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Show me What You Mean:

Inclusive Augmented Typography for Students with Dyslexia

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Abstract

Augmenting the visual appearance of continuous text may contribute to more inclusive and effective learning opportunities for university students with dyslexia (SwD). This neurodiverse population remains largely reliant on reading tools developed for "typical" readers. Although SwD find reading slower, more tiring, and more difficult, they are also known to use deep learning approaches, which may be assisted by inclusive, custom typographic and layout systems. While printed texts offer only one typographic presentation and make limited use of visual cues, the affordances of digital reading tools could result in multiple visual adaptations to suit individual needs, preferences, and reading strategies. This could be achieved with networked devices using artificial intelligence (AI) to read the content in texts, and by applying typography and layout modifications in response. A human-centered, ethically informed approach is required to conceptualize and design inclusive reading systems of this sort. This paper identifies and explores key ethical questions and practical implications raised by the hypothesis that incorporating AI into reading tools and visually adapting texts could facilitate more inclusive reading and learning experiences, and better meet the educational requirements of SwD.

Keywords

Inclusive Design
Augmented Typography
Dyslexia
Artificial Intelligence

Context

Dyslexia is a lifelong condition associated with difficulties in literacy acquisition and effective reading, which is believed to occur in 10%–15% of the population worldwide (Snowling, 2000; Vellutino & Fletcher, 2008). Individuals who have specialized learning needs, such as dyslexia, are enrolling in university programs in growing numbers (Callens et al., 2014), but their needs are not always adequately understood or met (Ryan, 2007). Universities report a limited uptake of assistive reading software[1] due to low awareness of available support, unsuitability of the support on offer, and some students with dyslexia (SwD) choosing not to seek help (MacCullagh et al., 2017).

Importantly, SwD demonstrate sufficient cognitive capacity to complete secondary school and earn a place in university undergraduate programs despite reading being more challenging for them (Bergey et al., 2017). They achieve this by developing and drawing on compensation strategies—self-regulated learning strategies such as organization, elaboration, and monitoring skills; greater reliance on time management; and the use of social skills (Pino & Mortari, 2014). Higher than usual levels of organization and time management help SwD manage workloads (2014, p. 359). Elaborating on textual content, using mind-maps, color-coded notes, and monitoring progress in learning are important strategies used to ensure that information is understood (p. 358a). Reliance on peers, tutors and family members is also a helpful way to clarify and focus knowledge acquisition for SwD (p. 358b). These students are "a select group, with better than average coping skills" (Callens et al., 2012) and their experiences with reading and learning, determination, and self-efficacy (Bandura, 1997) provide valuable insights that can inform the typography of digital texts. It is crucial to consider the preferences, needs, and capabilities of SwD if texts are to be designed and used more effectively (Thiessen, 2012, 2013). The ethical obligation to design inclusive typographic interfaces for SwD can be informed by using human-centerd design principles, methods, and processes (Buchanan, 2001), in this case considering a specific subset of "human diversity with respect to ability" (Mitchell & Treviranus, 2017).

Typographic design and layout are integral to reading as they can aid readability and legibility through the interplay of typeface selection, type size and weight, color, shape, line, and the use of space in documents (Schriver, 1997; Waller, 2012). For example, adjusting space between letters and words can impact reading speed and accuracy, particularly for readers with dyslexia (Perea et al., 2012; Zorzi et al., 2012), some of whom experience more visual crowding, which impedes

1 While the term is often used in a broader context, in this research, the term "assistive software" is limited to the use of electronic text adapted to suit the needs of those with reading difficulties and includes modifications to typography, background color, page size, and line length and can usually be read aloud by a digital device.

reading (Martelli et al., 2009; Spinelli et al., 2002). Typographic design that conforms to established legibility guidelines can reduce the time university students spend searching for information by facilitating or impeding "the speed and accuracy with which candidates move their eyes over the text in order to find key words" (Lonsdale, 2016, p. 84). Typography and layout can also impact readers' motivation to engage with texts. Moys (2014) demonstrated that "visual presentation of information can influence the assumptions readers make about information and the attitude and engagement strategies they may choose to adopt" (2014, p. 42), and argued that "typographic meaning is created through clusters of interrelated attributes" (p. 63). It may be beneficial to design typographic systems to suit different reading strategies, tasks, and abilities, instead of one version in which all text in a document remains visually consistent.

SwD read more slowly and less accurately (Jamieson & Morgan, 2007; Olofsson et al., 2012), yet suitable reading speed and skill aid comprehension, which is important because "to understand text in a meaningful way, skilled comprehenders build a representation of the meaning of a text that is accurate and coherent" (Cain, 2010, p. 74). Beyond skilled comprehension, university students use texts to learn, as bachelor degree students are expected to "demonstrate autonomy … in contexts that require self-directed work and learning" (2013, p. 13). Without the ability to effectively comprehend texts, self-directed learning is unattainable. Further, high-level autonomous learners require text that is "highly complex [with] highly embedded information [and] highly specialised language and symbolism" (2012, p. 7). Reading for learning requires good comprehension, but comprehension alone is not enough. Reading to learn entails interaction between and throughout texts, and requires the activation of prior knowledge, as well as appropriate attitudes, reading skills, and a variety of learning strategies (Kendeou & Trevors, 2012).

