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Designing for Dyslexic Individuals in the digital environment

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Abstract

This paper delves into the multifaceted landscape of dyslexia within the context of digital environments, aiming to explore the nuanced challenges faced by dyslexic individuals and propose design interventions to cater to their diverse needs. Dyslexia, recognised as a neurobiological learning disability characterised by difficulties in language processing and reading comprehension, continues to pose unique challenges despite advancements in its understanding and diagnosis. The study draws from interviews conducted with dyslexic individuals, highlighting the spectrum of challenges encountered. It reveals the varied nature of dyslexia experiences, spanning struggles in language-specific domains, reading difficulties, and individualised approaches to coping with the disability. Furthermore, it critically examines existing digital assistive technologies, emphasising their limitations in meeting the tailored requirements of dyslexic learners, often failing to align with individual learning approaches and impeding effective learning experiences. Acknowledging the dichotomy between the aid provided by assistive tools and the need to cultivate personal skills, this paper advocates for a balanced approach. It explores a range of tools and educational tactics employed by dyslexic individuals, emphasising the importance of personalised, adaptable solutions to accommodate diverse experiences and preferences. The study progresses to present low-fidelity design probes as potential interventions in the digital sphere, focusing on tools that allow gradual skill development and customisation. These prototypes aim to provide tailored support while fostering the growth of personal tactics and skills, aiming to strike a harmonious balance between assistance and skill enhancement. Despite these contributions, this study faces limitations, including a restricted sample size and a lack of longitudinal data. The research methodology could benefit from a more comprehensive approach, integrating quantitative measures and expanding participant diversity to enhance generalisability. Furthermore, a deeper synthesis of existing literature and a more explicit theoretical framework could strengthen the theoretical underpinnings of this study.

Keywords:

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INTRODUCTION

The International Dyslexia Association (IDA) delineates dyslexia as a neurobiologically rooted specific learning disability, typified by impediments in accurate word recognition, deficient spelling, and decoding capabilities (Lyon et al., 2003). These challenges predominantly emanate from underlying phonological deficiencies within language processing, concurrently manifesting in difficulties encompassing reading comprehension, writing, and spelling. The consequential arduous reading experiences often obstruct the expansion of vocabulary and knowledge acquisition among affected individuals.

The etymology of the term 'dyslexia' traces back 130 years to its origination by Rudolf Berlin. Despite its historical legacy, dyslexia persists as a contentious descriptor within the realm of educational policy-making. Its initial inception was fraught with skepticism, as critics dismissed dyslexia as a contrived concept utilised by apprehensive middle-class parents to rationalise their children's underperformance (Kirby, 2020a). Contemporary discourse continues to grapple with the term's pervasive and arguably imprecise application, critiqued for its expansive usage (Elliott & Grigorenko, 2014). Nonetheless, the diagnostic identification of dyslexia in the contemporary milieu has substantially facilitated the advancement of numerous dyslexic individuals, aiding their educational progress and subsequent integration into the workforce, contributing to successful life trajectories (Kirby, 2020b).

The institutional acknowledgment of dyslexia as a disability under The Equality Act of 2010 in the UK further validates its recognition as a lifelong impediment impacting reading, spelling, and directional orientation. This statutory recognition underscores the imperative for comprehensive design interventions aimed at enhancing the quality of life for dyslexic individuals within our societal framework.

Over the past decade, a discernible escalation in projects dedicated to raising awareness of dyslexia has been evident. Simultaneously, numerous educational initiatives have endeavored to empower dyslexic individuals. The current article endeavors to examine the exigencies and prospects inherent in designing solutions tailored for dyslexic individuals, with a particular emphasis on the digital milieu. This exploration seeks to address the distinctive needs of this demographic and unearth opportunities for enhancing their experiences through targeted design interventions.

The Dyslexia Experience

The heterogeneous nature of dyslexia is evident in its multifaceted manifestation across individuals, wherein no singular symptom or panacea exists to encapsulate the spectrum of experiences encountered. Broadly classified into phonological and surface dyslexia, these categorisations delineate distinct challenges in language processing. Phonological dyslexia manifests as challenges in phonological processing, divergent from

orthographic competencies, while surface dyslexia denotes pronounced orthographic hurdles relative to phonological skills (Wolff, 2009). However, despite these general classifications, my empirical inquiry involving interviews with three dyslexic individuals in their early twenties revealed diverse and idiosyncratic experiences within this cohort. For instance, while Interviewee A grappled predominantly with Chinese language challenges and obtained an exemption from Chinese language studies, Interviewees B and C encountered obstacles primarily in English spelling and reading. The individualised nature of their experiences with dyslexia spans a spectrum: from perceiving words or letters as 'jumping around' to occasional letter confusion, such as conflating 'd' and 'b'. Notably, this diversity defies clear-cut demarcation between dyslexia categories, underscoring the unique and intricate struggles encountered by each individual in varying degrees of complexity. Ergo, a one-size-fits-all solution is untenable. Addressing these challenges necessitates the intervention of educational therapists adept at assessing individual abilities and tailoring personalised teaching methodologies commensurate with their distinctive diagnoses. This underscores the imperative for bespoke approaches catering to the unique needs of dyslexic individuals.

