A mixed-method study with eye–tracking on the influence of luminescent floor markings on users' search path and ease in reaching the emergency exit, a pilot study

Master Thesis

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by

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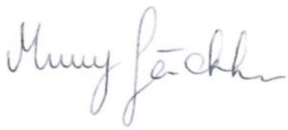
Declaration

I declare that I have developed and written the enclosed Master Thesis completely by myself and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are marked. This work was not used in the same or similar version to achieve academic grading or is being published elsewhere. (“The End atom171222project | PDF | Physical Fitness | Statistics - Scribd”)



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Preface

The digitalization and security in the healthcare sector are two essential aspects that have the potential for continuous growth. As an individual with a background in Clinical Engineering, I am particularly enthusiastic about devising novel solutions for the healthcare industry. I have a distinct interest in ensuring the safety of patients and healthcare staff, given that this domain demands expertise in both construction and the unique prerequisites of healthcare settings. Hence, my focus has gravitated towards investigating the safety of healthcare environments using mobile eye-tracking glasses.

I want to express my sincere gratitude to my supervisors, Vanessa Leung and Roman Schmied, for their support, expertise, motivation, and the invaluable equipment that contributed significantly to the completion of my thesis.

I would like to acknowledge my colleague, Sonia, for her support throughout our academic journey. Together, we navigated the challenges, celebrated the milestones, and contributed to each other’s growth.

Furthermore, I wish to express my appreciation to my family and my husband for their remarkable emotional support throughout my studies. Without their encouragement, understanding, and love, this thesis would not have come to fruition. Lastly, the entire team behind the master's program in Digital Healthcare has played a pivotal role in facilitating my research by providing resources, equipment, and managerial assistance.

List of Abbreviations

Abbreviation	**Meaning**
AOI	Area of Interest
HIT	Hit Time
IQr	Interquartile Range
MD	Median
Q1	First Quartile (Q1)
Q3	Third Quartile (Q3)
STD	Standard Deviation
TTFF	Time to First Fixate
VPS	Viewpoint System
WHO	World Health Organization

Abstract

OBJECTIVE: This study aims to assess the potential benefits of incorporating light floor markings, in addition to conventional escape route signage, to enhance the search paths for emergency exits in buildings, particularly within complex hospital environments.

METHODS: This pilot study employed a mixed-method approach, incorporating eye-tracking technology to investigate luminescent floor markings' impact on users' navigation and emergency exit location ease. Eligible participants were aged 18 or older without mobility issues or reliance on walking assistance; those aged 75 or older or with recognized vision impairments were excluded. The scenario included an environment with traditional escape route signage and a combination of conventional and light floor markings. The study used mobile eye-tracking devices to monitor gaze patterns and standardized user experience surveys for quantitative feedback.

RESULTS: In an initial study of 34 participants (n=34 eligibility), 30 qualified. Ultimately, 14 joined Group 1 (LED floor markings), and 10 in Group 2 (ceiling markings). No significant time differences emerged for identifying exits with floor markings (Group 1, p = 0.7), suggesting a moderate LED-floor marking effect. Fixation counts were similar for ceiling markings (AOI C) in both groups. However, Group 1 had significantly higher fixation counts in Area of Interest F (additional floor markings) (Mann-Whitney U test: U = 112.0, p = 0.00013). Light presence notably influenced dwell times in Areas F and C. The user experience showed higher positive ratings for support, efficiency, and clarity for the group with additional light floor markings.

CONCLUSION: In conclusion, the integration of light floor markings alongside conventional signage holds promise for improving emergency exit location, especially in complex environments like hospitals. Further research should validate alternative markings or strategies to enhance emergency egress times.

Kurzfassung

Zielsetzung: Diese Studie zielt darauf ab, das Potenzial der Integration von Lichtbodenmarkierungen in Verbindung mit herkömmlicher Fluchtwegbeschilderung zur Verbesserung der Suchpfade zu Notausgängen in Gebäuden zu bewerten, insbesondere in komplexen Krankenhausumgebungen.

Methoden: Diese Pilotstudie verwendete einen Mixed-Methods-Ansatz, der die Verwendung von Eye-Tracking-Technologie einschloss, um den Einfluss von leuchtenden Bodenmarkierungen auf die Navigation der Nutzer und die Leichtigkeit der Identifizierung von Notausgängen zu untersuchen. Teilnahmeberechtigt waren Personen ab 18 Jahren ohne Mobilitätsprobleme oder Abhängigkeit von Gehhilfen; Personen ab 75 Jahren oder mit anerkannten Sehbeeinträchtigungen wurden ausgeschlossen. Das Szenario umfasste eine Umgebung mit traditioneller Fluchtwegbeschilderung und einer Kombination aus konventionellen und leuchtenden Bodenmarkierungen. Die Studie verwendete mobile Eye-Tracking-Geräte, um Blickmuster zu überwachen, und standardisierte Umfrageinstrumente zur Erfassung quantitativen Feedbacks.

Ergebnisse: In einer anfänglichen wissenschaftlichen Studie mit 34 Teilnehmern (n=34 Berechtigung) qualifizierten sich 30 Probanden. Letztendlich nahmen 14 Personen an Gruppe 1 (LED-Bodenmarkierungen) teil, während sich 10 Personen in Gruppe 2 (Deckenmarkierungen) befanden. Es wurden keine signifikanten Zeitunterschiede bei der Identifizierung von Ausgängen mit Bodenmarkierungen festgestellt (Gruppe 1, p = 0,7), was auf einen moderaten Effekt der LED-Bodenmarkierungen hinweist. Die Fixierungszahlen waren für Deckenmarkierungen (AOI C) in beiden Gruppen ähnlich. Allerdings wies Gruppe 1 signifikant höhere Fixierungszahlen im Bereich des Interesses F (zusätzliche Bodenmarkierungen) auf (Mann-Whitney U-Test: U = 112,0, p = 0,00013). Die Anwesenheit von Licht beeinflusste signifikant die Verweildauer in den Bereichen F und C. Die Benutzererfahrung zeigte höhere positive Bewertungen für Unterstützung, Effizienz und Klarheit in der Gruppe mit zusätzlichen Lichtbodenmarkierungen.

Fazit: Zusammenfassend bietet die Integration von Lichtbodenmarkierungen neben herkömmlicher Beschilderung Potenzial zur Verbesserung der Lokalisierung von Notausgängen, insbesondere in komplexen Umgebungen wie Gesundheitseinrichtungen. Weitere Forschung sollte überprüfen, ob andere Arten

von Markierungen oder Strategien möglicherweise effektiver sind, um die Evakuierungszeiten im Notfall zu verbessern.

Table of Content

1 Introduction

Safety concerns every aspect of daily life. Public buildings and facilities must fulfill specific safety standards. With the help of modern technology, even higher safety standards can be reached nowadays.

Current technologies enable safety standards to reach new heights. Hospitals are an example of complex ecosystems with many different aspects, including people. Interactions between workers, tools, services, and information are of particular importance [1]. Hence, ensuring a secure environment signifies a necessary degree of skilled healthcare that must be met to guarantee patient safety [1]. In order to ensure the safety of individuals against fire hazards, established standards offer comprehensive directives for the planning, building, and functioning of structures [2]. Despite the ongoing research focus on the design and implementation of wayfinding systems, including healthcare settings, there remains a notable lack of in-depth exploration into the strategic positioning of wayfinding aids while considering users' performance [1].

In the following chapters, several topics will be discussed, including emergencies, types of security, patient safety, environmental safety, hospital fire protection, floor markings, and eye-tracking technology. A discussion of the requirements and methods used in this study will follow this chapter. The next section describes and presents the study's implementation, testing, and data evaluation. The author summarizes this thesis's results and limitations in detail in the penultimate chapter. Finally, the author concludes and addresses further limitations and improvements.

1.1 Context of the Study

The use of floor markings is common in many areas [3]. It is used to demarcate areas and can also serve as a guideline. Floor markings are essential in road traffic, industrial buildings, and construction sites, contributing to employee safety. In aviation, conditions are even more challenging to ensure the safety of employees and passengers in case of emergency. Therefore, higher standards are maintained than in ordinary premises. Hence, light floor markings are used in addition to typical escape route signs to provide additional visual assistance to passengers in emergencies. The reason for this is that, in the event of a fire in the closed body of an aircraft, smoke rises quickly and can hinder the visibility of standard escape routes and emergency exit signs. Due to these circumstances luminous floor markings are used [4]. Luminous floor markings could also be used in public buildings such as hospitals to prevent injuries and enable quick evacuations.

1.2 Research Gap

While there are existing guidelines and regulations on the minimum requirements for escape route markings, more research is needed to determine the optimal characteristics of escape route markings, such as colour, luminance, size, and placement to ensure their effectiveness in guiding occupants to safety in emergencies. Additionally, there is a research gap in understanding the human factors involved in the recognition and interpretation of escape route markings, such as cognitive load and decision-making processes, and how these factors are addressed to improve the effectiveness of escape route markings. Finally, even though there are existing studies addressind the effect of light markings on safety in street traffic, there needs to be sufficient knowledge on how light floor markings influence users' search for emergency exits in vulnerable facilities.

This work aims to improve understand the potential applications of additional light floor marking in case of emergencies. Further research could examine the effectiveness of light floor markings in medical facilities with complex layouts like public hospitals.

1.3 Aim of the Study

Fire accidents remain one of the biggest challenges for hospital safety management. Available statistics show that hospital fires always result in serious injuries [2, 5]. Therefore, the safe and quick evacuation of people in case of hospital fires remains a contemporary issue.

This thesis aims to determine whether the use of luminous floor markings, in addition to conventional escape route markings, affects and influences the search path of people finding the emergency exit. A mobile eye-tracking device and a standardized survey will collect the data. The thesis is allocated in environmental and patient safety, usability testing, function, and user experience.

Potential results could help create a safer work environment for health professionals and patients.

1.4 Research Questions

RQ 1: Can the use of additional LED strip floor markings for escape routes reduce the time needed to find an emergency exit?

RQ 2: Is the test subject's search path influenced by the use of floor markings in addition to the usual escape route signs?

RQ 3: Do participants find additional floor markings supportive in finding escape routes?

2 Theoretical Background and Definitions

An emergency is an event of natural or human origin that poses a significant risk to human life or property [6]. More specifically, an emergency can be defined as an imminent or ongoing event that endangers people, property, or the environment and requires a coordinated and rapid response [6]. Emergencies often arise unexpectedly in terms of their timing and location, but they can and should be prepared for [7]. Moreover, an emergency represents a situation in which regular procedures are suspended, and exceptional measures are taken to protect lives, ensure the safety of individuals, minimize damage, and restore normalcy [7, 8]. Emergencies and disasters provide essential insights for preparing for future events.

Emergencies can occur in every aspect of life. From an early age on individuals are trained how to behave in case of emergency in different environments. For instance, in primary school, individuals are trained how to read and interpret exit signs and follow directional signs. As such, evacuation route markings have been part of our daily lives since early on and can be found in every enclosed environment. Predicting human behaviour in emergency situations is necessary to enhance the safety of buildings and improve the effectiveness of response procedures and training programs, as the behaviour of involved individuals involved determines the outcome of such events [9]. Systems engineering principles are widely utilized in human factors and ergonomics and contribute significantly to understanding human behaviour and safety in fire and emergency situations. Previous studies have acknowledged the potential value of these principles in this subject area [10 , 11]. Utilizing these approaches, ergonomists can assist in guiding the design of buildings, aircraft, boats, evacuation procedures, and emergency response training [12 , 13 , 14, 15]. A survey of evacuations conducted after the disaster at the World Trade Center indicates how improvements can be made [16]. This survey can provide valuable insights for enhancing evacuation procedures during such emergencies. For example, factors have been identified which could have led to delay or acceleration of the start of evacuation and affect the intended duration of the evacuation. Such studies can help to develop improved evacuation plans and protocols to manage future emergencies better. Delays in initiating the evacuation process were found to be caused by numerous factors, such as concerns about physical ability or unfamiliarity with the building among some evacuees. In addition, poor signage, and difficulty in locating fire exits were identified as significant causes of delays [16]. Failure to participate in evacuation drills in advance is also believed to have delayed and hindered the effectiveness of the evacuation process. On the other hand, emergency preparedness training and experience positively impacts such a process [16, 17]. Studies have shown that physical or functional disability can significantly increase evacuation time [2, 17]. Being part of a group during an emergency, such as an escape, may also lead individuals to make unwise decisions, which can further hinder the evacuation process. This may result in herding or flocking behaviour, where individuals become disoriented and unable to make decisions on their own [18]. The principle of least effort pertains to this scenario, as people tend to opt for the most straightforward route and use a known entrance as their exit. The transition from rational behaviour to panic-induced behaviour is influenced by the parameter of 'nervousness,' which affects fluctuation strengths, desired speed, and the tendency of herding. This can result in effects such as 'freezing by heating, 'faster is slower' due to the ignorance of available exits [18].

Navigating through a large and complex building, such as a hospital, can be challenging, especially in combination with the stress and distraction experienced by patients and visitors. Even seemingly simple decisions, such as the numbering of the floors, can significantly impact orientation and wayfinding within the hospital. To address this issue, a study was conducted to determine the most comprehensible floor numbering scheme for separate groups, including hospital patients (both inpatients and outpatients), visitors, and employees [19]. In addition, the study explored the differences in preferences for floor numbering schemes and how they relate to the wayfinding process. The ability to orient oneself, understand one's location in space, and know how to proceed is essential. Research has shown that spatial disorientation can negatively impact individuals [19].

Additionally, a lack of orientation reduces a person's sense of control, leading to a sense of loss. In a hospital setting, where stress levels are already elevated, the experience of failed directions can be even more overwhelming. In complex environments like hospitals, every design element, including signage, colour scheme, and floor numbering, can be crucial for wayfinding and reducing stress. Within hospitals, the evacuation of patients can pose as an intricate procedure demanding careful preparation and synchronization among hospital personnel and emergency responders. For instance, research by Best found that errors in floor choice were the most common type of wayfinding mistake when individuals were trying to locate a particular destination within a town hall [19]. This highlights the importance of a well-designed flooring scheme for successful navigation in complex buildings such as hospitals [19]. Hospitals are critical centres for providing medical care during disasters and emergencies. Still, their structure makes them vulnerable to various intrinsic and extrinsic hazards, including fires. Evacuation plans and procedures that employees, patients, and visitors can rely on are especially important.

Moreover, medical facilities take special precautions for specific patient groups with particular needs, such as elderly patients, people with disabilities, or those who rely on life-sustaining equipment. In buildings where people with various levels of familiarity converge, there may also be delays in reaction time [19]. For example, in a hospital, staff and long-term inpatients may have a better conception of the layout of a particular building area. In contrast, visitors who are not familiar with the building layout look for other methods to find the exit, such as relying more on their memory and trying to recall the entrance they used to enter the building.

The difference in familiarity with the building is a principal factor to consider as it can lead to significant delays in evacuation or response time during emergencies crucial to evaluate the level of familiarity of all occupants when developing emergency plans and evacuation procedures. Evacuation plans should include detailed instructions on how to evacuate quickly in case of an emergency. This may involve marking exits, determining evacuation routes, designating responsible employees for coordinating the evacuation, and outlining how employees can support patients during the evacuation (see Chapter 2.2.3).

A different research endeavour [20] proposed a strategy for improving navigation by utilizing user performance data, aimed at addressing the challenges of wayfinding within extensive healthcare facilities. Conducted within an outpatient unit in Malaysia, the study advocates for the creation and dissemination of wayfinding aids through virtual reality settings. To evaluate efficacy, two virtual reality studies were conducted, comparing the existing wayfinding system with the new distribution approach informed by users' performance data [20]. The study demonstrated that adopting the new delivery method decreased the time and distance required to reach regional destinations. These findings suggest that virtual reality environments could enhance the design of medical facility wayfinding systems, complementing the designer's intuition [20].

Lovreglio [21] conducted virtual and augmented reality research on human behaviour during disasters. The results of this study indicate that behavioural design and training, as well as building design and environment, play a key role in enhancing the effectiveness of risk reduction.

The so-called reality orientation training can help people with mild or moderate forms of dementia maintain a connection to their environment. For example, redesigning the living environment by labelling clothes, rooms, or objects allows people with dementia to be more realistic and is used according to the severity of the disease. Spatial orientation includes the immediate surroundings, the apartment or house, and the location. Such guidance systems can help dementia patients achieve more autonomy in their everyday lives, especially in healthcare facilities [22].

Eye-tracking is increasingly used to analyze human behaviour in various life situations. Eye-tracking glasses have many applications in multiple fields, such as medical research, psychology, psychiatry, ergonomics, sports, marketing, agriculture, nutrition, accident analysis, UX design, and traffic safety [23]. Using eye-tracking devices along with predefined scales and scores can be valuable in identifying symptoms in non-verbal patients in medical settings. It can be challenging for patients who cannot communicate their symptoms to make accurate diagnoses, making this technique particularly beneficial. By using eye-tracking devices, medical professionals can track the patients' eye movements and analyze patterns to determine the presence and severity of symptoms [24]. Using predefined scales and scores can aid in analyzing eye-tracking data and facilitate comparing results across patients and settings. This technology may lead to earlier and more accurate diagnoses and better treatment outcomes for critically ill patients [24].

To succeed in overall community disaster planning or designing space use in high-rise buildings during emergencies, planners must possess accurate knowledge and understanding of human behaviour in such situations.

This study aims to assess the efficacy of light floor markings in directing individuals to the nearest emergency exit within a hospital environment. By studying people's search patterns and evacuation behaviours in a simulated emergency scenario, this research aims to contribute to understanding how the hospital environment can be designed and maintained to promote the safety and well-being of all occupants.

2.1 Patient Safety

Safety affects every workplace and particularly vulnerable facilities, such as medical institutions including hospitals, nursing homes, ambulances, and medical practices require sufficient safety measures to evacuate people quickly and safely in case of emergencies. According to the Workplace Ordinance, alarm devices must be installed and wired throughout the building to protect all individuals' health and physical integrity in a healthcare facility. In addition, an alarm device must be set up to provide enough time to safely evacuate patients and personnel during medical treatments in case of fire. Therefore, standalone fire detectors should be installed in such departments. Depending on the size of the rooms, one or more fire detectors are installed. In communal areas such as waiting rooms, break rooms, or treatment rooms, smoke detectors should be implemented according to ÖNORM EN 54-7, which ensures rapid smoke-generating fire detection [25].

