CeRIP
University of Messina

ISSN 2612-4033

Journal of Clinical & Developmental Psychology

Journal homepage: https://riviste.unime.it/index.php/JCDP/index

Evaluation of the Effect of Bionic Reading® on Reading Skills in Individuals With Specific Learning Disabilities and neurotypical control: A Pilot Study

Vascelli L.,[1]*, Cavallini C.A.,[12], Pelizzoni I.,[1], Fazzolari D.,[12], Ferrari S., [1] Villani E.,[1] Andolfi S., [1] Iacomini S., [1]

[1] Tice Cooperativa Sociale, Piacenza, Italy
[2] Department of Psychology, University of Magna Graecia, Catanzaro, Italy

ABSTRACT

Background: Specific Learning Disorders (SLD) often interfere with the acquisition of fluent reading skills, requiring adaptive strategies to support reading performance. Bionic Reading® is a digital tool that enhances textual readability by bolding the initial segments of words to guide visual attention. This pilot study explores its impact on reading performance in preadolescents and adolescents, particularly those with SLD.
Methods: Twenty-six participants (20 with SLD and 6 without) read age-appropriate narrative passages under two conditions: standard text and Bionic Reading® format. The number of correctly and incorrectly read letters per minute was recorded. No participant had prior exposure to the tool, and no standardized phonological or reading assessments were administered.
Results: Participants with SLD showed a significant increase in correctly read letters when using Bionic Reading®, though error reduction was not statistically significant. In contrast, neurotypical participants did not exhibit improvements and showed slightly decreased accuracy across conditions.
Conclusions: The findings suggest that Bionic Reading® may enhance decoding accuracy in students with learning disabilities, particularly those with SLD. However, the study's interpretability is limited by several methodological constraints, including the small sample size, age heterogeneity, and the absence of standardized measures of reading ability. Future studies should adopt controlled designs to verify these preliminary outcomes.

Keywords: Bionic Reading®; Specific Learning Disorder; reading performance; educational tools; dyslexia; learning disabilities

* *Corresponding author*: Luca Vascelli, Tice Cooperativa Sociale, Piacenza, Italy
E-mail address: Luca.vascelli@centrotice.it

https://doi.org/10.13129/2612-4033/0110-5056

Introduction

Reading is a complex cognitive process that involves the integration of several foundational skills, including the visual perception of graphemes, auditory processing of linguistic sounds, and the automation of grapheme-phoneme correspondences (Stella, 2004). Learning to read requires children to develop explicit awareness of phonological structures and to associate phonemes and syllables with arbitrary visual symbols, such as graphemes and morphemes (Mather & Wendling, 2011). Understanding the cognitive mechanisms involved in reading is particularly important when considering populations in which neurodevelopmental conditions disrupt these processes.

Neurodevelopmental disorders are a group of early-onset conditions characterized by impairments in cognitive, linguistic, motor, or social functioning that interfere with personal, academic, or occupational performance. These include disorders such as Autism Spectrum Disorder (ASD), Attention-Deficit/Hyperactivity Disorder (ADHD), and Specific Learning Disorders (SLDs) (American Psychiatric Association, 2013). The ability to read fluently is critical for academic success and broader social participation (Horn et al., 2023). However, many children with neurodevelopmental disorders, including those with Specific Learning Disorder (SLD), struggle to develop adequate reading skills. These difficulties, which persist throughout development, negatively affect academic, emotional, and behavioral domains (Conti-Ramsden et al., 2018). Among students with dyslexia, specific impairments in phonological awareness hinder the accurate segmentation and manipulation of phonemes (van Rijthoven et al., 2022; Goswami, 2000), often resulting in slow, effortful, and error-prone reading (Lyon et al., 2003; Conrad, 2008).

Structured and evidence-based interventions for children with reading difficulties typically include systematic phonics instruction and training in word recognition, fluency, and comprehension (Fletcher et al., 2019; Spear-Swerling, 2019). In parallel, recent technological developments have led to the creation of various assistive digital tools designed to support students with reading disorders. These include text-to-speech applications, customizable fonts (e.g., OpenDyslexic), speech recognition programs, interactive e-books, and mobile apps offering multimodal reinforcement (Reid et al., 2013; Madeira et al., 2015; Rauschenberger et al., 2019). These tools can enhance motivation, autonomy, and self-confidence in students with learning challenges (Novembli & Azizah, 2019).

However, technology alone does not solve all the challenges associated with reading difficulties. Research has shown that typographic variables—such as font size, line spacing, and word length—can significantly impact readability in individuals with dyslexia (Rello & Baeza-Yates, 2013; Bachmann & Mengheri, 2018). One explanation for this is the crowding effect, a perceptual phenomenon whereby closely spaced letters hinder visual recognition, thereby reducing reading fluency (Rello et al., 2012).

