

■ Which Tasks Best Discriminate between Dyslexic University Students and Controls in a Transparent Language?

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The need for a battery for testing adult dyslexia, and especially university students, is being increasingly recognized in view of the increased number of adult requests for a dyslexia examination in relation to both assistance and protection from discrimination. The present study examines the discriminative validity of a battery we have developed—the Battery for the Assessment of Reading and Writing in Adulthood—through comparison of the performance of 24 university students with a history of severe developmental dyslexia and 99 controls. All the reading, writing, lexical decision and spelling tasks of the battery, except omissions in a lexical decision task and reading comprehension, showed a good discriminatory power. In addition, use of just two of these tasks (fluency in reading a text and spelling under articulatory suppression) gave 87% sensitivity and 97% specificity. Our results confirm that in transparent languages, measures of phonological automaticity are the best indexes of reading decoding competence, particularly in adults. Copyright © 2011 John Wiley & Sons, Ltd.

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INTRODUCTION

Dyslexia in the Adult

Dyslexia is a disorder that persists throughout a lifetime (Kemp, Parrila, & Kirby, 2009). Studying adult dyslexia is therefore important both for understanding which aspects remain critical when reading should be highly automatized and for developing adequate procedures for identifying the needs of individuals with dyslexia, so helping to avoid adverse consequences in their lives that might result from the disorder. In this respect, an important longitudinal study following a group of 26 adults with dyslexia who received a late diagnosis highlighted the secondary effects of dyslexia on self-esteem and on life choices (Michelsson, Byring, & Bjorkgren, 1985). The authors found that most of the group completed only the minimum (legally required) number of years at school, a high percentage were early school leavers, whereas just one went to university. The authors stressed the need for full consideration of the risk of negative consequences of dyslexia in adulthood (Michelsson *et al.*, 1985).

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Until now, studies mainly concerned Anglophone subjects. From one of the first longitudinal studies (Shaywitz et al., 1999), where subjects were identified at an early age and followed until adolescence, we know that individuals with dyslexia continue to be slower than peers, whereas accuracy improves with schooling and that phonological awareness continues to be one of the major difficulties. There is also extensive evidence that in adulthood, individuals with dyslexia still exhibit limitations in tasks involving phonological processing, lexical access and working memory (Singleton, Horne, & Simmons, 2009). From the literature, we know that poor phonological awareness is one of the primary deficits in dyslexia and that this problem seems to persist through adulthood (Pennington et al., 1990). It has also been observed that slowness in decoding is one of the principal characteristics of dyslexia at every phase of life (Hatcher, Snowling, & Griffiths, 2002). Moreover, dyslexic adults show more slowness in reading words with high and low frequency (Bruck & Treiman, 1990).

A problem of dyslexia may cause severe difficulties in everyday life to all adults who are involved in processing written material including people who want to continue their studies. In fact, university students with dyslexia—who presumably were able to compensate for their difficulties in reaching higher education—still exhibit problems in specific tasks. For example, Snowling et al. (1997) compared dyslexic university students and their non-dyslexic peers on a series of cognitive and literacy tests. They found that the most marked differences between groups were on tests of phonological processing (e.g. non-word reading, spoonerism accuracy and speed, phonemic fluency and phoneme deletion). In another study, Hanley (1997) found similar results, again comparing dyslexic and non-dyslexic university students. In this research, individuals with dyslexia performed more poorly than controls on lexical decision tasks, non-word reading, non-word spelling and working memory. In a further, more recent study again comparing university students (dyslexic and non-dyslexic), Hatcher et al. (2002) found that although these students had performed well at school and had apparently compensated for their difficulties, they still performed worse than controls on reading and writing tasks. Typical difficulties they displayed included low reading speed, more errors in spelling tasks and poor writing skills. They needed extra time during exams and in reading and writing assignments.