The emergency markings should be independent of the power grid to ensure that emergency exit signs are visible during an evacuation or power outage. The signs are powered by the emergency power supply and battery [25].

2.2 Security and Safety

Environmental safety is essential in hospitals and other healthcare facilities, as it plays a critical role in the overall safety and well-being of patients, employees, and visitors. In contrast, hospital security refers to measures taken to protect people and property from crime and threats such as theft and violence. This may include using signs, CCTV cameras, and access control systems. Safety and security are related but distinct concepts that are often used together in the context of hospitals and other healthcare settings. Safety refers to protecting people from harm or injury, while security refers to protecting people and assets from crime or threats [26].

2.2.1 Security

The topic of healthcare security can be broken down into several aspects, as outlined below [27].

- Locking systems and access control, including measures to prevent unauthorized entry to secure areas.
- Personal security for both patients and employees, such as protection from physical harm or violence.
- Firewall and other measures to protect sensitive data from external access or cyber-attacks.
- Avoiding default passwords that could compromise system security.
- Controlling external access to data to protect patient privacy.
- Security areas in hospitals to limit access to certain areas.
- Types of security

Additionally, healthcare security can be classified into several types, such as unconditional, basic, conditional, indicative, and global safety, depending on their design, installation, inspection, maintenance, and user behaviour. All these measures combined play a vital role in maintaining the security of healthcare facilities and preventing any potential security breaches [27]. Unconditional security pertains to the security measures that are built into the design and manufacture of healthcare facilities. Basic security includes protection from direct physical hazards like fire, floods, and earthquakes. Conditional safety depends on installing, inspecting, and maintaining security systems and equipment. Indicative safety measures rely on user behaviour, such as adherence to safety protocols and reporting suspicious activity. Global safety encompasses a combination of all these measures and is critical in maintaining the security of healthcare facilities and preventing potential security breaches. These distinct security measures work together to create a secure environment for patients, staff, and visitors within healthcare facilities [27].

2.2.2 Safety

The word ‘safety’ is derived from the Latin sine salvate and means as much as (lat.) "injured, in good health, safe" [28]. There is no such thing as absolute safety. There is always a compromise of usefulness, usability, costs, and risks. In the Safety by Design approach, safety is considered at every stage of the design process, from selecting materials and components to testing and validating the final product. The primary objective of Safety by Design is to prevent incidents and accidents proactively rather than reacting to them after they have already occurred.

Such precautions in the Safety by Design approach relate to the following areas [27]:

• Emergency power supply
• Redundant power supply design
• IT redundancy design
• Network (including associated infrastructure)
• Firefighting equipment and infrastructure;
• Medical gas redundancy

2.2.3 Environmental Safety in Medical Facilities

Hospitals can face unique challenges during fire emergencies, as vulnerable populations such as patients with limited mobility or other health conditions are at a higher risk of injury or harm. This makes it especially important to have adequate emergency response plans in place.

The evacuation of hospital patients can be a complex process that necessitates far-reaching planning and coordination between hospital personnel and emergency responders. Factors such as patient acuity, mobility limitations, and the location of patients within the hospital can all impact the evacuation process.

In a hospital setting, environmental safety refers to the measures taken to protect patients, staff, and visitors from harm or injury caused by the physical environment, such as fires, falls, or hazardous materials. For example, environmental safety measures may include using fire-resistant construction materials, installing fall prevention systems, and implementing hazardous materials management procedures. Environmental safety is essential in hospitals and other healthcare settings, as it plays a critical role in the overall safety and well-being of patients, staff, and visitors. The architecture and configuration of a hospital facility can profoundly impact individuals' capability to vacate the premises safely in response to an emergency, such as a wildfire or natural disaster.

One of the critical challenges in evacuating patients during a fire emergency in a hospital is ensuring their safety while maintaining continuity of care. This process may involve devising evacuation procedures tailored to specific patient populations, including those who are bedridden or have mobility limitations. For example, evacuation chairs or stretchers may be necessary to move patients who cannot follow evacuation procedures. Hospitals also need to have a comprehensive fire prevention plan in place that includes regular fire drills, staff training, and fire extinguishers and sprinklers. Effective communication is also crucial in fire emergency situations in hospitals. Adequate and prompt communication between hospital personnel, patients, and emergency responders is essential in ensuring that everyone is informed about the situation and understands what actions must be taken. Communicating clearly can convey vital information leading to a better-coordinated and potentially saving lives.

Overall, hospitals need to have a robust fire safety plan that considers patients' unique needs reviewed and updated to ensure its effectiveness in case of fire emergency. This will help to minimize the risks and harm to patients and staff and ensure the continuity of care during fire emergencies in hospitals [29]. One of the key benefits of light floor markings is that they can provide a clear and visible optical guide for patients and staff during an evacuation in low visibility conditions, as in a smoke-filled environment. Light floor markings can also be programmed to activate automatically in the event of a fire, providing an immediate visual cue for evacuation and reinforce a discernible optical difference to non- emergency situations. This can prove especially beneficial in scenarios where patients or staff members may require assistance in comprehending and following verbal directives.

Additionally, light floor markings can be customized to meet the specific needs of a hospital, such as providing unique markings for patients with mobility limitations or special needs. This helps ensure that everyone can be evacuated as safe and quick as possible. Furthermore, light floor markings can help guide patients and staff to the spatial nearest emergency exit, which can be critical in a fire emergency. This helps reduce evacuation time, which is crucial in preventing injuries and saving lives. In summary, light floor markings can be an effective tool to improve the safety of patients and staff during fire emergency situations in hospitals. The clear and visible guidance for evacuation offers the possibility of fully automated activation and customization to meet a hospitals' specific needs. They can provide a clear and visible guide for patients and staff during an evacuation and can. An even higher valuability for patients or staff can be reached who may be disoriented or panicked and have difficulty following verbal instructions. Additionally, light floor markings can be programmed to activate automatically in the event of a fire, providing an immediate visual cue for evacuation. Despite the potential benefits, the use of light floor markings in hospitals is not as widespread as one could suppose, and more studies and research will be needed to ensure their efficacy and safety and therefore increase the application.

In general, environmental safety refers to measures taken to protect people and the environment from harm or injury caused by the physical environment or the use of products or substances. Examples of environmental safety measures include the use of protective equipment, the implementation of safety procedures, and the regulation of hazardous materials [30].

Several specific safety regulations apply to hospitals in Austria. Some of these regulations include:

The "Ordinance on Fire Safety in Hospitals and Similar Facilities" (Verordnung über den Brandschutz in Krankenhäusern und vergleichbaren Einrichtungen), which sets out requirements for fire safety in hospitals, including the use of fire-resistant construction materials, the installation of fire detection and suppression systems, and the development of evacuation plans [28]. The "Ordinance on the Implementation of the European Union Directive on the Safety of Medical Devices" (Verordnung über die Durchführung der EU-Richtlinie über die Sicherheit von Medizinprodukten), which sets out requirements for the safety and effectiveness of medical devices used in hospitals, including the use of appropriate labeling and documentation, and the implementation of quality management systems [25]. The "Ordinance on the Prevention of Accidents and Incidents in the Health Sector" (Verordnung über die Verhütung von Unfällen und Zwischenfällen im Gesundheitsbereich), which sets out requirements for the prevention of accidents and incidents in hospitals and other healthcare settings, including the implementation of risk assessment procedures and the development of emergency response plans [27].

Hospitals face a significant challenge in keeping abreast of the latest safety requirements and maintaining compliance due to the dynamic nature of safety standards, which are subject to constant evolution. In addition, hospitals are high-risk environments where accidents and incidents can occur due to various factors, such as human error, equipment failure, or natural disasters.

Effective management of the risk of accidents and incidents is crucial to ensuring the safety and well-being of patients, staff, and visitors in a hospital environment. Managing these risks effectively can be challenging, particularly in larger hospitals with complex layouts and many patients and employees. Ensuring the safety and effectiveness of medical devices holds essential implications for patient safety [31]. Traditionally, hospitals have relied on a range of escape route markings, such as signs and arrow symbols, to guide people to the nearest emergency exit. However, markings may only sometimes be effective, particularly in situations where visibility could be better, or the layout of the building is complex.

2.3 Fire Protection in Hospitals

Fire protection is an essential consideration in hospitals. Medical facilities, such as hospitals, are often extensive, complex buildings with a high occupancy rate and a diverse population that may include vulnerable individuals. In Austria, specific regulations and guidelines are in place to ensure that hospitals fulfill standards for fire safety. These may include fire detection and alarm system requirements, resistant construction materials, emergency lighting and exit signs, and evacuation procedures. It is crucial for hospitals to regularly review and update their fire protection measures to ensure the safety of everyone in the facility. According to ÖVE/ÖNORM E 8007, safety devices include all devices and equipment to provide the safety of people in the event of a fire or power failure [32]. This includes, in particular, emergency lighting. According to ÖVE/ÖNORM E 8007:2007, at least 50% of the room lighting on escape routes must be supplied by an emergency power supply. Illuminated escape route signs have a backup power supply in addition to the regular mains connection to the emergency power supply's switching time and supply and to continue to provide lighting for a certain period in the event of a failure [32].

2.4 Light Floor Markings

Many healthcare facilities already use floor markings to increase safety and optimize processes. One effortless way to facilitate the placement of items such as trash bins or soiled linen collectors is to use floor marking tapes in distinct colours. For example, the area around the trash bin can be marked to ensure it is in the right place. Another colour of floor marking tape indicates the area around the soiled linen collector placement. Floor markings are also used to help defining the placement of beds and wheelchairs. Such markings can show precisely where the bed should be placed to ensure an optimal environment.

Similarly, markings can help determine the proper stopping point for wheelchairs or mobile beds. In addition, light floor markings in a hospital could be classified as an environmental safety measure. Light floor markings are intended to assist individuals to find the closest emergency exit during an emergency situation, such as a fire or natural disaster. By providing an additional visual cue to help people navigate the hospital environment, light floor markings can help to promote the safety and well-being of patients, staff, and visitors. Other hospital environmental safety measures include fire-resistant construction materials, fall prevention systems, hazardous materials management procedures, and emergency response plans. These measures are designed to protect people from harm or injury that the physical environment may cause to ensure that the hospital environment is safe and secure for everyone who uses it.

Both the U.S. Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA) have mandated the presence of emergency floor path illumination as an essential safety element in aviation. It is imperative for passengers to visually identify the path leading to the nearest exits, which should remain clearly visible even in conditions of smoke or darkness due to appropriate illumination. Moreover, the emergency lighting must continue to operate reliably even during power outages.

Floor markings are also used in construction and in traffic tunnels in case of emergency. They can help indicate the location of emergency exits, first aid stations, and other essential safety features. These markings can also help guiding workers and emergency personnel to the appropriate areas in the event of an emergency. They must be visible and easy to interpret so that they can be followed quickly and accurately in a crisis. For several reasons, floor markings are used in tunnel construction for emergencies. These include situations, such as a fire or structural collapse. Workers and emergency personnel must be able to locate and access the necessary safety features and exits quickly. Floor markings can help guide them to the appropriate locations, improving response time and increasing a successful outcome [33]. Tunnel construction be large and complex, with many different areas and features. Floor markings can help indicate the location of features, such as emergency exits and make them more visible [33].

2.5 Eye–Tracking

Eye-tracking as a research method is gaining increased importance across diverse fields such as mobility, transportation, aviation, usability engineering, augmented and virtual reality, sports and training sciences, medicine, and nursing, as well as education and educational psychology. The development of technology in the field of eye-tracking measurements is one of the factors contributing to the considerable increase in attention, that eye-tracking receives as a research approach [34].

The first eye-trackers were developed to explore eye movements and gain an understanding of them. Today, with advanced modern technologies, the application areas for eye-trackers have expanded. Mobile eye-tracking technology provides a non-invasive and objective method for studying human behaviour and cognitive processes in real-world settings. As a result, it has the potential to facilitate the development of more effective interventions and technologies in various domains.

A significant development in eye-trackers history is the introduction of portable eye-tracking systems. Hartridge and Thompson made the first attempts to use a head-mounted eye-tracker [35]. This allowed for measurements of eye movements in much more natural environments for the subject and thus provided many more possibilities for its use. In the following years, the head-mounted eye-tracker was further adapted, and in 1968, Thomas added a front camera. This created the possiblility to record eye movements and field of view. However, it was only at the end of the 20th century that the head-mounted eye-tracker was first used in real-world applications. In 1994, Land and Lee jointly developed a portable eye-tracker that transmitted the subject's eye movements to the recorded field of view. Nowadays, mobile eye-trackers are widely used and extensively employed [36].

In today's world, two types of eye trackers have become popular: mobile and stationary devices. Due to the advancement of digitization, eye-trackers have become smaller and lighter, which means that subjects are no longer restricted in their movements, and a unique laboratory is no longer required [37]. These devices typically consist of a lightweight headset equipped with a tiny camera and sensors that detect the position and movement of the eyes. As a person moves their head and looks at different objects, the camera captures images of their eyes. The sensors in the eye-tracking system detect the pupils' movement. The gaze's postpositional-center reflection (PCCR) technique utilizes near-infrared light to create detectable reflections in both the pupil and the cornea by directing it toward the center of the eye. To achieve precise measurement of gaze direction, it is essential to ensure a distinct separation and effective identification of both the pupil and the corneal reflection [38]. An infrared light source and detection method enables precise differentiation between the pupil and the iris, which is impossible for sources and ordinary cameras due to reduced contrast [47]. The central point of the eye (pupil center) is monitored in correlation with the corneal reflection's position. The relative separation between these two points facilitates the computation of gaze direction [37]. Using visible spectrum light can result in uncontrolled specular reflection, whereas employing infrared light helps to minimize reflections and enables more accurate eye-tracking measurements [37]. This is because infrared light allows for better differentiation between the pupil and iris as the light directly enters the pupil and "bounces off" the iris. Additionally, since infrared light is not visible to humans, it does not cause distractions during eye-tracking [37].

This information is then processed by sophisticated software algorithms that can analyze the data to provide insights into the person's visual attention, cognitive processing, and emotional response. As a result, mobile eye-tracking has a wide range of applications in fields such as psychology, marketing, human-computer interaction, and sports training.

For instance, this technique can be utilized to examine people's interactions with websites, advertisements, or products and detect regions of visual attention patterns. Furthermore, it can be employed to evaluate cognitive performance, including attentional control and decision-making mechanisms, and to track physiological reactions in response to emotional or stressful stimuli [40].

These measures can be categorized into four types: movement measures, position measures, numerosity measures, and latency measures, as described by Holmqvist [31, 39]. However, it is essential to note that the eye is continuously moving between fixation points. Fixations refer to brief halts of eye gaze at a specific location, lasting at least ninety-nine milliseconds, while the movements between fixations are known as saccades [54]. Movement measures evaluate the patterns of eye movements during saccades, including the distance between successive saccades (saccade amplitude in degrees) and saccade speed (average or peak velocity) [40].

Eye-trackers play a significant role in the field of marketing, both in the market and consumer research. They are used, for example, to analyze and optimize shelves, displays, or even entire stores. The most frequently viewed areas are determined and considered when presenting goods and products. Eye-trackers are also used to determine what the customer is focusing on, what catches their interest, and what influences their decision-making. Product designs can then be adjusted and optimized [41]. Eye-trackers can serve as aids for medical procedures. Analyzing eye movements can help identify various diseases. Not only eye disease but also developmental disorders, as well as mental and neural disorders, can be examined and diagnosed early [41]. Eye-trackers in the entertainment and gaming industry have also made their way into the gaming industry. Over one hundred games already support the use of eye trackers, including well-known computer games such as Far Cry, Assassin's Creed, and Formula 1. The website tobiigaming.com offers a list of all supported games. In the field of education, eye-trackers can help identify disparities in how experts and novices manage scientific texts and graphics. These studies offer valuable insights that can be leveraged to enhance teaching materials for beginners, mitigate comprehension difficulties, and ultimately enhance the learning experience for newcomers.

For this pilot study, the eye-tracking glasses from Viewpointsystem (VPS) come with a Smart Unit and a connecting cable, forming an eye-tracker unit (see Table 4). The glasses are used to measure and analyze gaze direction and unconscious eye movements in real-time. In addition, a student license for the iMotions software was provided for data analysis.

Table 1 iMotions specifications

Manufacturer	**iMotions A/S**
Version	9.3, 9.3.0.17, 9.3.0.18
Supported OS	Windows 10, 8, and 7 (64-bit)
Languages	English, German, French, Spanish, Simplified Chinese,
Data export formats	CSV, EDF, EDF+, MAT, TSV, XLSX, TXT, WAV, and
License models	Single-user, lab, academic, and enterprise licenses are

Table 2 LED strip specification 1

Manufacturer	Govee
Type	Smart LED Strip Light
Connectivity	Wi-Fi
Colour	RGB
Length	5 m
Power Supply and Plug Type	Wired
Controller Type	App Control
Voltage	12 V
Number of Light Sources	150 LEDs
Model Number	H61593A1DE
Power Consumption	18 Watts

Table 3 LED strip specification 2

Manufacturer	SOLMORE LED
Power Supply	battery powered
Colour	RGB
Length	2 m
Material	Polycarbonate
LED-Type	SMD5050
Voltage	4.5 V
Number of Light Sources	30 LEDs
Model Number	S-SP-001
Light Strip Protection	IP65

Table 4 VPS eye-tracking glasses specification

Manufacturer	Viewpointsystem GmbH
System	VPS 19
Software	nellieOS 2.17 (custom version)

3 Requirements / Methods

The author conducted a mixed-method study using quantitative and qualitative methods for this research. Both quantitative and qualitative data generated helped answer the research questions comprehensively.

On January 14th, 2023, the study members convened at the campus to collect preliminary data. The study environment had specific requirements to ensure unbiased participant behaviour. To achieve this, a room with a screen was chosen, accessible from two separate entrances. This served to prevent participants from knowing the path in advance. In addition, a marked nearest emergency exit had to be easily accessible to all participants. To meet this criterion, Building A, Room A.138, located on the first floor of the university, was selected. The planned route was carefully evaluated to determine its suitability for installing lighting floor markers (see Appendix F).

