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Reading decoding and comprehension in children with autism spectrum disorders: Evidence from a language with regular orthography

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ABSTRACT

Decoding and comprehension skills in children with autism spectrum disorders (ASD) were analysed in children native speakers of a language (Italian) with a highly regular orthography. Children with ASD were compared to children with matched intellectual functioning: a subgroup of children with ASD and borderline intellectual functioning (BIF) was compared to a subgroup of children with BIF but no signs of ASD; a subgroup of children with ASD and cognitive functioning within normal limits was compared to a group of typically developing children. Children with ASD (whether with or without BIF) showed essentially spared decoding skills in text as well as word and pseudo-word reading; this was at variance with children with BIF who, as a group, showed overall deficient decoding skills, despite considerable individual differences. By contrast, children with ASD (once again, irrespective of the presence of BIF) showed a selective impairment in reading comprehension, just like children with BIF but unlike the typically developing ones. Therefore, results are generally consistent with a profile of hyperlexia for children with ASD learning a regular orthography, as previously reported for other languages. Notably, this pattern was present irrespective of the degree of cognitive impairment, and clearly distinguished these children from those with borderline intellectual functioning but not signs of autism.

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1. Introduction

The autism spectrum disorders (ASD) represent a group of clinical conditions characterized by abnormal communication, impaired socialization and restricted activities and interests. These conditions can be associated to varying degrees of cognitive disabilities. The cognitive profile of individuals with ASD is complex with areas of strength in visuo-spatial, sensory-motor and memory abilities and areas of weakness in executive functions, attention, abstract reasoning, formation

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of mental prototypes and categorization (Rutter, 1983; Sigman & Mundy, 1987; Courchesne, Lincoln, Yeung-Courchesne, Elmasian, & Grillon, 1989).

A typical characteristic of ASD is the presence of language disorders (Schopler & Mesibov, 1995). Early studies on language difficulties took into consideration unusual domains, such as echolalia (e.g., Kanner, 1946; Bartak, Rutter, & Cox, 1975). More recent investigations have focused on several domains of language development, such as grammar morphology, syntax, semantics, pragmatics; they have also examined other aspects, such as phonology and phoneme-grapheme correspondence, which are critical to writing and decoding a written text (e.g., Schopler & Mesibov, 1995).

How children with developmental disabilities can early decode a series of words has been already highlighted (Parker, 1919; Phillips, 1930) and referred to by Kanner (1943) in his first report describing childhood autism. However, it is only after Silberberg and Silberberg (1967) identified the exceptional ability to decode words (hyperlexia) in some children with developmental disorders that systematic studies on children with this special ability have taken place.

The term hyperlexia was first introduced by Silberberg and Silberberg (1967) and refers to an unusually high ability of children in decoding rather than understanding and integrating written words. Thus, in such children, the word reading ability goes beyond expectation, based on their overall cognitive and verbal functioning (Silberberg & Silberberg, 1967, 1968–1969). However, it is not clear whether this discrepancy should be expressed by contrasting the level of word identification with other cognitive functions (e.g., intelligence as expressed by IQ), with reading comprehension or both (for a discussion see Grigorenko, Klin, & Volkmar, 2003). In fact, it has been noted that the term hyperlexia has been used in different ways by different authors to mark either a superability (i.e., a special talent) or a disability (i.e., indicating a deficient reading comprehension in the face of spared decoding; Grigorenko et al., 2003).

Hyperlexia has been reported in children without autism (Nation, Clarke, & Snowling, 2002; Snowling & Frith, 1986), such as individuals with intellectual disability (Cossu, Rossini, & Marshall, 1993a) or Turner syndrome (Temple & Carney, 1996). However, there might be a strong correlation between autism and hyperlexia, such that many children with an hyperlexic profile show autism or features of autism (Whitehouse & Harris, 1984; Healy & Aram, 1986; Goldberg, 1987; Smith & Bryson, 1988; Patti & Lupinetti, 1993; Tirosh & Canby, 1993; O'Connor & Hermelin, 1994; Nation & Snowling, 1999; Grigorenko et al., 2002; Jones et al., 2009).