As research has concentrated on the case of adults who have difficulties in reading material in the English language, results cannot be fully generalized to languages with different characteristics, and in particular to transparent languages such as Finnish, Hungarian and Italian. In particular, English and Italian are nearly at opposite extremes as regards to the degree of transparency (i.e. in correspondence between written and spoken language), and it is widely documented that to some extent, different cognitive processes are implied in reading texts in languages that vary in transparency (e.g. Ziegler & Goswami, 2005). In Italian, a language with regular orthography, children develop their reading speed with a mean increase of 0.50 syllables/s per year, reaching a ceiling effect at about 6 syllables/s at 13–14 years of age (Tressoldi, 1996; Tressoldi, Iozzino, & Vio, 2006). But, whereas normal development of reading ability is well documented, very much less is known about Italian adults with dyslexia. A longitudinal study (Lami, Palmieri, Solimando, & Pizzoli, 2008) followed 33 young adults who received the diagnosis of dyslexia when they were children (about 10 years old). The authors found that reading abilities improve with schooling but this improvement depends on the severity of the disorder in childhood. In fact, there was a better improvement in reading speed in children with a medium or mild dyslexia (i.e. children with a reading speed within 2 SD below the mean); on the contrary, there were a small improvement in severe cases of dyslexia (i.e. children with a reading speed within 3 SD below the mean at the time of diagnosis). Nevertheless, dyslexia

seemed also to persevere in mild cases, because all individuals with dyslexia showed they needed extra time in reading and writing assignments (e.g. during exams or in academic situations). Phonological processes were compromised and were correlated with the severity level of dyslexia.

Assessment of Dyslexia in the Adult

One important aspect of dyslexia in adulthood is assessment and diagnosis. All assessment batteries and tests are standardized for children, and very few instruments are adapted and normed for adults. Furthermore, some dyslexic adults who had problems during their school years or were late in learning to read, may have developed strategies for decoding with the support of comprehension, such that in adulthood, they may not necessarily display obvious literacy difficulties (Beaton, McDougall, & Singleton, 1997; Fitzgibbon & O'Connor, 2002) but still present difficulties in complex and prolonged reading and writing tasks (Colombo, Fudio, & Mosna, 2009). A good battery for adults would therefore help in assessment and diagnosis also of the latter cases, helping to discriminate between university students who, owing to their dyslexia, need assistance in academic classes and students who simulate dyslexia to get facilitations. A screening test has to be able to discriminate between individuals with dyslexia and those without to a reasonable degree of accuracy. The accuracy of a screening system is indicated by the frequency of misclassifications it makes. False positives and false negatives are the two types of screening misclassification. A false positive is a 'false alarm', that is, occurring when a person is classified as 'dyslexic' when actually this is not the case. A false negative is a 'miss', for instance where a person is classified as 'not dyslexic' when actually the opposite is the case (i.e. in the context of this study, they are dyslexic). The value of any screening test depends on the frequencies of false positives and false negatives being low. False negatives are usually regarded as being more serious than false positives, because a high frequency of false negatives results in critical cases being overlooked, which could have serious consequences because the individuals concerned are likely to be denied the treatment or attention they need (Singleton *et al.*, 2009).

In developing a screening tool, it is important to attempt to minimize misclassifications as far as possible. Screening tests may be evaluated using the metrics of sensitivity (i.e. percentage of true cases correctly identified) and specificity (i.e. percentage of false cases correctly identified), although the appropriate levels must be defined taking into account the specific problems present in the context where the assessment is carried out. Levels <25% for false positives and false negatives have been advocated for effective screening in education (see Jansky, 1977; Potton, 1983; Singleton, 1997; Singleton *et al.*, 2009), but Glascoe and Byrne (1993) argue that sensitivity rates should be at least 80% and specificity at least 90% for a test to be considered satisfactory. These values, in our view, should be also applied to the case of a battery for adult individuals with dyslexia.

Informal screening tools for adults have been developed by Payne (1998) and used by Giovengo, Moore, and Young (1998). Weisel (1998) developed a more extensive battery called PowerPath. Another example is the Dyslexia Adult Screening Test (DAST), developed by Nicolson and Fawcett (1997). The PowerPath battery is based on the cerebellar hypothesis of dyslexia, which is consistent with a definition of dyslexia that encompasses deficit in motor co-ordination, balance and automaticity in learning among individuals with Learning Disabilities. The DAST includes tests that have been suggested may be related to cerebellar functioning and other cognitive tests such as non-verbal reasoning and semantic fluency. In their initial study, the authors reported a positive rate

of 94% and a false positive rate of 0%, using a group of 15 dyslexic students and a control group of 150 students. More recently, in Canada, Harrison and Nichols (2005) investigated the ability of the DAST to discriminate post-secondary students with and without dyslexia, in order to confirm earlier results and overcome the limitations of their earlier study (e.g. the limited number of cases in the dyslexic group) but identified only 74% of the students with dyslexia.

