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Text-to-speech applications to reduce mind wandering in students with dyslexia

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Abstract

Background: Mind wandering—that is, a shift in the contents of thought away from an ongoing task—can have detrimental consequences for students' reading comprehension. To date, no evidence is available on the effects of text-to-speech solutions on rates of mind wandering during reading.

Objectives: The study aimed to evaluate the effects of text-to-speech technology on frequency of mind wandering and reading comprehension in young students with dyslexia (20) and typical development (50).

Methods: Students were presented, on a personal computer, texts and comprehension questions in two modalities: self-paced silent reading and text-to-speech reading. Comprehension scores and mind wandering occurrence were considered. A battery of cognitive tasks and questionnaires on mind wandering and emotional traits was also included.

Results: There were no differences in baseline rates of mind wandering between the two groups. In the text-to-speech condition, both groups showed better reading comprehension and reduced rates of mind wandering. Students with dyslexia were significantly more on task in the text-to-speech condition compared to the self-paced reading condition.

Implications: These results suggest that text-to-speech might represent a reading solution that allows students with Dyslexia to diminish mind wandering during text-to-speech reading.

KEYWORDS

dyslexia, mind wandering, reading comprehension, specific learning disorders, text-to-speech

1 | INTRODUCTION

While reading, a student might disengage her attention from the chapter she is studying for the next day's exam to the images of a show she had been watching the night before. At that very moment, her eyes keep staring at the book, but her mind is paying attention to thoughts that are not related to the content of the text. When the student returns her attention to the book, she soon realizes that she cannot remember what she had just read. This phenomenon is generally referred to as mind wandering (MW) and can be broadly defined as a shift in the contents of thought away from an ongoing task and/or from events in the external environment to internally self-generated thoughts and feelings (Smallwood & Schooler, 2015). MW refers to a wide range of experiences that vary in terms of content, intentionality, and relationship between activities and external stimuli (Seli et al., 2018) and it can be argued that MW per se is not a dysfunctional process but rather an important phenomenon for human experience; actually, it has been estimated that healthy adults spend as much as to 50% of waking hours in MW (Killingsworth & Gilbert, 2010).

Researchers seem to agree on the fact that engaging in MW might have both positive and negative influences on cognitive performance (for a review, see Mooneyham & Schooler, 2013). Regarding the potential benefits, it has been suggested that MW might support adaptive functions such as planning and future thinking (Stawarczyk et al., 2011), creative incubation and problem solving (Baird et al., 2012), allowing dishabituation, and relieving tedium (Mooneyham & Schooler, 2013; Ruby et al., 2013). However, such benefits brought about MW seem to be counterbalanced by evident costs for cognitive performance (Mooneyham & Schooler, 2013). Of particular relevance for the scopes of the present study is the evidence for which MW might have detrimental effects on reading comprehension (Feng et al., 2013; Smallwood, 2011; Unsworth & McMillan, 2013). Despite a large body of evidence is currently available documenting the negative effects of MW for reading comprehension, to the best of our knowledge, no previous research addressed the extent to which MW might affect reading comprehension in children who have specific reading disorders (i.e., dyslexia).

When a child has difficulties in decoding skills, reading comprehension might be compromised (Snowling et al., 2020) and experts suggest that, for these children, text-to-speech tools might help compensate for their decoding difficulties, favouring better access to higher levels of reading comprehension (Elkind et al., 1993; Lopresti et al., 2004; MacArthur et al., 2001; Wood et al., 2018). Children with dyslexia, in the absence of previous Developmental Language Disorders, are expected to have, instead, adequate listening comprehension skills (Bonifacci & Tobia, 2016; Snowling et al., 2020). The present study aims to address an under-investigated issue in the literature, that is, the frequency of MW during reading in children with Dyslexia, compared to typical readers; the study also aimed to evaluate the effects of text-to speech and self-paced reading in the occurrence of MW in reading comprehension in the two groups.

2 | MW AND THE IMPACT OF DIFFERENT READING MATERIALS

Available evidence has repeatedly shown that surface characteristics (e.g., font size, letter spacing), as well as those related to content (e.g., narrative vs. scientific texts, text complexity), affect both the quality of reading comprehension and rates of MW in readers (Best et al., 2008; Eason et al., 2012; Tobia & Bonifacci, 2020). In addition, the presentation modality through which texts are presented seems to affect MW. For example, in a study involving students without reading difficulties, Varao Sousa et al. (2013) explored three different reading conditions: reading a passage aloud, listening to a passage being read to them, and reading a passage silently. The results showed that reading aloud led to the least amount of MW, followed by reading silently; listening to a passage of text resulted in the condition with the highest rate of MW.

In contrast to these findings, Franklin et al. (2014) involved participants in a reading task involving silent reading and reading aloud. Contrary to their expectations, the results showed that reading aloud produced more MW than silent reading. More recently, Kopp and D'Mello (2016) developed an experimental setting in which adult participants were exposed to three different conditions: reading at their own pace (self-paced reading), listening to an auditory presentation of the materials without any text (audio only), and reading a text with a concurrent presentation of a synchronized narration (audio + text). Results showed higher rates of MW in the audio only format, with no differences between the audio + text and self-paced reading conditions. These findings were considered in support of the executive resource hypothesis in that rates of MW increase when resources are available to attract attention away from the task towards task-unrelated thoughts and ideas (Kopp & D'Mello, 2016). Although the authors did not directly measure readers' interest, they found that the audio + text condition was the most beneficial to inhibit MW in supposed less interesting texts. The results of Kopp and D'Mello (2016) further suggest that the relationship between reading comprehension and MW might be influenced by the modalities through which students access the reading material and interact with it. Further, other evidences suggest that technologies might reduce the negative impact of MW in different ways, for example, by means of machine-learned computational models (D'Mello & Mills, 2021) and through interventions based on eye-movements detection. In these paradigms (Mills et al., 2021) it has been shown that detecting MW through an eye-gaze-based classifier and asking participants to self-explain the concept they were reading at that precise moment significantly increased reading comprehension, also in real-world classrooms (Hutt et al., 2021).

This aspect is of central importance when considering students with reading disorders or dyslexia. Indeed, for these students, a number of assistive technologies are available to help them overcome their decoding difficulties, such as text-to-speech, read-aloud tools and reading pens (Dawson et al., 2019; Smythe, 2005). In detail, text-to-speech software facilitates students' access to written texts by highlighting each word of a written text while reading it aloud, thus providing the reader with a synchronized auditory and visual presentation of the written text (Staels & Van den Broeck, 2015). This computer-supported reading strategy is thought to remove the need for the struggling reader to independently decoding the reading material and therefore has the potential to help students with reading disabilities better comprehend written texts (Perelmutter et al., 2017; Wood et al., 2018). In fact, the most recent meta-analysis to date on the impact of text-to-speech software and related read-aloud tools shows that this strategy effectively compensates the reading difficulties of children with reading disorders and improves their text comprehension (Wood et al., 2018).