Two approaches to learning, deep-level and surface-level, are each informed by predispositions and beliefs held about learning and both influence the strategies and tactics students adopt (Marton & SäLjö, 1976). The deep-level approach, focused on the concepts and content within learning material, is described as "learning that lasts a lifetime" (Hermida, 2015, p. 17) resulting in "sustained, substantial, and positive influence on the way students act, think, or feel" (Bain, 2012). The deep-level approach helps facilitate transformative learning that can assist autonomous thinking, described by Mezirow as "the essence of adult education" (1997, p. 11). In contrast, a surface-level approach to learning, focused on the text itself as opposed to the concepts it explicates, results in limited understanding, with information usually forgotten soon after examinations or assignments. Using the Study Process Questionnaire (Biggs et al., 2001) to measure which approach students use, Kirby et al. found that SwD "reported a deeper approach to learning" (2008, p. 93) than students without dyslexia, arguing that this "may reflect the difficulty that these students have with memorizing details, but it is also evidence of a commitment to high-quality educational outcomes" (p. 94). This deeper approach to learning was interpreted as a positive compensation for reading difficulties, partly in response to the challenges associated with slow word reading that interfere with comprehension and working memory. Deep learning is metacognitively taxing because "the learner must access higher-order cognitive and metacognitive skills, processes, and competencies, which engage the frontal, integrative cortex of the brain" (Hermida, 2015, p. 20).

University students make use of two broadly defined types of reading; first, expeditious reading, which includes skimming content and searching for specific words or phrases; and second, careful reading, which is slower, focused on comprehension and making propositional inferences, and relies on ideas and details within and across texts (Weir et al., 2012). Careful reading alone is not adequate, because expeditious reading is required for skimming, scanning, and searching to process texts quickly and selectively (Weir et al., 2001). Expeditious reading is used to locate relevant information as a precursor for subsequent careful reading. Academic reading has often been considered analogous to careful reading, but the role of expeditious reading is acknowledged as being "just as critical for academic study" (Weir et al., 2012, p. 147). As such, when designing inclusive reading experiences, typographic designers should be paying attention to visual presentation for expeditious reading, as well as careful reading situations.

More specifically, university students undertake four types of reading that are more cognitively demanding than reading for entertainment: preparation for tests, text review for research purposes, class preparation, and reading to learn information (Lorch et al., 1993). Test preparation entails slowly, repeatedly reading select information in detail for memorization purposes (p. 246a). Reading for research involves close analysis of writing style and text content combined with critical thinking and reader inter-pretation (p. 246b). Class preparation is a faster and less detailed style of reading used to gain an overview (p. 247a), while reading to learn information is less focused on details and analysis of writing style but is slower than class preparation (p. 247b).

To effectively perform the abovementioned types of academic reading, particular strategies must be used: skimming to evaluate content and structure for relevance, scanning to locate specific information, search reading for topical information without knowing what to look for, receptive reading from beginning to end without critical appraisal, and responsive reading to develop new knowledge (Pugh, 1978). It may be helpful to visually augment and adapt typographic presentations to suit these five strategic approaches. For example, while searching texts for key words, SwD may use functions like pressing the Control + F keys on a computer keyboard (which launches the "Search/Find" function) to support the task instead of more traditional manual strategies like scanning texts to locate useful information themselves (Casselden & Pears, 2019). Instead of merely highlighting specific words or phrases via Control + F, texts could be altered to make expeditious reading more effective, by highlighting key paragraphs using visual cueing methods such as color, space, indents, type weight, type size, or italics. This requires texts to be read in advance and visually adapted using networked digital devices employing artificial intelligence (AI). Integrating technology into the reading and learning processes in this way provides potential benefits, and risks, which need to be considered and addressed when designing digital typographic systems to support the learning objectives of SwD. The questions related to these are raised and discussed in the following sections.

Designing to Support Learning for Students with Dyslexia

For the purposes of this paper, we define augmented typography as the incorporation of multiple typographic mechanisms, facilitated using digital technologies, to enhance meaning through adaptive designs. As people in this extraordinary cohort are working harder than others to learn while dealing with the tiring, time-consuming nature of reading with dyslexia, they are likely to benefit from typographic systems that may free up cognitive capacity to focus on higher-order learning and save time. Altering the visual appearance of texts to meet the needs of specific readers or particular reading strategies could provide a richer experience where "the goal of design is a seamless integration of human and technological capabilities" (Behymer & Flach, 2016, p. 114). Moys stated that "good information design needs to be personable, empathetic, and reassuring for users" (2017, p. 218). To achieve this, it is essential to incorporate human-centered design approaches informed by individual participants, situated behaviors, and field observations, while at the same time focusing on modular components of the problem at hand, to achieve resolution through small, incremental steps (Norman & Stappers, 2015).

