Response to Emergency Wayfinding Systems by People from Different Cultures

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RESPONSE TO EMERGENCY WAYFINDING SYSTEMS BY PEOPLE FROM DIFFERENT CULTURES

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Abstract
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When talking about evacuation, the color employed for exit signs and flashing lights plays a
significant role because it is in charge of transmitting a message to the evacuees, either danger or
safety. The aims of this study are to evaluate the influence of red and green emergency
wayfinding systems on people with different cultural backgrounds and to analyze the possible
impact of the distance to the means of egress when having this kind of systems. Experiments in
which sixty persons participated, namely from China and from different European countries,
were performed in a virtual reality environment. The results of the experiments suggest that in
case of an emergency situation red and green have similar connotations for both groups of
participants. Chinese and Europeans make their choices in a comparable way, green being the
color of choice even when the distance to travel to the means of egress is longer.

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I

II

Summary

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The aims of this study are to evaluate the influence of red and green emergency wayfinding systems on people with different cultural backgrounds and to analyze the possible impact of the distance to the means of egress when having this kind of systems. Experiments in which sixty persons participated, namely from China and from different European countries, were performed in a virtual reality environment.

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Resumen

Algunos colores pueden llegar a tener diferentes connotaciones dependiendo de los antecedentes culturales de las personas. Cuando de evacuación se trata, el color utilizado en las señales de salida de emergencia y luces intermitentes juega un papel importante ya que está a cargo de transmitir un mensaje a los evacuados, sea éste de peligro o de seguridad.

Los objetivos de este estudio son evaluar la influencia de los sistemas de señalización de emergencia en personas con distintos antecedentes culturales utilizando los colores rojo y verde como opciones, así como también, analizar el impacto que puede llegar a tener la distancia a las vías de salida al tener este tipo de sistemas. Los experimentos se realizaron en un entorno de realidad virtual en los que sesenta personas participaron, provenientes tanto de China como de diferentes países europeos.

Los resultados de los experimentos sugieren que en caso de una situación de emergencia los colores rojo y verde tienen connotaciones similares para ambos grupos de participantes; chinos y europeos toman sus decisiones de manera análoga siendo el verde el color de preferencia incluso cuando la distancia a las salidas de emergencia es mayor.

Acknowledgements

Contents

Index of Tables

X

Index of Figures

1. Introduction

Emergency wayfinding systems are designed in order to provide safety to people in case of evacuation. They should be available at any moment and they must work even when the power supply is affected. Actually, this is the most important feature of this kind of systems, to work when the main systems fail in order to show evacuees the way to a safe place.

Exit signs are recognized and related with safety in case of an emergency but, in their daily routines, people tend not to be aware of their presence or to remember their locations. These conclusions were established by McClintock, Shields, Reinhardt-Rutland and Leslie [1] in their experiments concerning learned irrelevance of emergency exit signage. According to the authors, the phenomenon of learned irrelevance takes place *"when a person is continually exposed to a stimulus (emergency exit signage) but rarely, if ever, has to respond to it"* (p.23). This could be the explanation of why people do not notice emergency signage in their everyday activities. In their case in particular, McClintock et al proposed the use of blue flashing strobe lights as a method to overcome learned irrelevance during an evacuation.

Later, Nilsson, Frantzich and Saunders [2] performed experiments using flashing lights at emergency exits in order to see if there could be another color performing better than the blue one chosen by McClintock et al [1] for way-guidance in case of an emergency. The results showed that flashing lights increase the use of emergency exits and that green was the most suitable color for these devices. In the experiments, green was rated as the color with the most positive association in case of an emergency. In accordance with Wickens and Hollands [3], people associate green with safety and red with danger.

In the analysis of exit choices in fire emergencies, Nilsson [4] concluded that the utilization of flashing lights at emergency exits is a method that could influence people at the moment of selecting an evacuation route. Experiments were performed in order to investigate these systems and, as shown before, green lights were employed because of the positive association of this color in case of an emergency situation. These green flashing lights were placed next to escape emergency signs with the purpose of getting people's attention. The theory of affordances and simplicity were considered in the design in order not to confuse people with the pretended message.