A recently developed tool designed to address these challenges is Bionic Reading. This digital text-formatting method emphasizes the first part of each word through bolding, creating fixation anchors to guide the reader's gaze across lines of text. Perceptual and cognitive theories suggest that efficient eye movements enhance reading speed without compromising comprehension, and this approach builds upon those principles (Hooper et al., 2023). The tool also allows for manual adjustments of spacing, fonts, and bold intensity, enabling individualized formatting to meet the diverse needs of readers.

While Bionic Reading® has shown potential in improving self-efficacy and motivation in students with disabilities (Budomo et al., 2023), its actual impact on reading performance—particularly in students with SLD—has not yet been validated through experimental studies (Mangas Alfonso, 2022). Moreover, researchers have yet to determine whether the benefits of Bionic Reading® extend to neurotypical students or remain specific to populations with learning difficulties. Despite the increasing availability of digital tools for readers with learning challenges, few studies have investigated the empirical effects of typographic interventions, such as Bionic Reading, on actual reading accuracy and fluency. This lack of evidence is especially critical given the commercial promotion of such tools as educational aids.

This pilot study aims to address this gap by evaluating whether Bionic Reading® improves reading performance—measured in terms of correctly and incorrectly read letters—among pre-adolescents and adolescents with Specific Learning Disorder. The primary objective is to examine intra-subject differences in reading performance when using traditional text formats versus the Bionic Reading® method. A secondary aim is to investigate the differences in response to the intervention between students with and without a diagnosis of SLD.

Method

Participants

This study involved 26 participants: 20 with a formal diagnosis of Specific Learning Disorder (SLD) with reading impairments (ICD-11 code: 6A03.0) and six without any diagnosis. Certified clinical services operating under the national health authority issued the diagnoses, following internationally recognized criteria to ensure accurate classification of reading difficulties. Although the experimenters did not directly assess phonological awareness during the study, national health authorities had previously conducted comprehensive evaluations that included measures of phonological processing.

Participants with SLD had a mean age of 14.2 years (SD = 3.02; range = 10–18), while those without a diagnosis had a mean age of 14.8 years (SD = 2.48; range = 10–17). All participants attended a learning center offering individualized educational programs to enhance academic and communicative skills. Participation in these activities was unrelated to the study protocol.

To ensure functional reading ability, all participants underwent a brief pre-screening conducted by educational professionals, including reading aloud short age-appropriate passages to verify decoding and comprehension. Prior assessments by the health authorities documented persistent decoding and fluency deficits in participants with SLD, who typically required compensatory tools (e.g., text-to-speech applications or font adaptations). All participants or their legal guardians provided informed consent in accordance with ethical guidelines for research involving minors and vulnerable populations.

Materials

We conducted the study at a Research and Learning Center in Northern Italy that specializes in developing reading and writing skills in pre-adolescents and adolescents.

Bionic Reading® is a digital text-formatting system that enhances readability by emphasizing the initial segments of content words, creating visual anchors that facilitate eye movement and lexical processing. In this study, we created Bionic Reading® materials using the official web-based tool by Bionic Reading AG, which automatically bolded the first two to three letters of most content words. We exported the passages as fixed-layout PDFs containing the tool's watermark and branding to ensure ecological validity.

Traditional versions of the same texts were manually created by the research team using identical typographic parameters—sans-serif font (Helvetica), standardized line spacing, and identical layout. The only difference between conditions was the presence or absence of bolded segments.

The experimental set comprised six narrative texts (250–400 characters each) adapted from age-appropriate educational and literary sources, reflecting moderate linguistic complexity and varied syntactic structures. Themes included family life, humor, personal reflection, and peer interactions. We matched texts across conditions for length, lexical frequency, and structure.

Reading performance was measured using a digital stopwatch and a standardized scoring sheet to record correct and incorrect letters; this enabled computation of reading rate (letters per minute) and error frequency. We printed all materials on A4 paper and administered them individually in a quiet room.

Procedure

1. ***Participant selection.*** We recruited participants from a Research and Learning Center in Northern Italy that provides individualized educational support programs for students with and without SLD. We recruited participants with the assistance of educators, who identified

eligible students based on diagnostic documentation and reading proficiency. Participation was voluntary and not compensated.