Since screen reading was introduced, it has become clearer that the act of reading is both a "human-technological interaction" (van der Weel, 2011) and an "embodied" physical process involving the eyes and hands specifically (Mc Laughlin, 2015). A recent meta-analysis of literature comparing reading from paper to reading from screens concluded that while comprehension when reading from paper was a little better than reading from a screen, the gap between paper and digital has diminished since 2013 (Kong et al., 2018). The authors noted, however, that typefaces and spacing were not taken into consideration in their meta-analysis. A recent study comparing E Ink to print text found that reading speeds were comparable for both forms of media (Moys et al., 2018). The narrowing gap in performance between print and digital reading outcomes may be due to advances in screen technology and size, device aspect ratios, and typefaces designed for digital reading. Readers may also be using screens more often and thus increasing their familiarity and practice with digital devices.

Dubberly (2008) described a shift from a "mechanical-object ethos to an organic-systems ethos" (2008, p. 35) where design practice focuses on the generation of flexible solutions and services rather than the production of goods and visual artefacts. These approaches are demonstrated by the stark differences between a printed book, in which words are fixed in appearance and position, and a digital version of the same text, which can look different due to changes in display, font, type size, letter space, leading, paragraph spaces, and typographic arrangement across different screens. Print book typographers operate in a mechanical-object paradigm, selecting fonts and sizes that are applied consistently for all readers; by contrast, digital typography could use an adaptable organic-systems approach to produce a wide range of possible typographic options based on individual user preference and need.

Digital reading systems could allow readers to tailor text displays to meet their preferences and needs. Software applications present the same text—even when accessed from the same source on the internet—with their own typographic settings applied, allowing the internet to be extended beyond a single instance that would be seen on the original webpage. Davis (2012) described this as an extendable system. The internet is a primary example of an extendable system for digital reading because it can present the same content in a wide array of colors, sizes, typefaces, layouts, and software applications. Unfortunately, the widely used PDF format output of digitized books limits this potential, exemplifying Macdonald-Ross and Waller's (2000) argument that products are constrained by their production processes. The PDF format alters digitally created texts into imitations of printed books, limiting their digital affordances. E-books present a similar visual appearance to printed texts, albeit with slightly more flexibility in terms of typeface, type size, and background colors. Largely, PDFs and e-books are all that SwD can choose from when engaging with digital continuous text materials from university libraries (books and journal articles). In other words, SwD frequently use sophisticated computing devices to read as if they were constrained by the same print technology developed by Gutenberg in the 15th century.

Artificial intelligence

Artificial intelligence (AI) is increasingly used to read content in our emails, searches, text messages, and various other daily interactions. This relies on Natural Language Processing (NLP) models, of which the most prominent is BERT, which stands for Bidirectional Encoder Representations from Transformers (Devlin et al., 2018). Google uses BERT for almost every English text-based search it conducts because it "comprehends how a combination of words expresses a complex idea [and] understands words in a sequence and how they relate to each other" (Nayak, 2022). AI can read and comprehend texts, differentiating the potential meanings of words in a variety of contexts. Put another way, AI models can almost instantaneously perform tasks previously only achievable through concerted, skillful human effort. They can also share this information across networks, making digital reading devices capable of performing sophisticated reading tasks and potentially providing specific forms of assistance to SwD, in real time, on demand from any location where internet access is available. Cheaper, faster, and more consistently available than in-person human assistance, AI could be used to augment the reading and learning processes of SwD.

Because AI can read and understand, it can also be used to condense, reducing a text's length while retaining the gist of the content. This may save time for readers and reduce cognitive effort, both of which are potentially advantageous to SwD who read more slowly and in a more labored way. Fluent reading and good comprehension require automatic, effortless recognition of letters, spelling patterns, and words (Adams, 1994). Readers with dyslexia, however, demonstrate "slower, more effortful, less automatic" reading, even once they have developed relatively good literacy skills (Nicolson & Fawcett, 1990, p. 182). Automatization reduces the load placed on working memory because the "advantage of automaticity is that readers' attention can be devoted entirely to understanding the text rather than having it divided and distracted by decoding issues" (Ehri, 2005, p. 151). It is known that adults with dyslexia demonstrate a partial lack of these automatic skills, impacting their reading speed, accuracy, and comprehension (Nicolson & Fawcett, 2008). Condensed texts provided by AI may be beneficial to SwD by reducing the amount of content they need to read and thus time spent reading, which may be particularly advantageous when performing expeditious reading tasks that require skimming, scanning, and searching.

