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Beyond Prediction: Establishing the Causal Role of Self-Control in Achievement

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Running head: CAUSAL ROLE OF SELF-CONTROL

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Abstract

The predictive validity of personality for important life outcomes is well-established, but conventional longitudinal analyses cannot rule out the possibility that unmeasured third-variable confounds fully account for the observed relationships. Longitudinal hierarchical linear models (HLM) with time-varying covariates allow each subject to serve as his or her own control, thus eliminating between-individual confounds. HLM also allows the directionality of the causal relationship to be tested by reversing time-lagged predictor and outcome variables. We illustrate these techniques through a series of models which demonstrate that within-individual changes in self-control over time predict subsequent changes in GPA, but not vice-versa. The evidence supporting a causal role for self-control was not moderated by IQ, gender, ethnicity, or income. Further analyses ruled out one time-varying confound: self-esteem. The novel analytic approach taken in this study provides the strongest evidence to date for the causal role of self-control in determining achievement.

Keywords: Causal modeling, self-control, self-regulation, academic achievement.

Beyond Prediction: Establishing the Causal Role of Self-Control in Academic Achievement

As every graduate student in psychology knows, correlation does not necessarily imply causation. What every graduate student may not know, or remember, is that even prediction does not necessarily imply causation. Thus, whereas the predictive validity of personality in general and of self-control in particular for important life outcomes is well-established (Duckworth & Seligman, 2005; Mischel, Shoda, & Rodriguez, 1989; Ozer & Benet-Martinez, 2006), no study has incontrovertibly ruled out the possibility that some unmeasured confound (i.e., a lurking third variable) fully accounts for the observed associations.

According to John Stuart Mill's classical formulation (Shadish, Cook, & Campbell, 2002), establishing a causal relationship requires three criteria: (1) temporal precedence (i.e., the cause precedes the effect); (2) covariance (i.e., the cause and effect are related); and, (3) disqualification of alternative explanations (i.e., no third variable accounts for the observed relationship). Random-assignment, double-blind, placebo-controlled experimental designs meet all three criteria. Temporal precedence is established by manipulating the hypothesized cause and measuring its subsequent effect on outcomes. Covariance between the hypothesized cause and outcome is established through statistical tests. Finally, potential third-variable confounds are controlled by randomly assigning participants to condition.

Manipulating personality in a random-assignment experiment could, in theory, establish its causal role for later outcomes, but, alas, personality is not easily manipulated. To our knowledge, no empirical investigation to date has successfully manipulated trait-level self-control and measured subsequent effects on life outcomes. (However, see Bandura & Mischel, 1965; Diamond, Barnett, Thomas, & Munro, 2007; Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005 for studies that make important strides in this direction.). Consequently, researchers interested in the relationship between self-control and life outcomes have resorted to correlational designs. Prospective longitudinal designs can satisfy temporal precedence, and a significant correlation, by definition, fulfills the covariance criterion. However, ruling out third variables remains a challenge. Although potential third variables can (and should) be anticipated, measured, and statistically controlled, it is theoretically impossible to be sure that one has measured all *potential* confounds.

Traditional longitudinal analyses that control for prior levels of the outcome can demonstrate that the relationship between X (e.g., self-control) at time 1 and Y (e.g., GPA) at time 2 is not due to the cross-sectional correlation between X and Y at time 1 and the autocorrelation between Y at time 1 and 2 (i.e., Y at time 1 is treated as a third-variable which is controlled by partialling out it's correlation with Y at time 2), but these designs do not rule out other potential third-variable confounds. Most panel models through path analysis or structural equation modeling are basically variants of this type of analysis.

We propose that longitudinal growth-curve modeling using hierarchical linear models (HLM) offers a partial solution to the third-variable problem. In particular, longitudinal HLM offers an opportunity to have each subject serve as his or her own control, thus eliminating between-individual third-variable confounds. Using repeated measures of both predictors and outcomes, we can examine within-individual covariance of these variables over time. To illustrate, in the current study we used HLM to model student achievement trajectories over four years and treat self-control as a time-varying covariate. Our findings provide the strongest evidence to date that self-control indeed causes—and doesn't merely predict—academic performance.

