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Spelling Well Despite Developmental Language Disorder: What Makes it Possible?

Natalia Rakhlin[1], **Cláudia Cardoso-Martins**[2], **Sergey A. Kornilov**[1,3,4,5], and **Elena L. Grigorenko**[1,4,5,6]

[1]Yale University, New Haven, Connecticut

[2]Universidade Federal de Minas Gerais, Belo Horizonte, Brazil

[3]University of Connecticut, Storrs, Connecticut

[4]Haskins Laboratories, New Haven, Connecticut

[5]Moscow State University, Moscow, Russian Federation

[6]Columbia University, New York, New York

Abstract

The goal of the study was to investigate the overlap between Developmental Language Disorder (DLD) and Developmental Dyslexia, identified through spelling difficulties (SD), in Russian-speaking children. In particular, we studied the role of phoneme awareness (PA), rapid automatized naming (RAN), pseudoword repetition (PWR), morphological (MA) and orthographic awareness (OA) in differentiating between children with DLD who have SD from children with DLD who are average spellers by comparing the two groups to each other, to typically developing children as well as children with SD but without spoken language deficits. One hundred forty nine children, aged 10.40 to 14.00, participated in the study. The results indicated that the SD, DLD, and DLD/SD groups did not differ from each other on PA and RAN Letters and underperformed in comparison to the control groups. However, whereas the children with written language deficits (SD and DLD/SD groups) underperformed on RAN Objects and Digits, PWR, OA and MA, the children with DLD and no SD performed similarly to the children from the control groups on these measures. In contrast, the two groups with spoken language deficits (DLD and DLD/SD) underperformed on RAN Colors in comparison to the control groups and the group of children with SD only. The results support the notion that those children with DLD who have unimpaired PWR and RAN skills are able to overcome their weaknesses in spoken language and PA and acquire basic literacy on a par with their age peers with typical language. We also argue that our findings support a multifactorial model of developmental language disorders (DLD).

Keywords

developmental language disorder; developmental dyslexia; phonemic awareness; rapid automatized naming; comorbidity

Correspondence concerning this article should be addressed to Elena L. Grigorenko, Child Study Center, 230 South Frontage Road, Yale University, New Haven, CT 06519-1124. elena.grigorenko@yale.edu.
Natalia Rakhlin, Child Study Center, Yale University, natalia.rakhlin@yale.edu. Claudia Cardoso-Martins, Department of Psychology, Universidade Federal de Minas Gerais, Brazil, cardosomartins.c@gmail.com. Sergey A. Kornilov, Yale University, sergey.kornilov@yale.edu.

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It has been widely observed that difficulties with literacy acquisition are pervasive among children with Developmental Language Disorder (DLD)[1], and language difficulties or a history of language delay are common among children diagnosed with developmental dyslexia (DD; Botting, Simkin, & Conti-Ramsden, 2006; Catts, Bridges, Little, & Tomblin, 2008; Conti-Ramsden, Durkin, Simkin, & Knox, 2009, Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010; for a review, see Scarborough, 2009). For example, Conti-Ramsden, Botting, Simkin, and Knox (2001) reported that 77% of their sample of 11-year-olds with DLD scored more than 1 *SD* below the mean for their chronological age on measures of single-word reading. Similarly, McArthur, Hogben, Edwards, Heath, and Mengler, (2000) reported that 55% of their sample of children with dyslexia scored more than 1 *SD* below the population mean on a measure of general language development, CELF-R (Semel, Wiig, & Secord, 1987).

However, as such estimates reveal, the overlap between DLD and DD is far from perfect, and some children with DLD do not exhibit word-level reading difficulties and, likewise, some children with DD do not exhibit spoken language difficulties. The extent and character of the overlap between DLD and DD is still not fully understood. An important question in this regard concerns the factors that contribute to making some children with spoken language impairments more vulnerable to developing problems with basic literacy than others. The present study investigated the contribution of several factors to the literacy outcomes of Russian-speaking children with DLD and their matched controls. In particular, we tested the hypothesis that adequate rapid serial naming skills may act as a protective factor in literacy acquisition in children with DLD (Bishop, McDonald, Bird, & Hayiou-Thomas, 2009; Peterson, Pennington, Shriberg & Boada, 2009).

DLD is a disorder (or a spectrum of disorders) of language acquisition in the absence of obvious sensory or neurobiological explanatory factors (Leonard, 1998). Children with DLD have been documented to have a range of expressive and/or receptive difficulties in the grammatical and lexical components of language (e.g., Conti-Ramsden & Durkin, 2006) and typically underperform on certain tasks assessing cognitive functioning, particularly those measuring phonological short-term or working memory (Gathercole & Baddeley, 1990; Lum, Gelgic, & Conti-Ramsden, 2010, Montgomery & Evans, 2009). In particular, it has been widely observed that a low score on pseudo-word repetition (PWR), commonly assumed to be a measure of phonological short-term memory (pSTM; Gathercole & Baddeley, 1990), i.e., the capacity for temporary storage of unfamiliar phonological strings, is a reliable clinical marker of DLD (e.g., Conti-Ramsden, Botting, & Faragher, 2001; also see a meta-analysis by Graf Estes, Evans, & Else-Quest 2007). Moreover, deficits in phonological processing (e.g., Joanisse & Seidenberg, 1998; Leonard & Eyer, 1996) and in pSTM (Gathercole & Baddeley, 1990) have been posited as a core causal factor responsible for the difficulties in language acquisition experienced by children with DLD.

DD is characterized by a persistent difficulty to develop decoding and word recognition skills in otherwise typically developing children (Lyon, Shaywitz, & Shaywitz, 2003). Spelling difficulties are also prevalent in children with DD (Larkin & Snowling, 2010; Snowling, 2000). According to the model predominant in the literature – the phonological deficit model – these difficulties arise from incomplete or poorly specified phonological representations, which hamper children's ability to learn to read by processing and

[1]There are various labels used to refer to the condition in question, most commonly used of which is Specific Language Impairment (SLI). We will use the term DLD to refer to the clinical condition(s) in question, including when discussing or citing studies that use alternative terms. Our view is that although there may be distinct subtypes of the condition(s) in question, the DLD label can be applied as a general term if it is 1) a disorder of language (not speech), 2) of a developmental, not acquired, nature, 3) primary (not a direct consequence of another syndromic developmental or genomic disorder), and 4) appropriate exclusionary criteria are applicable/applied (e.g., normal hearing and non-verbal IQ above the cutoff for intellectual disability).

remembering letter-sound relations in words (e.g., Boada & Pennington, 2006; Liberman, Shankweiler, & Liberman, 1989; White et al., 2006). There is indeed ample evidence that children with DD show marked difficulties in tasks that assess phonological skills (for a review, see Vellutino, Fletcher, Snowling, & Scanlon, 2004), most notably in tasks of pSTM, phonemic awareness or PA, i.e. the ability to segment or manipulate sublexical constituents of speech (e.g., Wagner & Torgesen, 1987), and of rapid automatized naming (RAN; e.g., Kirby, Georgiou, Martinussen, & Parrila, 2010), although, whether slow naming is best conceptualized as stemming from phonological (Pennington, Cardoso-Martins, Green, & Lefly, 2001; Torgesen, Wagner, & Rashotte, 1994; Vellutino et al., 2004) or orthographic (Bowers & Newby-Clark, 2002) processing deficits has not been fully resolved.

