REARS: An Interface for Browser-Based Eye-Tracking in Remote Readability Studies

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Abstract

Readability research has traditionally relied on in-lab eye-tracking to capture how people read digital text. While these studies provide fine-grained measures such as fixations and saccades, they are often expensive, time-consuming, and difficult to scale. Recent efforts have explored webcam-based eye gazers as a lower-cost alternative, enabling some studies to crowdsource. The accuracy of webcam-based eye trackers remains insufficient for conventional readability analyses, especially when studies involve dense blocks of text and require sentence-level interpretation. Rather than attempting to further improve webcam eye-tracking accuracy, this work takes a different approach. We suggest a study design that better aligns with the capabilities of low-fidelity gaze data. We introduce REARS, a system based on a split-screen paradigm that supports remote, crowdsourced readability studies using Webgazer [1]. Our interface presents two spatially separated text regions, allowing researchers to compare reading behavior across conditions without relying on precise low-level measurements. We also propose a new set of gaze metrics, including region dwell time and transition-based measures, that replace traditional eye-tracking metrics. These design and measurement choices enable scalable, online readability studies with lower barriers to participation.

CCS Concepts

• **Human-centered computing → Human computer interaction (HCI)**.

Keywords

Readability, Eye Tracking, Webcam-Based Eye Tracking, Remote Studies, Human-Computer Interaction, Crowdsourcing, Interface Design, WebGazer

1 Introduction & Related Work

Digital reading is now the primary means by which people consume written information across educational, professional, and everyday settings. Understanding how readers interact with on-screen text remains a central topic in readability research[1, 19]. Eye-tracking has long been used to study reading behavior by capturing measures such as reading speed, fixations, and saccades. These measures provide insight into attention, processing effort, and comprehension during reading. Eye-tracking has been applied across a range of in-lab readability studies, some of which examine reading strategies in diverse reader populations [6–8, 10].

Research suggests that readability arises from a combination of topography, layout, medium, and reader characteristics [1, 17]. Most eye-tracking readability studies are conducted in laboratory settings using specialized eye trackers. While these systems offer high accuracy, they are often costly, require controlled environments, and lengthy procedures. These constraints limit the study's scalability and often result in small and homogeneous samples. As readability research increasingly focuses on accessibility and diverse reading experiences, these limitations have become more pronounced.

Recent work has explored webcam-based eye-tracking as a lower-cost alternative[11]. By using webcams, researchers can collect gaze data remotely and recruit participants online. However, webcam eye trackers remain substantially noisier than in-person research eye trackers[2, 5, 12, 15, 16]. Variations in lighting, head position, and camera quality introduce instability, making it difficult to record fine-grained reading behavior. This is especially problematic when text is presented as dense, continuous blocks that require interpretation at a sentence or word level.

In this work, we take a different approach. Rather than attempting to improve webcam gaze accuracy, we adapt the study design and user interfaces to better align with the limitations of low-fidelity eye-tracking data. We introduce a split-screen readability paradigm that presents two spatially separated text regions. This design supports coarse comparison of reading behavior across conditions and enables remote, crowdsourced readability studies without specialized hardware.

2 REARS System for Remote Readability

We introduce REARS, a web-based system designed to support remote readability studies using low-fidelity eye-tracking data from webcams using WebGazer. We build REARS around a simple design principle. Rather than attempting to capture fine-grained eye movements, the system structures the reading task to yield valuable lower fidelity eye-tracking data.

REARS presents participants with two spatially separated text regions, displayed side by side. Each region contains the same passage with a different text design (e.g., font variation, font size, etc.).

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[1]https://webgazer.cs.brown.edu/

