Towards Individualised Reading Support for Attention-Deficit/Hyperactivity Disorder (ADHD):

User-centred Development of an Adaptive Eye-Tracking-Based Reading Assistance System

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What is ADHD?

Definition

- Attention-Deficit/Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder
- Characterized by persistent patterns of inattention, hyperactivity, and impulsivity that interfere with daily functioning and development
- Symptoms emerge in childhood and often persist into adulthood

Three Core Presentations

1. Predominantly Inattentive
   - Difficulty sustaining focus, easily distracted
2. Predominantly Hyperactive-Impulsive
   - Restlessness, fidgeting, difficulty inhibiting responses
3. Combined Presentation
   - Features of both inattention and hyperactivity

Key Facts

- Affects ~5% of children (Polanczyk et al., 2007) and ~2.5% of adults (Simon et al., 2009) worldwide
- Strong genetic component (heritability ~74%) (Faraone & Larsson, 2019)
- Often persists into adulthood with shifting symptom profiles
- High comorbidity with, e.g., anxiety, depression, and learning disabilities

ADHD and Reading Challenges

Multiple cognitive and perceptual barriers affect reading in adults with ADHD

Inattention

- Difficulty sustaining focus
- Mind wandering during reading → Reduced text comprehension

[Bozhilova et al., 2018; Bonifacci, et al., 2023]

Hyperactivity

- Restlessness disrupts reading
- Difficulty staying seated
- Impulsive line-skipping

[Rapport et al., 2009; Hartanto et al., 2016]

Visual Perception

- Increased fixation counts
- More regressive saccades
- Decreased reading speed
- Reduced contrast and color sensitivity

[Molina et al., 2020; Caldani et al. 2022; Stern et al., 2024; Banaschewski et al., 2006]

Working Memory

- Centrality deficit: low-quality, less-connected text representations → recalling fewer central ideas, reduced text comprehension
- Slowed information processing speed

[Yeari & Lavie, 2021; Kofler et al., 2020]

The Gap in Assistive Technology

✓ What Exists

- Task management tools (reminders, timers)
- Attention training applications
- Text-to-speech for reading support
- Bionic Reading font (not scientifically proven effective)

⚠ **Clear need to investigate requirements for reading assistance tailored to adults with ADHD**

✗ What's Missing

- No validated assistive reading system for ADHD
- No adaptive systems developed or evaluated for ADHD
- Research predominantly focused on dyslexia
- Lack of user-centred design with ADHD adults
- No integration of eye-tracking for reading support

Our Approach

Eye-tracking-based adaptive reading assistance + user-centred participatory design

Research-Based Prototype

Developed an early-stage reading assistance system grounded in empirical evidence on ADHD reading patterns and existing design principles

Participatory Workshop

Explored the initial prototype with adults with ADHD (*N*=7) through user testing, group discussions, and co-design activities

Re-design + Evaluation

Refined click-prototype design was evaluated by *N* = 5 design experts with ADHD.

Design Principles

Derived initial design principles for ADHD-specific reading assistance, informed by workshop findings and user feedback

Methods

Prototype Development

Eye-tracking-based reading assistance with four highlighting features

Tobii Sparks Remote Eyetracker

Pupil Labs Neon Eyetracking glasses

System Architecture

- Eyetracker monitors gaze position on screen
- Calibration at startup for accuracy
- Identifies currently viewed line and word in real time while reading
- Highlight follows expected reading flow (left-to-right, line-by-line)
- Short delay before following unexpected gaze jumps
- Users can customise font, colours, line spacing via side menu