Given that phonological processing has been strongly implicated in both disorders (e.g. Fraser, Goswami, & Conti-Ramsden, 2010), it is not surprising that it has been suggested that the overlap between DLD and DD is due to the phonological processing deficit being a core impairment in both disorders. However, the proposed models differ with respect to the role they ascribe to phonological processing in the etiology of both disorders (for an overview, see Messaoud-Galusi & Marshall, 2010). For example, one model maintains that both DLD and DD result from a phonological processing deficit (which itself results from an auditory processing impairment), but either differ in severity, (i.e., a mild phonological impairment leads to reading impairments and a more severe one results in a mixed DLD/DD profile), or change their manifestation from DLD to DD with development (henceforth, the single-factor severity model; see Tallal, 2004, for a review). It is important to note that while this model predicts the existence of children with DD who do not have spoken language deficits, it does not predict the existence of children with DLD with no literacy difficulties, contrary to the observations of an incomplete overlap between DLD and DD mentioned above.

An influential two-dimensional model of the DLD/DD was proposed by Bishop and Snowling (2004). It maintained that although children with DLD and DD frequently share phonological processing deficits, DLD involves additional spoken language deficits, namely those in the syntactic and semantic components of language (henceforth, the two-factor model). Thus, the clinical profile of children with both phonological processing and syntactic/semantic deficits would constitute the overlapping DLD/DD category (what Bishop and Snowling called a “classic SLI” group), while that of children with phonological deficits only would correspond to the category DD only and that of children with syntactic/semantic deficits only (“poor comprehenders” in Bishop & Snowling’s terminology) may correspond to the category DLD only. This model predicts that while the DLD/DD group is expected to have phonological processing deficits, the DLD group should not be different from their typically developing (TD) peers in this respect.

The idea of shared deficits in phonological processing in spoken language and reading disorders has been challenged by some researchers. Thus, Catts, Adlof, Hogan, and Weismer (2005) found a relatively weak association between DLD and DD. Furthermore, they reported that while children with DD and children with DLD/DD significantly underperformed on measures of phonological processing across grades, children with DLD did not differ from TD controls on these measures. This was interpreted as evidence against the deficit in phonological processing as a shared etiological mechanism in both disorders. Instead, it was suggested that DD and DLD are best conceptualized as distinct disorders, albeit frequently co-occurring in the same individuals (henceforth, the comorbidity model). This model, as the two-factor model, also predicts that children with DLD only would not exhibit deficits in phonological processing found in children with DD and comorbid DLD/DD.

Phonological processing deficits (as measured by phonemic awareness tasks, as well as phoneme discrimination and pSTM tasks) have been widely reported in children with DLD (e.g., Briscoe, Bishop, Frazier, & Norbury, 2001; Fraser, Goswami, & Conti-Ramsden, 2010). Catts and colleagues' (2005) own findings were not fully compatible with an absence of a phonological processing deficit in the non-comorbid DLD group. Indeed, all impaired groups in their study performed significantly below controls and all performed equally poorly on the measure of PA in kindergarten. Thus, phonological processing deficits appear to be part of the clinical profile in both DLD and DD, even though in some cases, children with oral language difficulties but adequate decoding skills may have normal phonological skills (e.g., Nation, Cocksey, Taylor, & Bishop, 2010). In other cases, phonological deficits are insufficient for developing DD in the DLD population (e.g., Bishop et al., 2009; Catts et al., 2005, Vandewalle, Boets, Ghesquiere, & Zink, 2010) or are not associated with the same range of spoken language difficulties in children with DD in comparison with children with DLD (e.g., Fraser, Goswami, & Conti-Ramsden, 2010).

This ostensible paradox may be better captured by an approach maintaining that although phonological processing deficits are common among children with DLD and children with DD, they may not be sufficient to fully explain either DLD or even all instances of DD. Instead, both DLD and DD can be hypothesized to involve multiple cognitive deficits (not all of which are necessarily present in all cases), one or more of which can be shared by both disorders and thus lead to comorbid DLD/DD, an idea in line with the multiple cognitive deficit model argued for by Pennington and colleagues (Pennington, 2006; Pennington et al., 2012) for DD and developmental disorders in general.

An additional factor that has been suggested to play a role in the DLD/DD overlap is rapid serial (or automatized) naming (RAN; Bishop, McDonald, Bird, & Hayiou-Thomas, 2009). Beginning with Denckla and Rudel (1976a, 1976b), a large body of research has demonstrated a relationship between children's performance on RAN tasks and their reading development (for a review, see Wolf, Bowers, & Biddle, 2000). However, there has been much disagreement on the nature of this relationship. As mentioned previously, it has been suggested that RAN is an index of phonological ability (e.g., Wagner & Torgesen, 1987). On the other hand, Wolf and her colleagues (e.g., Bowers & Wolf, 1993) have suggested that RAN indexes processes that are, at least in part, independent of phonology and involve multiple cognitive processes, including attention, visual discrimination, integration of visual information with stored phonological representations, access and retrieval of phonological labels, etc. The latter view received support from a genetically informed study by Naples, Chang, Katz, and Grigorenko (2009), who found that RAN and PA, assessed in a large sample of unselected families, had only partially overlapping genetic etiology; i.e., each skill involved both shared and unique genes, consistent with the two being non-redundant contributors to reading ability. According to this view, RAN skills and reading are related because both require rapid sequencing of visually presented information and integration of visual recognition with lexical retrieval (e.g., Wolf, Bally, & Morris, 1986, Bowers & Wolf, 1993; Wolf & Bowers, 1999). In line with this view, there is ample evidence that RAN contributes to reading above and beyond PA and pSTM (e.g., Cardoso-Martins & Pennington, 2004; Clarke, Hulme, & Snowling, 2005; Compton, Defries, & Olson, 2001, but cf. Roman et al., 2008 for evidence to the contrary).

