Attention-centered Generative User Interfaces for All

Adrian Wegener
Karlsruhe Institute of Technology
Karlsruhe, Germany
adrian.wegener@kit.edu

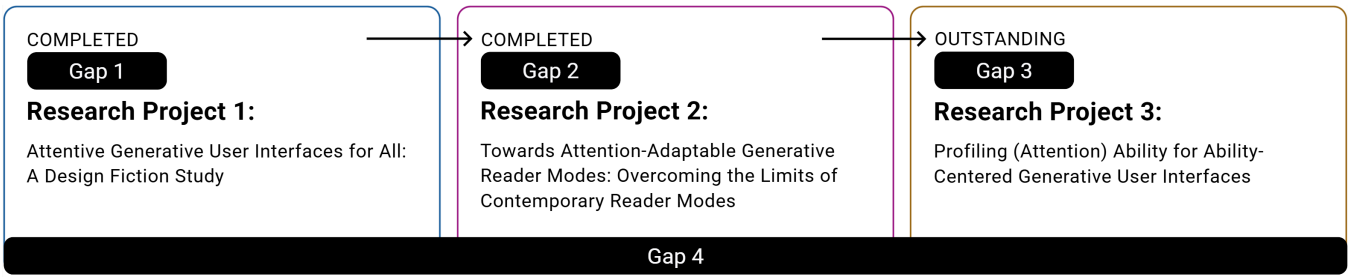

Figure 1: Overview of PhD thesis research projects.

Abstract

Attention is a variable and increasingly limited human ability, yet most interactive systems treat it as fixed or infer it implicitly through opaque signals. This PhD research investigates how attention-centered generative user interfaces (GenUIs) can be designed to support diverse attention abilities while preserving user trust and agency. Using reader modes as a design space, the dissertation integrates participatory design, empirical evaluation, and generative prototyping to move beyond content filtering toward user-controlled, ability-based interface generation. Across three research projects, it (1) elicits user expectations and ethical considerations for (attentive) GenUIs through Design Fiction, (2) empirically identifies the limits of contemporary reader modes on comprehension and cognitive load, followed by designs of attention-adaptable generative alternatives, and (3) examines how ability profiles shape perceptions of agency and epistemic trust in GenUIs. The research contributes design knowledge, empirical insights, and inclusive methods for attention-adaptive generative systems in HCI.

CCS Concepts

• **Human-centered computing** → **User interface design**.

Keywords

Attention, Participatory Design, Reader Mode, Generative User Interface, Design Fiction

ACM Reference Format:
Adrian Wegener. 2026. Attention-centered Generative User Interfaces for All. In *Extended Abstracts of the 2026 CHI Conference on Human Factors in Computing Systems (CHI EA '26), April 13–17, 2026, Barcelona, Spain.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3772363.3799191

CHI EA '26, Barcelona, Spain

ACM ISBN 979-8-4007-2281-3/26/04
https://doi.org/10.1145/3772363.3799191

1 Dissertation Status

I am a second-year PhD student in the Human-Centered Systems Lab at the Karlsruhe Institute of Technology, Germany. With a background as a user experience (UX) and accessibility practitioner, including roles as a startup founder and accessibility manager in a UX consulting agency, I'm highly motivated to expand underrepresented research in diverse attention ability. My dissertation will consist of three research projects to explore the problem space of contemporary reader modes and propose alternative designs using GenUIs that mitigate their issues. While my PhD program has no fixed timeline, I aim for completion of my research projects by the beginning of 2027. Post-graduation, I intend to continue HCI research on GenUIs in academia or industry.

2 Introduction and Related Work

This PhD thesis investigates attention as a grounded and variable human ability and explores how it can be supported through attention-centered GenUIs. The goal is to design user interfaces (UIs) that are centered on diverse attention abilities while supporting performance, trust, and agency. This work focuses on reader modes as a design space for studying attention-centered GenUIs. The following sections outline relevant related work.

Attention: The primary ability addressed in this research is attention. Attention is a compelling target for ability-based systems for two reasons. First, it is closely connected with other cognitive functions, including *decision and response selection*, *response execution*, *working memory*, and *perception*, thereby influencing overall cognitive performance [20]. Second, while attention is often discussed in the context of the 2–5% of the global population diagnosed with Attention-Deficit / Hyperactivity Disorder (ADHD) [2, 14, 17, 18], recent research suggests that sustained attention has declined across the general population [11]. Designing systems that support attention, therefore, has relevance beyond clinical populations. Interventions aimed at supporting lower attention abilities can also benefit other users through the curb-cut effect, whereby accessibility-driven improvements yield benefits for all users [1].