However, studies on reading skills carried out on larger samples of children with ASD highlighted partially inconsistent results. On one hand, several studies found good levels of decoding both in adults (Rumsey & Hamburger, 1990), adolescents (Jones et al., 2009), and in children with autism (Frith & Snowling, 1983; Szatmari, Tuff, Finlayson, & Bartolucci, 1990; Minshew, Goldstein, Taylor, & Siegel, 1994; O'Connor & Hermelin, 1994; Mayes & Calhoun, 2003; O'Connor & Klein, 2004; Turkeltaub et al., 2004; Davidson & Ellis Weismer, 2014); on the other, a few studies reported that poor language skills, typical of the disorder, may predict difficulties in decoding (Tager-Flusberg & Joseph, 2003; Bishop & Snowling, 2004; Catts & Kamhi, 2005).

Language skills play an important role in reading processes, either at basic levels – such as word reading decoding as well as lexical and syntactic analysis – or at higher levels, namely integration and inference between sentences and ideas in the text, monitoring of the comprehension and knowledge of the text structure (Cataldo & Cornoldi, 1998; Cain & Oakhill, 1999; Cain, Oakhill, & Lemmon, 2004). Comprehending is a dynamic process by which new information is integrated with pre-existing knowledge (Johnson-Laird, 1983; Gernsbacher, Varner, & Faust, 1990; Kintsch, 1998). Thus, text comprehension involves both basic cognitive functions, such as syntactic and lexical processing (Nation & Snowling, 1999), working memory (Carretti, Cornoldi, De Beni, & Romanò, 2005), and higher cognitive functions, such as comprehension monitoring and awareness of reading purposes and strategies (Yuill & Oakhill, 1991). Several studies reported these processes to be impaired in individuals with ASD and identified a certain number of deficient functions involved with text comprehension in the same population (for a meta-analysis see Brown, Oram-Cardy, & Johnson, 2013). In particular, it has been proposed that the status of reading and writing skills reflects deficits in mentalization skills, that is social skills that postulate the ability to "read" the other's mind (Baron-Cohen, 1995), as well as deficits determined by interests in details and consequent difficulties to integrate information (O'Connor & Klein, 2004; Wahlberg & Magliano, 2004).

In the literature there are studies mainly based on the comparison of reading skills between individuals with high functioning ASD and children with typical development or studies that compare different subgroups of children with ASD. However, there are several individuals with ASD who show cognitive deficits, particularly borderline intellectual functioning (BIF; Rutter & Schopler, 1987). By definition, BIF stands on the edge between typical intelligence and intellectual disability, with IQs between 71 and 84 (AAMR, 2002). Only a few studies have focused on the description of learning profiles in this population, although they have reported academic learning difficulties (Capozzi, Musatti, & Levi, 1991), and impairments in meta-cognitive and meta-language skills (Capozzi, Penge, & Levi, 1993; Melogno & Becciu, 1999). Karande, Kanchan, and Kulkarni (2008) analysed academic skills in 55 young persons with BIF (35 males, 20 females), reporting that 89% of the sample performed poorly, with 25% showing difficulties in reading. In a study on adolescents with intellectual deficits, Levy (2011) found that the relationship between phonological processing and reading was mediated by IQ; thus, she proposed that learning how to decode is an explicit task that requires general cognitive resources. Overall, there is evidence that general cognitive skills play an important role in reading acquisition in children with intellectual disability or BIF (for a review see Conners, 2003). Nevertheless, children with intellectual disability who read (decode) extremely well have been reported (Cossu et al., 1993a). Furthermore, there is a continuing controversy on the role that intelligence should be given in the case of learning disabilities (e.g., Siegel, 1989) in particular in relationship to the idea of using discrepancy measures to identify children with specific reading deficits (e.g., Stanovich, 2005). Therefore, it seems that general cognitive abilities may play an important role in mediating learning to read but it is uncertain whether this is a general finding or is it specific for children with intellectual

disability or BIF. Thus, to enucleate the possible role of intelligence in modulating reading difficulties it seems important to properly match children with ASD in terms of general cognitive abilities when evaluating their reading profile.