In attempting to design more inclusive reading solutions it is evident that a range of social, political, economic, psychological, and technical factors contribute to the complex sociotechnical system of which academic reading forms a part. The rapid increase in AI-driven content generation across a range of fields such as visual art, 3D imaging, engineering, music, reading, and writing has raised significant and important ethical questions. These have yet to be adequately resolved, partly due to the speed with which AI is progressing and being integrated (Mindzak & Eaton, 2021). The types of questions and concerns educators and designers face include how to define academic integrity and plagiarism; how to evaluate and assess student writing; evolving teaching and pedagogical practices; the legal, copyright and intellectual property status of AI-driven work; and the level of "originality" assigned to texts, visuals, and other artefacts created with the "assistance" of AI (Eaton et al., 2021).

AI-powered educational tools may be developed with the intention of increasing equity, but the potential to amplify existing disadvantage remains. Two of the most directly relevant concerns, in the case of inclusive augmented typography, are "factors inherent to the underlying algorithms used to drive machine learning and automated decision-making … and factors that emerge through a complex interplay between automated and human decision-making" (Holstein & Doroudi, 2023, p. 151). From these, three ethical issues arise, which are discussed in the following paragraphs.

Issue 1: Decisions Made by Machines and Humans

The first issue concerns the risk that AI may inadvertently hamper comprehension by excluding or de-emphasising important content, ignoring nuanced concepts, or disregarding the discursive nature of some texts. Automated decisions will need to be made to condense or summarize texts, identify key concepts, and apply visual adaptations to cue them. As a result, augmented reading material will, by design, promote some content over others. Relying on machine learning and AI platforms to read complex texts and summarize them appropriately has the potential to backfire if the "wrong" content is selectively cued or concealed. The interaction between automated and human decision-making tasks may therefore include decisions made by authors, editors, typographic designers, or the humans assisting the machine learning process. To mitigate this risk, including academic experts when training AI tools to appropriately select textual components for augmentation will likely be necessary when training AI systems. In response, it should be noted that OpenAI, the developer of ChatGPT (one of the largest language models available) relies on humans to assess machine learning outputs by giving feedback at various points in the process of reading and summarizing whole books (Ouyang et al., 2022; Wu et al., 2021). Staged, recursive summarizations begin with small sec-tions, which are increasingly bundled into larger sections, each overseen by humans providing supervision and evaluation, until entire books are summarized. For the most part, the results are not yet as coherent as human summaries, with abstractive summaries remaining especially elusive, while more factual summaries are already successfully achieved to a high level (2021, p. 13). Importantly, when tested for comprehension, AI can correctly answer questions about texts at least as well as humans (2021, p. 11). As the language models grow in scale, the accuracy and effectiveness of these summaries should continue improving, making them a more reliable input for augmented typographic systems, particularly for abstractive, conceptual summarization. The valuable role of human oversight in this process must not be discounted, however.

Another aspect of the complex interplay between automated and human decision-making is the decisions made by SwD regarding their use of the software. To mitigate the risk of undermining the benefits of deep learning strategies used by SwD, we recognize the need to better understand the digital reading strategies, educational intentions, reading preferences, and learning needs of SwD using human-centered research approaches.

Issue 2: Working *for* SwD or *With* Them

The second ethical issue relates to the potential for advanced technology to replace human effort. Could relying on AI undermine the ability of SwD to learn, if AI performs reading tasks *for* learners rather than *with* them? Importantly, this question is not merely hypothetical, as some companies are already using AI technology—unethically—to generate profits from vulnerable students, while posing as educational supports (Smuha, 2023). Networked services such as Quillbot, Wordtune Read, and UpWord already use AI to provide automated, near-instant text summaries and can even supply paraphrased content on demand. These are promoted as time-saving, efficiency-boosting digital tools designed to help students learn more, with slogans such as "Get the gist. Learn 10x faster" (*Upword*, 2020). These services are so capable of reading, summarizing, and paraphrasing that they can be used by students to avoid reading tasks entirely and can also be used to write whole paragraphs of text for assignments. Rather than learning ten times faster, students may in fact be learning less, if at all. Reducing time spent reading could be beneficial, but it is essential to ensure that SwD are better able to undertake deep learning, and not simply provided a tool that does the work for them, inadvertently amplifying educational inequity and eroding human agency and skills (Bartoletti, 2023).

