İŞ SAĞLIĞI VE GÜVENLİĞİ ÖNLEMLERİNİN ETKİNLİĞİNİN GÖZ İZLEME CİHAZI İLE BELİRLENMESİ[+]

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DETERMINATION OF THE EFFECTIVENESS OF OCCUPATIONAL HEALTH AND SAFETY MEASURES WITH EYE TRACKING DEVICE

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Öz

Bilişim sistemleri, iş sağlığı ve güvenliği alanındaki kontrol kayıtları, eğitimler ve çevre ölçümlerinde de kullanılmaktadır. Bununla birlikte, insan-bilgisayar etkileşimi alanında kullanılan kullanılabilirlik test yöntemlerinin iş sağlığı ve güvenliği (İSG) çalışmalarına uygulanması konusunda literatürde bir boşluk olduğu görülmektedir. Bu çalışmada iş sağlığı ve güvenliği önlemlerinin etkinliğinin kullanılabilirlik test yaklaşımı ile tespit edilmesi amaçlanmıştır. Kullanılabilirlik testi göz izleme cihazları yardımı ile gerçekleştirilmiştir. Bu deneysel araştırmaya 26 katılımcı dâhil edilmiştir. Çalışmada göz izleme cihazı takmış olan katılımcılardan yangın varmış gibi davranarak çıkışa yönelmeleri istenmiştir. İki farklı kurumda üç farklı deney yapılmıştır. Katılımcıların yangın ekipmanları, alarm butonları ve çıkış işaretlerine odaklanma süreleri ve odaklanma sayıları incelenmiştir. Ek olarak 12 İSG uzmanı ile görüşülerek uzman görüşleri çalışmaya dâhil edilmiştir. Sonuç olarak risk analizlerinin tek başına yeterli olmadığı ve risk analizi sonucunda alınması gereken önlemlerin tespitinde bilişim sistemleriyle yapılacak olan daha kapsamlı analizlere olan ihtiyaç ortaya koyulmuştur. Çalışmada önerilen yöntemin diğer acil durum ve afet bağlamında da değerlendirilebileceği önerilmiştir.

***Anahtar Kelimeler**: Göz Izleme Cihazı, Kullanılabilirlik, Insan-Bilgisayar Etkileşimi, Iş Sağlığı Ve Güvenliği.*

Abstract

Information systems are also used in control records, trainings and environment measurements in the field of occupational health and safety. Moreover, it seems to be a gap in the literature regarding the application of usability testing methods utilized in the field of human-computer interaction in to occupational health and safety (OHS) studies. In this study, it is aimed to determine the effectiveness of occupational health and safety measures via usability test approach. Usability testing was carried out with the help of eye tracking devices. In this experiment research, 26 people were participated. Participants wearing eye tracking devices were asked to find the exit assuming there is a fire. Three experiments were designed in two different institutions. The number of focuses and focus times for fire equipment, panic button and caution signs were examined. In addition, 12 OHS experts' opinions were included in the study. As a result imply that the risk analysis is not enough alone and more comprehensive analysis with information systems is required to improve the precautions to be taken as a result of the risk analysis. It is suggested that the method proposed in the study can also be employed in the context of other emergency cases and disasters.

***Keywords:** Eye Tracking Device, Usability, Human-Computer Interaction, Occupational Health And Safety.*

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1. INTRODUCTION

It occurs that the methods, tools and concepts used in the information systems (IS) have started to be used and expanded in many areas. Various applications are developed in order to contribute to the decision making process which is one of the main objectives of information systems. Therefore almost all fields required to utilize IS tools and methods. In the scope of this study, occupational health and safety (OHS) is one of the field which is handled from this perspective.

The increase in the number of occupational accidents and occupational diseases arising from the technological development has increased the significance of OHS practices. A number of obligations have been introduced to the employers with the regulations related with OHS (Risk Assessment Regulation, 2012). One of the most important of these obligations is risk assessment. This new proactive regulations sway managers to take precautions before accidents occur in the workplace. Thus, dangers and risks in the work environment should be identified properly to minimize them. It is also an obligation that occupational health and safety professionals should be appointed when these processes are carried out. The employer should also receive required services from the authorized health and safety unit.