In the present study, we aimed to examine the reading profile of a group of children with ASD who learnt to read in a language with a very regular orthography, such as Italian. It is well known that orthographic depth has an important modulating role in reading acquisition (e.g., Seymour, Aro, & Erskine, 2003; Ziegler & Goswami, 2005). In particular, languages with more irregular orthographies (such as English) may require more phonological proficiency while this may be less compelling in languages with more regular orthographies (Zoccolotti, De Luca, Di Filippo, Judica, & Martelli, 2009). The mediating role of phonology has been emphasized in the case of children with intellectual disability (Conners, 2003). In the case of children with ASD, the picture is more complex, with some studies reporting spared phonological processing (Frith & Snowling, 1983; Jones et al., 2009), and others indicating that children with autism may have difficulty in applying phonological decoding strategies (Nation, Clarke, Wright, & Williams, 2006). In particular, Nation et al. (2006) emphasized the presence of considerable inter-individual variability in children with ASD that may go undetected when only high functioning individuals are examined.

In this study, we separately examined the decoding and comprehension skills of children with ASD who also showed (or not) BIF. Performance of a subgroup of Italian children with ASD/BIF was compared to that of an age-matched group of children with BIF but no signs of ASD. Furthermore, performance of a group of children with ASD and cognitive functioning within normal limits was compared to an individually age-matched group of typically developing children. Our aim was to check whether the reading performance of children with ASD was determined by the presence of autism, by their cognitive level, or by a combination of these factors.

2. Materials and methods

2.1. Participants

A total of 30 children with ASD participated to the study. The sample was recruited among patients referring to the Diagnostic Clinics of the "Oasi Maria SS" Institute, based in Troina (Italy), specialized in the treatment and rehabilitation of intellectual disability. The ASD subgroup was diagnosed according to DSM-IV-TR (2000), as well as with data derived from the Childhood Autism Rating Scale (C.A.R.S.; Schopler, Reichler, & Renner, 1988), the Autism Diagnostic Observation Scale (ADOS; Lord, Rutter, Di Lavore, & Risi, 2005; Italian version by Tancredi et al., 2005) and the Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003; Italian version by Faggioli et al., 2005). All children with ASD attended public schools in regular classrooms with the support of a special education teacher.

Out of the total number of individuals with ASD, and based on the performance on the Wechsler Intelligence Scale for Children-III (WISC-III; Wechsler, 1991), 17 children met the criteria for borderline intellectual functioning according to the DSM-IV-TR (2000) criteria, i.e., they all scored below 85 at the FIQ (range VIQ = 55–85, range PIQ = 60–89, range FIQ = 63–79). Overall, performance was severely impaired both in VIQ (range = 55–85) and in PIQ (range = 60–89). The sample included 15 males and 2 females; their mean age was 9 years and 6 months (SD = 2.2, range 7.5–13 years). The subgroups' mean ages and IQ performance are presented in Table 1A. Thirteen children with ASD showed a cognitive performance falling within the normal range. To determine this, we used a lenient criterion, i.e., either a FIQ > 85 and/or at least one scale IQ above

Table 1
Main characteristics of participants. Part A of this table presents results from the comparison between age and intelligence data in ASD/BIF ($N = 17$) and BIF ($N = 22$) children subgroups. Part B presents age and intelligence data derived from the subgroup of children with ASD and cognitive performances within the normal range ($N = 13$) and the subgroup of typically developing children ($N = 16$); data from the Peabody test were available only for this latter control group (Part B).

(A)

	ASD/BIF children ($M = 15$; $F = 2$)			BIF children ($M = 17$; $F = 5$)			
	Mean	SD	Range	Mean	SD	Range	p
Age	9.6	2.02	7.5–13	10.4	1.5	8.6–13.11	.17
Verbal IQ	70.06	8.75	55–85	72.45	5.07	63–84	.29
Performance IQ	74.12	9.69	60–89	75.41	5.11	65–86	.59
Full IQ	68.35	5.85	63–79	71.5	3.08	63–77	.036*

(B)

	ASD children ($M = 11$; $F = 2$)			Typically developing children ($M = 13$; $F = 3$)			
	Mean	SD	Range	Mean	SD	Range	p
Age	9.2	2.32	7–13.2	9.9	1.5	8–13	.40
Verbal IQ	89.77	13.2	67–107	–	–	–	–
Performance IQ	104.08	11.03	72–115	–	–	–	–
Full IQ	96.08	7.79	82–104	–	–	–	–
Peabody test	–	–	–	94.75	10.12	85–115	–

* $p < .05$.

