Improving Online Accessibility for Individuals with Photosensitive Epilepsy

LAURA SOUTH, Northeastern University

Content with flashes, bright colors, and repeated patterns can cause seizures and migraines when viewed by people with photosensitivity. Exposure to seizure-inducing content is a serious risk in online environments, as evidenced by documented instances of people with photosensitivity being exposed to seizure-inducing material while playing video games or using social media. My thesis focuses on improving online safety and accessibility for people with photosensitivity by measuring the prevalence of seizure-inducing content online, developing new tools for detecting seizure-inducing content, and constructing a broad framework for protecting against seizure-inducing content at the level of content creators, platforms, and content consumers. Through this work, I hope to help build a better understanding of the current state of photosensitive risk online and contribute new solutions for mitigating seizure-inducing content with minimal adverse effects on the browsing experience for users with photosensitivity.

Additional Key Words and Phrases: accessibility, photosensitive epilepsy

1 INTRODUCTION

Individuals with photosensitivity experience seizures, migraines, and other symptoms when exposed to specific forms of light and pattern stimuli. Seizures can be triggered by a wide variety of phenomena encountered in daily life, such as fireworks [12], concert lighting [18], and wind turbines [13]. Encountering seizure-inducing content is a particular risk when interacting with technology. People with photosensitivity have reported seizures triggered while playing video games [19], engaging with social media [14], and even taking selfies with a mobile phone [5].

Despite the obvious risks of encountering seizure-inducing content when using technology, much remains unclear about the accessibility of digital spaces for individuals with photosensitivity. At the most basic level, we have little sense of the prevalence of seizure-inducing content across various online contexts – i.e., how bad is the problem? For example, isolated case studies of flashing GIFs being weaponized to cause seizures online have been reported since at least 2008, but no large-scale studies of seizure-inducing content in GIFs were completed until 2021 (Section 3.1). Very little work has been done to understand adherence to accessibility guidelines related to photosensitivity (e.g., Guideline 2.1 in WCAG 2.0 [6]), making it difficult for nonprofit groups such as the Epilepsy Foundation¹ and the Epilepsy Society² to effectively advocate for better protections for people with photosensitivity. The lack of studies investigating online accessibility as it relates to photosensitivity can in part be attributed to the limitations of currently available software tools for identifying photosensitive risk factors in online content. The leading free photosensitive risk detection system (Photosensitive Epilepsy Analysis Tool³, or PEAT) was built to analyze screen recordings and longer-form videos and is not suitable for accurately testing short, looping GIFs. PEAT is intended to be used by content creators to test for

¹<https://www.epilepsy.com/>

²<https://epilepsysociety.org.uk/>

³<https://trace.umd.edu/peat/>

Author's address: Laura South, Northeastern University, south.l@northeastern.edu.

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photosensitive risk before releasing videos online and does not allow for batch processing, making it challenging for researchers to conduct large-scale studies of seizure-inducing content.

In my thesis, I aim to improve online safety and accessibility for people with photosensitivity through three different approaches. First, I will continue building tools for automatically detecting seizure-inducing content that are available and useful for both individuals with photosensitivity and accessibility researchers. Second, I will continue measuring the prevalence of seizure-inducing content through large-scale studies of online artifacts and testing adherence to established accessibility guidelines for photosensitivity. Third, I will continue to refine and clarify my framework for eliminating exposure to seizure-inducing content by relying on consumer-, platform-, and creator-driven layers of protection. In the following sections I will describe my preliminary work on seizure-inducing GIFs (Section 3.1) and seizure-inducing data visualizations (Section 3.2), as well as my proposed work on seizure-inducing content in virtual reality and the potential for individualized risk detection systems. All four projects use these three approaches to provide a deeper understanding of the current state of accessibility for people with photosensitivity and to illuminate a path forward where the many online artifacts discussed above have less potential for harm.

2 RELATED WORK

The preliminary and proposed work described in this paper is informed and influenced by prior work in two other areas of research: online accessibility for people with disabilities other than photosensitivity and automated detection of photosensitive risk factors.

