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Cognitive profiles on the WAIS-III intelligence test in Brazilian adults with dyslexia

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Abstract

The present study investigated the cognitive profiles of dyslexic adults on the Wechsler Adult Intelligence Scale (WAIS-III, Brazilian version). A total of 31 adults with dyslexia and 31 control readers who were matched by age and education level performed a phonological awareness and word reading test. They also completed the WAIS-III. The outcomes of the tests showed that dyslexics underperformed on Verbal IQ and the Picture Completion, Coding, Matrix Reasoning, Similarities, Letter-Number Sequencing, and Vocabulary subtests. No differences were found between groups in the index scores. The analysis of cognitive profiles showed that dyslexics had a lower Verbal IQ compared with Performance IQ. The index score analysis showed poorer skills in Working Memory than in Verbal Comprehension, and the best performance was observed in Perceptual Organization. These results show the importance of cognitive assessment in understanding the difficulties faced by adults with dyslexia.
Keywords: dyslexia, intelligence, WAIS-III, cognitive profiles.

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Introduction

Developmental dyslexia is a neurodevelopmental disorder of biological origin that generates behavioral signs that mainly affect reading accuracy and fluency (Frith, 1999; American Psychiatric Association, 2003; Lyon, Shaywitz, & Shaywitz, 2003). Longitudinal studies have indicated that normal and struggling readers tend to maintain their position within the spectrum of reading skills. Therefore, adults with systematic reading difficulties that have not been previously identified may be diagnosed later in life (Galaburda, 2005; Shastry, 2007; Wadsworth, DeFries, Olson, & Willcutt, 2007). Intelligence tests are used to identify profiles of cognitive strengths and weaknesses using neuropsychological assessments in adults. Describing such profiles, therefore, is important because many dyslexics have an average or better than average level of intellectual ability.

One of the most commonly used measures for assessing intelligence in adults is the Wechsler Adult Intelligence Scale, 3rd edition (WAIS-III; Wechsler, 1997), which includes analysis and synthesis problem-solving tasks to provide scores for Total IQ (TIQ), Verbal IQ (VIQ), and Performance IQ (PIQ). The assessment of dyslexics using previous versions of the WAIS concluded that dyslexics present a discrepancy between the verbal and performance subtests and have a VIQ that is lower than PIQ. Dyslexics with higher levels of education were also found to perform better on verbal tests, thus demonstrating less of a discrepancy between VIQ and PIQ (Scarbough, 1984; Alm & Kaufman, 2002; Laasonen, Leppamaki, Tani, & Hokkanen, 2009).

Alm and Kaufman (2002) compared the profiles of scores between a dyslexic sample and a control sample on the WAIS-R, and they identified an ACID profile for dyslexics that showed poorer performance on the following subtests: Arithmetic, Coding, Information, and Digit Span. The results showed that almost 31% of the sample had lower performance on these four subtests, whereas 79.5% had lower scores on at least three of these subtests. These data indicate that identifying an ACID profile, whether full or partial, is an important indicator of a learning disorder, including dyslexia, although the lack of a profile does not exclude the possibility of the disorder.

When developing the manual for the 3rd American edition of the WAIS, Wechsler (1997) suggested that discrepancies between verbal comprehension (VC) and working memory (WM) scores and between perceptual organization (PO) and processing speed (PS) scores

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may be more useful in detecting learning disabilities than analyzing the ACID profile. However, the number of individuals with learning disabilities who presented discrepancies between these scores was particularly low. This result led Kaufman and Lichtenberger (2006) to propose another cognitive profile that may be present in learning disorders, the SCALD, which reflects the worst performance on the Symbol Search, Coding, Arithmetic, Letter-Number Sequencing, and Digit Span subtests. Laasonen et al. (2009) proposed yet another profile called the VSDLC, reflected by the worst performance on the Vocabulary, Similarities, Digit Span, Letter-Number Sequencing, and Coding subtests. This profile is similar to the one reported by Kaufman and Lichtenberger (2006), differing only in the absence of impairment in arithmetic and presence of impairments in vocabulary.