Bishop, McDonald, Bird, and Hayiou-Thomas (2009) proposed that adequate RAN skills serve as a protective factor against the development of DD in children with DLD (who, according to them, share a deficit in phonological processing with children with DD). They tested this hypothesis in a sample of English-speaking 9-year-old children drawn from a larger sample involved in an ongoing longitudinal twin study. All children were administered a battery of tests designed to assess oral language skills including semantic, syntactic and articulation abilities, as well as measures of reading, spelling, non-verbal intelligence, pseudoword repetition, PA, RAN Objects and RAN Digits. Based on their language and literacy skills, the children were divided into 4 groups: those with comorbid DLD/DD, children with DLD only, children with DD only, and children with typical language and literacy skills. The groups were compared on literacy-related cognitive skills. Results showed that the DLD and DLD/DD groups did not differ on the phonological measures and both underperformed relative to typically developing children. However, despite their numerous oral language difficulties, the DLD-only group performed as well as controls on the RAN tasks, and RAN speed was the best predictor of DLD-only versus DLD/DD status. Furthermore, children with DD-only performed as poorly as children with DLD/DD on the RAN, and both performed significantly more poorly than both controls and the DLD-only group.

There is some cross-linguistic research supporting the idea that RAN deficits may be associated with literacy acquisition difficulties in children with oral language deficits (e.g., Brizzolara et. al., 2006, in Italian; Vandewalle, Boets, Ghesquiere, & Zink, 2010, in Dutch) or act as a mediating factor between early oral language and later literacy skills (e.g., Torppa et al., 2010, in Finnish). However, more studies in languages other than English are needed to confirm this relationship. Our study is aimed at filling this gap by an investigation in a relatively understudied, with respect to literacy and language development, language, Russian.

Russian is a language with a fairly, albeit not absolutely, consistent orthography in the direction from letters to sounds, not requiring the beginning reader to learn complex orthographic patterns. However, some properties of Russian phonology, such as complex syllable structure, certain pervasive phonological processes altering the phonological shapes of words (such as unstressed vowel reduction or consonant voicing assimilation), complex morphological structure of words, preponderance of multisyllabic words and unpredictable word stress (Kornev, Rakhlin, & Grigorenko, 2010) may influence literacy acquisition dynamics by affecting the development of PA (Caravolas & Landerl, 2010) or word recognition (Kazanina, Dukova-Zheleva, Geber, Kharlamov, & Tonciulescu, 2008; Reinisch, Jesse, & McQueen, 2010; Yap & Balota, 2009) in unique ways.

Research has shown that in transparent orthographies, word reading accuracy is not a sensitive indicator of DD (e.g., De Luca, Borrelli, Judica, Spinelli, & Zoccolotti, 2002; Landerl, Wimmer, & Frith, 1997; Wimmer, Mayringer, & Landerl, 2000), whereas spelling accuracy is (Caravolas & Volin, 2001; Landerl & Wimmer, 2008; Wimmer & Mayringer, 2002). The reason for that is that even in languages considered highly orthographically transparent, like Russian, the mapping in the direction from sounds to letters contains a high degree of irregularity, unlike in English, where the mapping in both directions - from letters to sounds and sounds to letters - is notoriously opaque. Many complications of spelling in Russian stem from the phonological and morphological complexity of the language and/or from complex morpho-phonological analysis required for correct spelling. Thus, many spelling errors stem from having to represent in spelling the underlying (morpho-phonemic) representation of the word instead of the surface (allophonic) representation, i.e., phonetic form adjusted in language-specific ways based on the phonological and morphological context. For example, in Russian, unstressed vowels undergo phonological changes depending on the vowel quality, its position relative to the stressed syllable, and the status of the preceding consonant as palatalized or non-palatalized (Timberlake, 2004) resulting in the difference between the way the word is pronounced and the way it is spelled. For example, the phonological contrast between the vowels /a/ and /o/, when they follow a non-palatalized consonant and immediately precede the stressed syllable is neutralized and both are pronounced as [a].[2] In order to spell correctly, the underlying form has to be recovered,

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which children are taught to do by finding a morphologically related word, where the vowel in question is stressed and unaltered. This requires a high level of sophistication in phonological and morphological awareness and is expected to make spelling particularly taxing for children with DD.

The current study investigated the role of PA and RAN skills in DLD and DD phenotypes by assessing children with a singular (spoken or written deficits only) and double impairment (both spoken and written deficits), as well as typically developing Russian-speaking children. Thus, the study compared the three impaired groups to each other and to their typically developing peers to test the predictions of the various models of comorbidity between DLD and DD discussed above with respect to the presence of deficits in PA and RAN in children with basic literacy difficulties compared to children with spoken language deficits only.

Method

Population

The participants for the current study come from a small Russian-speaking population, which has been the focus of a genetic and epidemiological study of developmental language disorders because of its atypically high prevalence of DLD—high rates of atypical language development despite average non-verbal IQ and the absence of apparent neurobiological or sensory pathology, as ascertained by medical records, neurological and psychiatric screenings, and an evaluation for dysmorphology by a certified clinical geneticist (Rakhlin et al., 2013). Due to the relative isolation of the population because of a confluence of geographic, historical, and economic factors, it is genetically homogeneous (but with minimal levels of consanguinity). Environmental factors, such as cultural, socio-economic, and educational characteristics are also highly homogeneous and closely shared by the children.

At the time of this study, the total population consisted of 861 individuals, of whom 138 were children between the ages of 3 and 18. Our previous investigation (Rakhlin et al. 2013) revealed that about 25% of school-aged children had expressive grammar deficits in elicited production, in contrast to the 8% impaired in the comparison population (a rural population from the same geographic region matched on dialectal, educational, cultural and socio-economic variables). Both populations are described in detail in Rakhlin et al. (2013). Compared with their age peers from the comparison population, children from the study population performed significantly worse on measures of expressive phonology (e.g., frequency of phonological substitutions, deletions or reductions), morpho-syntax (errors of substitution including tense, aspect and agreement errors), syntactic complexity, and semantics/pragmatics (semantic and pragmatic errors, lexical richness). They also underperformed on a set of receptive measures, such as tests of receptive vocabulary, sentence comprehension and linguistic operators (Rakhlin et al., 2011).

In sum, the complex phenotype observed in the population involves multiple types of spoken language deficits. Even though it varies across the population in severity and the number of affected language domains, given the shared genetic and environmental characteristics of the individuals, it is highly probable that the various phenotypic profiles observed in the population have a common etiology making it particularly interesting for

[2]Although it is a common phenomenon, there are languages whose orthographies are more closely reflective of the pronunciation rather than the underlying phonemic or morphemic form. One example is Byelorussian, in which unstressed reduced vowels are spelled as they are pronounced (e.g., *górad* (town), *garadók* ("little town"), cf. with the Russian spellings of these words (*gorod, gorodok)*. This principle in Byelorussian, however, only applies to vowels.

studies seeking to understand cognitive underpinnings of such complex and heterogeneous disorders as DLD and DD.

