusted estimates singled out attention as the only unique predictor, when the correlations among the three types of problems were taken into account (Duncan et al., 2007; Breslau et al., 2009). An additional analysis suggested that change in attention problems during the early school years might be followed by change in academic achievement (Breslau et al., 2010), providing a clue for the relevance of more proximate behavior problems to high school academic success.

Previous investigations did not examine whether the observed longitudinal association between early behavior problems and achievement reflect the tendency of behavior problems to persist. The long-run effects of behavior problems at the start of schooling on academic achievement at the end of high school might be explained by more proximate behavior problems. Is there evidence of an enduring effect of behavior problems at the start of school on high school achievement, even when children change or “outgrow” their early problems? This question has not been examined in previous studies.

In this study we attempt to advance the longitudinal inquiry in the following way. Using data on behavior problems at ages 6, 11 and 17, we examine the contribution of behavior problems at ages 6 and 11, each adjusted for the other, to math and reading test scores at age 17, taking into account behavior problems at age 17. We use an analytic approach, latent variable modeling, which takes advantage of our rich assessment of key variables, the longitudinal design of the study, and the availability of information on important covariates.

2. Methods

2.1. Sample

Random samples of low birth weight and normal birth weight children were drawn from 1983 to 1985 newborn discharge lists of two major hospitals in southeast Michigan, one located in the City of Detroit and serving primarily the residents of the inner city (urban) and the other located in an adjacent suburb, serving residents of the surrounding middle-class suburbs. Of 1095 eligible children, 823 (75%) participated in the initial

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assessment in 1990–1992, when they were 6 years of age. Subsequent assessments were conducted in 1995–1997, when the children were 11 years of age ($n = 717$), and in 2000–2002, when they were 17 years of age ($n = 713$). Detailed information on the sample and its maintenance over the three assessments is available elsewhere (Breslau et al., 1996; Breslau and Chilcoat, 2000; Breslau et al., 2006; Breslau et al., 2009).

2.2. Measurement of key variables

At each assessment, children were rated by teachers using the Teacher's Report Form (TRF) (Achenbach, 1991a, 1991b). The TRF asks teachers to rate children based on observations of classroom behavior during the preceding 2 months. It consists of 118 items rated from 0 to 2 (0 indicates not true; 1, somewhat or sometimes true; and 2, very or often true). The TRF consists of eight syndrome scales: withdrawn, somatic complaints, anxious/depressed, social problems, thought problems, attention problems, delinquent behavior, and aggressive behavior. The TRF also yields scores on two broadband scales measuring externalizing and internalizing spectra. The externalizing broadband scale comprises the delinquent behavior and aggressive behavior scales. The internalizing broadband scale comprises the withdrawn, somatic complaints, and anxious/depressed scales. In this analysis, we used the attention syndrome scale and the externalizing and internalizing broadband scales as indicators of a latent variable of behavior problems. The attention problems subscale consists of 20 items, and the externalizing and internalizing problems scales consist of 34 and 36 items, respectively. The TRF scale scores are standardized (T) scores based on age and sex distributions of normative samples. The TRF has excellent reliability and validity. The 15 day test–retest reliability of externalizing problems is 0.92 and internalizing problems, 0.91. Internal consistency of the subscales and broadband scales range from 9.63 to 0. 97. Construct and criterion validity are also supported in methodological studies (Achenbach, 1991a, 1991b).

Academic achievement in math and reading at age 17 was measured by the Woodcock–Johnson Psycho-Educational Battery–Revised (WJ-R) (Woodcock and Johnson, 1990). Reading was measured by Basic Reading and Reading Comprehension. Math was measured by Calculation and Applied Problems. These tests are used in this analysis as indicators of latent variables of achievement in the two core school subjects, reading and arithmetic. The WJ-R tests are age-standardized and have a mean of 100 and SD of 15 in the general population.

The Wechsler Intelligence Scale of Children–revised (WISC-R) (Wechsler, 1974) was used to measure children's intelligence quotient (IQ) at age 6. The IQ test is age-standardized and has a mean of 100 and standard deviation of 15 in the general population. Mother's IQ was measured by the Two-Subset Short Form of the WAIS-R (Silverstein, 1982).

Mothers rated the family environment as measured on the Family Environment Scale (FES) (Moos and Moos, 1981; Moos and Moos, 1994) at baseline assessment. In this study we use three scales: active/recreational, which measures the variety and amount of participation in social and recreational activities, cohesion, which measures the degree of commitment and support family members provide for one another, and conflict, which measures the amount of openly expressed anger and conflict among family members. Cohesion and conflict have been related to children's behavior problems and active/recreational (as a measure of environmental complexity) can be expected to be related to children's cognitive development. Each of these subscales comprises nine true–false items. Internal consistency reliabilities of the FES scales range from 0.61 to 0.78, and test–retest reliability ranges from 0.68 to 0.86 for a 2-month interval and 0.54 to 0.91 for a 4-month interval.