2. ***Consent procedure.*** We obtained written informed consent from all participants or their guardians before participation. The consent form detailed the study's objectives, voluntary nature, and the right to withdraw without consequence.
3. ***Pre-screening process.*** Educational professionals conducted a brief informal screening to confirm each participant's ability to read connected text aloud and comprehend short passages. This step ensured sufficient reading fluency to complete the experimental tasks.
4. ***Preparation of materials.*** We assigned each participant two reading passages, one in the traditional format and one in the Bionic Reading® format, matched for length, lexical frequency, and syntactic complexity. We randomized the order of presentation (traditional first or Bionic first) across participants to control for sequence and fatigue effects.
5. ***Reading Test – Condition 1 (Traditional Reading).*** Each participant read one passage in the traditional format. The experimenter instructed: "You will read two short passages aloud. I will measure the time it takes you to finish each passage. Please read naturally, as you usually would, without worrying about speed." The participant was seated comfortably in a quiet room. We used a digital stopwatch to record the total reading duration and marked errors (omissions, substitutions, and mispronunciations) on a standardized scoring sheet.. Self-corrections within two seconds were considered correct. No feedback or prompts were given.
6. ***Break/Rest period.*** We provided a brief 2- to 3-minute rest period to control for fatigue and potential carryover effects across reading conditions.
7. ***Reading Test – Condition 2 (Bionic Reading®).*** The second passage, formatted with Bionic Reading®, was read under the same conditions as the first. Randomization ensured half of the participants began with the traditional format and half with the Bionic Reading® format.
8. ***Data recording and verification.*** After both trials, the experimenter recorded each participant's total reading time and the number of correctly and incorrectly read letters, and calculated the reading rate (letters per minute). Interobserver agreement was assessed for 40% of the sessions, averaging 97.6% (range = 96–100%).

Data Analysis

We performed data analyses using Jamovi (version 2.4; The Jamovi Project, 2023). The primary analysis examined intra-subject differences between traditional and Bionic Reading® conditions, while the secondary analysis explored descriptive group differences between participants with and without SLD.

Normality was assessed using the Shapiro–Wilk test for each dependent variable (frequency of correct and incorrect letters read per minute) under both conditions. We performed paired-samples t-tests when the normality assumption was met, and applied Wilcoxon signed-rank tests when it was violated. These analyses determined whether Bionic Reading® improved accuracy or reduced error rates compared to traditional reading.

Descriptive comparisons between groups (SLD vs. non-SLD) included mean, median, standard deviation, minimum, and maximum values to highlight patterns in performance variation. An a priori power analysis, conducted with *G*Power* (version 3.1.9.6; Faul et al., 2007), indicated that a sample size of 26 was sufficient to detect significant within-subject effects (Cohen's $dz = 0.8$). Statistical significance was set at $p < .05$, and effect sizes (r or Cohen's d, as appropriate) were reported.

Results

The study examined the effectiveness of Bionic Reading® on the reading performance of pre-adolescents and adolescents, comparing measurements between traditional reading and Bionic Reading® modes. The study's central hypothesis was that Bionic Reading® would improve the number of correct responses and reduce the number of errors compared to traditional reading.

Table 1 shows the normality results. The Shapiro-Wilk test was applied to assess the distribution of correct and incorrect response frequencies across the two reading conditions. The results indicate that, in some conditions, the data distribution significantly deviated from normality, as shown by p-values below .05, particularly for incorrect responses in traditional reading and Bionic Reading among participants with and without SLD diagnoses.

Table 1. Results of the Shapiro–Wilk test assessing the normality of correct and incorrect response frequencies under Traditional and Bionic Reading® conditions for participants with and without a diagnosis of SLD.

	Frequency of correct answers. Traditional reading. DSA	Frequency of incorrect answers. Traditional reading. DSA	Frequency of correct answers. Bionic Reading. DSA	Frequency of incorrect answers. Bionic Reading. DSA	Frequency of correct answers. Traditional reading. No diagnosis	Frequency of incorrect answers. Traditional reading. No diagnosis	Frequency of correct answers. Bionic Reading. No diagnosis	Frequency of incorrect answers. Bionic Reading. No diagnosis
Shapiro-Wilk W	0.978	0.802	0.964	0.822	0.900	0.686	0.869	0.664
Shapiro-Wilk p	0.907	< .001	0.629	0.002	0.374	0.004	0.221	0.003

Note. *The table reports Shapiro-Wilk normality test values for correct and incorrect response frequencies in traditional reading and Bionic Reading conditions for participants diagnosed with SLD and those undiagnosed. The Shapiro-Wilk W-value indicates the test statistic, while the p-value represents the significance level. A p-value of less than .05 suggests a deviation from normal.*

Table 2 presents the results concerning the frequency of correct responses. The analysis, conducted using the paired-samples Student's T-test, showed that participants obtained a significantly higher frequency of correct responses with Bionic Reading® compared to traditional reading (Mean: 606 vs. 556, p = 0.003). This result is consistent with the research hypothesis, which predicted improved reading performance using Bionic Reading®.