Participants

One hundred forty nine children, including language and/or literacy impaired (henceforth “study group”) and unimpaired (“control group 1”) children from the population of interest plus typically developing children from the comparison population (“control group 2”), aged 10.40 to 14.00 ($M = 12.38$, $SD = 1.00$) participated in the present study (see Table 1 for the descriptive statistics). The study group consisted of 42 children with spoken and/or written language impairments ascertained on the basis of their performance on a narrative task adapted for the purpose of the identification of children with language disorders in Russian (Rakhlin et al., 2013) and dictated spelling (see below). Children from the population of interest with at least average performance on both the narrative and the spelling task (determined using the cutoff criterion of performance at above −1 SD below the mean of the age-peer sample of the comparison population) were included in control group 1. Children from the comparison population with no history of DLD and at least average performance on the spelling task were included in control group 2. Only children with a non-verbal IQ above 75, a cutoff for intellectual disability, were included in the study. The recruitment of children was carried out through the two populations’ local secondary schools in the Arkhangelsk administrative region of Russia. Both the Yale Institutional Review Board and the board of the collaborating institution in Russia approved the study protocol.

Because of a substantial time commitment associated with administering the narrative task (due to the need to transcribe and manually code each one on a number of scales), the narrative assessment results were not available for all of the participants from the comparison population (although a large number of children from this population served as normative controls for deriving narrative norms in the larger epidemiological study). Therefore, children from the comparison population were selected for being included in control group 2 based on a teacher’s recommendation and based on their performance on the spelling task. Thus, for all of the children in control group 2, their teacher indicated that their oral language skills were typically developing, and they scored above −1 *SD* from the mean of the sample of this normative population on the spelling task.

All participants were classified in the following groups: overlapping developmental language disorder and spelling difficulties (DLD/SD), developmental language disorder with no spelling difficulties (DLD); spelling difficulties only (SD), typically developing from the target population (control 1), and typically developing from the comparison population (control 2). The groups did not differ in age and none of the impairment groups differed on IQ. There was a small, but significant difference between control 2 group and other groups on IQ.

In addition to the narrative task, spelling, non-verbal IQ, PA, and RAN, children were also given a number of language and literacy-related tasks, including two written tasks of morphological awareness, namely a morphological construction and a morphological decomposition task, tests of PWR, orthographic choice, and phonological choice (see below). For the individually administered measures, all children were evaluated separately in a quiet room in their schools. The paper-and-pencil group measures were administered in the classroom during times agreed upon by the school principle and each individual classroom teacher. Informed consents were obtained from the parents and the participant in order for the child to participate in the study.

Language Assessment

Since narratives have been reported to be a valid measure of language development in TD children as well as clinical populations (e.g., Botting, 2002; Norbury & Bishop, 2003) and no validated published standardized language development assessments are currently available for Russian, we used an elicited narrative task as the main tool of language assessment. For the narrative elicitation task, we used wordless storybooks for establishing the group status. Every child was assessed individually using two wordless storybooks: for children 13-yers-old and over – "*Free Fall*" (Wiesner, 1988) and "*Tuesday*" (Wiesner, 1991); for those under 13 – "*Frog, Where Are You?*" and "*One Frog too Many*" (Meyer, 1969).

Both the audio and the transcripts of the interviews were analyzed by two native-Russian linguists and rated on a number of characteristics in the phonological, syntactic, and semantic/pragmatic domains, combined to form the following measures: 1) Phonetic and Prosodic Characteristics (i.e., phonological simplifications and omissions, phonological substitutions, and prosodic abnormality), 2) Wellformedness (frequency of ill-formed sentences adjusted for the length of the narrative), 3) Syntactic Complexity (a combined rating based on the frequency of complex structures; e.g., embedded and conjoined clauses, passives, participial constructions, etc., and mean length of utterance in words (MLU_w), 4) Narrative Quality (a combined rating based on scores for elaboration, i.e., the amount of descriptive and/or explanatory details provided, and narrative structure, i.e., the ability to structure the narrative into a coherent and well-formed story with a set-up, logically and linguistically connected sequence of events, and a conclusion; 5) Semantic/Pragmatic Characteristics (a combined rating based on the score for lexical richness, i.e., a ratio of distinct lexemes to the number of words, and frequency of semantic and pragmatic errors). The interrater reliability for different scales was shown to be high, as reported in Rakhlin et al. (2013).

To be included in the DLD group in the current study, a child had to exhibit performance on the measure of Wellformedness at the level of below 1 *SD* from the mean score of the normative comparison group in their respective age band, in addition to a deficit in at least one other language domain. Children were included in control group 1 if they did not exhibit impaired performance on any of the narrative measures (i.e., performed within 1 standard deviation from the mean score of the comparison group in their age band) and if they didn't exhibit spelling difficulties (see below).

Literacy Measure

Spelling skills (SS) were assessed by the *Developmental Spelling Test* (Joshi & Aaron 2003), a group administered paper-and-pencil test adapted for Russian. Students were asked to spell 56 words that varied in terms of complexity (i.e., number of syllables and the complexity of syllabic structure) and frequency. The tester first pronounced the word and then used the word in a sentence providing grammatical and semantic context for it. The tester then repeated the word and the students were asked to write it down. The internal consistency of the task in the full sample was Cronbach's $\alpha = .84$. Those children in the population of interest who scored more than 1 *SD* below the mean of the normative comparison group (control group 2) were classified as having spelling difficulties (SD), and children whose scores were above that cutoff were classified as having no spelling difficulties.

Non-verbal Cognitive Functioning

All of the children, except a few who were unavailable at the time of testing, were given the group-administered Culture-Fair Intelligence Test, Scale 2 (CFIT; Cattell & Cattell, 1963).

Most children were also given the extended version of the Universal Non-Verbal Intelligence Test (UNIT; Bracken & McCallum, 1998), a detailed, individually administered assessment. For both tests, standardized general IQ scores were available (M = 100, SD = 15).

The CFIT (Cattell & Cattell, 1963) is a paper-and-pencil test for individuals ages 8 and above. It is a measure of non-verbal fluid intelligence thought to be relatively independent of verbal fluency, cultural background and educational level. The battery consists of four subtests. We used the standardized general IQ score ($\alpha = .79$).

