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Published in final edited form as:
Gift Child Q. 2013 October ; 57(4): . doi:10.1177/0016986213500342.

Differences between Children with Dyslexia Who Are and Are Not Gifted in Verbal Reasoning

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Abstract

New findings are presented for children in grades 1 to 9 who qualified their families for a multi-generational family genetics study of dyslexia (impaired word decoding/spelling) who had either superior verbal reasoning (n=33 at or above 1 2/3 standard deviation, superior or better range; 19% of these children) or average verbal reasoning (n=31 below population mean, but above – 2/3 standard deviation, average range; 18% of these children). Evidence-based rationale and results supporting the tested hypotheses are provided: (a) twice exceptional students with superior verbal reasoning and dyslexia significantly outperformed those with average verbal reasoning and dyslexia on reading, spelling, morphological, and syntactic skills, (b) but not on verbal working-memory behavioral markers of genetically based dyslexia related to impaired phonological and orthographic word-form storage and processing, naming orthographic symbols (phonological loop), writing orthographic symbols (orthographic loop), and supervisory attention (focus, switch, sustain, or monitor attention). Superior verbal reasoning may mask dyslexia if only very low achievement is used to identify this disorder of oral word reading and written spelling. Instruction for twice exceptional students who have dyslexia, but are also verbally gifted, should focus not only on oral word reading and written spelling but also the impaired working memory components within intellectually engaging lesson sets. These findings for gifted students with dyslexia are situated within the broader context of the many kinds of twice exceptionalities related to specific learning disabilities that exist in school-age children and youth.

The paradox that students who are gifted and talented can also have a specific learning disability has been recognized for over three decades (e.g., Barton & Starnes, 1989; Baum, 1984; Brody & Mills, 1997; Foley Nicpon, Allmon, Sieck, & Stinson, 2011; Foley-Nicpon, Assouline, & Colangelo, 2013; Schiff, Kaufman, & Kaufman, 1981; Waldron, Saphire, & Rosenblum, 1987; Whitmore, 1981). Keating (1991) contributed pioneering insight that the gifted and talented cannot be identified solely by a single test score because talents can express in many different ways.

Increasingly, the students who have both talents and disabilities are referred to as Twice Exceptional (for reviews of the more recent research, see Foley Nicpon et. al, 2011 and Gilger & Hynd, 2008). Moreover, there is increasing recognition that students who are twice exceptional may be (a) gifted in different kinds of cognitive abilities or areas of the curriculum or even non-academic domains such as the visual arts or performing arts (music, dance, and/or drama), leadership, or athletics; and (b) may have different kinds of specific learning disabilities such as reading disability (e.g., Gilger & Hynd, 2008), writing disability (Assouline, Foley Nicpon, & Whiteman, 2010; Ganshow, 1985; Yates, Berninger, & Abbott, 1994), or math disability (Busse, Berninger, Smith, & Hildebrand, 2001; Fox, Brody, &

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Tobin, 1983; Yates, 1996) or a specific developmental disability such as autism (Kalbfleisch, & Loughan, 2012).

The current research focused on one kind of twice exceptionality—children and youth who are gifted in verbal reasoning ability but also have dyslexia, a specific kind of learning disability that impairs word decoding during reading and word spelling during writing. Of interest was how students with dyslexia differed from other students with dyslexia who were not gifted in verbal reasoning.

The research reported in this article differs from some research on twice exceptionalities that is conducted in school-based or clinic-referred studies in that it was conducted in a family genetics project within multidisciplinary research center on learning disabilities for the specific aims of identifying probable behavioral markers of dyslexia and underlying genetic bases of dyslexia. As such it was part of a larger line of programmatic research on dyslexia at multiple learning disabilities research centers funded by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NCHD). For example, the University of Colorado center has a long standing research program with twin studies, which have shown that both heredity and environment influence reading disabilities (e.g., for overview, see Olson, Byrne, & Samuelson, 2009). Their linkage studies identified associations between reading disability and specific chromosomes such as chromosome 6 and 15 (e.g., Smith, Kimberling, Pennington, & Lubs, 1983). Now that the human genome has been sequenced, these studies have been extended to include genome-wide sequencing in collaboration with Smith at the University of Nebraska (work in progress).

The research funded by NICHD and other NIH institutes has shown that not all reading disabilities are the same, that is, not all reading disabilities are dyslexia. Some reading disabilities are related to oral language learning disabilities that emerge in the preschool years and often result in reading comprehension disability during the school age years or are late emerging during middle childhood (e.g., Catts, Fey, Tomblin, & Zhang, 2002; Scarborough, 2005). Yet other research programs focused on dyslexia, which is often first evident in kindergarten when children cannot name letters or learn the sounds that go with them (Berninger et al., 2006). Dyslexia is a word of Greek origin meaning impaired word-level skills. According to the International Dyslexia Association, dyslexia is impairment in word-level oral reading, especially decoding unknown words, and written spelling (Lyon, Shaywitz, & Shaywitz, 2003).