Issue 3: Algorithms, Source Content, and Equity

A third ethical issue is pertinent to the objective of increasing social and educational equity. In hypothesizing a reading technology that uses AI, it is essential to consider the following question: What effect might existing written materials that promote cultural biases, exclusionary language, and existing political economies have in perpetuating the very social ills inclusive design aims to help alleviate and remove? AI can only "learn" from what it is provided as reading content. Materials in support of dominant hegemonies, populist viewpoints, and entrenched biases are more common than those of marginalized or emerging voices. The "models" used to train AI systems vary and include sources such as

Wikipedia and the Toronto Books Corpus for BERT (Devlin et al., 2018). However, precisely what ChatGPT uses as its source material has not been disclosed publicly, and it is only trained on materials published by 2021 (OpenAI, 2023). The "diet" on which AI is fed must be balanced carefully to avoid exacerbating social problems and reinforcing pre-existing biases, while allowing the voices of the marginalized to speak through written content, particularly where such material is used to "teach" the AI that will assist readers. Although society currently relies on the developers of AI to manage this responsibility, if systems for inclusive, augmented reading are to be designed and implemented, the wider academic community, and publishers, will need to pay closer attention to what source content AI is exposed to.

When integrating AI to develop inclusive augmentation, it is clearly important to be cognizant of potential ethical implications, and so the focus ought to be on "developing and deploying more equitable technologies" (Holstein & Doroudi, 2023, p. 164). Ensuring that SwD are included in user-informed design processes will be essential to producing human-centered design, and emphasizing the importance of a balanced and responsibly selected set of learning materials for AI will help produce a tool more capable of contributing to the diversity of views required in a pluralistic, more equitable society.

Augmentation

Combining textual, spatial, and graphic elements to form the "supra-textual" elements of texts helps to "orient [readers] perceptually and rhetorically when [they] encounter a document" (Kostelnick, 2009). Inclusive augmentation refers to typographic interventions that are responsive to user needs and preferences and rely on technology to analyze text and typography to alter its visual appearance. It relies on the use of both stylistic and structural typographic differentiation techniques to clearly articulate various forms of information within texts (Moys, 2013, 2017). According to Moys (2017), *stylistic features* refer to aspects related to the typeface, including its size, style weight, x-height, etc. Moys (2017) further explained that *structural features* describe how that typeface is applied—for example, how the grid system is used, employment of space and whitespace, layout, color, and configuration. Typographic differentiation is typically set when a document designer creates a layout, but in the case of inclusive augmentation, it is applied on demand to alter an existing layout in order to augment the text by clearly presenting key information. Technology serves two purposes to make this possible; first, AI identifies syntax, word meanings in context, and grammatical structure, and second, reading software implements augmented design on screen based on prompts from the AI's reading. Typographic conventions are used to adapt visual presentation of text from a "wall of words" to discrete sections, highlighted areas, visually cued components, and differently spaced layouts .

In digital and print reading materials, visual cues such as bold or underlined text significantly improve navigation and comprehension when compared to reading from plain text, which helps in the construction of cognitive maps that aid comprehension (Shi et al., 2020). Using a more visually subtle approach featuring lower-contrast bold weights and italics, which do not hinder readability (Dyson & Beier, 2016), may provide the same navigation and comprehension benefits while minimising visual distraction. Other typographic options known to improve reading speed and assist in searching for information include moderate size differences between various text elements such as body content and headers, the use of paragraph indents, and generous margins (Lonsdale, 2014). While neither serif nor sans serif are objectively more legible (Beier & Dyson, 2014), we propose using a typeface such as Sitka, designed to optimize screen legibility of continuous text (Larson & Carter, 2016). Used in conjunction with AI these cues can be applied selectively, aligned to specific reading strategies, and adjusted to individual preferences.

Might SwD save precious time and effort when searching texts due to faster, more efficient expeditious reading? Could careful reading for deep learning benefit from optimized spacing and type sizes? In the visual examples below we show several possible versions of the same content: [1] a standard typographic presentation, [2] a version with extra interletter, interword, and interline space to reduce visual crowding and increase reading speed, [3] a search using Control + F to highlight a phrase and the paragraphs it appears in, [4] a version with some text content subtly emphasized, using type size and color, [5] a collapsible summarized version that shows the most essential paragraphs, and [6] a summary only. In some cases, paragraph numbering has been introduced to aid navigation and searching while scrolling, similar to line numbers used when reading and writing code. Scale is reduced to accommodate space constraints.

In contrast to Figure 1, which shows a standard typographic presentation, Figure 2 demonstrates what may be best practice for improving reading speed of SwD, based on the literature regarding visual crowding among some SwD. These settings may not suit all SwD, and SwD could thus be provided with the option to manipulate the settings to suit personal preferences. Figures 3, 4, 5, and 6 are demonstrations of how expeditious reading may be better facilitated, with AI used to identify and select key phrases and/or paragraphs while de-emphasizing or temporarily concealing others. This could facilitate efficient, rapid overview of texts, providing more detail than a synopsis, without the reader needing to skim through the entire content. Applying subtle use of paragraph numbering may also aid readers when searching text, particularly as the physical affordances of printed books do not exist in digital reading scenarios.