Occupational health professionals benefit from information systems in activities such as basic occupational health and safety (OHS) training, maintenance and periodic control records, health surveillance and work environment measurements. Computer software that can be used for managing these operations also helps OHS professionals and ensures that they do not make mistakes. However, there are limited IS research and applications that can be used a by OHS professionals other than such software or other basic operational level applications. This is also an evidence of originality of this study.

On the other hand, research methods and tools in information systems (IS) may provide important contributions to managerial decision making processes almost in all sector. For instance, eye tracking devices can be used to understand customers' attentions and focus in business environment such as retailing, digital interfaces and media studies. Such studies motivate us to study on understanding people awareness to the precautions taken by OHS context. So in this study it is focused on evaluating OHS precautions from usability testing perspectives.

In usability testing, eye tracking is one of the methods which is also used in different areas. Kupper, who made one of his first studies in this area, made it possible to watch his eye movements slowly in 1989. In Kupper's study, layout of titles and images evaluated based on eye movements in general (Ömür & Aydoğdu, 2017). In another similar study, the effect of local design factors on the visual behavior of readers was investigated (Holmqvist & Wartenberg, 2005). In another study, the availability of the Mazda company's website was tested with eye tracking technology (Centaur Communication, 2005, as cited in Özdoğan, 2008).

In the risk analyzes conducted within the OHS, the working environment is generally taken into consideration but the actual behavior of the employees, performance losses, psychological situation and individual faults kept in background. Risks can be analyzed by examining the physical and cognitive behaviours of the users are through usability test approaches, which are handled within the scope of human computer interaction. Through applications made with the help of eye tracking devices frequently encountered in usability studies, real behavior of users can be determined and more comprehensive data can be obtained. In this study, it is aimed to determine the OHS awareness of the employees by examining the real behaviors of the employees with the help of eye tracking device and to increase the efficiency of the risk analysis to be carried out with in this context.

As a result of the literature research, it can be said that the usability tests and eye tracking devices applied within the scope of human computer interaction have not been used in occupational

health and safety applications. However, the eye tracking device is used in various applications in different areas. Karaman et al. (2016) aimed to compare the reading performances of primary school students between normal writing and script. In another study, it was aimed to evaluate the usability of a library website with the tobii pro X2-30 eye tracker. As a result of the usability test consisting of seven tasks, suggestions were made to improve the usability of the website (Ritthiron & Jiamsanguanwong, 2017). Kaya (2007) conducted a sports science study which focuses on investigation of the influence of eye movements on multi ball training in table tennis players. İnce and Göktürk (2009) aimed to examine attention levels of the surveillance personnel to the changes. It is intended to offer a method to reduce negativity in case of a reduction in employee attention levels. In the study of Zambarbieri et al. (2008), the search behavior of the users and the reading status of the online newspaper pages over two online newspaper sites were investigated with the help of an eye tracking device. Kalaycı et al. (2011) have aimed to examine the usability of 3D virtual environments with eye tracking method.

In addition, the eye tracking device is one of the tools used in neuromarketing. In this context, studies using eye tracking devices in the field of neuromarketing by Yücel and Coşkun (2018) are discussed. For example, with the eye tracking device, the places focused on the product packaging and the places that are focused while walking around the market can be detected. According to a study conducted with an eye tracking device, the increase in sales from 28 percent to 44 percent by changing the location of the brand logo on the package reveals the importance of the eye tracker device (Girişken, 2015).

As can be seen, the focus time of the participants, number of focusing and striking objects were taken into consideration in general. Additionally, Rashid et al. (2013) aimed to examine the usability of occupational health and safety websites. Although the usability of websites in the field of OHS is examined, no study evaluating the usability of OHS measures has been found in the literature. Thus, this study is specific and original in terms of examining the usability of OHS measures.

As a result of risk assessment, the locations of emergency exit plates, emergency exit doors, emergency buttons and fire intervention equipment have investigated. The measurements have made within the educational institutions. In this study, two institutions providing associate degree and bachelor degree level education have taken into consideration. It is assumed that 26 employees included in the study acted in accordance with the working principles and behaved honestly. Occupational health and safety measures have only been used in the areas related to fire. Instead of a detailed risk assessment, the L type matrix risk analysis method was applied to identify the hazards that may occur only in the event of a possible fire and to take measures against the identified hazards. This study has also focused on the benefits of eye tracking technology in applied institutions taking into consideration spatial individuality.

