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Pragmatic competence and its relationship with the linguistic and cognitive profile of young adults with dyslexia

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Abstract

The study assessed the pragmatic skills of 19 well-compensated Italian-speaking young adults with dyslexia compared with controls. A comprehensive pragmatic assessment tool was employed, targeting production as well as comprehension (APACS). Participants were also administered a series of standardized tests to assess verbal and non-verbal cognitive abilities, including executive functions and social cognition tests. Data were analysed with the aim of understanding whether pragmatic abilities are compromised in dyslexia, and of exploring associations between pragmatic performance and other cognitive domains. The performance of the dyslexia group was poorer than that of the control group in both expressive and receptive modalities. Data showed diffuse problems across several domains, with the greatest challenge posed by inferring non-literal meanings, which indicates that pragmatic inefficiency is an important aspect of the linguistic and communicative profile of dyslexia in adulthood. Explorative correlations highlighted a relation between pragmatic performance and reading and vocabulary abilities, as well as between pragmatics and working memory. This suggests that pragmatic difficulties are strongly tied to the most distinctive aspects of dyslexia, namely phonological awareness, verbal short-term memory, pseudo-word repetition, while the link with high-level executive functions and Theory of Mind is negligible.

Keywords

pragmatics; figurative language; inference; narratives

Practitioner Points

- Pragmatics, especially inferring non-literal meanings, is a vulnerable aspect of the linguistic profile of dyslexia in adulthood
- Pragmatic difficulties are strongly tied to reading comprehension and vocabulary knowledge
- The inclusion of pragmatic aspects could help refining diagnostic tools
- Interventions focusing on pragmatic skills of people with dyslexia may be as beneficial for inclusion as treatment of reading problems

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INTRODUCTION

Communication is a complex social activity relying on both linguistic skills and pragmatic competence. The latter is commonly regarded as the capacity of the interlocutors to perform appropriately for the context (Levinson, 1983; Sperber & Wilson, 1995). Proficient pragmatic processing involves the ability to efficiently carry out many different linguistic and cognitive tasks. These include encoding the message for the function it must perform, correctly identifying such function in a given context, choosing the appropriate register for the communicative situation, as well as drawing inferences to recover non-literal and implicitly communicated information (Ariel, 2010; Bambini, 2010; Stemmer, 2000). The rapid integration of much and varied linguistic and extra-linguistic contextual information imposes complex processing demands which are taxing on the individual's attention, memory, mind-reading, and inferential abilities (Bara, 2010; Sperber & Wilson, 2002).

The complex interplay of the linguistic and cognitive resources necessary for a pragmatically successful behaviour is especially relevant for the comprehension of non-literal language, including figurative expressions such as metaphors and irony, which is supported by several cognitive and neural systems (Bambini, Gentili, Ricciardi, Bertinetto, & Pietrini, 2011; Spotorno, Koun, Prado, Van Der Henst, & Noveck, 2012). Non-literal meaning comprehension is proved to be a challenge for non-typically-developing children, as well as for neurological and psychiatric patients (Kalandadze, Norbury, Nærland, & Næss, 2016; Thoma & Daum, 2006). Across populations, difficulties with non-literal meanings and figurative language are often associated with impairment in executive functions and with poor performance in Theory of Mind tests,

which assess the ability to attribute attitudes and mental states (including communicative intentions) and to predict the behaviour of others (Bambini *et al.*, 2016a; Bambini *et al*., 2016b; Bosco, Parola, Sacco, Zettin, & Angeleri, 2017; Martin & McDonald, 2003; Wampers, Schrauwen, De Hert, Gielen, & Schaeken, 2017).