Reader Modes: Users across the attention spectrum already employ tools such as advertisement blockers and browser-based reader modes to manage attentional demands during web interaction. Reader modes act as filtering mechanisms that reduce visual clutter [12]. Although reader modes have existed for decades [3], they typically focus on removing content rather than restructuring or enhancing it [12]. As a result, they offer limited support for individual differences in attention ability.

Recent advances in generative artificial intelligence (AI) create new opportunities to extend reader modes beyond static filtering. In this research, reader modes serve as a concrete application domain for investigating how attention-centered generative adaptations can better support users' diverse attention needs.

Generative UI and Attention Adaptation: Traditional UIs are largely static, with limited adaptability beyond rule-based systems [5] or responsive layouts across devices [10]. GenUIs, whose specific definition is still under discussion [6], go further by dynamically adapting, modifying, or generating content to meet individual user needs [8]. Contemporary reader modes lack these capabilities but could substantially benefit from them. Where attention-centered adaptation is often based on implicit signals such as eye-tracking data [9], it may also be based on explicit user-defined profiles or self-reported attention abilities.

However, adaptive and generative systems raise important challenges, including risks to usability principles such as *predictability* [5] and ethical concerns, such as data bias [6]. Addressing these challenges requires direct user involvement to understand expectations, concerns, and acceptable boundaries of automation.

3 Research Objectives and Approach

To support attention abilities across a broad spectrum through emerging technologies such as GenUIs, this PhD project addresses the following overarching research question:

RQ: ***"How can attention-centered generative user interfaces be designed, using a participatory approach, to support attention, performance, trust, and user agency across diverse attention abilities?"***

A central commitment of this work is participatory design with people across the attention spectrum. Rather than focusing on a single diagnostic category (e.g., ADHD), the project adopts an ability-oriented perspective that foregrounds diversity and enables the identification of curb-cut effects, where design interventions benefit a subset of users and the broader population [1].

The dissertation comprises three tightly connected research projects aligned with established phases of the human-centered design process [16]. Collectively, these projects progress from eliciting user expectations and ethical requirements for attention-centered GenUIs to the design and empirical evaluation of such systems, including their implications for performance, trust, and agency. Across all projects, the dissertation integrates participatory design, empirical evaluation, and speculative inquiry to address the following research gaps, which are mapped to the individual research projects in Figure 1:

(1) **Knowledge Gap:** What expectations do users have towards attentive generative user interfaces?
(2) **Empirical Gap:** How do contemporary and attention-adaptable generative reader modes affect users' performance?
(3) **Empirical Gap:** What impact do ability-based generative user interfaces have on users' trust and agency?
(4) **Methodical / Population Gap:** What changes are needed to include people across the attention spectrum in participatory methods?

4 Completed Research Projects

A Design Fiction study provided early insights that have helped identify users' future requirements for attentive GenUI systems, guiding the research direction. The ongoing outcomes from the second research project on contemporary reader modes and GenUI-based alternatives, combined with the Design Fiction study results, are detailed here to provide an overview of the PhD thesis status.

Research Project 1: Attentive Generative User Interfaces for All: A Design Fiction Study

This study explores the future of attentive Generative User Interfaces (GenUIs), which use artificial intelligence to dynamically provide individualized interfaces that support users across a diverse spectrum of attention abilities.

Methodology: The research employed a multi-study participatory design approach to investigate how speculative technologies can cater to varied attentional needs.

- **Study 1 — Survey and Attention Test (N=30)**: Participants were recruited and grouped based on their sustained attention ability using the long-time established Rapid Visual Information Processing (RVP) test [13] and self-reported data. This allowed for the clustering into three groups: High Attention, Low Attention, and ADHD-Diagnosed.
- **Study 2 — Semi-structured Interviews (n=10)**: These sessions identified current attention-management strategies (e.g., ad blockers, "tab hygiene") and gathered requirements for future AI-driven support.
- **Study 3 — Design Fiction Exercises (n=12)**: Participants evaluated three speculative scenarios through tech-company-style presentation slides and worksheets. Participants used a *Cone of Plausibility* to rate the preferability and probability of each future. Exercises included accessibility adaptations, such as small group sizes, read-aloud options, and the use of worksheets to manage cognitive load.