On the one hand, there is a consensus that reading disability, whether early emerging in the school age years, at school entry, or in middle childhood, is a language-based impairment (Catts, Fey, Zhang, & Tomblin, 1999). On the other hand, there is considerable evidence that reading disability is related to working memory (e.g., Swanson, 1992; Swanson, Zheng, & Jerman, 2009; Swanson & Siegel, 2001). Evidence exists for dyslexia having both a phonological core deficit (Morris et al., 1999) and a phonological core deficit within a multi-component working-memory architecture (Berninger et al., 2006).

The concept of working memory with a phonological loop, visual scratch pad, and central executive function, as originally proposed by Hitch and Baddeley (1976), has evolved (Baddeley, 2002). The phonological loop has been re-conceptualized as a language learning device that integrates visual or orthographic codes and phonological codes (Baddeley, Gathercole, & Papagno, 1998). An orthographic loop has been identified. This loop integrates internal visual/orthographic codes and serial finger movements (for review of evidence, see Berninger & Richards, 2010). Both syntactic units for accumulating words (Daneman & Carpenter, 1980), and spoken (phonological), written (orthographic), and morphological (bases, prefixes, suffixes) word-forms can be stored and processed (e.g., Crosson et al., 1999; Richards et al., 2006). Evidence supports multiple executive functions —not a single central executive— in supervisory atention (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000).

In 1995 the NICHD-funded interdisciplinary learning disability center at the University of Washington (UW) launched a family genetics study of dyslexia. For two reasons, children referred to the research project because of ongoing struggles with reading and/or spelling had to meet research criteria based on their verbal reasoning falling in the average or higher ranges (top 75 percent of the population). First, large scale, NICHD-funded studies of referred children (Greenblatt, Mattis, & Trad, 1990) and un-referred children (Vellutino, Scanlon, & Tanzman, 1991) with reading disabilities showed that the verbal reasoning factor or index score explained more unique variance in reading disability than nonverbal measures of intellectual functioning. Second, a cut-off criterion for verbal reasoning of -2/3 standard deviation (standard score of 90, 25^{th} percentile) was set because of the high incidence of neurogenetic disorders other than dyslexia that occur below this cut-off (e.g., Batshaw, Roizen, Lotrecchiano, 2013). Because the goal was to identify genetic markers and mechanisms specific to dyslexia and not to the many other developmental and learning disorders, the cut-off was set to reduce the probability of those other neurogenetic disorders co-occurring with reading problems in the family genetics sample.

In addition, there had to be a multi-generational history of reading problems in the family for the child and family to meet criteria to participate in the study. This criteria increased the probability that the child's reading difficulties were probably in part related to genetic infleunces and not related solely to instructional variables.

Level of word reading and spelling achievement (Lefly, & Pennington, 1991) had to meet criteria of both low achievement (below the population mean) and some underachievement (at least one standard deviation or 15 standard score points below verbal reasoning). This size of discrepancy is less than that required to qualify for special education in public schools, but researchers have never identified a specific amount of discrepancy that can differentiate who does and does not have a specific learning disability. In fact, most of the children who met the research criteria for dyslexia in the family genetics study exhibited far larger differences between their verbal reasoning and word reading and spelling skills than 15 standard score points (Berninger et al., 2006).

Children in grades 1 to 9 who met these research criteria for dyslexia qualified their families for participation in the multi-generational family genetics study. In addition, clinical measures that appear to be associated with an underlying genetic basis for dyslexia were also admininstered. The initial set was based on measures that had already been used in studies of reading disabilities. Confirmatory factor analyses and structural equation modeling studies validated the following predictors for reading and spelling outcomes in the children and youth who qualified for this family genetics study:

- multiple word (phonological, orthographic, and morphological) (Berninger et al., 2006) and syntax (Daneman & Carpenter, 1980) storage and processing units
- phonological loops and orthographic loops (Brooks, Berninger, Abbott, & Richards, 2011); and
- executive functions for supervisory attention (Swanson, 1993, 1999, 2000).

See the Glossary in the Appendix for definition of these specialized terms used in this article. For an overview of the results of the validation studies for related behavioral markers of dyslexia in the first five years (waves 1–3) and next six years (waves 4 and 5) of the family genetics study, see Berninger and Richards (2010).