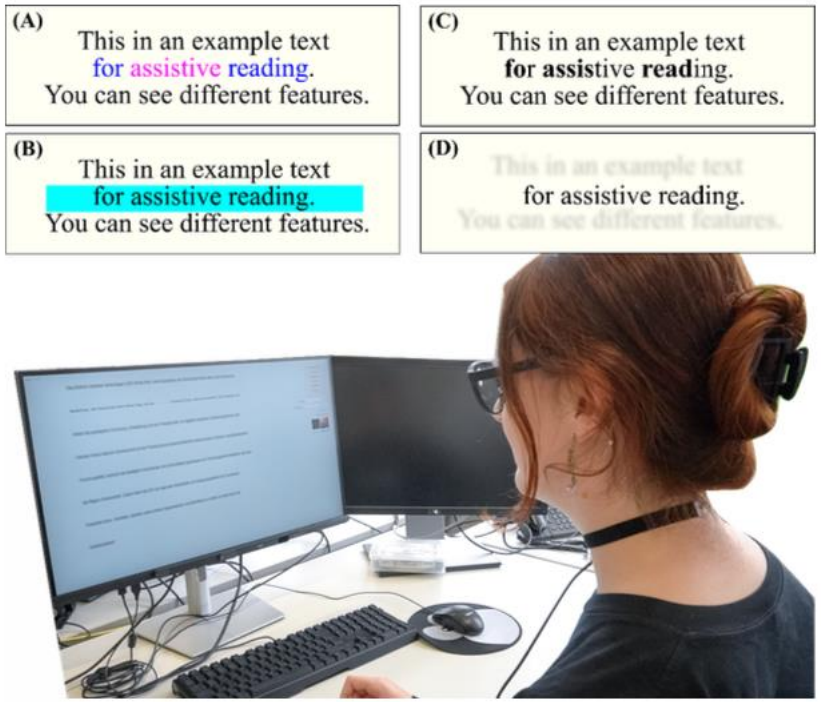
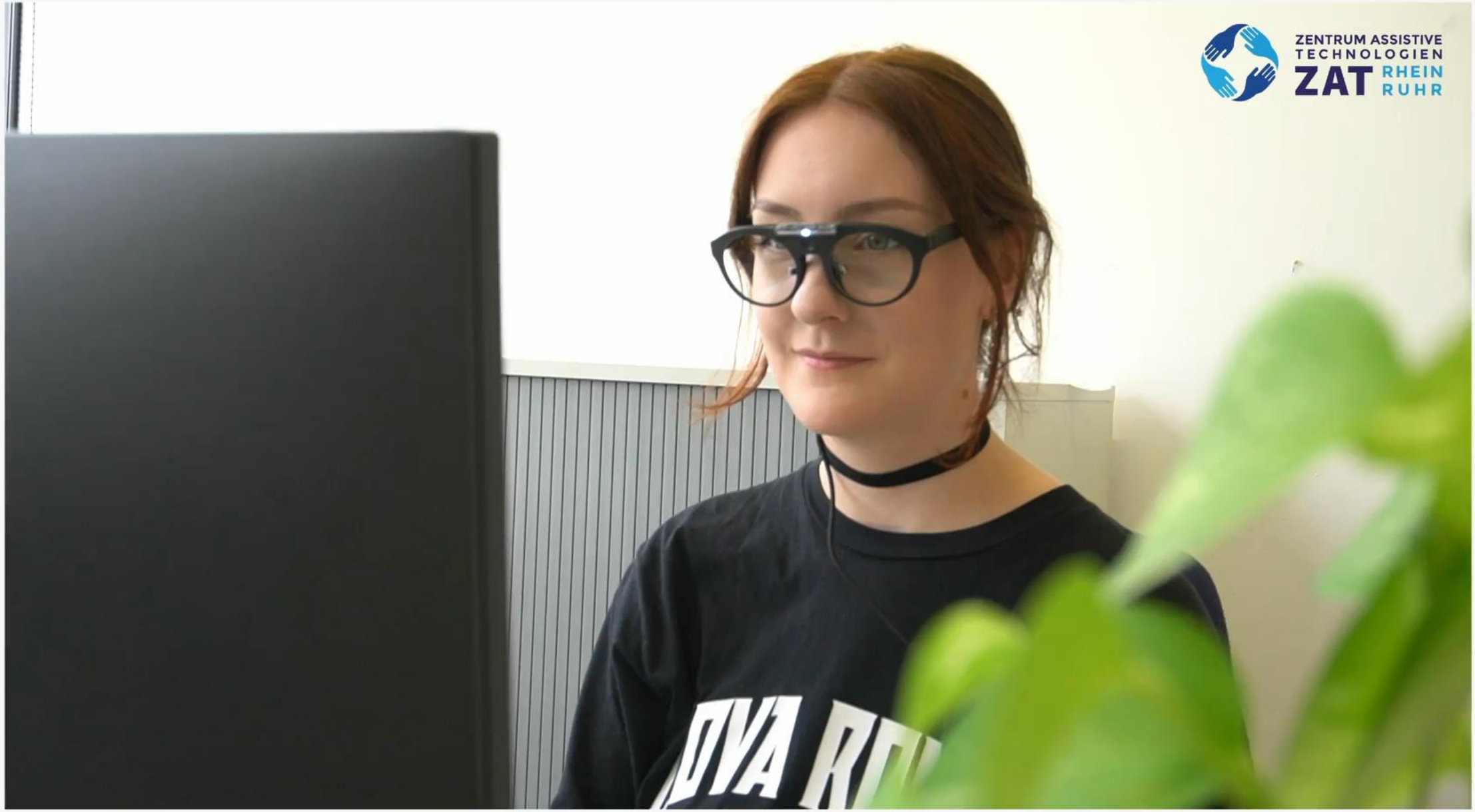