For this study, a total of 30 participants were recruited via email. The recruitment process involved sending emails and telephone inquiries to potential participants from various sources, including students enrolled in the Digital Healthcare master's program at St. Pölten University of Applied Sciences, healthcare professionals, and individuals from the surrounding area. Participants were prospectively divided into two equal-sized groups using computer-generated random numbers. Participants' agreement to the consent form was a prerequisite for participation in this study. This form included information on data processing and storage and inclusion and exclusion criteria (see Appendix B). The following inclusion and exclusion criteria were required for participation in this study:

Inclusion criteria:

- Age > 18
- Participants who do not need walking aids and are not restricted in their movement. Walking aids include:
    - Wheelchairs
    - Rollators
    - Walking sticks
- Restrictions in the movement include:
    - Casts
    - Neck braces

Exclusion criteria:

- Age > 75
- Individuals participating in the study possess confirmed visual impairments, which are defined in accordance with the criteria set forth by the World Health Organization (WHO): Visual acuity of 30% or less (0.3 vision) or visual acuity of 10% or less (0.1 vision) [8].
- Participants with diagnosed cataracts
- Participants with diagnosed amblyopia (lazy eye)
- Participants with diagnosed binocular vision disorders.
- Participants with diagnosed strabismus
- Subjects with a diagnosed corectopia
- Subjects with a diagnosed keratoconus (corneal curvature)
- Subjects with a diagnosed anxiety disorder
- Wearing false eyelashes
- Wearing mascara/mascara

Participants who wore glasses were informed beforehand to wear contact lenses instead. In this thesis, all instructions have been presented in German, given that all participants were German speaking. The study was conducted at two different time points, on February 9th, 2023, and March 4th, 2023, at the University of Applied Sciences in St. Pölten, Austria. Figure 1 shows the chart of the participants.

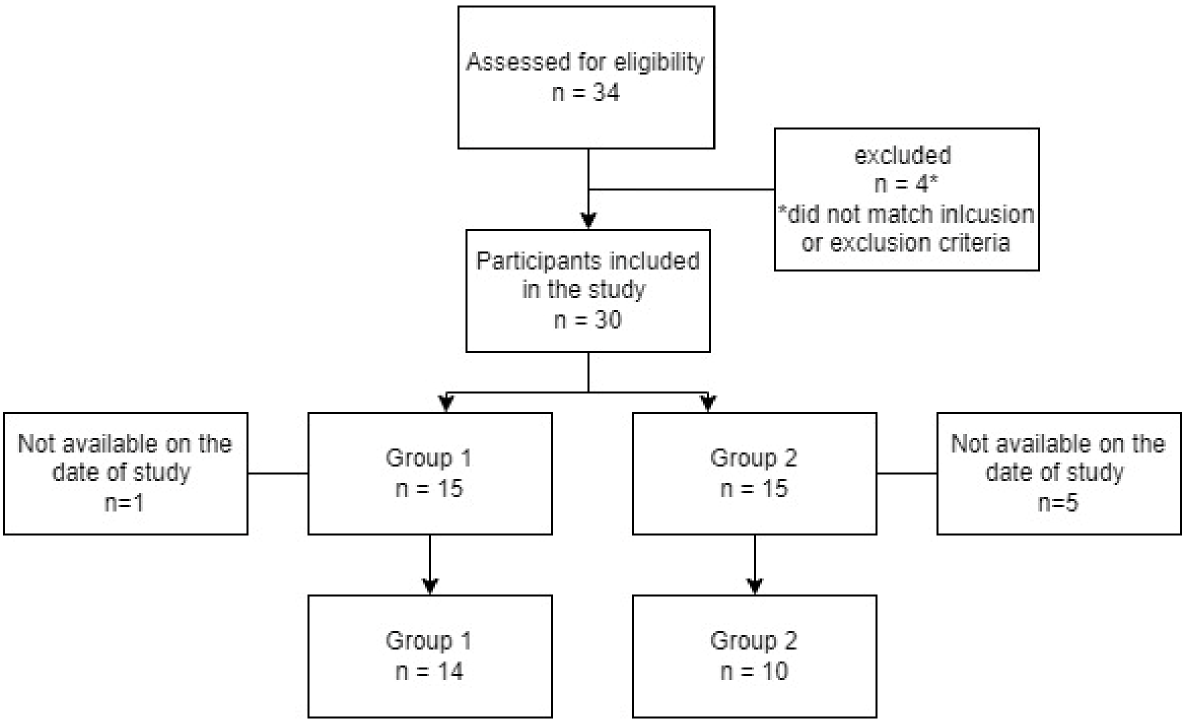

Figure 1 Flowchart showing participants

Participants were instructed to use the main entrance of building A and sit in the waiting area on the first floor. They were screened again for inclusion and exclusion criteria and advised to wear contact lenses. Subsequently, each participant was individually accompanied by the study leader to the meeting room, which was also the starting point. This route differs from the one the participants were supposed to take to avoid bias during the task.

An explanation of the eye-tracking glasses and their accessory module, a manual-sized module connected to the eye-tracking glasses via a cable, was given to the participants. The author documented whether the participant wore contact lenses or not. The participant was then asked to wear a small waist pouch on the left shoulder to hold the manual-sized module during the examination, allowing more freedom of movement. A study supervisor helped the participant put on the eye-tracking glasses and adjusted the nosepiece with a higher or lower mm count to ensure that the eye-tracking glasses appropriately detected the participant's pupils. The participant was instructed to sit on a chair in the room and look at a screen. On the screen was shown an image of a waterfall and sounds of calming waterdrops for 42 seconds (see Appendix D.1). After 42 seconds, an image appeared with the following instruction in German: "Attention, there is a fire! Please immediately find the nearest emergency exit. For safety reasons, we ask you not to run! Start now!". The instruction was displayed for an additional 18 seconds and the participants were asked to follow the instructions (see Appendix D.2). They were made aware of this before the start of the video. Participants from both groups were not provided with information regarding the light floor markings to prevent any prior influence. In this study, upon receiving the instruction displayed on the screen, participants commenced their search for the emergency exit. At the same time, a researcher observed their search path from a distance of approximately 2-3 meters. The researcher's presence served as a support mechanism to promptly address any technical issues that may arise during the data collection process. However, it is crucial to note that participants received no direct assistance or guidance from the researcher during the task. Regardless of whether participants chose the pre-planned emergency exit route or not, no additional instructions were provided to maintain the study's objectivity. The sole instruction given to participants were to locate the nearest emergency exit. Upon successfully identifying the emergency exit and reaching the designated endpoint, participants handed over the eye-tracking glasses and module to the researcher, completing the data collection phase with the eye-tracking glasses.

The data generated through the eye-tracking glasses were analyzed statistically to determine patterns and trends in users' behaviour and attention to answer research question 2. By defining dynamic AOIs (Areas of Interest), data on the participants' gaze patterns and fixation duration within those specific areas of the stimulus material was gathered. This data were then analyzed to gain insights into visual attention. For this thesis, Group one included AOI F, which marked the area with light floor markings, and AOI C, which marked the area with emergency markings on the ceiling. Dynamic AOIs were defined around the light floor markings and the ceiling markings to collect data on the participants' gaze patterns and fixation duration and fixation count within those specific areas. The data collected was then used to gain insights into how participants interacted with these safety features and whether they effectively drew participants' attention toward the emergency exits in the event of an emergency.

After successfully finding the emergency exit, participants were asked to complete a short User Experience Questionnaire (see Appendix E) with a completion time of 3-5 minutes [61]. The survey measured the user experience of a product or system on two scales: Pragmatic Quality and Hedonic Quality. It consisted of 8 items that assessed the user's satisfaction with various aspects of the experience, such as usability, usefulness, satisfaction, and aesthetics (see Figure 8). The aim was to obtain survey responses from all 24 participants to address research question 3.

4 Implementation / Testing / Evaluation Results

The study's primary objective was to address the first research question (RQ 1), which aimed to determine whether the inclusion of LED strip floor markings for escape routes could decrease the time it takes to locate an emergency exit. To accomplish this, the author utilized eye-tracking glasses to record each participant's start and end times during the experiment. The statistical analysis was conducted using Python, the source code can be found in Appendix A.

4.1 Evaluation Research question 1

Out of a total of 24 participants, 14 in Group with additional floor markings (Group 1) and 10 in Group with only conventional emergency exit signs (Group 2), technical issues prevented the complete recording of one participant in the former and two participants in the latter (see Figure 1). The start time was defined as when the participant first made eye contact with the escape route markings. The end time was defined as the moment when the participant reached the emergency exit. Table 5 shows that, on average, participants in the Group with additional floor markings took 43 seconds to find the nearest emergency exit. In comparison, participants in the Group with conventional emergency exit signs only took 39 seconds. The table therefore shows that participants in the Group with additional floor markings took an average of 4 seconds longer to find the nearest emergency exit than those in the Group with conventional emergency exit signs.

Table 5 Time difference in finding the emergency exit

	n = 21	**Mean value (in a sec)**
Group1	n = 13	43
Group 2	n = 8	39
time difference (sec)		4

The distribution of the data points were first examined to verify whether there is a significant difference in the time needed to find the emergency exit between both groups. The Shapiro-Wilk test was conducted to see the distribution of the generated data. Due to the small sample size, the Shapiro-Wilk test is better suited than the Kolmogorov-Smirnov test [42]. The following formula was used to accomplish this [43]:

$$W = \frac{(\sum_{i=1}^{n} a_j x_{(i)})^2}{\sum_{i=1}^{n}(X_i - \bar{x})^2}$$

- W is the test statistic
- Σ denotes the sum
- x(i) are the ordered random sample values [43]

- aj are constants generated from the covariances, variances, and means of the sample (size n) from a normally distributed sample [44]

The Shapiro-Wilk test, a statistical method, is employed to ascertain whether a provided dataset originates from a population characterized by a normal distribution [45, 46].

Null Hypothesis (H0): The data come from a normally distributed population.

Alternative Hypothesis (H1): The data does not come from a normally distributed population.

The results suggest that both the group data with additional floor markings (Group 1) and the data in the group with conventional emergency exit signs (Group 2) do not follow a normal distribution.

Table 6 Shapiro-Wilk test RQ 1

Group	Test Statistic	p-value
1	0.528	1
2	0.939	0.6

Subsequently, Levene's test was conducted to assess the homogeneity of variance across the groups. The following formula was used [47]:

$$L = \frac{(N-k)\sum_{i=1}^{k} N_i(\bar{V_{\iota.}} - \overline{V_{..}})2}{(k-1)\sum_{i=1}^{k}\sum_{j=1}^{N_j}\left(V_{ij} - \bar{V_{n.}}\right)2}$$

• Vij	X_{ij} - $\bar{X_J}$
• i	1, ..., k
• j	1, ..., ni
• $\bar{X_J}$	median

H0: The variances of the groups being compared are equal.

H1: The variances of the groups being compared are not equal.

The Levene test results indicate no significant difference in variance between the two groups, as the test statistic is 0.58 with a p-value of 0.5. Since the p-value is greater than the chosen significance level of 0.05, the null hypothesis is not rejected (see Table 7).

Table 7 Levene-Test RQ1

Test	Test Statistic	p-value	Equality of Variances
Levene's test	0.58	0.5	No significant difference in variances

The Mann-Whitney U-test is a non-parametric test used to compare two independent groups [48]. It is appropriate to use when the dependent variable is measured on an ordinal or continuous scale, and the data do not meet the assumptions of normality or equal variances required for a parametric test, such as the t-test. To answer the first research question, the following hypotheses are made.

H0: There is no significant difference in the underlying distribution of time required to locate an emergency exit between the group that utilized additional LED strip floor markings for escape routes and the group that did not employ them.

H1: The distribution of time needed to find an emergency exit shows lower values in the group that implemented additional LED strip floor markings for escape routes, compared to the group that did not use such markings.

Mann-Whitney U-Test formula [49]:

$$U_1 = n_1 * n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

$$U_2 = n_1 * n_2 + \frac{n_2(n_2+1)}{2} - R_2$$

n_1 = Sample size of the group with the more considerable rank sum

n_2 = Sample size of the group with the smaller rank sum

R_1 = Sum of ranks for Group 1 (with additional light floor markers)

R_2 = Sum of ranks for Group 2 (ceiling markers only) [50]

$$\mu_U = \frac{n_1 * n_2}{2} \quad \sigma_U = \sqrt{\frac{n_1 * n_2(n_1 + n_2 + 1)}{12}}$$

μ_U = Mean of the U-distribution (U-value, without distinction between the groups)

σ_U = Standard error of the U-value

$$Z = \frac{U - \mu_U}{\sigma_U}$$ [51, 52]

The p-value assesses the probability of obtaining outcomes that are distinct from the ones observed, under the assumption that the null hypothesis is valid [53].

The Mann-Whitney U test yielded a U value of 58.0, accompanied by a computed p-value of 0.7 (see Table 8). Given that the calculated p-value surpasses the pre-defined significance level of 0.05, the null hypothesis cannot be rejected. Consequently, there exists no statistically significant discrepancy in the underlying distribution of the time required to ascertain an emergency exit between the two examined groups. Furthermore, the effect size, represented by the coefficient r, was determined to be 0.59, indicating a moderate effect magnitude (as outlined in Table 8). This underscores a moderate association between the incorporation of supplemental LED strip floor markings and the temporal aspect of locating emergency exits.

Table 8 Mann-Whitney U-Test RQ 1

Group	Sample size (n)	Median (Q2) value per time (s)	U statistic	p-value	Effect size (r)
1 (with light floor markings)	13	39	58.0	0.7	0.59
2 (no light floor markings)	8	40	104.0	9*10-6	

The median time needed for the Group with additional floor markings was 39 seconds, while for the Group with conventional emergency exit signs, it was 40 seconds. The interquartile range (IQR) for the Group with additional floor markings was 6 seconds, while for the Group with conventional emergency exit signs, it was 10 seconds (see Table 9). The lower quartile (Q1) for the Group with additional floor markings was 36 seconds, while for the Group with conventional emergency exit signs, it was 33 seconds (see Table 9).

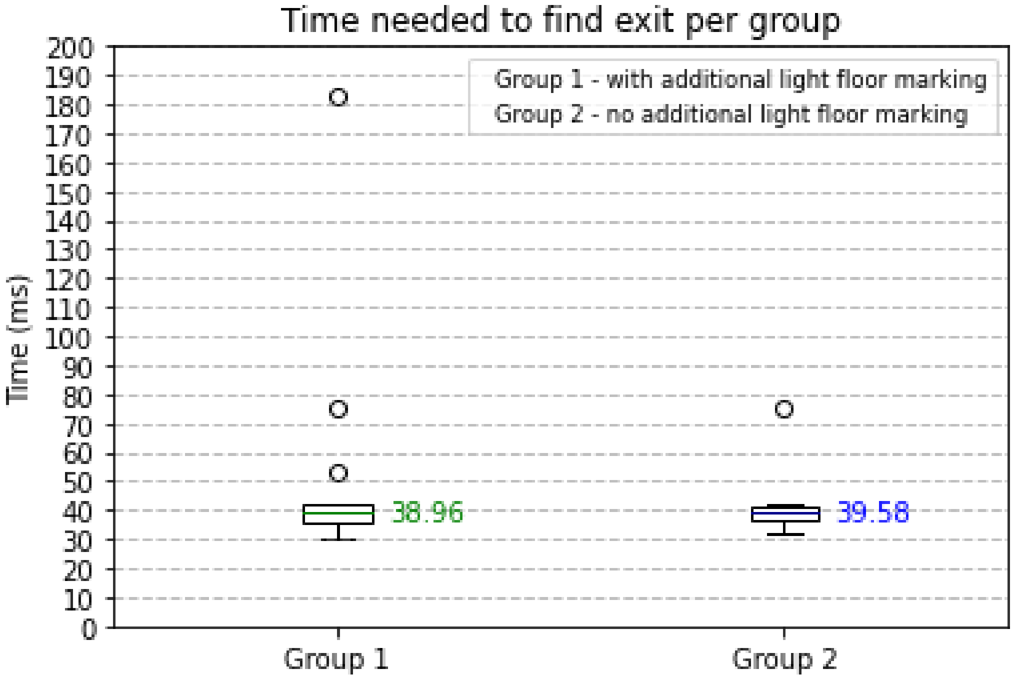

Figure 2: Whisker-Box Plot

The analysis also detected outliers in both groups. In the Group with additional floor markings, there were three outliers with completion times of 76, 53, and 183 seconds. In the Group with conventional emergency exit signs, there was one outlier with a completion time of 60 seconds (see Figure 2). The Violin Plot in Figure 3 displays the distribution of both groups

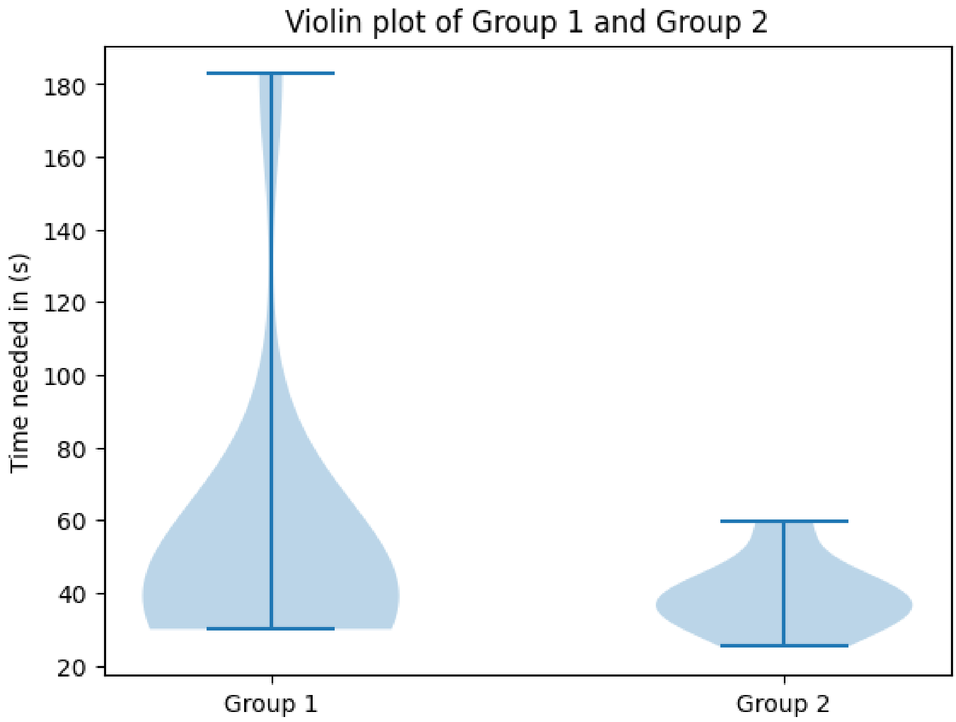

Figure 3: Violin Plot distribution

The mean time needed for the group with additional floor markings (Group 1) was 52 seconds, with a standard deviation of 39 seconds. The mean time required for the group with conventional escape route markings (Group 2) was 39 seconds, with a standard deviation of 10 seconds.

