CHAPTER 10.
THE RELATIONS AMONG THE DEVELOPMENT OF WRITTEN LANGUAGE AND EXECUTIVE FUNCTIONS FOR CHILDREN IN ELEMENTARY SCHOOL

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Writing is a critical skill that is necessary for success in school, the workplace, and within society (Bazerman et al., 2018; Graham & Harris, 2005)—across the lifespan. Unfortunately, writing problems for students in the US are significant. According to the 2011 National Assessment of Educational Progress (NAEP) writing report, a mere 27 percent of eighth and 12th grade students scored at or above the proficient level (NAEP, 2012). Furthermore, this percentage has not changed significantly from previous reports in 2007 and 2002.

The NAEP data are indicative of a number of potential concerns including the nature and quality of writing instruction, the developmental appropriateness of that instruction, and trends in students' cognitive capabilities. The unsettling fact is that a student who cannot write at the proficient level cannot create a text that clearly accomplishes its communicative purpose, that is coherent and well structured, or that includes appropriate connections and transitions (National Center for Education Statistics, 2012). This difficulty may be attributable to the fact that writing is complex (Bazerman et al., 2018) and, as such, it requires the coordination of multiple skills including organization, transcription, orthographic and mechanical knowledge, understanding of audience, executive functions (EF), and social context (Graham, 2018; Kim & Schatschneider, 2017). Further complication comes from the fact that writing develops across the lifespan with variations among people and the nature of the communication demanded by a particular task or situation. To study these complex skills

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and developmental trajectories, researchers must gather data regarding children's writing in environments that are easily accessible with an abundance of data collection opportunities where the phenomena of interest play a central role in children's cognitive, social, and identity development (i.e., strategic research sites; Bazerman, 2008).

The primary purpose of this study was to investigate the complexities of writing development, specifically the individual and interactive developmental trajectories of EF and writing performance, by using longitudinal methodology and associated statistical strategies in a strategic research site: elementary classrooms where educators were focused upon initiating children into the practice and identity of writing. The elementary school developmental period for children is fraught with demanding changes in skills and processing (Zins & Hooper, 2012), which in turn affect children's later performance and identification as a "writer." For instance, children in kindergarten are asked to generate simple sentences, whereas by fifth grade these same children must be able to write reports and make arguments. How these functions evolve over time and how the various factors interact with one another at different developmental time points remain challenging to understand and study.

WRITING

As noted in the chapters in this volume, when writing a person must have an idea, understand the meaning of symbols used to express the idea (e.g., hieroglyphics, Roman alphabet), translate the idea to symbols, and have the capability to produce the symbols. As children develop the ability to hear and manipulate units of sound (e.g., phonemes) and acquire knowledge that letters and letter groups are used to represent sounds (i.e., alphabetic principle), they apply this knowledge to writing. To write successfully, writers need to comprehend the structure (i.e., sentence, paragraph, and text), content (i.e., ideas and their relationships), and purpose (i.e., writer's goals and audience) of the writing process (Collins & Gentner, 1980).

Hayes and Flower (1986) described planning, translating, and reviewing as the three most important cognitive processes used to produce written output. Specifically, the writer generates and organizes ideas, and then sets goals during the planning process, followed by sentence generation (i.e., translating ideas into sentences), reviewing, and editing. Whereas later in development students can self-regulate their own writing, in early years students rely on support from others to enact basic cognitive processes necessary for writing, such as EF (e.g., attention, planning; Berninger & Amtmann, 2003). At the elementary age, educators have the optimal opportunity to provide instruction and interventions for students who need assistance in developing effective writing skills, including those related to EF. In later grade levels, it is assumed that students have internalized these skills; therefore, those students who have acquired ineffective skills must not only acquire skills that are more effective but, perhaps, also unlearn ineffective ones.

