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Cognitive ability influences on written expression: Evidence for developmental and sex-based differences in school-age children☆

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ABSTRACT

Some studies have demonstrated that the Cattell-Horn-Carroll (CHC) cognitive abilities influence writing; however, little research has investigated whether CHC cognitive abilities influence writing the same way for males and females across grades. We used multiple group structural equation models to investigate whether CHC cognitive ability influences on written expression differed between grades or sex using the Kaufman Assessment Battery for Children, Second Edition and the Kaufman Tests of Educational Achievement, Second Edition co-normed standardization sample data ($N = 2117$). After testing for consistent measurement of cognitive abilities across grades and sex, we tested whether the cognitive ability influences on written expression were moderated by grade level or sex. An important developmental shift was observed equally across sex groups: Learning Efficiency (G*l*) influences decreased whereas Crystallized Ability (G*c*) influences increased after fourth grade. Further, Short-Term Memory (G*sm*) and Retrieval Fluency (G*r*) influences on written expression depended on sex at grades 1–4, with larger G*r* influences for females and larger G*sm* influences for males. We internally replicated our main findings using two different cognitive explanatory models, adding further support for the developmental and sex-based differential cognitive ability influences on writing. Explanatory cognitive models of writing need to incorporate development, and possibly, sex to provide an expanded understanding of writing development and guard against potential generalizability issues characteristic of special population (i.e., male-female) studies.

1. Introduction

Skills in written expression are critical for school success, and these skills are highly desired in the workplace (Graham, Gillespie, & McKeown, 2013; National Commission on Writing, 2004). A better understanding of how writing skills develop may lead to improved writing instruction, which in turn may yield meaningful educational and occupational implications. Theories of writing

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development often include a number of individual-level influences, contextual-level influences, or both (e.g., Hayes, 2006; Schultz & Fecho, 2000). Theories that include underlying individual differences in cognitive components have demonstrated excellent explanatory power with regard to individual differences in writing skills (see Abbott & Berninger, 1993; Deane et al., 2008; Hayes, 2006; Kim & Schatschneider, 2017). These theories, and the explanatory statistical models that are derived from them, however, need to be applied to and studied within selected populations (e.g., grade levels, males-females) in addition to general populations:

> Researchers must investigate whether patterns of empirical results vary in important ways across special populations or when moving from the general population to a special population. If results vary importantly across groups, then special population status is a moderator of results, and conclusions about "the ways that things work" do not generalize across groups. Thus, special populations constitute a crucible for research in the social sciences, and we must guard against unwarranted generalization of findings across groups unless research supports such conclusions (Widaman, Early, & Conger, 2013, p. 62).

For example, the relative influences of cognitive components in writing skills have been shown to change as a result of cognitive development and shifts in writing demands (Abbott & Berninger, 1993). Therefore, a static explanatory model of writing skills that is used for students across many grade levels provides an inadequate description of cognitive influences on writing because the influences depend on grade level. Cognitive influences on writing may differ across other selected populations as well. In particular, research investigating whether cognitive influences are generalizable across sex, while also taking into account development, is lacking.

It has been shown that females demonstrate a reliable, moderate advantage over males on measures of writing (e.g., Camarata & Woodcock, 2006; Halpern et al., 2007; Kaufman, Kaufman, Lui, & Johnson, 2009; Malecki & Jewell, 2003; Pargulski & Reynolds, 2017; Scheiber, Reynolds, Hajovsky, & Kaufman, 2015). Reasons for that advantage are not well understood, but explanatory models of individual differences in writing skills may provide clues. Constructs that explain individual differences in writing among females may not operate the same way in explaining individual differences in writing among males, and thus sex specific models may be needed. Conversely, combining male and female information into one explanatory model for writing may unwittingly obfuscate findings related to individual differences in writing (e.g., Gustafsson & Balke, 1993; Widaman et al., 2013). Research with sex specific models, while accounting for development, may provide a more descriptive model of how writing develops for school-age children. Therefore, it is important to address this research gap and investigate whether differences exist among females and males in their cognitive influences on writing throughout school-age development.

Our purpose in this study was twofold. First, we wanted to develop an explanatory model of writing based on an underlying system of cognitive abilities. Second, we wanted to test whether that explanatory model of writing performed in the same way across grade level groups and the sexes. Put differently, we aimed to investigate whether the patterns and strength of relations between underlying cognitive abilities and written expression differed across grade level groups and sexes.

1.1. Theoretical models of writing

Several different theoretical models of writing have been used to explain the complex process of producing clear and coherent written text. Many of these models incorporate basic writing skills, language skills, and cognitive processes to help explain the act of writing—transferring mental representations into language structures to produce coherent written text (Berninger, 1999; Berninger, Abbott, Abbott, Graham, & Richards, 2002; Deane et al., 2008; Kim & Schatschneider, 2017). It is this type of model that was used as a framework in this research.

According to Berninger (1999), writing consists of two major components: text generation and transcription. Text generation is the translation of ideas into language representations within memory storage, whereas transcription (e.g., spelling, handwriting) is the translation of those stored language representations into written language. Taken together, text generation and transcription components form the basis of the *simple view of writing*. Other expanded views of this model posit that cognitive resources, in addition to transcription and text generation components, are critical in writing (e.g., Kim & Schatschneider, 2017). For example, as transcription skills become well-developed and automatized (i.e., accurate and fluent spelling and handwriting), writing performance increasingly depends on both text generation and higher-order cognitive skills. Specifically, executive functions (e.g., planning, organization, comprehension monitoring, and reviewing), working memory, and language (e.g., oral language, background knowledge, and inferencing) are all influential in writing. Incorporating these diverse cognitive abilities and skills into a single framework for writing development, however, requires a comprehensive theoretical structure of cognitive abilities and an analysis so that the combined and relative influences of the cognitive constructs important for writing can be studied simultaneously.

Cattell-Horn-Carroll (CHC) theory (Carroll, 1993; Schneider & McGrew, 2012), which is a taxonomy for the organization of human cognitive abilities, has also been applied as a system of cognitive abilities used to explain individual differences in achievement (Benson, 2008; Hajovsky, Reynolds, Floyd, Turek, & Keith, 2014). It provides a useful framework for the study of cognitive ability influences on writing. According to the CHC theory, cognitive abilities are organized into three levels (known as strata), with the *g* factor (general intelligence) at the apex. Many researchers do not consider *g* an ability or cognitive process per se, but as a property of the mind or brain with no certain locus (Jensen, 1998; Thurstone, 1947). In one interpretation of CHC theory, the *g* factor subsumes, or influences, a set of specific cognitive abilities and processes (broad abilities) that are different reflections of *g*