Visual Gaze Analytics for Hazard Detection with Various Levels of Training

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ABSTRACT

Previous studies have been conducted to show if image type (2D vs 3D) has an effect on hazard detection. This inspired us to design an experiment in which the goal was to see if training a group of subject would cause them to find more hazards than an untrained group. We collected data on 16 subjects, 8 trained and 8 untrained, and had them look at 4 images and find the safety hazards. We then measured how many hazards each group found. We hypothesized that the trained group would find more hazards over all than the untrained group, due to their prior exposure and knowledge of what hazards are. Statistically, our results did not support our hypothesis, as there was no numerical correlation between training prior to searching for hazards and the number of hazards found looking at trained versus untrained subjects. However, there were some bias that we may have created, such as only training with trip hazard or the simplicity of our hazards, that skewed the data. Redesigning this experiment and eliminating these biases could yield new results.

KEYWORDS

gaze, gazepoint, hazards, safety, thegazepoint, training

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1 INTRODUCTION

We encounter safety hazards on a daily basis. Whether it be in a chemistry lab, on a construction site or even eating in your favorite restaurant, every person has knowingly and unknowingly encountered a safety hazard. While some of these hazards may be more threatening to us than others, they could all do harm if not acknowledged soon enough. Different people have different responses to these hazards. Some recognize them quickly, some slowly and others not at all. These differences in response times and detection of hazards could have to do with someone's exposure to similar hazards in the past.

After reading articles about search patterns and data visualization technologies, we wanted to see if prior exposure and training had an effect on one's ability to perceive a hazard as such. To do this, our group ran studies with two different groups of subjects, a trained group and an untrained group, in hopes to show that there is a difference in how fast and accurately hazards are detected between groups.

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1.1 Hypothesis

The purpose of this study is to see if there is a correlation between safety training and safety hazard detection. We hypothesize that the group of subjects who undergo our safety training prior to searching for hazards will find the hazards faster and more accurately than the group who did not undergo training.

Our hypothesis is derived from the idea that pre-exposure to and practice searching for certain objects, in our case hazards, will decrease the time need to recognize and find those items in the future.

2 BACKGROUND

2.1 Hazard Detection

The research paper that originally inspired our topic was Eye-Tracking Technology for Construction Safety: A Feasibility Study [4]. In the experiment conducted in this research, they used eye tracking to study how workers at a construction site perceive the site. This is done in order to understand why some hazards go unseen by the workers in order to try and lessen the number of accidents that occur on construction sites because of inability of workers to identify hazards and make timely decisions. The experimenters two have two different types of image for the subjects to look at. One group of subjects looked at a real picture from an active construction site that was modified to introduce hazards and another looked at a 2D sketch-representation of the same construction scenario. All participants were giving a checklists and mark the hazards they saw. Though there were no clear results between the groups for who best perceived the hazards, this sparked our idea to see if prior training could cause more hazards to be found faster.

2.2 Safety

New methods and technology applications are being considered and studies are being performed to encourage the use of more dynamic and precise methods, such as 3D training environments or personnel tracking and monitoring. Global Positioning System (GPS) and radio frequency technology, for instance, can be used to monitor workers distance from risky areas, fall prevention from height and collision avoidance [4]. Studies have shown sensing devices as a useful tool for safety managers identify, monitor and assist risky situations involving workers and equipment in construction sites. Eye tracking can also be used as a tool for education. In the 3D game "Safety Inspector", students act as a controlling contractor's safety inspector on the job site, identifying on-site hazards during a virtual walk-thru [2]. There are different levels of challenge, according with the player safety background. For every point obtained, the game provides the player with valuable information such as corrective actions, rules and regulations. This game can be used as a supplemental educational resource in the classroom and as an alternative to walk-throughs.This approach can also be used for training, helping to facilitate the comprehension of the workers perception of construction sites, potential risks and its relationship with their visual attention [3]. Games in a virtual environment also increase the learning interest of the participant and potentially lead to a more critical awareness of safety hazards [4].