Controlling for time-invariant confounds

The lurking third-variable problem is rarely mentioned explicitly as a limitation in longitudinal studies, probably because one can never rule out *all* potential unmeasured confounds. But, we argue, one can and should at least admit the *possibility* of unmeasured third variables. Moreover, one should seek out innovations in statistical analysis that improve our ability, as Cronbach (1957) put it, to "observe and organize data from Nature's experiments" (p. 672).

Growth curve analysis using HLM is one such innovation. HLM can, for example, model change in an outcome over time by estimating a growth curve for each individual. Each growth curve conveys information about an individual's baseline (i.e., the intercept), and the change from one year to the next (i.e., the slope). When predictors are treated as time-varying covariates, they can be used to explain short-term deviations from the overall growth trajectory. By treating a predictor as a time-varying covariate in the prediction of trajectories, one can rule out the possibility of *all* time-invariant confounds (e.g., relatively stable variables such as socioeconomic status). Specifically, if short-term changes in a predictor predict subsequent short-term changes in achievement, a confounding variable Z would have to predict these changes and *also* be tightly yoked to changes in the predictor over time (i.e., the confound and predictor would have to go up and down together in synchrony over time). HLM also allows the directionality of the causal relationship to be confirmed by reversing the time-lagged predictor and outcome variables.

The current study

In the current study, we used HLM growth curve analysis with time-varying covariates to test the hypothesis that self-control plays a causal role in academic achievement. To increase reliability and validity, we employed a multi-source approach to measurement. Parent-, teacher-, and self-report ratings of self-control were collected in the fall of four consecutive academic years. At the conclusion of each academic year, final GPA was recorded from school records. In addition, in order to demonstrate how to control for possible time-varying confounds, we replicated these analyses with self-esteem as a covariate. Measured IQ, gender, ethnicity, and socioeconomic status were tested as possible moderators.

Method

Participants

The participants were students from a socioeconomically and ethnically diverse public magnet school in a city in the Northeastern United States. Students were admitted to this middle school based on prior grades and standardized test scores.

In Fall 2003, about 86% of the school's 164 fifth grade students (n = 142) elected to participate in a longitudinal study of character strengths and academic achievement in children. Signed child assent and parent consent forms which assured participants of the confidentiality of their data were received for all participants. In Fall 2004, 3 students left and 38 new students joined the cohort (now composed of sixth graders). In this revised cohort, 49 new students joined the study and 17 students did not reconsent. The final sample was composed of 189 participants who contributed data at least once in 2003 or 2004.

In mid-November 2003, when the first set of self-control measures were administered, the mean age of participants was 10.6 years (*SD* = 0.37). Approximately 48.9% of participants were Caucasian, 29.6% were Black, 13.2% were Asian, 5.8% were Latino, and 1.6% were of other ethnic backgrounds. Fifty-four percent of participants were female. Twenty-four percent of participants were from low-income families, as indicated by participation in the federal lunch program.

Procedure

We collected data over the four school years between 2003 and 2007 (i.e., from fifth to eight grade). Each fall, we collected self-report, parent, and teacher self-control questionnaires and self-report self-esteem questionnaires. Each spring, we recorded report card grades from school records. Approximately 57% of our sample had GPA and self-control data for all four years of the study, 26% had data for three years, 5% had data for two years, and 13% had data for one year. In Spring 2003, we collected IQ scores.

