Proposal: Perceiving Colour

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1 Executive Summary

Problem Statement: Colour rich media is everywhere, but we still do not fully understand how the intensity of colour influences people's attention and responses. This project explores how viewers react to colourful and black and white video stimuli by examining eye movements. The insights gained will support the development of Perceiving Colour, a concept for a wearable device that adjusts colour levels in real time based on users' engagement.

This project investigates how colour intensity in visual media influences visual attention during gameplay viewing, using eye-tracking as an objective measure of engagement. The central research problem is whether colour-rich content, compared with black-and-white stimuli, systematically alters fixation patterns, dwell time, gaze distribution, and arousal-related indicators such as saccade rate and gaze-path complexity. Target users are general viewers of digital gameplay media, with the product context oriented toward future adaptive visual technologies, including concepts like how individuals perceive colour, which could dynamically adjust hue levels in response to user attention. Data will be collected from twenty participants watching a ten-minute composite gameplay video in either split-screen colour/monochrome or full-colour format, using a Tobii screen-based eye tracker and associated software. Quantitative eye-tracking data (fixation duration and count, dwell time, saccade measures, gaze distribution) will be complemented by descriptive visualisations (heat maps, scan paths, bee-swarm plots) and brief qualitative interviews. The intended outcome is a set of data-driven insights showing whether and how colour intensity modulates visual engagement, and whether combined eye-tracking features can help classify engagement levels in ways that inform the design of adaptive, screen-exposure-limiting visual products.

2 Introduction & Problem Definition

Excessive screen use is linked with multiple health-related issues, such as increased anxiety, sleep problems and stress, especially at high daily usage levels (Ndayambaje and Okereke, 2025). Greyscale display modes can reduce daily screen time and improve perceived control, but device-level greyscale settings are easy to disable and are often used only part of the time (Dekker and Baumgartner, 2023), which limits their effectiveness. The proposed product suggested are a pair of smart glasses that apply an external greyscale filter to screens aims to address this compliance gap by making the intervention harder to bypass while leaving devices themselves unchanged.

The project sits in the context of product design and UX testing for digital wellbeing technology. Eye-tracking during gameplay, with half the screen in colour and half in greyscale, functions as a controlled testbed for the glasses' core mechanism: reducing the attentional pull of screens by stripping away colour. Measuring fixation patterns, dwell time, and time to first fixation on colour versus greyscale regions allows direct assessment of whether greyscale reduces visual salience and sustained attention in dynamic, game-like environments (Falkowska et al., 2025).

This problem is significant for applied analytics and product development because many existing digital wellbeing tools rely on self-control (timers, limits) and suffer from poor adherence, whereas greyscale is more effective but still frequently disabled (Dekker and Baumgartner, 2023). Analytics from HCI methods, including eye tracking, make it possible to move beyond assumptions and quantify how visual design changes (such as removing colour) alter attention at a fine-grained, temporal level. Demonstrating a reliable reduction in attention to colour-stripped content would justify further investment in hardware-based interventions and guide decisions about integrating such products into digital wellbeing ecosystems.

The intended contribution is twofold. First, the work provides perceptual-level evidence on how greyscale affects gaze behaviour in realistic, time-limited gameplay scenarios (Jusufi and Andersson, 2025), extending prior research that focused mainly on total screen time rather than underlying attentional mechanisms. Second, gaze-based insights from the study can inform design choices for the smart glasses, such as whether a uniform greyscale filter is sufficient or whether adaptive filtering is needed for specific content types where colour plays a critical role in capturing attention. In this way, the project demonstrates how HCI analytics can directly shape evidence-based product decisions in digital wellbeing.

3 Background & Contextual Review

Eye tracking has been widely used to study visual attention in games and interactive media, typically via metrics such as time to first fixation, fixation duration, and scan paths (User Experience Magazine, 2012). Studies with educational and commercial games show that gaze patterns over dynamic gameplay scenes reflect how players allocate attention to UI, enemies, and critical information, and these patterns correlate with individual differences in visual attention and performance. In game UX research, eye tracking is often combined with think-aloud, questionnaires, or performance logs to interpret whether players notice feedback, understand visual cues, or miss key interface elements (Lu et al., 2021).

Human visual attention tends to be focussed on 'bottom-up salience' (Lindkvist, 2023) (such as colour, contrast and motion), as well as top-down goals (task demands or expectations). In games, colour is used to guide attention to important objects or threats. Empirical work has shown, for example, that certain colours (like yellow) can reduce time to first fixation and increase fixation duration on target elements compared with other hues (Tulleken, 2015). Greyscale filters remove chromatic information and leave only luminance differences, which can make it harder for key elements to stand out if they rely on colour coding; game case studies report that enemies or indicators in monochrome scenes are sometimes overlooked until colour or stronger cues are added.