In a more recent study, Singleton *et al.* (2009) developed a computerised screening for dyslexia in adults. The battery included three tests investigating phonological processing (word recognition test), lexical access (word construction test) and working memory. Comparing 70 dyslexic adults and 69 matched controls, with different levels of education, the authors found that the battery discriminated the two groups with a sensitivity rate (i.e. percentage of true cases correctly identified) of 90.6% and a specificity rate of 90% (i.e. percentage of false cases correctly identified).

For languages other than English, literature is scarce. In Sweden, Wolff (2003) created a battery to screen adults with/without dyslexia. The battery was based on the theoretical approach of decomposing phonological skills. This battery can be divided into three components: phonological awareness (explicit ability to manipulate individual phonemes of words, such as the spoonerism task); phonological representations (vocabulary task); and working memory, assessed by a dual task in which the phonological loop is subjected to stress. In addition, it includes a self-report of dyslexia. The authors assessed 117 students, 50 of whom displayed dyslexia and 67 were without problems. Results showed that the battery clearly discriminated between groups, even though not all components of the battery discriminated equally well. For example, the vocabulary showed the lowest discriminating power, whereas the spoonerism task and (not surprisingly) the self-report showed the best discriminative power. Unfortunately, Wolff's study did not include direct measures of reading and writing. Furthermore, it is not clear how far results obtained with Swedish can be generalised to other languages. For example, although in non-transparent languages the core aspect of high reading competence is accuracy, in transparent languages (such as Italian) is speed; indeed, even a very poor reader can avoid making errors through use of a phonological strategy (Landerl & Wimmer, 2008). Furthermore, another important aspect that should be considered in assessing adults with dyslexia is level of reading comprehension; even if accuracy as well as speed are lower, reading comprehension may not be compromised in general (Simmons & Singleton, 2000) and in particular, in Italian individuals with dyslexia (Pazzaglia, Tressoldi, & Cornoldi, 1993), especially when reading comprehension is measured following the procedure, typically adopted in the Italian standardized reading comprehension tests that eliminates the influence of decoding speed and text memory. A good comprehension level is in particular expected in dyslexic students who, despite their disturbance, succeeded in reaching university level.

In 2006, the Learning Disabilities Unit at the University of Padova, a large university with more than 60 000 students, was involved in a project designed to assess and support students reporting a history of dyslexia. In devising a battery to examine the reading skills of adults with dyslexia, we chose to include the classical procedures used in Italy for assessing younger individuals with dyslexia, that is, text, word, and non-word reading, some writing and, as a control, a measure of reading comprehension. In designing the battery, we also examined the specific implications of a request of simultaneous articulation. Studying a group of Italian university students who presented mild reading problems at primary school, Colombo *et al.* (submitted) found that even where reading and writing are apparently well compensated, these students may still have problems where perfect automatization is required. In fact, these students behaved similarly to controls and made

very few spelling errors when writing normally, whereas their accuracy dropped dramatically when they were writing under articulatory suppression. Articulatory suppression prevents the use of the articulatory loop, which is used extensively during language processing, in particular during reading and writing (Baddeley, 1986; Gathercole & Baddeley, 1989). The involvement of the articulatory loop may be reduced in adult experts and in highly automatized reading and writing, but the above authors postulated that it is still important in less expert readers and writers who nevertheless need the support of a series of underlying articulatory processes for adequate performance. If the use of articulatory processes is prevented by the simultaneous request of articulation, these students may encounter severe difficulties. A side advantage of this procedure is that it could be used to identify liars, that is students falsely producing dyslexia symptoms (in order to receive facilitations in the examinations, e.g. extra time), because anyone exaggerating these symptoms is likely to make similar high numbers of errors in writing, whether with or without articulatory suppression.