100. Twelve out of thirteen children scored above 85 in FIQ (range = 86–104); the odd one case scored 102 in PIQ and 67 in VIQ (FIQ = 82). Furthermore, twelve children scored above 100 in PIQ (range = 100–115) and four above 100 in VIQ (range = 100–107). Therefore, as it might be expected, there was a bias for children to show a higher performance in the PIQ than in the VIQ (mean group difference = 14.3). However, there was one exception with a child performing 104 in VIQ and 72 in PIQ (FIQ = 87). The sample was made of 11 male and 2 female children; their mean age was 9 years and 2 months (SD = 2.3, range 7–13.2 years). The subgroup mean ages and IQ performance are presented in Table 1B.

The two subgroups of children with ASD were compared to two separate control groups. The children with ASD/BIF were compared to a group of children of the same chronological age with a diagnosis of BIF according to DSM IV-TR (2000), i.e., with a FIQ between 71 and 84. This group included 22 children, 17 males and 5 females with a mean age of 10 years and 4 months (SD = 1.5, range 8.6–13.11 years). These were selected among a larger group of children referred to the Oasi Maria SS. Institute for difficulties in school achievements but no additional diagnoses of syndromic type, motor deficits or epilepsy. Children with BIF were then matched individually with children with ASD/BIF on chronological age and IQ (though matching was kept blind to reading performance). Data from the subgroup of children with BIF are presented in Table 1A. ASD/BIF and BIF subgroups did not differ for chronological age ($t_{(37)} = -1.41$, $p = .17$, Cohen's $d = .45$; see Table 1A). As expected based on the selection procedure, the two subgroups did not differ for VIQ ($t_{(37)} = -1.07$, $p = .29$, Cohen's $d = .35$) and PIQ ($t_{(37)} = -.54$, $p = .59$, Cohen's $d = .29$). However, a small (about 3 points) albeit reliable ($t_{(37)} = -2.16$, $p = .03$, Cohen's $d = .71$) difference was found in FIQ, with performance being higher in children with BIF than in children with ASD/BIF (see Table 1A).

Children with ASD and cognitive performance within normal limits were compared with a second control group of 16 typically developing children, 13 males and 3 females, with a mean age of 9 years and 9 months (SD = 1.5, range 8–13 years). These children were selected from local public schools located in the same area; they showed no signs of motor or cognitive disability. They were matched individually with children with ASD on chronological age and gender before measuring reading performances. The two groups did not differ for chronological age ($t_{(27)} = -.98$, $p = .40$, Cohen's $d = .35$; see Table 1B). Only for this control subgroup, additional data from the PPVT-R Peabody Test were also available (Dunn & Dunn, 1981; Italian version and norms by Stella, Pizzoli, & Tressoldi, 2000): mean performance of receptive vocabulary turned out to fall within expected limits for these children (see Table 1B).

Informed consent was obtained from all participants to the study.

2.2. Reading assessment

To assess decoding skills (*accuracy* and *speed*) we used tests requiring the reading of words and pseudo-words as well as meaningful texts, which are standardized for Italian children, thus providing norms for the critical ages of our children.

The *Word and Pseudo-word Reading* subtests from the Battery for the *Assessment of Developmental Reading and Spelling Disorders* (Sartori, Job, & Tressoldi, 1995) were administered following the standard procedure. These subtests assess speed and accuracy while reading a list of 112 words (four sets of 28 words varying for frequency and imageability) and a list of 48 pseudo-words (three sets of 16 pseudo-words). Errors and reading speed were scored. Reading speed was measured dividing the total number of words read by the total time spent for reading, expressed in seconds; reading accuracy was assessed by counting the number of words incorrectly decoded. Test–retest reliability coefficients are reported as .80 for speed and .71 for accuracy (Sartori et al., 1995). Since groups included children from different grades, individual raw data were converted into *z* scores based on normative data (Sartori et al., 1995). In all the cases, positive values indicate better performances (i.e., fewer errors and higher speed), whereas negative values are indicative of lower performances.