Existing game eye-tracking studies have focused on questions such as whether players see

HUD elements and tutorials, how animation vs colour vs outlines capture attention, or how players navigate complex menus (Fatehi et al., 2022). There is also work on using eye tracking to guide narrative game design and to understand individual differences in visual attention during gameplay (Holm et al., 2021). However, there are relatively fewer controlled experiments that directly manipulate colour vs greyscale within the same game content to quantify how this affects gaze allocation across the screen over time, especially in short, repeatable gameplay clips. The proposed design explicitly targets that gap by splitting the screen into colour and black-and-white halves and comparing gaze metrics between them.

UX analytics in games typically combine behavioural logs (clicks, deaths, wins), subjective measures (surveys, enjoyment), and physiological or behavioural traces like eye movements to inform design decisions. Eye-tracking data provide concrete, quantitative evidence of what players actually look at, which helps designers move beyond assumptions: for example, analytics have been used to show that players ignore critical buttons at screen edges, or fail to notice enemy indicators until their colour and size are changed (Holm et al., 2021). In an industry context, this kind of data-driven insight supports iterative design, as one can justify layout changes, colour schemes, or tutorial timing by pointing to measurable changes in fixation patterns and task performance rather than purely aesthetic preference.

Eye trackers such as Tobii systems continuously record where on the screen a player is looking, at high temporal resolution, while they interact naturally with the game. This provides unique insights that other UX methods lack: it can be detected whether players saw an element but did not understand it (they fixated it but did not act), or whether they never visually registered it at all (no fixations on the AOI), which is crucial when comparing colour and greyscale halves on a screen. In gaming specifically, Tobii-based integrations are already used in commercial titles and research to enhance immersion and to assess user experience, so using the same kind of eye-tracking hardware aligns this study with current industry practice while enabling fine-grained analytics such as time to first fixation and total dwell time per side of the screen(Tobii Developer Zone, 2024).

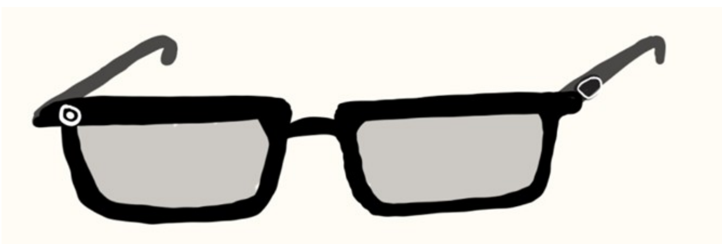

Figure 1: Probing the idea of ‘Smart Glasses’ as a potential product

4 Project Aims, Objectives, and Research Questions

This project's main goal is to examine how colour intensity in visual media affects user attention patterns using eye-tracking data as an objective measure of engagement. The project aims to generate evidence that can guide the future development of adaptive visual technologies, such as the Perceiving Colour product, which suggests dynamically adjusting colour levels based on user responses, by analysing gaze behaviour across both colour-rich and black-and-white gameplay sequences.

To pursue this aim, the project sets out several measurable objectives. The first objective is to gather a comprehensive dataset of eye-movement recordings from twenty participants using a Tobii screen-based tracker while they view a ten-minute composite gameplay video presented either in full colour or in a split-screen colour and monochrome format.

The second objective is to use well-established analytical tools to calculate a variety of attention-related measures, including fixation duration, fixation count, dwell time, gaze distribution, and saccaderate. In order to find comparison patterns between situations, the third objective is to create statistical and visual representations of gaze activity, such as heat maps, scan paths, and bee-swarm diagrams. In order to provide data-driven insights for upcoming design applications, the ultimate goal is to understand these outputs and assess if colour intensity consistently modifies visual engagement.

These aims and objectives are guided by three research questions:

RQ1: How does colour intensity influence fixation patterns, dwell time, and gaze distribution?

RQ2: How do eye-tracking indicators of arousal, including saccade rate and gaze-path complexity, differ between colour and black-and-white stimuli?

RQ3: To what extent can combined eye-tracking features be used to classify levels of user engagement during different visual stimuli?

5 Project Methodology & Technical Approach

This project employs a quantitative experiment-driven methodology designed to examine how colour intensity influences patterns of visual attention during gameplay viewing. A controlled data collection process was implemented to ensure that all visual attention metrics were captured with precision and consistency. Eye-tracking served as the primary measurement technique, enabling fine-grained observation of gaze behaviour across a diverse set of visual stimuli.

5.1 Data Collection Plan

Data will be gathered exclusively through eye-movement recording, focusing on metrics indicative of attention and visual engagement. The data includes: fixation duration, fixation count, dwell time, saccade rate, complexity of the gaze path, and gaze distribution. Since the participants' role is passive observation rather than task performance, no physiological or behavioural interaction data will be gathered. Each participant's raw eye-tracking data will be collected in various ways, heat maps, bee-swarm representations, and scan-path diagrams.