To the best of our knowledge, only a few studies have discussed the impact of dyslexia on pragmatic competence (Cardillo, Basso Garcia, Mammarella, & Cornoldi, 2017; Griffiths, 2007; Lam & Ho, 2014). Dyslexia is primarily described as a specific learning disability caused by a deficit in the phonological component of language, which results in an unexpected discrepancy between cognitive abilities and literacy skills. Among its secondary consequences, the International Dyslexia Association includes "problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge." Over the past two decades, other difficulties have been observed in children and adults with dyslexia including poor executive functioning (Baker & Ireland, 2007), issues in working memory capacity (Baddeley, 1998; Gathercole, Willis, Emslie, & Baddeley, 1992), processing speed and skill automatization (Nicolson & Fawcett, 2008), vocabulary storage and retrieval (Cappelli & Noccetti, 2016; Kormos & Smith, 2012), text comprehension (Ransby & Swanson, 2003; Simmons & Singleton, 2000), and in the control of attentive resources (Lallier *et al.*, 2009), including orienting spatial and temporal attention (Facoetti *et al*., 2010; Ruffino, Gori, Boccardi, Molteni, & Facoetti, 2014). Some studies also report social and emotional problems in people with dyslexia, including distress with managing everyday life tasks (Griffiths, 2007; Miles, Gilroy, & Du Pre, 2007), and problems in maintaining social interaction because of frequent misunderstanding of implicit statements or misreading of social events (Chinn & Crossman, 1995; Hales, 1995). Most of these issues have been

associated with pragmatic difficulties in autism spectrum disorder and clinical populations such as traumatic brain injury and schizophrenia (Bosco, Bono, & Bara, 2012; Martin & McDonald, 2003; Vulchanova, Saldaña, Chahboun, & Vulchanov, 2015). However, pragmatic abilities in dyslexia have remained nearly unexplored.

Two recent studies (Lam & Ho, 2014; Cardillo *et al.*, 2017) have focused on pragmatic abilities in children with dyslexia. Both have concluded that the latter have reduced pragmatic skills compared with their typically-developing peers. Specifically, Cardillo *et al.* (2017) found that children with dyslexia performed worse than the control group in several pragmatic tasks from the APL Medea battery (Lorusso, 2009), as well as in verbal Theory of Mind tasks. Moreover, the authors performed a discriminant function analysis to distinguish between children with dyslexia, children with non-verbal learning disabilities, and typically developing children. Results indicated that two tasks, i.e., the pictorial metaphor comprehension task from the APL and the verbal Theory of Mind task, were able to predict which group each child belonged, with a 52% accuracy in case of dyslexia, which confirms that pragmatics and Theory of Mind might be crucial in identifying children with dyslexia. Accuracy was 81% for typically developing children and 38% for children with non-verbal learning disabilities, indicating a less crucial pragmatic difficulties in the latter population. The authors hypothesized that children with dyslexia do not have the ability to suppress literal meaning and create a coherent representation of the intended metaphorical meaning. Such abilities mature with age and develop across the lifespan (Matthews, 2014). Consequently, assessing whether the pragmatic difficulties observed in children with dyslexia persist into adulthood seems especially interesting.

Griffiths (2007) is the first and only study on pragmatic skills in young adults with dyslexia. Her article compares the results of 20 English-speaking university students with dyslexia and of 20 non-dyslexic peers on subtests from Fawcett & Nicolson's (1998) Dyslexia Adult Screening Test (DAST) and on four adapted subtests from Bryan's (1995) Right Hemisphere Language Battery (RHLB) assessing pragmatics in comprehension. Results evidenced marked difficulties in understanding humour and deriving inferential information from a storyline, and also problems in figurative language. Griffiths (2007) also showed deficits in the Phonemic Segmentation, Rapid Naming and Backward Digit Span subtests of the DAST, indicative of reduced processing speed, working memory inefficiency, and deficit in automatization. The author hypothesized that these difficulties might produce cognitive overload that would in turn result in the inefficient processing of non-literal language. Consistently, the DAST data correlated with the RHLB scores.