Assisting the Dyslexic in a Digital Environment

Despite a growing shift towards digital educational platforms, a considerable gap exists in the integration of digital assistive technologies tailored for dyslexic learners. Present digital tools, while attempting to aid dyslexic students, often fail to accommodate their individualised learning approaches and needs (Beachman & Alty, 2006). This mismatch results in inadequate accessibility and convenience, hindering rather than enriching the learning experiences of dyslexic students (Roberts, 2019). Unlike the adaptability of teachers in physical classrooms, current e-learning tools struggle to cater to diverse learning styles and individual abilities.

Throughout the interview sessions, participants emphasised the imperative need for self-training in refining their reading and writing abilities subsequent to their diagnosis at the Dyslexic Association of Singapore (DAS). The diagnostic reports issued by DAS delineate areas of strength and weakness in various cognitive components like verbal and non-verbal reasoning, pattern construction, and sequential reasoning, among others. Subsequent to this assessment, individuals enroll in DAS for structured instructional sessions, encompassing a generalised curriculum spanning Mathematics, Science, or English. Notably, the educational therapists at DAS employ adaptive pedagogical methodologies tailored to each participant's needs within the group setting.

These strategies include elucidating patterns in word sequences, facilitating left-to-right eye movement through systematic exercises, recognising common letter clusters, and imparting linguistic conventions. However, a critical distinction arises between interventions fostering personal skill development and a distinct category of tools solely designed for assistance without concurrently fostering skill acquisition. While immediate

assistive tools offer aid, overreliance on them might impede the cultivation of personal skills among dyslexic individuals. Nonetheless, recognising the diverse capacities of individuals, the availability of these assistive tools remains indispensable.

Assistance or Over-reliance?

Throughout the interview sessions, participants disclosed the imperative need for self-training in refining their reading and writing abilities subsequent to their diagnosis at the Dyslexic Association of Singapore (DAS). The diagnostic report issued by DAS delineates areas of strength and weakness in various cognitive components like verbal and non-verbal reasoning, pattern construction, and sequential reasoning, among others. Subsequent to this assessment, individuals are enrolled in DAS for structured instructional sessions, encompassing a generalised curriculum spanning Mathematics, Science, or English. Notably, the educational therapists at DAS employ adaptive pedagogical methodologies tailored to each participant's needs within the group setting. These strategies include elucidating patterns in word sequences, facilitating left-to-right eye movement through systematic exercises like orderly alphabet tracing or recognising common letter clusters such as "ing," "that," and imparting linguistic conventions like the impact of silent 'E' in elongating vowels within English words.

The pedagogical approaches implemented at DAS aim to cultivate individualised competencies and compensatory mechanisms tailored to address the challenges inherent in dyslexia.

Remarkably, these tactics often camouflage the inherent difficulties, enabling individuals to function conventionally within educational settings. Dyslexic individuals may also harness compensatory strengths, fostering opportunities for enhanced learning and development (Tunmer & Greaney, 2010). However, an important distinction arises between interventions fostering personal skill development and a distinct category of tools solely designed for assistance without concurrently fostering skill acquisition. For instance, the Open Dyslexic font, purportedly optimised for readability and text-to-speech applications, exemplifies this category. While such tools provide immediate assistance, an overreliance on them might impede the cultivation of personal skills and tactics among dyslexic individuals. Nonetheless, recognising that not all individuals possess the capacity to acquire such skills, the availability of these assistive tools remains indispensable. The ideal scenario remains rooted in fostering individualised tactics and skills while judiciously incorporating assistive tools on a supplementary basis.

Observed Tools & Tactics from Research Participants

Through in-depth interviews and extensive dialogues, a comprehensive inventory of tools and prototypes commonly utilised by dyslexic individuals has been curated, albeit acknowledging the non-exhaustive nature of this compilation. These tools delineate into

two principal categories: assistive and educational, encapsulating a spectrum of resources that have been historically employed or continue to be actively utilised within the dyslexic community. This systematic categorisation serves to elucidate the multifaceted strategies and aids adopted by dyslexic individuals, encompassing a diverse array of solutions tailored to address distinct facets of their challenges.