Table 2. Results of the paired-samples t-test comparing the frequency of correct responses between Traditional and Bionic Reading® conditions.

	t of Student			Descriptive			
	Statistics	WG	p	Mean with traditional reading	SD Traditional Reading	Mean with Bionic Reading	SD with Bionic Reading
Frequency of correct responses	-3.054	19.00	0.003	556	231	606	271

Note. *The frequency of correct answers was measured under two conditions: during reading in traditional mode and reading using Bionic Reading. The difference was assessed using the Student's test for paired samples. The alternative hypothesis tested was that the frequency of correct answers was higher during the reading tests involving Bionic reading (H_a μ Measure 1 - Measure 2 < 0).*

Table 3 presents the results concerning the frequency of incorrect responses. Although the reduction in errors was not significant according to the Wilcoxon test (p = 0.133), a lower mean frequency of incorrect responses was observed in the Bionic Reading® mode (Mean: 4.83) compared to traditional reading (Mean: 7.54); this suggests a positive trend in line with the primary objective, although statistical significance was not reached for this parameter; this does not allow definitive conclusions to be drawn about the reduction of reading errors and suggests the need for further studies with larger samples to obtain more reliable results.

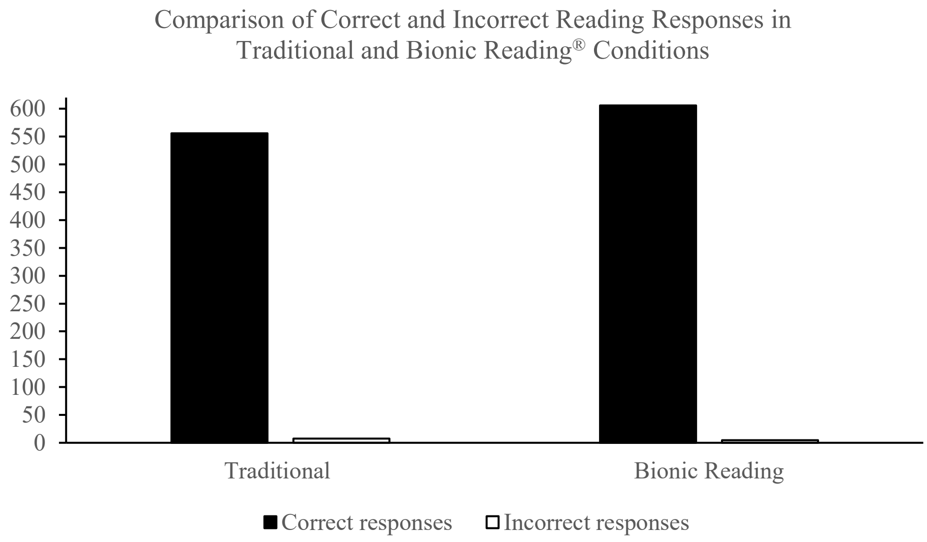
Table 3. Results of the Wilcoxon signed-rank test comparing the frequency of incorrect responses between Traditional and Bionic Reading® conditions.

	W di Wilcoxon		Descriptive			
	Statistics	p	Media with traditional reading	SD Traditional Reading	Media with Bionic Reading	SD with Bionic Reading
Frequency of incorrect responses	90.00	0.133	7.54	8.90	4.83	5.80

Note. *The frequency of incorrect responses was measured under two conditions: during reading in traditional mode and using Bionic Reading. The difference was assessed using Wilcoxon's test for paired samples. The alternative hypothesis tested was that the frequency of incorrect answers was higher during reading tests involving the traditional modality (H_a μ Measure 1 - Measure 2 > 0).*

Figure 1 provides a graphical representation of the performance trend across the two reading conditions for all participants.

Figure 1. Graphical representation of correct and incorrect reading responses in Traditional and Bionic Reading® conditions.



The study's secondary objective was to examine potential differences in reading performance between participants diagnosed with specific learning disabilities (SLD) and those without diagnoses, without formulating a priori hypotheses. The results presented in Table 4 show that participants with SLD recorded a mean increase of 49.932 correct responses compared to baseline. In contrast, for incorrect responses, they showed a mean reduction of -2.702 responses. These results suggest that Bionic Reading® could significantly benefit participants with SLD in terms of accuracy and error reduction. In contrast, participants without diagnoses showed a negative mean difference in correct responses (-57.289) and a slight positive variation in incorrect responses (+0.499); this may indicate that Bionic Reading® has a different impact on participants without diagnoses compared to those with SLD, suggesting greater effectiveness in individuals with learning difficulties.