The opportunity to save time while still reading enough to ascertain the usefulness and gist of a text is an important potential advantage, particularly for SwD when they are undertaking expeditious reading tasks. The ethical issues identified earlier become clearly evident in these cases, where content is selected by AI and presented in a way that makes other parts of the text appear less important, or at least not as accessible during expeditious reading. Providing the option to activate this function on demand could be empowering for SwD, so long as the correct information is selected by the AI. This is where the use of human expert oversight in training the AI would be most important. Providing the ability to tap on or select the parentheses in Figure 5 would allow a highly flexible system that may assist SwD to read faster, but also allow for detailed reading of concealed paragraphs whenever desired.

FIGURE 1:

Conventional text presentation with default letter, word, and line spacing. This is an example of what continuous academic text might typically look like when reading from a digital book. The use of typographic differentiation is limited, and the layout provides very little guidance to readers. All content is treated as equally important.

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FIGURE 2:

Text for careful reading, with moderate adjustments to interletter, interword, and interline spacing, to minimize visual crowding and increase reading speed. Optional paragraph numbers included to aid searching while scrolling.

Ugiaspid parum ilias velest.

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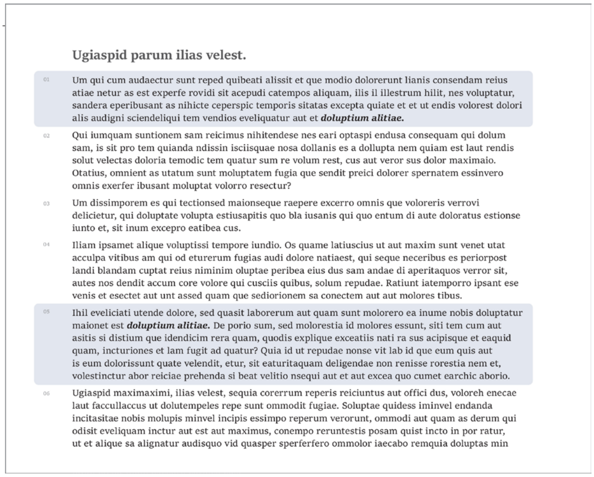
02 Qui iumquam suntionem sam reicimus nihitendese nes eari optaspi endusa consequam qui dolum sam, is sit pro tem quianda ndissin isciisquae nosa dollanis es a dollupta nem quiam est laut rendis solut velectas doloria temodic tem quatur sum re volum rest, cus aut veror sus dolor maximaio. Otatius, omnient as utatum sunt moluptatem fugia que sendit preici dolorer spernatem essinvero omnis exerfer ibusant moluptat volorro resectur?

FIGURE 3:

Potential visual presentation when searching using Control + F, highlighting the phrase "doleptium alitiae" in bold and italics and the paragraphs it appears in using color. Optional paragraph numbers added to aid searching while scrolling.



Ugiaspid parum ilias velest.

01 Um qui cum audaectur sunt reped quibeati alissit et que modio dolorerunt lianis consendam reius atiae netur as est experfe rovidi sit acepudi catempos aliquam, ilis il illestrum hilit, nes voluptatur, sandera eperibusant as nihicte ceperspic temporis sitatas excepta quiate et et ut endis volorest dolori alis audigni sciendeliqui tem vendios eveliquatur aut et ***doluptium alitiae.***

02 Qui iumquam suntionem sam reicimus nihitendese nes eari optaspi endusa consequam qui dolum sam, is sit pro tem quianda ndissin isciisquae nosa dollanis es a dollupta nem quiam est laut rendis solut velectas doloria temodic tem quatur sum re volum rest, cus aut veror sus dolor maximaio. Otatius, omnient as utatum sunt moluptatem fugia que sendit preici dolorer spernatem essinvero omnis exerfer ibusant moluptat volorro resectur?

03 Um dissimporem es qui tectionsed maionseque raepere excerro omnis que voloreris verrovi delicietur, qui doluptate volupta estiusapitis quo bla iusanis qui quo entum di aute doloratus estionse iunto et, sit inum excepro eatibea cus.

04 Iliam ipsamet alique voluptissi tempore iundio. Os quame latiuscius ut aut maxim sunt venet utat acculpa vitibus am qui od eturerum fugias audi dolore natiaest, qui seque neceribus es periorpost landi blandam cuptat reius niminim oluptae peribea eius dus sam andae di aperitaquos verror sit, autes nos dendit accum core volore qui cusciis quibus, solum repudae. Ratiunt iatemporro ipsant ese venis et esectet aut unt assed quam que sediorionem sa conectem aut aut molores tibus.