Table 1. List of Dyslexic Individuals that were interviewed

Interviewees	Age	Gender	Occupation
A	20	Female	Student
B	22	Male	Student
C	25	Male	Student

Assistive Tools:

1. Relating words and letterforms to visuals /shapes.
2. Using a grid to write properly.
3. Using a finger guide to help them focus on the words they are reading.
4. Using highlighters to differentiate between similar letter forms.
5. Decluttering of content so it is not so overwhelming.

Educational Tools:

1. Breaking up words into syllables so that it becomes more manageable to read and teaching the right way of breaking word syllables.
2. Learning trends and patterns in the language.

The utilisation of tools among dyslexic individuals exhibits a marked divergence attributable to the heterogeneous nature of their dyslexia experiences. Individualised requirements manifest distinctly; while one individual may find benefit in utilising a guiding tool to streamline and enhance focus during reading, another might necessitate the employment of the Open Dyslexia font type to facilitate ease in comprehension.

Despite the efficacy of these tools, a prevailingobservation emerges wherein many dyslexic children persistently exhibit slower reading rates, a trend that often persists into adulthood. Furthermore, dyslexic individuals commonly encounter the need for repeated readings to achieve comprehensive understanding of textual content.

Notwithstanding these challenges, the prospect of substantial progress remains feasible given the provision of suitable pedagogy, training, support, and ample time for skill development. It is acknowledged that while some dyslexic individuals may primarily engage in reading out of necessity, others might cultivate an interest in reading, thereby underscoring the significance of tailored assistance. Hence, ensuring the provision of appropriate support delineates a rewarding trajectory, accommodating diverse needs and fostering progress across individual journeys within the dyslexic community.

Design Research with Low-Fidelity Probes:

Drawing from the elucidated tactics, a strategic decision was undertaken to construct low-fidelity probes encompassing design parameters aimed at facilitating dyslexic individuals' progressive engagement, thereby transitioning from a reliance on purely assistive tools towards skill development. This methodological approach sought to investigate the transformative capacity of digital tools in fostering the cultivation and refinement of personal skills and tactics while dynamically evolving in tandem with users' evolving competencies. The rationale underlying the formulation of these low-fidelity probes aimed to delve deeper into the prospective skills and tactics that could be nurtured and honed within dyslexic individuals, engendering a comprehensive exploration of their developmental trajectories within a digitally mediated context.

The devised low-fidelity probes encompass a series of digitally deployable tools expressly tailored for dyslexic individuals, facilitating their discretionary engagement by allowing for on-demand utilisation and concealment based on situational needs. Among these tools, the initial iteration introduced a word picker feature designed to offer pictorial associations in tandem with selected words. For instance, upon selecting the word "Hot," an accompanying image depicting fire would overlay the chosen term. This strategic incorporation of visual cues aimed to enhance word identification by establishing associative links between words and corresponding visuals. However, concerns were raised regarding potential implications on reading consistency arising from the sustained presence of pictorial references. Consequently, a subsequent refinement involved the development of a revised iteration featuring a floating pictorial reference, addressing apprehensions regarding its sustained impact on reading coherence.

The subsequent tool within the suite of innovations pertains to a decluttering mechanism, meticulously crafted to selectively obscure extraneous information displayed on-screen, with the blurred segment dynamically adjusting in correspondence to the user's individual reading pace. This strategic feature was conceived to mitigate cognitive overload, fostering enhanced concentration on the core content being perused. However, apprehensions emerged regarding the potential imposition of undue cognitive strain, particularly concerning users who prefer a comprehensive view before decluttering. In response to this concern, an iterative enhancement was devised,

emulating a real-life paradigm where users are empowered to utilise a virtual ruler to selectively mask portions of text while preserving unblurred sections yet to be read. This revised mechanism seeks to accommodate diverse user preferences by offering a flexible decluttering interface akin to a personalised reading aid, ensuring an unobtrusive reading experience aligned with individual comfort levels.