The stimulus video will be produced by duplicating an original full-colour recording and converting the duplicate into a greyscale format. The two versions will then be overlaid and split vertically, resulting in a composite video in which the left half retains full colour and the right half is presented in black and white.

5.2 Tools and Devices

All gaze behaviours will be recorded using a screen-based Tobii eye-tracker. Tobii Lab software, which enables synchronised data logging, stimulus presentation, and calibration, will be used to conduct the experiment. Python, together with libraries like Pandas and NumPy, will be used for data cleaning, transformation, and statistical analysis. Heat maps, fixation charts, and comparison A/B visualisations will be produced for visual analytics using Python-based plotting tools.

5.3 Participants

The study will include a sample of twenty people with a balanced gender distribution and a diverse age range. Fifteen participants will see the split-screen version with colour on the left and black and white on the right, while five participants will see the unaltered, full-colour film, creating the A/B comparison group. All participants will be informed about data protection, anonymisation, and their ability to withdraw, and recruitment will be conducted in accordance with the principles of voluntary participation. Ethical considerations will be addressed by ensuring that no personally identifiable information is recorded and that all procedures follow standard HCI research guidelines.

5.4 Screening Survey and Post-viewing Interviews

In addition to eye-tracking data, supplementary qualitative and demographic data will be collected through a short screening survey and semi-structured post-viewing interviews. Prior to the experiment, participants will complete a screening questionnaire designed to capture key background variables, including age, gender, prior gaming experience, and familiarity with the game content. This information will be used to contextualise gaze behaviour and to ensure a broadly representative participant sample, while avoiding the collection of personally identifiable information.

Following the viewing session, each participant take part in an interview to capture subjective perceptions of the visual material. The interviews focusses on participants' awareness of colour intensity, perceived visual clarity, areas of interest, and any noticeable differences between colour and black-and-white footage. This qualitative feedback won't be treated as primary data but instead used to triangulate and interpret eye-tracking results, helping to explain observed gaze patterns and attention shifts. Interview responses will be anonymised, summarised thematically, and used to support the quantitative findings rather than to generate standalone conclusions.

5.5 Data Analysis Methods

Both descriptive and inferential analytical methods will be employed to evaluate visual attention patterns across experimental conditions. Raw eye-tracking outputs will be cleaned and structured using Python to remove incomplete recordings, calibration errors, and data inconsistencies. Key gaze metrics, including fixation duration, fixation count, dwell time, saccade behaviour, and gaze distribution, will then be aggregated per participant and per viewing condition.

Descriptive statistics will be used to summarise overall attention patterns, while comparative A/B analyses will be conducted to identify differences between colour and black-and-white stimuli. To statistically assess differences between conditions with unequal sample sizes and variance, Welch's t-test will be applied where parametric assumptions are reasonably met. Visual analytics, including aggregated heat maps, scan-path diagrams, and bee-swarm plots, will be generated to support interpretation by revealing spatial and temporal attention trends that may not be apparent from numerical metrics alone. Qualitative insights from post-viewing interviews will be used to contextualise quantitative findings, supporting interpretation without serving as a primary source of analysis.

5.6 Expected Outputs and Feasibility

Expected outcomes include: (1) full sets of heat maps, scan paths, and bee-swarm plots for each participant; (2) cleaned Excel datasets of all recorded eye-tracking metrics; and (3) quantitative findings that reveal whether colour intensity significantly alters attention. The project is technically feasible, relying on established eye-tracking hardware, accessible software tools, and a manageable participant sample, though limitations include the absence of physiological measures and the reliance on passive viewing rather than interactive tasks.

Figure 2: Exploring a contemporary example of greyscale vs colour in games

6 Project Development Plan

This project was developed using an organised workflow that was strengthened by a distinct distribution of duties among team members. At the beginning, a week-by-week schedule, Gantt chart, was developed to direct the process, detailing important benchmarks in the areas of literature review, experimental setup, participant recruitment, data collection, data processing, analysis, visualisation, and report compilation. As the project's operational timeframe, this schedule made ensuring that tasks were finished effectively and in the correct order.

Aasia serves as the Team Lead, providing overall direction and maintaining oversight of methodological decisions. Her responsibilities include coordinating the study design, managing the experimental environment, and taking primary responsibility for data collection using the Tobii screen-based eye tracker. She will contribute as a Data Analyst and Technical Developer, cleaning and analysing the qualitative data and supporting the interpretation of eye-tracking metrics.

