Effects of cognitive abilities on child and youth academic achievement: Evidence from the WISC-V and WIAT-III

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1. Introduction

Individually administered intelligence tests are key for measuring an individual’s general intelligence and specific cognitive strengths and weaknesses (Kaufman, Raiford, & Coalson, 2015). Many modern intelligence tests measure constructs described by the Cattell-Horn-Carroll (CHC) theory of cognitive abilities (Carroll, 1993; Cattell & Horn, 1978). These constructs include general intelligence and broad cognitive abilities such as fluid reasoning, verbal comprehension/knowledge, short-term memory, visual processing, and processing speed. In the CHC model of intelligence, general intelligence and the broad cognitive abilities may be interpreted to operate together within a system of interrelated cognitive abilities.

Numerous research studies have examined the effects of CHC cognitive constructs on areas of academic achievement (see McGrew & Wendling, 2010). Results from these studies have shown that there are some relatively predictable effects of CHC constructs (i.e., general intelligence and broad cognitive abilities) on achievement areas such as reading and math (e.g., Floyd, Meisinger, Gregg, & Keith, 2012; Glutting, Watkins, Konold, & McDermott, 2006; Hajovsky, Reynolds, Floyd, Turek, & Keith, 2014; McGrew, 1993; Niileksela, Reynolds, Keith, & McGrew, 2016; Vanderwood, McGrew, Flanagan, & Keith, 2002). One limitation of conclusions drawn from previous research is that a majority of these studies have been conducted using standardized data from the Woodcock-Johnson (WJ) co-normed cognitive and achievement batteries (McGrew & Wendling, 2010). For example, although the Wechsler Intelligence Scale for Children (WISC) is widely used in practice (Archer, Buffington-Vollum, Stredny, & Handel, 2006; Cashel, 2002), to date, only four studies have examined the effects of CHC-type cognitive abilities measured by the Wechsler scales on academic achievement (Beaujean, Parkin, & Parker, 2014; Glutting et al., 2006; Oh, Glutting, Watkins, Youngstrom, & McDermott, 2004; Parkin & Beaujean, 2012). Some of the results from these WISC studies were interpreted as inconsistent with results from previous research that used the Woodcock tests. If the relations between cognitive and achievement abilities vary across tests, then it would be important to consider these inconsistencies when interpreting findings based on specific tests.

There are several possible reasons for the inconsistent findings between the WJ and WISC tests. The divergent findings may be due to the different tests, different constructs measured by the WISC, or differences in what is interpreted as a meaningful effect size. But differences may also be related to an inconsistent consideration of developmental
differences across the studies. For example, research has shown that CHC cognitive effects on achievement are also a function of age (e.g., Hajovsky et al., 2014).

In addition, research with the WISC-IV also only focused on achievement areas that were broadly defined (e.g., language), rather than specific aspects of achievement (e.g., basic reading). Because broad achievement variables are emergent combinations of more specific acquired achievement skills, it is especially useful to investigate the cognitive ability influences on these specific achievement areas (e.g., basic reading and reading comprehension versus broad reading). For example, lack of basic word reading skills may result in a reading comprehension weakness that is not necessarily due to poor comprehension, but due to a weakness in word reading skills. It is important to understand cognitive ability influences on word reading because these cognitive influences may differ from those involved in reading comprehension (e.g., Christopher et al., 2016).

The co-norming sample of the newly revised WISC, Fifth Edition (WISC-V; Wechsler, 2014) and the Wechsler Individual Achievement Test, Third Edition (WIAT-III), in which each participant completed both tests, provides an opportunity to test whether CHC constructs measured by the WISC-V have the same effects on academic achievement as found in research with other cognitive and achievement batteries. Examination of CHC cognitive-achievement effects with a measure other than the WJ tests will not only provide information about the effects of WISC-V constructs on achievement, it will also contribute to the development of CHC theory (Beaujean et al., 2014). Further, an analysis that allows for differential age effects may shed light on differences found across previous studies. Last, a focus on specific (as opposed to broad) achievement areas should allow a more fine-grained understanding of the cognitive influences on areas such as basic reading, reading comprehension, basic math, math problem solving, written expression, and fluency skills. Consequently, the current study examined how CHC constructs measured by the WISC-V explain school-age students’ academic achievement in nine specific academic domains, and whether these effects vary by age.

2. Effects of CHC cognitive abilities on academic achievement

Of the broad abilities delineated by CHC theory, five are likely measured by the WISC-V: verbal comprehension/knowledge (Gc), fluid/novel reasoning (Gf), visual processing (Gv), short-term memory (Gsm), and processing speed (Gs; see Table 1 for definitions of these abilities; Schneider & McGrew, 2012). Below, we review previous research findings about which of these broad abilities affect achievement in specific and broad areas of reading, math, and writing and which effects show developmental differences.