The aim of this study was to assess the pragmatic skills of well-compensated Italian-speaking young adults with dyslexia compared with controls, given that only one pilot study on the topic is available and limited to comprehension abilities. To this purpose, we employed a comprehensive pragmatic assessment tool, targeting production as well (APACS, Arcara & Bambini, 2016). As in Griffiths (2007), participants were also administered a series of standardized tests to assess verbal and non-verbal cognitive abilities. Based on other evidence from children with dyslexia (Cardillo *et al.*, 2017) and other pathological conditions (Bambini *et al.*, 2016a; Bosco *et al.*, 2017), assessment included executive functions and social cognition tests. Data were analysed with the aim of (a) understanding whether pragmatic competence is compromised in dyslexia, and (b) exploring associations between pragmatic performance and other cognitive domains. For (a), we expected to confirm Griffiths's results; for (b) we expected to observe a relation

between pragmatic difficulties and a deficit in verbal and working memory abilities (as in Griffiths, 2007), while for other cognitive domains literature is too scant to derive clear hypotheses.

METHODS

Participants

All participants were selected among students at the University of Pisa and were native speakers of Italian. The final sample included 19 young adults (13 F) who had been diagnosed with dyslexia by experienced clinicians within the previous three years and were registered with the University Specific Learning Differences Unit, and 19 controls (14 F). The dyslexia group had a mean age of 21 years (SD 1.08; range 19-25) and a mean education of 13.95 years (SD 1.08; range 13-16), whereas the control group had a mean age of 21.58 (SD 1.61; range 19-25) and a mean education of 13.84 years (SD 0.76; range 13-15). Age and education were not significantly different between the two groups when compared through t-tests (Age $t(36)=-1.1$, $p=0.30$; Education $t(36)=0.35$, $p=0.73$). Gender was not significantly different in the distribution across the two groups when compared with a Chi-square test ($\chi^2(1)=0$, $p=1$, with Yates' continuity correction). To exclude any possible difficulty due to the participants' language background, bilingualism was considered an exclusion criterion. Other exclusion criteria were major neurological or psychiatric history and the regular consumption of medications for chronic conditions. None of the participants had visual or hearing impairments. The study was approved by the local Ethics Committee. Informed Consent was obtained from all participants.

Assessment

All participants were tested individually by trained clinicians or research assistants at 5 single sessions of 60 minutes each. Scores were assigned by the members of the research group individually. The most problematic cases were discussed collectively.

For pragmatics, we used the Assessment of Pragmatic Abilities and Cognitive Substrates (APACS). This is a recently developed and standardized battery for assessing pragmatics in adult Italian-speaking populations (Arcara & Bambini, 2016), already used with neurological (Bambini *et al.*, 2016a; Carotenuto *et al.*, 2017) and psychiatric patients (Bambini *et al.*, 2016b). APACS includes a production section, with a semi-structured interview about autobiographical topics (Interview) and a photograph description task (Description), as well as a comprehension section, encompassing a task in which participants are asked to answer questions about narrative texts (Narratives), two multiple-choice tasks assessing the ability to infer non-literal meanings (Figurative Language 1) and verbal humour (Humour), and a task assessing the ability to understand non-literal meanings through verbal explanation of familiar idioms, novel metaphors and common proverbs (Figurative Language 2). Three composite scores are derived from the 6 tasks: Pragmatic Production, Pragmatic Comprehension, and APACS Total. In addition, in order to replicate Griffiths's (2007) study as closely as possible, pragmatic comprehension was also assessed with 5 subtests from the "Batteria sul Linguaggio dell'Emisfero Destro SantaLucia" (BLED; Rinaldi, Marangolo, Lauriola, 2006). The battery was specifically developed for Italian and follows the model of the Right Hemisphere Language Battery (Bryan, 1995) used in the aforementioned study. The

subtests included were Picture Metaphors, Written Metaphors, Inference, Requests, and Humor (as in Griffith, with the addition of the Requests subtest).

Instrumental reading was assessed for speed and accuracy with an oral reading fluency task (ORF - "Le origini della tecnologia") and word (WR) and pseudo-word reading (PWR) task from Cornoldi, Pra Baldi, & Friso (2010) MT avanzate-2 battery. Reading comprehension (RC) was investigated through two silent reading comprehension tasks from the same battery (narrative and instrumental texts).