EXECUTIVE FUNCTIONS

Numerous definitions of EF have been proposed as well as several models, theories, and frameworks (e.g., Miyake et al., 2000; Pennington et al., 1996; Zelazo et al., 1997). Researchers have advanced theory and empirical evidence for a variety of EF related to writing including working memory, sustained attention, inhibitory control, and planning (Pennington et al., 1996; Roberts & Pennington, 1996; Zelazo et al., 2003; Zelazo et al.; 2010). Even though none of these researchers explicated sustained attention in their models, Pennington suggested that attentional control is an executive function behavior as well. They posited the purpose of executive functioning was to enable a process to solve a problem, and explained that success occurs through creating an accurate mental representation of the task and then generating a plan to execute that task.

RELATIONS AMONG EXECUTIVE FUNCTIONS AND WRITING

As Bazerman et al. (2018) highlighted, writing development influences and is influenced by the development of a range of factors, including EF, perhaps implicating a bidirectional relationship for these factors, as well as developmental interactions. Research to date has demonstrated various relations between written language and cognitive (McCutchen, 2006), perceptual-motor (Graham & Harris, 2005), and linguistic functions (Berninger et al., 2006). Based on the Not-So-Simple View of Writing model (Berninger & Winn, 2006), and earlier work (Kellogg, 1996), EF are important contributors to the development of written language. EF are associated with handwriting automaticity, which requires orthographic-motor integration and processing speed, as well as with high-level composing (Altemeier et al., 2008). In particular, the EF components of attention, inhibitory control, planning, and working memory have been linked to writing (Hooper et al., 2011).

Altemeier et al. (2008) examined how performance changed on three EF tasks in elementary-aged students using a cross-sectional design. They found that typically developing writers showed steady improvement on an inhibition task from first to fifth grade, but switching and inhibition performance scores increased from first to fourth grade and then leveled off. In addition, their results suggested EF tasks contributed to spelling and written language. Hooper et al. (2011) also addressed the relations between writing and EF and concluded that language-related functions and EF were more highly associated with written language and spelling than fine-motor functions. Both of these studies found strong relations between EF and written language, but more research is needed regarding how the relationship between EF and writing performance changes over time. In particular, more research is needed regarding the trajectory of EF growth and writing performance over time. Most researchers have posited a consistent linear growth trajectory for both EF and writing performance, but Altemeier et al.'s (2008) findings regarding a leveling of development suggest it is important to investigate whether that growth is more curved than linear. A clear understanding of the trajectory of growth in EF and writing over time (i.e., linear versus curved) is necessary to subsequently examine how the growth in one might relate to the growth in the other.

CURRENT STUDY

Given the apparent importance of EF to written language in school-age children (Altemeier et al., 2008; Hooper et al., 2011), for this study we aimed to examine one key gap in the literature; namely, the relations among EF, writing skills, and their development over time. We used longitudinal data and contemporary statistical strategies, including latent growth curve analysis, to answer the following research questions: (1) Does EF performance over time grow in a linear or curvilinear manner? Does writing performance over time grow in a linear or curvilinear manner? (2) How do EF and writing performance relate to each other at each time point, as well as across time points?

METHODS

Participants

Two hundred five students from seven elementary schools in one suburban-rural school system in the southeastern US participated in this study. Each of these students had a primary placement in the regular education setting, completed kindergarten, and spoke English as a primary language. Of these students, 117 (57%) were male and 88 (43%) were female, and their ages ranged from 6 years 3 months to 7 years 4 months at the time of recruitment (i.e., first grade). Almost three-quarters (74%) of the students were of European American ethnicity, 20 percent were African-American, 4 percent were multi-racial, and 1 percent were Native American and Asian American (see Table 10.1). The students participated in the study from first to fourth grade. Of the 205 students, 67 were typically developing writers, and 138 struggled with written language. As part of the larger study, the participants who were identified as struggling writers were randomly assigned to either a treatment group (*n* = 68) or control condition (*n* = 70). It is important to note that all of the classrooms were following the state curriculum for writing instruction such that all students were receiving the same type and amount of instruction for writing skills development in the regular classroom setting, thus making this an effective strategic research site.