Table 9 Response Time Data for Group 1 and Group 2

Group	**n**	**Mn (s)**	**SD (s)**	**SEM (s)**	**Med (s)**	**Q2**	**IQR (s)**	**Q1 (s)**	**Q3 (s)**	**Outliers (s)**
1	13	52	40	11	40		6	36	42	[76, 53, 183]
2	8	39	10	3	39		10	33	42	[60]

Mn: Median time needed SD: Standard deviation SEM: Standard Error of the Mean IQR: interquartile range Q1: First quartile, lower quartile Q3: Third quartile, upper quartile

4.2 Evaluation Research question 2

To answer the question of whether the test subject's search path is influenced by the use of floor markings in addition to the usual escape route signs, the author employed an eye-tracking system from Viewpointsystem (VPS). The data analysis and evaluation were conducted using iMotions software, with detailed specifications provided in Chapter 2.5. A total of 21 data sets were evaluated, consisting of 13 participants from the group with additional light floor markings for orientation and 8 participants from the group with conventional escape route markings.

For each participant, the recordings were initially marked with dynamic Areas of Interest (AOIs) to quantify fixations and saccades in specific areas. In the group with additional light floor markings for orientation, two dynamic AOIs were created per sample band: one for the conventional escape route markings (AOI C) and one for the additional light floor markings (AOI F). Figure 1 illustrates an AOI 1 (for this study AOI F) on the light floor markings, where the circle represents gaze visualization and indicates the fixation point. The size of the circle corresponds to the duration of the fixation, with larger circles indicating longer fixation durations. The orange lines indicate the fixation trail.

Figure 4 Areas of Interest

The author considered the following parameters to compare the results of both groups. Within each of these categories, there are several sub-metrics. The following definitions of parameters are taken from the iMotions software [55]:

Gaze-based metrics:

Revisit count: Total of how often the respondents looked back at the AOI after the first dwell [55].

Hit time (HIT) AOI (ms): Total time that passed since the Area of Interest (AOI) start time until the gaze entered the AOI for the first time [55].

Fixations Based metrics:

Fixation duration (ms): Average duration of all fixations detected Inside the AOI [55].

Dwell time (%): Total of how long the respondents fixated on the AOI about the time duration during which the AOI was active [55].

Dwell time (ms): Total of how long the respondent fixated on all the AOI [55].

Time to first fixate (TTFF) AOI (ms): Average time that passed from the AOI's start time until the first fixation was detected on the AOI [55].

Fixation count: Total number of fixations detected inside the AOI [55].

Revisit Count: Total number of fixations detected inside the AOI [55].

Saccade based metrics:

Saccade count: Total number of saccades detected inside the AOI [55].

First, the tables (see Appendix G.1, G.2, G.3, G.4) were examined, and differences and similarities were observed. After checking for normal distribution and assessing the homogeneity of variances, the next step involved formulating hypotheses. Based on the research question, hypotheses were formulated to examine potential differences or relationships. The significance was evaluated using appropriate statistical tests based on the data type.

Dwell time (ms)

As described before, it appears that Group 1 (with light), AOI F has a higher number of participants with a higher total dwell time compared to AOI C (ceiling markings). To evaluate this, first, a visualization with a bar chart was made (see Figure 5).

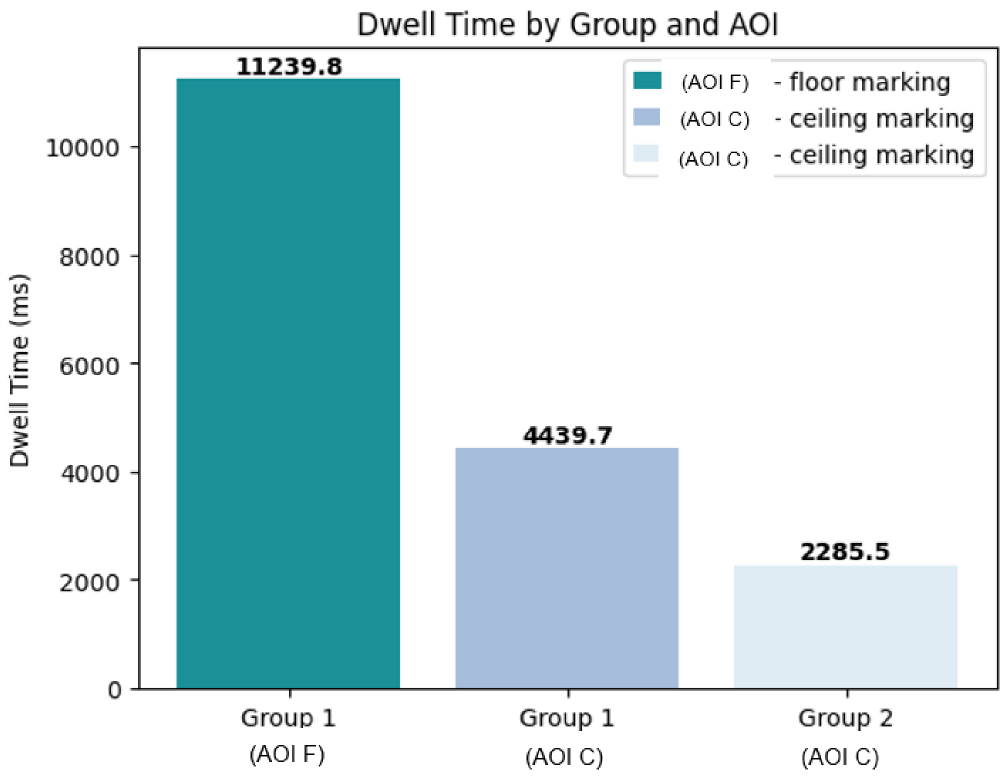

Figure 5 Dwell time (ms) by Group and AOI

Due to the limited size of the data sample, a normal distribution cannot be assumed. Since the data are not normally distributed for both groups, the non-parametric Mann-Whitney U-test was performed to compare the total dwell times between the two groups.

H0: There is no significant difference in total dwell time between Group 1 and Group 2.

H1: There is a significant difference in total dwell time between Group 1 and Group 2.

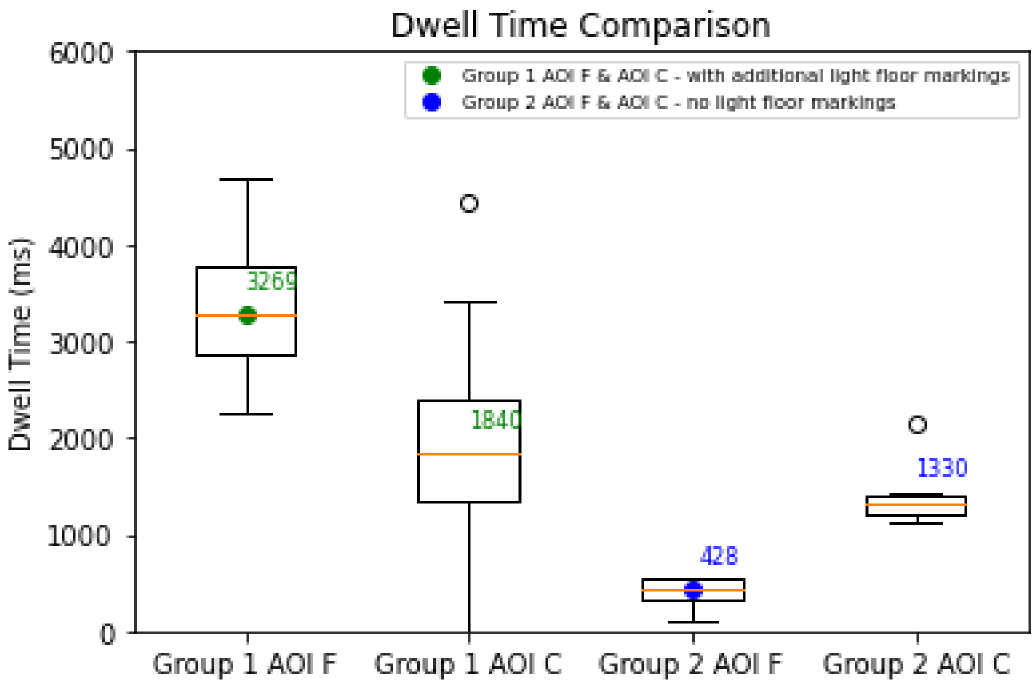

Figure 6 Dwell Time (ms) distribution

Group 1 (with light) - AOI F: The median total dwell time for Group 1 - AOI F (with light) was 3269 ms, with an interquartile range (IQR) of 910 ms. The first quartile (Q1) dwell time was 2856 ms, and the third quartile (Q3) dwell time was 3765 ms (see Table 10).

Group 1 (with light) - AOI C: The median total dwell time for Group 1 - AOI C (with light) was 1840 ms, with an interquartile range (IQR) of 1059 ms. The first quartile (Q1) dwell time was 1341 ms, and the third quartile (Q3) dwell time was 2399 ms (see Table 10).

Group 2 (no light) - AOI F: The median total dwell time for Group 2 - AOI F (no light) was 428 ms, with an interquartile range (IQR) of 220 ms. The first quartile (Q1) dwell time was 331 ms, and the third quartile (Q3) dwell time was 550 ms (see Table 10).

Group 2 (no light) - AOI C: The median total dwell time for Group 2 - AOI C (no light) was 1330 ms, with an interquartile range (IQR) of 189 ms. The first quartile (Q1) dwell time was 1202 ms, and the third quartile (Q3) dwell time was 1390 ms (see Table10).

Comparison: Group 1 AOI F vs. Group 2 AOI F

The t-statistic for comparing the total dwell times between Group 1 - AOI F (additional light floor markers) and Group 2 - AOI F (ceiling markings only) was 10.93, with a p-value of 1.24×10^{-9}. These results indicate a significant difference in total dwell times between the two groups, suggesting that participants in Group 1 - AOI F (with light) had significantly longer dwell times compared to participants in Group 2 - AOI F (no light).

Comparison: Group 1 AOI C vs. Group 2 AOI C (ceiling markers only)

The t-statistic for comparing the total dwell times between Group 1 - AOI C (with light) and Group 2 - AOI C (no light) was 1.50, with a p-value of 0.15. These results indicate that there is no significant difference in dwell times between the two groups, suggesting that the presence or absence of light did not have a significant impact on the dwell times in AOI C.

In summary, the results demonstrate that there was a significant difference in dwell times between Group 1 - AOI F (with light) and Group 2 - AOI F (no light), with participants in the light condition having longer dwell times. However, there was no significant difference in dwell times between Group 1 - AOI C (with light) and Group 2 - AOI C (no light).

Table 10 Dwell Time (ms) statistics

Group	Median total Dwell time (ms)	Interquartile Range (IQR) Dwell time (ms)	Q1 Dwell time (ms)	Q3 Dwell time (ms)
Group 1 - AOI F (with light)	3269	910	2856	3765
Group 1 - AOI C (with light)	1840	1059	1341	2399
Group 2 - AOI F (no light)	428	220	331	550
Group 2 AOI C (no light)	1330	189	1202	1390

Saccade Count

After analyzing and investigating the saccade count data, there are notable disparities in the number of saccades between the two groups. Therefore, the data suggest that Group 1 had a higher number of saccades than Group 2. To evaluate whether there is a significant difference in saccade count between the two groups, the following hypotheses are made:

H0: There is no significant difference in saccade count between Group 1 and Group 2.

H1: The saccade count for Group 1 is significantly different from the saccade count for Group 2.

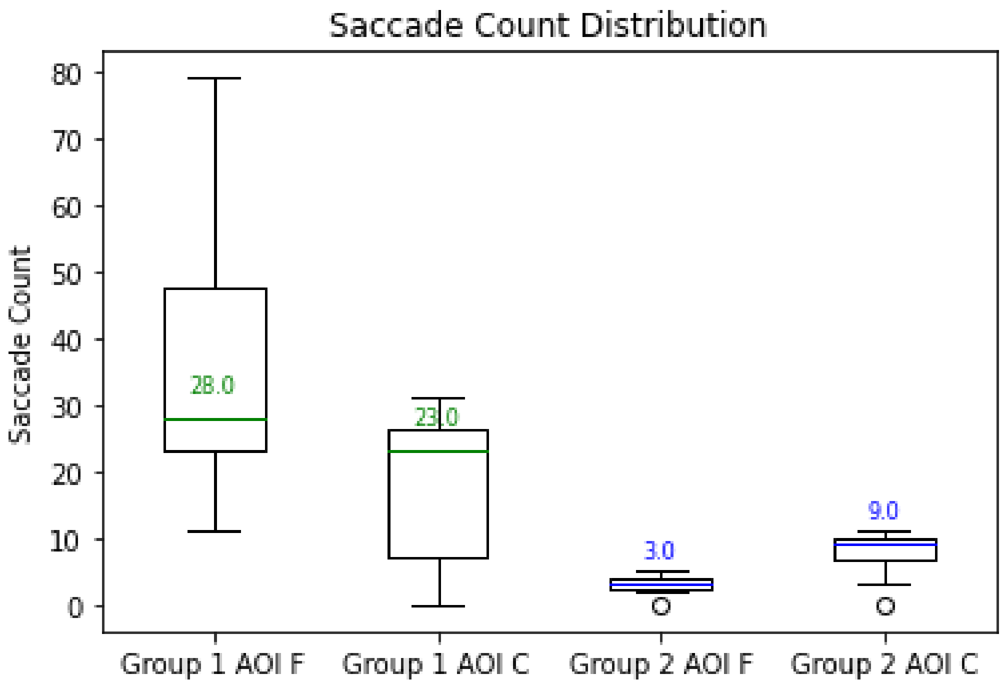

Figure 7 Saccade Count distribution

Saccade Count distribution: Group 1 AOI F (floor marking) and Group 2 AOI F differ significantly, while Group 1 AOI C (ceiling marking) and Group 2 AOI C don't.

The Mann-Whitney U test was conducted to compare the saccade count since the data were not normally distributed. The test yielded a U statistic of 98.0 and a p-value of 0.0003 (see Table 11). Since the p-value is less than the significance level of 0.05, the null hypothesis is rejected, and a statistically significant difference in the saccade count between Group 1 AOI F and Group 2 AOI F is given.

Table 11 Saccade Count Mann-Whitney U test

Comparison	**Mann-Whitney U Statistic**	**p-value**	**Significant**
Group 1 AOI F vs. Group 2 AOI F	98.0	0.0003	Yes
Group 1 AOI C vs. Group 2 AOI C (ceiling markers only)	85.0	0.051	No
Group 1 AOI F vs Group 2 AOI C	104.0	0.00018	Yes

In summary, the analysis indicates that there is a significant difference in the saccade count between Group 1 AOI F (with light floor marking) and Group 2 AOI F (no light floor marking).

At a significance level of 0.05, the p-value is greater than the alpha ($\alpha = 0.05$), indicating that there is not enough evidence to reject the null hypothesis. Therefore, there is insufficient evidence to conclude that there is a significant difference in the saccade count between Group 1 AOI C and Group 2 AOI C (ceiling markers only).

The analysis indicates that the presence of light floor marking (Group 1 AOI F) has a significant effect on the saccade count compared to the absence of light floor marking (Group 2 AOI F).

Time to first fixate (TTFF) (ms)

This chapter focuses on the analysis of the "Time to First Fixation" (TTFF) metric, which measures the average duration between the initiation of an Area of Interest (AOI) and the detection of the first fixation on that AOI [56]. For this study the total TTFFs have been used. This metric provides insights into how quickly participants directed their attention to specific visual elements, aiding in understanding their initial engagement with the designated areas [56].
Due to the limited size of the data sample, a normal distribution cannot be assumed. Therefore, the non-parametric Mann-Whitney U test was performed.

Table 12 TTFF (ms) Mann Whitney U- test

Test	Statistic	P-value
Mann-Whitney U	65.0	0.56

The Mann-Whitney U test was conducted to determine if there was a significant difference in the median time to first fixation (TTFF) between Group 1 AOI F and Group 2 AOI C (ceiling markers only).

The null hypothesis (H0) stated that there was no significant difference in the median TTFF between the two groups, while the alternative hypothesis. The alternative hypothesis stated that there was a significant difference.

In this case, since the p-value (p = 0.56) is greater than the chosen significance level of 0.05, therefore the null hypothesis cannot be rejected. This suggests that there is no statistically significant difference between Group 1 (AOI F) and Group 2 (AOI C) in the population from which the samples were drawn (see Table 12).

Hit time (ms)

The Hit time (HIT) metric offers insights into our visual exploration patterns. By focusing on the time, it takes for our gaze to return to an Area of Interest (AOI), HIT reveals how we process visual information. [57] Because of the small size of the data sample, a normal distribution cannot be assumed. Therefore, the author proceeded with the Mann-Whitney U test to compare the Hit time between the groups and Area of Interest (AOI) (see Table 13).

The p-values for both comparisons are greater than 0.05, indicating that the null hypothesis cannot be rejected (see Table 13). This suggests that there is no significant difference in HIT times between the two groups for both AOI F (light floor markings) and AOI C (ceiling markings) (see Table 13).

Table 13 HIT (ms) Mann-Whitney U-test

Comparison	Mann-Whitney U test	p-value
Group 1 AOI F vs. Group 2 AOI C	58.0	0.09
Group 1 AOI C vs. Group 2 AOI C	47.5	0.60

Fixation count

This metric offers a quantitative way to evaluate and quantify the depth of attention directed toward specific regions of interest, often referred to as Areas of Interest (AOIs). Fixation count provides a comprehensive measure of the average number of fixations that occur within an AOI [56].

By including an AOI F in Group 2 without the light floor markings, it allowed for a direct comparison between the fixation counts of the light marked AOI F in Group 1 and the corresponding region in Group 2. This comparison helps to assess the specific impact of the light markings on fixation behaviour, independent of other factors.

Therefore, the analysis considered both the AOI F in Group 1 with light and the AOI F in Group 2 without light to provide a comprehensive understanding of the influence of the light markings on fixation counts.