The *Text Reading* task from the *M.T. Reading Battery for Primary School* (Cornoldi & Colpo, 1998) was administered following the standard procedure. In this test, the child is required to read a text passage aloud within a 4-min time limit; reading speed (total number of syllables divided by the total time spent, expressed in seconds) and accuracy (number of errors, adjusted for the amount of text read) are scored. In scoring accuracy, errors, self-corrections, long pauses (above 5 s), and repetitions are given full (1 error) or partial (1/2 error) credit. Texts vary depending on the child's school grade. Test–retest reliability coefficients are reported as ranging from .75 to .87 for accuracy and from .94 to .97 for speed depending on grade level (Cornoldi & Colpo, 1998). Raw data were converted into *z*-scores based on normative data (Cornoldi & Colpo, 1998). In all cases, positive values indicate better performance, while negative values are indicative of lower performance.

In order to assess reading comprehension, the *Comprehension* task from the *M.T. Reading Battery for Primary School* (Cornoldi & Colpo, 1998) was used. The child is required to read a text silently and check it subsequently during the answering phase. There are 10 multiple-choice questions. The total number of correct responses is the measure of performance. Texts vary depending on the child's school grade. Test–retest reliability coefficients are reported between .70 and .75 depending on grade level (Cornoldi & Colpo, 1998). Raw data were converted into *z*-scores based on normative data (Cornoldi & Colpo, 1998), with positive values indicating better performance.

3. Results

3.1. Comparison between children with ASD/BIF and children with BIF

A MANOVA, with group (ASD/BIF vs. BIF) as between-subjects measure and reading measure (accuracy vs. speed) as repeated measure, was carried out on the standardized, age-adjusted scores from the Text reading subtest of the *M.T. Reading*

Table 2
Mean performance (and SDs) in the reading tasks for children with ASD/BIF and children with BIF. An asterisk marks the performance for the conditions which significantly deviate from normative values (i.e., mean = 0) with at least $p < .05$. Percentages of children with pathological performance (i.e., a score at least 1.65 SD below the means of the respective norms) are presented separately for each group.

		Children with ASD and BIF			Children with BIF		
		Mean	SD	Mean	SD	Mean	SD
Text reading	Accuracy	−.03	1.76	5.9	−1.31*	1.71	40.9
	Speed	−.57	1.18	17.6	−1.69*	.77	50.0
Word reading	Accuracy	−.40	1.83	11.8	−1.97*	2.06	45.5
	Speed	−.42	1.22	23.5	−1.65*	1.06	54.5
Pseudo-word reading	Accuracy	−.26	1.84	0	−1.66*	1.90	54.5
	Speed	.18	1.94	11.8	−.94*	.91	13.6
Text comprehension	Accuracy	−1.28*	.70	29.4	−1.41*	.94	45.5

* Significantly different from normative values (i.e., mean = 0) with at least $p < .05$.

Battery (Cornoldi & Colpo, 1998). Relevant means for this analysis are reported in Table 2. The group effect was significant [$F_{(1, 37)} = 11.62$, $p < .01$; partial eta$^2 = .24$], thus indicating better performances in children with ASD/BIF (−.39) than in children with BIF (−1.50). Neither the reading measure effect [Wilks $\lambda = .934$, $F_{(1, 37)} = 2.63$, $p = .11$; partial eta$^2 = .07$], nor the reading measure by group interaction [Wilks $\lambda = .998$, $F_{(1, 37)} = .81$, $p = .78$; partial eta$^2 = .002$] turned out to be significant.

A MANOVA, with group (ASD vs. BIF) as between-subjects measure and lexicality (words vs. pseudo-words) and reading measure (accuracy vs. speed) as repeated measures, was carried out on the standardized, age-adjusted scores from the *Word and Pseudo-word Reading* subtests (see relevant means in Table 2). The analysis indicated the main effect of lexicality [Wilks $\lambda = .807$, $F_{(1, 37)} = 8.82$, $p < .01$; partial eta$^2 = .19$], with lower performances for words (−1.11) than pseudo-words (−.67). Neither the reading measure effect [Wilks $\lambda = .956$, $F_{(1, 37)} = 1.68$, $p = .20$; partial eta$^2 = .04$], nor the lexicality by reading measure interaction [Wilks $\lambda = .934$, $F_{(1, 37)} = 2.60$, $p = .11$; partial eta$^2 = .07$] turned out to be significant. The group effect was significant [$F_{(1, 37)} = 10.96$, $p < .01$; partial eta$^2 = .23$], thus indicating better performances in children with ASD/BIF (−.22) than in children with BIF (−1.55). All interactions involving the group factor were far from significance.