Research by Fridolf, Ronchi, Nilsson and Franzitch [5] concerning exit choice in smoked-filled rail tunnels, focused on the effectiveness of using different sets of wayfinding systems in case of an evacuation. The results of these experiments support the previous findings about green flashing lights concerning people's association of the color green with safety and emergency exits, as well as the importance of using flashing lights in order to get people's attention and therefore, stimulating the use of an emergency exit.

When referring to colors from a cultural perspective it could be noted that, in some cases, the same color might have different meanings for people depending on the region of the world they come from. Actually, there are certain cultural issues and demographic stereotypes when talking about this topic. In his study about the metaphor of "Red" in Chinese culture, Huang [6] enhances the great significance and importance of this color, which is deeply rooted in the

history and traditions of China. For the Chinese population red is related to life, happiness, good fortune and joy.

On the other hand, western cultures consider red mostly as a synonym of danger or precaution and associate green to safety and permission [7]. In these facts lies the importance of considering the possible influence of colors at the moment of performing an evacuation with people having different cultural backgrounds.

Virtual reality is a useful tool for experiments because of the possibility of exposing human beings to controlled situations in environments designed according to the needs of the researcher and the study itself. Despite of the many advantages of the use of virtual reality, it is very important to consider the validation of this tool for the purposes of the intended study, in this case, evacuation.

There is specific research made in evacuation and exit choice using a virtual reality environment at Lund University [8]. In this case, two sets of experiments were conducted. The first one was performed in order to validate the use of basic virtual reality environments with flashing lights as a tool for experiments on evacuation by showing that people experience the virtual environment and make their choices in a similar way as it would be in reality. After this, in the second set, the researchers experimented with the use of emergency escape signs combined with flashing lights using red and green separately in order to observe if it was possible to direct people in evacuation using these two colors.

The results of these tests showed that virtual reality is valid as an instrument for evacuation experiments and that it is possible to direct people during an evacuation using red and green as the colors for the flashing lights.

Other research was performed by Kobes [9] as validation of the virtual reality method using serious gaming. The study was performed in order to investigate the response of people in buildings and to determine which design fitted the best for this type of structure during a situation of fire considering the behavior of humans. Human factors, building factors and fire factors were considered as to determine their influence on people's wayfinding decisions during the situation they were exposed to.

These experiments were held in a real hotel in the Netherlands, where people had to evacuate after receiving a call in the middle of the night, as well as in a virtual version of the same environment.

Both research projects were very useful at the moment of the validation of the virtual reality environments as a tool to study human behavior during an evacuation. The first one specifically using escape signs in combination with flashing lights in which case, red and green were employed as colors for these devices, as in the present study. The second research was considered as a backup of the validation itself considering different factors that could influence people's wayfinding decisions.

1.1 Objectives

Possible issues concerning exit choices using emergency wayfinding systems and virtual reality were introduced in the previous section. These concerns suggest a potential influence of the different connotations people from different cultures might give to colors in case of a simulated evacuation. Taking this into account, the present study aims to answer the following three objectives by the performance of human behavior experiments in a virtual reality environment:

i) To evaluate people's exit choices when having to choose between red and green exit signs in combination with flashing lights at the means of egress in case of a simulated evacuation.

ii) To analyze if the distance to the means of egress plays a role in people's exit choices when having different color options, i.e. red and green, for the emergency wayfinding systems between two possible exits.

iii) To observe if subjects with different cultural backgrounds, namely Chinese and European, react in a different manner to the system design.

1.2 Methodology

This section gives a description of the different stages of the research. It includes an overview of the literature review, the performed experiments, the recollection of data and its analysis.

1.2.1 Literature review

In the first stage, a literature review was conducted in order to collect information on how cultural backgrounds could influence the perception of colors in people from various regions of the world.

The first part analyzes literature on the different connotations given to red and green in order to have an idea of the message these colors might transmit to the participants when exposed to a simulated evacuation. After this, a revision of the legislation, codes and standards related to exit signage and color coding applicable to it at the different regions under consideration was performed. This was done in order to expose what the current regulations state concerning emergency exit signs at the means of egress.