Figure 1. Assistive digital reading features. (A) Font Highlighting, (B) Background Highlighting, (C) Bionic Reading, and (D) Blurring. While reading, gaze can be tracked using eye-tracking glasses, a remote eye tracker or mouse cursor.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User-Centred Workshop

Participants & Setup

Sample

- ***N*** = 7 adults (5 female, M_{age} = 27.57)
- 4 diagnosed, 3 suspected ADHD

Screening Instruments

- ASRS-V1.1 (ADHD symptoms)
  - 4/7 screened positive for ADHD
- Adult Checklist (Dyslexia)
  - *M* = 44.14, *SD* = 9.72 (negligible risk)
- ARHQ (Reading history)
  - *M* = 44.29, *SD* = 10.29 (indicative of dyslexia)

Interaction Modes

- Eye-tracking-based (remote eyetracker)
- Cursor-based (mouse simulation)

Workshop Procedure

Phase 1: Assessment

- Questionnaires
- System demonstration for shared understanding

Phase 2: Prototype Testing

- Individual testing of both interaction modes
- Feature ratings on 5-point Likert scale (Perceived helpfulness)
- System Usability Scale (SUS)

Phase 3: Co-Design

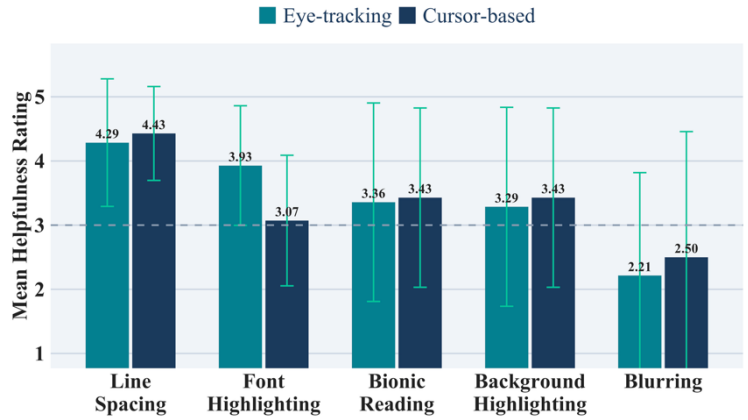
- Interface critique and improvement suggestions
- Group discussion (e.g., coping strategies)
- Evaluation of proposed adaptive features

Results

Results

81.79 **Mean SUS Score** (*SD* = 12.48)

Indicating good overall usability of the prototype (<68 = good)



Feature Helpfulness Ratings

- **Line spacing** received the highest overall ratings across both conditions
- **Font highlighting** most preferred in eye-tracking condition
- **Bionic reading** and **background highlighting** received mixed reviews in both conditions
- **Blurring** received the lowest overall rating (high SD suggests mixed individual responses)