2.1 Accessibility

My work on measuring adherence to WCAG guidelines for photosensitivity in GIFs and interactive data visualizations (Section 3.1 and 3.2) is influenced in large part on similar studies measuring website accessibility for users with vision impairments (e.g., [1, 15, 17]). Gleason et al.’s study of accessibility of GIFs for users with vision impairments is closely related to the work on seizure-inducing GIFs described in Section 3.1. There are several key browser extensions that provide consumer-driven improvements to web accessibility which were formative in developing PhotosensitivityPal, such as Twitter A11y [10], Caption Crawler [11], and Firefixia [8].

2.2 Detection of photosensitive risk factors

My research into accessibility for people with photosensitivity is built on a large and comprehensive body of work aimed at defining photosensitive risk factors. Fisher et al. summarize the results of multiple EEG studies that found the specific characteristics that are commonly found in flashing sequences that cause seizures (e.g., rate of flashes, area covered by flashes, luminance difference between flashes) [9]. Wilkins et al. provide a similarly thorough explanation of the risk factors that can cause a repeated pattern to be hazardous [22]. My work is also informed by a handful of implementations of photosensitive risk detection systems that use machine learning (e.g., [4]) or rule-based (e.g., [3]) approaches for risk detection.

3 COMPLETED WORK

3.1 Seizure-inducing GIFs

GIFs are short, looping videos that are ubiquitous on many social media platforms. Despite their reputation as light-hearted methods of communicating tone in online communities [16], GIFs are frequently used to orchestrate malicious

Fig. 1. Creator-driven systems rely on content creators to actively check their work for seizure-inducing content before releasing it online, leaving those with photosensitivity vulnerable when creators avoid such protections out of ignorance or malice. Consumer-driven systems protect users in both accidental and malicious attack scenarios.

attacks against people with photosensitivity online. In recent years, attacks against journalist [14], the Epilepsy Society [21], and the Epilepsy Foundation [2] have all been conducted using GIFs with strobing or flashing sequences. Because of the prevalence of animated GIFs in these malicious attacks, I chose to focus my first study into online accessibility for people with photosensitivity within the context of animated GIFs encountered on social media.

We conducted a series of interviews with people with photosensitivity that use social media regularly and found that most participants felt uncomfortable and at risk of accidentally encountering seizure-inducing content while using the internet. They felt that there were few options available to them to help avoid seizure-inducing content except for low-tech solutions such as asking friends to check for dangerous content in videos for them or relying on content creators to include warnings about strobes or flashes. To address this gap, we built PhotosensitivityPal, a browser extension that automatically scans for seizure-inducing content in all GIFs the user encounters. We also introduced a framework for categorizing photosensitive risk detection systems as consumer-driven, platform-driven, or creator-driven. PhotosensitivityPal was a prototype example of a consumer-driven system because it allowed the end user to have control over what content was blocked, rather than relying on platforms or content creators to decide if content is photosensitive safe or not. Figure 1 contrasts creator- and consumer-driven protection systems for two examples of seizure-inducing GIFs found online. PhotosensitivityPal served a dual purpose by helping users with photosensitivity browse the internet more safely while also providing a way for researchers to test GIFs for photosensitive risk in bulk far more efficiently. This allowed us to conduct the first large-scale study of photosensitive risk factors in GIFs posted to social media. We found that approximately 8% of 2000 GIFs collected for the study had the potential to cause seizures when viewed by someone with photosensitivity, establishing the severity of the problems faced by users with photosensitivity on social media. The development of PhotosensitivityPal and its subsequent use in our quantitative study of seizure-inducing GIFs on social media were formative in shaping the rest of my thesis;

once it became clear that we could use this approach to understand and improve accessibility of GIFs on social media, I knew that we could expand the approach to examine other contexts beyond social media.

3.2 Seizure-inducing data visualizations

My first project in accessibility research focused on identifying and mitigating seizure-inducing content in GIFs posted to social media (Section 3.1), but as I continued to explore the research space I realized that there was a need to better understand photosensitive risk in other online contexts beyond social media. I chose to investigate the risks people with photosensitivity face when navigating interactive online data visualizations, a content format that is more common than GIFs in professional and mission-critical contexts. The potential for seizure-inducing data visualizations was established in 2005 by Conti et al., although they refrained from performing a comprehensive study on the specific ways in which a data visualization could cause seizures [7]. Interactive visualizations are non-deterministic, making them more challenging to test for photosensitive risk than a deterministic GIF that will play exactly the same sequence regardless of context. An interactive visualization could be completely innocuous and safe when used by a careful user who interacts with the system slowly and without sudden movements, but the same visualization might produce seizure-inducing sequences if the user interacts with sharp, sudden movements.