This present paper presents the Battery for the Assessment of Reading and Writing in Adulthood (BARWA), in particular during the university period, devised at the request of University of Padova authorities for identifying students with dyslexia and implementing support for them. In addition, the paper presents the results obtained from assessment of those students who, in the first 2 years of the unit's project, requested support from the university for their dyslexia, that is, facilitations at the examination (extra time and oral rather than written examinations) and supervision during study. These students were compared with a control group of students with similar characteristics.

METHOD

Participants

The dyslexia group comprised 24 dyslexic students (13 men and 11 women) attending first year of undergraduate studies. All students of this group had received a diagnosis of dyslexia during their school years (primary or secondary school) from specialist services of the Italian National Health System. The diagnosis followed the DSM-IV recommendations (American Psychiatric Association, 1994) and the guidelines typically adopted in public services and recently officially presented in a shared document (see also Consensus Conference, 2007), namely normal level of general intelligence (IQ above 85), reading performance at a clinical level (reading decoding below the 5th percentile) and no neurological, sensory or educational deficit that could be cause of their reading impairment. As usual in the Italian school system, all these children attended normal schools and received some additional help. Some of these students followed specific training during their school years. These students were compared with a control group of 99 university students, matched for age and sociocultural level.

All the students were first year undergraduates. Their age range was 18 to 27, with mean age of 20.74 (SD = 1.95). Control group members were invited to participate in the study and so were all volunteers.

Procedure

All participants were assessed individually in a dedicated room remote from noise or any other cause of disturbance. The assessment lasted around 1 h. The Battery included four

tasks, which are recommended by the Italian guidelines for the assessment of dyslexia (Consensus Conference, 2007), three tests of reading decoding (reading text, words and non-words) and a passage reading comprehension task. The other tasks were the following: a lexical decision task in articulatory suppression, two word-list dictations, one in normal condition and one in articulatory suppression, two writing speed tasks, one in normal condition and one in articulatory suppression. Some tasks were based on tasks typically used in Italy for the assessment of younger dyslexic children, but adapted for the case of older individuals (see Cornoldi, Friso, & Pra Baldi, 2010), whereas the tasks under articulatory suppression were specifically devised for assessing university students.

Tasks

Reading tasks. Text reading—Speed and accuracy of text reading were assessed using the Memory-Transfer (MT) battery (Cornoldi et al., 2010). This battery is the most commonly used Italian instrument for measuring passage reading speed and accuracy and has a high test-retest reliability ($r = .97$ for reading and $r = .86$ for accuracy, respectively). It comprises different passages for each grade level with increasing number of syllables and complexity of text. We used the most complex passage, which had been designed for 10th graders. The text was long (1287 syllables) and quite difficult to read, because it contained some uncommon technical words.

Participants were required to read the passage aloud, paying attention to accuracy and speed. The instructions were as follows: 'read as accurately and rapidly as you can'. Reading speed was calculated by dividing the number of syllables of the passage by the time (in seconds) taken to read it. Accuracy corresponded to the number of words read incorrectly.

Words reading—This task is a subtest of a specific battery for assessing developmental dyslexia and dysorthographia (Sartori, Job, & Tressoldi, 2007). The battery includes five subtests for assessing various aspects of reading and three for evaluating writing. The battery has a medium reliability (e.g. mean test-retest coefficients are $.77$ for speed and $.56$ for accuracy) but has been validated in a series of studies and included in the recommended tests for assessing reading in Italian (Consensus Conference, 2007). Participants were asked to read four lists of isolated words aloud and as accurately and rapidly as possible. The material varied in frequency and concreteness, starting with a list of very common and concrete words, followed by lists of words decreasing in frequency and concreteness. Reading speed was calculated by dividing the number of syllables read by the time (in seconds) taken to read them. Accuracy corresponded to the number of words read incorrectly.

Non-words reading—This task is another subtest of the specific battery for assessing developmental dyslexia and dysorthographia (Sartori et al., 2007). As for the previous task, participants had to read the material aloud and as accurately and rapidly as possible. Again, reading speed was calculated by dividing the number of syllables read by the time in seconds taken to read them. Accuracy corresponded to the number of non-words read incorrectly.