Table 14 Fixation Count Data Distribution

	Group 1 - AOI F (with light)	**Group 1 - AOI C (with light)**	**Group 2 - AOI F (no light)**	**Group 2 - AOI C (no light)**
Mean fixation count	15.6	8.8	2.0	5.6
Standard Deviation	5.4	4.4	0.9	2.2
Q1 (First Quartile)	12.0	8.0	2.0	5.0
Median fixation count	13.0	9.0	2.0	6.0
Q3 (Third Quartile)	16.5	11.0	3.0	6.0

Table 15 Fixation Count Mann Whitney U test

Comparison	**U value**	**p-value**
Group 1 AOI F vs. Group 2 AOI F	91	0.0003
Group 1 AOI C vs. Group 2 AOI C	91	0.02

The analysis of fixation counts between different groups and areas of interest (AOIs) revealed significant differences in fixation behaviour. Firstly, the median fixation count for each group and AOI was calculated. In Group 1 with lights (AOI F), the median fixation count was 13.0, whereas in Group 1 without lights (AOI C), it was 9.0. For Group 2 with lights (AOI F), the median fixation count was 2.0, and for Group 2 without lights (AOI C), it was 6.0.

To further investigate the distribution of fixation counts, the Shapiro-Wilk test was performed, indicating that the data were not normally distributed. Therefore, the non-parametric Mann-Whitney U test was used to compare the fixation counts between groups and AOIs.

The Mann-Whitney U test results revealed a significant difference in fixation counts between Group 1 AOI F and Group 2 AOI F ($U = 91$, $p = 0.0003$) (see Table 15). This indicates that the presence of lights had a substantial impact on fixation behaviour, with Group 1 AOI F exhibiting significantly higher fixation counts compared to Group 2 AOI F.

However, when comparing Group 1 AOI C and Group 2 AOI C (ceiling markers only), there was no significant difference in fixation counts ($U = 91$, $p = 0.02$) (see Table 15). The observed outcome indicates that both groups exhibit comparable viewing behaviours towards the ceiling lights, suggesting that the floor lighting does not influence the observed ceiling light viewing behaviour.

Additionally, the Mann-Whitney U test was used to compare fixation counts between Group 1 AOI F and Group 2 AOI C (ceiling markers only). The results indicated a significant difference ($U = 112.0$, $p = 0.00013$), suggesting that the fixation counts for Group 1 AOI F were significantly different from those of Group 2 AOI C (ceiling markers only). Notably, the median fixation count in Group 1 AOI F (additional light floor marking) was 13.5, while in Group 2 AOI C (ceiling markers only), it was 6.0, further supporting the substantial disparity between the two groups.

Fixation Duration (ms)

The fixation duration is a metric in the study of eye movements, which helps understanding the cognitive and perceptual processes underlying visual attention. It refers to the temporal span during which the eye remains relatively stationary and focused on a specific point within a visual scene. Fixation duration offers valuable insights into how the human visual system allocates cognitive resources, processes information, and extracts relevant details from the environment [56] (see Table 16).

Table 16 Fixation Duration (ms) Mann Whiney U test

Group Comparison	U Statistic	p value
Group 1 (AOI C) vs Group 2 (AOI C)	38.0	0.2
Group 1 (AOI F) vs Group 2 (AOI F)	91.0	0.002
Group 1 (AOI F) vs Group 2 (AOI C)	58.0	0.9

Group 1 AOI C vs. Group 2 AOI C:

H0: There is no significant difference in fixation duration between Group 1 AOI C and Group 2 AOI C.

H1: There is a significant difference in fixation duration between Group 1 AOI FC and Group 2 AOI C.

The Mann-Whitney U test showed no significant difference in fixation duration between Group 1 AOI C and Group 2 AOI C ($U = 38.0$, $p = 0.2$) (see table 16).

Group 1 AOI F vs. Group 2 AOI F (ceiling markers only):

H0: There is no significant difference in fixation duration between Group 1 AOI F and Group 2 AOI F.

H1: There is a significant difference in fixation duration between Group 1 AOI F and Group 2 AOI F.

The Mann-Whitney U test revealed a significant difference in fixation duration between Group 1 AOI F and Group 2 (ceiling markers only) AOI F ($p = 0.002$). This suggests that the fixation durations significantly vary between these two groups.

Group 1 AOI F vs. Group 2 AOI C:

H0: There is no significant difference in fixation duration between Group 1 AOI F (additional light floor markers) and Group 2 AOI C (ceiling markers only).

H1: There is a significant difference in fixation duration between Group 1 AOI F (additional light floor markers) and Group 2 AOI C (ceiling markers only).

The Mann-Whitney U test did not show a significant difference in fixation duration between Group 1 AOI F and Group 2 AOI C ($p = 0.9$). Therefore, the null hypothesis is not rejected, indicating that there is no substantial evidence of a significant difference in fixation duration between these two groups.

4.3 Evaluation Research question 3

User Experience Survey

After locating the nearest emergency exit, the participants were asked to return to the starting point and complete the short UEQ questionnaire (see Appendix E). The questionnaire aims to assess the participants' user experience and consists of a limited number of 8 items rated on a scale. Each item in the semantic differential comprises a bipolar pair of adjectives, with two opposing adjectives comprising each item [61, 62]. Users are requested to rate each item on a seven-point scale ranging from -3 to +3, where negative values indicate one end of the adjective pair and positive values indicate the other [61, 62]. The survey assesses the user experience using two scales: Pragmatic Quality and Hedonic Quality, with a score range of -3 (worst) to 3 (best) for each scale. Based on the data provided, a score of 1.98 on the Pragmatic Quality scale indicates that users of Group 1 (with light markings) found the emergency markings to be effective and efficient in meeting their needs and goals (see Table 17). A score of 0.82 on the Hedonic Quality scale indicated that users found the emergency markings enjoyable and visually appealing (see Table 17). The overall score, calculated as the average of the Pragmatic and Hedonic Quality scores, is 1.5 (see Table 17). This score indicates that the overall user experience is positive but needs improvement. The standard deviation for pragmatic quality was 0.70, while for hedonic quality, it was 1.5 (see Table 17). This indicates less variability in the group's ratings for pragmatic quality compared to hedonic quality.

In contrast, Group 2 (ceiling markings) had a slightly positive rating for pragmatic quality (1.78) but a low rating for hedonic quality (0.05) (see Table 17). The overall rating was 0.91, indicating an overall positive experience. However, the standard deviation for pragmatic quality was 0.82, while for hedonic quality, it was higher at 1.44 (see Table 17). This suggests greater variability in the group's ratings for hedonic quality compared to pragmatic quality.

Table 17 short User experience questionaire (S-UEQ)

Scale	Standarddeviation (Group 1)	Overall (Group 1)	Standarddeviation (Group 2)	Overall (Group 2)
Pragmatic Quality	0.7	1.98	0.82	1.78
Hedonic Quality	1.5	0.82	1.44	0.05
Overall	-	1.5	-	0.91

Table 18 S-UEQ Item Score Group 1

Item	Mean	Std. Dev.	Negative	Positive	Scale
1	2.2	1	hindering	supportive	Pragmatic Quality
2	1.8	0,9	complicated	easy	Pragmatic Quality
3	2.1	1	inefficient	efficient	Pragmatic Quality
4	1.1	1,8	confusing	clear	Pragmatic Quality
5	0.4	1	boring	exciting	Hedonic Quality
6	0.5	1,4	uninteresting	interesting	Hedonic Quality
7	-0.6	2	conventional	original	Hedonic Quality
8	-0.9	2,1	conventional	new	Hedonic Quality

The survey was conducted in the German language as the participants were German speakers. The items were quantified using a scale ranging from -3 to +3. Table 18 presents the results of the per-item average ratings, which reflect the overall usability experience. Ratings between -0.8 and 0.8 indicate a neutral evaluation of the corresponding scale. Ratings above 0.8 indicate a positive evaluation, while ratings below -0.8 indicate a negative evaluation [61].

The data in table 17 reveal that, on average, pragmatic items received higher ratings than hedonistic items. Specifically, items 1, 3, and 4 obtained higher ratings (see Table 18). For instance, item 1 (representing supportive) had an average score of 2.2, and item 3 (representing efficiency) received an average score of 2.1 (refer to Figure 8). The Mann Whitney U - test states no significant difference.

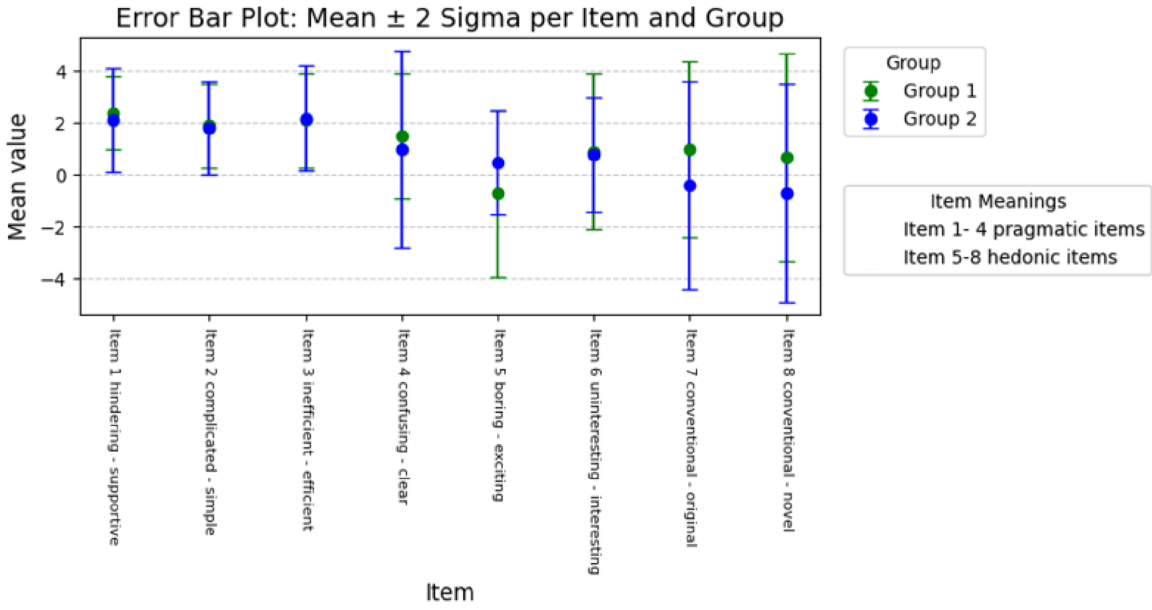

Figure 8 Figure 8 S-UEQ, Mean Value per Item

5 Discussion

In this monocentric pilot study, the influence of light floor markings on the search path of users when finding emergency exits was examined using eye-tracking technology. The discussion of the results focuses on their relevance to the research interest, as well as their alignment with the introduction, theory, research questions, and hypotheses.

The results of the first research question "Can the use of additional LED strip floor markings for escape routes reduce the time needed to find an emergency exit?" showed there is no significant difference between the group with additional ground light markings and the group with conventional emergency markings. The Mann Whitney U statistics showed a p-value of 0.7. Since the p-value is greater than the chosen significance level of 0.05, the null hypothesis which stated " There is no difference in the median time needed to find an emergency exit between the group that used additional LED strip floor markings for escape routes and the group that did not use them." cannot be rejected. The median time required for the Group with extra floor markings was 39 seconds, compared to 40 seconds for the Group with traditional emergency exit signs. The interquartile range (IQR) for the Group with additional floor markings measured 6 seconds, whereas for the Group with conventional emergency exit signs, it spanned 10 seconds. In terms of the lower quartile (Q1), the Group with extra floor markings displayed 36 seconds, contrasting with 33 seconds for the Group with traditional emergency exit signs. This could be due to the fact that participants had an additional visual marker in their field of vision, but it could also indicate that subjects were unsure whether these should have been part of the way markings or not.

However, individual differences and the number and placement of the markings can influence their impact on the search path. Therefore, it is crucial to consider the specific context in which these markings will be used. Nonetheless, the results indicate that floor markings can still positively impact the user experience by attracting attention and guiding individuals who rely on them. In further studies it would be advantageous to use a larger sample size and a longer route to gather more data regarding the time needed to find the emergency exit.

The focus was on the following eye-tracking data to answer the second research question, whether the search path of participants with additional light floor markings are influenced by finding the emergency exit. Dwell time is a metric that conveys the level of interest with a certain AOI [60]. This metric refers to the total amount of time that a person's gaze remains within a specific AOI. It is the cumulative time that a person spends looking at and processing information within that area. The greater the dwell time, the greater the level of interest in the AOI. Dwell times less than 100 ms imply the participant processed a limited amount of information [60, 56]. A dwell time higher than 500 ms implies the participant had an opportunity to process the information [56]. Fixation duration is the average time for the fixations. Fixation duration typically ranges from 150 to 300 ms [58]. Fixations are short periods of time during which the eyes are not moving rapidly but rather focusing on processing visual information from a specific point. The greater the average fixation duration, the greater the level of engagement [56].

In summary, both fixations and dwell time provide insights into a person's visual attention and engagement with specific areas of a visual stimulus. Fixations represent individual moments of focused gaze, capturing the points of greatest attention. Dwell time represents the cumulative attentional investment, reflecting how much time is spent on a particular area. The interpretation of these metrics involves considering factors like fixation duration, dwell time thresholds, and the relationship between these metrics and the person's level of interest or engagement. Fixation duration, similar to the number of fixations and dwell time, also represents the relative engagement with the object [56]. The longer the average fixation duration, the bigger the level of engagement [56]

In order to be able to draw a direct comparison between the two groups, Group 1 with AOI F (light floor markings) was compared to group 2 AOI F (no floor markings, but AOI showing the same floor area) in relation to the dwell time of the gaze. For the Dwell time (ms) comparisons Group 1 AOI F vs. Group 2 AOI F the t statistics resulted a p-value of 1.24×10^{-9}.

The results indicate a significant difference in dwell times between the two groups, suggesting that participants in Group 1 - AOI F (with light) had significantly longer dwell times compared to participants in Group 2 - AOI F (no light). Longer durations of looking at a specific region can indicate an elevated level of interest, in this case the light floor markings [56]. Light's presence significantly affects participants' dwell times in visual search tasks [56].

For group 1 AOI C vs. group 2 AOI C the t-statistic for comparing the dwell times between Group 1 - AOI C (with light) and Group 2 - AOI C (no light) was 1.50, with a p-value of 0.15. These results indicate that there is no significant difference in total dwell times between the two groups compared by emergency exit signs, suggesting that the presence or absence of light did not have a significant impact on the dwell times in AOI C.
The Mann-Whitney U test did not show a significant difference in fixation duration between Group 1 AOI F (additional light floor markers) and Group 2 AOI C (ceiling markers only) (p = 0.12). Therefore, the null hypothesis cannot be rejected, indicating that there is no substantial evidence of a significant difference in fixation duration between these two groups.

The significant difference in total dwell times between Group 1 (additional light floor markers) and Group 2 (ceiling markers only) suggests that the presence of light impacts participants' search behaviour. Longer durations of looking at a specific region can indicate an elevated level of interest, while shorter durations suggest that other areas may be more captivating [59 n]. Light's presence significantly affects participants' dwell times in visual search tasks [59].

The Mann-Whitney U test was used to compare fixation counts between Group 1 AOI F and Group 2 AOI C. The results indicated a significant difference (p = 0.00013), suggesting that the fixation counts for Group 1 AOI F were significantly higher from those of Group 2 AOI C.

The examination for the saccade count, reveals that the existence of illuminated floor markings (Group 1 AOI F) significantly impacts the saccade count when contrasted with the lack of such markings (Group 2 AOI F). This outcome implies that the visual cues offered by the illuminated floor markings might exert an influence on eye movement behaviour, potentially resulting in distinct saccade patterns within the two groups.

Group 1 AOI F participants, who had access to light floor marking, might have shown greater attentiveness or engagement towards the visual stimulus. The light floor marking could have attracted participants' attention, leading to a higher saccade count as they explored the illuminated areas more thoroughly. The difference in saccade counts may indicate that participants in Group 1 AOI F were more visually attentive and responsive to the visual stimulus (light floor marking) than those in Group 2 AOI F. However, drawing more specific conclusions about the underlying reasons for the differences would require further investigation, possibly through follow-up experiments, participant feedback, or additional analysis of eye movement patterns.

Regarding HIT (ms), TTFF (ms) and revisits counts, there was no significant evidence to suggest that the presence of light or the specific AOI being observed had a significant effect on the fixation count data.

Based on the findings, it can be concluded that the presence of luminescent floor markings influenced participants' search path and attention. The floor markings attracted attention and affected search behaviour, as evidenced by the higher dwell time (ms) in the group with additional light floor markings.

These results suggest that floor markings, in addition to conventional escape route indicators, can positively impact the user experience during emergencies by providing clear instructions and facilitating efficient evacuation. However, it is important to acknowledge the limitations of the study, such as the small sample size and the controlled laboratory environment. Future research should consider larger and more diverse samples, as well as conducting studies in realistic emergency scenarios. Additionally, exploring the effects of different types of emergency markings or lighting designs in various contexts could provide further insights into their potential benefits and limitations.

The results of the short User experience questionnaire were used to answer research question three, to find out whether participants find additional floor markings supportive in finding the escape route. The survey assesses the user experience using two scales: Pragmatic Quality and Hedonic Quality, with a score range of -3 (worst) to 3 (best) for each scale. Based on the data provided, a score of 1.98 on the Pragmatic Quality scale indicates that users of Group 1(with light markings) found the emergency markings to be effective and efficient in meeting their needs and goals (see Table 17). A score of 0.82 on the Hedonic Quality scale indicated that users found the emergency markings enjoyable and visually appealing (see Table 17). The overall score, calculated as the average of the Pragmatic and Hedonic Quality scores, is 1.5 (see Table 17). This score indicates that the overall user experience is positive but needs improvement. The standard deviation for pragmatic quality was 0.70, while for hedonic quality, it was 1.5 (see Table 17). This indicates less variability in the group's ratings for pragmatic quality compared to hedonic quality. In contrast, Group 2 (ceiling markings) had a slightly positive rating for pragmatic quality (1.78) but a low rating for hedonic quality (0.05) (see Table 17). The overall rating was 0.91, indicating an overall positive experience. However, the standard deviation for pragmatic quality was 0.82, while for hedonic quality, it was higher at 1.44 (see Table 18). This suggests greater variability in the group's ratings for hedonic quality compared to pragmatic quality. The results showed a positive tendency regarding the pragmatic scale in relation to the escape route signage than group 2 indicating that additional light floor markings can be supportive in in finding the escape route. It is essential to acknowledge that the sample sizes of both groups in this study were relatively small, with 14 participants in Group 1 and 10 participants in Group 2. The limited sample sizes may impact the generalizability and statistical robustness of the results. Therefore, any conclusions drawn from the data should be approached with careful consideration, and further research with larger and more representative samples may be necessary to validate and strengthen the findings.