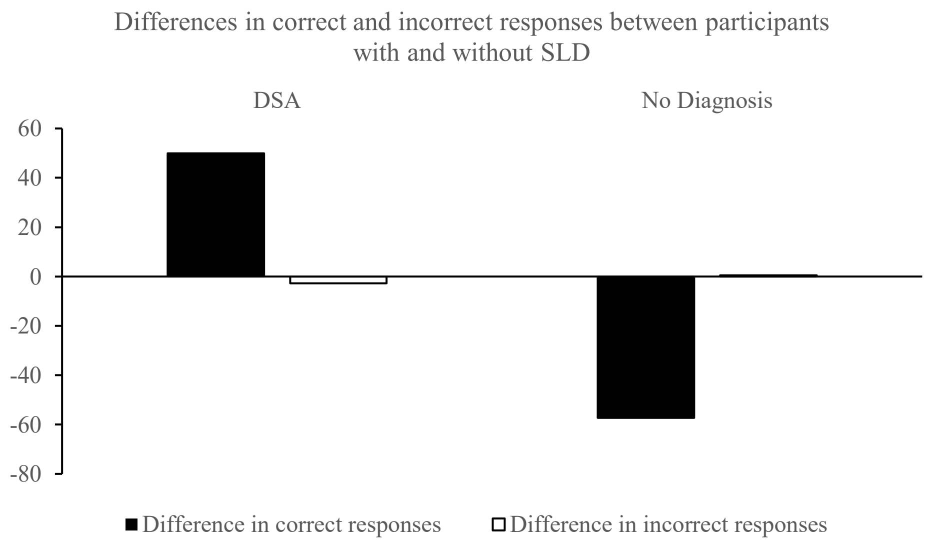
Table 4. The table presents descriptive information on differences in correct and incorrect response frequencies between participants with and without a SLD diagnosis.

	Diagnosis	Average	Median	SD	Minimum	Maximum
Differences between the frequency of correct answers	SLD	49.932	46.4	73.11	-70.2	198.8
	No SLD	-57.289	-35.7	144.01	-299.7	110.2
Differences between the frequency of incorrect responses	SLD	-2.702	0.0	8.33	-25.0	10.7
	No SLD	0.499	0.0	7.92	-10.9	13.8

Note. *The table shows the average differences in the frequencies of correct and incorrect answers between participants diagnosed with SLD and those without a diagnosis under the different experimental conditions. Median, standard deviation, minimum, and maximum values for each group are also reported, showing the variability of participants' performance based on diagnosis and experimental conditions. Negative values indicate lower performance than the traditional reading, while standard deviation reflects the dispersion of data among participants.*

Figure 2 shows the differences in performance between participants with and without a diagnosis of Specific Learning Disorder (SLD) in terms of correct and incorrect responses across reading conditions.

Figure 2. Mean differences in correct and incorrect responses between participants with and without SLD. Positive values indicate improved performance with Bionic Reading®, while negative values indicate lower performance than with traditional reading.



Discussion

The results of this pilot study provide initial support for the effectiveness of Bionic Reading® on the reading performance of pre-adolescents and adolescents, aligning with cognitive theories that view reading as a complex process involving various cognitive skills, such as visual perception and visual-phonological correspondence (Stella, 2004). Reading requires the development of phonological awareness, which is essential for connecting phonemes and graphemes (Mather & Wendling, 2011). These skills are often lacking in pre-adolescents and adolescents with neurodevelopmental disorders, such as dyslexia (van Rijthoven et al., 2022).

The study results support the central hypothesis, demonstrating that participants obtained a significantly higher number of correct responses using Bionic Reading® compared to traditional reading; this is particularly relevant considering that pre-adolescents and adolescents with specific learning disabilities often struggle to correctly identify, segment, and manipulate the sounds of words (Goswami, 2000; Conrad, 2008). The improvement observed with Bionic Reading could be attributed to its ability to facilitate visual perception and guide the eye through the text, thereby making grapheme recognition easier (Hooper et al., 2023).

However, despite reducing the frequency of incorrect responses, the difference between the two reading modes was not statistically significant; this may suggest that although Bionic Reading® could minimize visual fatigue and the stress associated with reading, as highlighted by Kim et al. (2012), further studies with larger samples may be needed to confirm its effectiveness in reducing reading errors.

The growing use of mobile technologies in learning, such as Bionic Reading®, represents a promising strategy for promoting autonomy and individualized learning paths, particularly for students with neurodevelopmental disorders (Politi-Gergousi & Drigas, 2020; Novembli & Azizah, 2019). While progress has been made in adapting texts to make them more readable for individuals with dyslexia (Rello & Baeza-Yates, 2013; Bachman & Mengheri, 2018), Bionic Reading offers an innovative approach that not only relies on static visual modifications but also activates a more dynamic reading process.

Regarding the secondary objective, the differences between participants with and without specific learning disabilities (SLD) were evident. Participants with SLD benefited more from Bionic Reading®, as shown by increased correct responses and reduced errors. This result reflects the intrinsic difficulties that pre-adolescents and adolescents with SLD experience in reading complex and infrequent words (Lyon et al., 2003) and suggests that Bionic Reading could be a particularly suitable intervention for improving reading performance in this group.