Goals and Tested Hypotheses for the Current Research

In the course of the eleven years of the family genetics project, many parents whose children had superior or very superior verbal reasoning shared with the research team how difficult it was to convince educators that their child had a learning disability. Frequently they reported being told that their child was bright and the problem was just a matter of motivation and their child not being willing to work hard. However, only for purposes of the current study did the research team systematically examine whether there were differences in the hallmark impaired skills for dyslexia depending on whether verbal reasoning fell in the superior and above range or in the average range but below the population mean.

Raskind, Rubenstein, Matsushita, Berninger, and Wijsman (2012) found that verbal reasoning was unrelated to the genetic basis for Rapid Automatic Naming (RAN, phonological loop measure) and Rapid Automatic Switching (RAS, flexible switching attention measure). Yet, Rubenstein et al. (2011) found that verbal reasoning was related to the genetic basis for written dictated spelling disability. Thus, the research team tested the hypotheses that verbal reasoning may be related to word reading and spelling skills, but not to the verbal working memory components supporting language learning that tend to be impaired in dyslexia such as phonological and orthographic word-form storage and processing, phonological and orthographic loops, and the executive functions for supervisory attention such as RAS. Children with dyslexia do not have the morphological or syntax problems that children with specific language impairment (SLI), also known as oral and written language learning disability (OWL LD), do (Silliman & Berninger, 2011). Thus, we predicted that the twice exceptional children with dyslexia would outperform the contrasting average verbal reasoning group on morphology and syntax measures.

To test this hypothesis, the research team identified, among the children who met research criteria for dyslexia in the last six years of the family genetics study, those whose verbal reasoning fell in the superior or above range or in the average range of verbal reasoning but below the population mean. These two contrasting groups were compared to test the hypothesis that those who were superior in verbal reasoning would score higher than those with average verbal reasoning in spelling, reading, morphology, and syntax, but not the hallmark behavioral markers of dyslexia, as described earlier in this section.

Method

Participants

Human participation in this study complied with procedures approved by the Institutional Review Board. In the last six years of the genetics study for families with a multigenerational history of dyslexia (total N=174 children), 31 children (17.8% of the children who qualified the family for participation) had verbal reasoning scores in the average range (90 to 99) but below the population mean, and 33 children (18.9% of the children who qualified the family for participation) had verbal reasoning scores in the superior range (120 and above). Also inspection of the verbal reasoning scores showed that verbal reasoning scores were evenly distributed across ranges (average below the population mean, average above the population mean, above average, and superior and above); the range in which a score falls is generally considered more reliable than the score itself.

Of the 31 children falling within the average range, 61.6% were male, their mean age at first testing was 138.29 months (SD=23.06 months), and their grade distribution was grade 3 (19.4%), grade 4 (19.4%), grade 5 (19.4%), grade 6 (16.1%), grade 7 (9.7%), grade 8 (6.5%), and grade 9 (9.7%). Of the 33 children whose verbal reasoning fell in the superior range, 60.6% were male, their mean age at first testing was 132.45 months (SD=20.65

months) and the grade distribution was grade 1 (3%), grade 2 (3%), grade 3 (12.1%), grade 4 (18.2%), grade 5 (30.3%), grade 6 (12.1%), grade 7 (15.2%), grade 8 (13.0%), and grade 9 (3.0%). Thus, the groups defined on the basis of verbal reasoning were comparable in gender composition and mean age.

Measures Used in Defining Dyslexia

Verbal reasoning—Three subtests of the Verbal Reasoning Factor of The *Wechsler Intelligence Scale for Children, 3rd edition (WISC-III*) (Wechsler, 1991) were given: similarities, vocabulary, and comprehension. Note that when the family genetics study began in 1995 the fourth edition of this instrument had not yet been published. So, as in other genetics studies, the same version of the measure used when the study began continued to be used to keep the test constant. One task asks children to explain how two words are similar, another one asks them to define words, and yet another one asks them to answer questions to show comprehension of the world. No reading or writing is needed for the assessment, which requires oral answers to aurally administered items. Raw scores were converted to a standard score (*M*=100, *SD*=15) for age for the Verbal Reasoning score. Reliabilities reported in the test manual ranged from .91 to .95.

Real word reading--accuracy—The *WRMTR Word Identification* (Woodcock, 1987) subtest requires a child to read a list of pronounceable real words accurately, and, thus, is a measure of oral word identification without sentence context clues. Raw scores were converted to standard scores for age (*M*=100, *SD* =15). Average reliability reported in the test manual was .97.

Pseudoword decoding—accuracy—The *WRMTR Word Attack* (Woodcock, 1987) subtest requires a child to read a list of pronounceable non-words accurately, and, thus, is a measure of oral decoding. Raw scores were converted to standard scores for age (*M*=100, *SD* =15). Average reliability reported in the test manual was .87.