UNIT (Bracken & McCallum, 1998) is a non-verbal test battery for ages 5–18 designed to be a fair assessment of general cognitive functioning, especially in individuals with speech, language and hearing impairments and from differing cultural and linguistic backgrounds since the administration procedure is fully non-verbal. It requires multiple response modes, including the use of manipulatives, paper-and-pencil and pointing. The extended battery includes six subtests: Object Memory, Spatial Memory, Symbolic Memory, Cube Design, Analogic Reasoning, and Mazes, with the first three designed to assess memory, and the last three reasoning. The test also provides scores for the development of symbolic versus non-symbolic components in general cognitive functioning. We used standardized Full-Scale scores (FSIQ; $\alpha = .92$). For the present analysis. UNIT scores were used only if a CFIT score for a given child was unavailable. Otherwise, CFIT scores were used.

Literacy-related Cognitive Measures

Phonological coding skills were assessed using the *Silent Phonological Choice Task* (Olson et al., 1994), a group administered untimed paper-and-pencil test adapted to Russian. Participants had to choose a printed non-word that would sound like a real word if pronounced. Each target was accompanied by two non-word foils that would not sound like an existing word (e.g., in English, an equivalent triplet may consist of coum/baim/goam). To choose the correct non-word, the student had to be able to decode the word and recognize its phonological identity with a real word. There were five practice items and 60 test items. Accuracy scores were derived from the number of correct responses ($\alpha = .88$).

Orthographic Awareness (OA) was assessed by the *Orthographic Coding Task* (Olson et al., 1994), a group administered untimed paper-and-pencil test adapted to Russian. Participants were given a set of three letter strings, two of which were real words and the third a non-word phonologically identical to a real word, i.e., a phonological word in an incorrect orthographic form. This task required the recognition of the non-word. There were 45 such triplets ($\alpha = .92$).

Morphological Awareness (MA) was assessed by two untimed written tests of morphological structure: *Morphological Derivation* and *Morphological Decomposition* (Kornilov, Rakhlin, & Grigorenko, 2012). The first task assessed the ability to manipulate a root of a word by changing it to a morphologically related word to fit the provided syntactic frame. For example, in English, the participant would read a priming word such as *farm* and then may have to complete the sentence, "My uncle is a __________ ." The second task assessed the ability to decompose a morphologically complex word by segmenting out a morpheme to create a new word. For example, in English, the participant would read the word *friendship* and would have to complete the sentence, "Betsy is my ________ ." Each test contained 28 items; the corresponding internal consistencies were $\alpha = .78$ for the derivation task, and $\alpha = .79$ for the decomposition task. In both tasks, only morphological errors (e.g., an incorrect case form or an inappropriate affix), not spelling errors, were counted as errors.

Phoneme Awareness was measured using Rosner's *Test of Auditory Segmentation* (RAS; Rosner, 1975), an individual assessment adapted to Russian. Children were first trained on items, in which they had to elide a morpheme from a compound word (e.g., 'arm' from "armchair"). The test consisted of eliding segments ranging from a syllable to a single phoneme from the beginning, the middle, or the end of a word and pronouncing the word resulting from the elision. The responses were timed and scored for accuracy (maximum 40 correct items; $\alpha = .86$).

The pseudo-word repetition test we used was modeled after *Children's Test of Non-word Repetition* (Gathercole & Baddeley, 1996) thought to measure phonological working memory (Gathercole & Baddely, 1990). Each participant was individually presented with items ranging from 2 to 5 syllables in length with an equal number of items of each length. In addition, the complexity of the syllable structure was systematically varied with half of the items containing consonant clusters in the initial syllable onset or coda and with the remaining half containing no clusters. Thus, the syllable complexity of the pseudo-words ranged from CV and VC syllables, to CVC, and to CVCC or CCVC. The responses were timed and scored for accuracy. The pseudo-words were presented by a native-Russian speaker of the same regional dialect as the participants using live voice. The live presentation rather than a recording was used in order to make sure that the child's attention was engaged before presenting an item (as recommended by Adams & Gathercole, 1995). The test was scored 'on-line' with each item judged as correctly or incorrectly repeated (40 items, $\alpha = .79$).

Rapid Serial Naming was measured using the *Rapid Automatized Naming* (RAN) task (Denckla & Rudel, 1974) adapted for Russian. The child was asked to name, as fast as possible, series of repeating familiar stimuli printed in the form of a matrix consisting of five rows and 10 columns. There were four different color cards, each comprised of a different type of stimuli (letters, digits, objects, and colors). On each card, five different stimuli were presented 10 times each in a random order. Responses were timed using a stopwatch.

Results

First, we established the size of the overlap between DLD and SD. We found that only 42% of the children with DLD could also be classified as SD. Of those children who were classified as SD, 31% were also classified as DLD. Thus, our results confirmed that an overlap between DLD and SD is indeed incomplete, with a substantial proportion of children with DLD being able to develop average spelling skills, and a substantial proportion of children with SD exhibiting no oral language difficulties.

Next, to test the effect of group on each of the literacy and cognitive measures, univariate ANCOVAs were performed controlling for IQ. Significant effects were followed up by pairwise post-hoc tests, with p values adjusted for multiple comparisons using the False Discovery Rate (FDR) method. First, we found that the Phonological Choice task did not produce significantly different results across groups, $F(4, 143) = 1.50$, $p > .05$, thus confirming previous finding from transparent orthographies that accuracy of decoding does not differentiate between impaired and unimpaired readers beyond the initial stages of reading acquisition (Wimmer & Schurz, 2010). With respect to orthographic awareness, we found that the SD group significantly underperformed on the Orthographic Coding task in comparison with both control groups and, somewhat surprisingly, in comparison with the DLD/SD group, $F(4, 143) = 4.44$, $p < .05$, post-hoc p*'s* $< .05$, with no other significant contrasts.

Next, we found a significant effect of group on accuracy in both morphological measures, namely Morphological Derivation, $F(4, 139) = 6.93$, $p < .001$, and Morphological Decomposition, $F(4,139) = 6.66$, $p < .001$. The post hoc comparisons revealed that on the measure of Morphological Derivation, the SD group underperformed in comparison with Control 2 group ($p < .001$) and the DLD group ($p < .05$). Also, the DLD/SD group significantly underperformed in comparison with both control 1 and control 2 groups (all *p's* < .001). The second measure revealed analogous results: the SD group underperformed in comparison with control 1 ($p < .05$), control 2 ($p = .001$), and the DLD (p < .05) groups, and the DLD/SD group underperformed in comparison with both control groups (both *p*'s < .05), with no other significant differences on either measure. Thus, the two groups with literacy impairment exhibited difficulties with the tasks designed to measure MA, unlike their DLD counterparts, whose performance did not differ from the controls. These results support the previous finding that among middle school children acquiring literacy in Russian, morphological awareness skills are a good predictor of spelling ability (Grigorenko, Boulware-Gooden, & Rakhlin, 2012).