Participants' verbal abilities were assessed using tests for phonological and semantic fluency (PF and SF; Novelli *et al.*, 1986), and the Italian adaptations of the Information and Vocabulary subtests of the WAIS-IV battery (INF and VOC; Orsini & Pezzuti, 2013), of the Test of Reception of Grammar (TROG-2; Suraniti, Ferri, & Neri, 2009), and of the Peabody Picture Vocabulary Test – Revised (PPVT-R; Stella, Pizzioli, & Tressoldi, 2000).

Working memory and phonological processing skills were tested through the Digit Span subtest of the WAIS-IV battery (digit span forward, backward and sequencing - DigSpF, DigSpB, DigSpS), the spoonerisms test (SP) from Marotta, Ronchetti, Trasciani, & Vicari (2008) Metaphonological Competence Assessment battery (CFM), and the pseudo-word repetition task from Bertelli & Bilancia's (2006) VAUMeLF (PsWRep).

Non-verbal reasoning, flexibility, and executive functions were investigated using the Matrix Reasoning subtest of the WAIS-IV battery (MAT) and the Wisconsin Card Sorting Test (WCST). To assess mental states attribution skills, we selected a non-verbal task (to avoid overlap between Theory of Mind and verbal pragmatic aspects), namely Dodich *et al.*'s (2015) Story-based Empathy Task (SET), measuring attribution of

intentions and emotional states through cartoons, already used in conjunction with APACS (Carotenuto *et al.*, 2017).

Data analysis

The performance of individuals with dyslexia and matched controls in APACS was compared through a series of separate t-tests. All p-values associated with these t-tests were corrected according to the False Discovery Rate method (Benjamini & Hochberg, 1995). The same analysis was adopted for performance in the BLED test.

To estimate the frequency of pragmatic impairment in pragmatic abilities, we calculated the percentage of individuals with a performance below cut-off in the APACS Total score.

In an exploratory analysis restricted to the dyslexia group, the relationship between APACS tasks and composite scores and other neuropsychological tests was assessed by means of Pearson correlations, using uncorrected p-values.

RESULTS

On average, people with dyslexia showed a worse performance as compared with controls in all APACS tasks and composite scores (all ps<0.05 after FDR correction). Among the APACS tasks, the largest effect sizes were found in Figurative Language 2, Figurative Language 1, and Interview tasks. Table 1 reports detailed statics, along with the scores in each APACS task obtained by the two groups. Higher scores indicate a better pragmatic performance.

---Table 1---

---Figure 1---

When tested with the BLED, people with dyslexia performed significantly worse in the Metaphors-picture task and in Humor (ps<0.05). A trend to significance was observed in the Metaphors-written and Inferences tasks. Table 2 reports detailed statics, along with the scores in each BLED subtest obtained by the two groups. Higher scores indicate a better pragmatic performance.

---Table 2---

In the dyslexia group, 7 out of 19 participants (36%) had a performance below cut-off in the APACS Total score. None of the participants in the control group had a performance below cut-off in APACS Total score. Among the different tasks, Figurative Language 2 was the one where most often individuals with dyslexia performed below cut-off (16 out of 19 participants; 84%). The performance below and above cut-off in the APACS tasks and composite scores is represented in Fig. 2.

---Figure 2---

The exploratory analysis of correlations showed significant correlations between APACS scores and reading, vocabulary, and working memory tests, but not with the tests tapping on Theory of Mind abilities (i.e., SET), or with prominent role of executive function (i.e.,

Verbal Fluency and Wisconsin Card Sorting Test). See Tab. 3 for details on the correlations.

---Table 3---

DISCUSSION

This study aimed at assessing pragmatic abilities in adults with dyslexia, to confirm observations coming from an isolated pilot study on this population (Griffiths, 2007). Moreover, we aimed at exploring associations between pragmatic abilities and other domains that are known to be impaired in dyslexia (i.e., verbal abilities and working memory) or associated with pragmatics in patients (i.e., executive functions and Theory of Mind).