Real word reading—rate—The *TOWRE Sight Word Efficiency* (Torgesen, Wagner, & Rashotte, 1999) subtest measures the child’s accuracy in pronouncing printed words in a list without context clues within a time limit of 45 seconds. Raw scores were converted to standard scores for age (*M*=100, *SD* =10). Average reliability reported in the test manual was .91.

Pseudoword decoding—rate—The *TOWRE Phonemic Decoding Efficiency* (Toregesen et al., 1999) requires a child to read a list of pronounceable non-words accurately within a time limit of 45 seconds. Raw scores were converted to standard scores for age (*M*=100, *SD*=15). Average reliability reported in the test manual was .90.

Dictated spelling of real words—*WRAT 3 Spelling* (Wilkenson, 1993) requires the child to spell, in writing, dictated real words pronounced alone and in sentence context for meaning clues. Scores for number of correctly spelled words were converted to standard scores for age (*M*=100, *SD* =15). Reliability reported in the test manual was .96.

Dictated spelling of real words—*sWIAT-2 Spelling* (Wechsler, 2001) requires the child to spell, in writing, dictated real words pronounced alone and in sentence context for meaning clues. Scores for number of correctly spelled words were converted to standard scores for age (*M*=100, *SD* =15). Reliability reported in the test manual was .94.

Measures Used in Assessing Verbal Working Memory Components Related to Dyslexia

Phonological word-form storage and processing—*CTOPP Nonword Repetition* (Wagner, Torgesen, & Rashotte, 1999) requires children to listen to taped spoken nonwords of an increasing number of syllables and then to repeat them. Raw scores were converted to standard scores for age (*M*=100, *SD*=15). Reliability reported in the test manual was .80. Genetic analyses showed this measure was one of the best markers of dyslexia (for review, see Berninger & Richards, 2010); and brain imaging showed that children with dyslexia differed from controls without dyslexia in analyzing the sound patterns in the heard words during the processing phase of a nonword repetition task (Richards et al., 2007).

Orthographic word-form storage and processing—*UW Receptive Coding* (Berninger et al., 2006) requires children to view written words for 1 second, then close eyes, and answer yes or no to questions about whether the word that followed matched it exactly or had the displayed letter or letter group in it. Correct answers do not require that the word be phonologically decoded because the letter or letters to be stored and produced either have alternative sounds or no sounds associated with them. Rather, correct answers require attention to and memory for letter patterns in the originally displayed written words. Raw scores were converted to *z*-scores for grade. Test-retest reliability in the research sample was .76.

Morphological word-form storage and processing—For *UW Comes From* (Nagy, Berninger, & Abbott, 2006), children view and listen to word pairs pronounced by the examiner. The task was to decide if the second word comes from (is related in meaning to) the first word. For example, the child had to decide whether *corner* comes from *corn* (no), and whether *builder* comes from *build* (yes). Raw scores were converted to *z*-scores for grade. Test-retest reliability in the research sample was .62.

Syntax storage and processing—For *CELF 3 Sentence Formulation* (Semel, Wiig, Secord, 1995), children view three pictured words pronounced by the examiner and construct an oral grammatical sentence using the three words. Raw scores were converted to scaled scores with a mean of 10 and standard score of 3 for age. Reliability reported in the test manual was .71.

Phonological loop—*RAN Letters* measures ability to integrate letter codes and name codes quickly in time. Scores are based on the amount of time the child takes to name four rows of lower case letters as quickly as possible. This measure, which assesses a different skill than phonological memory or phoneme awareness, used a prepublication measure and research norms from Wolf's lab at Tufts University to create *z*-scores for grade. Test-retest reliability in the research sample was .65.

Orthographic loop—For *Alphabet 15,* children write the alphabet from memory as quickly as possible in alphabetic order so that others can recognize the letters. The score was the number of legible letters in correct alphabetic order in the first 15 seconds (for review of evidence, see Berninger & Richards, 2010). Raw scores were converted to *z* scores (*M*=0, *SD*=1) for grade. Interrater reliability in programmatic research using this measure was .97.

Selective focused attention—*Delis Kaplan Color Word Form Inhibition* (Delis, Kaplan, & Kramer, 2001) subtest is based on the classic Stroop task. The child is asked to read orally a color word in black and then name the ink color for a written word in which the color of the ink conflicts with the color name of the word (e.g., red written in green ink). The difference in time for reading the words in black and naming the color of the ink that conflicts with the name of the color word is an index of ability to inhibit irrelevant information. Raw scores were converted to scaled scores for age (*M*=10, *SD*=3). Reliability reported in the test manual was .62.