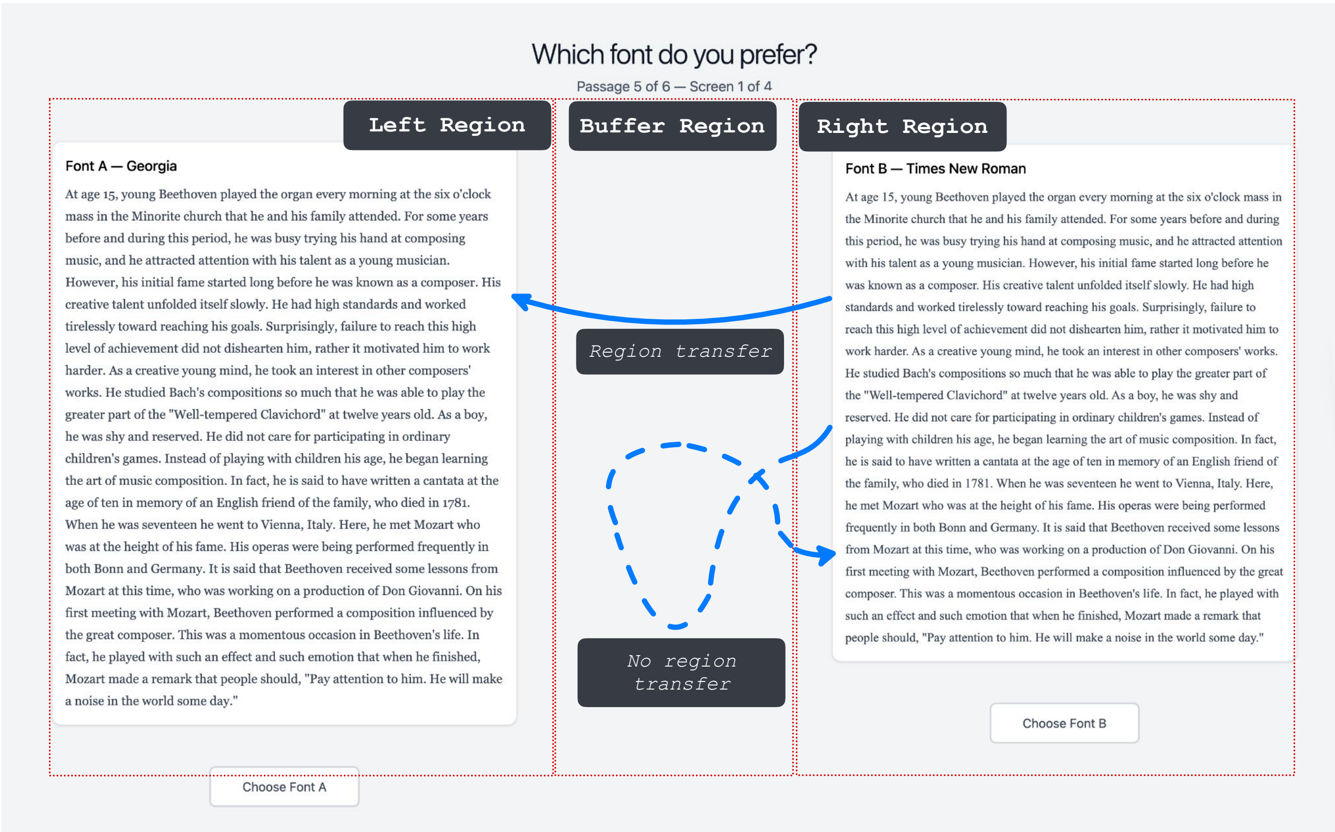

Figure 1: REARS interface layout with two spatially separated text "regions" and a central buffer zone. Here, each region is a column.

The separation between regions is intentional and large enough to reduce the capture of larger, noisy saccades between participants' eye movements. The goal of the system is to allow robust comparison of reading behavior across conditions. We mainly focus on which region a participant is looking at, rather than where they are looking within the text.

2.1 REARS: Region-based Evaluation for Attention in Remote Readability Studies

The REARS system interface divides the screen into three vertical zones. A left text region and a right text region contain the reading passages. The system has a neutral "buffer zone" in the middle that separates the two regions. This buffer zone plays a critical role in accounting for gaze instability. Gaze samples that fall within the buffer are assigned to the last text region the participant was actively reading from. A region change is only registered when gaze transitions from one text region, through the buffer, and into the opposite region.

Each text region is visually balanced in contrast and alignment. The differences between the two regions are minimized to avoid unintended biases, and the only differences between them are the intentional experimental manipulations under study. Participants are instructed to either (1) read both texts naturally or (2) read from the text they prefer and then proceed at their own pace based on the experimental design. No scrolling is required, and zooming in and out is disabled for more control. All text should be visible within the normal screen size to minimize unnecessary head movements.

2.2 Webgazer and Regions

REARS uses Webgazer[11] to estimate the participant's eye location on the screen. While the estimates are sometimes noisy, they are sufficient to determine which broad region of the screen the participant is attending to. Gaze samples are continuously mapped to two of the three regions: left region, buffer region, or right region (See Figure 1).

To account for noisy jitter and brief tracking errors, REARS applies temporal smoothing at the region level. Short gaze excursions into the buffer region are treated as transitional and do not immediately trigger a region switch. Time accumulation for a given text region begins only when gaze has been stably detected within that region for some minimum duration. This approach ensures overall reliable measurement of gaze allocation.

2.3 Interface design implications

REARS design language intentionally avoids assumptions commonly found in more traditional eye-tracking studies. It does not attempt to identify these traditional measures, such as fixations, saccades, or reading order within a passage. Instead, it aims to study readability at a broader regional level comparison. This shift is necessary for the system to produce meaningful data effectively, even with low-fidelity eye-tracking. REARS enables conducting readability studies remotely and at scale, making it easier to reach even more specialized participant pools.