In conclusion, this pilot study's findings highlight the potential of implementing floor markings to improve emergency egress. However, their effectiveness may vary depending on the specific context and individual characteristics. Clear escape route markings are crucial for facilitating efficient evacuation and should be considered in emergency preparedness efforts. Further research is needed to validate these findings and explore additional aspects of floor markings in emergency situations. The author suggests the following points to explore this research gap in future studies better. For instance, different types of light markings could be used in terms of the light area, colour intensity, colour schemes, and their combination [18]. Additional signposting light markings in the form of directional-pointing arrows or light effects that additionally support them. Also, the position of the light markings could play a role, such as on the ceiling, at eye level, or on the floor. For future studies with a larger sample. The investigation in a more real emergency situation under the observation of heart rate and stress measurement using biosensors would be helpful to compare with the eye-tracking data to have more meaningful results regarding nervousness and awareness of the participant’s search path. Also, a longer, more branched path over several floors can provide additional insights.

6 Conclusion

This pilot study aimed to investigate whether the use of additional LED strip floor markings could reduce the time needed to find an emergency exit in an escape route. The results of the Mann-Whitney U test indicated no significant difference in the time taken to complete the task between the two groups (with and without LED strip floor markings). The statistical analysis conducted in this study suggests that the null hypothesis, stating that the use of additional LED strip floor markings does not reduce the time required to locate an emergency exit, cannot be rejected (see Table 8). These findings suggest that additional research may be necessary to determine whether other types of markings or strategies could be more effective in improving emergency egress times. The results of this study could serve as a basis for further research into alternative markings or strategies that may enhance emergency egress times. For instance, future studies could explore the effectiveness of other types of floor markings or visual cues, such as illuminated exit signs or directional arrows.

Another aspect investigated in this study was, whether the use of floor markings, in addition to the standard escape route signs, would affect the search path of the test subjects. The data collected through the eye-tracking glasses were analyzed for patterns (see Appendix G). The scatter plot (see Figure 6) indicates that participants in Group 1 tended to fixate on the area, where the illuminated floor markings were positioned, more frequently than those in Group 2, who had the conventional escape route signs. Furthermore, the number of fixations on AOI F (floor marking) in Group 1 was more prominent than the fixation count on AOI C (ceiling marking) in Group 1 and Group 2. These results suggest a tendency for the illuminated markings to attract more attention, as a higher number of fixations and revisit on specific areas or markings indicates that participants' attention was more focused on those areas. This can also suggest a higher perception and processing of this information. For Group 1, AOI F has more participants with a higher dwell time than AOI C. However, AOI C has a lower value for the HIT time metric. These findings suggest that participants in Group 1 tended to focus more on AOI F, possibly due to the presence of the additional LED strip floor markings. However, participants were quicker to focus on AOI C, which indicates that the traditional escape route signs were still effective in directing attention to the intended areas. The results of the data gathered by the eye-tracking glasses will be summarized in the following passage. In Group 1, there were notable differences in participants' gaze behavior and attention between AOI F (floor markings) and AOI C (ceiling markings), with AOI F receiving a higher number of fixations, revisits, and overall dwell time. Participants in Group 1 had higher dwell times for both AOIs than Group 2, and AOI F had overall higher dwell times than AOI C in both groups. These findings suggest that, participants in Group 1 may have found AOI F more interesting or relevant to their task compared to participants in Group 2, who may have found AOI C more interesting. The variation in saccade counts, TTFF AOI, and other metrics also suggest that participants had different strategies for searching and attending to the relevant areas, which may have been influenced by individual differences in cognitive processing and visual attention, as well as task demands and stimuli presented. Overall, combining LED strip floor markings and traditional signs may be more effective in drawing attention to emergency egress routes. These results are based on small sample sizes, so caution is advised.

The results of the user experience survey conducted in the final part of this study provide insight into whether participants found the additional floor markings helpful in locating escape routes. Based on the provided data, there is a tendency to suggest that users found the emergency markings to be effective and efficient in meeting their needs and goals (see Table 17). Users also found the emergency markings visually appealing, as indicated by the score of 0.821 on the Hedonic Quality scale (see Table 17). However, the overall score of 1.40, calculated as the average of the Pragmatic and Hedonic Quality scores, indicates that there is still some room for improvement in the user experience (see Table 17). The standard deviation for pragmatic quality was 0.70, meaning there was low variability in the group's ratings for pragmatic quality. However, the standard deviation for hedonic quality was higher at 1.48, indicating that there was more variability in the group's ratings for hedonic quality (see Table 17). This suggests that, users' subjective experiences with the emergency markings may have been more varied regarding their enjoyment and visual appeal of the light floor markings. Further research could explore ways to improve the hedonic quality of the emergency markings, such as testing different visual designs or colours. Additionally, it may be useful to investigate the user experience of emergency markings in different settings and with different user groups to see if the results generalize to other contexts.

In conclusion, to ensure the safety and well-being of patients with a range of conditions, implementing customized measures and labeling strategies across different departments becomes imperative. For instance, some patients may require increased supervision or specialized equipment for secure navigation. Concurrently, prioritizing the visibility and accessibility of emergency exits situations in crises is paramount. Achieving this can be facilitated through the use of illuminated floor markings and signs that clearly indicate emergency exit locations. These markers should be thoughtfully designed to be conspicuous and easily recognizable, even in low lighting or situations where patients may feel disoriented. The choice of colours for these markings could also have a significant impact, as individuals with various colour vision deficiencies might find it challenging to interpret solely colour-based cues. Utilizing universally understood symbols is essential, as light serves as a versatile communication medium, offering static and dynamically directional cues. Furthermore, incorporating such a wayfinding system during the initial stages of construction planning could yield potential cost efficiencies. This is based on the understanding that the costs and consequences associated with prolonged evacuations, especially in emergencies like fires, may outweigh the expenses of preemptive measures like improved wayfinding signage within enclosed structures, particularly in healthcare facilities like hospitals. Amidst the drive to economize in energy-intensive environments, it remains critical not to compromise essential safety equipment, as such compromises could have extensive and far-reaching ramifications.

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List of Figures

List of Tables

Appendix

A. Source Code Python statistical analysis

.1 Listing – Source Code descriptive statistics, RQ 1

```
import numpy as np
# Group 1
group1_data = [ 32.4, 31.33, 75.651, 36.195, 41.97, 41.755,
29.972, 37.165, 38.956, 52.978, 182.777, 35.977, 40.206]
# Group 2 d a t a
group2_data = [32.444, 36.195, 41.197, 41.755, 37.165, 38.956,
40.206, 75.651 ]

# Calculate descriptive statistics for Group 1
group1_mean = np.mean(group1_data)
group1_std = np.std(group1_data)
group1_sem = group1_std / np.sqrt(len(group1_data))
group1_median = np.median(group1_data)
group1_iqr = np.percentile(group1_data, 75) -
np.percentile(group1_data, 25)
group1_q1 = np.percentile(group1_data, 25)
group1_q3 = np.percentile(group1_data, 75)
group1_outliers = [x for x in group1_data if x > group1_q3 + 1.5 *
group1_iqr or x < group1_q1 - 1.5 * group1_iqr]

# Calculate descriptive statistics for Group 2
group2_mean = np.mean(group2_data)
group2_std = np.std(group2_data)
group2_sem = group2_std / np.sqrt(len(group2_data))
group2_median = np.median(group2_data)
group2_iqr = np.percentile(group2_data, 75) -
np.percentile(group2_data, 25)
group2_q1 = np.percentile(group2_data, 25)
group2_q3 = np.percentile(group2_data, 75)
group2_outliers = [x for x in group2_data if x > group2_q3 + 1.5 *
group2_iqr or x < group2_q1 - 1.5 * group2_iqr]

# Print descriptive statistics for Group 1
print("Group 1 (n={})".format(len(group1_data)))
print("Mean time needed: {:.3f} seconds".format(group1_mean))
print("Standard deviation: {:.3f} seconds".format(group1_std))
```

```
print("Standard error of the mean: {:.3f}
seconds".format(group1_sem))
print("Median time needed: {:.3f} seconds".format(group1_median))
print("Interquartile range: {:.3f} seconds".format(group1_iqr))
print("Q1: {:.3f} seconds".format(group1_q1))
print("Q3: {:.3f} seconds".format(group1_q3))
print("Outliers: {}".format(group1_outliers))

# Print descriptive statistics for Group 2
print("Group 2 (n={})".format(len(group2_data)))
print("Mean time needed: {:.3f} seconds".format(group2_mean))
print("Standard deviation: {:.3f} seconds".format(group2_std))
print("Standard error of the mean: {:.3f}
seconds".format(group2_sem))
print("Median time needed: {:.3f} seconds".format(group2_median))
print("Interquartile range: {:.3f} seconds".format(group2_iqr))
print("Q1: {:.3f} seconds".format(group2_q1))
print("Q3: {:.3f} seconds".format(group2_q3))
print("Outliers: {} ".format(group2_outliers))
```

.2 Listing – Source Code Box Plot, RQ1

```
import matplotlib.pyplot as plt

# Group 1 data
group1_data = [32.4, 31.33, 75.651, 36.195, 41.97, 41.755, 29.972,
37.165, 38.956, 52.978, 182.777, 35.977, 40.206]

# Group 2 data
group2_data = [32.444, 36.195, 41.197, 41.755, 37.165, 38.956,
40.206, 75.651]

# Create a figure and axes
fig, ax = plt.subplots()

# Set the median color for Group 1 as green and Group 2 as dark
blue
median_color_group1 = dict(color='g')
median_color_group2 = dict(color='darkblue')

# Create box plots for Group 1 and Group 2
box1 = ax.boxplot(group1_data, positions=[1], patch_artist=True,
medianprops=median_color_group1)
box2 = ax.boxplot(group2_data, positions=[2], patch_artist=True,
medianprops=median_color_group2)
```

```
# Set the boxes' facecolor to white
box1['boxes'][0].set_facecolor('white')
box2['boxes'][0].set_facecolor('white')

# Add labels and title
ax.set_xticks([1, 2])
ax.set_xticklabels(['Group 1', 'Group 2'])
ax.set_ylabel('Time (ms)')
ax.set_title('Time needed to find exit per group')

# Set y-axis range and ticks
ax.set_ylim(0, 200)
ax.set_yticks(range(0, 201, 10))

# Add a legend with smaller font size and no boxes for the first
entry
ax.legend(['Group 1 - with additional light floor marking', 'Group
2 - no additional light floor marking'],
          loc='upper right', fontsize='small', handlelength=0,
fancybox=True)

# Add horizontal reference lines at 10s intervals
for y_tick in range(0, 201, 10):
    ax.axhline(y_tick, color='gray', linestyle='dashed',
linewidth=1, alpha=0.5)

# Add numbers (medians) next to the boxplots
medians_group1 = [box1['medians'][0].get_ydata()[0]]
medians_group2 = [box2['medians'][0].get_ydata()[0]]
ax.text(1.20, medians_group1[0], f'{medians_group1[0]:.2f}',
ha='center', va='center', color='g')
ax.text(2.20, medians_group2[0], f'{medians_group2[0]:.2f}',
ha='center', va='center', color='b')

# Show the plot
plt.show()
```

.3 Listing - Source Code for Violin Plot, RQ1

```
import matplotlib.pyplot as plt

group1_data = [32.4, 31.33, 75.651, 36.195, 41.97, 41.755, 29.972,
37.165, 38.956, 52.978, 182.777, 35.977, 40.206]
group2_data = [33.453, 44.701, 38.242, 25.208, 36.458, 41.822,
31.794, 59.634]
```

```
# Create a violin plot for the two groups
plt.violinplot([group1_data, group2_data])

# Add labels and a title
plt.xticks([1, 2], ['Group 1', 'Group 2'])
plt.ylabel('Time needed in (s)')
plt.title('Violin plot of Group 1 and Group 2')

# Show the plot
plt.show()
```

.4 Listing – Mann-Whitney U test, RQ 1

```
import numpy as np
from scipy.stats import mannwhitneyu
group1 = np.array([32.4, 31.33, 75.651, 36.195, 41.97, 41.755,
29.972, 37.165, 38.956, 52.978, 182.777, 35.977, 40.206])
group2 = np.array([33.453, 44.701, 38.242, 25.208, 36.458, 41.822,
31.794, 59.634])
u_statistic, p_value = mannwhitneyu(group1, group2)
print('Mann-Whitney U statistic:', u_statistic)
print('p-value:', p_value)
```

.5 Total Dwell Time Comparison

```
import matplotlib.pyplot as plt
import numpy as np

# Dwell time data for Group 1, AOI F and AOI C
group1_aoiF_dwell_time = [2370.5, 3212.6, 4159, 3617.5, 4692.4,
2254.4, 2646.5, 2925.5, 3324.6, 3828.9, 2832.3, 3026.7, 3814.5,
3503.8]
group1_aoiC_dwell_time = [1276.5, 4439.7, 1533.3, 1232, 1901.6,
1665.5, 1840, 1840, 0, 0, 3413, 3134.4, 2565.1, 1901.6]

# Dwell time data for Group 2, AOI F and AOI C
group2_aoiF_dwell_time = [116, 331.3, 331.3, 524.5, 558.9, 558.9]
group2_aoiC_dwell_time = [2137.5, 1355.8, 1265.9, 1425, 1138.1,
1138.1, 1329.6]

# Calculate the medians
group1_aoiF_median = np.median(group1_aoiF_dwell_time)
group1_aoiC_median = np.median(group1_aoiC_dwell_time)
group2_aoiF_median = np.median(group2_aoiF_dwell_time)
```

```
group2_aoiC_median = np.median(group2_aoiC_dwell_time)

# Calculate the average median time for all groups and AOIs
average_median_time = np.mean([group1_aoiF_median,
group1_aoiC_median, group2_aoiF_median, group2_aoiC_median])

# Create a whisker plot
fig, ax = plt.subplots()

# Plot the whiskers
ax.boxplot([group1_aoiF_dwell_time, group1_aoiC_dwell_time,
group2_aoiF_dwell_time, group2_aoiC_dwell_time],
           labels=['Group 1 AOI F', 'Group 1 AOI C', 'Group 2 AOI
F', 'Group 2 AOI C'])

# Add the median markers with numbers
ax.plot(1, group1_aoiF_median, 'go', label=f'Group 1 AOI F & AOI C
- with additional light floor markings', markersize=6)
ax.plot(3, group2_aoiF_median, 'bo', label=f'Group 2 AOI F & AOI C
- no light floor markings', markersize=6)

# Annotate the median values
ax.annotate(f'{group1_aoiF_median:.0f}', (1, group1_aoiF_median),
textcoords="offset points", xytext=(10,10), ha='center',
fontsize=8, color='green')
ax.annotate(f'{group1_aoiC_median:.0f}', (2, group1_aoiC_median),
textcoords="offset points", xytext=(10,10), ha='center',
fontsize=8, color='green')
ax.annotate(f'{group2_aoiF_median:.0f}', (3, group2_aoiF_median),
textcoords="offset points", xytext=(10,10), ha='center',
fontsize=8, color='blue')
ax.annotate(f'{group2_aoiC_median:.0f}', (4, group2_aoiC_median),
textcoords="offset points", xytext=(10,10), ha='center',
fontsize=8, color='blue')


# Set the y-axis label
ax.set_ylabel('Dwell Time (ms)')

# Set the title
ax.set_title('Dwell Time Comparison')

# Set the y-axis limit
ax.set_ylim(0, 6000)  # Adjust the limit as needed
```

```
# Add a legend with smaller font size
ax.legend(fontsize='x-small')

# Show the plot
plt.show()
```

.6 Dwell Time Statistics

```
import matplotlib.pyplot as plt
import numpy as np

# Dwell time data for Group 1, AOI F and AOI C
group1_aoiF_dwell_time = [2370.5, 3212.6, 4159, 3617.5, 4692.4,
2254.4, 2646.5, 2925.5, 3324.6, 3828.9, 2832.3, 3026.7, 3814.5,
3503.8]
group1_aoiC_dwell_time = [1276.5, 4439.7, 1533.3, 1232, 1901.6,
1665.5, 1840, 1840, 0, 0, 3413, 3134.4, 2565.1, 1901.6]

# Dwell time data for Group 2, AOI F and AOI C
group2_aoiF_dwell_time = [116, 331.3, 331.3, 524.5, 558.9, 558.9]
group2_aoiC_dwell_time = [2137.5, 1355.8, 1265.9, 1425, 1138.1,
1138.1, 1329.6]

# Calculate statistics
group1_aoiF_median = np.median(group1_aoiF_dwell_time)
group1_aoiF_iqr = np.percentile(group1_aoiF_dwell_time, 75) -
np.percentile(group1_aoiF_dwell_time, 25)

group1_aoiC_median = np.median(group1_aoiC_dwell_time)
group1_aoiC_iqr = np.percentile(group1_aoiC_dwell_time, 75) -
np.percentile(group1_aoiC_dwell_time, 25)

group2_aoiF_median = np.median(group2_aoiF_dwell_time)
group2_aoiF_iqr = np.percentile(group2_aoiF_dwell_time, 75) -
np.percentile(group2_aoiF_dwell_time, 25)

group2_aoiC_median = np.median(group2_aoiC_dwell_time)
group2_aoiC_iqr = np.percentile(group2_aoiC_dwell_time, 75) -
np.percentile(group2_aoiC_dwell_time, 25)

# Create a summary table
summary_table = {
    'Group 1 - AOI F (with light)': {
        'Median Dwell time (ms)': group1_aoiF_median,
```

```
        'IQR Dwell time (ms)': group1_aoiF_iqr,
        'Q1 Dwell time (ms)':
np.percentile(group1_aoiF_dwell_time, 25),
        'Q3 Dwell time (ms)':
np.percentile(group1_aoiF_dwell_time, 75)
    },
    'Group 1 - AOI C (with light)': {
        'Median Dwell time (ms)': group1_aoiC_median,
        'IQR Dwell time (ms)': group1_aoiC_iqr,
        'Q1 Dwell time (ms)':
np.percentile(group1_aoiC_dwell_time, 25),
        'Q3 Dwell time (ms)':
np.percentile(group1_aoiC_dwell_time, 75)
    },
    'Group 2 - AOI F (no light)': {
        'Median Dwell time (ms)': group2_aoiF_median,
        'IQR Dwell time (ms)': group2_aoiF_iqr,
        'Q1 Dwell time (ms)':
np.percentile(group2_aoiF_dwell_time, 25),
        'Q3 Dwell time (ms)':
np.percentile(group2_aoiF_dwell_time, 75)
    },
    'Group 2 - AOI C (no light)': {
        'Median Dwell time (ms)': group2_aoiC_median,
        'IQR Dwell time (ms)': group2_aoiC_iqr,
        'Q1 Dwell time (ms)':
np.percentile(group2_aoiC_dwell_time, 25),
        'Q3 Dwell time (ms)':
np.percentile(group2_aoiC_dwell_time, 75)
    }
}

# Display the summary table
for group, stats in summary_table.items():
    print(group)
    for label, value in stats.items():
        print(f'{label}: {value:.1f} ms')

# Show the plot
plt.show()
```