Switching attention—total time—The *Rapid Automatic Switching* (RAS) (Wolf, 1986) requires rapid switching between naming of letters and naming of numerals. This score is based on total time summarized across rows for the child to switch attention as orthographic stimuli to be named change categories. This measure used prepublication measures and norms from Wolf's Tufts University research group to create *z*-scores for grade. Test-retest reliability in the research sample was .81.

Switching attention time row by row—This *Rapid Automatic Switching* (RAS) required rapid switching among naming of letters, naming of numerals, and naming of colors. In contrast to the RAS total Time, for this RAS task, time is recorded for each of four rows and evaluated for how switching attention time changes over time. As such it is a measure of sustaining attention and staying on task for an activity requiring naming of varying visual stimuli. The *z*-scores for each row were based on the growth mixture modeling that identified and validated two kinds of patterns of RAS over time among the children with dyslexia compared to children without dyslexia in the family genetics study: (a) steady slow, and (b) slow and slower (Amtmann, Abbott, & Berninger, 2007). This measure was given because of the frequent parent-report, self-report of those with dyslexia, and professional observation that many students with dyslexia have difficulty sustaining their attention over time on tasks that require them to process spoken and/or written language.

Data Analyses

For each measure in Table 1, which had been validated in prior structural equation modeling studies as contributing to the reading and writing outcomes of children with dyslexia during early and middle childhood (e.g., Berninger, Abbott et al., 2006), the statistical significance of the differences in the mean level of performance was evaluated for the groups with superior and average verbal reasoning. Of interest were observed significant differences between those with superior and average verbal reasoning on measures of (a) reading, writing, morphology, and syntax skills, and (b) hallmark markers of dyslexia as described earlier.

Because of the number of measures tested with between-group ANOVAs, the significance level was set at .001 or less because of the large number of multiple comparisons. However, the comparisons were based on measures that had been previously validated in multidisciplinary research studies (for overview, see Berninger & Richards, 2010). Even though the current study was the first comparison of those with superior verbal reasoning ability and average verbal reasoning ability in the eleven-year family genetics study, the specific tested comparisons were grounded in an evidence-based theoretical framework validated in prior cross-disciplinary studies.

Results

Descriptive Statistics

The means and SDs for each measure and the ANOVA results for each measure are reported in Table 1. Effect sizes are also reported in Table 1 for each of the reading and writing outcomes and each of the hallmark markers of dyslexia. Effect sizes were not computed for verbal reasoning ability because groups were selected on the basis of very high verbal reasoning (at least in superior range) or very average verbal reasoning (below the population mean but in average range). Results based on inferential statistics, which follow, are organized by those on which the two verbal reasoning ability groups did not differ and those on which they did.

Measures Not Affected by Verbal Reasoning Ability

The groups with superior verbal reasoning and dyslexia did not differ reliably from those with average reasoning and dyslexia on the following measures at the significance level set given the multiple comparisons: CTOPP Nonword Repetition (phonological coding in working memory), UW Receptive Coding (orthographic coding in working memory), Rapid Automatic Naming of Letters (phonological loop), Rapid Automatic Writing of Letters (orthographic loop), and all the supervisory attention functions of working memory (low-level executive functions) including Inhibition (selective focus on what is relevant and inhibiting what is not relevant), rapid automatic switching attention (flexible focus), sustaining attention (staying on task across time), and repetitions during verbal fluency (self-monitoring and updating working memory over time). Thus, children with superior verbal reasoning and average verbal reasoning did not differ in the hallmark markers of dyslexia validated in prior studies. Effect sizes for these verbal working memory markers of dyslexia ranged from moderately high (phonological and orthographic coding and phonological loop) to moderately low (orthographic loops and supervisory attention for inhibition and self-monitoring). See Table 1.

Measures Affected by Verbal Reasoning Ability

Those with superior verbal reasoning were significantly higher on morphological coding and syntactic coding measures that did not require reading because they were administered orally. They were also significantly higher on all measures of word-level reading and spelling skills. Thus, superior verbal reasoning may result in higher learning outcomes both for oral language skills which are not associated with dyslexia and word-level written language skills that are defining markers of dyslexia. Indeed effect sizes were quite large for the morphological and syntactic skills, which influence responses on Verbal Reasoning test items, and word reading and spelling. See Table 1.

DISCUSSION

Significance of Findings for Identifying and Teaching the Twice Exceptional with Dyslexia

Superior verbal reasoning may mask effects of dyslexia on oral and written language skills if only those with the very lowest achievement in word reading and word spelling are identified as having dyslexia. Twice exceptional students with dyslexia may be below the population mean (as half the population is on many variables) in word reading and spelling, even if they are not necessarily the lowest readers and spellers in their class. Nevertheless they may be underachieving for their verbal ability and struggle visibly or invisibly in reading and spelling across the school years and even adult years if not identified and given appropriate, specialized instruction. Likewise, they may respond to reading and writing instruction in that they are not the very lowest achievers in the response to intervention (RTI) measures used in schools to monitor progress in reading and writing. Their relative strengths in oral language may mask their struggles with written language that result in underachievement for their verbal reasoning ability.