Measures

Self-control. The Brief Self-Control Scale (BSCS: Tangney, Baumeister, & Boone, 2004) includes 13 items endorsed on a 5-point scale where 1 = *not like me at all* and 5 = *very much like me* (e.g., "I have a hard time breaking bad habits" and "I do certain things that are bad for me, if they are fun."). Parents and teachers completed a version of the BSCS written in the third-person, with the student as the target (e.g., "This child/student has a hard time breaking bad habits"). To avoid confounding teacher ratings and teacher-determined grades, students' homeroom advisors rather than course teachers completed the questionnaires. Observed internal reliabilities for self, parent, and teacher report self-control across the four years ranged from α = .83 to .96.

Self-esteem. The Rosenberg Self-Esteem Scale (Rosenberg, 1965) includes 10 items (e.g., "On the whole, I am satisfied with myself") endorsed on a four-point scale ranging from 1 = *Strongly Disagree* to 4 = *Strongly Agree*. Observed reliabilities across the four years ranged from α = .87 to .89.

Report card grades. GPA was measured on a 100-point scale. Overall GPA was used for statistical analyses.

Gender, ethnicity, and family income. We obtained gender, ethnicity, and home address information from school records. We used home address information in conjunction with U.S. Census Bureau (2000) data to estimate household income. To normalize the distribution for statistical analyses, we performed a natural log transformation on the income data.

IQ. As a measure of intelligence, we used the Otis–Lennon School Ability Test—Seventh Edition (Otis & Lennon, 1997) Level F. This 40-min group-administered, paper-and-pencil test measures verbal, quantitative, and figural reasoning skills. The school ability index for this test is a standard score normalized according to the student's age in months, with a mean of 100 and a standard deviation of 16. Normal curve equivalent scores were derived from percentile ranks for use in statistical analyses.

Data analysis strategy

We used HLM growth curve models to estimate baseline and annual change in observed outcomes for each student as they moved from 5^{th} grade through 8^{th} grade. Because the main goal of our analyses was to examine whether within-individual changes in self-control predicted changes in GPA, we included baseline and time-varying predictor variables to explore the potential causal relationship between self-control and achievement. In order to assess the possibility of bidirectional causality, we analyzed two sets of models: 1) GPA as the outcome with self-control as a time-varying covariate, and 2) self-control as the outcome with GPA as a time-varying covariate. In both sets of models, the time-varying covariates were measured six months prior to the outcome (see Figure 1). Time-varying covariates were centered around the individuals' means (see Raudenbush & Bryk, 2002, p. 31 for a discussion of centering). The individual mean was used as the baseline measure, which shows the long-term relationship between self-control and achievement, while the time varying measure shows the short-term (i.e., 6-month periodic) relationship between self-control and achievement. To improve interpretation of the models, we centered time at fifth grade (i.e., fifth grade = 0, sixth grade = 1, seventh grade = 2, etc.) so that the growth curve intercept for each student represented their baseline achievement (or self-control for the second model) for 5th grade.

Results

Self-control

Cross-sectional correlations among parent, teacher, and self-report ratings of self-control ranged from r = .18 to .51. We created a composite measure of self-control by averaging parent, teacher, and self-report scores on the BSCS. Over the four years of the study, approximately 15% of assessments were missing either parent, teacher, or self-report ratings; in these cases, we averaged the two non-missing scores. About 4% were missing two of these three scores; in these cases, we used the single non-missing scores.

Following Nunnally (1967), we calculated the reliability of these composite scores: .94, .95, .94, and .93, in grades 5 through 8 respectively.

Descriptive statistics

Mean differences in GPA across grades suggested that GPA increased slightly from fifth to sixth grade, and then declined through eighth grade (see Table 1). Mean self-control and self-esteem both declined from fifth to eighth grade.

Changes in self-control prospectively predict GPA

Preliminary analyses revealed that a quadratic growth model provided a better fit to the GPA data than a linear growth model. Consequently, we added individual-mean centered self-control as a time-varying covariate at Level 1 to a quadratic growth model of GPA. Centering self-control around an individual's mean essentially removes between-individual information, so we added the individuals' mean self-control back into the model as a grand mean centered predictor of the intercept at Level 2. We also added individuals' mean self-control as a predictor of the slope and quadratic term. This modeling strategy allows us to estimate the relationship between short-term changes in self-control and short-term changes in GPA, along with the relationships between a student's average self-control and baseline GPA and the rates of change in GPA.