On the other hand, participants without diagnoses did not show comparable improvements. They recorded a slight decrease in the number of correct responses. This result could indicate that Bionic Reading® is less effective for readers without specific difficulties; this could be because these participants do not benefit from the same compensatory strategies necessary for those with SLD, or it may be due to cognitive interference related to using a new reading method. Additionally, the crowding phenomenon, where letters that are too close together reduce reading speed and fluency, might make Bionic Reading® less advantageous for these readers (Bachman & Mengheri, 2018).

In general, the results of this study provide a preliminary indication of Bionic Reading®'s effectiveness in improving reading performance, especially for individuals with SLD. However, further research is needed to fully explore this tool's potential and better understand its impact on readers without learning difficulties. As observed by Budomo et al. (2023), Bionic Reading also appears to increase motivation and self-efficacy in students with disabilities; however, further studies are needed to document its effectiveness in terms of reading performance (Mangas Alfonso, 2022).

Conclusion

In conclusion, the results of this pilot study suggest that Bionic Reading® could represent a promising tool for improving reading performance, particularly for pre-adolescents and adolescents with specific learning disabilities (SLD). Although the benefits of this technology still need to be explored in more depth, the data collected indicate that Bionic Reading could offer significant support for those who encounter specific reading difficulties, with a more evident impact on correct responses.

The methodological limitations encountered in this study, including the small sample size, the absence of a control group, and the variability in age, underscore the need for further research. Future studies must include larger samples, standardized tests, and segmentation by age group to validate the effectiveness of Bionic Reading® with greater scientific rigor. Only through such a rigorous investigation will it be possible to confirm the preliminary results and fully understand the impact of this tool on reading.

A fundamental issue that emerges is the ethical question related to commercializing products like Bionic Reading® without solid and definitive scientific validation. Although the technology offers innovative and potentially practical solutions, the risk of promoting inadequately tested tools may lead to inappropriate use or create unrealistic expectations, especially among those with learning difficulties. The commercialization of tools that are not yet validated may harm the most vulnerable users, who rely on such technologies to improve their academic performance and life skills. It is, therefore, imperative that such technologies be disseminated only after rigorous and independent scientific studies have been conducted to ensure that the benefits are accurate and evidence-based.

Ultimately, Bionic Reading® represents an attractive educational opportunity and support for individuals with reading difficulties. However, its full potential can only be recognized and utilized once it is accompanied by robust scientific validation to support its use in educational contexts.

Limit of the research and future prospective

Despite the promising results, this study presents several limitations that must be considered. The first significant limitation is the absence of a control group. The lack of a comparison group makes it difficult to determine whether the improvements observed using Bionic Reading® are attributable to the intervention or other external factors. Without a control group following a different approach (for example, using another reading tool or no modification), it becomes challenging to isolate the specific effects of Bionic Reading®. Future studies should, therefore, include a control group to evaluate the tool's effectiveness rigorously.

Another significant limitation is the small number of participants without a diagnosis of specific learning disabilities. Of the 26 participants, only six did not have an SLD diagnosis, which reduces the possibility of generalizing the results to pre-adolescents and adolescents without learning difficulties. Additionally, the small number of participants in the group without a diagnosis limits the ability to make significant comparisons between the two groups, making the results less reliable for this population. The small sample size for participants without diagnoses may have also reduced the statistical power of the analyses, increasing the likelihood of random results.

Another limitation concerns the variability in participant age. The study involved pre-adolescents and adolescents with a wide age range, which may have introduced variability in the results. Differences in cognitive development stages and reading abilities between pre-adolescents and adolescents could significantly influence reading performance. Future studies should consider more accurate segmentation of participants by age to mitigate the confounding variable's effect and determine whether Bionic Reading has different effects across age groups.

Another significant limitation of the present study concerns the absence of standardized assessments for participants' reading abilities and phonological awareness. Reading performance was measured solely in terms of correct and incorrect letters read, without reference to age- or grade-based normative data. Although 20 participants had a certified diagnosis of Specific Learning Disorder (SLD) with reading impairments—typically based on comprehensive neuropsychological evaluations—no independent, study-specific tests were administered to assess reading level or phonological processing at the time of the study. Additionally, the 6 participants without a diagnosis were included based on informal screening procedures, without formal documentation of their phonological or reading profiles. As a result, individual differences in cognitive functioning, particularly in phonological awareness, may have influenced the outcomes and limited the interpretability of the observed effects. Future studies should incorporate formal standardized tests to establish clearer baselines, enable comparisons with normative expectations, and clarify whether phonological skills moderate the efficacy of Bionic Reading®. Doing so would improve the scientific validity and generalizability of the findings.