Table 10.1. Participants' Demographic Profile

	Sample *f* **(%)**	**SWC** *f* **(%)**	**SWT** *f* **(%)**	**TDW** *f* **(%)**
1st graders ages[a]	205	70	68	67
6	46 (22.4)	17 (24.3)	14 (20.6)	15 (22.4)
7	149 (72.7)	49 (70.0)	52 (76.5)	48 (71.6)
8	10 (4.9)	4 (5.7)	2 (2.9)	4 (6.0)
2nd graders ages[a]	200	68	67	65
7	44 (22)	15 (22.1)	14 (20.9)	15 (23.1)
8	145 (72.5)	49 (72.1)	50 (74.6)	46 (70.8)
9	11 (5.5)	4 (5.9)	3 (4.5)	4 (6.2)
3rd graders ages[a]	189	64	65	60
8	46 (24.3)	16 (25)	14 (21.5)	16 (26.7)
9	132 (69.9)	44 (68.8)	48 (73.9)	40 (66.7)
10	11 (5.8)	4 (6.3)	3 (4.6)	4 (6.7)
4th graders ages[a]	179	62	60	57
9	40 (7.1)	14 (22.6)	11 (18.3)	15 (26.3)
10	129 (72.1)	44 (70.1)	46 (76.7)	39 (68.4)
11	10 (5.6)	4 (6.5)	3 (5.0)	3 (5.3)
Female	88 (42.9)	27 (38.6)	27 (39.7)	34 (50.8)
Ethnicity 1				
Asian	2 (1.0)	0 (0)	0 (0)	2 (3.0)
Black	40 (19.5)	14 (20.0	17 (25)	9 (13.4)

	Sample *f* (%)	SWC *f* (%)	SWT *f* (%)	TDW *f* (%)
Ethnicity 1 (Continued)				
2 or More Races	9 (4.4)	3 (4.3)	4 (5.9)	2 (3)
Native American	2 (1.0)	1 (1.4)	1 (1.5)	0 (0)
White	152 (74.1)	52 (74.3)	46 (67.7)	54 (80.6)
Ethnicity 2				
Hispanic or Latino	36 (17.6)	7 (1.0)	12 (1.8)	7 (1.0)
School				
School 1	37 (18.1)	15 (21.4)	9 (13.2)	13 (19.4)
School 2	17 (8.3)	6 (8.6)	7 (10.3)	4 (6.0)
School 3	48 (23.4)	19 (27.1)	16 (23.5)	13 (19.4)
School 4	24 (11.7)	9 (12.9)	10 (14.7)	5 (7.5)
School 5	29 (14.2)	10 (14.3)	10 (14.7)	9 (13.4)
School 6	24 (11.7)	8 (11.4)	8 (11.8)	8 (11.9)
School 7	24 (11.7)	2 (2.9)	8 (11.8)	14 (20.0)
Out of County	2 (1.0)	1 (1.4)	0 (0)	1 (1.5)
Retained	15	6	7	2
Retained 2nd grade	5	5	0	0
Retained 3rd grade	7	1	4	2
Retained 4th grade	3	0	3	0
Mother's Education				
No HS diploma	18 (10.1)	6 (10.7)	9 (14.5)	3 (5.0)
HS diploma	77 (43.3)	18 (32.1)	36 (58.1)	23 (38.3)
Associates or College Degree	83 (46.6)	32 (57.1)	17 (27.4)	34 (56.7)

Note: SWC = struggling writers control group; SWT = struggling writers treatment group; TDW = typically developing writers group.

[a] *ages rounded to the closest year.*

Procedure

For the initial screening into the study, students in each of the first-grade classes were administered the Wechsler Individual Achievement Test (WIAT II) Written Expression Subtest and, once enrolled in the study, they participated in a battery of cognitive measures. The measures were divided into two administration blocks to minimize order effects (e.g., fatigue, learning). After the first year of the project, three assessments were changed per school system request because their school psychologists were using the measures. After the initial screening, all participants were administered a battery of neuropsychological and cognitive assessments by trained research assistants and graduate students. All of the measures can be seen in Table 10.2.