Text comprehension—This task was also derived from 10th grade material in the MT battery (Cornoldi et al., 2010). The administration exactly followed the standard procedure used by all the Italian standardized reading comprehension tasks, which mainly focuses on the student's ability to find appropriate information in the text for answering to a series of comprehension requests, in order to study comprehension independently from the contribution of decoding and memory of the text (Cornoldi & Oakhill, 1996). Participants had

to silently read two passages and answer 20 questions (10 for each passage) related to the text. They were given unlimited time to complete the task and were insured that the time was not considered in any way, and were allowed to consult the text.

Lexical decision task under articulatory suppression—The material for this task was derived from a subtest of the specific battery for assessing developmental dyslexia and dysorthographia (Sartori *et al.*, 2007). Twenty-four words and 24 non-words were presented mixed altogether. Participants had to silently read them as soon as possible, and put a mark to indicate the true words, ignoring the non-words. At the same time they had to repeat the syllable 'la' continuously and aloud. Parameters taken into account for the scoring were as follows: time, errors (i.e. non-words marked as words) and omissions (i.e. words not marked).

Writing tasks. Words Dictation—This task consisted in a normal dictation but involved two conditions: normal and with articulatory suppression. Material included two lists each of 24 words; all the words contained three or four syllables, had the same level of frequency and did not present any particular orthographic difficulties (see list in Appendix). The experimenter dictated at a constant rhythm of one word every 3 s. In the condition with articulatory suppression, the task was exactly the same, but participants had to repeat the syllable 'la' continuously and aloud during the dictation. A preliminary control verified that subjects were perfectly able to understand and repeat dictated words even if they were presented while articulating. The score was represented by the number of words, which were incorrectly written.

Speed writing task—This task was derived and adapted from the Italian 'Battery for the assessment of writing skills of children from 7 to 13 years old' (Tressoldi & Cornoldi, 2000). Again it involved two conditions: normal and in articulatory suppression. In the normal condition, participants had to write numbers in letters, starting from one, as quickly as possible (1 min was allowed). In the condition with articulatory suppression, they had to do the same but repeating the syllable 'la' continuously and aloud during the task. In this task, the score was represented by the number of written graphemes.

RESULTS

First, we compared the two groups in the different tasks in order to find any statistically significant differences. In order to obtain the magnitude of the difference between groups, we calculated the standardized mean difference (Cohen's *d*). This effect size measure is interpreted as the difference between the two groups' means on the dependent variable *Y* relative to the variability on *Y* within groups, calculated as a pooled estimate of the within-groups standard deviation (Cohen, 1988). Because this measure is sensitive to a number of additional influences, we calculated the probability-based measure *A*, which is insensitive to base rates and more robust to several other factors (e.g. extreme scores, non-linear transformations). This effect size measure is defined as the probability that a randomly chosen member of group 1 scores higher than a randomly chosen member of group 2 in the dependent variable (Ruscio, 2008). See results in Table 1.

Reading Tasks

As expected, we found significant differences in fluency and accuracy for all reading tasks except text comprehension. Although control group students were able to read a mean

Table 1. Descriptive, inferential statistics and effect sizes of the comparison between typical and dyslexics students

	Controls		Dyslexics		<i>t</i>	d.f.	<i>p</i>	<i>d</i> (0.95% CI)	<i>A</i>
	(n=99)		(n=24)						
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>					
Text accuracy	3.08	1.88	10.25	5.04	6.85	24.56	<.001	2.5 (2–3.1)	.96
Text syllable/s	5.96	0.55	3.93	0.98	9.83	26.66	<.001	3.1 (2.5–3.7)	.99
Words accuracy	.64	0.84	3.19	2.89	4.01	20.72	.001	1.8 (1.2–2.3)	.88
Words syllable/s	5.14	0.85	2.99	.91	9.32	112	<.001	2.5 (1.8–3.1)	.96
Non-words accuracy	1.79	1.63	6.86	4.46	5.13	21.14	<.001	2.1 (1.6–2.6)	.96
Non-words syllable/s	3.21	0.66	1.82	0.65	7.84	113	<.001	2.1 (1.5–2.7)	.92
Text Comprehension	15.73	2.30	15.67	2.50	0.10	118	>.05		