Additionally, references were analyzed as to get an overview of the relevance of using flashing lights as a complement for the exit signs in wayfinding situations, namely in case of evacuation. At last, several studies about what has been done until the moment using virtual reality are reviewed.

This section is an extension of the background information introduced in the first section with the purpose of confirming the validity of the use of virtual reality as a tool for evacuation experiments and to create a baseline on its different uses and limitations.

The intention of the literature study is to give readers a better understanding of the following stages of the project.

1.2.2 Experiments

In the second stage, experiments were performed using a virtual reality environment with the participation of sixty subjects divided into two groups according to their origins, namely Chinese and Europeans.

A description on how participants were recruited and their main characteristics concerning nationality, gender and age is first presented in order to have an idea of the sample traits used for the study. After this, an explanation on how the virtual reality environment was built, the tools used during this stage and the purposes of the layout are incorporated. The tools included the software and hardware required for the experiments, as well as the questionnaires filled out by the participants in order to complement the information used in the analysis. This stage concludes with the procedure followed with the intent of getting the results and the ethical aspects involved in experiments with human subjects.

The aim of the experiments stage is to provide information on the preparation and performance of the virtual reality experiments.

1.2.3 Recollection of data and analysis

In the last stage, the results are presented, analyzed and discussed. Tables and figures expose the results obtained from the virtual reality sessions. The relevance of the outcomes, possible trends and their influence are discussed in this section. The results were based on the observed behavior during the experiments and the information given in the questionnaires. Two methods were used, a statistical and a descriptive one.

The statistical methods used were the Chi-Square and the Wilcoxon signed rank tests. First, the Chi-Square test was performed in order to verify the possible relationship between the nationality of the participants and their preferences during the experiments. The preferences included the green wayfinding systems and the shortest distance to the emergency exits in the corridors where the participants had to deal with it. The options accounted as special considerations were not included in this test. After this, the Wilcoxon signed rank test was performed in order to see if on average the subjects ranked the perceived levels of importance of the considered variables in a different way, i.e. one higher than the other one. The considered variables were the color of the emergency wayfinding systems and the distance to the means of egress.

The descriptive method showed some particular aspects collected through the observed behavior of the subjects and the questionnaires filled out by them. These aspects were the participants' exit choices and their preferences during the experiment regarding the color of the emergency wayfinding systems and the distance to the means of egress when having this kind of systems.

The objective of the recollection of data and analysis section is to show the results of the participant's behavior to the different variables considered in the experiments, discussing possible explanations for it, in order to prepare the gathered information for the final conclusions.

1.3 Limitations

Some variables are out of the control of the researcher. These are called limitations. For the present study there were certain restrictions concerning time, budget availability and readiness of the subjects to participate in the study.

The time and budget for the research were limited by the university. The readiness or availability of the subjects under study was conditional to their willingness to attend the experiment and to concede their time for it. Also, the use of the virtual reality itself was also considered as a restriction because it does not reflect 100% real life situations.

The project was limited to red and green emergency wayfinding systems and their influence on the exit choice of people from different cultures. Distances were considered in the layout of the virtual building in order to see if the participants would change their minds when having red and green as choices for the color of the emergency wayfinding systems at the means of egress.

2. Literature review

A review on the literature concerning the different connotations given to red and green in different parts of the world and the legislation, codes and standards applicable in these regions is first presented. The subsequent sections give an overview of the uses of flashing lights in case of evacuation and virtual reality with fire safety purposes.

2.1 Connotations of colors

From country to country language changes but, even if in some occasions the same mother tongue is shared between nations, the connotation of specific words can differ depending on the culture and traditions to which they belong to. Colors play an important role in this situation; the perception people have about some of them may vary from culture to culture depending on the context in which they are treated [10], in fact, there are symbolic associations with colors since ancient times. They can be considered as an important part of the cultural legacy and traditions of a nation because of their active presence in religion, nature and arts. Because of this, every color can have both positive and negative significance, that is to say, their meaning can be ambiguous.