Despite increasing evidence on the benefit of text-to-speech on reading comprehension, however, the underlying cognitive mechanisms supported by such technology remain largely unknown (Schiavo et al., 2021). According to the cognitive theory of multimedia learning (Mayer, 2014), for instance, integrating cross-channel representations (e.g., auditory/visual) of the same stimulus (e.g., a written word) is supposed to help the reader overcome the capacity limitations of the cognitive system when accessing material to be learned. In this view, multimodal (i.e., auditory–visual) text presentation through text-to-speech software may help readers with dyslexia mitigate visual distraction due to their high sensitivity to crowding, which is supposed to impair letter identification in the periphery, thus reducing reading speed by limiting the number of letters able to be perceived at a glance (Pelli et al., 2007; Schneps et al., 2019). In addition, it has been recently suggested that the ability of text-to-speech software to highlight words can also improve verbal and visual information processing in working memory, increasing the mental resources that can be devoted to comprehension (Schiavo et al., 2021).

3 | READING COMPREHENSION, MW AND READING DISORDERS

Reading comprehension is a complex and multifaced process. Kintsch's construction-integration model (Kintsch & Rawson, 2005) distinguishes between two levels of representation: the local level (i.e., the word and sentence level), and the global level (i.e., the overall or text level). The construction of a situation model is considered the highest outcome and involves combining text-based information and knowledge-based inferences. A reader creates coherence in the representation of the text by inferring the type of relationship that exists between text parts, using background knowledge and/or cohesive devices (i.e., connectives, signalling words). In this view, reading comprehension involves a complex interaction between bottom-up representations of the text that is being read and top-down representations of the more general context that help keep the readers' minds on what they are doing. When MW occurs during reading tasks, the mind switches to internal thoughts and feeling while the eyes continue to scan the words without due attention to their meaning (also referred to as 'mindless reading'). According to the Cascade model of inattention (Smallwood, 2011), there is reduced processing of sensory information and the coupling between the reader and the text breaks down; the degraded perceptual representations might, consequently, detract from detailed lexical processing of a word, interfering in the creation of the propositions which make a sentence. The absence of bottom-up information processing hinders, by cascade, the ability of the reader to create a more complex propositional and situational model of the narrative. Therefore, it is clear how much wandering with the mind has a significant cost when reading; it determines both lexical-specific understanding deficits, as well as model-building ones (Smallwood et al., 2008). Within this interactive and constructive process, MW might interrupt inferences and meaning construction. Current evidence suggests that MW during reading might be activated by many factors, such as low working memory capacity (McVay & Kane, 2012) or executive functions (Keulers & Jonkman, 2019), low interest in the topic, experience with the topic and motivation (Unsworth & McMillan, 2013), reading difficult (Feng et al., 2013) or long (Forrin et al., 2019) texts, as well as negative mood (Seli et al., 2019).

Another influential model of reading comprehension is the simple view of reading (Gough & Tunmer, 1986), which states that reading comprehension is the product of decoding skills (word and nonword reading) and linguistic skills (listening comprehension). According to this model, reading comprehension might be impaired either because of poor decoding skills or poor linguistic skills. When children have mastered their decoding skills after the first years of primary school, the role of linguistic skills resulted in being the strongest predictor of reading comprehension both in opaque and transparent languages (Bonifacci & Tobia, 2017; Florit & Cain, 2011; Tobia & Bonifacci, 2016). However, when decoding skills are impaired, as in the case of children with dyslexia, comprehension might be, at least in part, compromised. Inaccurate decoding might intensify cognitive load and interfere with correct access to meanings.

According to the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; DSM-V; American Psychiatric Association, 2013), specific learning disorders (SLD) are defined as neurodevelopmental disorders that impede learning or efficiently using reading, writing, or mathematics skills, which are not primarily due to intellectual disability or global developmental delay; nor to neurological, motor, or sensory disorders; or to a lack of opportunity of learning/inadequate instruction. Dyslexia is a SLD that implies inaccurate or disfluent decoding (American Psychiatric Association, 2013). Disfluency, or the inability to read accurately and quickly, is a widespread deficit in poor readers (Shaywitz & Shaywitz, 2005) and might persist longer than inaccurate decoding. The increase of reading fluency over time is predictive of reading comprehension (Kim et al., 2010) and, for transparent languages such as Italian, reading speed rather than accuracy, is considered a more sensitive index of dyslexia (Seymour et al., 2003). Dyslexia, as other neurodevelopmental disorders, is currently interpreted within a multiple deficit model (McGrath et al., 2020; Pennington, 2006), which states that multiple predictors contribute probabilistically to neurodevelopmental disorders and shared risk factors contribute to comorbidity. Within this view, disfluency might have different determinants (e.g., phonology, attentional and visuo-perceptual processes, speed of processing), acting at different levels (genetic, cognitive, behavioural). Thus, although disfluency can be considered a strong behavioural marker of dyslexia, its determinants might vary depending on the different underlying functional profiles.

Despite the rich literature on reading comprehension and MW, there is a lack of evidence about the frequency of MW in children with dyslexia. Despite the lack of available evidence, one might expect these children to mind wander more than their typical reader peers in part for their disfluency, which in itself might increase MW because the reading process becomes more fragmented and strenuous, providing the mind with more opportunities to wander. At the same time, in children with dyslexia, MW may also increase because of their often-reported associated deficits in working memory (Giofrè et al., 2017) and attentional resources (Helland & Asbjørnsen, 2000), factors that have been proved to be related to MW occurrence (Keulers & Jonkman, 2019; McVay & Kane, 2012). Further, consistent findings suggest that greater text difficulty is associated with more MW (Feng et al., 2013), and, for children with dyslexia, the perceived text difficulty might be greater compared to typical readers.

4 | THE PRESENT STUDY

In light of the aforementioned considerations, it can be argued that text-to-speech software may support reading comprehension by reducing reader's attentional and executive (i.e., working memory) load. In this study, we explored how text-to-speech software can be considered a reliable strategy to reduce the negative effects of internally generated distractions, such as MW. Specifically, the aims of the study were threefold: 1) to analyse differences in MW occurrence and reading comprehension in children with SLD and typical readers; 2) to understand how text presentation modalities relate to MW occurrence; 3) to evaluate if text presentation modalities had a different impact on MW and reading comprehension in the two groups (dyslexia; typical readers) considered. To better control for external variables that might modulate the occurrence of MW, and to directly assess participants' reading and writing skills, children were administered a battery of cognitive tasks and a set of questionnaires assessing emotional variables and mind-wandering traits, which were found to be related to direct measures of MW in young people (Stawarczyk et al., 2014; Varao-Sousa & Kingstone, 2019). We developed an experimental setting where two groups of participants (aged between 8 and 13 years old), one of children with dyslexia and one of typical readers, were presented, on a personal computer, texts and comprehension questions in two different modalities: self-paced silent reading (participants were presented with a text and could read at their own pace) and text-to speech reading. In the latter condition, assistive technology accommodations were used to translate written text into spoken text, enabling participants to listen to written text while reading. Previous evidence has documented that children in the chosen age range (i.e., 8–13) were (a) able to report MW in a valid way (Keulers & Jonkman, 2019; Mrazek et al., 2013; Ye et al., 2014), and (b) do not show associations between age and frequency of MW (Frick et al., 2020).