Some studies with different aims that were conducted with dyslexic adults and normal readers compared their performance on the Vocabulary and Block Design subtests. Based on these subtest scores, an allowance for the calculation of the estimated IQ was made. Most of these studies reported no significant difference between groups in these tasks (Jones, Branigan, Hatzidaki, & Obregon, 2010; Conlon, Wright, Norris, & Chekaluk, 2011; Leong, Hamalainem, Soltesz, & Gostwami, 2011; Hamalainen, Rupp, Soltesz, Szucs, & Goswami, 2012; Jones, Ashby, & Branigan, 2013). However, some experiments found significant differences in vocabulary (Jones, Obregón, Kelly, & Branigan, 2008; Laasonen et al., 2009), Digit Span (Bennett, Romano, Howard, & Howard, 2008; Leong et al., 2011; Conlon et al., 2011; Hamalainen et al., 2012), and Coding (Bennett et al., 2008). The differences between the findings of these studies may be attributable to the heterogeneity of the cognitive profiles of dyslexics (Ramus et al., 2003).

Although confirming some of the reported profiles alone is not sufficient to diagnose dyslexia, these are some indicators of different impairments that may be present in this condition, which presents heterogeneous cognitive and behavioral features (Frith, 1999; Ramus, 2003). Thus, although studies have been unable to verify a single performance profile for dyslexics using the WAIS, all of the results have converged in the sense that people with dyslexia present impairments in the subtests that assess WM, information processing speed, and visual-motor coordination skills. The present study sought to verify the cognitive profile of Brazilian adults with developmental dyslexia compared with the performance of normal readers on the WAIS-III.

Methods

Participants

The study included 62 adults who completed high school. The sample comprised 25 men (40.3%) and 37 women (59.7%), 31 of whom had developmental dyslexia and 31 were normal readers that were matched by age and education level. The ages ranged from 17 to 32 years (M = 23.45 years, SD = 3.82 years). All of the participants were tested using an extensive neuropsychological battery, including reading, writing, and phonological awareness tests.

All of the participants in the dyslexic group were college students who were diagnosed with dyslexia by a multidisciplinary team during childhood. Initially, 47 students with a dyslexia diagnosis were referred to the Cognitive and Social Neuroscience Laboratory by the university entrance exam department of Mackenzie Presbyterian University. This department performs exams with adaptations for candidates with developmental disorders. The inclusion criteria for the dyslexic group were meeting the requirements for a reading disorder diagnosis according to the *Diagnostic and Statistical Manual of Mental Disorders*, 4th edition, text revision (DSM-IV-TR; American Psychiatric Association, 2003). Dyslexic participants performed below –2 standard deviations on the word reading and phonological awareness tests (as described in Table 1). All of the adults had an intelligence level at or above the average (Full Intelligence Quotient [FIQ] > 80). Participants with clinical, neurological, or psychiatric disorders, sensory deficits, attention-deficit/hyperactivity disorder (ADHD), or other developmental disorders were excluded. The Concentrated Attention Test (Cambraia, 2003) and Stroop Test (Strauss, Sherman, & Spreen, 2006) were applied to exclude individuals with inattention symptoms: < 20th percentile on the Concentrated Attention Test and average score on the Stroop Test according to a normative Brazilian sample (Campanholo et al., 2014). Sixteen of the 47 participants were excluded from the sample because they presented low attentional scores or because they did not agree to participate in the study. The inclusion criteria for the control participants were the same as those for the dyslexic group in terms of age, IQ, and the presence of associated medical conditions. However, participants with no history of learning disabilities were accepted together with those without low performance on reading and phonological awareness tasks.