Level 1 – Within individual:

$$GPA_{ti} = \pi_{0i} + \pi_{1i}(Time_{ti}) + \pi_{2i}(Time^2_{ti}) + \pi_{3i}(\text{Individual mean centered } SC_{ti}) + \varepsilon_{ti} \quad (1a)$$

Level 2 – Between individual:

$$\pi_{0i} = \beta_{00} + \beta_{01}(\text{Individual mean } SC_i) + \zeta_{0i} \quad (1b)$$
$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Individual mean } SC_i) + \zeta_{1i} \quad (1c)$$
$$\pi_{2i} = \beta_{20} + \beta_{21}(\text{Individual mean } SC_i) + \zeta_{2i} \quad (1d)$$
$$\pi_{3i} = \beta_{30} \quad (1e)$$

Controlling for time, changes in self-control during middle school predicted changes in GPA, $\beta_{30} = 1.81$, $t(610) = 4.47$, $p < .001$. The associated effect-size correlation (see

Rosenthal & Rosnow, 1991, p. 441) was $r_{effect} = .18$, indicating a small-to-medium size effect (Cohen, 1992) of short-term changes in self-control on changes in GPA six months later. At Level 2, individual differences in mean self-control were associated with individual differences in GPA, $\beta_{01} = 5.35$, $t(187) = 6.12$, $p < .001$, $r_{effect} = .47$, suggesting a stronger relationship between a student's average self control and their baseline achievement in 5th grade. Individual differences in mean self-control also predicted the slope, $\beta_{11} = 1.83$, $t(187) = 2.25$, $p < .05$, and the quadratic term, $\beta_{21} = -.52$, $t(187) = -2.17$, $p < .05$, indicating that individuals with higher self-control tend to have a steeper increase in GPA between fifth and sixth grade but also a steeper decline from seventh to eight grade relative to their more impulsive peers.

Changes in GPA do not prospectively predict self-control

Using a linear growth model with self-control as the outcome, we added individual-mean centered GPA as a time-varying covariate at Level 1 and added the individuals' mean GPA into the model as a predictor of the intercept at Level 2. A quadratic term does not appear because this model used only the three time points where GPA was measured six months prior to self-control (see Figure 1).

Level 1 – Within individual:

$$\text{Self-control}_{ti} = \pi_{0i} + \pi_{1i}(\text{Time}_{ti}) + \pi_{2i}(\text{Individual mean centered GPA}_{ti}) + \varepsilon_{ti} \quad (2a)$$

Level 2 – Between individual:

$$\pi_{0i} = \beta_{00} + \beta_{01}(\text{Individual mean GPA}_i) + \zeta_{0i} \quad (2b)$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Individual mean GPA}_i) + \zeta_{1i} \quad (2c)$$

$$\pi_{2i} = \beta_{20} \quad (2d)$$

Short term changes in GPA did not predict subsequent changes in self-control, $\beta_{20} < .001$, $t(424) = .05$, $p = .96$, $r_{effect} < .01$. Although individual differences in mean GPA were associated with individual differences in baseline self-control, $\beta_{01} = .05$, $t(162) = 4.61$, p

< .001, r_{effect} = .34, mean GPA did not predict annual change in self-control, β_{11} = -.001, t(162) = -0.30, p = .77, r_{effect} = .02.

Mean self-control, IQ, gender, family income, and ethnicity do not moderate the effect of self-control on GPA

Next, we examined whether individual-level variables moderated the effect of within-individual changes in self-control on GPA by adding potential moderators at Level 2 in separate models.