The objectives of the study translate into the following five specific hypotheses:

H1. *To find higher MW in students with dyslexia.*

The hypothesis is based on convergence of other evidence that highlighted: (a) children with reading disorders were distinctively disadvantaged compared to average readers on working memory measures (Giofrè et al., 2017; Swanson et al., 2009) and individual differences in working memory and executive functions should predict MW (McVay et al., 2009); (b) more difficult texts can be associated with a higher MW rate (Feng et al., 2013) and children with dyslexia might perceive texts as more difficult than their typical peers. However, no previous study directly tested MW in children with SLD. Alternatively, the absence of differences in MW between children with SLD and TD controls would suggest that MW is independent of decoding difficulties.

H2. *To find lower scores in reading comprehension in children with dyslexia compared to typical readers.*

Reading disfluency is known to affect reading comprehension (Kim et al., 2010) and although dyslexia does not necessarily lead to reading comprehension impairments (Snowling et al., 2020), a higher degree of MW associated to reading disfluency are expected to negatively interfere with reading comprehension.

H3. *Not to find differences in MW occurrence between the two conditions of text presentation (self-paced and text-to speech).*

This hypothesis would replicate Kopp and D'Mello (2016) study, who did not find differences in the general population on a similar paradigm.

H4. *Text-to-speech condition to be associated with better text comprehension in children with reading disorders.*

If reading comprehension is affected by disfluency (Kim et al., 2010), removing decoding difficulties would lead to better comprehension processes than self-paced reading conditions.

H5. *To detect a minor occurrence of MW when using text-to-speech in children with dyslexia because, in this condition, they might dispose of higher attentional resources and therefore be more able to inhibit shifts to internal thoughts.*

Previous evidence suggested that MW during reading comprehension might significantly decrease when appropriate interventions and technologies are adopted (Hutt et al., 2021; Mills et al., 2021) and we hypothesized that text-to speech reading might be considered an appropriate tool to reduce MW in children with dyslexia.

Finally, explorative correlation analyses were run to evaluate the main patterns of relationships amongst the study variables and evaluate the consistency of the experimental measures with expected significant relationships with baseline measures.

5 | METHOD

5.1 | Participants

The sample included 70 children (50% females) aged between 8 and 13 years (M = 10.99 ± 1.21 years) recruited through ads in schools and associations, word of mouth, and snowball sampling in the north of Italy and Repubblica of San Marino. Participants represented two groups: students with dyslexia (SLD; n = 20; 45% females, mean age = 10.74 ± 1.14 years) and students with typical development (TD; n = 50; 52% females, mean age = 11.09 ± 1.23 years). Children with SLD received a diagnosis of reading or spelling disorders (ICD-10 classifications: F 81.1, F81.2) within the Italian National Health System or in accredited clinical centres, according to Italian guidelines (PARCC, 2011).

Groups were matched for gender, $\chi^2(1) = 0.280$, $p = 0.597$, and age, $t(68) = -1.099$, $p = 0.276$. The two groups were also balanced for familiar socioeconomic status (SES), $t(68) = -1.459$, $p = 0.149$, measured with the Hollingshead Four Factor Index of Social Status (Hollingshead, 2011). In particular, SES mean values were 36.40 ± 13.65 for SLD and 41.05 ± 11.36 for TD. Finally, SLD (mean IQ = 102.70 ± 17.69) and TD (mean IQ = 107.52 ± 13.84) groups showed a similar nonverbal IQ measured with the KBIT-2 (see Section 2), $t(68) = -1.213$, $p = 0.229$. Exclusion criteria were: having an IQ < 70, being exposed to a language different from Italian in the family, presence of other neurodevelopmental disorders, sensory/neurological impairments. Based on informal baseline interviews, all children in the SLD group were occasional users of assistive technologies such as text-to-speech, concept maps, and auto-correction tools. Informed consent was obtained by all parents' participants, and the protocol was approved by the Ethics Committee of the local university. The participants' legal representatives provided written informed consent for the participants' involvement in the study.

5.2 | Measures

All participants underwent the same test battery, which included, in addition to the experimental protocol, questionnaires for collecting main demographic and personal information for parents; cognitive, reading and comprehension tasks for children together with questionnaires for the evaluation of dispositional tendency to MW and emotional aspects.

5.2.1 | Socio-demographic information

The Hollingshead Four Factor Index of Social Status (Hollingshead, 2011) was used. For this study, indexes of educational level (EL) and occupation (O) were chosen. For both indexes, scores ranged from 1 to 9. SES scores for fathers and mothers were managed with the formula $EL \times 3 + O \times 5$, and an aggregate SES score for children resulted from the mean of the two values. Scores ranged from a minimum of 8 to a maximum of 66; suggested classification for interpreting the scores is given by the questionnaire's instructions (8–19 low; 20–29 medium-low; 30–39 medium; 40–54 medium-high; 55–66 high; Hollingshead, 2011). Parents were also asked to respond to questions about children's age, languages spoken at home, and main medical history.

5.2.2 | Cognitive tests

Nonverbal IQ

The Matrices subtest of the KBIT-2 (*Kaufman Brief Intelligence Test—*Second edition; Bonifacci & Nori, 2016; Kaufman & Kaufman, 2004) was administered. The 46 items contain pictures and abstract designs and evaluate the ability to solve new problems by perceiving relationships and completing analogies. The test has different starting points based on the participant's age and stops after four consecutive wrong responses. Raw scores (the maximum score was 46) were converted into standard scores. The split-half reliability coefficient in developmental age (4–18 years) was 0.87.

Working memory

Working memory was assessed through two subtests of WISC-IV (*Wechsler Intelligence Scale for Children*—Fourth edition; Orsini et al., 2012; Wechsler, 2003): Digit span and letter-number sequencing. These two tasks allow defining a composite working memory index. The child was asked to listen and repeat 3–9 digits forwards and 2–9 digits backward. The test–retest reliability was $r = 0.79$ for digits forwards and $r = 0.73$ for digits backward (Orsini et al., 2012). In the letter-number sequencing, children are asked to listen to a string of digits and letters read aloud, then recall the information by repeating the numbers in chronological order, followed by the letters in alphabetical order. The test–retest reliability was $r = 0.88$.