The first finding is the poorer performance of the dyslexia group compared with the control group in all pragmatic tasks in the APACS test. Our data confirm Griffiths's findings (2007) in showing difficulties in understanding the pragmatic aspects of language. In addition, by using a more comprehensive pragmatic assessment tool, we showed that difficulties also affect production, resulting in impaired conversational exchanges. A closer look at the results of each APACS task helps sketching a more detailed profile of pragmatic competence in adults with dyslexia. Understanding figurative language (metaphors, idioms, and proverbs) seems the main challenge for these individuals, especially when assessed through an explanation task requiring to verbalize abstract and general meanings of non-literal expression (Figurative Language 2 task), but

also when assessed through multiple choice (Figurative Language 1). Interestingly, Cardillo *et al.* (2017) found that metaphor comprehension is the most compromised pragmatic aspects in children with dyslexia: our findings suggest that these difficulties might persist into adulthood. Problems extend to understanding jokes (Humor task), and to infer different aspects of a narrative text (Narratives task), confirming previous evidence (see Simmons & Singleton, 2000 and Griffith, 2007). Difficulties might surface also in conversation as assessed in the Interview task (although the ceiling effect in the control group might affect the effect size), with fewer problems in sharing relevant information in the Description task. However, a qualitative exploration of the errors in the production tasks evidenced problems at the lexical and grammatical level, rather than more genuine pragmatic difficulties. In sum, the pragmatic profile of adults with dyslexia shows compromised competence across both expressive and receptive modalities, with the greatest challenges posed by inferring meanings from figurative expressions and from texts.

The presence of pragmatic difficulties is confirmed by the performance in the BLED, where significant differences between individuals with dyslexia and controls were reported for metaphor and humor comprehension. However, the BLED battery seems less sensitive to capture the whole range of pragmatic problems in this population, presumably because it was created for right hemisphere brain-damaged patients.

From the point of view of the frequency of the pragmatic impairment, 36% of subjects in our dyslexia group seemed to have a deficit compared with normative data in the APACS Total score. Remarkably, 84% of individuals with dyslexia performed below cutoff in the Figurative Language 2 task. Although this estimation is based on a small sample, it is

indicative of a diffuse impairment, and it suggests that pragmatic inefficiency is an important aspect of the linguistic and communicative profile of dyslexia in adulthood.

The explorative correlations highlighted a relation between the pragmatic performance and reading and vocabulary abilities, as well as between pragmatics and working memory as assessed in the Digit Span tests. By contrast, we did not observe significant correlations with the domains of executive functions assessed in verbal fluency, Matrix Reasoning, and Wisconsin Card Sorting task, and with Theory of Mind (SET task). Although exploratory, these correlations seem to suggest that pragmatic difficulties are strongly tied to the most distinctive aspects of dyslexia, namely phonological awareness, verbal short-term memory, pseudo-word repetition, while the link with high-level executive functions and Theory of Mind is negligible. Along with Griffiths (2007), who also reported correlations between pragmatic skills and naming, phonetic and working memory scores, one might hypothesize that reduced abilities in automatized language processing might cause overload and result in misunderstanding and difficulties at the pragmatic level. The relation to vocabulary tasks is also interesting, as reported also for pragmatic difficulties in other neurodevelopmental conditions such as Autism Spectrum Disorder (Kalandadze *et al.*, 2016; Vulchanova *et al.*, 2015).

By contrast, the pragmatic performance of adults with dyslexia does not seem to be linked to non-verbal reasoning, flexibility, or mind-reading skills. Cardillo *et al.* (2017) reported the crucial role of both metaphor comprehension and verbal Theory of Mind skills in discriminating among children dyslexia vs typical development vs other learning disabilities (Cardillo *et al.*, 2017). The tie between metaphor (and pragmatics in general) and Theory of Mind was not observed here, since the performance in the SET task was not associated with any APACS score. A possible explanation for this discrepancy might