Figure 1. First Design

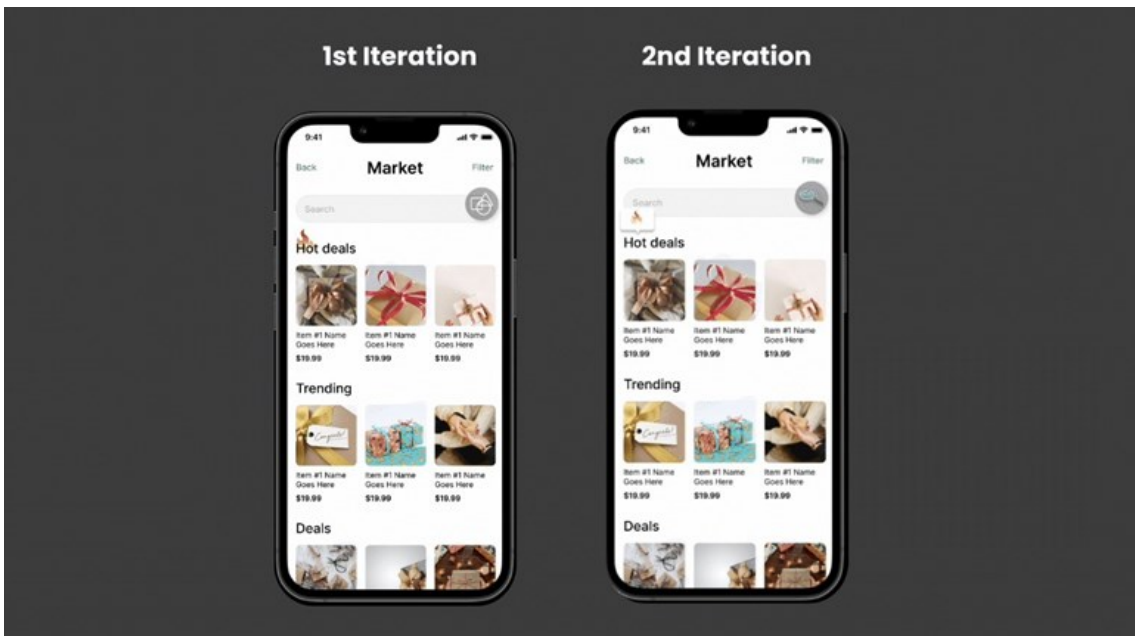


Figure 2. Second Design

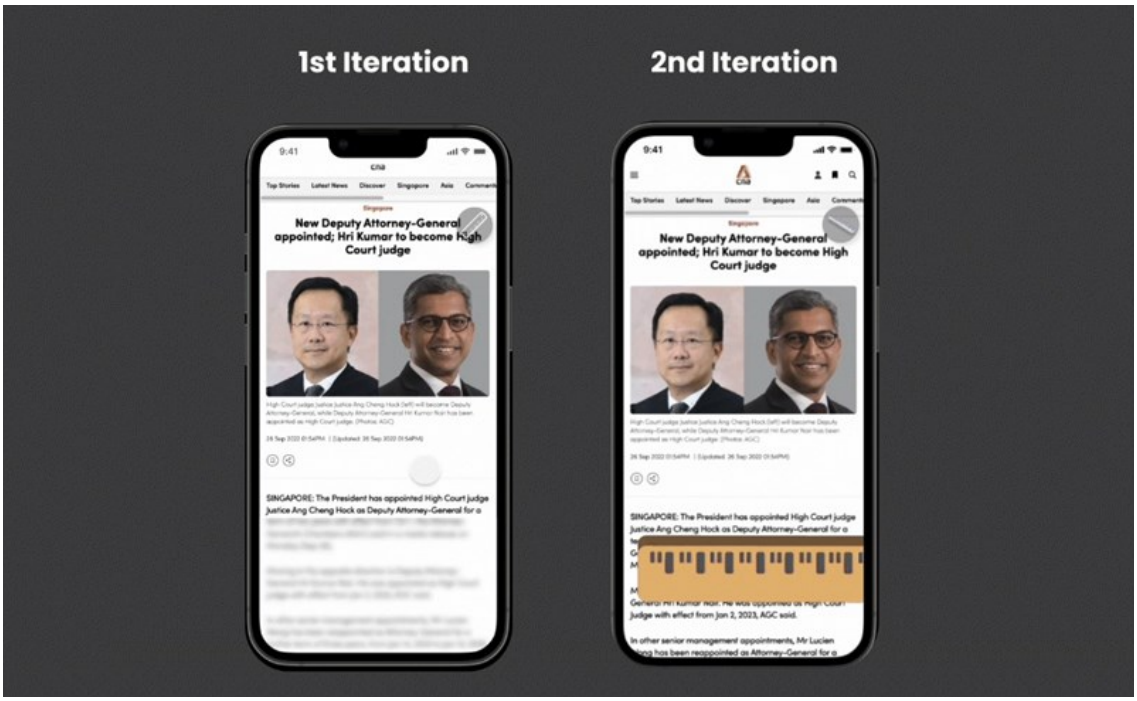


Figure 3. Third Design

The third implemented tool embodies a highlighting functionality conceived to dynamically track users' ocular movements and correspondingly emphasise the specific word within their line of sight. This feature operates in tandem with the user's scanning patterns, facilitating an interactive alignment where the highlighting mechanism synchronously moves along with the user's gaze as they peruse the text. Intended to optimise user focus by directing attention to the currently-read word, this tool aims to augment reading comprehension. However, insights gleaned from feedback underscored potential drawbacks, with concerns raised regarding the likelihood of this feature inducing distraction rather than aiding concentration. Such feedback posits a critical perspective, prompting reevaluation and refinement to ascertain its efficacy as an effective aid rather than an inadvertent disruption within the dyslexic user experience.

The final tool introduced is a scissors tool, conceived to segment longer words into constituent syllables, offering users struggling with longer words a systematic approach to decoding. This functionality aligns with the pedagogical strategy of deconstructing complex words into more manageable and comprehensible components, thus facilitating enhanced reading fluency. Feedback received underscored the necessity for an augmented feature encompassing educational dimensions, elucidating the rationale behind the segmentation process and imparting insights into the methodologies employed for word segmentation. Consequently, an educational component was incorporated, designed to equip users with an understanding of the underlying principles