Instruments

A semi-structured interview was conducted with all of the participants to verify the presence of clinical, neurological, or psychiatric disorders and the presence of sensory disability, ADHD, or other developmental disorders. A neuropsychological test battery was applied to assess cognitive skills such as attention, memory, language, motor skills, and executive function, to exclude participants with other cognitive conditions that are unrelated to learning disorders or normal development. The participants also performed phonological and reading tests. Phonological awareness skills were evaluated using the Phonological Awareness Test (PAT-2; Oliveira, Lukasova & Macedo, 2008), which assesses the ability to manipulate speech sounds through tasks that involve rhyme, alliteration, phonemic addition, phonemic subtraction, and phonemic transposition. As a word recognition measure, the Word Reading Competence Test 2 (WRCT-2; Oliveira, Lukasova, &

Macedo, 2009) was applied. The WRCT-2 is a lexical decision test with items that are presented both orally and visually. The pairs can be congruent, in which case the spoken word and written word are identical, or incongruent, in accordance with specific types of errors in the written words. Evidence of validity of the PAT-2 and WRCT-2 was reported in previous studies (Pinto & Macedo, 2011; Morão & Macedo, 2011). Finally, intelligence and the cognitive profile were assessed by the Brazilian version of the WAIS-III (Nascimento, 2005). The following subtests were applied: Picture Completion, Information, Coding, Similarities, Picture Arrangement, Arithmetic, Vocabulary, Block Design, Object Assembly, Comprehension, Digit Span, Matrix Reasoning, and Letter-Number Sequencing.

Procedures

The present study was approved by the Research Ethics Committee of Mackenzie Presbyterian University (CAAE-0089.0.272.000-11). All of the individuals participated voluntarily and gave their written informed consent to participate in the study. The testing sessions were conducted over three sessions, each with an average duration of 1 h 30 min.

The data analysis initially comprised a descriptive analysis that was performed to calculate averages and standard deviations. Repeated-measures analyses of variance (ANOVAs) followed by Least Significant Difference (LSD) *post hoc* tests and *t*-tests were then performed. For all of the statistical tests, the level of significance was 5%, and the effect sizes (Cohen's d) were calculated. Analyses of the PAT-2 and WRCT-2 scores were performed using raw scores. However, scaled scores were used for the WAIS-III subtests. Finally, IQ values were used for the index and general averages.

Results

The two-sample *t*-test revealed no significant age differences (t_{60} = .000, p = 1.000) between dyslexics (M = 23.45 years, SD = 4.29 years) and controls (M = 23.42 years, SD = 3.34 years).

Group comparisons of WRCT-2 scores revealed a significant difference (t_{42} = 4.263, p < .001) and a high effect size (d = 1.29), with poor achievement in the dyslexic group. As expected, dyslexics also performed worse than controls on the phonological awareness test (t_{40} = 10.413, p = .002), with a high effect size (d = 1.00). Differences between groups were observed on the alliteration task (t_{40} = 8.623, p = .005), phonemic transposition task (t_{39} = 5.030, p = .030), and phonemic subtraction task (t_{40} = 4.261, p = .046). No difference was observed on the rhyme task (t_{40} = 2.703, p = .108) and phonemic addition task (t_{40} = 1.713, p = .198). Table 1 shows the averages, standard deviations per group, *t* values, and effect sizes related to word recognition and phonological awareness skills.

Comparisons between general and index averages of the WAIS-III revealed higher scores on all of the measures in the control group. Table 2 shows the averages, standard deviations per group, ANOVAs, and effect sizes.

Dyslexics presented significantly lower VIQ than controls, with a moderate effect size and a lower FIQ, Verbal Comprehension, and WM index values. No significant differences were found in PIQ or Perceptual Organization index scores.

The dyslexic sample exhibited differences between VIQ and PIQ averages (t_{30} = 4.024, p < .001), with lower scores in VIQ (M = 113.00, SD = 11.52) compared with PIQ (M = 118.84, SD = 9.49). The control group showed no difference in these measures (t_{30} = 1.778, p = .085). The dyslexic group showed a significant difference between VC and PO (t_{30} = 3.558, p = .001), PO and WM (t_{30} = 7.115, p < .001), and VC and WM averages (t_{30} = 2.997, p = .005). The dyslexic group presented lower averages in WM (M = 102.48, SD = 13.64) followed by VC (M = 110.68, SD = 10.60) and PO (M = 117.58, SD = 10.89). In the control group, no difference was observed between the VC and PO averages (t_{30} = 1.198, p = .240).

Table 1. Means, standard deviations, *t* values, and effect sizes in dyslexics and controls on Word Reading and Phonological Awareness skills.