Table 10.2. Measures

Construct	Measure	Task
Written Language	Wechsler Individual Achievement Test – Second Edition form A (WIAT-II; Wechsler, 2002	Written word fluency from the Written Expression subtest Spelling Subtest
	Process Assessment of the Learner: Test Battery for Reading and Writing (PAL; Berninger, 2001	Timed Alphabet-writing
EF: Planning	Woodcock Johnson-III Test of Cognitive Abilities (WJ-III; Woodcock et al., 2001)	Planning subtest
EF: Sustained attention and Inhibitory control	Vigil Continuous Performance Test (Vigil CPT; Psychological Corporation, 1998)	Errors of Omission Errors of Commission
EF: Working Memory	The Wechsler Intelligence Scale for Children IV Integrated (WISC-IV I; Wechsler et al., 2004)	Spatial Span Backward

The results from the initial assessments were used to group students as typically developing writers (TDW) or struggling writers (SW), the latter group defined by scores falling in the bottom quartile for grade placement. Then, SW students were randomly assigned to either a treatment or control condition. Therefore, group status (GS) consisted of three categories: TDW, struggling writers in the treatment group (SWT), and struggling writers in the control group (SWC). For this study, we were not interested in testing differences across group status or school, therefore we controlled for these covariates in our analyses.

Data Analysis

We used latent growth curve analysis to investigate our research questions. Our models included summed scores of the observed variables (i.e., raw scores) to represent written language and EF, with latent factors (i.e., unobserved variables) representing initial starting point (i.e., intercept) and growth over time (i.e., slope). Figure 10.1 shows our hypothesized model. All results were examined for outliers, influential cases, and normality.

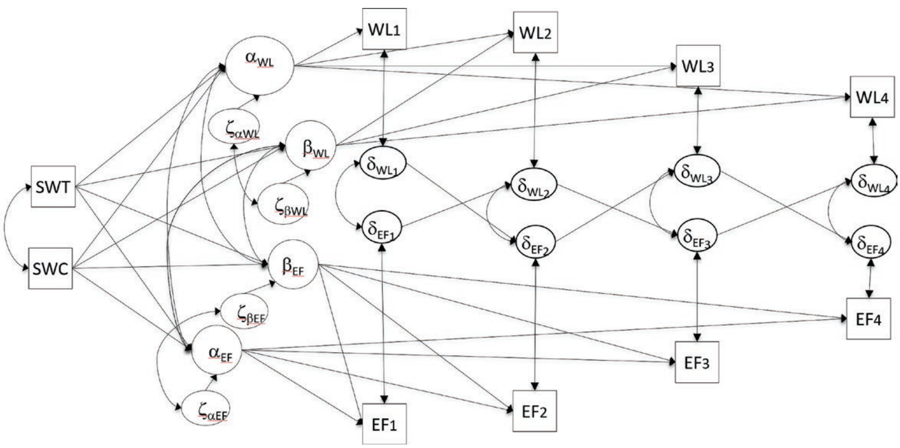

Figure 10.1. Final model. WL = Written Language, EF = Executive Functions, SWT = struggling writers' treatment, SWC = struggling writers control.

Research Question 1. Does EF performance over time grow in a linear or curvilinear manner? Does writing performance over time grow in a linear or curvilinear manner?

Our longitudinal design allowed us to model each participant's specific, individual growth in both written language and EF over multiple time points, as opposed to inferring such growth using different participants at different time points, as in a cross-sectional design. The former captures actual intraindividual change in writing performance and EF over multiple time points, whereas the latter requires the unlikely assumption that different participants' scores at each time point accurately represent actual intraindividual change.

Following accepted methods for quantitative analysis of writing phenomena (see Zajic et al., this volume), we conducted latent growth curve analyses in a structural equation model (SEM) framework to examine the change over time of written language and EF scores. We chose to estimate latent growth curve models (LGCMs) over other traditional repeated measures statistical techniques (e.g., Analysis of Variance) for several reasons. First, ANOVA techniques require unlikely assumptions regarding the equivalence of change over equidistant multiple time points, cannot account for missing data at any time point, and do not account for the error inherent in any measure. On the other hand, LGCM analyses do not have these restrictive assumptions, can accommodate missing data, and allow for better measurement of the latent constructs by disattenuating measurement error (Hancock et al., 2013). LGCM analyses estimate an initial starting point (i.e., intercept), growth over time (i.e., slope), and residuals. LGCM analyses are a good option for modeling growth as they capture intra- as well as inter-individual variability in EF and writing performance from a quantitative perspective.