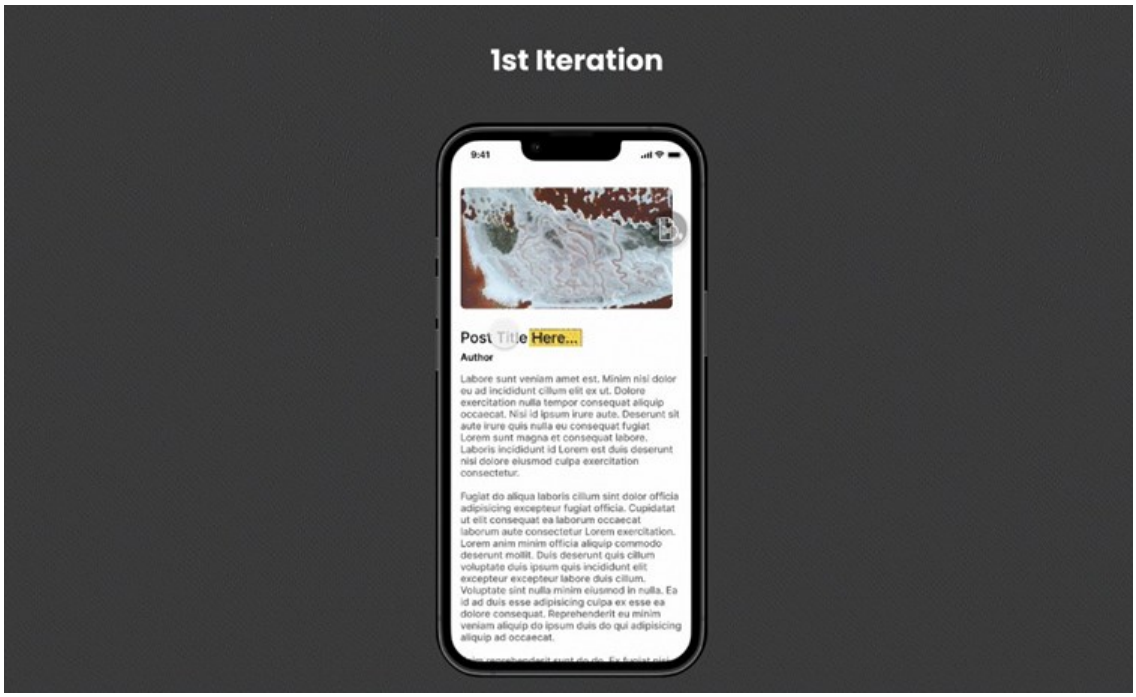


Figure 4. Fourth Design

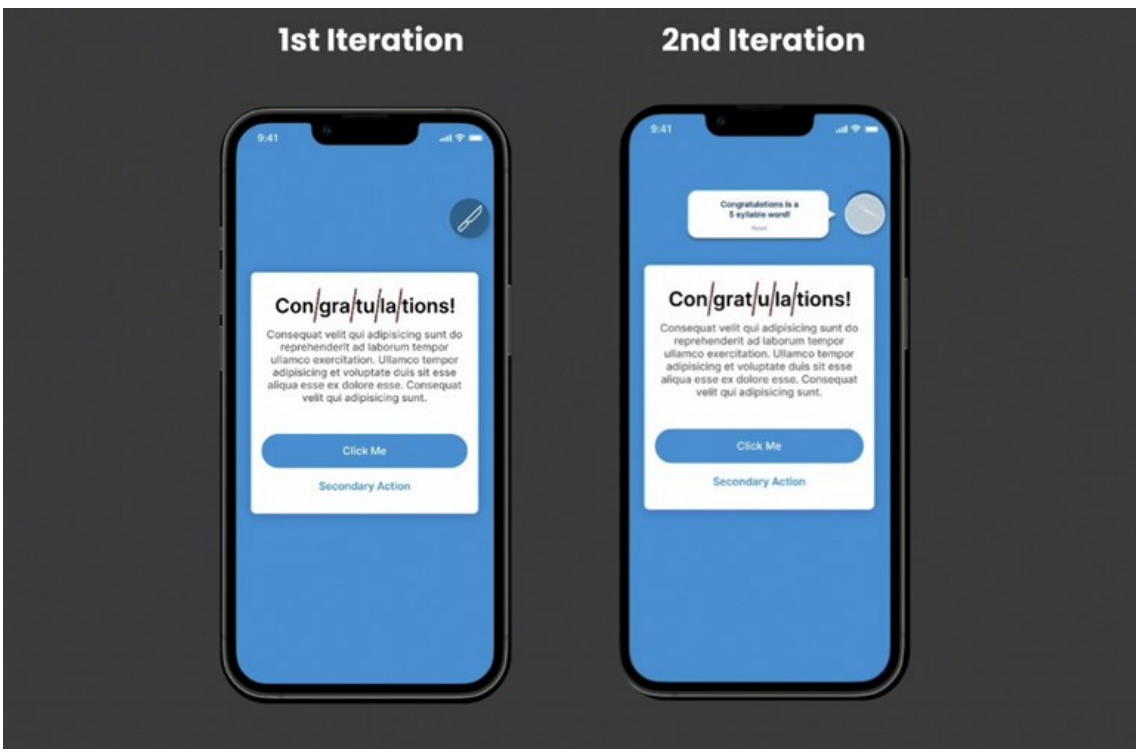


Figure 5. Fifth Design

governing word segmentation, aiming to empower dyslexic individuals with the knowledge and skills requisite for effective word deconstruction.

Upon soliciting feedback from dyslexic individuals regarding the prototype, several crucial insights emerged. Primarily, the envisioned prototype necessitates a customisable toolkit catering to individual preferences, acknowledging the inherent diversity among dyslexic individuals in their responses to various aids. This bespoke toolkit envisages an array of tools that individuals can selectively adopt based on their idiosyncratic preferences and experiences, recognising their nuanced requirements. For instance, preferences may vary widely in terms of optimal contrast ratios between text and background colors; some individuals may find dark blue text against a cream background more conducive to readability, while others may prefer grey text on a white background. Secondly, the imperative integration of pedagogy within these tools emerges as pivotal. Overcoming the challenges posed by dyslexia inherently entails an understanding of the rationale behind specific skills and tactics. Educating users about the underlying principles and methodologies is paramount, as it empowers them to comprehend and effectively apply these strategies. Consequently, incorporating educational components within the toolkit is deemed essential to foster comprehension and utilisation of these tools.