Interaction Mode Comparison

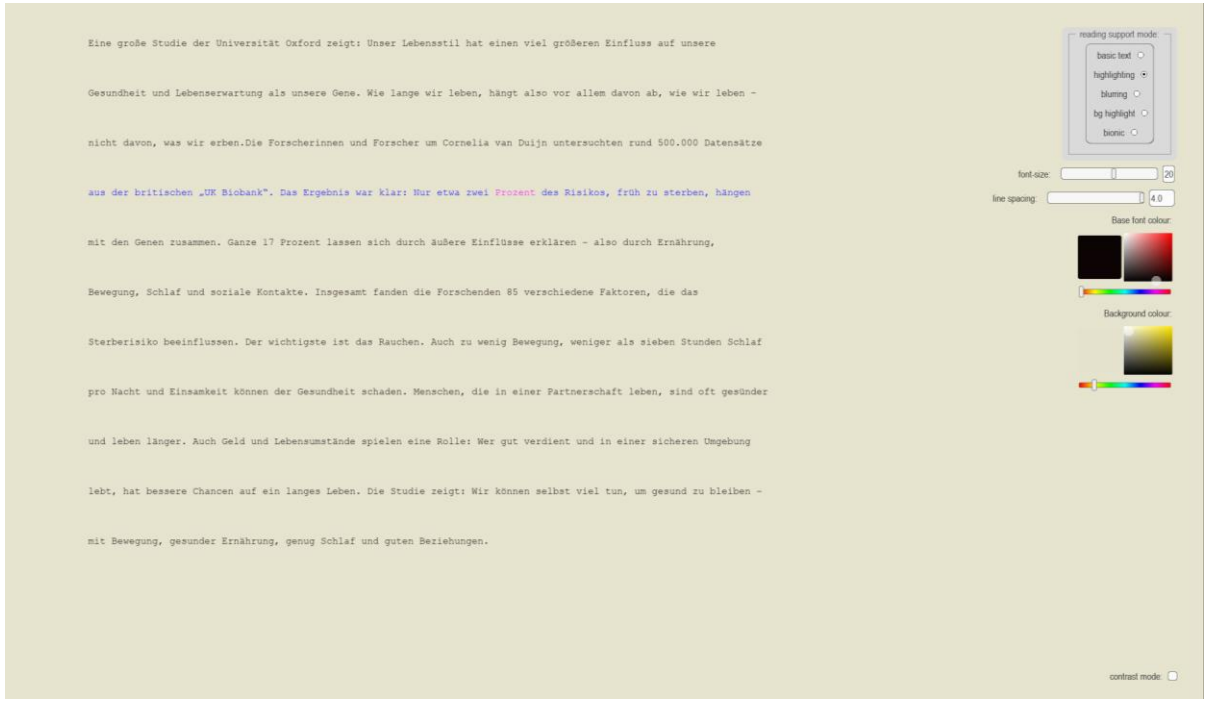
- **Eye-tracking:** M = 3.41, SD = 0.49
- **Cursor-based:** M = 3.37, SD = 0.42
- No clear preference for either interaction mode
- Cursor-based may offer a viable, cost-effective alternative to eye tracking
- Eye-tracking valued for hands-free reading but reported eye strain

Key Takeaway: High personalisability is essential to accommodate the heterogeneous needs of users with ADHD