The invisible struggles have been shown in multiple research studies to be related to component processes in verbal working memory that interfere with their ability to analyze sounds in spoken words, analyze letters in written words, integrate letters with saying sounds or letter codes with writing letters, or supervise their attention to focus on the task at hand, switch among tasks, and/or stay on task. As a result, they have to exert more mental effort and work harder and longer than peers to complete reading and writing assignments in

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and out of school. Thus, an evidence-based approach to identifying dyslexia includes not only measures of reading and spelling achievement in assessment but also measures of the hallmark skills programmatic research has shown are related to dyslexia (see Silliman & Berninger, 2011, for dyslexia and other developmental and learning disabilities).

As the results showed, superior verbal reasoning does not eliminate the core impairments in dyslexia related to the verbal working memory architecture that supports written language learning: (a) storage and processing units for spoken words and written words, (b) phonological and orthographic loops for integrating those word codes and their parts with output systems through the mouth or hand, respectively, and (c) the supervisory attention/ executive functions of working memory for focusing, switching, sustaining, and self-monitoring attention. Unless these skills are assessed and educators are aware of which skills are impaired in an individual student, the nature of the learning struggles a twice exceptional student with dyslexia faces remains invisible. Many students with dyslexia self-report that no one sees how much harder they have to work to achieve the same reading and writing outcomes as classmates. That is because they truly do have genetically based impairments in the verbal working memory architecture supporting their written language learning. Such an invisible disability may be especially frustrating in an individual with superior verbal reasoning—a talent in oral language despite a specific learning disability in written language.

To summarize, neither an IQ-achievement discrepancy nor response to intervention (RTI) approach with focus on only the lowest achieving readers is likely to identify all the twice exceptional students who are verbally gifted but also have dyslexia. Not only these students but also those with dyslexia but average verbal reasoning need instruction individually tailored to their weaknesses or impairments in verbal working memory components identified through assessment of their individual learning profiles, as discussed next.

Individually Tailored Instruction for Twice Exceptional Students with Dyslexia

Assessing the profile of skills associated with a specific learning disability such as dyslexia also provides clues for individually tailoring the instructional program to develop skills for (a) holding spoken words in working memory while analyzing their sounds, (b) holding written words in working memory while analyzing their letters, (c) naming letters and written words, (d) finding and producing legible letters automatically in writing, and (d) supervising attention (focusing, switching, sustaining, and monitoring) while reading and spelling words. For example, effective strategies in instructional studies that included twice exceptional students with dyslexia in grades 4 to 9 from the family genetics study were as follows:

- **a.** clapping number of syllables in spoken words and holding up fingers for number of phonemes in each syllable,
- **b.** finding and writing letters that come before and after other letters in the alphabet,
- **c.** focusing attention by looking at and touching a letter or letter group, saying the name of letter or letter group, and name of pictured word, and making the sound in the word that corresponds to the letter or letter group,
- **d.** switching attention in left to right order within a word by first writing the spelling units that correspond to a sound in alphabetic principle in alternating colors with colored pencils and then sounding out the alternating units in order,
- **e.** continuing to write in response to teacher-provided prompts until time is called,
- **f.** teaching strategies to self-check one's own work, and

g. using feedback in one lesson to set goals for the next lesson.

All these strategies should be taught in lesson sets with intellectually engaging themes to teach to the student's verbal talent and not just the disability. That is, appropriate education for twice exceptional students is aimed at both their specific talents and their specific disabilities. For details of planning, implementing, and evaluating such lessons based on research with the children in the family genetics study, which always included intellectually engaging science activities as well as specialized instruction for the learning disability, see Berninger and Wolf (2009).

Limitations of the Current Study

These findings should be generalized only to students who have multi-generational family history of dyslexia and whose verbal reasoning, word reading and spelling achievement, and verbal working memory skills associated with dyslexia have been appropriately assessed by a qualified examiner. As discussed in the introduction, there are many different kinds of reading disabilities which have different genetic bases (Raskind, Peters, Richards, Eckert, & Berninger, 2013). Different kinds of reading disabilities probably require different kinds of assessment batteries and different kinds of specially designed instruction for the different associated impaired skills. The results of the current study only generalize to those who are twice exceptional in that, on one hand, they are verbally gifted in the upper range of the distribution of verbal reasoning, but, on the other hand, they have a specific reading disability—dyslexia, and fall in the lower half of the distribution of reading ability and often much lower than the population mean. Although a student with dyslexia may not be the lowest achieving reader in a class, they still need to have their dyslexia diagnosed and treated regardless of their level of verbal reasoning ability within the normal range. They need more than accommodations—they need specialized instruction and ongoing progress monitoring during K-12.