Somewhat unexpectedly, similar results were obtained for the measure of PWR. Although we found a significant effect of group, $F(4,140) = 6.56$, $p < .001$, only the SD and the DLD/SD groups performed significantly worse than control 2 ($p < .05$ and < .001, respectively), with no other significant differences. Thus, the DLD only group did not differ significantly from the controls on this measure indicating that poor PWR skills are not present in all children with DLD and are related to poor literacy outcomes.

Next, with respect to the measure of PA, we again found a main effect of group, $F(4,140) = 6.56$, $p < .001$, with all three clinical groups performing significantly lower than the two control groups (all *p*'s < .05). These results indicate that in Russian, PA is a factor implicated in both spoken and written language difficulties, similarly to what has been reported for English (Bishop et al., 2009; Fraser, Goswami, & Conti-Ramsden, 2010).

With respect to RAN, it is common for researchers to combine the non-alphanumeric and the alphanumeric tasks for the analysis. However, since our goal was to compare our results with the results obtained by Bishop et al. (2009), who reported separate analyses for RAN Objects and RAN Numbers, we ran separate analyses for each of the RAN tasks. We found a main effect of group on all RAN subtests, with the pattern of results being different across the four subtests. On RAN Objects, in addition to the main effect of group, $F(4,139) = 7.78$, $p = .000$, the post hoc pairwise comparisons revealed that the two groups with spelling difficulties (SD and the DLD/SD) were significantly slower than both control groups (all *p*'s < .05), while the DLD group was not significantly different from either of them (all *p*'s > .05). Similarly, we found the effect of group on RAN Numbers; $F(4,139) = 6.54$, $p < .001$, with both groups with spelling difficulties underperforming: the SD group being significantly slower than Control 2 group, and the DLD/SD than both control groups and the DLD group (all *p*'s < .05). At the same time, the DLD group was not significantly different from either of the control groups (*p*'s > .05), and no other contrasts were statistically significant.

On RAN Letters, we again found a main effect of group, $F(4,139) = 7.91$, $p < .001$, with the pattern of performance somewhat different: while SD and DLD/SD groups were again slower than both controls, the DLD group was also significantly slower than control 2 group (*p*'s < .05), with no other significant contrasts. On RAN Colors, we found an effect of group $F(4,139) = 5.74$, $p < .001$, with the two groups with spoken language impairments underperforming. Namely, the DLD group was significantly slower compared with both control groups, and the DLD/SD group was significantly slower than control 2 group (all *p*'s

< .05), with no other significant differences. The group means and effect sizes for pairwise comparisons are presented in Tables 2 and 3, respectively.

In sum, we found that all three groups with language and/or spelling deficits underperformed on PA and RAN Letters. RAN Objects and Numbers differentiated children with spelling difficulties (SD and DLD/SD) from children with unimpaired spelling skills (control 1, control 2, and DLD). Thus, children with spoken language difficulties only were not significantly slower on these RAN measures than either of the control groups; moreover, they were significantly faster than the group with both spoken and written language deficits on RAN Numbers. In contrast, RAN Colors seemed to differentiate children with oral language difficulties (DLD and DLD/SD) rather than children with literacy impairment (SD) as being significantly slower on this task than the controls.

Discussion

One goal of this study was to consider what cognitive skills could account for the overlap between developmental disorders of spoken and written language in Russian-speaking children, widely reported in the literature on other languages, and to examine whether our findings support any of the existing models of this overlap. Another goal was to investigate what cognitive skills differentiated children with DLD able to achieve basic literacy on a par with their typically developing peers from those who developed difficulties acquiring literacy, and thus to account for the incompleteness of the overlap between DLD and DD, also reported in the literature.

To these ends, we assessed children with spoken, written, and overlapping spoken and written deficits on a number of language- and literacy-related cognitive skills and compared their performance with that of typically developing children. We have found that children who had spelling difficulties without overlapping spoken language deficits underperformed on many of the areas previously identified as related to literacy acquisition in other languages, namely orthographic awareness, morphological awareness, PA, RAN Objects, RAN Numbers and RAN Letters. They also underperformed on the measure of PWR, typically associated with spoken language deficits. In contrast, children with spoken language deficits underperformed only on the measures of PA, RAN Letters and RAN Colors. The group with both spoken and written deficits underperformed on all of these measures.

First, these results confirm that naming speed of objects and digits is an important concurrent predictor of literacy skills in Russian beyond the initial stages of literacy acquisition (i.e., during middle school years). Furthermore, among children with DLD, RAN speed comparable to that of typically developing children appears to be associated with a better literacy outcome, as indicated by the finding that the group of children with spoken language deficits with spelling skills comparable to those of the children from the control group did not differ from the controls on rapid naming of objects and digits. Another factor with respect to which children with spoken language deficits did not differ from controls, unlike their counterparts with both spoken and written difficulties, was PWR accuracy. Similarly, a recent study by Ramus and colleagues (2013) found that PWR deficits do not necessarily co-occur with other language deficits in DLD.

Thus, it appears that some children with spoken language deficits may have a relatively spared pSTM and rapid serial naming speed. Such children seem to be able to compensate for their deficits in grammatical processing and PA and acquire basic literacy skills on a par with their peers with typical language development, thus, accounting for the incompleteness of the overlap between DLD and DD. These results are similar to the findings by Bishop and colleagues (2009) even though they focused on younger English-speaking children, used reading instead of spelling to identify basic literacy difficulties and standardized tests instead of narratives to identify DLD.

Another goal was to investigate what aspect(s) of the cognitive profiles of children with spoken and written language deficits could explain the substantial overlap between the two disorders. We found that the groups with only spoken and only written language difficulties had certain shared and certain unique characteristics. On the one hand, deficits in PA and RAN Letters were associated with spoken as well as written language deficits and thus appear to be an overlapping factor in the disorders of both spoken and written language. On the other hand, certain other skills were associated only with spoken or written language. Thus, while underperforming on RAN Colors was associated with spoken language impairments, underperforming on RAN Digits and Ran Objects was associated with spelling deficits. In addition, spelling deficits were associated with poor accuracy in orthographic and morphological awareness and PWR.

The finding that children with DLD only underperformed on PA, but not on RAN Objects and Digits, supports the view that RAN and PA are not fully redundant measures and confirms previous findings (Naples et al., 2009; Swanson et al., 2003). Moreover, our findings with respect to different subtests of RAN suggest that there may be multiple underlying factors at play as determinants of children's performance on rapid naming involving different types of stimuli, differentially contributing to literacy acquisition.