3 METHODOLOGY

3.1 Apparatus

The Gazepoint GP3 eye tracker is a standalone eye tracking device to be used with computer displays and laptops. The sampling frame rate is 60 Hz. The eye tracker is positioned or mounted at the top or bottom of a display unit. Using the Gazepoint GP3 is very similar to using a regular computer monitor. Users are free to move their head, and are not restrained in any way. The eye tracking process is unobtrusive. There are no protrusions, headgear, bright lights, noises or other obvious distractions for the user. The Gazepoint is very easy to use, and can be used by people with very little computer experience. In order to use the Gazepoint, the user sits in front of it, as he or she would a computer monitor. The user then begins one of many applications made for use with the Gazepoint. The first step in all of these programs is to calibrate the device, a process involving watching a dot move from between two to nine places on the screen. This is done to bolster the accuracy of the eye tracking data. When the user is finished using the Gazepoint, no special steps are needed. The user simply gets up and walks away from the device. If a new user wishes to use the Gazepoint, the calibration step must be re-done, but it requires no additional steps of shutdowns. With the exception of the calibration step, using the Gazepoint is exactly like using a regular computer.

The Gazepoint can track where the user is looking on the screen, with a degree of accuracy of half a degree, about 50 pixels. The Gazepoint tracks the gaze of both eyes, and the distance of the eyes from the screen. It can tell when the user blinks, or winks, and what eye was winked with, all without distracting the user.[1]

3.2 Stimulus

We have a total of 5 different images. One will be used to train half of the subjects, while the others will be seen by all subjects. The differences among these images are the room settings and the specific hazards. Settings vary from break rooms and offices to restaurants and warehouses. Each image has its own safety hazards, all varying in type. Subjects will be asked to look at these images and find any hazards they can. After 45 seconds, the screen will change on its own to the next image.

The trained group will do this as well, but prior to that, they will get trained with the first image. This image has hazards just like the next that are pointed out and explained to the subjects by us. Examples of two of the images can be seen below, including the image used for training.

Figure 1: the fifth scene, used for training

Figure 2: another example of the stimulus used in the experiment.

3.3 Subjects

We recruited 16 unpaid volunteers, all of which were college students, to look at images and find safety hazards throughout them. Each participant used a computer and eye tracker provided by us to observe the images. The ages range of the participants was 18-25. The participants were at least pursuing a bachelorâĂŹs degree. The majors and concentrations of study varied by participant, however, all had a basic understanding of computers. Participants included 3 females and 13 males. Five participate wore contacts, 4 wore glasses and 7 did not have corrected vision. Eight participants were given safety training prior to observing images on their own, and eight participants were told to observe the images without training.

Each participant was given an initial survey which asked if they have had any prior training in safety hazards of any kind. If so, they were asked how extensive the training was, how long ago, and in what situation. This let us know if their previous training was too extensive to be able to include them as a controlled factor in the study. This was not a problem in our study. They were also asked general questions such as age, gender, major and any relevant past work experience. After the survey, the participants were walked through how to calibrate the eye trackers. This was done by following a series of dots with there eyes and helped to optimize the settings for the eye tracker to be able to follow the participants gaze. After the calibration, 8 randomly chosen participants were trained by us to be able to find and acknowledge safety hazards as such. These participants as well as the other 8 were then shown 4 images and asked to find the hazards in them. They were all asked to talk out loud about the hazards they were seeing as we wrote down the ones they saw and what they said about them. The images changed after 45 seconds.

3.4 Experimental Design

To investigate the effect of safety training on response time and awareness of hazards, we sought to create a situation where we could train a group on what and why certain things are hazards. To do this, we performed an experiment in which we showed half of our participants an image of an office setting and walked them through the safety hazards around the office, explaining why each one was a hazard. Then this group was given 4 other images with different hazards and asked what was wrong with them. The other half of participants were given no prior training by us. They were showed the same 4 images as the first group and asked to identify hazards. We tracked whether the participants found hazards by having them talk out loud about what was wrong in the images and what they would fix. We also tracked their eye gaze to see how fast and how long the participants looked at the hazards that they found. This was an untrained versus trained design. This design allowed us to have safety training as our independent variable in order to best see if the training affected the participantâĂŹs response time and awareness of the hazards shown to them.

3.5 Procedures

Each participant was given an initial survey which asked if they have had any prior training in safety hazards of any kind. If so, they were asked how extensive the training was, how long ago, and in what situation. This let us know if their previous training was too extensive to be able to include them as a controlled factor in the study. They were also asked general questions such as age, gender, major and any relevant past work experience. After the survey, the participants were walked through how to calibrate the eye trackers. This was done by following a series of dots with there eyes and helped to optimize the settings for the eye tracker to be able to follow the participants gaze. After the calibration, 8 randomly chosen participants were trained by us to be able to find and acknowledge safety hazards as such. These participants as well as the other 8 were then shown 4 images and asked to find the hazards in them. They were all given a piece of paper and asked to write down the hazards as they found them as well as talk out loud about them. The participants could take as long as they wanted with each image.