Another limitation of the current study is that it did not address students with dyslexia who may be superior or above in nonverbal but not verbal reasoning. They are also deserving of individually tailored instruction based on research evidence specific to their profile of relative strengths and weaknesses in specific cognitive, language, and working memory skills.

Situating Findings within Multiple Ways of Being Twice Exceptional

As an ever growing body of research has shown, some individuals may be at the upper end of one distribution of a human trait and at the same time be at the lower end of the distribution of another human trait. Yet, as shown in the current study, even if inherited independently, some traits such as verbal reasoning may influence the acquisition of other skills like word reading and writing skills, but not acquisition of all skills such as the verbal working memory components that support written language learning.

The current study focused on one kind of twice exceptionality—children and youth with dyslexia and verbal reasoning giftedness-- in families with multi-generational history of dyslexia—in a research center. However, future research might build upon the progress being made in identifying the gifted and talented among students from diverse cultural and ethnic backgrounds in school settings (e.g., see Worrell, 2013) to study twice exceptional with dyslexia and verbal reasoning talent across different cultural and ethnic groups. Such research, which might use the model employed in the current study, is needed because even if some human traits are inherited independently of each other, environment and culture also influence development of human traits.

As a result, a child can be both gifted in verbal reasoning and affected with dyslexia, but whether and how the twice exceptionality is identified and dealt with may depend on a host of environmental issues, which need to be taken into account if educators are to optimize learning for all students.

Future Directions

Clearly more research is needed to further our understanding of early identification and continuing monitoring of children who are twice exceptional in many different ways in school and outside school. Moreover, it is likely most students who are twice exceptional may best be served in general education where their talent benefits from exposure to the regular curriculum, enrichment activities, and interactions with typically developing students. To ensure that their educational needs are met, however, requires that preservice teachers are adequately prepared to identify and teach students with a "different kinds of twice exceptionalities," and inservice teachers receive adequate support services from other members of the interdisciplinary team including school psychologists, speech and language specialists, occupational and physical therapists, and medical professionals.

Summary and Conclusions

Students may be both verbally gifted and learning disabled. For those with evidence-based dyslexia, a genetic-based disorder in learning to read words orally and spell written words, talent at the upper end of the distribution of verbal reasoning may mask their dyslexia. However, although these twice exceptional students with dyslexia may respond to reading and writing instruction in that they are not be the very lowest readers and spellers in their classes, they may be readers and spellers who are underachieving for their verbal reasoning ability and struggling more than peers in completing assignments in and out of school. The evidence-based way to identify them and plan appropriate instruction is not to rely on IQ-achievement discrepancy or RTI alone, but rather to provide comprehensive assessment with measures of reasoning, reading and spelling achievement, and evidence-based working memory skills associated with a specific learning disability such as dyslexia. The pattern of relative strengths and weaknesses in that profile of skills should also be taken into account in planning, implementing, and evaluating response to instruction and monitoring twice exceptional students with dyslexia (and other disabilities) throughout schooling to ensure that both their talent and disability receive appropriate instruction and support. More research on identification and treatment for the various kinds of twice exceptionalities in multiple cultures and school settings is needed.

Acknowledgments

The results in this article were presented at the annual meeting of the American Association for Educational Research on April 14, 2012 in Vancouver, British Columbia in a symposium organized by Layne Kalbfleisch, President Brain and Education Special Interest Group, "*Twice exceptional: Insight into paradoxical learners through neurological and neuropsychological investigation*." The authors thank Jeff Gilger for suggesting that they examine the twice exceptional in their family genetics sample.

Grant Support:

This research was supported by P50HD071764 and P50 HD 33812 from the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) at the National Institutes of Health (NIH) to the University of Washington.

Glossary

See section in text on "Individually Tailored Instruction for Twice Exceptional Students with Dyslexia" for instructional strategies for each of the components of the working memory architecture supporting language learning.