3. Basic reading skills

Basic reading skills include decoding and word recognition skills. Basic reading skills are likely influenced by multiple broad cognitive abilities, which vary by age (Floyd et al., 2012; Nilleskela et al., 2016). Verbal comprehension/knowledge (Gc) has been shown to affect basic reading skills throughout schooling (Cormier, McGrew, Bulut, & Funamoto, 2017; Evans, Floyd, McGrew, & Leforgee, 2002; Floyd, Keith, Taub, & McGrew, 2007; García & Stafford, 2000; Hajovsky et al., 2014; McGrew, 1993; Nilleskela et al., 2016; Oh et al., 2004; Vanderwood et al., 2002), with stronger effects at older ages (Cormier et al., 2017; Hajovsky et al., 2014; McGrew, 1993), although one study found Gc effects did not emerge until age 12 or 13 (Benson, 2007). Short-term memory (Gsm) and processing speed (Gs) have been shown to influence basic reading skills throughout schooling (Cormier et al., 2017; Evans et al., 2002; Floyd et al., 2007; Hajovsky et al., 2014; McGrew, 1993; Nilleskela et al., 2016), but some of the findings are contradictory and depend on the WJ test edition.

4. Reading comprehension

Reading comprehension is the ability to construct meaning from written text. As with basic reading skills, Gc has the strongest influence on reading comprehension for students in grades 1–12 (Benson, 2007; Evans et al., 2002; Floyd et al., 2012; Keith, 1999; McGrew, 1993; McGrew, Flanagan, Keith, & Vanderwood, 1997; Nilleskela et al., 2016; Oh et al., 2004; Vanderwood et al., 2002). Gc’s influence increases with age (Cormier et al., 2017; Floyd et al., 2012; Hajovsky et al., 2014; Keith, 1999; McGrew, 1993). Longitudinal research has shown Gc is a leading indicator of growth in reading comprehension—increases in Gc result in improved reading comprehension over time (Quinn, Wagner, Petscher, & Lopez, 2015; Reynolds & Turek, 2012).

Previous research also suggests that Gs and Gsm are also directly or indirectly related to reading comprehension, although the effects are not as consistent across different ages (Cain, Oakhill, & Bryant, 2004; Evans et al., 2002; Floyd et al., 2012; Hajovsky et al., 2014; McGrew, 1993) and depend on the edition of the WJ test (Nilleskela et al., 2016). Research across the three most recent editions of the WJ tests suggests that fluid reasoning (Gf) has a moderate effect on reading comprehension beginning at a young age (Cormier et al., 2017; McGrew, 1993; Nilleskela et al., 2016) or in early adolescence (Evans et al., 2002). Additionally, one study using the Kaufman Assessment Battery for Children-Second Edition (KABC-II; Kaufman & Kaufman, 2004) found a significant effect of visual processing (Gv) on reading comprehension in grades 1–3 (Hajovsky et al., 2014), although no other studies have found effects for Gv on reading comprehension.

5. Reading fluency

Reading fluency is the speed at which someone can read a written passage with understanding. Little research has examined the cognitive predictors of reading fluency. Existing research found that Gc and processing speed have significant effects on reading rate (Benson, 2007; Cormier et al., 2017; Nilleskela et al., 2016). The effect of Gs on reading fluency may increase with age. There is some suggestion that Gf exerts a significant effect too, with a stronger influence among younger students (Cormier et al., 2017).

6. Broad reading

The effects of cognitive abilities on broad reading achievement have also been studied; such analyses involved achievement latent variables that were measured by a combination of basic reading and reading comprehension (Beaujean et al., 2014; Glutting et al., 2006; Oh et al., 2004). Such analyses are focused on the aspects of reading shared in common among all reading measures and not the specific components of reading.1 Despite differences in the broad and specific reading constructs, Gc has also been shown to exert an important influence on broad reading achievement using the Wechsler tests (Beaujean et al., 2014; Glutting et al., 2006; Oh et al., 2004), as have Gsm and Gf (Beaujean et al., 2014).

7. Basic math skills

Basic math skills include calculation and computation skills. Gs, Gc, and Gf have been shown to influence basic math skills across studies (Floyd, Evans, & McGrew, 2003; Keith, 1999; McGrew & Hessler, 1995; Nilleskela et al., 2016). Most studies have found consistent effects for Gs across all school ages, but one found stronger effects from ages 5 to 11 (McGrew & Hessler, 1995). Further, Gc may exert a larger effect after age 9 (Floyd et al., 2003; McGrew & Hessler, 1995). Gsm may also

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1 The specific components could also be included in these models, but do not appear to have been analyzed.
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