We evaluated the adequacy of model fit with the data using the chi-square test statistic and other fit indices. The chi-square test statistic is the oldest fit measure in SEM, although many researchers do not rely exclusively on this measure because this statistic is sensitive to sample size and excessive kurtosis (i.e., multivariate distributions of observed variables; Bollen & Curran, 2006; Hox, 2010). Thus, model fit was evaluated based upon several criteria including the chi-square test statistic, as well as several data-model fit indices including the Comparative Fit index (CFI), the root mean squared error of approximation (RMSEA), *p* of close fit (PCLOSE), and the standard root mean square residual (SRMR). A statistically non-significant chi-square test statistic indicated adequate data-model fit. CFI values greater than .90 were considered adequate and values greater than .95 were considered good. RMSEA values were examined using a 90 percent confidence interval (CI). Confidence intervals whose lower value was no higher than .05 and upper value was less than .08 were considered good. PCLOSE is a measure that provides a one-sided test that the RMSEA is less than 0.05. If the PCLOSE value was greater than .05 the data-model was considered good. SRMR values less than .08 were considered indicators of good fit (Hu & Bentler, 1999).

Unconditional LGCMs. As an initial attempt to model participants' writing performance and EF growth trajectories, we estimated models without covariates (i.e., unconditional LGMs). First, an intercept-only model and a linear LGCM were estimated and compared. When the linear model demonstrated better fit to the data than the intercept only model, then the linear model was compared to a curvilinear model. Per Zajic et al., (this volume) models that resulted in the best fit to the data were used in subsequent analyses.

Conditional LGCMs. Next, we included covariates in the LGCMs to control for differences in the growth parameters of the latent factors as a function of school and GS, treating both as time-invariant covariates (TIC), given each was a person-specific variable that did not change over the course of the study. Both were used as control variables, thus differences in GS and school were not interpreted. Specifically, we modeled school and GS as predictors with equal factor variances, factor covariances, and time-specific error variances, where the functional forms of the model were equal across groups (Bollen & Curran, 2006).

Research Question 2. How do EF and writing performance relate to each other at each time point, as well as across time points?

To answer our second research question, we conducted several analyses. First, we regressed the constructs on each other across time points to determine whether scores at one time point on a construct predicted scores on the other construct at the subsequent time point. Next, we correlated the latent growth parameters (e.g., written language intercept with EF slope) to determine the relations between written language and EF. In addition, we estimated a "nonstandard effect" (Curran et al., 2012, p. 243) by correlating the time-specific residual of written language with the time-specific residual of EF (Figure 13.1) to determine if there were within-person effects.

With this plan, we were able to determine the relations between written language and EF beyond systematic growth from first to fourth grade. The interpretation of these effects can be problematic given it is conceivable that the constructs could exert a within-person and a between person effect, only a between person effect, only a within person effect, or none of the above (Curran et al., 2012). Thus, we reported the results for each effect as necessary. For instance, EF may influence the rate of growth for written language for a participant, and simultaneously influence differences in the growth trajectories across individuals.

RESULTS

Descriptive Statistics

The results presented in Table 10.3 suggested that the means and standard deviations were as expected for this sample. However, a few of the skewness and kurtosis values for the individual measures (see Costa, 2014) were out of normal range (i.e., skewness values whose absolute values were less than two and kurtosis values less than seven; Kline, 2005). Based on the results of the Shapiro-Wilk W test, we rejected the null hypothesis that all of the variables were normally distributed. After consideration of the initial descriptive statistics and tests of univariate normality, we decided to use robust estimation techniques in our analyses. We used a resampling method (i.e., bootstrap) to estimate standard errors and confidence intervals that are robust to non-normality (Kolenikov & Bollen, 2012). This is beneficial because the bootstrapped distribution (i.e., sampled from the empirical distribution of the observed data) of each parameter estimate is used to determine the confidence intervals. These values take the non-normality of the parameter estimate distribution into account. The descriptive statistics for the individual measures comprising the summed scores and correlation matrix of all the continuous variables can be found in Costa (2014).