STORAGE AND PROCESSING UNITS

SYNTAX	accumulating words are coded into working memory where processed for serial order, content and function words, clause structures, grammar, idioms

LOOPS

PHONOLOGICAL LOOP	naming visual or orthographic stimuli for cross-code integration
ORTHOGRAPHIC LOOP	writing orthographic stimuli through cross-code integration of mind's eye (letters or orthographic word forms in working memory) and serial finger movements

PANEL OF EXECUTIVE FUNCTIONS FOR SUPERVISORY ATTENTION

FOCUSED ATTENTION	inhibit what is irrelevant, focus on what is relevant
SWITCHING ATTENTION	change focus of attention—what was relevant becomes irrelevant and what was irrelevant becomes relevant
SUSTAINING ATTENTION	maintaining attention over time to stay on task
SELF-MONITORING	keeping track of unfolding mental activity

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Table 1

Results for Comparing Children in Grades 1 to 9 who Qualified Their Family for Multigenerational Study of Dyslexia with Verbal Reasoning 90–99 and Verbal Reasoning 122-142

($p < .001$ significant; $p > .001$ non-significant; see notes below table about measures and ES)

	Probands (n=31) VIQ 90—99		Probands (n=33) VIQ 122-142		ANOVA Results			
	Mean	SD	Mean	SD	F (df)	MS Error	P value	ES
Cognitive								
WISC3 Verbal Index	95.03	3.29	129.88	6.45	727.35 (1,62)	26.69	.001	
Working Memory Components								
CTOPP Nonword Repetition	7.45	1.65	8.30	1.74	4.11 (1,62)	2.82	.047	.51
UW Receptive Coding	−1.29	0.71	−0.60	0.82	8.14 (1,42)	0.61	.007	.88
UW Comes From	−1.37	1.37	0.22	0.55	30.83 (1,49)	1.04	.001	1.56
CELF3 Sentence Formulation	8.61	2.00	12.30	1.93	56.62 (1,62)	3.84	.001	1.88
Wolf RAN Letters	2.64	3.12	1.43	1.66	3.75 (1,60)	6.13	.058	0.49
UW Alphabet 15	−0.90	0.83	−1.11	0.69	1.16 (1,61)	0.58	.285	0.28
RAS Letters, Digits Total Time	3.07	2.70	2.24	1.92	2.01 (1,61)	5.40	.162	0.36
Delis Kaplan Inhibition	8.53	3.20	8.10	3.13	0.29 (1,59)	10.04	.593	0.14
Delis Kaplan Verbal Fluency Repetitions	6.48	2.72	7.31	2.28	1.72 (1,61)	6.27	.194	0.33
RAS Line 1	7.13	3.56	7.67	2.24	0.14 (1,15)	8.59	.709	0.18
RAS Line 2	15.50	5.32	18.67	2.96	2.38 (1,15)	17.87	.144	0.75
RAS Line 3	25.38	9.13	29.56	4.64	1.47 (1,15)	50.41	.244	0.59
RAS Line 4	37.88	15.69	39.67	5.77	0.10 (1,15)	135.59	.753	0.15
Reading and Writing Skills								
WRMTR Word ID	77.48	11.70	96.70	13.19	37.83 (1,62)	155.98	.001	1.54
WRMTR Word Attack	78.42	13.01	92.30	10.47	22.23 (1,62)	138.59	.001	1.18
TOWRE Sight Word Efficiency	83.68	10.21	96.64	11.99	21.53 (1,62)	124.68	.001	1.16
TOWRE Phonemic Decoding Efficiency	80.23	11.50	90.06	8.62	15.11 (1,62)	102.34	.001	0.97
WRAT-3 Spelling	80.81	8.53	90.06	8.53	18.82 (1,62)	72.75	.001	1.09
WIAT-2 Spelling	76.80	8.11	87.64	10.70	20.21 (1,61)	91.32	.001	1.13

Notes for Measures: WISC 3 Verbal Index assesses verbal reasoning. CTOPP nonword repetition assesses phonological word-form storing and processing. UW Receptive Coding assesses orthographic storing and processing. UW Comes-From assesses morphological storing and processing. CELF3 assess syntactic coding ability. RAN assesses rapid automatic naming of letters (phonological loop). UW Alphabet 15 assesses rapid automatic letter writing (orthographic loop). RAS assesses rapid automatic switching of supervisory attention in working memory. Delis-Kaplan Color Word-Form Inhibition assesses selective attention for focusing attention. Delis-Kaplan Verbal Fluency Repetitions assesses self-monitoring of working memory. RAS for letters, number, and colors across lines 1, 2, 3, and 4 assesses sustaining switching attention across time. WRMTR Word Identification assesses accuracy of real word reading. WRMTR Word Attack assesses accuracy of pseudoword decoding. TOWRE Sight Word Efficiency assesses rate of real word reading. TOWRE Phonemic Reading Efficiency assesses rate of pseudoword decoding. WRAT3 and WIAT 2 assess accuracy of dictated written spelling for words pronounced alone and in sentence context.

Notes for ES. Effect sizes based on difference in means for the two groups divided by the pooled SD for the whole sample.