Since performance was expressed as *z*-converted values with respect to established norms, it was also possible to compare performance in separate conditions with the norms by means of one-sample *t* tests (with 0 as the expected mean). All means of children with ASD/BIF did not significantly differ from norms (all $ps > .05$), unlike those of children with BIF, which significantly deviated from expected values (at least $p < .05$; see Table 2).

Table 2 also reports the proportion of children for each group showing a pathological performance, with −1.65 below the mean being the cut-off point (assuming a normal distribution, it marks a performance below which about 5% of cases are expected). Percentages of pathological performance were found to be generally low in children with ASD/BIF (ranging from 0 to 23.5% depending on the reading condition; median: 11.8%). By contrast, in about half of the cases, children with BIF were pathological across text and word conditions, except for speed in reading pseudo-words, where a decreased proportion was observed. However, analysis of individual data indicated large inter-individual variability in this subgroup of children. For example, 2 to 10 children showed a performance within half SD from the norms (or higher), depending on the reading condition used. This indicates that in 9.1% to 45.4% of cases performance was fully normal (median across conditions: 25.0%).

At the *Comprehension* task from the *M.T. Reading Battery for Primary School* (Cornoldi & Colpo, 1998), the two groups of children did not significantly differ from one another ($t_{(37)} = .48$, $p = .64$; Cohen's $d = .16$). However, they both significantly deviated from norms (at least $p < .05$; see Table 2). A pathological performance was present in 45.5% of children with BIF and in 29.4% of children with ASD/BIF.

3.2. Summary of results

Children with ASD/BIF showed generally spared decoding skills: their mean performance did not significantly deviate from the norms across reading tasks (text and word/pseudo word reading) and measures (accuracy and speed), and only a few instances of impaired performance were detected. These children also showed overall better performance than children matched on intellectual abilities, i.e., children with BIF without ASD. Notably, no selective effect was detected in terms of stimulus materials, i.e., children with BIF were similarly impaired in reading words and pseudo-words. Indeed, an unexpected trend for lower scores in words than pseudo-words reading was detected, but it was general and did not interact with group.

As a group, children with BIF were slower and less accurate readers, though considerable inter-individual variation was also present. Indeed, these children showed the full range of possible performance: namely, in about half of cases, performance was severely impaired, in a few was moderately deficient, and in about one fourth was fully within normal limits. As for text comprehension, both groups of children deviated from the norms and deficiencies were rather similar for the two groups.

Overall, at least in terms of a group trend, the profile of children with ASD/BIF was consistent with the diagnosis of hyperlexia, where decoding is slightly or not impaired at all, unlike reading comprehension. By contrast, reading performance impairments (deficient decoding and comprehension) were rather homogeneously distributed in the group of children with BIF.

Table 3
Mean performance (and SDs) in the reading tasks for children with ASD and cognitive performances within the normal range and for the typically developing children. An asterisk marks the performance for the conditions which significantly deviate from normative values (i.e., mean = 0) with at least $p < .05$. Percentages of children with pathological performance (i.e., a score at least 1.65 SD below the means of the respective norms) are presented separately for each group.

		Children with ASD			Typically developing children		
		Mean	SD	% pathol.	Mean	SD	% pathol.
Text reading	Accuracy	−.03	1.24	15.4	.73	.59	0
	Speed	−.06	.46	23.1	.41	.81	0
Word reading	Accuracy	−.46	1.83	23.1	.27	.64	0
	Speed	.4	2.1	0	1	1.01	0
Pseudo-word reading	Accuracy	−.15	1.26	7.7	.52	.6	0
	Speed	1.12	2.6	0	.78	.96	0
Text comprehension	Accuracy	−.69*	.92	15.4	0	.69	0

3.3. Comparison between children with ASD and typically developing children

A MANOVA, similar to that presented above, was carried out on the scores from the Text reading subtest from the *M.T. Reading Battery* (Cornoldi & Colpo, 1998). Relevant means for this analysis are reported in Table 3. The group effect was significant [$F_{(1, 37)} = 5.49$, $p < .05$; partial eta$^2 = .17$], thus indicating better performances in typically developing (.53) than in children with ASD (−.11). The reading measure effect showed only a slight trend [Wilks $\lambda = .879$, $F_{(1, 27)} = 3.70$, $p = .065$; partial eta$^2 = .12$] for higher values in accuracy (.36) than reading speed (.05). The reading measure by group interaction [Wilks $\lambda = .977$, $F_{(1, 37)} = .64$, $p = .54$; partial eta$^2 = .02$] was not significant.