number of 5.96 syllables/s in a passage, dyslexic students read 3.93 syllables/s for the same passage. The difference in reading speed between the groups was even larger for reading both words and non-words, which were separately analysed. Controls read a mean number of 5.14 syllables/s when reading words and of 3.21 syllables/s when reading non-words, whereas individuals with dyslexia read 2.99 syllables/s when reading words and 1.82 syllables/s when reading non-words, respectively. As can be seen from Table 1, the effect size is always large (ranging from $d = 1.8$ to 3.1); in addition, the probability that a randomly chosen member of the control group scored higher than a randomly chosen member of the dyslexic group on the dependent variables is very high (from 0.88 to 0.99).

It should be noted that even if the speed and accuracy of reading are very different between groups, there was no significant difference in the comprehension task: students of both groups correctly answered about 15 questions out of the 20 presented. This result suggests that even though individuals with dyslexia read at a speed that is about half that of controls and make more errors owing to their uncertainties, their comprehension and consequently their study abilities are not compromised.

Lexical Decision

As can be seen from Table 2, significant differences between groups were also found in the lexical decision task under articulatory suppression (which was satisfactorily understood and performed by all participants). Individuals with dyslexia were slower than controls in deciding whether the word being read was real or not and also made more errors (i.e. marking a non-word as a word) and omissions (i.e. confounding a word as a non-word, by

Table 2. Means, standard deviations and effect size measures (*d* and *A*) of the lexical decision tasks under articulatory suppression

	Controls		Dyslexics		<i>t</i>	d.f.	<i>p</i>	<i>d</i> (0.95% CI)	<i>A</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>					
Lexical decision errors	0.55	1	2.50	2.03	3.54	13.91	.003	1.6 (1.06–2.2)	0.85
Lexical decision omissions	0.48	0.85	1.29	1.44	2.03	14.31	0.06	0.86 (0.29–1.24)	0.71
Lexical decision time	34.26	7.09	75.36	31.06	4.93	13.19	<.001	3.2 (2.5–3.9)	0.99

not marking it) than controls. Comparison of the effect size *A* values showed that they showed particular poor performance in speed, taking extra time to try to compensate for their difficulty; the group difference was less dramatic in the case of omissions.

Writing Tasks

We also found significant differences in the writing tasks. Both groups were penalized by the condition with articulatory suppression, in both the writing speed tasks and the dictation. Comparing groups, we found that, in the writing speed tasks, individuals with dyslexia were slower than controls in both conditions, normal and with suppression (see Table 3). In the dictation, no significant difference between groups was found in the normal condition (both groups on the whole performed well), but an important difference was found in the condition with suppression: controls committed a mean of 2.01 errors (SD = 2.68), whereas for individuals with dyslexia, this figure was six times greater, partly because in the suppression condition, some individuals with dyslexia could not even attempt to write the word, finding the request too difficult. As Table 3 shows, the effect sizes are high. In particular, the probability-based measure *A* is 0.98 for the errors under

Table 3. Means, standard deviations and effect sizes Cohen's *d* and *A* of writing speed and spelling

	Controls		Dyslexics		<i>t</i>	d.f.	<i>p</i>	<i>d</i> (.95% CI)	<i>A</i>
	<i>M</i>	SD	<i>M</i>	SD					
Writing speed	164.25	21.33	123.96	25.52	7.86	120	<.001	1.8 (1.3–2.3)	.88
Writing speed with articulatory suppression	139.74	27.69	81	31.75	8.6	118	<.001	2.06 (1.5–2.6)	.92
Dictation errors	0.46	1.12	0.58	0.93	.48	121	0.63		
Dictation errors with articulatory suppression	2.01	2.68	12	5.9	7.93	24.1	<.001	2.8 (2.2–3.4)	.98

articulatory suppression, meaning that a subject chosen randomly has 98% probability of being included in the correct group.

In order to identify the minimum number of tasks sufficient for discriminating individuals with dyslexia from those without, we tested various different models of logistic regression. Logistic regression applies maximum likelihood estimation after transforming the dependent into a logit variable (the natural log of the odds of the dependent variable occurring or not). In this way, logistic regression estimates the odds of a certain event occurring. In our case, we used this statistical analysis to obtain a measure of the power of our tests to correctly discriminate individuals with dyslexia from typical readers. On the basis of the values of effect size *A*, we selected the most discriminative tests and used them to obtain a measure of their discriminative power.