2. MATERIAL AND METHOD

Usability is the process of measuring the time required to achieve the desired goals, the money spent to achieve the goals, the mental effort to achieve the goals, and the effectiveness of the system (Evcil ve İslim, 2012). Usability tests are one of the most effective methods used to identify usability issues that provide a realistic experience before a product is released. Usability tests provide researchers with direct information on how the system is used and help identify unforeseen problems during evaluation (Kaplan, 2015). Usability testing approaches are divided into four: design guide-based approach, expert approach, user-based approach and model-based approach (Çağıltay, 2011). In this study, it is aimed to determine the effectiveness of occupational health and safety measures with user-based (experimental) test approach. In this context, the applicability of eye tracking devices in the context of occupational health and safety has also been investigated. To

do so three experiments including same procedure were conducted. Before the experiments, not only primary risk analysis was carried out with the help of a checklist but also risk analysis was carried out using the L type matrix risk analysis method.

A total of 26 people, eight female an 18 male, have participated the experiments. They were between 24 and 56 years old. Those of six have PhD degrees, seven participants have master degree, seven people have under graduate degree whereas remaining six people have had compulsory schooling. All participants have normal vision and have no experience with eye-tracking studies. During the experiments participants who were wearing eye tracking devices were asked to go to the exit of the building and behave as if in the case of fire.

Experiments were conducted two different locations and with three different participants group. In the first experiment, 11 participants who are familiar to the location were asked to complete the task. Similarly, in second experiment conducted at another location, 10 participants who are familiar to that location were asked to complete the task. The third experiment were conducted in the location where first experiment conducted with the five participants who are un-familiar to the building. These buildings are educational institution.

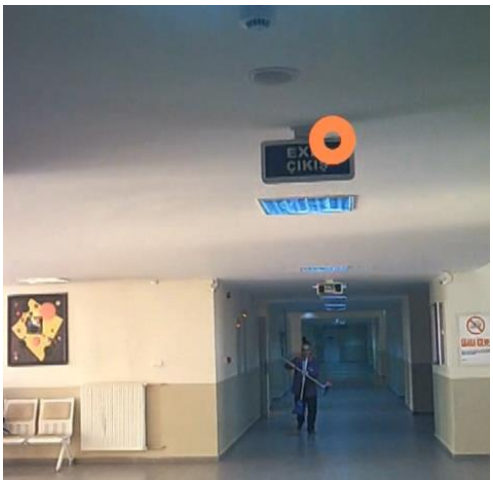
An eye tracking device was used to determine the awareness of occupational safety measures. SMI ETG 2W eye tracking device, Samsung S4 (SMI) and one powerbank were used in the study. The features of the eye tracking device used in this study are summarized in Table 1 and presented.

Table 1. The Features of the Eye Tracking Device

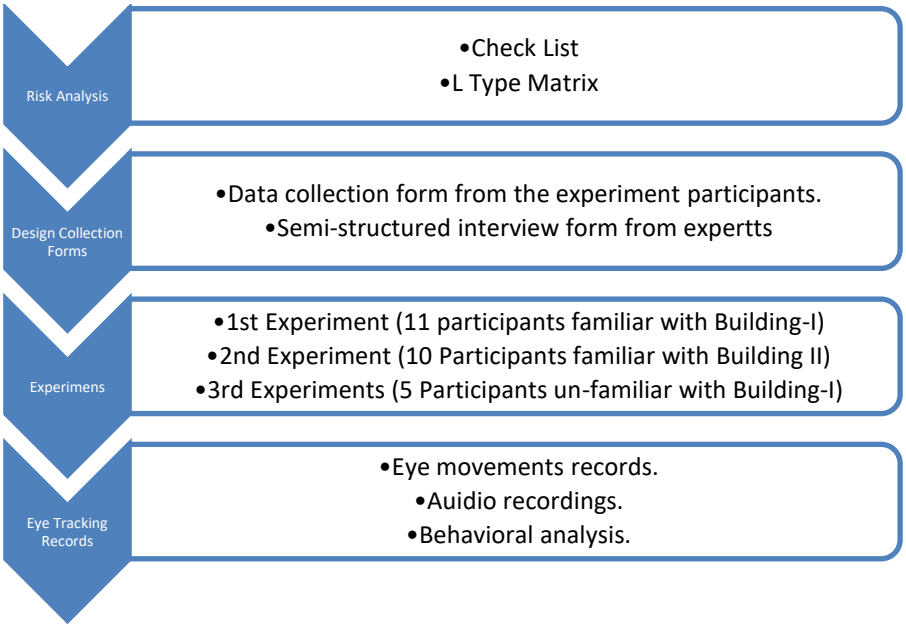
Weight	47g
Calibration	1-/3-Point Calibration
Sampling Rate	60Hz Binocular
Gaze Tracking Range	80° Horizontal, 60° Vertical
Resolution	1280x960p @24 fps, 1024x720p @30 fps
Scene camera field of view	60° Horizontal, 46° Vertical