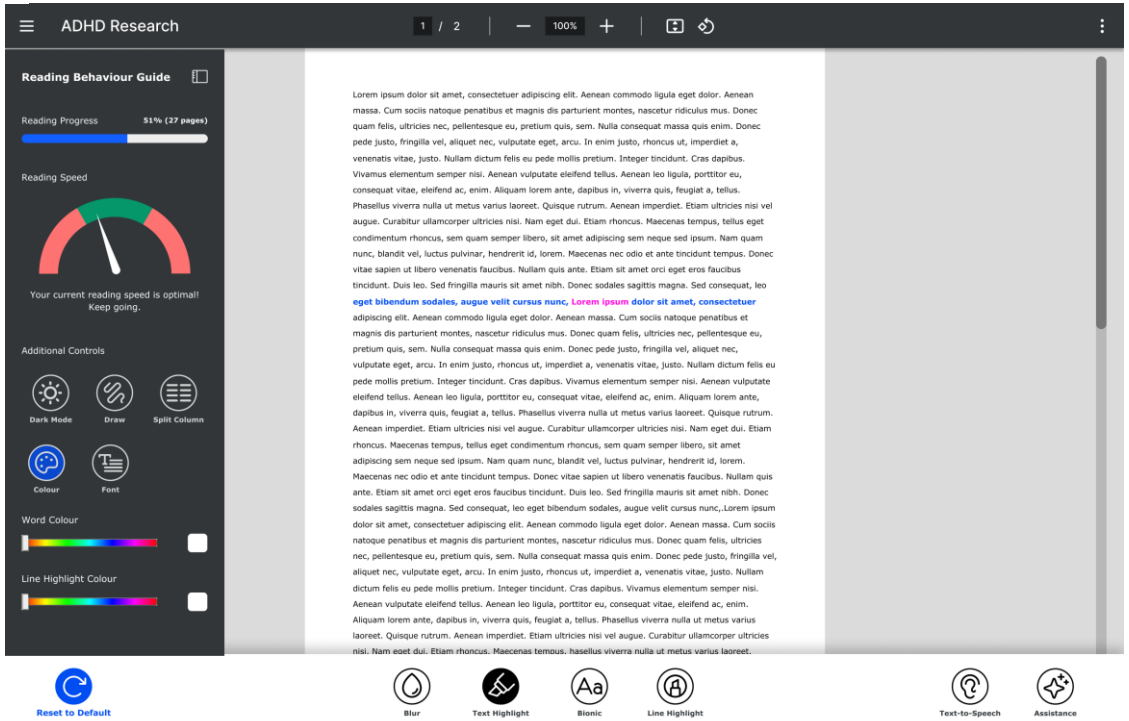
Re-Design & Evaluation

Re-design in Figma

First functional Prototype



Click Prototype in Figma



Design Evaluation

N = 5 Professional UX and UI designer with (confirmed or suspected) ADHD (22-28 years, ***M*** = 25.60, ***SD*** = 2.19)

Procedure:

- Project Overview: Research context, motivation, and design rationale
- Evolution Demo: Initial prototype screenshots, features, and limitations
- Prototype Exploration: Think-aloud protocol with Figma prototype via Zoom
- Questionnaire (async): SUS, heuristic evaluation, and open-ended feedback

Results:

SUS score ***M*** = 88.50 (***SD*** = 10.98)

Table 7: ADHD-Specific Usability Ratings by Evaluator (N = 5, Scale: 1–5)

Item	P1	P2	P3	P4	P5	*M* (*SD*)
Minimizes visual distractions	5	5	4	4	3	4.20 (0.84)
Typography supports ADHD reading	5	5	4	3	4	4.20 (0.84)
Layout reduces cognitive overload	5	5	5	4	5	**4.80 (0.45)**
Interactive elements predictable and clear	5	5	3	4	5	4.40 (0.89)
Customization accessible, not overwhelming	5	5	4	4	5	4.60 (0.55)
Visual hierarchy guides attention	5	5	4	3	4	4.20 (0.84)
Color and contrast support focus	5	5	5	3	4	4.40 (0.89)
Spacing and whitespace effective	5	5	4	4	5	4.60 (0.55)
Helps ADHD users sustain attention	5	4	4	4	4	4.20 (0.45)
Overall well-suited for ADHD users	5	5	4	4	4	4.40 (0.55)
Overall Mean	5.0	4.9	4.0	3.7	4.3	4.38 (0.68)

Note. Scale: 1 = Strongly Disagree; 5 = Strongly Agree. M = mean; SD = standard deviation. Bold M indicates the highest-rated item. Overall mean computed across all ten items per evaluator and across the full matrix.

Discussion

Design principles for ADHD-specific reading assistance systems

1. **Personalisation by Design**
   Adjustable visual features (colour, contrast, font, line spacing) with individual user profiles
2. **Support Without Overload**
   Restrained visual aids; optional and configurable intensity to avoid increased cognitive load
3. **Sustain Reading Flow**
   Continuous, low-latency feedback on reading position (word- and line-level highlighting)
4. **Ensure Accessible Interaction**
   Usable on existing devices; cursor-based tracking as entry point, eye tracking optional
5. **Enable Flexible Feature Combination**
   Combine and layer features rather than single-mode for personalised configurations
6. **Integrate Adaptive Mechanisms**
   AI-based adaptation detecting line jumps, rereading, or movement for dynamic support

Limitations

- Small sample size
- Inclusion of participants without formal ADHD diagnosis
- Exploratory nature of the workshop
- Prototype limitations affecting results
- Intentional delay in visual reading features was sometimes perceived as a system flaw rather than a deliberate design choice
- Focus on user experience only (not objective reading performance)

Future Work

- Randomised controlled trial: ADHD group vs. neurotypical controls
- Multimodal (neuro-)physiological data collection (brain, cardiac, body activity)
- Adaptive extensions: motion tracking to trigger support or suggest breaks
- Integration of LLMs for text simplification and summarisation of challenging passages
- Subsequent user-centred workshop to evaluate and refine the adjusted prototype

Conclusion

- Prototype was perceived positively
- High mean SUS score: good usability and accessible interaction concept
- Line spacing received highest overall ratings; font highlighting preferred in eye-tracking condition
- High degree of personalisation essential to accommodate heterogeneous ADHD needs
- Cursor-based interaction is a viable, accessible alternative to eye tracking

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Scan for project website

Thank you!

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