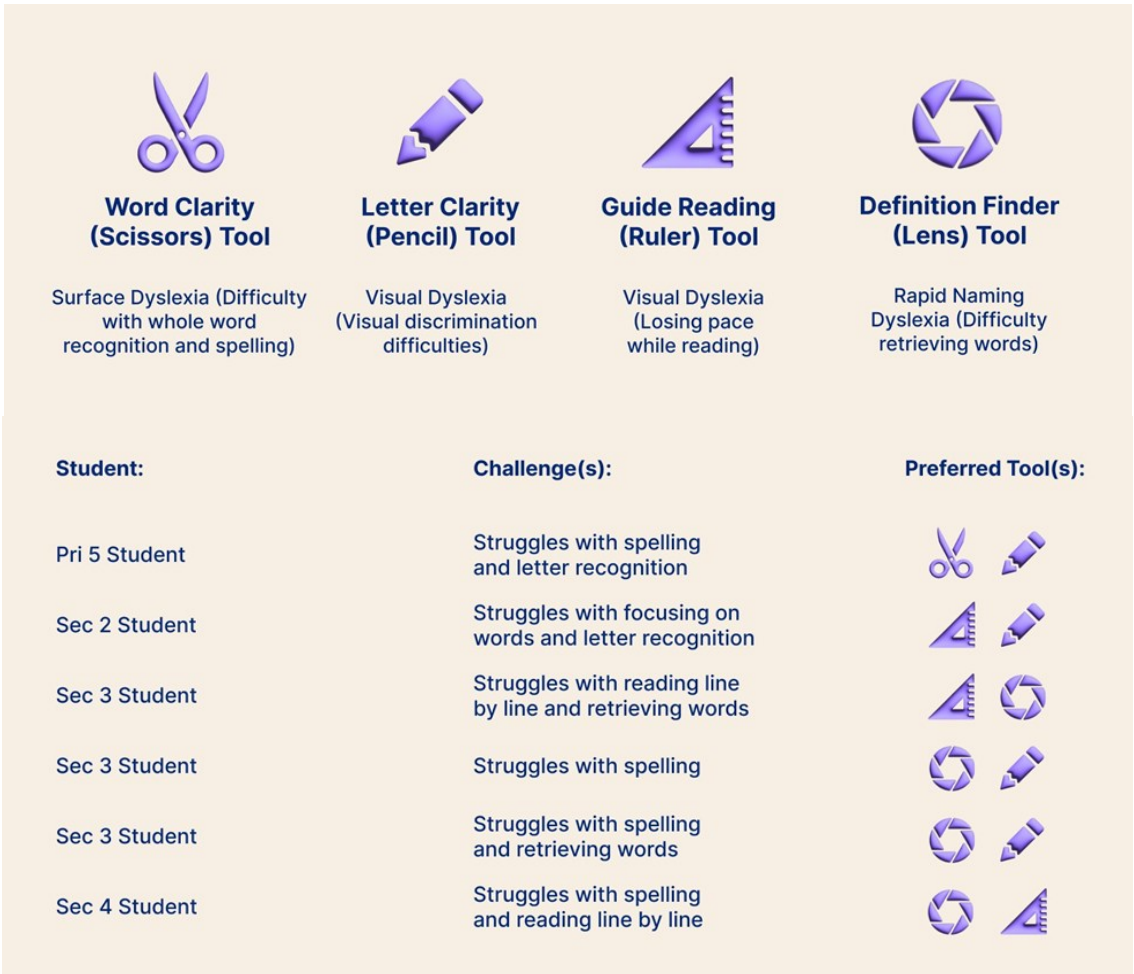
Lastly, addressing the needs of both dyslexic children and adults presents a significant challenge. While younger individuals may be in the process of developing personal tactics, older dyslexic individuals have often established coping mechanisms. Designing a progressive toolkit that accommodates the varying needs and proficiencies of diverse age groups within the dyslexic community becomes imperative. Therefore, an overarching concern pertains to crafting tools that facilitate continual learning and aid, ensuring applicability across diverse age demographics, from children navigating initial challenges to adults seeking supplemental support.

Findings

In a later version of these digital tools, I presented 6 students from the Dyslexia Association of Singapore (DAS) with a set of 4 tools, namely the scissors tool, pencil tool, ruler tool and lens tool and conducted interviews.

The empirical exploration conducted with six dyslexic individuals revealed distinct preferences and resonances with specific digital tools aimed at addressing their diverse learning challenges. These individuals, aged 11 to 16 and engaged with the Dyslexic Association of Singapore (DAS), articulated unique preferences linked to their learning difficulties. Notably, the scissors tool garnered positive resonance among individuals grappling with whole word recognition and spelling challenges. The segmentation of longer words into manageable syllables using this tool emerged as a favored method among participants, aligning with established pedagogical strategies. Additionally, the

pencil tool, designed to address visual discrimination difficulties, showcased adaptive features such as contrast reduction over successive readings, indicating promising progress towards self-reliance. The ruler tool, targeting pace retention while reading, demonstrated potential enhancements in increasing the number of words displayed per line, aligning with participants' adaptive reading patterns. Lastly, the lens tool, formulated to aid word retrieval difficulties, received commendation for its support in easing word recall.



Participants' feedback emphasised the pivotal role of gradual tool adaptability in fostering independence from reliance on these aids. Notably, the incremental decrease in tool reliance with successive usage sessions emerged as a notable marker of tool effectiveness. Moreover, the incorporation of user analytics within the digital tools showcased promise in fostering sustained user engagement. Extrinsic motivators, such as

experience levels and badges, elicited positive responses, complemented by intrinsic motivators like progress reminders, bolstering continued tool utilisation.

The interviews underscored the heterogeneity of dyslexia experiences, reframing the importance of bespoke interventions catering to individual needs. Participants' preferences for specific tools highlighted the necessity for adaptable digital solutions aligning with their diverse learning difficulties. The insights gleaned from these interviews underscored the significance of personalised approaches in designing digital tools aimed at empowering dyslexic individuals by fostering autonomy and skill development.