The eye movements of the users have recorded and have analyzed using the eye tracking device. A sample image as an eye tracking output is shown below.

Figure 1. A Sample Image as an Eye Tracking Output



A data collection form has been created to detect demographic information of users. Users were asked to fill the form including age, gender, educational status, experience, position at the institution, body height and weight information. In order to support the results, a meeting was organized with OHS experts. A semi-structured form consisting of 10 open-ended questions has been prepared for the interview and 12 OHS experts opinions were asked. The institutions where the study conducted was selected according to the adequacy of the OHS measures. Finally, the data collected with the help of the eye tracking device was analyzed with the SMI BeGaze software. 26 people from two different institutions participated to the study. Data collection process summarized below.



3. RESULTS AND DISCUSSION

The first experiment was conducted at institution K and second experiment was conducted at institution E with institutions' own employees. The last experiment was conducted at institution E with employees of institution K. The purpose of the last experiment is to evaluate the OHS measures with participant who are unfamiliar the workplace. Assuming that the risk of fire in E and K institutions is at an equal level, it is aimed to determine the awareness of people in an institution they do not know about occupational health and safety measures.

The number and duration of focuses for each participant towards fire equipment (panic button, fire hose, and fire extinguisher) and caution signs were examined. The study composed of three different experiments. The participants' awareness of fire equipment and emergency exit signs has been shown in Figure 2.

Figure 2. Caution Sign (Focus)

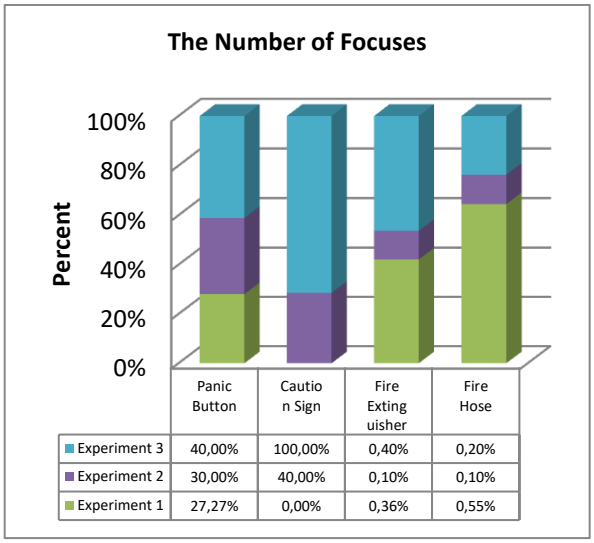


Figure 2 shows that the awareness of the employees for emergency exit signs and fire equipment is weak. For example, 10 % participants realized the "file extinguisher" in the experiment 2. According to the analysis, only "caution sign" were realized by all participants contributed to the experiment 3.

3.1. Experiment 1

This experiments were performed in two different faculties within a university in 2017. The institution where the first experiment was conducted named as "K" and the participants named as "K1, K2, K3 ...". Eleven staff members were included in the first experiment. In K institution, three out of 11 participants saw the panic button, and the average focus duration for the panic button was calculated to be 2250 milliseconds. Similarly, four of the participants saw the fire extinguisher, while the others did not see. It was observed that six of the participants saw the fire extinguisher. When the data were examined it was determined that none of the participants saw the caution sign. The focus periods of the participants are given in Figure 3-5.