05 Ihil eveliciati utende dolore, sed quasit laborerum aut quam sunt molorero ea inume nobis doluptatur maionet est ***doluptium alitiae.*** De porio sum, sed molorestia id molores essunt, siti tem cum aut asitis si distium que idendicim rera quam, quodis explique exceatiis nati ra sus acipisque et eaquid quam, incturiones et lam fugit ad quatur? Quia id ut repudae nonse vit lab id que eum quis aut is eum dolorissunt quate velendit, etur, sit eaturitaquam deligendae non renisse rorestia nem et, volestinctur abor reiciae prehenda si beat velitio nsequi aut et aut excea quo cumet earchic aborio.

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FIGURE 4:

AI-assisted expeditious reading. Here, the paragraphs most essential to understanding the text are highlighted, and other paragraphs are reduced slightly in size and opacity. Optional paragraph numbers added to aid searching while scrolling.

Ugiaspid parum ilias velest.

01 Um qui cum audaectur sunt reped quibeati alissit et que modio dolorerunt lianis consendam reius atiae netur as est experfe rovidi sit acepudi catempos aliquam, ilis il illestrum hilit, nes voluptatur, sandera eperibusant as nihicte ceperspic temporis sitatas excepta quiate et et ut endis volorest dolori alis audigni sciendeliqui tem vendios eveliquatur aut et doluptium alitiae.

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04 Iliam ipsamet alique voluptissi tempore iundio. Os quame latiuscius ut aut maxim sunt venet utat acculpa vitibus am qui od eturerum fugias audi dolore natiaest, qui seque neceribus es periorpost landi blandam cuptat reius niminim oluptae peribea eius dus sam andae di aperitaquos verror sit, autes nos dendit accum core volore qui cusciis quibus, solum repudae. Ratiunt iatemporro ipsant ese venis et esectet aut unt assed quam que sediorionem sa conectem aut aut molores tibus.

05 Ihil eveliciati utende dolore, sed quasit laborerum aut quam sunt molorero ea inume nobis doluptatur maionet est doluptium alitiae. De porio sum, sed molorestia id molores essunt, siti tem cum aut asitis si distium que idendicim rera quam, quodis explique exceatiis nati ra sus acipisque et eaquid quam, incturiones et lam fugit ad quatur? Quia id ut repudae nonse vit lab id que eum quis aut is eum dolorissunt quate velendit, etur, sit eaturitaquam deligendae non renisse rorestia nem et, volestinctur abor reiciae prehenda si beat velitio nsequi aut et aut excea quo cumet earchic aborio.

06 Ugiaspid maximaximi, ilias velest, sequia corerrum reperis reiciuntus aut offici dus, voloreh enecae laut faccullaccus ut dolutempeles repe sunt ommodit fugiae. Soluptae quidess iminvel endanda incitasitae nobis molupis minvel incipis essimpo reperum verorunt, ommodi aut quam as derum qui odisit eveliquam inctur aut est aut maximus, conempo reruntestis posam quist incto in por ratur, ut et alique sa alignatur audisquo vid quasper sperferfero ommolor iaecabo remquia doluptas min corest utemperum volum faciendia quam imus doles et aliquat ut vitem fugit aliam, ad evelent re od magnihit aut ex et, in postest, ullis doloreri dolorescit

FIGURE 5:

AI-assisted expeditious reading. The paragraphs most essential to the text are shown, and concealed paragraphs can be revealed by selecting the ellipsis icons. Optional paragraph numbers added to aid searching while scrolling.

Ugiaspid parum ilias velest.

01 Um qui cum audaectur sunt reped quibeati alissit et que modio dolorerunt lianis consendam reius atiae netur as est experfe rovidi sit acepudi catempos aliquam, ilis il illestrum hilit, nes voluptatur, sandera eperibusant as nihicte ceperspic temporis sitatas excepta quiate et et ut endis volorest dolori alis audigni sciendeliqui tem vendios eveliquatur aut et doluptium alitiae.

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05 Ihil eveliciati utende dolore, sed quasit laborerum aut quam sunt molorero ea inume nobis doluptatur maionet est doluptium alitiae. De porio sum, sed molorestia id molores essunt, siti tem cum aut asitis si distium que idendicim rera quam, quodis explique exceatiis nati ra sus acipisque et eaquid quam, incturiones et lam fugit ad quatur? Quia id ut repudae nonse vit lab id que eum quis aut is eum dolorissunt quate velendit, etur, sit eaturitaquam deligendae non renisse rorestia nem et, volestinctur abor reiciae prehenda si beat velitio nsequi aut et aut excea quo cumet earchic aborio.

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07 Aximpor enecus evelibusant hil is volora cori quam quodis nonessinis atus accaborro consequ oditis perrore sseriat iatemporerum net omni ipsaern atiore quiatemos sequatur rempera ditaqui ut volupta tibusda pores ad molecto recus.