Sustained attention

We administered the sustained attention task from the Leiter International Performance Scale-Revised (Leiter-R; Roid & Miller, 2002, Cornoldi et al., 2016, Italian version). Children were asked to cross out as many objects matching the target as possible, without accidentally crossing out any other objects, given a limited amount of time. The number of correct hits was scored according to the manual. Cronbach's alpha coefficient was 0.83 for children 8–10 years; the reliability coefficient for the total sample was $\alpha = 0.87$.

5.2.3 | Decoding and reading comprehension

Decoding

To assess baseline's measures of decoding skills, participants read aloud four lists of words ($n = 112$) and three lists of nonwords ($n = 48$) from BVDDE-2 (Battery for the Assessment of Developmental Dyslexia and Dysgraphia—2; Sartori et al., 2007), reading speed (syllables per second) and accuracy were measured. Reported test–retest reliability is 0.77 for reading speed and 0.56 for accuracy.

Reading comprehension

The MT Comprehension Test for primary schools and middle schools (Cornoldi & Carretti, 2016) was administered. Participants were asked to read carefully a story—suitable for their age—taking as much time as they need. Immediately after reading, participants were given 10 multiple-choice questions, and they were allowed to go back to text. Total scores ranged from 0 to 10. Reliability scores ranged from 0.71 to 0.84 (Cronbach alpha).

5.2.4 | Mind wandering

At the beginning of the session, children were familiarized with the concept of MW through a set of questions proposed orally by the experimenter, who helped the child in responding when necessary. Questions and examples were about what it means to be On Task or Off Task while reading. The questions were: 1) *When you read a text and think of something that happened to you yesterday with a friend, are you focused on the text?*; 2) *If you reflect on the meaning of a passage's sentence, are you paying attention to what you are reading?*; 3) *If you think about what you ate last night while you are reading, do you think you are focused on the text?* 4) *If, after having read a page of a book, you cannot make a summary of what you read, do you think you have been focused?*

Then, three questionnaires assessing the disposition to mind wander were administered:

1. The Mind Wandering Questionnaire (MWQ; Mrazek et al., 2013) is a 5-item self-report measure of the *frequency* of mind-wandering, irrespective of whether mind-wandering is deliberate or spontaneous. Items for the MWQ were written in simple language, and it has also been used with young participants. Response options were designated along a 6-point Likert scale from 1 (almost never) to 6 (almost always). Examples of items include 'I have difficulty maintaining focus on simple or repetitive work' and 'While reading, I find I haven't been thinking about the text and must therefore read it again'. Scores were from 6 to 30, and reliability was 0.84 (Cronbach's alpha).
2. The Attention Related Cognitive Errors Scale (ARCES; Carrière et al., 2008) measures the frequency of attention-related errors in daily life due to absentmindedness/MW. The questionnaire includes 12 items that propose daily errors like 'I have gone to the fridge to get one thing (e.g., milk) and taken something else (e.g., juice)' and 'I fail to see what I am looking for even though I am looking right at it' for which the participants are asked to rate the frequency with which they experience them on a 5- point scale, ranging from 1 (never) to 5 (very often). The total score on the ARCES was used as a trait measure of MW level in daily life. Scores were from 1 to 60, and reliability on the present sample was 0.74 (Cronbach's alpha).
3. The Mindful Attention Awareness Scale modified for Children (MAAS-C; Lawlor et al., 2014) assesses the lack of attention and awareness in daily situations. It consists of 15 items such as 'I could be feeling a certain way and not realize it until later' and 'I break or spill things because of carelessness, not paying attention, or thinking of something else'. Questions were answered on a 6-point scale ranging from 1 (almost never) to 6 (almost always). Minimum and maximum scores ranged from 15 to 90, reliability was 0.76 (Cronbach's alpha).

5.2.5 | Emotional correlates

The test of anxiety and depression (TAD; Newcomer et al., 1995) was administered. It is a 22-item questionnaire, which requires responses on a 4-point Likert scale from 1 (never) to 4 (almost always). In the scoring, 11 items contribute to the definition of an index of depression, while the remaining 11 furnish an index of anxiety. Raw scores were transformed into standard scores according to the test manual. The reliability for this scale was 0.82 (Cronbach's alpha).

Finally, an ad hoc questionnaire was developed for the purposes of the present study in order to ascertain involvement in the study and physical and psychological wellbeing on the day of the experiment. It included the following 6 questions: 1. *I enjoyed doing these tests*; 2. *I concentrated during these tests*; 3. *Today I feel rested*; 4. *Today I feel fine physically*; 5. *Today I feel cheerful*; 6. *Today I feel calm*. Students answered these questions on a 5-point scale ranging from 'not agree at all' to 'absolutely agree'. Scores ranged from 8 to 40, and the scale's reliability was 0.69 (Cronbach's alpha).

5.2.6 | Experimental session

Participants were presented on a PC monitor two narrative texts followed by 10 reading comprehension questions each. The experiment was run on the E-Prime software V. 2.0.10.356 (Schneider et al., 2002). Children read each sentence silently (self-paced reading condition—SPR), or they heard the text-to-speech audio while each word became highlighted in yellow in correspondence to the audio (text-to-speech condition—TtS). The recorded voice was from the second author of the study. The Text-to-Speech condition was realized by matching the audio of each word with the corresponding written word through E-Prime software. In both conditions, they were asked to press the space bar to the next slide. At unpredictable intervals, they were required to respond to the sampling probe: 'How much are you focused on the task?' along a 5-point Likert scale from 1 (not at all) to 5 (very much), by pressing with the mouse the square corresponding to the chosen number. The probe-caught method is one of the most widely used methods for collecting MW occurrence (Weinstein, 2018). Then, they were presented 10 multiple-choice reading comprehension questions, according to the same modalities of text presentation (SPR, TtS). They responded by pressing with the mouse on the correct option. Outcomes variables considered were (1) reading comprehension, expressed in a proportion of correct answers on the 10 comprehension questions (range 0–1), (2) reading speed, referred to the mean number of syllables per second for reading each text in the SPR condition, and (3) mean probe score, that is the mean score at the eight sampling probes assessing the focus on the task. The two texts were 'Lo scudiero del re' [The king's squire] (Text A) and 'Ladri con le biglie' [Thieves with marbles] (Text B) and were taken from the ALCE Battery (Bonifacci et al., 2014), a standardized tool for the assessment of reading and comprehension in developmental age (for a full description see: Tobia et al., 2017). The two texts were similar in length (Text A: 289 words; Text B: 294), text readability (Gulpease index; Text A: 45,2; Text B: 51,1), and comprehension difficulty (Mean accuracy scores from the test's manual: Text A = 12.36 ± 3.96; Text B: 12.57 ± 3.33). Reliability scores for the two texts were: 0.63 and 0.56 (Cronbach's alpha). Texts were written in sans-serif typeface (Bianconero Edizioni), and font size, inter-letter, and line spacing have been adapted based on guidelines for designing dyslexia-friendly content (Schiavo & Buson, 2014). The first text was divided into 16 short sections while the second one into 13 short sections (mean words length for each section Text A = 19; Text B = 24). The TtS condition was realized by recording the audio of each word (second author) and by matching audio and word through E-prime to reconstruct the complete sentence. This technique has allowed recreating the typically mechanical voice, without a particular intonation, which distinguishes most speech synthesis programs. Reading speed in the TtS condition was about 3.83 syllables/s. The text also featured the 'karaoke' function, allowing words to progressively highlight as they were read. The TtS condition was pilot-tested with two SLD children to assess its comprehensibility and accessibility prior the study took place. This pilot test served to troubleshooting the entire procedure and adjust the speed at which the speech-synthesis read aloud the text. The data of the SLD children involved were not included in the final analyses.