As Table 4 shows, the use of a single test, that is, dictation under articulatory suppression, can discriminate 96% of controls and 73.9% of individuals with dyslexia ($B = 0.45$, $p = .002$). In other words, the odds that an individual of the control group is not dyslexic are 96%, whereas the odds that an individual of the dyslexic group is dyslexic are 73.9%.

If we add text reading speed as a second predictive variable, the percentage of correct identification improves to 97% for controls and 87% for individuals with dyslexia

Table 4. Predictive results of the discriminative variable dictation with articulatory suppression

Observed	Predicted		
	Non-dyslexics	Dyslexics	Percentage correct
Non-dyslexics	95	4	96.0
Dyslexics	6	17	73.9
Overall percentage			91.8

Table 5. Predictive results of the discriminative variables dictation with articulatory suppression and text reading speed

	Observed	Predicted		Percentage correct
		Group		
		Non-dyslexics	Dyslexics	
Step 1	Non-dyslexics	96	3	97.0
	Dyslexics	3	20	87.0
	Overall percentage			95.1

(dictation: $B = .22$, $p = .002$, passage reading: $B = -2.79$, $p = .004$). These values are highly superior than the values of 75% or 90% suggested by the literature (Table 5).

CONCLUSIONS

This paper presents the main results obtained with a new Battery for the Assessment of Reading and Writing in Adulthood (BARWA). The BARWA battery was devised in order to meet the requests of the University of Padova for identifying, assessing and supporting students with a history of dyslexia.

In the study, a number of key results were obtained. First, dyslexic students in general had a performance that was dramatically poorer than that of the control group. Speed in decoding texts, words and non-words typically took a value slightly above half that of the controls with a typical decrease progressing from texts to words to non-words. An interesting finding is that although individuals with dyslexia were as good as controls in the reading comprehension task, they were not able to compensate and attenuate their slowness when tackling a text. Their slowness was evident when they read the text but was also observed when the reading comprehension test was administered.

Furthermore, for both text and words, a speed measure had a higher powerful discriminatory power (indicated by the d and A effect sizes) than an accuracy measure. However, the accuracy of individuals with dyslexia was also poorer than that of controls, although it should be noted that the number of errors in typical normal readers is close to zero. Consequently, an apparently surprising result was obtained, that is, individuals with dyslexia do not read well and make errors in reading some words, but nevertheless understand the text they read as well as controls. This seems to be because of the particular procedure we adopted for assessing reading comprehension, focused on the

ability to do detective work in a text for finding the appropriate answer to a request and to the fact that reading errors were not high and most did not change the text meaning or were simple distortions of a word to-be-read. The finding lends further support to the conclusion that with a transparent language (or at least in the case of Italian) and using a reading comprehension task without memory or time constraints or request to read aloud, reading comprehension and decoding may be dissociated (Cornoldi & Oakhill, 1996). This seems particularly plausible for the group of students considered, who managed to overcome their dyslexia limitations and reach university, presumably thanks to their good general skills, an aspect we were not able to consider in our assessment. Even so, good comprehension is not sufficient to meet all the skill demands of university study. In order to avoid putting the students we examined under pressure, we did not record the time taken for the reading comprehension task, but it was generally observed that the dyslexic students needed more time. However a more accurate measure of the time required for the reading comprehension test should be collected in future assessing for having more precise information of the extra time needed by students with dyslexia.

The BARWA battery also included other measures where a critical variable was represented by the request of a concurrent articulatory suppression. Results clearly showed that the request of simultaneously articulating a syllable emphasised the differences between dyslexic and control groups. Because it is impossible to simultaneously read aloud and articulate, a first task we introduced was a lexical decision task, which is considered a good measure of reading decoding (Coltheart *et al.*, 2001). The time requested for completing the task was found to be higher for the dyslexic group who needed more than double the time of controls. Errors and omissions were less informative measures, because the values were relatively low in both groups, suggesting that the effort for performing the task correctly had a direct impact on speed.