4 RESULTS

As stated previously in the paper, the primary goal was to determine if receiving hazard identification training would have any effect on an individual's ability to identify hazards in future scenes. 8 participants were given training on an additional hazard scene, while 8 separate participants were not given training and merely asked to identify hazards in the given scenes. Results were then gathered based on an individual's ability to identify hazards with visual fixations and auditory explanations. The data collected with the Gazepoint Analysis tool was then converted and run through a series of Python scripts to organize the data into visual representations like the one shown in figure 2. By comparing the trained subject in figure 3 and the untrained subject in figure 4, we can observe that the trained subject had longer fixations on different safety hazards. We can also observe that the untrained subject had a centralized fixation while the trained subject looked around the edges of the image. Figures 5 and 6 also show that the untrained subject had a more centralized fixation compared to the trained subject who more around the image for hazards. There is a correlation in the search pattern between trained and untrained subjects. When comparing figure 3 and figure 4, we can observe that the untrained subject search pattern crossed more compared to the trained subject. This is also noticeable when comparing figures 5 and 6. Figure 6's search pattern crossed more than the trained subject in figure 5.

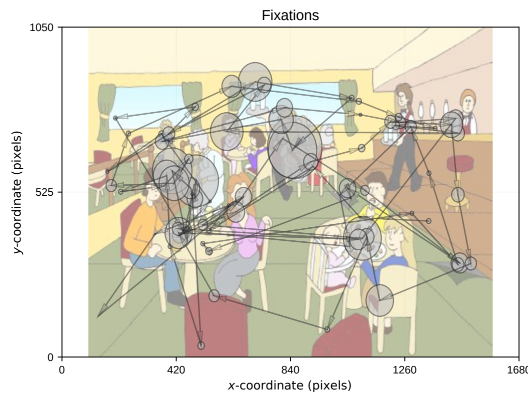

Figure 3: a fixation map of the "restaurant" scene from a trained subject.

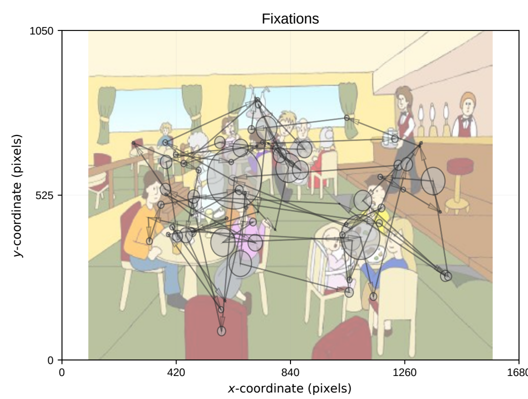

Figure 4: a fixation map of the "restaurant" scene from a untrained subject.

4.1 Discussion and Conclusions

Our data was used to compare the hazard identification rates of the two groups of participants. From this, we were able to see that, for the four images, there was a small visible correlation between training prior to the experiment starting and the number of hazards found. This can be seen in Figure 7. However, this correlation was not statistically proven. Statically, there was no correlation between

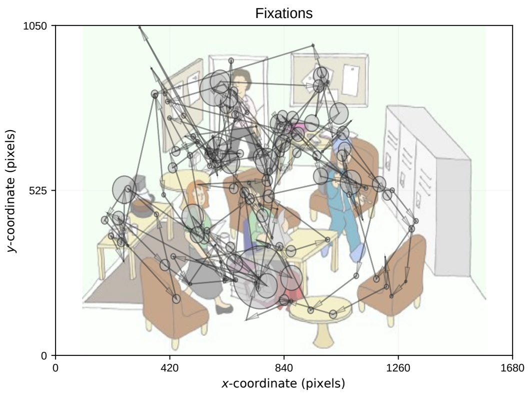

Figure 5: a fixation map of the "health staffroom" scene from a untrained subject.

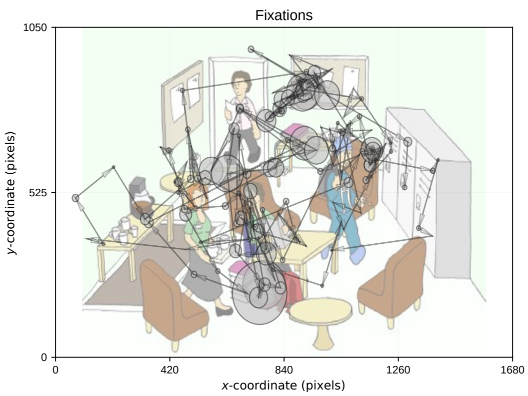

Figure 6: a fixation map of the "health staffroom" scene from a trained subject.

training prior to searching for hazards and the number of hazards found looking at trained versus untrained subjects.