Level 1 – Within individual:

$$GPA_{ti} = \pi_{0i} + \pi_{1i}(Time_{ti}) + \pi_{2i}(Time^2_{ti}) + \pi_{3i}(\text{Individual mean centered } SC_{ti}) + \varepsilon_{ti} \quad (3a)$$

Level 2 – Between individual:

$$\pi_{0i} = \beta_{00} + \beta_{01}(\text{Individual mean } SC_i) + \zeta_{0i} \quad (3b)$$

$$\pi_{1i} = \beta_{10} + \beta_{11}(\text{Individual mean } SC_i) + \zeta_{1i} \quad (3c)$$

$$\pi_{2i} = \beta_{20} + \beta_{21}(\text{Individual mean } SC_i) + \zeta_{2i} \quad (3d)$$

$$\pi_{3i} = \beta_{30} + \beta_{31}(\text{Potential moderator}) \quad (3e)$$

Although HLM can handle unbalanced or missing data at Level 1, higher levels cannot have missing predictors. Consequently, we excluded subjects who did not have Level 2 predictors from the respective analysis. As shown in Table 2, mean self-control, IQ, gender, and family income did not moderate the effect of within-individual changes in self-control on GPA. Because ethnicity was coded as a set of dummy variables, we conducted an omnibus General Linear Hypothesis (GLH) test. Ethnicity did not moderate the effects of self-control on GPA as indicated by a non-significant GLH test, $\chi^2(4)$ = 3.94, p = .41. In all moderation analyses, the relationship between within-individual changes in self-control and within-individual changes in GPA (β_{30}) remained significant.

Changes in self-control prospectively predict GPA controlling for changes in self-esteem

The relationship between changes in self-esteem and changes in GPA was slight in magnitude and only marginally significant, β_{30} = .71, t(584) = 1.95, p = .052, r_{effect} =

.08, in a quadratic growth model with self-esteem as a time-varying covariate and individual mean self-esteem as a Level 2 predictor of the intercept, slope, and quadratic term. When both self-control and self-esteem were added simultaneously as time-varying covariates and Level 2 predictors of the intercept, slope, and quadratic term, the relationship between short-term changes in self-control and changes in GPA remained significant, β_{30} = 1.89, $t(580) = 4.27$, $p < .001$, $r_{effect} = .17$, whereas the relationship between short-term changes in self-esteem and changes in GPA was insignificant, β_{31} = .39, $t(580) = 1.08$, $p = .28$, $r_{effect} = .04$. Interestingly, this effect of self-esteem is marginally significant if self-control is not included in the model, suggesting that the effect of self-esteem may actually be explained by the effect of self-control. Considering that the multi-source approach to measuring self-control might have provided an unfair advantage in terms of increased reliability, we conducted the analysis again with just self-reported self-control (as opposed to the composite measure). This analysis produced similar results, β_{30} = 1.52, $t(579) = 4.76$, $p < .001$, $r_{effect} = .19$, and β_{31} = .07, $t(579)$ = 0.18, $p = .86$, $r_{effect} = .01$.

Discussion

The current study provides the most rigorous evidence to date that self-control causally influences academic achievement. A series of HLM growth curve analyses demonstrated that changes in self-control over time predicted subsequent changes in GPA, but changes in GPA over time did not predict subsequent changes in self-control. The evidence supporting a causal role for self-control was not moderated by IQ, gender, ethnicity, or income. Third-variable confounds that were stable over time did not account for the observed relations between self-control and GPA. Further analyses ruled out at least one time-varying confound, self-esteem, which was associated with both self-control and academic achievement but did not account for the effect of self-control on achievement. Rather, results suggested that the effect of self-control may have accounted for the association between self-esteem and achievement.