The comprehension questions presented the same characteristics of reading modalities as for the referenced passage. Text presentation modality was a within-subject condition, and a pseudorandom order of presentation was adopted. It considered text type (A, B) and modality (TtS; SPR) across four combinations (1: text A TtS + text B SPR; 2: Text A SPR + Text B TtS; 3: text B TtS + text A SPR; 4: Text B SPR + Text A TtS). Therefore, each participant read one passage in SPR conditions and the other with TtS, and outcomes variables were computed separately for the two conditions.

5.3 | Procedure

The study took place in individual form, mainly at participants' home, in a quiet room. The complete battery of tests lasted about 90 min. Parents completed the consent form and the questionnaire on socio-demographic information. Participants were first administered cognitive tests, decoding and reading comprehension assessments, and finally questionnaires on emotional variables. The questionnaires to measure participants' MW levels in daily life (ARCES, MAAS-C), were administered immediately after the examples given to familiarize with the MW construct. The MWQ was administered twice, before and after the experimental session, and the mean scores were considered in data analysis in order to have a more consistent measure of dispositional MW. Finally, participants performed the experimental task.

5.4 | Data analysis

t Tests were run as preliminary analyses for exploring any difference based on the order of presentation modality (TtS vs. SPR), Text order (AB vs. BA) and type of text (A vs. B), in reading comprehension and probe scores (MW) as dependent variables, in order to exclude main effects of type of text and order of modality/text presentation. A series of analysis of variances (ANOVAs) and multivariate analyses of variance (MANOVAs), with Group (SLD vs. TD) as a between-subject factor, were run as preliminary analysis in order to identify group differences in the cognitive tasks and in the questionnaires administered. Then, in order to investigate the effects of the experimental manipulation on decoding, reading comprehension, and focusing skills, a series of 2 × 2 repeated measures ANOVA was run, with Reading condition (SPR vs. TtS) as within-subject factor and Group (SLD vs. TD) as between-subject factor. Dependent variables were reading comprehension, reading speed (for the self-paced condition), and the mean probe score. Finally, correlations analyses among all the study's variables were run for exploratory purposes.

6 | RESULTS

6.1 | Preliminary analysis

Results of preliminary analysis revealed non-significant differences based on order of presentation modality ($ts(68) = 0.477$–1.024, $ps = 0.310$–0.636), Text order ($ts(68) = -1.483$– -0.238, $ps = 0.143$–0.813) or type of text ($ts(68) = -0.226$–1.396, $ps = 0.167$–0.822), for both reading comprehension and probe scores (MW). Descriptives of the cognitive and reading tasks, and of the questionnaires' scores, obtained by children with SLD and TD, are shown in Table 1, together with the univariate results of the ANOVAs and MANOVAs.

The MANOVA run on the four reading *z*-scores (speed and accuracy of word and nonword reading) showed a significant multivariate Group effect, $F(4, 65) = 11.118$, $p < 0.001$, $\eta^2 = 0.527$, with the SLD group showing a worse performance in all the indices considered (see Table 1). Also, the working memory index was higher in the TD group. However, similar scores were found for reading comprehension, non-verbal IQ, and for the sustained attention task. The analysis of the questionnaires' scores revealed similar levels of internalizing symptoms measured with the TAD, as shown by the non-significant Group effect, $F(2, 67) = 0.776$, $p = 0.464$. Similarly, no significant differences between groups were found in the questionnaires assessing MW.

6.2 | Main analysis

The repeated-measures ANOVA run on reading comprehension as a dependent variable (Figure 1) revealed a significant effect of the Reading condition, $F(1, 68) = 5.634$, $p = 0.021$, $\eta^2 = 0.076$, with an overall more accurate reading comprehension performance in the text-to-speech condition. A tendency to significance was found for the Group effect, $F(1, 68) = 3.907$, $p = 0.052$, $\eta^2 = 0.054$, showing weaker reading comprehension accuracy in children with SLD. The Reading condition × Group interaction was non-significant, $F(1, 68) = 0.046$, $p = 0.830$.

The analysis of the mean probe score (Figure 2) showed a significant effect of the Reading condition, $F(1, 68) = 15.358$, $p < 0.001$, $\eta^2 = 0.184$, with globally lower scores in the self-paced reading condition, indicating that students were more vulnerable to MW in the self-paced condition compared to the text-to-speech condition. The

TABLE 1 Descriptives of the cognitive and reading tasks, and of the questionnaires' scores, obtained by children with specific learning disorders (SLD) and typical development (TD)

		SLD	TD	Univariate results	
Variables		***M* (SD)**	***M* (SD)**	***F*(1,68), *p***	η^2
SES	Socio-economic status	36.40 (13.65)	41.05 (11.36)	2.129, 0.149	/
Cognitive	Working memory index	92.58 (10.97)	107.74 (14.96)	16.149, <0.001	0.194
	Sustained attention	9.75 (2.63)	9.98 (2.35)	0.128, 0.722	/
	Non-verbal IQ	102.70 (17.69)	107.52 (13.84)	1.472, 0.229	/
Reading z-scores	Word reading—Sill/second	−1.41 (1.14)	−0.13 (0.80)	28.401, <0.001	0.295
	Word reading—Accuracy	−1.13 (1.23)	0.24 (0.80)	30.127, <0.001	0.307
	Non-word reading—Sill/second	−0.95 (0.98)	0.03 (0.78)	19.422, <0.001	0.222
	Non-word reading—Accuracy	−0.82 (1.07)	0.52 (0.72)	36.749, <0.001	0.351
	Reading comprehension	−0.31 (1.04)	−0.08 (1.00)	0.768, 0.384	/
Questionnaires	TAD—Anxiety	100.75 (13.11)	103.80 (12.96)	0.786, 0.378	/
	TAD—Depression	98 (10.93)	97 (12.41)	0.099, 0.754	/
	ARCES	31.85 (7.16)	32.58 (6.68)	0.163, 0.688	/
	MAAS-C	34.85 (6.93)	35.48 (8.13)	0.092, 0.763	/
	MWQ—Mean score PP	14.12 (3.97)	14 (4.43)	0.012, 0.913	/
	Study questionnaire	24.35 (3.76)	23.78 (4.14)	0.284, 0.596	/

Abbreviations: ARCES, Attention Related Cognitive Errors Scale; MAAS-C, Mindful Attention Awareness Scale modified for Children; MWQ, Mind Wandering Questionnaire; SES, socioeconomic status; TAD, test of anxiety and depression.