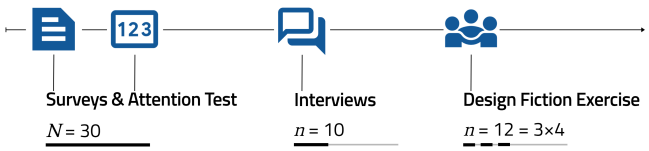

Figure 2: Studies of Research Project 1. Showing how many of the total 30 participants were present per study.

The Design Fiction scenarios included:

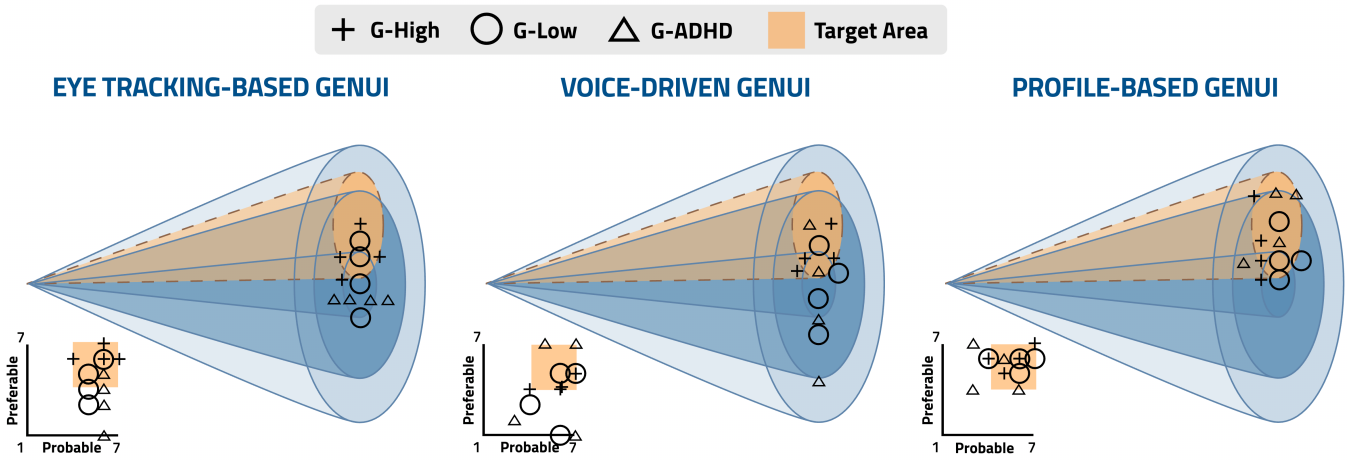

Figure 3: All three scenarios are compared in the *Cone of Plausibility*. The farther the markers of the participants are from the center, the less likely they are to see the scenario. If a value of 4 or above was reported on a 1-7 Likert scale for preferability, the markers are placed in the top half. If the preferability was reported as 3 or lower, it is in the bottom half. The cone shows preferable and likely scenarios in the off-center cone in the top half, which describes the optimal scenarios for implementation.

(1) **Eye Tracking-based GenUI (Research-grounded)**: Adapting UI structure based on visual focus.
(2) **Voice-driven GenUI (Corporate-inspired)**: An audio-only interaction model.
(3) **Profile-based GenUI (Literary-inspired)**: Interfaces generated based on an individual's ability profile.

Results: The study revealed a clear hierarchy of preference among the proposed futures:

Unanimous Support for Profile-based GenUI (Scenario 3): This was the most preferred scenario, as participants valued user-controlled generation tailored to their specific ability profiles.

Divergent Views on Eye-Tracking (Scenario 1): While some saw it as an inevitable next step, others feared surveillance or being judged for having "simplified" views.

Resistance to Voice-driven Interfaces (Scenario 2): Most participants feared a loss of control and discomfort with non-visual interaction.

Future Requirements: Across all groups, these were the essential requirements for future (attentive) GenUIs:

- **User Control:** A mandatory on/off toggle and the ability to revert changes.
- **Transparency:** Clear notifications when the AI modifies the interface.
- **Personalization:** Foundation on dynamic ability profiles that reflect fluctuating (attention) ability states.