be that the link between pragmatics and Theory of Mind is stronger in development, while in adulthood the two domains are to some extent independent from one another. Our findings also point to a pattern that differs from adult clinical populations, such as for instance multiple sclerosis, traumatic brain injury, and schizophrenia, where the relationship between deficits in pragmatics, Theory of Mind, and executive functions is much stronger (Bambini *et al.*, 2016b; Bosco *et al.*, 2017; Carotenuto *et al.*, 2017; Parola, Berardinelli, & Bosco, 2018). This might be due to specific aspects differentiating dyslexia from schizophrenia and other clinical populations, as well as to differences in age and education, since our sample included university students. In conclusion, the pattern emerging from correlations suggests that pragmatic difficulties in adults with dyslexia might be a consequence of difficulties in processing language and information at a basic level, i.e., of the core aspects of this disorder. Problems in reading and accessing words, as well as in maintaining information in the memory buffer, might affect the ability to integrate linguistic and contextual information, to infer non-literal meanings, and to engage in context-appropriate conversation.

The main limitation of this study is the small sample of participants, motivated here by the difficulty of recruiting students with dyslexia given their limited access to University education. Although the sample size is comparable to previous literature, a larger sample is needed, especially for a more reliable estimation of the frequency of the pragmatic deficit in this population. We thus take the current findings as preliminary with respect to a larger-scale assessment aiming at identifying the major communicative problems in university students with dyslexia, which would provide further insight into the factors potentially contributing to academic success and ultimately social integration for these

learners (MacCullagh, Bosanquet, & Badcock, 2017). The results might, moreover, help design increasingly effective teaching aids, materials and strategies.

Another limitation is the exploratory nature of the correlations. Although the pattern seems to consistently point to the relationship of pragmatics with reading, vocabulary and working memory skills, but not with higher executive and mind-reading aspects, the large number of tests employed, as well as the non-causal information they provide, does not allow to derive strong conclusions. Once data from a bigger sample of participants are collected, more stringent information on the relationship between variables could be gained through regression analyses, as done in previous studies on pragmatic abilities in clinical populations (Bambini *et al*., 2016a; Bambini *et al*., 2016b; Parola *et al*., 2018).

Moreover, with regard to Theory of Mind, future studies should further explore its relation to pragmatics in dyslexia by using other tests, as only one (SET) was used here, which – although it proved to be related to pragmatic skills (Carotenuto *et al.*, 2017) – is less known in the literature compared to tests such as False Belief or Strange Stories. In future studies we will use the evidence collected here for more hypothesis-driven analysis of the relationship between different domains and the neurocognitive substrates of pragmatic difficulties in dyslexia, and its specificity compared to other populations.

Overall, our study contributes by shedding light on an underestimated problem in dyslexia, namely communicative effectiveness and pragmatic competence. Difficulties seem especially pronounced in tasks requiring inferences on figurative language. Applied to clinical settings, our findings might be of relevance for diagnostic procedures. Previous studies showed the discriminatory power of a metaphor test for children with dyslexia (Cardillo *et al*., 2017). We thus believe that figurative language might be a suitable test-ground for assessing pragmatic competence in dyslexia, and that it might complement

assessment tools for reading comprehension and other language-related aspects. This might be of special importance in the assessment of well-compensated adults with dyslexia, who have overcome the other major difficulties associated with their condition (e.g., impaired reading speed and accuracy) but might retain pragmatic difficulties. Another implication of our work concerns intervention. Inference plays a central role in text comprehension and thus in learning (Cain, Barnes, Bryant, & Oakhill, 2001; Simmons & Singleton, 2000). The ability to infer the meaning of figurative language specifically predicts employment (Adamczyk *et al*., 2016), and, more generally, pragmatic competence correlates with social integration (Galski, Tompkins, & Johnston, 1998) and quality of life at large (Bambini *et al.*, 2016b). Extending treatment to include interventions focusing on the pragmatic skills of individuals with dyslexia should, thus, be of primary interest to promote successful access to all levels of education and inclusion across their lifespan. Recently, a number of training programs to promote pragmatic abilities and figurative language have been developed (Gabbatore *et al.*, 2015; Melogno, Pinto, & Di Filippo, 2017), and we believe that, with proper adjustments, they could be beneficial also for individuals with dyslexia.