2.3. Analytic framework

We use multivariate models developed within latent variable modeling (LVM) (Muthen, 2002; Raykov and Marcoulides, 2006; Raykov and Marcoulides, 2008), using Mplus (Muthen and Muthen, 2008). Latent variables are not directly measurable; they can only be evaluated through their indicators. The LVM method offers important advantages over standard regression approaches. One, LVM allows us to examine complex models of relationships among multiple outcome and explanatory variables. Two, common sources of observed variability that underlie interrelated response variables are explicitly taken into account. Three, fallible explanatory variables, which would lead to unreliable parameter estimates if used in traditional regressions that assumes error-free predictors (Bollen, 1989), are included in the models as indicators of latent variables. Four, robust maximum likelihood estimation permits use of all available data, including those from subjects with incomplete data. This allows an efficient handling of missing data in the empirical setting of this longitudinal study, in addition to dealing with mild deviations from multinormality in response variables. Note that sample retention has been high and that the sample with complete data from all assessments has been found to represent closely the initial sample (Breslau et al., 2009). Five, latent variable models in a repeated measure context, as in this study, do not make restrictive assumptions of classical analysis-of-variance approaches, such as sphericity, covariance matrix homogeneity and error-free covariates (Bollen and Curran, 2006). Moreover, in this study, the models utilize information about temporal order of longitudinally measured variables, whereas in traditional regression approaches there is no temporal distinction among predictors (Fitzmaurice et al., 2008).

2.4. Models

Figs. 1 and 2 display graphically the two models used in this analysis. The figures follow a path-diagram convention in LVM applications (e.g., Jöreskog and Sörbom, 1996). Observed variables are represented by squares, while latent variables are represented by circles. Long one-way lines, or curves, ending with an arrow head, symbolize assumed explanatory role played by the variables at the lines' origin in relation to dependent variables. Two-way arrows represent correlation of the variables they connect. Short one-way arrows symbolize residual terms, such as measurement error for observed variables and disturbance terms for dependent latent variables (the combined effect of variables not included explicitly in the model). For graphic simplicity, observed covariates measured at age 6 and the latent variable behavior problems at age 6 are listed in a single vertical rectangle on the left side.

Model 1(Fig. 1) is a confirmatory factor analysis that represents the relationships of each of the five latent variables with its indicators. Model 1 can be referred to as a measurement model (Anderson and Gerbing, 1988). Model 2 (Fig. 2) uses the latent constructs of math and reading, which represent the common sources of variability in the WJ-R tests that measure their respective areas (Woodcock and Johnson, 1990). Additionally, the model uses the latent constructs of behavior problems at ages 6, 11 and 17, which represent the common sources of variability in the teacher-rated Attention, Externalizing and Internalizing scales at corresponding ages. Behavior problems constructs at ages 6 and 11 are posited as predictors for the math and reading constructs at age 17, as well as the behavior problems construct at age 17. In this model, the error terms associated with the same indicator of the behavior problems construct are assumed to be correlated over time. Such correlations are commonly used as model parameters in repeated measures analysis and reflect the residual term interrelationships of the indicator's unique component (not explained by the common factor) that persists over repeated assessment. The model controls for the following covariates measured at age 6: (1) mother's characteristics — IQ, education, and marital status; (2) family environment characteristics — community: urban or suburban, Cohesion, Conflict, and Active/Recreational Orientation; and (3) child characteristics — birth weight, sex, and IQ.

3. Results

3.1. Measurement model of latent variables

Model 1 (corresponding to Fig. 1) has the following fit indexes: $\chi^2 = 145.333$, degrees of freedom (d.f.) = 54, and root mean square error of approximation (RMSEA) = 0.045; 90% confidence interval 0.037, 0.054. Table 1 shows high factor loadings of the individual indicators of each latent variable. At all ages, the attention scale had the

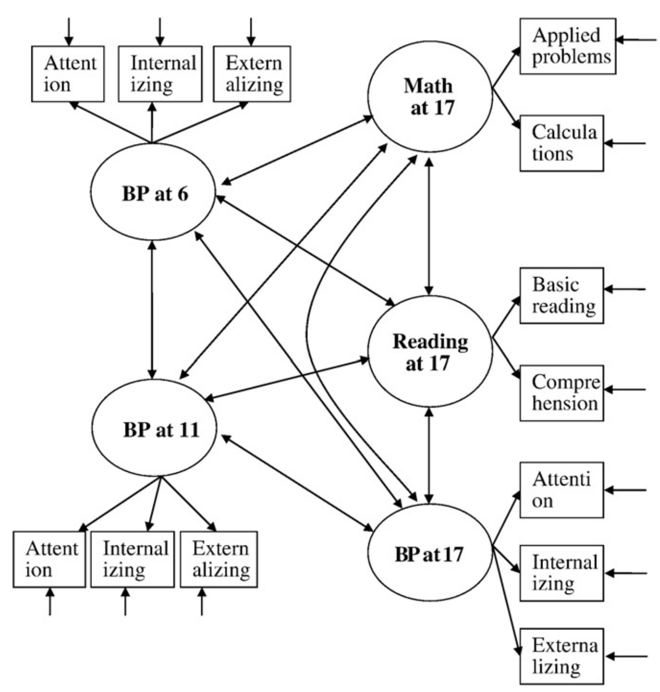

Fig. 1. 1. BP6, BP11, and BP17 = behavior problems constructs at ages 6, 11 and 17, respectively. 2. Error terms of the same indicators of behavior problems constructs are correlated over time. (These are not depicted, to avoid graphical clutter).