Figure 3. Focus Time of the Participants to Panic Button (Experiment 1 – millisecond)

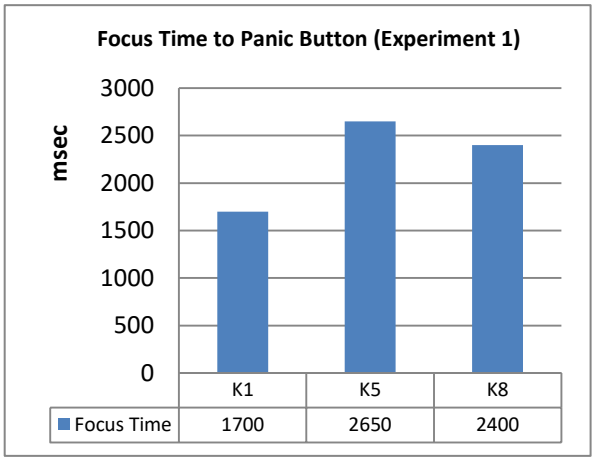


Figure 4. Focus Time of the Participants to Fire Extinguisher (Experiment 1 – millisecond)

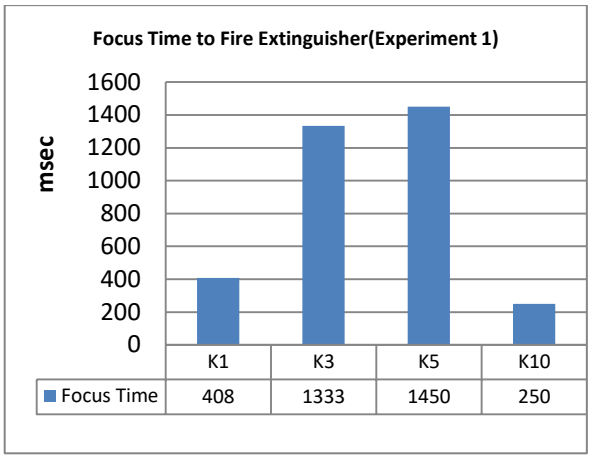
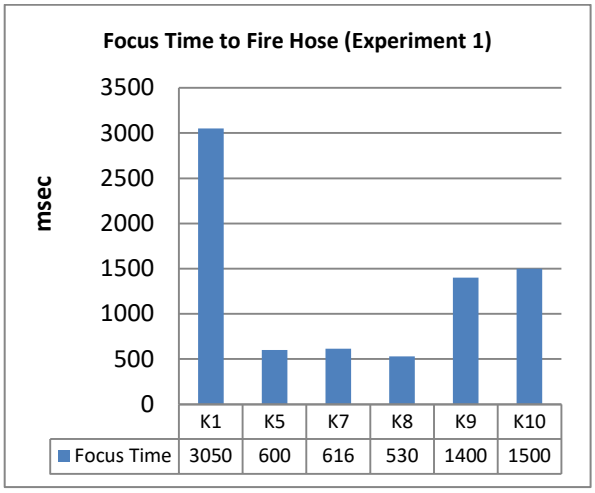


Figure 5. Focus Time of the Participants to Fire Hose (Experiment 1 – millisecond)



As can be seen in the Figure 4, four participants saw the fire extinguisher. The fire extinguisher is located on the side of the fire hose inside the fire cabinet.

3.2. Experiment 2

The institution where the second experiment was conducted named as “E” and the participants named as “E1, E2, E3 ...”. Ten staff members were included in the second experiment. In institution E, three out of 10 participants saw the panic button. Only one participant saw the fire extinguisher and the fire hose. Unlike the first experiments, four participants have seen the caution sign and while others have not seen it. The focus periods of the participants are given in Figure 6, Figure 7.