Discussion: The findings highlight both the potential and the risks of using AI to mediate attention:

The "Battle" for Attention: Participants identified a fundamental conflict between user-centric UX (designed for task completion) and corporate-centric design (designed to capture attention for profit).

Data Security and Stigma: A significant concern was the sensitivity of attention data. Participants feared that profiles reflecting lower reading levels or medical diagnoses could lead to algorithmic ableism or personal embarrassment if shared.

Balancing Individualization and Usability: While personalization is key, excessive dynamic changes risk breaking UI consistency and predictability, potentially increasing cognitive load rather than reducing it.

Methodological Insights: The study demonstrates that Design Fiction is an effective, inclusive research tool. By using predefined scenarios and structured worksheets, researchers can successfully involve neurodiverse participants in speculating about complex, technical futures without causing cognitive overload.

Research Project 2: Towards Attention-Adaptable Generative Reader Modes: Overcoming the Limits of Contemporary Reader Modes

This research investigates the performance impacts of contemporary reader modes and proposes a new paradigm of attention-adaptable generative reader modes to overcome identified performance limitations. While the previous Design Fiction study explored the speculative future and ethical requirements of attentive GenUIs, this consecutive study provides an empirical evaluation of contemporary reader modes and a functional design framework for generative ones.

Method: This research project has already completed two out of three consecutive studies to address the lack of performance improvements in contemporary reader modes and explore design solutions for mitigation.

- **Study 1 — Performance Evaluation (N=96):** A within-subject online experiment was conducted to assess how contemporary reader modes affect perceived cognitive load (NASA-TLX [4]) and reading comprehension (using SQuAD 2.0 [15]). Participants were clustered into High, Mid, and Low attention groups using another RVP sustained attention test [13]. They interacted with a controlled self-build representative news website (baseline) and contemporary

Figure 4: Studies on the evaluation of contemporary reader modes and design of attention-adaptable generative reader modes.

reader mode, followed by comprehension quizzes and the opportunity to provide feature requests for reader modes that further improve their attention.

- **Study 2 — Parallel Design and Conjoint Analysis:** Building on future requests from Study 1, a design brief was developed for an attention-adaptable generative reader mode. Parallel design was employed, where three human designers (N=3) and three AI system designers independently created mid-fidelity prototypes. These six designs were evaluated using a pairwise ranking-based conjoint analysis (N=50) to identify which design best fulfilled the requirements for adaptive, generative attention support.

Results: *The Effort-Performance Gap:* Results showed that contemporary reader modes significantly reduced subjective cognitive load ($p<0.01$, medium Effect Size (η_p^2) 0.098) across all attention groups, while there were no significant differences between groups. However, they did not improve reading comprehension, challenging the assumption that reduced visual clutter automatically leads to better task performance.

Design Requirements: Users requested features beyond simple restyling, specifically adaptive content filtering, automatic sectioning, and generated summaries. These needs were synthesized into one of the four design requirements of "Attention Zoom": the ability of a GenUI to dynamically adjust content detail by restructuring and regenerating information rather than just hiding it, informed by self-reported user attention data.

Winning Prototype: The conjoint analysis identified design E as the highest-ranked approach for balancing attention support with user agency, which builds the foundation for the upcoming performance evaluations of attention-adaptable generative reader modes.

Discussion: *Nuancing Expectations:* The findings suggest that lowered cognitive effort can not fulfill expectations on improved performance in reading comprehension. This mismatch highlights that contemporary static filtering is insufficient for comprehension support.

Empowering Agency through GenUI: Unlike traditional attentive user interfaces (AUIs) that often infer states through uncertain biosignals, this study treats attention as an explicit interaction input. By allowing users to control the "zoom" of their content attention, GenUIs can provide deep structural adaptations while preserving the user-controlled activation central to reader modes.

Diverse Abilities in GenUIs: Although this research centers on attention, many identified requirements regarding user control, data security, and personalization extend to GenUIs targeting other abilities. Focusing on a single ability enables controlled empirical investigation; however, it leaves open the complexities that arise when multiple abilities are integrated as inputs to GenUIs. Addressing such multi-layered ability profiles will be essential for accommodating diverse user populations beyond attention.

5 Outstanding Research Projects

Research Project 2: Continued

Currently, the completed studies in Research Project 2 have established the design requirements and the final prototype based on the finding that contemporary reader modes lack performance effects on reading comprehension. The third study of this project will also do a **performance evaluation on cognitive load and reading comprehension this time in the attention-adaptable generative reader mode prototype** to determine if these generative adaptations successfully translate into measurable gains in performance compared to contemporary reader modes.