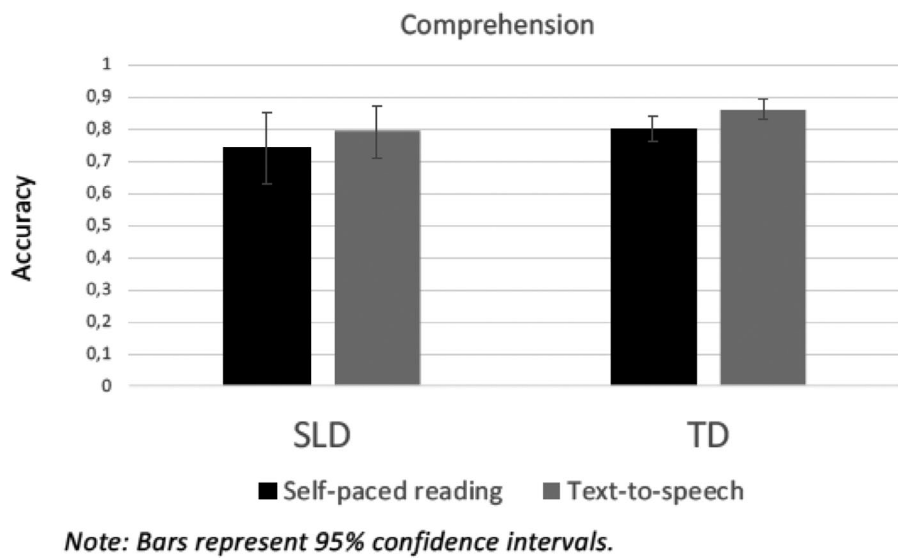

FIGURE 1 Reading comprehension performance for children with specific learning disorders (SLD) and typical development (TD) in the self-paced reading and text-to-speech conditions. Bars represent 95% confidence intervals

main effect of Group was not significant, $F(1, 68) = 1.618$, $p = 0.208$. On the contrary, a significant interaction Reading condition × Group interaction was found, $F(1, 68) = 8.488$, $p = 0.005$, $\eta^2 = 0.111$, showing similar probe scores for the two groups in the text-to-speech condition, and a significantly lower probe score for the SLD group in the self-paced reading condition.

As for text reading speed, Reading condition was significant, $F(1, 68) = 9.663$, $p = 0.003$, $\eta^2 = 0.124$, with a global faster reading in the self-paced reading condition. Also the Group effect was significant, $F(1, 68) = 15.843$, $p < 0.001$, $\eta^2 = 0.189$, with TD children being faster than children with SLD. However, as showed by the significant Reading condition × Group interaction, $F(1, 68) = 14.421$, $p < 0.001$, $\eta^2 = 0.175$, children with SLD read as fast as TD children in the text-to-speech condition (3.46 ± 0.54 sill/s and 3.46 ± 0.48 sill/s, respectively), but they were significantly slower in the self-paced reading condition (3.03 ± 0.85 sill/s and 3.40 ± 0.59 sill/s, respectively). The similar performance in the text-to-speech condition is related to the use of the same pace of reading by speech synthesis.

Pearson correlations were run among all the study's variables (Table 2); for being conservative, only correlations significant at $p < 0.01$ have been considered.

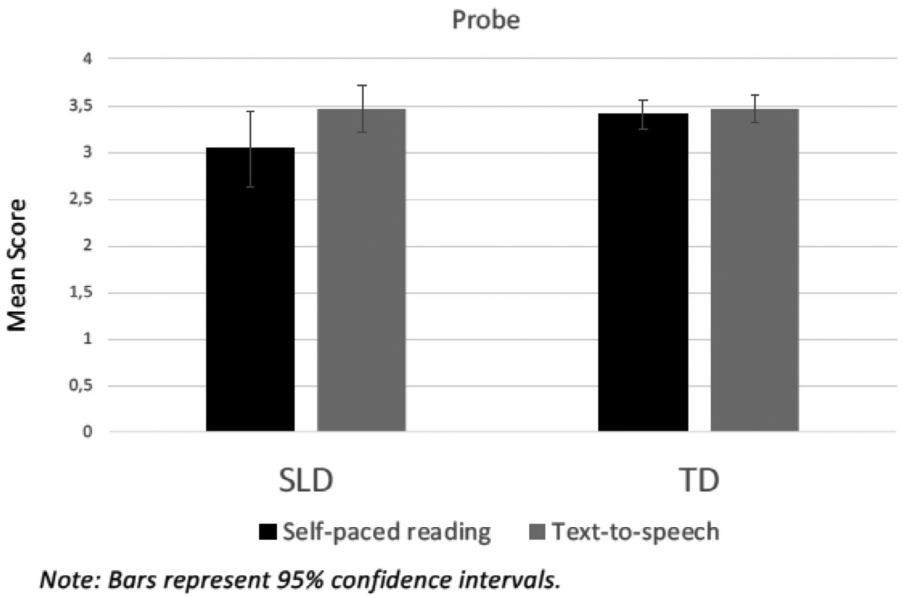

FIGURE 2 Probe scores for children with specific learning disorders (SLD) and typical development (TD) in the self-paced reading and text-to-speech conditions. Bars represent 95% confidence intervals

First, significant associations between the measures of reading comprehension collected during the experiment and the reading comprehension baseline collected via the standardized (MT) test were found. Similarly, reading speed in the self-paced reading condition was significantly related to children's performance in the word and nonword reading tasks. Regarding the associations between the two probe scores collected during the experiment and the MWQ, a significant association was found only for the self-pace reading condition. Working Memory Index was related to reading comprehension (text-to-speech), reading speed (self-paced reading), most measures of standardized reading skills, and baseline reading comprehension, but not to MW measures (probes and questionnaires). MW questionnaires (MWQ, ARCES, MAAS-C) were related to anxiety and depression, but anxiety and depression were not related to MW probes. Finally, SES did not show significant relationships with other study's measures, except with word reading accuracy.