Rebecca will act primarily as the UX Designer, Data Analyst, and Report Coordinator. She developed conceptual sketches related to the Perceiving Colour system, ensuring that the project retains a strong user-centred design orientation. To maintain a balanced distribution of workload, Rebecca will take on a greater proportion of the data analysis. In her role as Report Coordinator, she will ensure structural coherence across written components, integrating analytical outcomes into the final documentation.

Collaboration will be maintained through messenger for communication and shared cloud storage for file exchange and version control. Both individuals will create, edit, and share each other's files on a shared OneDrive folder. This structured and transparent workflow enables efficient coordination, equitable contribution, and clear attribution of tasks, ensuring that each member's role is identifiable for assessment purposes.

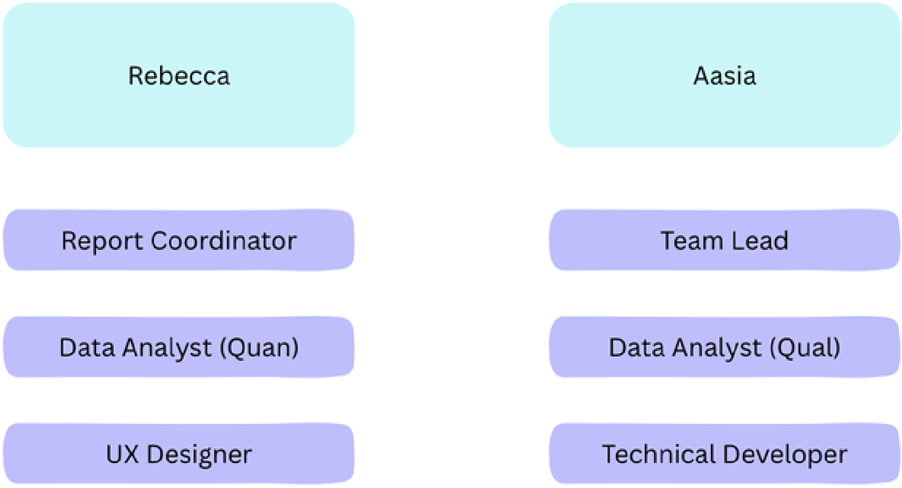

Figure 3: Role breakdown

7 Feasibility, Risks, and Ethics

An expectation when starting a project is to map out the feasibility, risks and ethics that surround the process, to ensure that the study performs as intended. Starting off with resource availability, the Tobii eye-tracker and associated software are available through the university, and the researchers have been gathering experience using this system. Testing will take place in a controlled lab environment with access to a suitable computer, display, and seating. The technical setup is well established and involves standard calibration and validation procedures. Pilot testing will be conducted to ensure reliable gaze tracking before data collection begins. Participant recruitment methods will follow university guidelines, and no vulnerable groups will be targeted. A demographic and screening survey has been put together to reflect this.

Risks associated with this project include: data quality (poor calibration, head movement, or loss of tracking) - this will be managed by careful calibration, monitoring tracking validity, and excluding unusable trials where necessary; participant compliance - clear instructions, practice trials, and regular breaks will be provided and equipment malfunctions - technical failures could interrupt data collection. Pilot testing and equipment checks before each session will reduce this risk.

Finally, ethics-wise, participants will receive clear information about the study and provide informed consent before taking part. They may withdraw at any time without penalty, as outlined in the Information Sheet. Eye-tracking outputs will be used solely for research purposes and will not be used to identify individuals, and all data will be randomly coded (e.g P1) and stored on secure, university-approved systems in accordance with GDPR, with access restricted to the research team (Rebecca and Aasia).

8 Expected & Impact

The project's expected conclusions are that visual attention patterns during gaming viewing will be greatly influenced by colour intensity. Participants exposed to split-screen stimuli are particularly expected to exhibit a quantifiable bias towards the coloured side of the screen, as evidenced by greater fixation counts, longer dwell periods, and denser gaze distributions in comparison to the black-and-white areas. Across both conditions, attention is also expected to cluster around central screen areas, reflecting established visual saliency and layout effects.

A structured setof eye-tracking visualisations, such as heat maps, scan-path diagrams, and bee-swarm plots, as well as cleaned and anonymised Excel files including all collected gaze metrics, will be among the project's primary outputs. These outputs will provide both quantitative and spatial representations of attention behaviour.

This work's direct application to data-driven product design is what gives it potential worth. The Perceiving Colour concept and other adaptive visual systems may benefit from the findings, enabling design choices for the use of colour in digital media, gaming interfaces, and accessibility-focused goods. The degree to which analytical results can assist practical design insights, the statistical significance of important measures, and the consistency and clarity of observable gaze differences between situations will all be used to gauge success.

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Appendices

Please refer to the shared file to access the ethics forms, consent forms, data samples, and code snippets.