The MANOVA on the scores from the *Word and Pseudo-word Reading* subtests indicated the main effect of lexicality [Wilks $\lambda = .775$, $F_{(1, 27)} = 7.83$, $p < .01$; partial eta$^2 = .22$], with lower performances for words (.27) than pseudo-words (.61). The reading measure effect was significant [Wilks $\lambda = .738$, $F_{(1, 27)} = 9.60$, $p < .01$; partial eta$^2 = .26$], thus indicating better performances in reading speed (.83) than accuracy (.05). The lexicality by reading measure interaction was not significant [Wilks $\lambda = .999$, $F_{(1, 27)} = .03$, $p = .87$; partial eta$^2 = .001$]. Neither the group effect [$F_{(1, 27)} = .84$, $p = .37$; partial eta$^2 = .03$] nor the totality of interactions involving the group factor turned out to be significant.

When performance in separate conditions was checked by means of one-sample *t* tests (with 0 as the expected mean), none of the means of both children with ASD and typically developing children significantly deviated from the norms (see Table 3).

Table 3 also reports the proportion of children for each group showing a pathological performance (cut-off: −1.65). Percentages of pathological performance were generally low among children with ASD (ranging from 0 to 23.1%; median: 11.5%). None of the typically developing children showed a pathological performance in any of the conditions.

On the *Comprehension* task from the *M.T. Reading Battery*, children with ASD scored significantly lower than typically developing children (.69; $t_{(27)} = -2.57$, $p = .01$; Cohen's $d = .86$), and their performance (−.69) significantly deviated from the norms ($p < .05$; see Table 3). A pathological performance was found in 15.4% of children with ASD and in none of the typically developing children.

3.4. Summary of results

Again, results indicate generally spared decoding skills in children with ASD and cognitive performance within normal limits: their mean performance did not significantly deviate from the norms across reading tasks and measures. Furthermore, only a small (although not zero) proportion of children showed impaired performance with respect to normative values. Their performance was comparable to that of age-matched typically developing children in word and pseudo-word reading. A small but reliable difference was observed for text reading with a somewhat lower performance for ASD than controls (with a difference of ca. .6 standard points).

Data on text comprehension indicated an impairment in children with ASD and cognitive performance within normal limits with regard to both the norms and the group of age-matched controls.

Once again, the profile of children with ASD turned out to be consistent with the diagnosis of hyperlexia, with largely spared (or minimally impaired) decoding and impaired reading comprehension.

4. Discussion

Results of this study indicate that the reading performance in children with ASD depends more upon the presence of the pathological condition and less upon the cognitive level per se. In fact, as a group, performance profiles were characterized by a dissociation between decoding (largely spared) and comprehending (deficient) a written text, both in the case of children with ASD and BIF, as well as in the case of children with ASD and cognitive performance within normal limits. Therefore, children with ASD can develop efficient decoding in spite of their limited expertise in linguistic skills. Indeed, some authors noted a compulsive interest in reading at the expense of other communication means (Elliot & Needleman, 1976; Huttenlocher & Huttenlocher, 1973; Mehegan & Dreifuss, 1972). This pattern is consistent with the idea proposed by some

authors that reading decoding represents an encapsulated module which is largely independent from other linguistic skills (e.g., Cossu, Rossini, & Marshall, 1993b).