Figure 6. Focus Time of the Participants to Panic Button (Experiment 2 – millisecond)

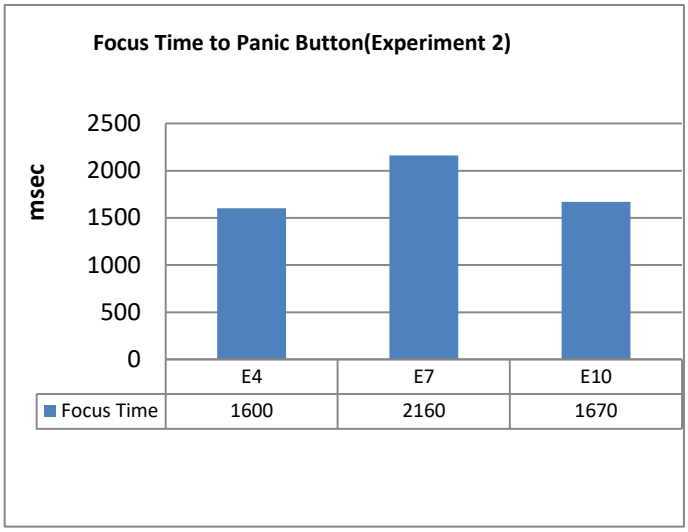
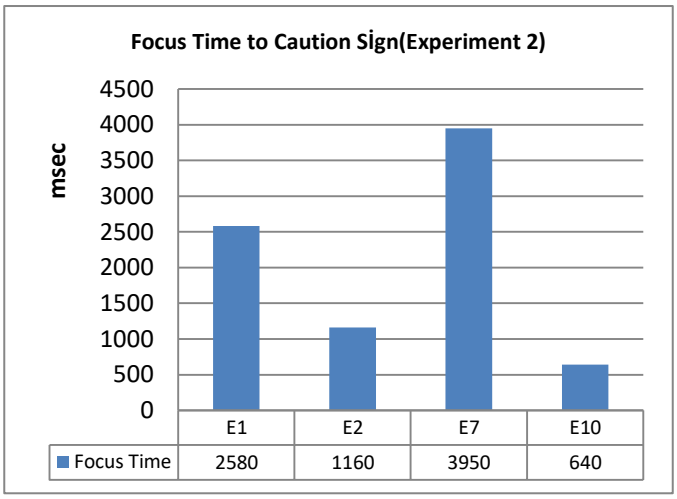


Figure 7. Focus Time of the Participants to Caution Sign (Experiment 2 – millisecond)



3.3. Experiment 3

In the third experiment, unlike other experiments, five employees in K institution were taken away to E institution. In this experiment, it is aimed to determine the awareness of the personnel who are not familiar to the building against measures. five participants included in the experiment were named D1, D2, D3, D4 and D5. In the third experiment, two out of five participants saw the panic button and all of the participants saw caution sign. Three out of five participants saw the fire extinguisher and two out of five participants saw fire hose. The focus periods of the participants are given in Figure 8-11.

Figure 8. Focus Time of the Participants to Caution Sign (Experiment 3 – millisecond)

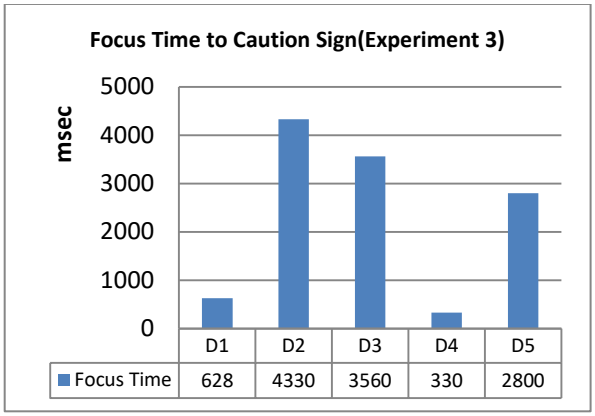


Figure 9. Focus Time of the Participants to Panic Button (Experiment 3 – millisecond)

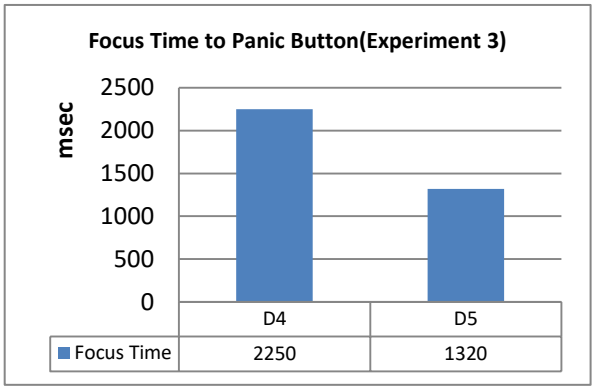


Figure 10. Focus Time of the Participants to Fire Extinguisher (Experiment 3 – millisecond)