7 | DISCUSSION

The present study aimed to evaluate MW during reading comprehension tasks in children with dyslexia and typical readers peers, accounting for the effects of two different reading modalities, namely self-paced reading and text-to-speech. More specifically, the study had three main objectives: 1) to evaluate differences in MW (and reading comprehension) between the two groups; 2) to evaluate the effect of different reading modalities on reading comprehension and MW; and 3) to evaluate differential effects of reading modality on reading comprehension and MW in the two groups.

In contrast to our first hypothesis (H1), children with dyslexia did not show increased rates of MW compared to typical readers, neither as a main effect in the experimental condition (probes) nor in the MWQ or in the two additional questionnaires assessing MW correlates: ARCES and MAAS-C.

It has, however, to be underlined that children with SLD showed more MW in the self-paced reading condition compared to the text-to-speech condition (see below). Therefore, results allow suggesting that MW as a dispositional trait might not be influenced by a reading disorder, whereas children with dyslexia might be more prone to MW during self-paced reading, possibly due to disfluency, weaknesses in working memory or to a higher perceived text difficulty. The tendency to mind-wander seems more related to emotional traits, as evidenced in previous literature (Desideri et al., 2019; Seli et al., 2019) and from correlation analyses in the present study. Indeed, in the present study, only MW dispositional measures but not probes were related to anxiety and depression (Desideri et al., 2019; Seli et al., 2019). Therefore, it might be hypothesized that mood disorders might detract additional resources from working memory, leading to having one's mind engaged in negative thoughts during cognitive tasks. A previous study assessed rumination in children with SLD (Bonifacci et al., 2020). Rumination can be considered a proxy of MW, with the difference that the first is focused on negative and repetitive thinking, whereas, in the second, thoughts might be both positive and negative (Ottaviani et al., 2015). The Bonifacci et al. (2020) study showed that children with SLD had higher rumination scores only regarding the social domain (repetitive thinking about social failures) but not when considering the scholastic, familiar, and personal domains. This is in line with results from the present study, suggesting that dyslexia is not directly related to increased MW, but that this relationship might emerge under specific conditions.

As regards reading comprehension (H2), partially in contrast with our hypothesis, children with dyslexia showed a heterogeneous profile. They did not show differences in the baseline standardized reading comprehension task but showed a tendency towards lower scores in reading comprehension in the experimental task than TD peers. Previous literature highlighted that children with dyslexia are at higher risk of reading comprehension deficits, but this is best viewed as an additional difficulty rather than a core deficit (Snowling et al., 2020).

TABLE 2 Pearson correlation among all the study's variables

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1) Reading comprehension—Self-paced reading	0.375**	0.220	0.062	0.053	0.18	0.061	0.195	0.009	0.245	0.375**	0.222	0.307	0.017	0.017	−0.026	0.103	0.023	−0.045	−0.036
2) Reading comprehension—Text-to-speech		0.200	0.033	0.139	0.040	0.244	0.298	0.086	0.289	0.366**	0.235	0.354**	0.140	−0.016	−0.013	0.161	0.058	−0.008	0.126
3) Mean probe score—Self-pace reading			0.696**	0.069	0.184	0.228	0.315**	0.253	0.149	0.136	0.043	0.066	−0.192	−0.381**	−0.097	−0.114	−0.238	−0.219	0.021
4) Mean probe score—Text-to-speech				−0.095	0.101	−0.022	0.131	0.070	0.011	0.088	0.069	−0.100	−0.104	−0.124	−0.033	−0.064	−0.159	−0.138	0.361**
5) Reading speed sill/second—Self-paced reading					0.137	0.463**	0.390**	0.455**	0.412**	0.243	0.020	0.368**	0.126	−0.049	0.082	−0.031	−0.052	0.035	0.335**
6) SES						0.207	0.377**	0.183	0.218	0.142	0.155	0.191	0.006	−0.216	−0.031	−0.082	−0.246	−0.197	−0.043
7) Word reading—Sill/second							0.418**	0.718**	0.277	0.12	0.101	0.398**	0.044	−0.116	−0.124	−0.008	−0.038	−0.088	0.131
8) Word reading—Accuracy								0.295	0.619**	0.169	0.183	0.354**	0.056	−0.139	−0.155	−0.137	−0.086	−0.138	−0.045
9) Non-word reading—Sill/second									0.257	0.089	0.106	0.294	−0.006	−0.087	0.039	0.077	−0.02	−0.166	0.113
10) Non-word reading—Accuracy										0.041	0.151	0.414**	0.105	0.055	0.036	0.027	0.067	−0.022	−0.136
11) Reading comprehension											0.280	0.384**	0.169	−0.013	−0.021	0.19	0.055	−0.057	−0.051
12) Non-verbal IQ												0.305	0.364**	0.242	0.053	0.129	0.153	0.15	−0.225
13) Working memory index													0.300	−0.014	−0.003	0.259*	0.008	−0.017	−0.112
14) Sustained attention														0.129	0.105	0.274	0.134	0.249	−0.208
15) MWQ—Mean score PP															0.473**	0.384**	0.677**	0.738**	−0.242
16) TAD—Depression																0.501**	0.511**	0.521**	−0.079
17) TAD—Anxiety																	0.508**	0.428**	−0.115

(Continues)

TABLE 2 (Continued)

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
18) ARCES																		0.713**	−0.184
19) MAAS-C																			−0.095
20) Study questionnaire																			

Abbreviations: ARCES, Attention Related Cognitive Errors Scale; MAAS-C, Mindful Attention Awareness Scale modified for Children; MWQ, Mind Wandering Questionnaire; SES, socioeconomic status; TAD, test of anxiety and depression.

** $p < 0.01$ (two-tailed).

Of note, reading and comprehension tasks were related between the baseline and the experimental conditions, supporting the validity of the measures used.

In addition, children with dyslexia did not differ in anxiety and depression levels compared to their TD peers. Considering their cognitive profile, as measured by baseline tasks, they showed adequate IQ and attention skills, but lower scores in all reading tasks and in the working memory index. On the one side, this profile confirms the robustness of diagnostic classification and the weaknesses in working memory associated to reading impairments reported in previous literature (Giofrè et al., 2017; Swanson et al., 2009). The absence of differences in anxiety and depression scores compared to TD peers seems to be in contrast with previous evidence that reported a higher incidence of emotional disorders in SLD (Francis et al., 2019; Ghislanzoni et al., 2020). However, some studies found that, when considering self-administered measures and not parents' reports, there were no differences in anxiety and depression scores between children with SLD and TD peers (Bonifacci et al., 2016; Rotsika et al., 2011).