Spared decoding along with deficient comprehension is referred to as hyperlexia (Silberberg & Silberberg, 1967). As stated in the introduction, several authors see this condition as being either a special talent or a selective disability in reading comprehension (Grigorenko et al., 2003). The dissociation between cognitive level and reading decoding observed here adds up information to this debate; in particular, spared decoding appears to be as a superability, to the extent in which it appreciably surpasses the general cognitive skills at least in children with ASD/BIF. The comparison with children with BIF showing no autistic signs is particularly informative here. The performance of this subgroup showed more consistent deficiencies across different domains, with deficits in reading decoding, reading comprehension, as well as verbal and non-verbal intellectual skills. This pattern is consistent with previous reports on these children (Conners, 2003). However, it should also be acknowledged that the performance of this group of children was highly variable, with several children performing within normal limits. The presence of exceptional children with intellectual disability but spared decoding ability has been reported (Cossu et al., 1993b), although it is still unclear which factors over and beyond intelligence can account for these individual differences.

These results, obtained in a language with a highly regular orthography like Italian, are generally consistent with previous reports on languages with a highly irregular orthography, such as English (Aaron, Frantz, & Manges, 1990; Perfetti, 1985; Stothard & Hulme, 1996; Minshew et al., 1994; O'Connor & Klein, 2004; Catts & Kamhi, 2005; Huemer & Mann, 2010). It may be added that there are a few recent case reports of children with hyperlexia reading Spanish (Talero-Gutierrez, 2006) and Swedish (Asberg & Miniscalco, 2014), two languages with relatively regular orthographies. Therefore, it seems that the sparing of decoding ability in children with ASD may occur independent from the orthographic depth of the language. In languages with less transparent orthographies, and in particular in English, some authors (Nation et al., 2006) emphasized the modulating role of phonological skills. In this study we examined performance in both words and pseudo-words reading, obtaining largely similar results. These findings indicate that children with ASD can effectively decode letters strings based on the application of grapheme-to-phoneme conversion (and presumably in the absence of lexical support). Therefore, there is no indication in the present data for the possible critical role of phonological skills in mediating reading in children with ASD as reported for English (Nation et al., 2006).

In spite of spared decoding skills, children with ASD show a selective deficit in reading comprehension, irrespective of the presence of BIF. This deficiency has important implications for their academic achievements and calls for active intervention. A recent meta-analysis (El Zein, Solis, Vaughn, & McCulley, 2014) indicates that cognitive and metacognitive interventions focusing on strategy instruction, student grouping practices, and explicit instruction appear to have a positive impact on the reading comprehension of students with ASD. These programs offer important cues to help educators in optimizing teaching to students with ASD.

This study has a number of limitations. In particular, to reliably place the performance of our children in relation to consolidated normative values, we opted for the use of standardized clinical instruments for the analysis of reading and focused on a group analysis of the performance of children with ASD. Since the presence of individual differences was rather evident, in future studies it seems important to use experimental measures that would allow more exhaustive descriptions of individual children's profiles (for a discussion on this issue, see Mervis & Klein-Tasman, 2004). Furthermore, because of time limitations, this study focused only on reading measures. While children were assessed with basic instruments testing autistic symptoms, it would certainly be useful to administer a comprehensive battery assessing their language functioning. In particular, this would enable the investigation of the relationship between children's reading comprehension deficits and language skills. In comparing groups with pathological performance, it is comparatively difficult to obtain perfectly matched groups. In particular, ASD/BIF and BIF subgroups did not differ on VIQ and PIQ, but a small difference was detected in the case of FIQ, with children with BIF scoring higher than children with ASD/BIF. However, as children with ASD/BIF performed better (not worse) in reading, it seems unlikely that this small IQ difference is responsible for the pattern of results obtained. Finally, due to time limitations, information on children with typical development was limited to their receptive vocabulary skills; in future investigations, a more comprehensive evaluation of the cognitive ability of the control group would certainly strengthen the value of the results.

5. Conclusion

Italian children with ASD (whether with or without BIF) showed essentially spared decoding skills in text, word and pseudo-word reading, and a selective impairment in reading comprehension, just like children with BIF but unlike typically developing children. Therefore, reading performance in children with ASD was related more to the presence of the pathological condition, and less to children's overall cognitive level. These results are generally consistent with a profile of hyperlexia for children with ASD learning a regular orthography, as previously reported for languages with a more irregular orthography.

Ethical approval

This study was approved by the Ethical Committee of the Research Institute "IRCCS Associazione Oasi Maria SS.", Troina (EN), Italy.

Conflict of interest statement

The authors declare they have no conflicts of interest to disclose.

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