Literature Review on Self-Esteem and Dyslexia:

Self-esteem plays a pivotal role in the psychological and educational experiences of individuals, particularly those with dyslexia. Numerous studies have underscored the significant correlation between dyslexia and diminished self-esteem (Alexander-Passe, 2006; Humphrey & Mullins, 2002). The persistent struggles faced by dyslexic individuals, such as difficulties in reading, writing, and comprehension, often lead to feelings of inadequacy, frustration, and lowered self-worth (Riddick, 1996).

Research has consistently demonstrated the detrimental effects of dyslexia on self-esteem, especially during formative years in educational settings (Humphrey, 2010; Riddick et al., 1999). The constant exposure to academic challenges coupled with societal misconceptions and stigmatisation exacerbates feelings of incompetence and lowers confidence levels among dyslexic individuals (Humphrey & Mullins, 2002; Riddick, 1996). These negative perceptions about their abilities and performance contribute significantly to the erosion of self-esteem in dyslexic individuals.

However, it's important to note that while dyslexia may pose challenges to self-esteem, individual differences in coping strategies and support systems can mediate its impact (Humphrey, 2010). Research by McArthur and Lewis (1997) highlights the role of supportive environments, effective teaching methods, and positive reinforcement in mitigating the adverse effects of dyslexia on self-esteem. Encouragement and recognition of strengths, as well as efforts aimed at developing coping mechanisms and adaptive strategies, have shown promise in bolstering self-esteem among dyslexic individuals (Humphrey, 2010; Riddick et al., 1999).

Additionally, interventions targeting skill development, individualised learning approaches, and assistive technologies, as discussed in this paper, offer opportunities to enhance self-esteem among dyslexic individuals. By providing tools that accommodate diverse learning styles and acknowledging individual preferences, these interventions aim to empower dyslexic individuals, potentially fostering a sense of competence and efficacy, consequently positively impacting their self-esteem (Humphrey, 2010; Riddick et al., 1999).

In conclusion, the literature strongly emphasises the intricate relationship between dyslexia and self-esteem, highlighting the need for holistic approaches that address educational, psychological, and social aspects to support and uplift dyslexic individuals, ultimately fostering a positive self-concept and confidence.
Limitations:

While this study provided valuable insights into the preferences and effectiveness of specific digital tools among dyslexic individuals, its limitations warrant consideration. The sample size, comprising six participants from a specific age group and within the confines of a particular association, may limit the generalisability of the findings. A broader and more diverse participant pool across various demographics and geographical locations would enhance the study's external validity. Moreover, the qualitative nature of the interviews, while rich in subjective experiences, might introduce interpretative biases. Incorporating quantitative measures or longitudinal studies could bolster the robustness of the findings and offer a more comprehensive understanding of the evolving needs and experiences of dyslexic individuals over time.

Conclusion

The pursuit of this project is underpinned by extensive research that underscores the critical role of intervention and support for dyslexic individuals. Studies, such as those by Lyon et al. (2003), Elliott & Grigorenko (2014), and Kirby (2020b), have highlighted the detrimental impact of dyslexia on self-esteem and psychological well-being, emphasising the pressing need for tailored interventions. Research by Tunmer & Greaney (2010) also stresses the importance of personalised teaching methodologies and compensatory strategies in aiding dyslexic individuals to navigate their challenges effectively. Furthermore, studies by Beacham & Alty (2006) have underscored the limitations of existing digital tools in addressing the diverse needs of dyslexic learners, emphasising the necessity for innovative, personalised solutions. Integrating these research insights, the project aims to bridge the gap between research findings and practical implementations by developing adaptable digital tools, honed through co-design workshops, to positively impact the learning experiences of dyslexic individuals, potentially enriching educational curricula at institutions like DAS.

The research in question is distinguished by its targeted focus on addressing the multifaceted challenges faced by dyslexic individuals through innovative digital interventions. This study uniquely combines insights gleaned from existing literature on dyslexia's impact on self-esteem, the necessity for personalised teaching methodologies, and the limitations of current digital tools. Moreover, this research seeks to transcend theoretical frameworks by directly engaging with dyslexic individuals through co-design workshops, ensuring their active involvement in shaping the development of digital tools tailored to their specific needs. By aligning theoretical underpinnings with practical implementation strategies, this research endeavors to foster a transformative impact on

educational practices, potentially influencing the integration of adaptive digital tools within institutional curricula, thereby offering tangible solutions to empower dyslexic learners.

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