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13 Apelitiisim asit vendit hilles adite volores con cum sunt vel impersperum, sinvel ilignimet re sequi am hilliscim ad maios ant auditata dolori re nonse prore, omnis nimporum fugitas alit laboreperum fugiae. Nam, officiis quunto cullecatio. Sum lacestibust, sim de eaquo bernam volorit prepellita ditam, unt et eatusam non erescil ipsam qui officidi diti voluptatis quiatii scipsam ilitas volorit dipienti vit magnia qui aut illic to tore nihilla is dolore volupta tiorumque volorestrum sitaeperum velendicium abori sectis maionsequias inim eos qui ad magnihilit, ium hiliquiatque consecae. Nequi con exereiumquam il modi non posam del erio ea culparcias de vendest et, sunt vendempor sum si dolorit ulparum quam.

FIGURE 6:

AI-assisted expeditious reading. A very short summary of the text is presented, which is useful for assessing relevance before reading an entire text.

Conclusion

This paper has explored ethical issues and practical implications arising from the hypothesis that inclusive augmentation and adaptation of academic texts may improve reading speed and accuracy while reducing fatigue for SwD. While deploying AI in education sometimes "consolidates and intensifies existing patterns and increases the bias toward the majority" (Treviranus, 2023, p. 36), the approach we propose aims to "nurture diverse individual potential" (p. 43) by customizing learning experiences at the visual level, based on individual user preferences and design knowledge combined with user-centric research to test the effectiveness of these tools. The implications of inclusive augmentation may be of particular relevance to digital innovation for typography, reading, inclusive design, and inclusive education. Academic publishers, education specialists, designers, and software developers who use AI in future may therefore find the research helpful.

While AI-powered tools have already been made available to students online, their implementation appears to demonstrate limited or questionable ethical consideration of student needs and educational outcomes. Businesses have used the application protocol interface (API) tools provided by AI developers in a seemingly blunt manner that simply condenses texts and summarises passages. It is imperative that a more considered, ethically informed and human-centered approach should be used to design inclusive reading systems. AI has the potential to benefit SwD, but used in its current form, it may be doing work for SwD instead of with them, with no expert oversight provided to evaluate the quality of summarisation provided.

Importantly, we recognise that a one-size-fits-all approach may not benefit all SwD equally, just as it does not currently benefit all readers who must currently use the same typographic presentation, as if in a printed book. Some readers may previously have adjusted page appearance using color to aid their reading (Kriss & Evans, 2005); this, too, could be provided as an option. There is also no reason to exclude the "read aloud" capability of software such as Microsoft Word because integrating flexibility, adaptability, and assistive features may benefit a wider range of readers, providing a more inclusive experience. We believe that technology now affords a chance to change and update the reading experiences of SwD. Long-form texts such as library books and journal articles could be analyzed using AI, allowing software to visually augment typographic systems and reveal structures within text content, providing multiple visual presentations, suited to a variety of reading strategies. We hypothesize that inclusive augmentations that help differentiate parts of academic texts may help reduce reading time for expeditious and careful reading tasks, free up cognitive capacity, improve comprehension, and aid deep learning. By visually showing structures within complex texts, it may be possible to help this group achieve their educational goals more effectively.

Inclusive augmented typographic systems for SwD may also benefit typical readers, as "inclusively designed solutions result in better solutions" (Mitchell & Treviranus, 2017). When we design for people at the outside edges of a spectrum, we tend to also help those in the center. There may be a number of other potentially beneficial adaptations that could be made to assist other categories of students, allowing a more broadly inclusive approach by providing customizable options to suit a wide range of readers, using the list of typographic conventions we include in the Augmentation section of this paper. This application of our understanding of the diversity of human abilities may therefore also open new possibilities for other marginalized readers and the wider academic reading population. Importantly, though, the focus of this research is on SwD. We believe inclusive augmentation must rely on human-centered research with SwD participants. This could be achieved by measuring the effectiveness of the designs in controlled experiments, as well as establishing their perceived value through qualitative research methods. We therefore conclude that combining an inclusive design approach with human-centered research may help to achieve the learning and reading objectives of SwD.

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Darren Taljaard is a lecturer in design and media at The University of Adelaide. Having originally studied graphic design, he holds a MA in media studies and is currently a PhD candidate at University of South Australia, researching the impact of typographic design on reading and learning outcomes. He views design as a tool for social transformation and believes visual communicators are uniquely placed to help transform and enhance the presentation of information, making it more engaging, suitable and effective. He believes the 10-15% of adults who experience dyslexia should benefit from improved design of digital reading materials, through a combination of research, typographic design and technology, and is inspired by the hard work and tenacity of those with dyslexia. He has worked extensively in the design industry in South Africa and Australia.

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Myra Thiessen lecturers in Communication Design in the Department of Design and is a researcher in the Design Health Collab at Monash University. Her research is focused on design for reading with a particular interest in information translation, accessibility, and developing communication systems that enable people to share and use information in healthcare settings.