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Table 1. Comparisons between adults with dyslexia and controls in APACS

APACS tasks and composite scores	t-value	Cohen's d	p-value	Mean Adults with dyslexia (SD)	Mean Controls (SD)
Interview (max score 44)	-3.1	-1	0.0051	43.11 (1.24)	44 (0.00)
Description (max score 48)	-2.5	-0.81	0.019	46.58 (1.8)	47.68 (0.67)
Narratives (max score 56)	-2.9	-0.93	0.0087	48.74 (3.6)	51.79 (2.92)
Figurative Language 1 (max score 15)	-3.2	-1	0.005	14.21 (0.98)	14.95 (0.23)
Humor (max score 7)	-2.3	-0.74	0.03	6.37 (0.83)	6.84 (0.37)
Figurative Language 2 (max score 30)	-5.5	-1.8	<0.001	21.26 (3.12)	26.32 (2.54)
Pragmatic Production (range 0-1)	-4.3	-1.4	0.00031	0.98 (0.02)	1 (0.01)
Pragmatic Comprehension (range 0-1)	-5.1	-1.7	<0.0001	0.86 (0.07)	0.94 (0.03)
APACS Total (range 0-1)	-5.3	-1.7	<0.0001	0.92 (0.04)	0.97 (0.02)

Note. The table reports the results of the comparison between the performance of individuals with dyslexia and controls in the APACS tasks and composite scores. From the left, columns indicate the APACS tasks and composite scores, the t-values (in all t-values the degrees of freedom were 36), the p-values (corrected with FDR method), the mean score for individuals with dyslexia (Standard Deviation enclosed in parentheses), and the mean score for controls (Standard Deviation enclosed in parentheses). Scoring is assigned as follows: for Interview: the frequency of a series of communication difficulties is annotated (always/sometimes/never) and converted into scores (0/1/2); for Description, for each element in each picture, missed, partial, and correct identification are scored 0/1/2; Narratives includes yes/no questions on the story content and questions on figurative expressions (scored 0/1 and 0/1/2, respectively); for Figurative Language 1, multiple-choice answers are scored 0/1; for Humor, multiple-choice answers are scored 0/1; for Figurative Language 2, wrong, partial, and correct explanations are scored 0/1/2, respectively. Pragmatic Production is derived from Interview and Description, by averaging and transforming the scores in proportions; Pragmatic Comprehension is derived from Narratives, Figurative Language 1, Humor, and Figurative Language 2, by averaging and transforming the scores in proportions; APACS Total is the mean of Pragmatic Production and Pragmatic Comprehension.

Table 2. Comparisons between adults with dyslexia and controls in BLED

BLED subtest	t-value	Cohen's d	p-value	Mean Adults with dyslexia (SD)	Mean Controls (SD)
Picture Metaphor (max score 10)	-4.2	-1.4	0.0006	9 (0.88)	9.89 (0.32)
Written Metaphor (max score 10)	-2.2	-0.71	0.057	9.58 (0.69)	9.95 (0.23)
Inference (max score 10)	-1.9	-0.61	0.085	7.87 (1.31)	8.53 (0.77)
Request (max score 10)	0	0	1	9.95 (0.23)	9.95 (0.23)
Humor (max score 10)	-4.1	-1.3	0.0006	8.89 (1.1)	9.95 (0.23)

Note. The table reports the results of the comparison between the performance of individuals with dyslexia and controls in the BLED subtests. From the left, columns indicate the BLED subtests, the t-values (in all t-values the degrees of freedom were 36), the p-values (corrected with FDR method), the mean score for individuals with dyslexia (Standard Deviation enclosed in parentheses), and the mean score for controls (Standard Deviation enclosed in parentheses). For each of the 5 BLED subtest, multiple-choiche answers are scored as wrong or correct (0/1).