Another factor that may have influenced the results, but was not explicitly analyzed, is the number of years of reading experience among participants. Since the sample included both pre-adolescents and adolescents, age differences likely correspond to differences in exposure to reading activities, which may have affected reading fluency and the ability to adapt to the Bionic Reading® format. This variable, while not directly assessed, may act as a latent factor influencing the magnitude of improvement observed across participants. Future research should include age-stratified analyses or collect data on reading history to explore how developmental factors moderate the effectiveness of visual reading aids, such as Bionic Reading®.

Acknowledgements, Grants and Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declarations of interest: none.

Ethical Considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki and adhered to national guidelines for research involving minors. Informed consent was obtained from all participants' legal guardians. At the time of data collection, the institution did not require ethics committee approval for low-risk, non-invasive educational interventions. Therefore, no ethics approval number is available.

Authors' contribution

Author 1 contributed to the study concept and design, conducted the statistical analysis, and was responsible for manuscript preparation, editing, and final linguistic revision. Authors 2, 3, 4, 5, 6, 7, and 8 contributed to data collection. All authors reviewed and approved the final version of the manuscript.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Bachmann, C., & Mengheri, L. (2018). Dyslexia and fonts: Is a specific font useful?. *Brain sciences*, *8*(5), 89. https://doi.org/10.3390/brainsci8050089

Braten, I., Amundsen, A., & Samelstuen, M. S. (2010). Poor readers—Good learners: A study of dyslexic readers learning without and without text. *Reading & Writing Quarterly, 26*, 166-187. https://doi.org/10.1080/10573560903123684

Benalcázar Chicaiza, D., Barrera G, M. I., Páez Quinde, M. C., & Pilamunga P, M. E. (2019). M-Learning Didactic Strategy for Children Diagnosed with Dyslexia. In *Digital Science* (pp. 143-149). Springer International Publishing.

Budomo, X. M., Pamaran, E. C. W., So, L. M. F., Capuno, R. G., Reyes, N. R. T. D., Pinili, L. C., & Añero, M. B. (2023). The Impact of Bionic Reading on the Reading Motivation and Self-

Efficacy of Students with Learning Disabilities. *International Journal of Advanced Multidisciplinary Studies*, *3* (10), 402-416.

Conrad, N. J. (2008). From reading to spelling and spelling to reading: Transfer goes both ways. *Journal of Educational Psychology, 100*(4), 869–878. https://doi.org/10.1037/a0012544

Conti-Ramsden, G., Durkin, K., Toseeb, U., Botting, N., & Pickles, A. (2018). Education and employment outcomes of young adults with a history of developmental language disorder. *International journal of language & communication disorders*, *53*(2), 237-255. https://doi.org/10.1111/1460-6984.12338

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior research methods*, *39*(2), 175-191. https://doi.org/10.3758/BF03193146

Fletcher JM, Lyon GR, Fuchs LS, & Barnes M (2019). *Learning disabilities: From identification to intervention*. Guilford Press.

Göbel, S. M., & Snowling, M. J. (2010). Number-processing skills in adults with dyslexia. *Quarterly Journal of Experimental Psychology, 63*(7), 1361–1373. https://doi.org/10.1080/17470210903359206

Goswami, U. (2000). Phonological representations, reading development and dyslexia: Towards a cross-linguistic theoretical framework. *Dyslexia, 6*(2), 133–151. https://doi.org/10.1002/(SICI)1099-0909(200004/06)6:23.0.CO;2-A

Hoeft, F., McCandliss, B. D., Black, J. M., Gantman, A., Zakerani, N., Hulme, C., . . . Gabrieli, J. D. E. (2011). Neural systems predicting long-term outcome in dyslexia. Proceedings of the *National Academy of Sciences, 108*(1), 361-366. https://doi.org/10.1073/pnas.1008950108

Hooper, C., Oldham, D., Beasley, C., & Brandi, L. (2023). Eye Tracking, Reading, and Font Characteristics.

Horn, A. L., Roitsch, J., & Murphy, K. A. (2023). Constant time delay to teach reading to students with intellectual disability and autism: a review. *International Journal of Developmental Disabilities*, *69*(2), 123-133. https://doi.org/10.1080/20473869.2021.1907138

Horowitz-Kraus, T. (2015). Differential effect of cognitive training on executive functions and reading abilities in children with ADHD and in children with ADHD comorbid with reading difficulties. *Journal of attention disorders*, *19*(6), 515-526. https://doi.org/10.1177/1087054713502079

Jiménez-Porta, A. M., & Diez-Martínez, E. (2016). Dyslexia: Analysis of technological resources (mobile applications, pc applications, websites) in Mexican Spanish to support its therapeutic in basic education. In *INTED2016 Proceedings*(pp. 5297-5305). IATED. https://doi.org/10.21125/inted.2016.0261

Kim, W., Linan–Thompson, S., & Misquitta, R. (2012). Critical factors in reading comprehension instruction for students with learning disabilities: A research synthesis. *Learning Disabilities Research & Practice, 27*(2), 66-78. https://doi.org/10.1111/j.1540-5826.2012.00352.x