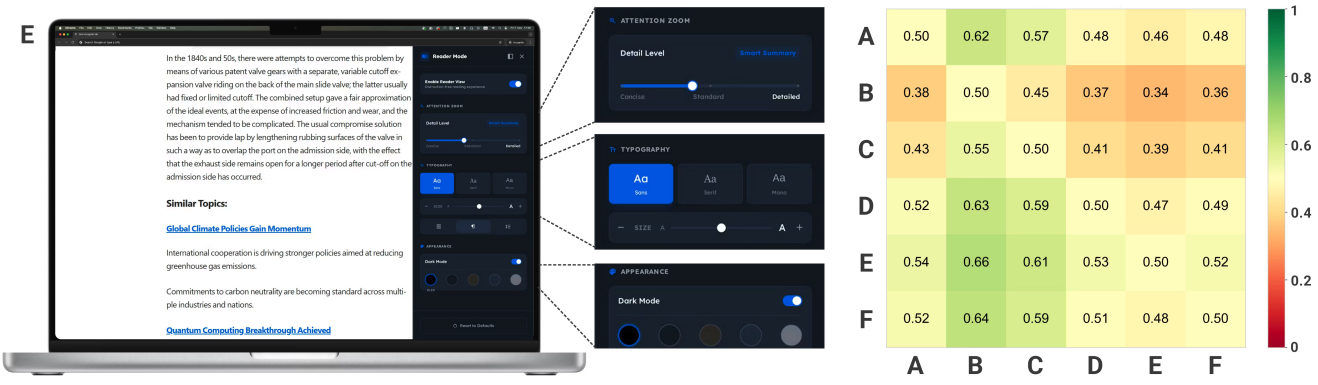

Figure 5: Results of pairwise conjoint analysis and visualization of the highest ranking mid-fidelity design concept E.

Research Project 3: Profiling (Attention) Ability for Ability-Centered Generative User Interfaces

The final research project investigates the impact of attention-centered GenUIs on epistemic trust ("defined as trust in socially transmitted knowledge"[19, p. 1]) and the sense of agency, which is the user's "perceived control over one's actions and their consequences" [7, p. 1], as these topics came up regularly in the first two research projects. Especially in contexts involving individualized learning content, an emerging use case of GenUIs [8], measures to strengthen epistemic trust are essential. Moreover, findings from Research Project 1 indicate that participants emphasized the importance of maintaining a sense of agency in workplace settings, expressing concerns that reduced control could negatively affect productivity and work ownership. Utilizing a within-subject experimental design, Research Study 3 compares a GenUI without a user profile against an ability-profile-based GenUI. The latter system generates UIs based on existing GenUIs capabilities [8] and extends this by considering (attention) ability profiles, which are derived from various data sources, such as psychometrics, behavioral metadata, or biosignals. This upcoming research addresses the research question:

RQ: *"How does the integration of user ability profiles into the UI generation process moderate users' sense of agency and epistemic trust?"*

By analyzing how these profiles can ground generative adaptations and how users react to them, the study explores whether ability profiles can serve as a "bridge" to make AI-driven changes more predictable and trustworthy.

6 Expected Contribution and Long Term Goals

Expected Contributions: This PhD thesis contributes to HCI by advancing a participatory, empirically grounded approach to designing attention-centered GenUIs. It provides evidence that contemporary reader modes, while reducing cognitive load, do not necessarily improve task performance, and introduces attention-centered generative reader modes that treat attention as an explicit, user-controlled interaction input. The work contributes design knowledge for GenUIs that adapt content structure and level of detail.

Beyond performance, the thesis will offer insights into how ability-based generative adaptations shape users' perceptions of trust and agency, identifying conditions under which AI-driven interface changes are perceived as transparent, predictable, and acceptable. Methodologically, it contributes guidance on inclusive participatory and speculative research practices involving users across the attention spectrum.

Long Term Goals: In the long term, this work aims to support the development of human-centered GenUIs that integrate adaptive and generative capabilities while prioritizing user control, transparency, and participation. By foregrounding attention as a variable design concern rather than an inferred internal state, the thesis seeks to help shape generative systems that support effective interaction without compromising trust or agency.

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