Our final results concern writing. For writing speed, the number of letters written in 1 min was always higher in the control group, but the difference was highlighted in the articulatory suppression condition. In fact, in the time allowed (1 min), the dyslexic students wrote approximately three quarters of the number of letters written by the control group, whereas in the suppression condition, they wrote less than 60% of the controls' value. Considering accuracy in writing dictated words more directly, we again found that the articulatory suppression condition highlighted the difficulties of the dyslexic group. The dictation under suppression task presented very high sensitivity in discriminating between groups, largely higher than the levels indicated as necessary by the literature (see Glascoe & Byrne, 1993; Jansky, 1977; Potton, 1983; Singleton, 1997; Singleton *et al.*, 2009). This suggests that the procedure could be also used in the routine assessment of dyslexic university students.

In order to produce a battery with a reasonable time demand, the lists of dictated words are not particularly long, and it is perhaps not surprising that non-dyslexic university students made few errors with a list of 24 words. However, it is interesting to note that even dyslexic students make few errors as controls (a result that should be applied for identifying students who aim to exaggerate their difficulties). On the contrary, when articulatory suppression was required, the dyslexic group had severe difficulties. In particular, some dyslexic students reported having problems, feeling the task to be beyond them. The articulatory suppression therefore represented a critical manipulation in highlighting the dyslexic group difficulties, confirming that articulatory processes are required in reading and writing (Gathercole & Baddeley, 1989), particularly relevant when these abilities are not perfectly mastered. Dyslexic adults are not only slower and less accurate in reading and writing but are also more susceptible to the disruptive effects of a

concurrent task, which, as suggested by Colombo *et al.* (submitted), involves processes also involved in reading and writing. Again considering the effects of articulatory suppression, another possibility is that the difficulties encountered were not due to a difference in the processes involved in reading and writing but rather to a lower availability of resources related to activity of the articulatory loop. There is in fact evidence (e.g. Felton, Naylor, & Wood, 1990) that individuals with dyslexia often have a lower capacity in this particular subsystem of working memory.

In conclusion, this study covers a relatively new topic and presents results of interest in both scientific and clinical contexts interested in adult dyslexia. However, the study had some limitations. In particular, research concerned only a particular group, that is, Italian university students with an earlier diagnosis of dyslexia because of a relevant reading decoding problem: future studies of interest would collect more information on the assessment procedures used for the early diagnosis of dyslexia, in order to explore their degree of overlap with the assessment procedures proposed in the present Battery. Furthermore future research should examine the development of dyslexic adults who ended their formal education at school level and did not attend university and consider the generalizability of our results to other languages, both at high and low transparency and other contexts.

APPENDIX

Dictation

CANARINO (canary)
CARNEVALE (carnival)
CASALINGA (housewife)
CICALA (cicada)
COMETA (comet)
CORONA (crown)
DELFINO (dolphin)
DIVANO (sofa)
FUNERALE (funeral)
GIGANTE (giant)
MANIFESTO (poster)
MONUMENTO (monument)
PANTALONE (slacks)
PARADISO (paradise)
PASTORE (shepherd)
PEPERONE (pepper)
PULCINO (chick)
RAPINA (robbery)
RECINTO (enclosure)
SUSINA (plum)
TARTARUGA (turtle)
TULIPANO (tulip)
VALANGA (avalanche)
VEGETALE (vegetable)

Dictation in articulatory suppression

CANTINA	(cellar)
CAPITALE	(capital)
CASTIGO	(punishment)
COCACOLA	(coke)
CONTADINO	(farmer)
CORNICE	(frame)
DINAMITE	(dynamite)
FARINA	(flour)
LABIRINTO	(labyrinth)
LAMENTO	(moan)
MARATONA	(marathon)
MARITO	(husband)
MOMENTO	(moment)
MULINO	(mill)
PANORAMA	(landscape)
PERGAMENA	(parchment)
PILOTA	(pilot)
POMODORO	(tomato)
ROSMARINO	(rosemary)
SALMONE	(salmon)
TEGAME	(saucepan)
TEMPORALE	(storm)
VAGABONDO	(tramp)
VAGONE	(carriage)

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