In his study about the comparison of English and Chinese cultural connotation of color words, He [11] emphasizes the different messages certain colors transmit depending on the cultural backgrounds and traditions of people focused in the Chinese and English language. He states that this understanding between cultures allows people's effective communication. The different connotations of red, white and black color are present in He's study but only the ones related to red were considered for the matter of the present study.

In accordance with He [11], red is considered as the most important color for the Chinese. Accounted as the basic cultural color, it has many positive connotations: happiness, good luck, success, prosperity, progress and revolution. It is dressed by brides in weddings and used as decoration during important Chinese celebrations as the Spring Festival and the Chinese New Year. Red is deeply rooted in the Chinese culture and traditions as something with a very positive meaning but, in some occasions, it can also have an opposite meaning associated with the terrorist times in China in which case, it means death. That is why, depending on the situation, red can also be a synonym of danger. On the other hand, Western cultures consider red color as a bad presage and as a synonym of evil, danger, cruelty and disaster. The color is associated also to political radicals. According to the research made by this author, red is mainly taken as a symbol of danger and alarm in the Western world.

Another Chinese researcher, Huang [6], presents the "metaphor" of red for the Chinese culture. For this author, red with its different connotations can represent the Chinese culture itself, the traditions and people's ways of thinking. Red is considered as a very symbolic color for the Chinese. The political connotation of the color red in China is related with revolution and socialism but, its ancient connotation is fortune, fame and power. Emotions are also deeply involved, red is linked with the feelings of angriness and embarrassment and it is considered as a symbol of danger and emergency in which case, a red blinking light or a red alert are accounted as warning signs. Therefore red, in this kind of situations, is used in order to catch people's attention and to warn them about a possible risk.

As it can be noted, among all the colors, red is the most significant one for the Chinese. Regarding culture and traditions, red has a positive meaning in China but when related to emergency situations its connotation is similar to the one given by Western cultures, i.e. danger.

Emergency lights follow a similar concept as the one used for traffic lights worldwide in which case red means stop and green implies go. In his research about the origins and globalization of traffic control signals, McShane [12] states that the use of red does not have a cultural value of the color as an origin as it could be thought but has it in empirical transparency tests made to the stained glass in 1806. Red was chosen because it was the most transparent color that could be applied to the available materials for the lamps used in lighthouses. The color red used in lighthouses gave origin to the maritime signals and those to railroad signal systems. Afterwards, the use of red and green in traffic lights was taken from the railroad system.

According to McShane, the intent of traffic lights is to enforce one of the most basic behaviors in humans, whether to move or to be still. This kind of directive is pursued also by the emergency wayfinding systems showing people, by the use of the correct signs and colors, the route to a safer place.

2.2 Legislation, codes and standards

In times where globalization is the norm, the challenge is to get people with different cultural backgrounds and ideas to understand in the simplest way possible the pretended message of the emergency wayfinding systems, breaking the barrier of language and culture. This is the objective pursued by standards and codes; to unify the signage used in case of emergency in order to transmit a message to the people living in a certain region, no matter if they speak or not the language used in the place. The next paragraphs give an overview of the different codes, regulations and standards used in different parts of the world.

In the United States, according to the NFPA 1 Fire Code Handbook [13] exit doors *"shall be marked by an approved sign that is readily visible from any direction of exit access"*. Red is the mandatory color by law in many states of the US and it is accounted as the traditional color for emergency exit signs. However, the NFPA Code does not stipulate a specific color for the exit signs because depending on the situation, either red or green can be used. In specific cases, it is even possible to use a different color than these two depending on the visibility provided. Pictograms are allowed with the approval of the authority having jurisdiction; otherwise, the sign with the legend EXIT shall be used.

A different situation is given in Canada where also red emergency exit signs have been used. Canada has decided to move forward to the International Fire Code (IFC) from 2015 onwards [14] replacing the sign with the legend EXIT in red for the green running man, namely the green emergency exit sign with the pictogram, for new buildings and large renovations. According to the National Building Code of Canada [15] the exit signs in this new version *"consist of a green pictogram and a white or lightly tinted graphical symbol meeting the colour specifications referred to in ISO 3864-1"*. However, the authorities will give some time for the people and companies to adapt to these changes.