Table 10.3. Sample Statistics for Summed Variables

Construct	**Time point**	*N*	*M*	*SD*	**Min**	**Max**
Written Language	1	205	17.61	7.40	0	36
	2	200	26.31	7.15	3	44
	3	189	31.99	7.87	6	53
	4	179	36.28	9.64	3	59
Executive Functions	1	202	11.07	2.26	6.82	19
	2	200	12.64	2.20	6.83	18.17
	3	188	14.18	2.18	6.16	19.37
	4	176	14.94	2.24	7.32	19.42

Research Question 1

First, we tested several models to determine the type of growth over time (i.e., linear or curvilinear) in both written language and EF. Once this was determined for written language and EF, we conducted additional analyses to control for group status and school. Here we provide a summary of this modeling; detailed results can be found in Costa (2014).

Written language. We found the written language linear model had the best fit with the data [$\chi^2(df) = 228.58\ (121)$, bootstrap p-value = 0.06, CFI = 0.92, SRMR = 0.06]. The parameter estimates and p-values for the unconditional model suggested that participants' initial written language scores significantly differed ($p < 0.001$), but not their rate of growth (i.e., slope variance; $p > 0.05$). Group and school differences were not the focus of this study, but they were included in the models as covariates to control for their effects. Overall, we did not find school effects, but the groups did differ in their initial scores and growth trajectory. We controlled for these differences in all subsequent models.

Executive functions. After removing some of the modeling restrictions, the preponderance of evidence (i.e., data-model fit results) supported a nonlinear LGCM. Thus, we concluded that a positive nonlinear model best represented the growth trajectory of EF for students from first grade to fourth grade after controlling for school [$\chi^2(df)$ = 305.59 (203), bootstrap *p*-value = 0.24, RMSEA (PCLOSE) = 0.05 (0.51), RMSEA CI = 0.04-0.06].

Group and school differences were included in the models as covariates to control for their effects. Overall, we did not find school effects. The groups did differ in their initial scores but not in their growth trajectory. We controlled for these differences in all subsequent models.

Research Question 2

Final LGCM. We estimated several models, none of which we deemed to have good fit with the data (Costa, 2014), thus any interpretation of these results should be done with caution. The final model was selected as the most interpretable model [$\chi^2(df)$ = 132.70 (29), bootstrap *p*-value <0.001, RMSEA (PCLOSE) = 0.132 (<0.001), RMSEA CI = 0.11-0.15, CFI = 0.90, SRMR = 0.09].

A diagram of the final model can be seen in Figure 10.1. The majority of the parameter estimates for the structural paths were not statistically significantly different from zero, which revealed that there is no evidence to support within-person (i.e., intraindividual) effects among written language and EF. Therefore, EF did not predict written language scores across time, nor did written language predict EF scores across time. That said, there were statistically significant positive relations (all *p*-values < 0.001) between written language intercept and written language slope as well as written language intercept and EF intercept. These results provided evidence to support between-person effects among written language and EF, and suggested that individual variability in written language at grade 1 was positively related to the individual variability in rate of change over time of written language and the individual variability in EF at grade 1.

DISCUSSION

In this study, we investigated a component of writing development and provided one of the first longitudinal examinations of both written language and EF in elementary-aged children. Specifically, we examined how to best model the development of written language and EF as well as the relations between written language and EF from first to fourth grades. At a minimum, the results of this study are a testament to the complexity of the relationship of writing to EF over time, and perhaps to the complexity inherent in the development of any academic skill.

Written Language and Executive Functions Summary

Based on the work of Curran et al. (2012), we decided that the most comprehensive way to understand the relations between written language and EF was by modeling the between-person (i.e., directly predict growth parameters), within-person (i.e., directly influence the repeated measures), and across-time differences in growth. We discovered that EF did not predict written language scores across time, nor did written language predict EF across time. On the other hand, on average, individual variability in written language at grade 1 was positively related to the individual variability of growth in written language and the individual variability in EF at grade 1. Thus, scores of written language in first grade were positively related to scores of EF in first grade. In general, written language performance in first-grade predicted growth in written language over time, and therefore first grade seems like a good place to intervene to improve performance (e.g., increase the growth trajectory).