Notwithstanding the adage that correlation does not imply causation, the social science literature is littered with studies that confuse the two. The urge to attribute causal status to a psychological variable X for determining later outcome Y is particularly strong when design features rule out *many* threats to internal validity. For instance, well-designed prospective, longitudinal studies often include the following features: (1) X is measured at time 1 and Y is measured at time 2, (2) the effect of X on Y is theoretically predicted, (3) outcome Y is measured objectively, (4) the effect of X at time 1 on Y at time 2 holds when controlling for Y at time 1, and (5) theoretically predicted third-variable confounds are controlled for. Whereas such studies (e.g., Duckworth & Seligman, 2005) provide robust evidence for predictive validity, they nevertheless are vulnerable to the possibility that an unmeasured third-variable confound fully accounts for the observed predictive relationship between X and Y.

The current longitudinal HLM study introduced an innovative analytic strategy that effectively controlled for *all* time-invariant third-variable confounds. Further, we tested and ruled out the possibility that self-esteem, which varies over time and is highly correlated with both self-report and composite measures of self-control, accounted for the observed findings. What our analyses did not rule out, however, is the possibility of an *unmeasured* time-varying third variable that changes in sync with self-control and causally determines subsequent academic performance. What might such time-varying third-variables be? We can only speculate. Intrinsic interest in academic work? Self-efficacy expectations? Why modulations in these variables would be synchronized with changes in self-control is not obvious, but the current investigation does not conclusively rule out these possibilities.

As mentioned earlier, a tightly controlled experimental study could go one (final) step further to establish the causal role of self-control for life outcomes. We hope that by providing the strongest evidence to date for the causal importance of self-control to objectively measured important outcomes, our findings underscore the theoretical and practical import of such intervention research.

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Table 1

Means, Standard Deviations, and Number of Participants Contributing GPA, Self-Control, and Self-Esteem Data at Each Time Point

	GPA			Self-control			Self-esteem		
Grade	*M*	*SD*	*N*	*M*	*SD*	*n*	*M*	*SD*	*n*
5	87.83	5.92	142	4.07	0.51	142	3.34	0.53	138
6	89.84	5.79	165	4.05	0.53	168	3.32	0.54	168
7	88.30	6.35	156	3.87	0.53	158	3.28	0.55	149
8	87.77	5.90	157	3.90	0.53	157	3.30	0.58	144

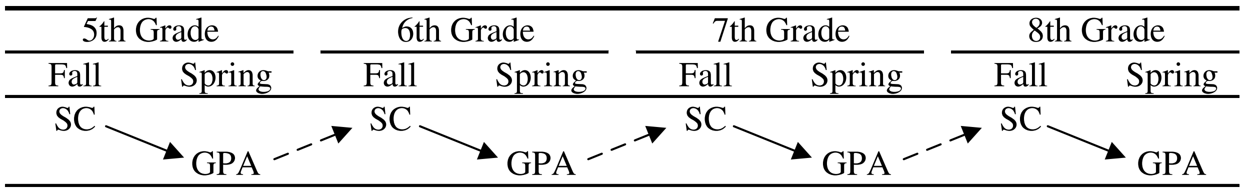
Table 2

Moderation Analyses of the Within-Individual Effect of Self-Control on GPA in Quadratic Growth Models with Self-control as a Time-Varying Covariate

Level 2 predictors	Coefficient	*SE*	Effect size *r*	*p*	*n*
Individual mean self-control, β_{31}	-.59	0.93	.03	.53	189
IQ, β_{31}	.04	0.04	.05	.28	141
Gender, β_{31}	.64	0.79	.03	.39	189
Income, β_{31}	.53	0.83	.03	.53	187
Ethnicity					186
Black, β_{31}	1.04	0.89	.05	.24	56
Latino, β_{32}	-.25	1.65	.01	.88	11
Asian, β_{33}	-.87	1.22	.03	.48	25
Other, β_{34}	-2.25	3.44	.03	.51	3

Figure Caption

Figure 1. Illustration of self-control and GPA time-varying covariates.


5th Grade
6th Grade
7th Grade
8th Grade
Fall
Spring
Fall
Spring
Fall
Spring
Fall
Spring
SC
GPA
SC
GPA
SC
GPA
SC
GPA