The main difference on the exit signage comparing with most of the countries in the world is that the US and Canada are still using the red emergency exit sign with the legend EXIT and/or

SORTIE (in case of the French speaking part of Canada) instead of using the green exit sign with the running man pictogram.

The International Organization for Standardization (ISO) has specific standards concerning principles for fire safety signs. The document ISO 3864-1 [16] establishes the meaning assigned to the geometric shapes and to the safety and contrast colors of emergency signs. In this case specifically, the shape for the exit sign can be either rectangle or square and the safety and contrast color must be white with the safety color green representing at least 50% of the total sign area.

The present research is focused on the study of two different groups of subjects, namely people from the different European countries and people from China. According to the Council Directive of the European Parliament of 1992 [17] the emergency escape signs have as an essential feature, the employment of the white running man pictogram on either a square or rectangular green background; similar characteristics as the ones present in the ISO 3864-1 standard. Also in this case, the green background must represent at least 50% of the sign area.

The Chinese Code for safety colors [18] is a modification of the ISO 3864-1:2002 standard. The features presented for the emergency exit signs are the same but some technical differences comparing with the ISO standard are present. One of these differences is the introduction of a method to measure safety and contrast colors and photometric performance.

As it can be observed, green exit signs are widely utilized. The white running man pictogram on a green background is basically used all around the globe with some few exceptions, namely The United States and Canada. For the present study, it is noticed that the same characteristics for the emergency exit signs apply for the countries where the participants of the experiments come from. Therefore, the majority of them were supposed to be familiar with these features.

2.3 Flashing lights

In the present study, flashing lights were used in the experiments as part of the wayfinding systems in order to complement the exit signs at the means of egress. These devices have two variants, travelling and static flashing lights.

The travelling flashing lights are mainly used for wayguidance to the emergency exits by marking the correct direction of the escape route during and evacuation using a row of light sources. A study made by Jin and Yamada [19] showed that these devices might be considered as an influential tool for safety evacuation even when smoke is present, depending on the separation of the lights.

The static flashing lights are utilized in order to catch people's attention by highlighting a specific location, namely the emergency exits. These lights are normally used as a complement of the exit signs and its purpose is to highlight the location of the means of egress. Experiments performed in order to evaluate the contribution of these devices in an emergency situation [4] [5] [7] indicate that green flashing lights are an effective method to increase the usage of emergency exits during an evacuation.

2.4   Virtual reality with fire safety purposes

Virtual reality is widely used in experiments and it has been validated as a tool for it. An immersive experience in a virtual reality environment enables the experimenter to have similar results as the ones obtained in a real situation. Virtual reality has the advantage of giving the researcher the possibility of having control over more features than in a real life experiment and avoids the exposure of the participants to situations that could compromise their safety.

Experiments as the ones performed by Kobes [9] and by Johansson and Petersson [8] give an important overview over the validation of the use of serious gaming and virtual reality for research in the fire safety field, respectively.

The main objective of Kobes' research was the validation of the use of serious gaming as a new research method. The secondary aim was to study the human behavior in fire and the influence of human, building and fire factors to response and wayfinding performance.

In their research, Johansson and Petersson made first a validation of the virtual reality environments and then they performed experiments with exit signs in combination with flashing lights in order to see if it was possible to direct people's evacuation by the use of red and green flashing lights.

Both researches corroborated the use of this technology in order to get reliable results for fire safety purposes. The results showed no significant difference between the experiments performed using virtual reality and the ones performed in a real environment.

For the purposes of the present research, red and green were chosen to be the colors for the exit signs and flashing lights inside the virtual environment because of its wide use for emergency signaling and the well-known message these colors represent. The running man pictogram with a red background is used only for the matters of the present study. In fact, this kind of signage is not regulated or specified in any of the codes or standards but, it was included in the virtual environment in order to make a clear differentiation between the two wayfinding systems used.