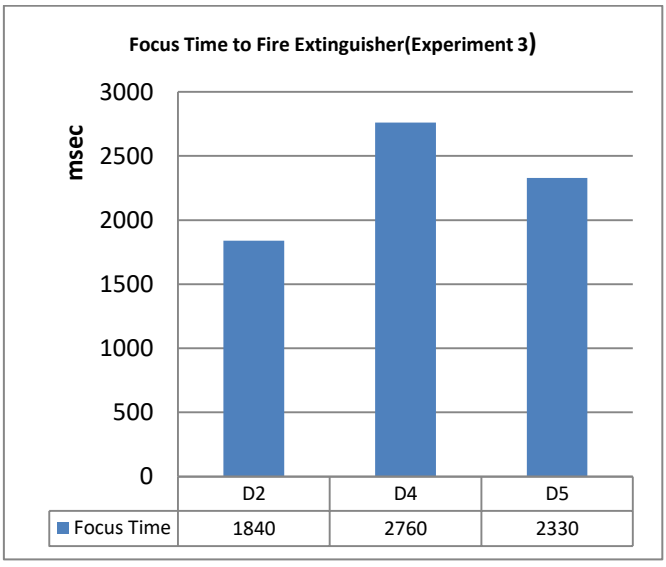
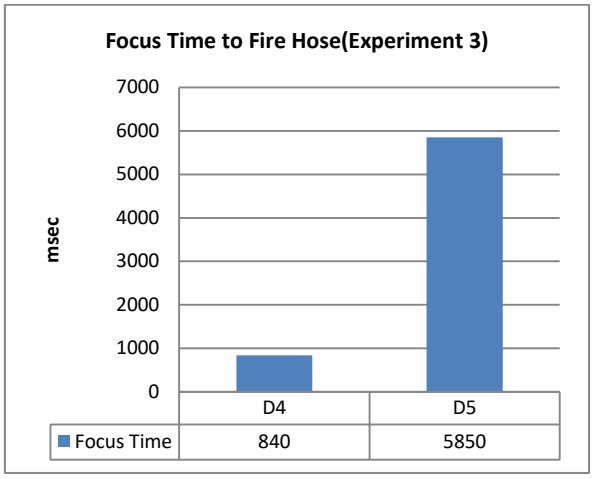
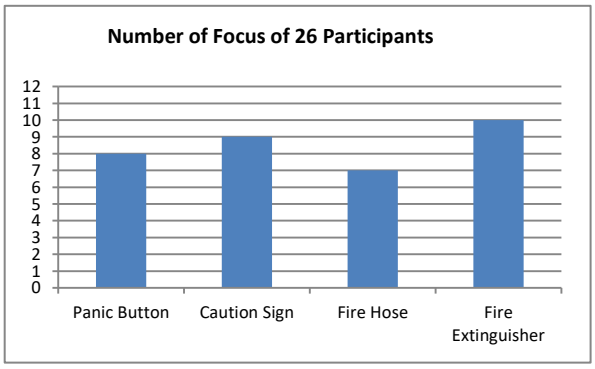


Figure 11. Focus Time of the Participants to Fire Hose (Experiment 3 – millisecond)



Although emergency exit signs and fire equipment are sufficed according to the previous risk analysis with the checklist, it can be said that employee awareness is not sufficient. Figure 12 shows the number of participants focused on to emergency exit sign and fire equipment.

Figure 12. Number of Focus of 26 Participants



4. OHS SPECIALIST OPINIONS

In order to examine the results, 12 occupational health and safety specialists were asked their opinions via a semi-structured form. Questions addressed to the participants and answers given by the participants to the questions are summarized below.

First, participants were asked questions about the use of technology in the work of OHS. Six participants stated that technology is being used effectively in occupational health and safety applications, while others disagree with this view. Seven participants stated that they are actively using technology in their studies.

When asked about the use of IT systems in OHS works, eight of the participants stated that IT systems were used effectively in OHS works and remaining six participants stated that they are actively using information systems in their past applications. All of the participants stated that eye tracking devices was not used in OHS works. Seven participants suggested that eye tracking devices will contribute to the field. Similarly, all participants stated that taking the actual behavior of employees into account in risk analysis would increase the efficiency. Finally, the exper asked whether OHS applications can be supported by usability tests within the scope of human computer

interaction. Nine participants stated that it could be supported. However, two participants did not agree about us contribution of usability tests. One participant did not report any opinions.