Thus, performance on RAN Letters and Digits has been previously shown to be a strong predictor of literacy skills in orthographies of a wide range of transparency and among both typically and atypically developing readers at different stages of literacy development, while the predictive strength of RAN Colors and Objects typically faded after the initial stages of literacy acquisition (Misra, Katzir, Wolf, & Poldrack, 2004). Our results add to this literature by showing that rapid naming of Letters and Digits may represent not fully overlapping cognitive underpinnings of literacy. Rapid naming of letters seems more closely related to phonemic awareness skills than naming of digits. In our study, all three groups with impairments exhibited slower letter naming latencies than the controls. All three groups also underperformed on the phonological elision task. Thus, both spoken and written language difficulties in our sample seem to be associated with a deficit in the speed of letter naming and phonemic awareness, perhaps indicating that poor PA weakens access to letter names, which, however, could be overcome in achieving foundational level literacy by the group without deficits in rapid naming of digits and objects.

Secondly, our results indicate that slow color naming latencies are not related to literacy skills in middle-school-aged children, but appear to be a marker of spoken language difficulties, unlike object and digit naming, markers of written language difficulties. We propose that the explanation for the contrast between color and object naming we found lies in the language-specific characteristics of the morphological system of Russian. In English, RAN objects and RAN colors have not been previously found selectively related to written or spoken language (dis)ability even though the two subtests involve words of two different grammatical categories: nouns in the case of RAN Objects and adjectives in the case of RAN Colors. This may be due to both types of items in English being morphologically simple, i.e., consisting of mono-morphemic stems (roots). Given that both subtests use familiar high frequency items, the difference in their grammatical category does not typically create a contrast in performance. In Russian, on the other hand, the items used in the two subtests differ in their morphological complexity: names of colors (adjectives) are more morphologically complex than names of objects (nouns in the basic form). The former (color adjectives) contain a derivational suffix attached to the root marking the word as an adjective, in addition to the inflectional morphemes marking gender/number and case of adjectives. The latter (i.e., basic concrete sortal nouns), on the other hand, consist of a root morpheme and a grammatical morpheme marking its gender, number, and case, which in many instances is phonetically null in the citation form (e.g., masculine, singular, nominative case). Thus, in naming colors, the child has to produce morphologically complex words, while in naming objects, the items typically consist of monomorphemic stems.

The literature on the relationship between morphological processing and mental lexicon contains theories that favor full listing (i.e., a listing of complex words as wholes), total decomposition (complex words represented as their constituent components) or hybrid interactive models, with access to both full-form representations as well as constituent parts (see Verhoeven & Perfetti, 2011, for a review). If lexical representations are morphologically decomposed (i.e., roots or stems are represented independently of affixes), and the access procedure operates with morpheme-level units that have to be merged on-line, this would have a measurable effect on naming latencies of morphologically complex words compared to morphologically simple words and translate into individual differences between individuals with compromised morphological processing skills, as is the case with children with DLD.

Of note is that the DLD group in our study did not underperform on the measure of morphological awareness, even though the children in this group have documented deficits in expressive and receptive grammar. We suggest that the reason for this seeming paradox is that the morphological awareness measure was an off-line written test without time pressure, which allowed the DLD group with no written language deficits to perform at the same level of accuracy as the controls removing processing constraints that operate during real time spoken language processing. In contrast, those children with DLD who had written language deficits underperformed on this measure, as did the children with written language difficulties only. The RAN Colors measure, on the other hand, involves online lexical access to morphologically complex words, which differentially affected children with spoken language difficulties.

The final goal of the study was to consider which model can best account for the substantial overlap between DLD and DD observed in the literature. To summarize the relevant findings, 1) the speed of letter naming and PA accuracy was related to both spoken and written language impairment, 2) speed of color naming only to the former, and 3) that of digits and objects, as well as accuracy on WPR, morphological and orthographic awareness, only to the latter.

As we discussed above, existing models of the overlap between DLD and DD include 1) the single-factor severity model (i.e., both disorders are considered to stem from the same underlying cognitive deficit in phonological processing varying in severity from milder in DD to more severe in DLD; Tallal, 2004); 2) the two-factor model (i.e., both DD and DLD involve the same phonological deficit, but DLD involves additional oral language-related deficits; Bishop & Snowling, 2004); 3) the comorbidity model (i.e., DD stems from a phonological processing deficit and DLD from another, oral-language-related deficit, but the two frequently co-occur in the same individuals; Catts et al., 2005); and 4) the multiple deficit model (i.e., both DLD and DD may involve a number of partially overlapping deficits, expressed probabilistically (Pennington et al., 2012). The single-factor severity, comorbidity, and two-factor models all make predictions unsupported by our results. Thus, the severity model does not expect to find children with DLD without literacy difficulties, which is contradicted by the existence of the DLD only group in our sample. The comorbidity and the two-factor models rule out PA deficits in children with DLD only, again unsupported by our findings.

The view our findings are most consistent with considers both DLD and DD to be multidimensional disorders (in line with Pennington, 2006; Pennington et al., 2012), in which multiple cognitive components may be impaired on a probabilistic basis, and the same constellation of impairments does not have to co-occur in all cases. According to this model, DLD would be associated with deficits in the domain of grammatical processing (including morphological processing indexed in Russian by RAN Colors), while DD with phonological processing deficits. In addition, DD is associated with compromised RAN skills.[3] Grammatical deficits in DLD may co-occur with phonological processing deficits (pSTM or phonemic awareness deficits). The latter, however, are not necessary, nor always sufficient to cause DLD in the absence of the former.[4] Furthermore, phonological processing deficits can be offset by adequate naming speed and pSTM and prevent the child from developing DD symptoms (or as argued previously, lead to less severe cases of DD). Finally, when grammatical processing, phonological memory/processing and RAN deficits co-occur, this leads to a comorbid DLD/DD.

Conclusion

Traditionally, the attempts to explain both DLD and DD involved a search for a core cognitive deficit that would allow explaining all behavioral symptoms observed in each of the two disorders as an upstream consequence stemming from this single underlying deficit (Tallal, 2004; Joanisse, 2004). However, recently, it has been widely acknowledged that DLD and DD are highly heterogeneous disorders, and that there is also a lot of variation in the DLD/DD overlap presenting a challenge for the single core deficit approach (Pennington, 2006). The current study adds to the body of research that treats both DLD and DD as multifactorial, rather than single factor disorders. Furthermore, instead of considering each diagnostic category as either the same disorder of varying severity or two distinct disorders with different etiology, our results are consistent with the view that DLD and DD both belong to a group of related disorders, with certain shared and certain distinct features. Whether or not a specific combination of deficits would present as DLD, DD or comorbid DLD/DD may depend on the constellation of the deficits and their relative severity, such that a weakness in phonological awareness or pSTM may be compensated by strong naming fluency.