.7 Listing – Saccade Count Distribution

```
import matplotlib.pyplot as plt
import numpy as np
```

```python
# Saccade count data for the different groups
group1_aoiF_saccade_counts = [53, 23, 57, 73, 79, 28, 28, 28, 30,
31, 18, 18, 24, 11]
group1_aoiC_saccade_counts = [17, 4, 21, 25, 31, 20, 4, 29, 0, 0,
27, 25, 27, 25]
group2_aoiF_saccade_counts = [0, 2, 3, 3, 5, 4, 4]
group2_aoiC_saccade_counts = [3, 10, 10, 11, 0, 8, 8, 10]

# Calculate the medians
group1_aoiF_median = np.median(group1_aoiF_saccade_counts)
group1_aoiC_median = np.median(group1_aoiC_saccade_counts)
group2_aoiF_median = np.median(group2_aoiF_saccade_counts)
group2_aoiC_median = np.median(group2_aoiC_saccade_counts)

# Create a whisker plot
fig, ax = plt.subplots()

# Plot the whiskers
boxplot = ax.boxplot([group1_aoiF_saccade_counts,
group1_aoiC_saccade_counts, group2_aoiF_saccade_counts,
group2_aoiC_saccade_counts],
                     labels=['Group 1 AOI F', 'Group 1 AOI C',
'Group 2 AOI F', 'Group 2 AOI C'])

# Set the y-axis label
ax.set_ylabel('Saccade Count')

# Set the title
ax.set_title('Saccade Count Distribution')

# Color the medians
medians = [group1_aoiF_median, group1_aoiC_median,
group2_aoiF_median, group2_aoiC_median]
boxplot_median_artists = boxplot['medians']
for median_artist, median_value in zip(boxplot_median_artists,
medians):
    if median_value in [group1_aoiF_median, group1_aoiC_median]:
        median_artist.set(color='green')
    elif median_value in [group2_aoiF_median, group2_aoiC_median]:
        median_artist.set(color='blue')

# Annotate the median values
```

```
ax.annotate(f'{group1_aoiF_median:.1f}', (1, group1_aoiF_median),
textcoords="offset points", xytext=(0,10), ha='center',
fontsize=8, color='green')
ax.annotate(f'{group1_aoiC_median:.1f}', (2, group1_aoiC_median),
textcoords="offset points", xytext=(0,10), ha='center',
fontsize=8, color='green')
ax.annotate(f'{group2_aoiF_median:.1f}', (3, group2_aoiF_median),
textcoords="offset points", xytext=(0,10), ha='center',
fontsize=8, color='blue')
ax.annotate(f'{group2_aoiC_median:.1f}', (4, group2_aoiC_median),
textcoords="offset points", xytext=(0,10), ha='center',
fontsize=8, color='blue')

# Show the plot
plt.show()
```

.8 Listing – Mann-Whitney U-test, Saccade count

```
import matplotlib.pyplot as plt
# Group 1 data
group1_data = [32.4, 31.33, 75.651, 36.195, 41.97, 41.755, 29.972,
37.165, 38.956, 52.978, 182.777, 35.977, 40.206]
# Group 2 data
group2_data = [33.453, 44.701, 38.242, 25.208, 36.458, 41.822,
31.794, 59.634]
# Combine the two groups into a list
data = [group1_data, group2_data]
from scipy.stats import mannwhitneyu
# Data for Group 1 (AOI_F)
group1_data = [53, 23, 57, 73, 79, 28, 28, 28, 30, 31, 18, 18, 24]
# Data for Group 2 (AOI C)
group2_data = [3, 10, 10, 11, 0, 8, 8, 10]
# Perform Mann-Whitney U test
stat, p_value = mannwhitneyu(group1_data, group2_data,
alternative='two-sided')
# Print the results
print("Mann-Whitney U test results:")
print("Statistic:", stat)
print("P-value:", p_value)
# Check for significance at the 0.05 alpha level
alpha = 0.05
if p_value < alpha:
    print("The difference between the groups is statistically
significant.")
else:
```

```
    print("The difference between the groups is not statistically
significant.")
```

.9 Listing – Mann-Whitney U-test, TTFF

```
from scipy.stats import mannwhitneyu

group1_aoiF_ttff = [10123, 25519.7, 12249.6, 2039.5, 15325.7, 0,
13677, 18372.2, 37895.5, 90.1, 240.8, 25992.4, 3319.3, 19415.4]
group2_aoiC_ttff = [1974.2, 28055.9, 3023.3, 1542.8, 0, 11112.2,
45357.7, 1359.5]

statistic, pvalue = mannwhitneyu(group1_aoi1_ttff,
group2_aoi1_ttff)
print("Mann-Whitney U test results:")
print(f"Statistic: {statistic}")
print(f"P-value: {pvalue}")
```

.10 Listing – Source Code Mann-Whitney U-test, HIT

```
import numpy as np
from scipy.stats import mannwhitneyu

# Data for Group 1 AOI F, Group 1 AOI C, Group 2 AOI F, and Group
2 AOI C
group1_aoiF_data = [11.4, 10772.6, 1119.1, 1974.8, 3485.6, 2368.1,
2303, 1570.8, 1239.5, 1444.1, 1653.4, 2064.7, 2541.5, 3809.2]
group1_aoiC_data = [2617.4, 4564.2, 16983.5, 11491.9, 26568.9,
12922.2, 17178.3, 939.7, 0, 0, 14705.9, 16770.3, 19564.9, 23063.4]

group2_aoiC_data = [2165.2, 13093.7, 12939.9, 1435.3, 0, 12939.7,
44803.2, 12808.2]

# Perform Mann-Whitney U test
u_statistic, p_value_aoiF_C = mannwhitneyu(group1_aoiF_data,
group2_aoiC_data, alternative='two-sided')
u_statistic, p_value_aoiC_C = mannwhitneyu(group1_aoiC_data,
group2_aoiC_data, alternative='two-sided')

# Print comparison results
print("Comparison Mann-Whitney U test P-value")
print("Group 1 AOI F vs. Group 2 AOI C:", p_value_aoiF_C)
print("Group 1 AOI C vs. Group 2 AOI C:", p_value_aoiC_C)
```

.11 Listing – Mann-Whitney U-test, Fixation and Revisit count, RQ2

```
from scipy.stats import mannwhitneyu

# Fixation count
fix_g1aoi2 = [7, 5, 7, 3, 8, 3, 0, 8, 0, 0, 16, 6, 10, 5]
fix_g2aoi1 = [7, 8, 3, 6, 0, 10, 2, 5]

# Revisit count
rev_g1aoi2 = [2, 0, 2, 2, 4, 2, 0, 1, 0, 0, 4, 2, 5, 0]
rev_g2aoi1 = [4, 4, 2, 3, 0, 5, 0, 4]

# Mann-Whitney U test for fixation count
stat_fix, p_fix = mannwhitneyu(fix_g1aoi2, fix_g2aoi1)
print("Mann-Whitney U test results for fixation count data:")
print("Test statistic:", stat_fix)
print("p-value:", p_fix)

# Mann-Whitney U test for revisit count
stat_rev, p_rev = mannwhitneyu(rev_g1aoi2, rev_g2aoi1)
print("Mann-Whitney U test results for revisit count data:")
print("Test statistic:", stat_rev)
print("p-value:", p_rev)
```

.12 Listing – Mann Whitney U test, Fixation Count

```
from scipy.stats import mannwhitneyu

# Data for Group 1 AOI F and Group 2 AOI F
group1_aoiF_data = [11, 24, 24, 27, 12, 12, 13, 15, 17, 12, 12,
14, 10]
group2_aoiF_data = [0, 1, 2, 2, 3, 3, 3]

# Data for Group 1 AOI C and Group 2 AOI C
group1_aoiC_data = [9, 5, 10, 8, 11, 8, 9, 9, 0, 0, 15, 14, 14,
11]
group2_aoiC_data = [7, 6, 6, 6, 0, 5, 5, 6]

# Perform Mann-Whitney U test
u_statistic_aoiF_F, p_value_aoiF_F =
mannwhitneyu(group1_aoiF_data, group2_aoiF_data, alternative='two-
sided')
u_statistic_aoiC_C, p_value_aoiC_C =
mannwhitneyu(group1_aoiC_data, group2_aoiC_data, alternative='two-
sided')
```

```
# Print Mann-Whitney U test results
print("Mann-Whitney U Test Results for Fixation Count")
print("Group 1 AOI F vs. Group 2 AOI F:")
print(f"U Statistic: {u_statistic_aoiF_F:.1f} | P-value:
{p_value_aoiF_F:.3f}")

print("\nGroup 1 AOI C vs. Group 2 AOI C:")
print(f"U Statistic: {u_statistic_aoiC_C:.1f} | P-value:
{p_value_aoiC_C:.3f}")
```

.13 Listing - Fixation Count statistics

```
import numpy as np

# Data for Group 1 AOI F and Group 2 AOI F
group1_aoiF_data = [11, 24, 24, 27, 12, 12, 13, 15, 17, 12, 12,
14, 10]
group2_aoiF_data = [0, 1, 2, 2, 3, 3, 3]

# Data for Group 1 AOI C and Group 2 AOI C
group1_aoiC_data = [9, 5, 10, 8, 11, 8, 9, 9, 0, 0, 15, 14, 14,
11]
group2_aoiC_data = [7, 6, 6, 6, 0, 5, 5, 6]

# Function to calculate Q1 and Q3
def calculate_q1_q3(data):
    q1 = np.percentile(data, 25)
    q3 = np.percentile(data, 75)
    return q1, q3

# Calculate mean, standard deviation, median, Q1, and Q3 for Group
1 AOI F
group1_aoiF_mean = np.mean(group1_aoiF_data)
group1_aoiF_std = np.std(group1_aoiF_data)
group1_aoiF_median = np.median(group1_aoiF_data)
group1_aoiF_q1, group1_aoiF_q3 = calculate_q1_q3(group1_aoiF_data)

# Calculate mean, standard deviation, median, Q1, and Q3 for Group
2 AOI F
group2_aoiF_mean = np.mean(group2_aoiF_data)
group2_aoiF_std = np.std(group2_aoiF_data)
group2_aoiF_median = np.median(group2_aoiF_data)
group2_aoiF_q1, group2_aoiF_q3 = calculate_q1_q3(group2_aoiF_data)

# Calculate mean, standard deviation, median, Q1, and Q3 for Group
1 AOI C
```

```
group1_aoiC_mean = np.mean(group1_aoiC_data)
group1_aoiC_std = np.std(group1_aoiC_data)
group1_aoiC_median = np.median(group1_aoiC_data)
group1_aoiC_q1, group1_aoiC_q3 = calculate_q1_q3(group1_aoiC_data)

# Calculate mean, standard deviation, median, Q1, and Q3 for Group
2 AOI C
group2_aoiC_mean = np.mean(group2_aoiC_data)
group2_aoiC_std = np.std(group2_aoiC_data)
group2_aoiC_median = np.median(group2_aoiC_data)
group2_aoiC_q1, group2_aoiC_q3 = calculate_q1_q3(group2_aoiC_data)

# Print the results
print("Group 1 AOI F:")
print("Mean:", group1_aoiF_mean)
print("Standard Deviation:", group1_aoiF_std)
print("Median:", group1_aoiF_median)
print("Q1:", group1_aoiF_q1)
print("Q3:", group1_aoiF_q3)
print()

print("Group 2 AOI F:")
print("Mean:", group2_aoiF_mean)
print("Standard Deviation:", group2_aoiF_std)
print("Median:", group2_aoiF_median)
print("Q1:", group2_aoiF_q1)
print("Q3:", group2_aoiF_q3)
print()

print("Group 1 AOI C:")
print("Mean:", group1_aoiC_mean)
print("Standard Deviation:", group1_aoiC_std)
print("Median:", group1_aoiC_median)
print("Q1:", group1_aoiC_q1)
print("Q3:", group1_aoiC_q3)
print()

print("Group 2 AOI C:")
print("Mean:", group2_aoiC_mean)
print("Standard Deviation:", group2_aoiC_std)
print("Median:", group2_aoiC_median)
print("Q1:", group2_aoiC_q1)
print("Q3:", group2_aoiC_q3)
```

.14 Listing - Fixation Duration Mann Whitney U test – Group Comparison

```
import numpy as np
from scipy.stats import mannwhitneyu

# Fixation duration data for Group 1 AOI F, Group 2 AOI F, Group 1
AOI C, and Group 2 AOI C
group1_aoiF_data = [158, 185.4, 169.1, 149.5, 168.7, 166.5, 191.8,
189.9, 207.6, 225.6, 226.7, 243.8, 280.9, 320.5]
group2_aoiF_data = [0, 116, 149.1, 149.1, 150, 167.7, 167.7]
group1_aoiC_data = [141.8, 165.7, 160.4, 159.4, 166.1, 208.7,
204.4, 204.4, 0, 0, 211.2, 207.8, 174.6, 166.1]
group2_aoiC_data = [305.4, 202.3, 180.1, 237.5, 0, 187.5, 187.5,
183.3]

# Perform Mann-Whitney U test for Group 1 AOI F vs. Group 2 AOI F
u_statistic_aoiF_F, p_value_aoiF_F =
mannwhitneyu(group1_aoiF_data, group2_aoiF_data, alternative='two-
sided')

# Perform Mann-Whitney U test for Group 1 AOI C vs. Group 2 AOI C
u_statistic_aoiC_C, p_value_aoiC_C =
mannwhitneyu(group1_aoiC_data, group2_aoiC_data, alternative='two-
sided')

# Perform Mann-Whitney U test for Group 1 AOI F vs. Group 2 AOI C
u_statistic_aoiF_C, p_value_aoiF_C =
mannwhitneyu(group1_aoiF_data, group2_aoiC_data, alternative='two-
sided')

# Print Mann-Whitney U test results
print("Mann-Whitney U Test Results:")
print("Group 1 AOI F vs. Group 2 AOI F")
print(f"U Statistic: {u_statistic_aoiF_F:.1f}")
print(f"P-value: {p_value_aoiF_F:.4f}")

print("\nGroup 1 AOI C vs. Group 2 AOI C")
print(f"U Statistic: {u_statistic_aoiC_C:.1f}")
print(f"P-value: {p_value_aoiC_C:.4f}")

print("\nGroup 1 AOI F vs. Group 2 AOI C")
print(f"U Statistic: {u_statistic_aoiF_C:.1f}")
print(f"P-value: {p_value_aoiF_C:.4f}")
```

.15 Listing – S-UEQ- Mean value per Item

```
import numpy as np
import matplotlib.pyplot as plt
```

```
# Data for Group 1
group1_means = [2.4, 1.9, 2.1, 1.5, -0.7, 0.9, 1.0, 0.7]
group1_std = [0.7, 0.8, 0.9, 1.2, 1.6, 1.5, 1.7, 2.0]

# Data for Group 2
group2_means = [2.1, 1.8, 2.2, 1.0, 0.5, 0.8, -0.4, -0.7]
group2_std = [1.0, 0.9, 1.0, 1.9, 1.0, 1.1, 2.0, 2.1]

# Plot settings
items = ['Item 1 hindering - supportive', 'Item 2 complicated - simple', 'Item 3 inefficient - efficient', 'Item 4 confusing - clear', 'Item 5 boring - exciting', 'Item 6 uninteresting - interesting', 'Item 7 conventional - original', 'Item 8 conventional - novel']
x = np.arange(len(items))

# Create the figure and axes with improved readability
fig, ax = plt.subplots(figsize=(12, 6))  # Increase figure size for better readability

# Plot Group 1
group1_plot = ax.errorbar(x, group1_means, yerr=2*np.array(group1_std), fmt='o', label='Group 1', color='g', capsize=4)

# Plot Group 2
group2_plot = ax.errorbar(x, group2_means, yerr=2*np.array(group2_std), fmt='o', label='Group 2', color='b', capsize=4)

# X-axis and labels
ax.set_xticks(x)
ax.set_xticklabels(items, rotation=90, ha='right', fontsize=10)  # Rotating labels by 90 degrees on the right side
ax.set_xlabel('Item', fontsize=12)
ax.set_ylabel('Mean value', fontsize=12)
ax.set_title('Error Bar Plot: Mean ± 2 Sigma per Item and Group', fontsize=16)

# Group legend (outside the diagram)
group_legend = ax.legend(loc='upper left', title='Group', fontsize=12, bbox_to_anchor=(1.02, 1))

# Item meanings legend (without markers)
```

```
item_legend_labels = ['Item 1- 4 pragmatic items', 'Item 5-8
hedonic items']
item_legend = ax.legend([group1_plot, group2_plot],
item_legend_labels, title='Item Meanings', fontsize=12, loc='upper
left', bbox_to_anchor=(1.02, 0.5), handlelength=0)

# Add both legends to the plot
ax.add_artist(group_legend)
ax.add_artist(item_legend)
ax.set_xticklabels(items, rotation=270, ha='right', fontsize=10)

plt.grid(axis='y', linestyle='dashed', alpha=0.7)
plt.tight_layout()

# Save the figure with both legends outside the diagram
plt.savefig('error_bar_plot_with_legends.png',
bbox_inches='tight')
plt.show()
```

B. Patient information and declaration of consent

Probandinneninformation

Sehr geehrte Probandin, sehr geehrter Proband,
Sie wurden eingeladen an einer monozentrischen Pilotstudie teilzunehmen. Bevor Sie sich zur Teilnahme an dieser Studie entscheiden können, müssen Sie Wesen, Bedeutung und Tragweite sowie die Risiken und den möglichen Nutzen kennen. Lesen Sie sich die folgenden Informationen bitte sorgfältig durch. Bei Unklarheiten oder Fragen oder wenn Sie weitere Informationen benötigen, wenden Sie sich bitte an die unten angegebenen Kontaktdaten. Die Teilnahme an dieser Studie ist freiwillig und ein Rücktritt jederzeit ohne Angaben von Gründen möglich.
Bitte stimmen Sie der Einwilligungserklärung nur zu, wenn Sie Art und Ablauf der Studie verstanden haben, bereit sind, der Teilnahme zuzustimmen und - sich über Ihre Rechte als Teilnehmer/in an dieser Studie im Klaren sind.