We collected screen recordings of interactions with over 1000 interactive visualizations and used PEAT to test for photosensitive risk factors. Approximately 8% of the visualizations included in our study were capable of producing seizure-inducing sequences through interaction. We categorized the potentially dangerous visualizations into eight hazard categories based on the interaction techniques used to produce the dangerous sequences (i.e., click, zoom, hover) and contributed mitigation techniques that visualization creators can use to avoid inadvertently creating webpages with seizure-inducing sequences in the future. As a result of this project, we have a better understanding of how webpages with interactive data visualizations can be made safer for users with photosensitivity.

4 PROPOSED WORK

4.1 Seizure-inducing content in virtual reality

Virtual reality (VR) is growing in popularity as a way to play video games, communicate with others, watch immersive videos, and more. VR platforms pose a particular challenge for people with photosensitivity because VR headsets occupy almost the entire field of view. Research has shown that photosensitive risk is strongly correlated with the area of retina stimulated by the strobing or flashing content [9], so it is likely that content that is safe when viewed on a laptop or phone could become seizure-inducing when viewed in an immersive VR context that stimulates a larger percentage of the retina. Interview participants with photosensitivity have described a low-tech solution they use for mitigating seizure-inducing content on a phone or laptop, which is to quickly remove the offending device by shutting the laptop or throwing the phone away from [20]. Getting away from the dangerous content is more involved when the user is wearing a VR headset, making it even more important to establish protective systems within VR software to automatically detect and block seizure-inducing content.

I plan to conduct a study investigating seizure-inducing content in the context of VR, including estimate of the prevalence of dangerous content in various types of VR media (i.e., video games, immersive videos, social platforms). This project will also incorporate the development and testing of a new software for automatically detecting seizure-inducing content in VR, similar to the browser extension for testing GIFs (PhotosensitivityPal) that was described in Section 3.1.

4.2 Individualized photosensitive risk thresholds

Not all people with photosensitivity will experience the same sensitivity to the three primary risk factors identified in EEG trials as common triggers (flashes, repeated patterns, and transitions to and from saturated red). While some people might be extremely sensitive to content with repeated striped patterns, others will not be affected at all. Additionally, Fisher et al. observed in EEG trials that the precise thresholds at which a sequence becomes problematic differs at an individual level [9]. Fisher et al. aggregated individual results to produce general guidelines that would prevent seizures for most people with photosensitivity when applied unilaterally to content that would be viewed by many people, such as television programs or films. However, a major advantage of a consumer-driven system such as PhotosensitivityPal is that it has the potential to be customized for the specific person using the browser extension, rather than implementing generalized rules that may or may not be appropriate for the sensitivities of the current user.

I plan to implement an updated version of PhotosensitivityPal that can be customized by the user to detect and block content that exceeds thresholds specified by the user. Based on the interviews I conducted for my study of seizure-inducing GIFs (Section 3.1), people with photosensitivity are often aware of what content is most triggering for them. By allowing users with photosensitivity to have more control over what content is automatically blocked, we can increase their autonomy over their browsing experience while still providing an extra layer of protection against accidental or malicious exposure to dangerous content. I will conduct a mixed methods evaluation of my personalized risk detection system to determine if such an individualized approach is beneficial to people with photosensitivity when interacting online.

5 QUESTIONS FOR THE PANEL

I welcome all feedback the panel may have regarding the work I have proposed, in addition to responses to several specific questions. First, does the panel have thoughts on the correct balance of developing prototype systems for improving accessibility and conducting studies to measure the current state of accessibility in various online contexts? Should I focus on one type of research over the other? Second, is the scope of my proposed projects suitable for the remaining one to two years of my PhD? Finally, I would love to know if the panel has advice for connecting with accessibility advocacy groups, such as the Epilepsy Foundation, to make sure that my research is benefiting the epilepsy community as much as possible, rather than only influencing researchers within the HCI community.

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