Like all studies, this study has a number of limitations, which largely stem from the constraints imposed by the nature of the population under consideration. Thus, the relatively small sample of the study is a consequence of the small size of the child population in the village (around 140 children between the ages of 3 and 18). Also, the uniqueness of this population, with its high genetic and environmental homogeneity, which makes it such an interesting object of inquiry, also opens the question of the generalizability of the results. Given the heterogeneity of DD, our study groups may represent a sub-population of children with DD with a cognitive-behavioral profile different from other DD subtypes. On the other hand, having found a confirmation to studies that were done with very different types of samples, in our opinion, presents very compelling supporting evidence for the importance of

[3]Whether RAN deficits can be present without deficits in PA has been a subject of some controversy because such cases have been rather difficult to find (Pennington, Cardoso-Martins, Green, & Lefly, 2001; Vaessen, Gerretsen, & Blomert, 2009). However, even if this is the case, this does not invalidate the multifactorial view: even if RAN is indeed distinct from PA, the two are clearly related. Therefore, we may expect the two to co-occur in most cases.

[4]Although some theories of DLD claim that a single phonological processing deficit is a core causal factor in DLD (e.g., Joanisse 2004), there is strong empirical support that the complete range of oral language impairments (particularly, in the population involved in the current study) cannot be fully explained by phonological deficits (Bishop, Adams, & Norbury, 2006; Rakhlin et al., 2013; van der Lely, 2005). Children with DLD with and without phonological processing deficits may constitute different subtypes of DLD, but are likely to exhibit similar performance on many clinical language assessments measuring general language development typically used to diagnose DLD.

PA in both DLD and DD, a protective quality of RAN for children with DLD in their ability to acquire basic literacy skills, and the multifactorial composition of both disorders.

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Table 1

Demographics and IQ Descriptive Statistics

Group	**N**	**Gender (% boys)**	**Age**	**IQ**
			M (SD)	***M (SD)***
DLD	18	39	12.06 (.95)	95.00 (10.47)
SD	13	54	11.86 (.73)	92.38 (8.42)
DLD/SD	11	73	12.16 (1.02)	93.00 (10.43)
Control 1	29	52	12.30 (1.00)	100.48 (11.80)
Control 2	78	52	12.60 (1.01)	110.82 (15.64)

Table 2

Descriptive Statistics for Study Measures and F ratios for ANCOVAs

	DLD/SD n = 11		SD n =13		DLD n = 18		Control 1 n = 29		Control 2 n = 78		*F(4)*
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	
Spelling	43.27	3.85	41.46	4.18	50.17	1.87	50.55	2.03	51.09	2.36	45.84***
Wellformedness[a]	.054	.033	.033	.020	.067	.073	.025	.015	-	-	4.23**
Phonological Choice	46.64	7.20	47.31	7.52	48.44	5.03	50.83	6.45	48.76	5.89	1.50
Orthographic Awareness	36.45	5.54	28.85	7.48	32.83	8.37	37.24	3.43	36.71	5.98	4.44**
Morphological Derivation	10.82	4.29	10.31	3.97	14.83	3.93	16.83	4.27	17.37	3.59	9.36***
Morphological Decomp.	17.00	4.76	15.77	5.96	20.28	3.32	21.03	3.35	21.32	3.23	6.67***
Phoneme Awareness	33.18	3.71	32.42	3.94	33.61	4.30	36.83	3.04	37.80	2.53	11.06***
Pseudoword Repetition	34.45	4.57	36.15	3.72	36.89	2.11	37.07	3.08	38.64	1.90	6.56***
RAN Objects time	62.09	11.77	61.15	11.80	55.89	10.68	47.45	8.73	48.36	8.79	7.79***
RAN Numbers time	31.55	7.78	29.08	7.74	25.00	4.50	24.07	4.68	23.11	4.44	6.55***
RAN Letters time	32.00	7.89	28.00	6.12	27.83	4.96	25.14	5.25	22.95	4.00	7.91***
RAN Color time	48.09	11.13	46.69	8.94	47.11	8.80	39.59	6.85	37.49	7.06	5.74***

Note.

** $p < .01$

*** $p < .001$.

[a] df=3 for Wellformedness. Spelling, Phonological Choice, Orthographic Awareness, Morphological Derivation, Morphological Decomposition, Phoneme Awareness, Pseudoword Repetition are measures of accuracy with a higher score indicating better performance; Welformedness is a measure error rate with a lower score indicating better performance, RAN is a measure of time with a lower score indicating better performance.

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Table 3

The Effect Sizes (Cohen's *d*'s) for Pairwise Comparisons on Study Measures

	DLD/SD vs. DLD	DLD/SD vs. SD	DLD/SD vs. C1	DLD/SD vs. C2	DLD vs. SD	DLD vs. C1	DLD vs. C2	SD vs. C1	SD vs. C2	C1 vs. C2
Spelling^R	−2.53	.46	−2.80	−3.05	2.91	−.19	−.41	−3.23	−3.62	−.24
Wellformedness^L	−.22	.80	1.38	-	.60	.92	-	.49	-	-
Phonological choice	−.31	−.09	.64	−.35	.19	−.41	−.06	−.52	−.24	.34
Orthographic Awareness	.49	1.17	−.20	−.04	.51	−.77	−.60	−1.70	−1.27	.10
Morphological Derivation	−1.00	.13	−1.42	−1.79	1.16	−.33	−.70	−1.58	−1.95	−.14
Morphological Decomp.	−.85	.23	−1.08	−1.25	1.00	−.23	−.32	−1.24	−1.50	−.09
Phoneme Awareness	−.11	.20	−1.14	−1.73	.29	−.91	−1.44	−1.34	−1.96	−.36
Pseudoword Repetition	−.77	−.42	−.75	−1.78	.26	−.07	−.91	−.28	−1.12	−.69
RAN Objects time	.57	.08	1.54	1.50	−.48	.90	.83	1.42	1.39	−.10
RAN Numbers time	1.12	.33	1.34	1.72	−.69	.20	.43	.88	1.20	.21
RAN Letters time	.68	.59	1.15	1.97	−.03	.53	1.17	.52	1.17	.50
RAN Color time	.10	.14	1.05	1.40	.05	.99	1.31	−.95	1.26	.30

Note.

^{L}Tests denoted

^{R}were used to define DLD and SD, respectively.

Spelling, Phonological Choice, Orthographic Awareness, Morphological Derivation, Morphological Decomposition, Phoneme Awareness, Pseudoword Repetition are measures of accuracy with a higher score indicating better performance; Welformedness is a measure error rate with a lower score indicating better performance, RAN is a measure of time with a lower score indicating better performance.