Lyon, G. R., Shaywitz, S. E., & Shaywitz, B. A. (2003). A definition of dyslexia. *Annals of Dyslexia, 53*(1), 1–14. https://doi.org/10.1007/s11881-003-0001-9

Madeira, J., Silva, C., Marcelino, L., & Ferreira, P. (2015). Assistive mobile applications for dyslexia. *Procedia computer science*, *64*, 417-424. https://doi.org/10.1016/j.procs.2015.08.535

Mangas Afonso, H. (2022). *Improving paragraph reading: The effect of beginning-of-line additions in readability, an eye tracking experiment* (Master's thesis).

Martinussen, R., & Mackenzie, G. (2015). Reading comprehension in adolescents with ADHD: Exploring the poor comprehender profile and individual differences in vocabulary and executive functions. *Research in Developmental Disabilities, 38*, 329–337. https://doi.org/10.1016/j.ridd.2014.12.007

Mather, N., & Wendling, B. J. (2024). *Essentials of dyslexia assessment and intervention*. John Wiley & Sons.

Miranda, A., Mercader, J., Fernández, M. I., & Colomer, C. (2017). Reading performance of young adults with ADHD diagnosed in childhood: Relations with executive functioning. *Journal of Attention Disorders, 21*(4), 294-304. https://doi.org/10.1177/1087054713507

Novembli, M. S., & Azizah, N. (2019, April). Mobile learning in improving reading ability dyslexia: A systematic literature review. In *International Conference on Special and Inclusive Education (ICSIE 2018)* (pp. 220-226). Atlantis Press. https://doi.org/10.2991/icsie-18.2019.41

Politi-Georgousi, S., & Drigas, A. (2020). Mobile Applications, an Emerging Powerful Tool for Dyslexia Screening and Intervention: A Systematic Literature Review. https://doi.org/10.3991/ijim.v14i18.15315

Purvis, K. L., & Tannock, R. (2000). Phonological processing, not inhibitory control, differentiates ADHD and reading disability. *Journal of the American Academy of Child & Adolescent Psychiatry*, *39*(4), 485-494. https://doi.org/10.1097/00004583-200004000-00018

Rauschenberger, M., Baeza–Yates, R., & Rello, L. (2019). Technologies for dyslexia. *Web Accessibility: A Foundation for Research*, 603-627. https://doi.org/10.1007/978-1-4471-7440-0_31

Reid, G., Strnadová, I., & Cumming, T. (2013). Expanding horizons for students with dyslexia in the 21st century: universal design and mobile technology. *Journal of Research in Special Educational Needs*, *13*(3), 175-181. https://doi.org/10.1111/1471-3802.12013

Rello, L., & Baeza-Yates, R. (2013, October). Good fonts for dyslexia. In *Proceedings of the 15th international ACM SIGACCESS conference on computers and accessibility* (pp. 1-8). https://doi.org/10.1145/2513383.2513447

Rello, L., & Baeza-Yates, R. (2014, April). Evaluation of DysWebxia: a reading app designed for people with dyslexia. In *Proceedings of the 11th Web for All Conference* (pp. 1-10). https://doi.org/10.1145/2596695.2596697

Rello, L., Kanvinde, G., & Baeza-Yates, R. (2012, April). Layout guidelines for web text and a web service to improve accessibility for dyslexics. In *Proceedings of the international cross-disciplinary conference on web accessibility* (pp. 1-9). https://doi.org/10.1145/2207016.2207048

Spear-Swerling, L. (2019). Structured literacy and typical literacy practices: Understanding differences to create instructional opportunities. *Teaching Exceptional Children, 51*(3), 201-211. https://doi.org/10.1177/0040059917750160

Stella, G. (2004). *La dislessia. Quando un bambino non riesce a leggere: cosa fare, come aiutarlo*. Bologna, il Mulino.

Tamm, L., Epstein, J. N., Denton, C. A., Vaughn, A. J., Peugh, J., & Willcutt, E. G. (2014). Reaction time variability associated with reading skills in poor readers with ADHD. *Journal of the International Neuropsychological Society, 20*(3), 292–301. https://doi.org/10.1017/S1355617713001495

The Jamovi Project. (2023). *Jamovi (Version 2.4)* [Computer software]. https://www.jamovi.org

Van Rijthoven, R., Kleemans, T., Segers, E., & Verhoeven, L. (2022). Compensatory role of verbal learning and consolidation in reading and spelling of children with dyslexia. *Annals of Dyslexia, 72*(3), 461-486. https://doi.org/10.1007/s11881-022-00264-2

Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. *Biological psychiatry*, *57*(11), 1336-1346. https://doi.org/10.1016/j.biopsych.2005.02.006