The expert opinions are summarized and presented in Table 2.

Table 2. OHS Specialist Opinions

Answer	**Yes**	**No**	**n/a**
Do you think technology is used effectively in today's occupational health and safety applications?	6	6	-
Have you benefited from technology in your past practices within the scope of occupational health and safety?	7	5	-
Do you think that information systems are used effectively in today's occupational health and safety applications?	8	4	-
Have you used information systems in your past practices within the scope of occupational health and safety?	6	6	-
Is an eye tracking device used in today's occupational health and safety applications?	-	12	-
Have you used an eye tracking device in your past applications within the scope of occupational health and safety?	-	12	-
Can the use of eye trackers within the scope of occupational health and safety increase efficiency in risk analysis?	7	2	3
Could taking into account the actual behavior of employees improve productivity?	12	-	-
There are 2 options in the checklists used for risk analysis (yes / no). In this context, would increasing the number of options and making ratings increase productivity?	9	1	2
Can occupational health and safety practices be supported by usability tests?	9	2	1

5. CONCLUSION AND RECOMMENDATIONS

Within the scope of this study, it is focused on evaluating OHS precautions from usability testing perspectives and the applicability of the eye tracking devices in terms of OHS measures. To do so, three experiments were designed to test the environment based on experimental testing methodology from human-computer interaction context. That is, the environment and precautions towards fire case (panic button, caution sign, fire hose and fire extinguisher) taken as a result of the risk analysis were assumed as an interface. In each experiments, participants wearing eye tracking glasses were asked to behave as if in a fire case and find the exit of the building. Data gathered from eye tracking device including number of focus and focusing time were analyzed to evaluate the precautions in terms of OHS measures. Results were also evaluated to understand the feasibility of using eye tracking glasses during risk analysis.

According to the results of the experiments in the institutions, it can be reported that participants may missing the signs and equipment including fire equipment and emergency exit warning signs although they are approved in terms of OHS according to the check list method used for risk analysis. For instance, in the risk analysis carried out with the help of the control list in terms of OHS, all equipment was approved as sufficient. However, almost half of the participants could not be able to focus on the equipment and signs. This may imply that, instead of making risk analysis based on any check list or other methods, eye tracking devices and usability testing methods should be applied to improve efficiency of OHS precautions.

In the first experiment made in institution K, it is found that participants went towards the exit without looking at emergency exit signs. This may be due to the fact that employees are familiar with the institution and know the points where the exit doors are located. Therefore, it is recommended that such practices should be carried out with employees who unfamiliar to the workplace. It has been observed that the employees in the second experiment look at the warning

signs more than the employees in the first experiment. In this case, it can be said that the positioning of emergency exit and warning signs in the second institution is better. Also, in the first experiment, it was observed that two of three participants who saw the alarm button used the student door and one used the staff door. It was determined that the alarm button on the route where the student door is located is at the top of the stairs. This may be the reason for providing more visibility.

In the second experiment, it is seen that the average focusing time on the alarm button is less than the first application. This may be due to the fact that the alarm button is placed in the corridor and its visibility is lower.

In the third experiment, it was observed that the employees did not head to the fire equipment, and they preferred to leave the building quickly. The reason may be because of the fact taht the employees are not familiar with the building or do not feel responsible.

According to the experts' opinion, it may be concluded that taking the actual behavior of employees into account via usability tests using ey-tracking device may increase the efficiency of the risk analysis.

In this study, employees were asked to act like there is fire in the institution. This is a limitation of the study since this may not provide a realistic environment. Moreover, the effectiveness of occupational health and safety measures were evaluated only in the context of fire. Possible further studies about evaluation of OHS measures and precautions can be conducted with the help of VR applications. The immersiveness of the environment can be increased by wearing virtual reality glasses to employees. The proposed method can also be applied in other disasters and emergency cases. In addition, such possible further studies in the class of hazardous workplaces may increase the widespread impact of usability testing in this context, and reveal the conformability and effectiveness of OHS measures.

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