3 Metrics

To support REARS, we replace traditional eye-tracking metrics with broader measurements specifically focused on regional analysis. The proposed metrics are tailored towards the limitations of low-fidelity eye-tracking and the system itself.

3.1 Region Dwell Time

Region dwell time measures the total time a participant spends in each region of the REARS interface. Dwell time is assigned to either the left or right text regions (i.e., columns) when the estimated eye location falls within the corresponding region box boundary. When the eye location falls within the buffer zone, the time spent attending the buffer zone gets saved. From there, there are two possibilities. If the participant moves from one region to the buffer zone to the other region, the buffer zone time gets dismissed. If the participant moves from one region to the buffer zone and then back to the same region, the buffer zone time gets allocated towards that region's time.

This approach provides a direct estimate of the attention allocated by the participant between the two text conditions. Unlike metrics like fixations, region dwell time does not assume stable eye-tracking data or reading order within the text. It just captures how long participants choose to engage with each region during the reading task.

3.2 Region Transition Count

Region transition count captures how often a participant switches their reading between the two text regions. A transition is registered when gaze moves from one text region, through the buffer zone, and into the opposite region. Brief gazes within the buffer zone that do not result in entry into the other region are not counted as transitions. Higher transition counts may indicate comparative reading behavior or uncertainty, while lower counts may suggest sustained engagement with one region at a time. Because transitions are recorded at the region level, the measure remains robust to webcam eye-tracking noise.

3.3 Relative Attention Ratio

Relative attention ratio summarizes the balance of the attention spent by each participant on each text region. It is a proportion of dwell time of each region over the total dwell time across both regions. Expressing time spent as a proportion rather than an absolute duration leads to easier comparisons across participants. Since the layout of REARS is designed with crowdsourcing in mind, absolute reading times between readers can vary widely.

4 Discussion

Traditional in-lab eye-tracking studies of reading typically rely on precise spatial and temporal measurements[4, 8, 9, 13, 14]. Many study designs assume good collection of metrics such as fixations, saccades, and regressions to interpret reading behavior. In remote settings, gaze estimates are noisier and vary with hardware, lighting, and participant posture, making these assumptions harder to sustain[2, 5, 11, 12, 15, 16]. Designing interfaces for low-fidelity browser-based gaze data (using WebGazer [11]) requires shifting where uncertainty is handled [1, 3, 17, 19].

Instead of treating this noise as something to eliminate, our system treats it as a constraint on study design. Many studies of typography and layout focus on comparing how readers engage with different text presentations. For these comparisons, relative patterns of attention can be informative even when precise gaze position is unreliable [10, 17, 18].

We use spatially separated text regions to interpret gaze at a coarse level. These larger regions make the system less sensitive to small tracking instability. Changes in reading state are handled conservatively because of the buffer zone, so brief or unstable gaze samples do not immediately register as a transition. This helps reduce the impact of jitter and momentary tracking loss and emphasizes sustained attention.

The proposed metrics are chosen to match the low fidelity of the webcam-based eye tracker. Region dwell time and transition counts capture relative engagement and comparison behavior, while ignoring a specific reading order. This makes our proposed metrics suitable for remote settings, where high-precision eye-tracking is not available.

REARS system is sensitive to practical factors common in remote studies like screen size, camera quality, and room lighting. While the interface design helps reduce the impact of noisy gaze estimates, variability in reading environment remains a constraint.

The system is best suited for comparative readability studies where relative attention and engagement are of interest, and where remote participation or broader sampling is a priority. This is especially important for studying diverse reader populations, such as individuals with low vision, dyslexia, or attention-related differences [6, 8, 20], where scalability may be more valuable than precise gaze measurements.

5 Conclusion

Readability studies have traditionally relied on high-precision eye-tracking to analyze participants' reading behavior [14]. While traditional eye-tracking yields highly detailed data for researchers, it is difficult to scale, expensive, and often incompatible with remote studies.

In this work, we propose a study design principle and interface to address the insufficient fidelity of webcam-based eye trackers in remote readability studies. Rather than fighting, we try to address WebGazer's limitations.

REARS split-screen interface spatially separates text conditions, and our three region-level metrics, region dwell time, transition count, and relative attention ratio, measure attention at a resolution webcam tracking can reliably support. This approach trades fine-grained reading patterns for scale and accessibility.

Our system and interface, REARS, reduce barriers to conducting eye-tracking readability research by eliminating reliance on specialized hardware and laboratory settings. Browser-based deployment enables broader participation and supports more inclusive study populations.

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