In our observations while administering the experiment, we found that in the case of two hazards in particular, the trained group were able to identify them 25% more often. These two hazards, a poorly placed stack of books and an upturned rug corner in figure 1. Both of these were floor hazards, and as such may point to a bias in our training towards identifying tripping hazards more than other unsafe conditions. Our training image consisted mostly of trip hazards which could have created bias with the trained subject to only look at the floor for hazards. In order to identify a true correlation, a larger scale experiment in which this bias is eliminated must be conducted.

With this in mind, we must conclude that our training was null in proving our hypothesis and that there was no correlation between training prior to searching for hazards and the number of hazards found looking at trained versus untrained subjects found at this time. As a potential further study, the experiment could be continued with a younger participant demographic to ensure that they have not received previous training in any form, as opposed to our mostly adult demographic. This brought the variable that many college students know of hazards just from experience and knowledge obtained while working jobs and experimenting in labs. Using a younger or less experienced subject pool would lessen this variability. It would also be interesting to try this experiment again with harder images, as ours were simple with few hazards to be found. This could have caused the untrained group to be able to find the hazards almost as accurately and fast as the trained group. Making hazards more difficult and numerous could make it more difficult and may lead to a correlation supporting our hypothesis.

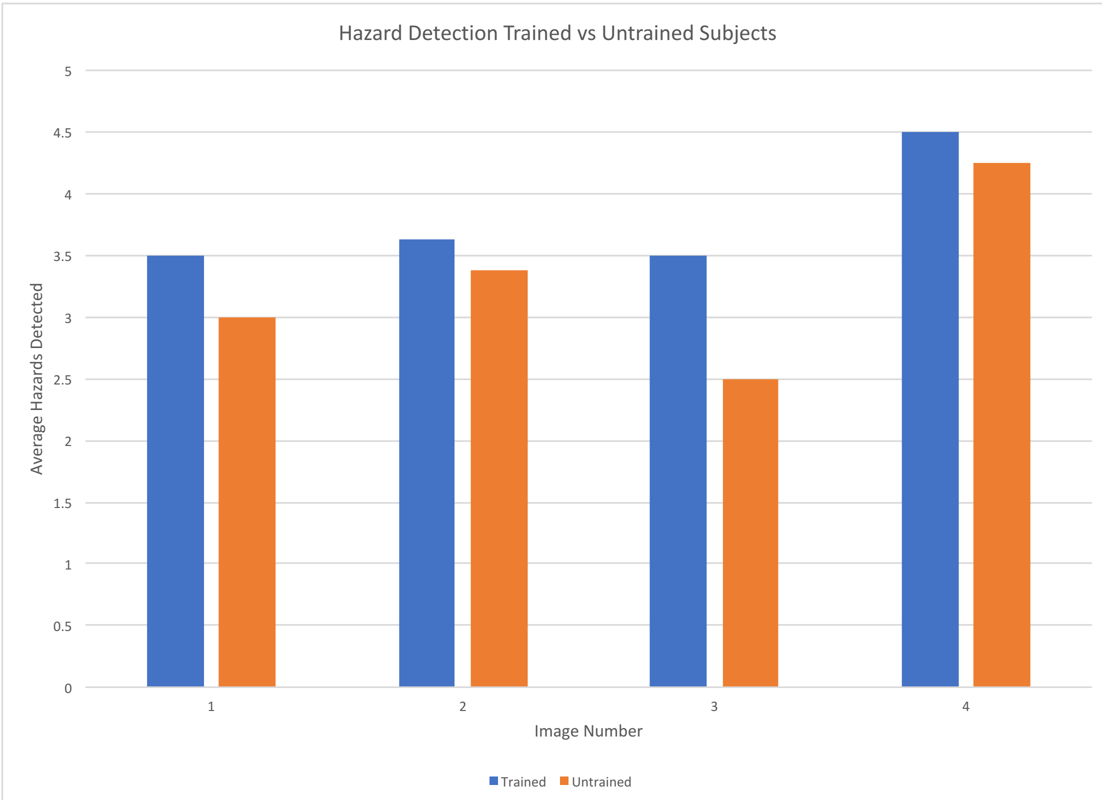

Figure 7: a clustered column graph of correlation between training level and hazards detected in each scene

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