3. Experiments

During the month of March 2014, sixty sessions of experiments were performed at the faculty of engineering at Lund University in a virtual reality environment using the Oculus Rift headset. The experiments took place in a conditioned room at the Kemicentrum building where the department of Fire Safety Engineering was temporarily located. The room was equipped with the virtual reality headset, a computer to run the required software and a sound system in order to make the experience more realistic.

3.1 Participants

Lund is a student's city; most part of the population of the city is formed by young students from Sweden and from all over the world. Erasmus Mundus and other exchange and master programs coexist in a multicultural environment that is renewed partially every semester. The subjects taking part of the experiments for the present study were part of this population and, for their participation, every one of them got as compensation a ticket for the cinema in Lund.

The sample consisted in 60 participants, namely 30 Chinese and 30 Europeans. They were recruited via social networks and by ads posted at the different accommodations the university offers. This process started one month before the experiments took place and the selection criteria, apart from the nationalities of the subjects, were two: having no color vision deficiency, better known as color blindness, nor being a student of the fire safety engineering career.

People with color blindness were not considered as participants for the experiments because of the possible influence this condition might have in their exit choices, as well as for the fire safety students, in which case their previous knowledge in the field might bias their behavior during the experiments.

In Table 1, the participant characteristics concerning nationality and gender can be noted. A total of 32 females and 28 males took part on the experiments. The subjects' age ranged from 20 to 45 years with an average of 24.1 years and a standard deviation of 3.735. The European sample included students from 12 different countries, namely from Finland, Germany, Great Britain, Greece, Hungary, Italy, Lithuania, Romania, Russia, Spain, Sweden and Switzerland.

Table 1: Participant Characteristics

| | | | GENDER | | Total |
			Female	Male	
Nationality	Chinese	Count	19	11	30
		% within Nationality	63.3%	36.7%	100.0%
	European	Count	13	17	30
		% within Nationality	43.3%	56.7%	100.0%
Total		Count	32	28	60
		% within Nationality	53.3%	46.7%	100.0%

Almost half of the Europeans subjects, this is, 46.7% (14 participants) and 26.7% (8 participants) of the Chinese group said they have lived in another country before coming to Sweden for a period between 2 weeks and 5 years. Thus, people inside this group might be considered to have a cultural influence besides the one acquired in their home countries.

Participants' previous experience in some aspects related to the research can be observed in Table 2. At least half of the participants were in at least one evacuation drill or had any kind of training or education in fire safety. On the other hand, most of the participants had previous experience with computer or videogames, namely 85% (51 participants). This was observed by the easiness with which participants handled the controls during the experiments.

Table 2: Previous experience by nationality

			PREVIOUS EXPERIENCE IN				
			Evacuation drills	Real fires	Training or education in fire safety	Virtual reality environments	Gaming
Nationality	Chinese	Count	12	1	23	4	26
		% within Nationality	40.0%	1.7%	76.7%	13.3%	86.7%
	Europeans	Count	18	4	17	4	25
		% within Nationality	60.0%	13.3%	56.7%	13.3%	83.3%
Total		Count	30	5	40	8	51
		% within Nationality	50%	8.3%	66.7%	13.3%	85.0%

All the participants stated being aware of the color used for the exit signs in their home countries but only half of them knew green emergency exit signs are used in Sweden.