Measure	Dyslexics Mean (SD)	Controls Mean (SD)	*t*	*p*	d
WRCT-2	61.38 (± 9.40)	70.80 (± 4.21)	4.263	.001	1.29**
Total PAT-2	21.29 (± 3.13)	23.62 (± 1.07)	3.230	.004	1.00**
Rhyme (PAT-2)	4.00 (± 1.09)	4.48 (± .75)	1.644	.108	.51*
Alliteration (PAT-2)	4.38 (± .86)	4.95 (± .21)	2.936	.005	.91**
Phonemic Addition (PAT-2)	4.29 (± .84)	4.62 (± .80)	1.309	.198	.40*
Phonemic Subtraction (PAT-2)	4.57 (± .67)	4.90 (± .30)	2.064	.046	.64*
Phonemic Transposition (PAT-2)	4.05(± 1.16)	4.67 (± .48)	2.256	.030	.70*

*Moderate effect size.

**High effect size according to Cohen (1988).

Table 2. Means, standard deviations, ANOVAs, and effect sizes in dyslexics and controls on the WAIS-III indices.

Measure	Dyslexics Mean (SD)	Controls Mean (SD)	*F*	*p*	d
Verbal IQ	113.00 (± 11.52)	119.00 (± 6.70)	6.277	.015	.63*
Performance IQ	118.84 (± 9.49)	121.77 (± 7.65)	1.795	.185	.34*
Full IQ	116.48 (± 10.73)	121.23 (± 6.29)	4.504	.038	.54*
Verbal Comprehension	110.68 (± 10.60)	118.19 (± 9.36)	8.754	.004	.75*
Perceptual Organization	117.58 (± 10.89)	121.61 (± 9.09)	1.416	.239	.30*
Working Memory	102.48 (± 13.64)	110.77 (± 15.52)	4.987	.029	.57*

However, differences were found between the PO and WM averages (t_{30} = 3.194, p = .003) and between the VC and WM averages (t_{30} = 2.248, p = .032). The results of the performance comparisons between groups for each of the WAIS-III subtests are presented in Table 3.

Control group performance was superior in eight subtests: Arithmetic, Coding, Information, Digit Span (ACID profile), Matrix Reasoning, Similarities, Letter-Number Sequencing, and Vocabulary. However, the effect sizes were moderate for Arithmetic, Digit Span, Information, Matrix Reasoning, Similarities, and Vocabulary. Large effect sizes were found for Coding and Letter-Number Sequencing. In the Digit Span subtest, dyslexics performed worse than controls in both

Table 3. Means, standard deviations, ANOVAs, significance, and effect sizes on the WAIS-III subtests.

Subtest	Group	Mean (SD)	*F*	*p*	d
Picture Completion	Dyslexics	13.13 (± 1.33)	3.074	.085	.45*
	Controls	13.65 (± .95)			
Picture Arrangement	Dyslexics	13.13 (± 1.92)	.133	.717	.09
	Controls	13.29 (± 1.53)			
Arithmetic	Dyslexics	11.16 (± 2.95)	4.205	.045	.52*
	Controls	12.52 (± 2.18)			
Object Assembly	Dyslexics	12.55 (± 3.12)	.150	.700	.10
	Controls	12.84 (± 2.77)			
Comprehension	Dyslexics	12.52 (± 2.40)	.991	.324	.25
	Controls	13.00 (± 1.23)			
Block Design	Dyslexics	13.65 (± 2.89)	.318	.539	.15
	Controls	14.06 (± 2.43)			
Coding	Dyslexics	11.13 (± 2.90)	10.597	.002	.83**
	Controls	13.32 (± 2.37)			
Digit Span	Dyslexics	11.23 (± 3.07)	7.056	.010	.67*
	Controls	13.29 (± 3.04)			
Information	Dyslexics	13.03 (± 3.09)	4.243	.044	.53*
	Controls	14.39 (± 1.96)			
Matrix Reasoning	Dyslexics	12.74 (± 1.99)	5.704	.020	.61*
	Controls	13.81 (± 1.47)			
Similarities	Dyslexics	12.55 (± 1.74)	7.776	.007	.71*
	Controls	13.68 (± 1.52)			
Letter-Number Sequencing	Dyslexics	10.16 (± 3.14)	19.675	.000	1.13**
	Controls	13.42 (± 2.61)			
Vocabulary	Dyslexics	10.90 (± 2.46)	8.523	.005	.75*
	Controls	12.68 (± 2.31)			

*Moderate effect size.