Table 3. Correlations between APACS and other tests in the dyslexia group

The table reports the correlations between each APACS score (task and composite scores) and the other tests administered to participants with dyslexia. These include: oral reading fluency task (ORF), word (WR) and pseudo-word reading task (PWR), reading comprehension (RC), phonological fluency (PF), semantic fluency (SF), information subtest (INFO) and vocabulary subtest (VOC), Test of Reception of Grammar (TROG-2), Peabody Picture Vocabulary Test-Revised (PPVT-R), digit span forward (DigSpF), backward (DigitSpB), and sequencing (DigSpS), spoonerism test (SP), pseudo-word repetition task (PsWRep), s Reasoning subtest (MAT), Wisconsin Card Sorting Test (WCST), and Story-based Empathy Task (SET). Given the exploratory nature of this analysis, p-values were not corrected. Asterisks (*) denote p-values below 0.05. The degrees of freedom for the correlations were 19, except for 8 tests (WR, PWR, VOC, INFO, DigitSpF, DigitSpB, DigitSpS, and SP), in which the df were 18.

APACS tasks and composite scores	ORF	WR	PWR	RC	PF	SF	INFO	VOC	TROG-2	PPVT.R	DigSpF	DigSpB	DigSpS	SP	PsWRep	MAT	WCST	SET
Interview	0.1	0.11	0.06	0.16	0.31	0.23	0.13	0.33	0.5*	0.37	0.23	0.51*	0.5*	-0.22	0.17	-0.17	-0.25	0
Description	0.22	0.28	0.12	-0.01	0.16	0.24	0.53*	0.38	-0.02	0.14	0.24	0.11	0.06	0.09	0.4	0	0.05	0.02
Narratives	0.47*	0.32	0.25	0.35	0.33	0.2	0.36	0.64*	0.4	0.59*	0.09	0.17	0.32	-0.01	0.29	0.03	0.17	-0.23
Figurative Language 1	0.09	0.24	0.05	-0.01	0.32	0.18	0.29	0.09	0.5*	0.31	0.41	0.14	0.14	-0.27	0.48*	0.37	-0.25	0.34
Humor	0.38	0.51*	0.11	0.38	0.22	0.07	0.43	0.31	0.41	0.52*	0.14	0.44	0.53*	-0.43	0.25	0.05	-0.13	0.22
Figurative Language 2	0.6*	0.46	0.14	0.46*	0.11	0.33	0.57*	0.5*	0.13	0.57*	-0.05	0.39	0.52*	-0.41	0.14	-0.16	0.29	-0.39
Pragmatic Production	0.26	0.32	0.14	0.1	0.35	0.37	0.58*	0.57*	0.32	0.37	0.38	0.45	0.4	-0.07	0.47*	-0.11	-0.12	0.02
Pragmatic Comprehension	0.53*	0.52*	0.17	0.43	0.3	0.25	0.58*	0.51*	0.45	0.67*	0.17	0.42	0.55*	-0.42	0.35	0.06	0.03	-0.03
APACS Total	0.5*	0.5*	0.17	0.37	0.33	0.3	0.62*	0.56*	0.44	0.63*	0.23	0.46	0.55*	-0.36	0.4	0.02	0	-0.02

Figures' caption

Figure 1. Performance of adults with dyslexia and controls in APACS tasks and composite scores.

The figure shows the performance of people with dyslexia and control in the pragmatic tasks and in the three composite scores, i.e., Pragmatic Production, Pragmatic Comprehension and APACS Total. Raw scores in the pragmatic tasks were transformed to proportions (relative to the maximum obtainable score) before plotting. Gray bars indicate the mean performance of individuals with dyslexia, whereas white bars indicate the mean performance of controls. Error bars denote standard errors.

Figure 2. **Performance below cut-off in APACS**.

The figure shows the participants with performance below cut-off (as based on the normative data in Arcara & Bambini, 2016) in the APACS tasks and in the three composite scores. Each row denotes a participant. The first 19 rows (from top) report the performance of individuals with dyslexia, while the remaining 19 rows report the performance of controls. Each column denotes a task or composite score. White cells indicate a performance equal to or above cut-off, whereas colored cells indicate a performance below cut-off. Light blue cells are used in the columns with the APACS tasks included in the Pragmatic Production score, and dark blue cells are used in the column of the Pragmatic Production score. Light orange cells are used in the columns of the APACS tasks included in the Pragmatic Comprehension score, and dark orange cells are used in the column of the Pragmatic Comprehension score. Dark gray is used for APACS Total.