The third hypothesis (H3) was related to the effects of reading modality on reading comprehension scores and MW. It was found that in the text-to-speech condition, both groups showed better reading comprehension scores and reduced rates of MW, although in the latter case, this was better explained by the Group × Modality interaction. Considering the effect of reading modality on reading comprehension, our pattern of results is consistent with current evidence showing that coupling written text with read-aloud solutions might benefit reading comprehension in students with reading difficulties (Li, 2014; Perelmutter et al., 2017; Wood et al., 2018). On the other hand, they partially contrast with Kopp and D'Mello (2016), who did not find differences in MW between text-to-speech and self-paced reading. However, as discussed in the following paragraphs, the difference between the two reading modalities was mainly observed in children with dyslexia; therefore, results on children with TD are similar to what was found by Kopp and D'Mello (2016).

Regarding the fourth hypothesis (H4), results evidenced similar positive effects in reading comprehension brought about text-to-speech for children with dyslexia and typical readers. This further suggests that the text-to-speech condition possibly allows focusing cognitive resources on reading comprehension. There was indeed an improvement in children with dyslexia as already shown by previous evidence (for a review, see, e.g., Wood et al., 2018), but this result is also in keeping with current evidence showing that both students with and without reading difficulties might benefit from reading supports (Li, 2014). The present pattern of results, therefore, suggests that text-to-speech reading is a useful modality for improving reading comprehension in children with reading impairments, who reach similar scores compared to typical readers in the self-paced reading condition. However, it might not be sufficient to allow them to reach typical readers performance if all children are given the same tool.

Finally, and most notably, the fifth hypothesis (H5) was confirmed; the text-to speech condition showed a significant Group × Modality interaction when MW probes were considered as a dependent variable. Children with dyslexia were significantly more on task in the text-to-speech condition compared to the self-paced reading condition. In the text-to-speech condition, children with dyslexia had similar scores of being on task as typical readers. This suggests that alleviating the cognitive load associated with decoding in children with dyslexia would allow them to be more on task, or, conversely, being involved in decoding increases the likelihood of engaging in MW. As we saw before, being free from the decoding load also increases their comprehension scores, although not sufficiently to reach typical readers' performance. Taken as a whole, these results suggest that text-to-speech might represent a reading solution that not only supports all children in achieving adequate comprehension performance but also allows children with dyslexia to shield their attentional resources from distraction that might originate from task-unrelated thoughts (i.e., MW). Future research might expand the role of reading modality on MW and reading comprehension to other populations that may benefit from the use of text-to-speech solutions, such as children with attention deficit hyperactivity disorder (ADHD), for whom previous evidence (Frick et al., 2020) reported significantly increased rates of MW. Specifically, our results align with those from a prior study in which post-secondary students ($n = 20$) with a primary diagnosis of attention disorder reported that they experienced (a) reduced zoning-out and (b) improved focus on reading for longer periods when they used text-to-speech solutions (Hecker et al., 2002). However further investigations involving larger samples are needed to understand the relationship between ADHD diagnosis/symptoms, reading comprehension performance, and reading modality in students of different age ranges (Grunér et al., 2018).

Correlation analyses further highlighted that reading and comprehension measures were also mostly related to working memory (Giofrè et al., 2017; Swanson et al., 2009), which, in turn, and in contrast with previous evidence involving only typically developing participants, was not related to MW measures (McVay & Kane, 2012). Also, support for the correlation between trait MW and probes was found for the self-paced reading condition (Stawarczyk et al., 2014; Varao-Sousa & Kingstone, 2019). Finally, SES did not show significant relationships with other study's measures, except with word reading accuracy, suggesting that demographic variables did not significantly influence the results of the present study.

Some limitations of the study need to be acknowledged. First, text length was relatively short, which might have impacted the absence of differences in MW between the two groups considered. Secondly, the sample size did not allow for the development of mediation models between emotional dispositions, cognitive traits, and MW and further research would be needed in this regard, particularly for children with dyslexia. Third, we did not control for a variety of intervening factors that may influence both reading comprehension and MW in typical readers, such as topic interest and text difficulty (Babbitt Bray, & Barron, 2004; Kahmann et al., 2021; Soemer & Schiefele, 2019). Future research involving SLD students may include these factors as independent variables to explore further the conditions under which text-to-speech software modulates the occurrence of MW. Fourth, students' reading texts presented on screen are usually provided with accessibility features to improve the readability of the written material. Examples of such features include the possibility of changing the size, colour and font of the text, line-spacing and text-background contrast (Schiavo & Buson, 2014). Moreover, in most commercially available text-to-speech software, the speed at which the speech-synthesis reads the text can be controlled by the user. However, for practical reasons, we did not allow the participants to adjust such features according to their preferences in this study. Consequently, it remains an open question whether providing the reader with the possibility to access the text according to his/her accessibility preferences could change the occurrence of MW in both experimental conditions as observed in this study in which only a standard text and speech-synthesis were available. Finally, we did not assess the extent to which participants were familiar with assistive technologies; therefore we cannot exclude that novelty and familiarity effects might had an impact on their performance.

Despite its limitations, this study is, to our knowledge, the first empirical study that documents the effect of an assistive solution on the internally generated thoughts that may divert the students' attention away from the task at hand. In addition, this is the first contribution that evaluated MW traits and during reading comprehension tasks in children with dyslexia, and results suggested that having a reading impairment, per se, is not directly associated with higher MW occurrence. Given the little attention paid by researchers so far to the relationships between dyslexia, MW and text-to-speech solutions, the current study results need to be carefully interpreted before suggesting reliable implications for practice. Future studies may build on current results to first explore the impact of text-to-speech technologies on MW, particularly for children with SLD and other neurodevelopmental disorders, over a longer period of use (e.g., academic year) to ensure that any benefit from such solutions is not due to any 'novelty effect'. In addition, taking a user-centred approach to the understanding of the effect of technology on student's performance, future research efforts might be aimed at exploring the effects of text-to-speech solutions when used in a variety of contexts (e.g., while studying at home or in the classroom) and conditions (e.g., with students studying in small groups or individually).

To conclude, the present study, in line with other evidence (Mills et al., 2021), suggest that technologies might help in ameliorating reading comprehension and reducing MW; this is particularly important for people with learning disorders as well as their educators, who should be informed about potential benefits of technologies for compensating their weaknesses and bringing out their potential. These technologies should be viewed as complementary to rehabilitation and education practices to provide students with support in real life situations within personalized solutions that target their specific needs. On certain occasions such as long/difficult texts or low levels of motivations, text-to-speech solutions might be proposed to all students and not only to students with dyslexia.

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CONFLICT OF INTEREST

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

PEER REVIEW

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DATA AVAILABILITY STATEMENT

The data presented in this study are openly available in Open Science Framework (DOI: 10.17605/OSF.IO/9JVG) and can be accessed online: https://mfr.osf.io/render?url=https://osf.io/b56gr/?direct%26mode=render%26action=download%26mode=render

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