**High effect size according to Cohen (1988).

the forward items (t_{60} = 4.786, *p* = .033) and backward items (t_{60} = 9.941, *p* = .003).

No group differences were observed in the Picture Completion, Picture Arrangement, Object Assembly, Comprehension, or Block Design subtests. The effect size was small for the Picture Arrangement, Object Assembly, Comprehension, and Block Design subtests and moderate for the Picture Completion subtest.

With regard to the dyslexics' scores on the performance subtests, the best performance was observed in the Block Design subtest, whereas the poorest performance was observed in the Coding subtest. In the verbal subtests, the best and worst performance occurred in the Information and Letter-Number Sequencing subtests, respectively. The best performance in the control group was in the Block Design subtest, with poorer scores in the Object Assembly subtest. In the verbal subtests, the best performance was observed in the Information subtest, and the lowest score was found in the Arithmetic subtest.

To verify the relationships between reading and intelligence skills, Spearman correlations were performed using WRCT-2, PAT-2, and WAIS-III index scores. Correlations of the data from the total sample and dyslexic sample were not significant ($p > .05$). The control group presented a positive and moderate correlation with a moderate effect size between WRCT-2 accuracy and the Perceptual Organization index (*rho* = 0, 52; *p* = 0, 011) and a tendency toward a correlation between the WM index and PAT-2 score (*rho* = 0, 42; *p* = 0, 053).

Discussion

The present study examined the cognitive profiles of adults with developmental dyslexia compared with normal readers on the WAIS-III. Dyslexics showed significantly poorer VIQ than the control group and a nearly significant difference in PIQ. Felton, Naylorand, and Wood (1990) analyzed the performance profile of dyslexics on the WAIS-R and also reported a VIQ that was significantly lower than PIQ.

According to Alm and Kaufman (2002), the discrepancy between VIQ and PIQ may be associated with the education level of dyslexics because individuals with lower education levels presented a greater discrepancy between these measures. The sample was composed of dyslexics with complete and incomplete higher education. However, a significant discrepancy remained between VIQ and PIQ, regardless of the education level. This may indicate that, despite their education levels, dyslexics continue to present a reduction of language skills compared with the non-verbal domain. Such difficulties may be related to impairments in phonological processing, which are directly related to phonological memory (Laasonen et al., 2009). Thus, deficits in tasks that involve short-term phonological memory, as well as auditory WM, are expected and consistent with the impairments found in dyslexia. Furthermore, the poor development of orthographic skills that hinder the comprehension of printed material may harm the development of verbal conceptualization (Jones et al., 2008).

Dyslexics presented the following performance standards in the index scores: PO > VC > WM. The same author suggests that discrepancies among the WM, VC, and PO scores appears to clearly reflect the cognitive strengths and weaknesses pattern more than the ACID profile, once the ACID profile was partially found in 24% of adults with learning disorders and completed ACID only in 6.5%. Furthermore, our dyslexic sample presented a cognitive profile of weaknesses that were similar to those reported by Laasonen et al. (2009), referred to as VSDLC (Vocabulary, Similarities, Digit Span, Letter-Number Sequencing, and Coding). According to this profile, we can verify impairment in skills in dyslexics that are related to sequencing, acquired knowledge, auditory WM, and verbal skills in general.

Laasonen et al. (2009) conducted a factorial analysis similar to the one performed by Bannatyne (1974) to group the WAIS-III subtests. They found that dyslexics presented better performance in subtests that demanded spatial skills as a factor (i.e., the Picture Completion and Block Design subtests). In the present study, we verified the same profile in the Block Design and Picture Completion subtests. The other factors that were described previously are related to Sequential Skills (Arithmetic, Digit Span, Letter-Number Sequencing, and Coding). We found moderate and large effect sizes for all of these factor subtests. This profile is considered a good clinical predictor of reading disorders and may be related to aspects of distraction, impairment in sequencing skills, anxiety, impairments in WM, and difficulties in reasoning and numerical skills (Alm & Kaufman, 2002).