Limitations

Model diagnosis is not an exact science, thus there are several possible reasons why our models did not converge or have good fit with the data (e.g., Heywood cases, variables were not normally distributed). The current study was a secondary data analysis of a more comprehensive longitudinal study designed to examine the many factors shown to influence the development of written language as well as to investigate the effectiveness of an intervention. The presence of an intervention complicated the analyses, and potentially could have led to issues with power. It is plausible that the model did not include enough information to explore the relation between written language and EF. For example, other cognitive functions, such as language skills, as well as environmental variables, such as teacher quality and gender, may be necessary to understand the developmental interplay of writing and EF, and their longitudinal relations.

Further, the models may have had a better fit if we had employed different measures of written language and EF; i.e., the full range of components used to indicate written language and EF may not have been represented in this study. In addition, the lack of specifically developed measures to assess writing and EF for struggling writers may have been problematic. This is limiting because it is possible that the measures did not assess the full range of performance for the population. Restriction of range can be problematic because the true range of ability for the participants may not be captured by the measures used. In this case, a participant's ability may be lower than the score reflects, but a lower score was not possible given the measure. For instance, 33 percent of the sample received a score of zero for alphabet writing in first grade. This suggests that these participants did not write one legible letter of the alphabet in 15 seconds. Perhaps our chosen measure was not able to capture the full range of written language performance at first grade. Overall, the limitations discussed above should not be used to disregard the results of this study, but are reasons for caution when interpreting the results. The limitations also provide ideas for improvement of future writing development research.

Implications and Future Directions

This study illustrated how latent-variable statistical techniques can be used to model longitudinal data in educational research. Future researchers should continue to explore the use of latent variable statistical techniques in education research given their advantages over traditional ANOVA repeated-measures techniques (see Zajic et al., this volume). Even though the current study did not provide definitive answers regarding the relations between written language and EF, the questions are nonetheless important to understanding the factors associated with the development of written language in younger children. Theorists who have described the relations between written language and EF suggest that there are overlapping components between the two constructs, including planning and working memory (Berninger & Winn, 2006). Indeed, researchers who have studied written language and EF in a cross-sectional fashion have found relations among these constructs (Altemeier et al., 2008; Hooper et al., 2011). More longitudinal research is needed to examine actual change over time in these constructs, and their commonalities and differences.

This study provided new ways for researchers to think about the relations between writing and EF, and perhaps other cognitive functions. Researchers can begin to think of new interventions that could be used to test the proposed causal relations between EF and written language. For instance, it is likely that a student who has weak EF also has weak writing skills. Therefore, an intervention for this type of student may need to include writing instruction along with strategies to improve selected EF components. It is also possible that new writing interventions could be developed that embed EF training (e.g., Self-Regulated Strategy Development Model; Graham & Harris, 2005). In this type of intervention, students would be taught writing skills and EF strategies simultaneously. Educators and researchers need to continue to collaborate to discover effective methods of teaching writing to all children, and such methods require additional scientific inquiries into the relationship between the development of written language skills and other key factors such as EF. Further, how these cognitive factors relate to other environmental facilitators and barriers to the development of written expression remains a fruitful avenue for future exploration.

EF and writing are both complex and dynamic constructs that change across the lifespan with a range of variability between people in the amount and rate of growth. This variability likely is influenced by a large number of potential factors (e.g., classroom instruction, lifespan experiences), and how these factors contribute to the evolution of written language skills over the course of development remain largely unexplored to date. Indeed, as Bazerman et al. (2018) have noted, this relation may be bidirectional, but when that bidirectionality occurs and under what conditions (e.g., one factor may be more influential than another) remains unknown. Consequently, the field is in need of increased examination of this interrelationship, with additional factors including different disorders, different conditions, and different ages, in an effort to increase our understanding of the development of written language and this overall developmental interplay. Such findings might be helpful in guiding future research on intervention and classroom instruction. In that regard, we echo Charles Bazerman's plea (Bazerman et al., 2018) for writing researchers to conduct longitudinal studies of writing development as exemplified in this chapter.

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