Ansprechpartner für Fragen zur Studie
Wenn Sie Fragen zu dieser Studie haben, wenden Sie sich bitte an:
Name: Merry Bakuns
Telefon: 0676 951 9991 E-
Mail: dh211821@fhstp.ac.at

Informationen zur Studie:
Ort: Fachhochschule St. Pölten, Campus-Platz 1, A-3100
Zeitraum der Untersuchung:
09.02.2023 **oder**
04.03.2023

Bitte lesen Sie sich die Einschluss- und Ausschlusskriterien sorgfältig durch und bestätigen Ihre Teilnahme nur, wenn diese Kriterien vollständig auf Sie zutreffen.
Für den Untersuchungszeitraum werden ProbandInnen gebeten keine künstlich angebrachten Wimpern sowie Wimperntusche (Mascara) zu tragen. ProbandInnen, die eine Brille tragen werden gebeten am Tag der Untersuchung Kontaktlinsen, statt einer Brille zu tragen.

Einschlusskriterien:

- Alter > 18
- ProbandInnen, die keine Gehhilfen benötigen und in Ihrer Bewegung nicht eingeschränkt sind.
  Zu Gehhilfen zählen:
  Rollstühle
  Rollatoren (Gehgestell)
  Gehstöcken
  Zu Einschränkungen in der Bewegung zählen:
  Gips
  Halskrause

Ausschlusskriterien:

- Alter > 75
- ProbandInnen mit einer diagnostizierten Sehschwäche
- ProbandInnen mit einem diagnostizierten Katarakt (Grauer Starr)
- ProbandInnen mit einer diagnostizierten Amblyopie (Lazy Eye)

Was ist der Zweck der Studie?
In dieser Arbeit sollen neue Erkenntnisse über den Einsatz von beleuchteten Bodenmarkierungen zur Kennzeichnung von Fluchtwegen in gefährdeten Einrichtungen geliefert werden.

Wie läuft die Studie ab?
ProbandInnen werden im Vorfeld darauf hingewiesen einen bestimmten Eingang zum Gebäude zu wählen. Mithilfe der Eye tracking Brille können Augenbewegungen, Fixationen sowie die Blickrichtungen der ProbandInnen erfasst werden. Am linken Zeigefinger wird ein Pulsoximeter aufgesetzt. Mithilfe des Pulsoximeters wird die Herzfrequenz der ProbandInnen erfasst. Nach erfolgreichem Testdurchlauf werden ProbandInnen gebeten einen kurzen Fragebogen zur Benutzererfahrung mit einer Ausfühlzeit von 3-5 Minuten auszufüllen.

Gibt es Risiken bei der Durchführung der Studie und ist mit Beschwerden oder anderen Begleiterscheinungen zu rechnen?

Bei der Datenerhebung besteht aus medizinischer Sicht keine potentielle Gefährdung oder Risiko für ProbandInnen.

VPS Eye Tracking Brillen, die zum Einsatz kommen, stellen ebenfalls keine potenzielle Gefährdung für ProbandInnen dar. Diese sind gemäß Norm EN 166 zertifiziert und erfüllen die Anforderungen für persönlichen Augenschutz sowie den Aufbau der Brille.

Auch beim Einsatz des Pulsoximeters handelt es sich um nicht invasive Messmethoden.

In welcher Weise werden die im Rahmen dieser Studie gesammelten Daten verwendet?

Die Datenerfassung und Datenbearbeitung erfolgt mittels kommerzieller Software (Excel, PSPP, IMotions), alle gewonnenen Daten werden in Computerdateien gespeichert, nur das Studienteam hat Zugang zu diesen Daten. Um die Anonymisierung der Daten sicherzustellen, wird beim Erfassen von personenbezogenen Daten der Name durch eine Kodierung ersetzt. Die Auswertung der Daten erfolgt ausschließlich zu statistischen Zwecken.

Einwilligungserklärung zur Teilnahme an der Studie

Titel: Der Einfluss lumineszierender Bodenmarkierungen auf den Suchpfad der Nutzerinnen beim Auffinden des Notausgangs, gemessen mit Hilfe der Eye-tracking-Technologie, eine monozentrische Pilotstudie

Hiermit erkläre ich, dass ich über die Ziele der Studie und ihren Ablauf sowie über mögliche mit der Studie verbundene Risiken ausführlich und verständlich aufgeklärt worden bin. Ich hatte genügend Zeit, meine Entscheidung zur Teilnahme an der Studie zu überdenken und frei zu treffen.

Mir ist bekannt, dass ich jederzeit und ohne Angabe von Gründen meine Einwilligung zur Teilnahme an der Studie mündlich oder schriftlich zurückziehen kann, ohne dass mir daraus irgendwelche Nachteile entstehen. Mir ist bekannt, dass bei der Studie personenbezogene Daten von mir erhoben und in Protokollen niedergeschrieben und elektronisch gespeichert werden.

Die Daten sind gegen unbefugten Zugriff gesichert. Zugriff auf die personenbezogenen Daten haben nur die zuständigen Personen im jeweiligen Studienzentrum. Hiermit erkläre ich mich einverstanden. Ich erkläre mich bereit, an der oben genannten Studie freiwillig teilzunehmen. Eine Kopie der Einwilligungserklärung wurde mir ausgehändigt. (Erfolgt am Tag der Durchführung)

Studienteilnehmer/in (Name, Vorname):______________________

____

Ort, Datum   Unterschrift des Teilnehmers/Inn

Projektleiter/in (Name, Vorname): ______________________

____

Ort, Datum   Unterschrift der Projektleiterin

C. Protocol

PROTOKOLL | MDH |04.03.2023

Datum der Studiendurchführung | Uhrzeit
04.03.2023 | 09:00 – 17:00
Ort der Studiendurchführung | Fachhochschule St. Pölten

Protokollführerin: Bakuns Merry

Teilnehmeridentifikation:

Videonummerierung:

PROTOKOLL ZUM ABLAUF

Geplante Dauer | *30 Minuten* *tatsächliche Dauer* |

Patienteninformation

☐ Ein & Ausschlusskriterien treffen zu

Einwilligungserklärung

☐ gelesen + ausgefüllt
☐ unterschrieben
☐ an Studienleitung übergeben
☐ Proband/In hat Kopie erhalten

Eye-Tracking-Brille (Blickerfassungsbrille)

Probandinn trägt Kontaktlinsen

☐ JA ☐ NEIN

Set-Up beim ersten Versuch erfolgreich

☐ JA ☐ NEIN

☐ Nasenaufsatz verwendet

☐ Brille sitz locker / zu eng

Notizen:

Nosepad Nr.:

Aufgabenstellung
wurde verstanden

☐ JA ☐ NEIN

Geplante Fluchtroute wurde verwendet:

☐ JA ☐ NEIN

UEQ-Fragebogen vollständig ausgefüllt:

☐ JA ☐ NEIN

Aufgabenstellung wurde vollständig abgeschlossen:

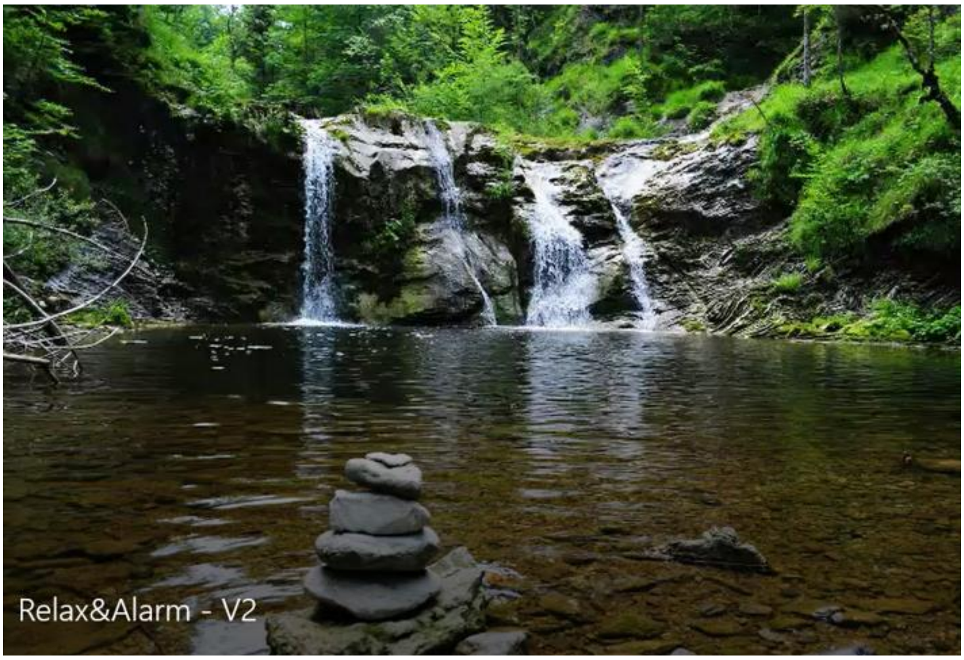
☐ JA ☐ NEIN

Falls nein, welche Fragen sind offen:

NOTIZEN

D. Image of Video Instruction

.1 Image of Waterfall



.2 Image of Alarm Instructions

E.Survey Data

An dieser Umfrage teilgenommen am:

☐ 09.02.2023

☐ 04.03.2023

Teilnehmeridentifikation:

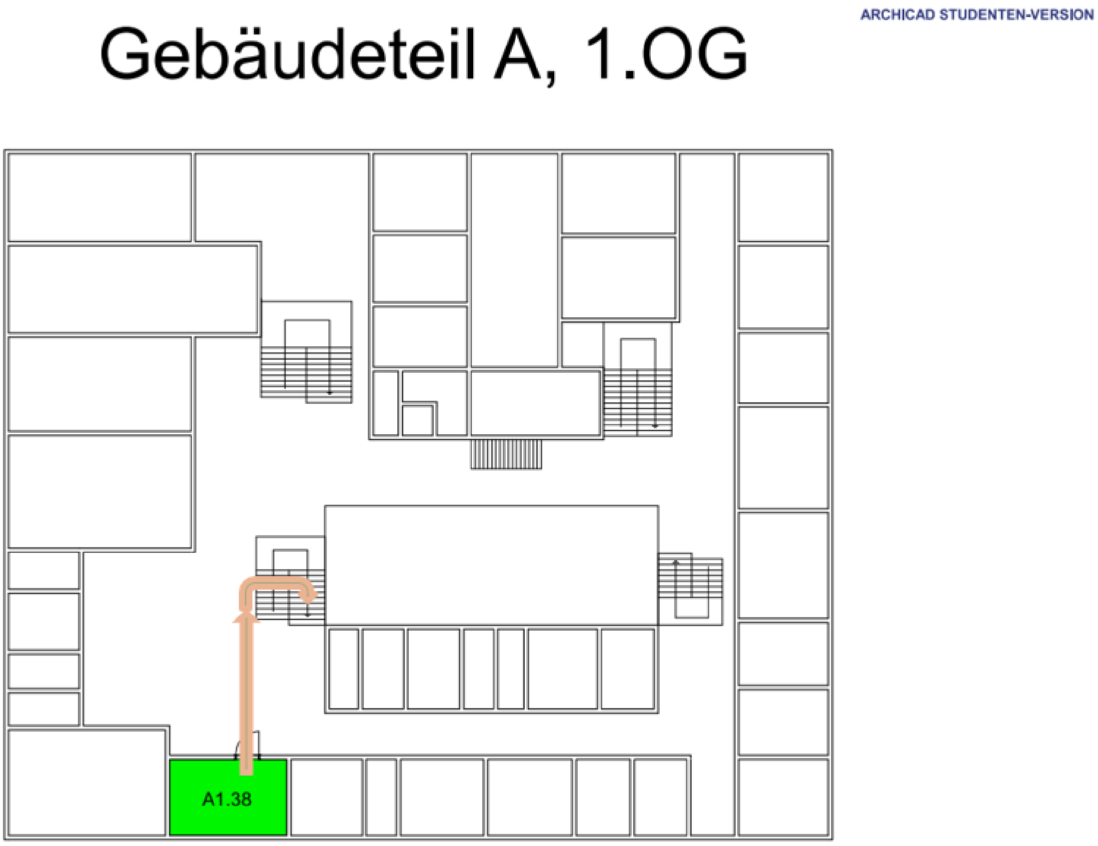
____

Bitte bewerten Sie die Fluchtwegskennzeichnungen.

Kreuzen Sie bitte immer eine Antwort an, auch wenn Sie der Meinung sind, dass keine der Optionen gut zum Produkt passt. Es gibt keine „richtigen" oder „falschen" Antworten. Ihre persönliche Meinung zählt.

behindernd	o o o o o o o	unterstützend
kompliziert	o o o o o o o	einfach
ineffizient	o o o o o o o	effizient
verwirrend	o o o o o o o	übersichtlich
langweilig	o o o o o o o	spannend
uninteressant	o o o o o o o	interessant
konventionell	o o o o o o o	originell
herkömmlich	o o o o o o o	neuartig

F. Planed Escape Route



G. iMotions Eye -Tracking Data

G.1 iMotions metrics Group 1, AOI F

Group 1 AOI F	Gaze based metrics		Fixation based metrics						Saccade based metrics	

Participant	Hit time (ms)	Revisit count	TTFF AOI (ms)	Fixation count	Revisit count	Dwell time (ms)	Dwell time (%)	First Fixation Duration (ms)	Entry saccade onset AOI (ms)	Saccade Count
1	11.4	18	1378.4	15	6	2370	5.1	158	0	53
2	10772	11	122245	11	5	3212	4.1	185	10791	23
3	1119	25	1823	24	11	4159	7	169	0	57
4	1974	27	4324	24	9	3617	5.4	149	3627	73
5	3485	27	5291	27	10	4692	5.7	168	3627	79
6	2368	12	5844	12	4	2254	4.5	166	2391	28
7	2303	13	5844	12	4	2646	5.2	191	2376	28
8	1570	13	4579	13	5	2925	5.7	189	2376	28
9	1239	14	1711	15	5	3324	6.5	207	2376	30
10	1444	13	1822	17	6	3828	7.5	225	2841	31
11	1653	10	1999	12	6	2832	5.7	226	2841	18
12	2064	11	2450	12	11	3026	6	243	2841	18
13	2541	13	3041	14	6	3814	7.8	280	3966	24
14	3809	12	4562	10	5	3503	6.6	320	13966	11

G.2 iMotions metrics Group 1, AOI C

Group 1 AOI C	Gaze based metrics		Fixation based metrics						Saccade based metrics	
Participant	**Hit time (ms)**	**Revisit count**	**TTFF AOI (ms)**	**Fixation count**	**Revisist count**	**Dwell time (ms)**	**Dwell time (%)**	**First Fixation Duration (ms)**	**Entry saccade onset AOI (ms)**	**Saccade Count**

1	2617	14	7197	9	5	1276	2.9	141	0	17
2	4564	3	4429	5	0	4439	1.8	165	0	4
3	16983	10	19261	10	4	1533	2.8	160	0	21
4	11491	13	15714	8	3	1232	2	159	451	25
5	26568	13	29729	11	4	1901	2.3	166	451	31
6	12922	6	7421	8	4	1665	3.5	208	33275	20
7	17178	6	10341	9	5	1840	4.1	204	33275	4
8	939	11	10341	9	5	1840	4.1	204	33275	29
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	14705	12	17338	15	5	3413	5.7	211	3832	27
12	16770	12	20176	14	5	3134	4.7	207	3832	25
13	19564	11	24209	14	4	2565	4.3	174	3832	27
14	23063	11	29729	11	3	1901	2.3	166	4733	25

G.3 iMotions metrics Group 2, AOI F

Group 2 AOI F	Gaze based metrics		Fixation based metrics						Saccade based metrics	
Participant	Hit time (ms)	Revisit count	TTFF AOI (ms)	Fixation count	Revisist count	Dwell time (ms)	Dwell time (%)	First Fixation Duration (ms)	Entry saccade onset AOI (ms)	Saccade Count
1	0	0	0	0	0	0	0	0	0	0
2	7721	3	25788	1	0	116	0.3	116	0	2
3	12316	2	21174	2	0	331	0.9	149	16493.8	3
4	13147	2	21174	2	0	331	0.9	149	16498	3
5	0	0	0	0	0	0	0	0	0	0
6	13692	3	19344	3	0	524	1.2	150	15879	5
7	19269	3	24933	3	1	558	1.2	167	22297	4
8	17703	2	24933	3	1	558	1.2	167	222972	4

G.4 iMotions metrics Group 2, AOI F

Group 2 AOI C	Gaze based metrics		Fixation based metrics						Saccade based metrics	
Participant	Hit time (ms)	Resvisit count	TTFF AOI (ms)	Fixation count	Revisit count	Dwell time (ms)	Dwell time (%)	First Fixation Duration (ms)	Entry saccade onset AOI (ms)	Saccade Count
1	2165	5	1974	7	4	2137	3.2	305	0	3
2	13093	5	13203	6	3	1355	2.8	202	4106	10
3	12939	4	13203	6	3	1265	2.6	180	3841	10
4	1435	5	1542	6	3	1425	3.4	237	1377	11
5	0	0	0	0	0	0	0	0	0	0
6	12940	4	13267	5	3	1138	2.8	187	1516	8
7	4480	0	45357	5	3	1138	2.3	187	1516	8
8	12808	5	13117	6	3	1329	2.7	183	1645	10