Comparisons of the WAIS-III subtest scores showed that dyslexics had poorer performances in the subtests of WM index, with a high effect size in Letter-Number Sequencing and a moderate effect in Digit Span and Arithmetic. Other studies reported the same performance profile (Leong, Hamalainem & Goswami, 2011; Conlon et al., 2011; Hamalainen et al., 2012; Bennett et al., 2008; Alm & Kauffman, 2002; Kaufman & Lichtenberger, 2006; Laasonen et al., 2009). The higher effect on the Letter-Number Sequencing subtest may be attributable to its higher task complexity, which demands phonological loops and central executive components (Baddeley, 2000). Meanwhile, the Arithmetic subtest assesses other cognitive skills in addition to auditory WM, such as mental calculation, comprehension of verbal statements, and reasoning ability.

Group performance in Digit Span was slightly different according to each subtest, as reported by Brunswick, Martin, and Marzano (2010) and Savill and Thierry (2012). The comparison of the groups' performance in the forward and backward items showed that dyslexics presented an auditory attention span that was similar to the control group, although they had greater difficulty manipulating auditory information. Such data may explain the lack of a group difference in the Digit Span subtest. Other studies compared performance on the forward and backward items and reported poor performance in dyslexics in forward items and no difference in backward items compared with normal readers (Bennett et al., 2008). Hatcher, Snowling, and Griffiths (2002) found significant impairments in dyslexics in both parts of the subtest.

The subtest performance analyses indicated lower accuracy among dyslexics in Similarities, Vocabulary, and Information. Laasonen et al. (2009) verified the same profile for Similarities and Vocabulary, which may be related to an impairment in complex verbal comprehension and a lack of background knowledge that is required for fluent reading. Additionally, the high effect size found in Vocabulary performance was also reported by Jones et al. (2008). This can be partially explained by the low mastery of orthographic skills in dyslexics. Nevertheless, other studies that used the Vocabulary subtest for sample characterization found no differences between dyslexics and normal readers (Hatcher et al., 2002; Jones et al., 2010; Conlon et al., 2011; Hamailanem et al., 2012).

The poor performance in dyslexics on the Coding subtest in the present study was also reported by Bennett et al. (2008) and Brunswick et al. (2010). This result may indicate impairments in processing speed, the automatization of numbers, and an association between symbols and visual-motor coordination. This pattern was also found in adults with dyslexia and ADHD by Laasonen et al. (2009). The poor performance was correlated with other processing speed measures such as the Stroop Test, Trail Making Test, and Rapid Naming Test.

Subtest score comparisons in the dyslexic group revealed the worst performance in the Letter-Number Sequencing subtest and best performance in the Block Design subtest, consistent with the results of Laasonen et al. (2009). Few studies have assessed Letter-Number Sequencing performance. Therefore, this subtest was included in the WAIS-III despite not being present in previous versions of the test. Nonetheless, the superior performance of dyslexics in the Block Design subtest was reported by other researchers (Jones et al., 2008; Hamalainen et al., 2012). Brunswick et al. (2010) verified performance in dyslexic adults and controls in visuospatial tasks and found superior performance in dyslexics in the Block Design subtest and in forms of identification that involve ambiguous pictures and the reproduction of a complex design. These results may indicate visuospatial processing skills that are more advanced in dyslexics than in normal readers.

The present study presented some possibilities of analyzing cognitive profiles with regard to strengths and weaknesses in adults with dyslexia using the WAIS-III. Dyslexics presented preserved perceptual organization skills, with performance that was similar to the control group. Additionally, the WAIS-III allowed differentiating dyslexics from normal readers in tasks that are related to auditory WM and sequential and verbal skills that are generally impaired in dyslexia. This performance pattern is consistent with the cognitive profiles observed in other neuropsychological tasks. Therefore, this information is important for making a differential diagnosis of dyslexia and designing cognitive interventions in dyslexic adults.

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