3.2 Virtual reality environment

The environment consisted on a one-storey building with a total of 31 corridors in a labyrinth disposition leading to 32 possible exits. The starting point was common in all cases. Each corridor had two emergency exits leading to the subsequent corridors which had the same number of exits as the previous one and so on until arriving to a safe place in the open field. The outside of the building was reached after exiting five consecutive corridors. Figure 1 below shows the layout of the virtual reality environment.
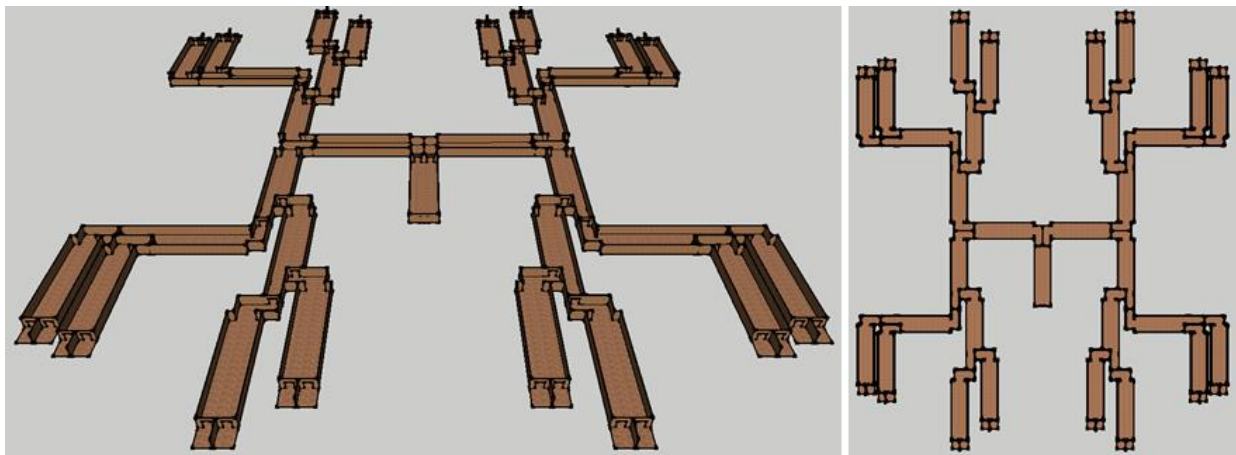
Figure 1: Layout of the virtual reality environment

Each of the 32 possible paths consisted in 5 corridors in total, from the starting point until the final exit leading to the outside of the building. The first two and the fifth corridor had a length of 30 meters with both exit doors at the same distance with respect to the entrance. The third and fourth corridors had a difference of 10 meters between the two possible exits, in other words, they were positioned at 25 and 35 meters respectively from the entrance of the corridors. This situation can be observed in Figure 2.
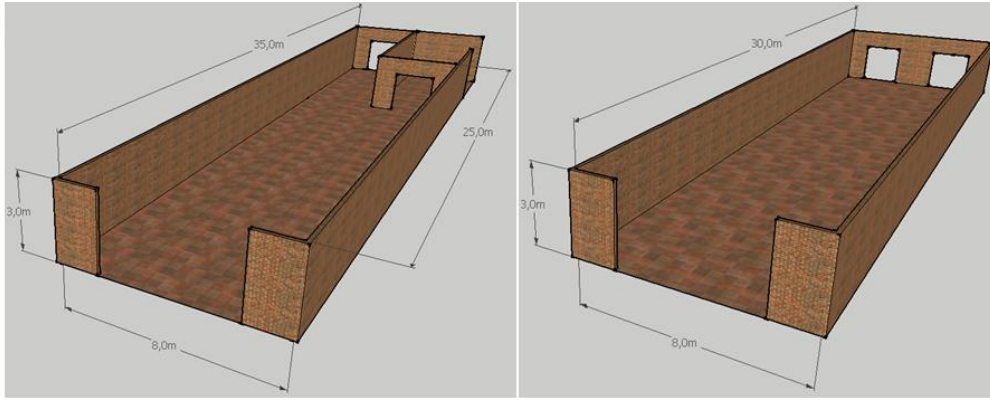
Figure 2: Setups for the two kinds of corridors

Every corridor had a width of 8 meters, a height of 3 meters and a wall thickness of 15 centimeters. The textures of the walls, the ceiling and the floor were chosen in order to create a similar environment to the one present at the faculty of engineering at Lund University. This was done for the participants to feel familiar with the place.

Each corridor had two emergency exits situated at the opposite side of the corridor's entrance. The exits consisted in a double door opening in the direction of escape with panic bars in each of the door leafs. At the same time, every exit had an emergency wayfinding system above it with a self-illuminated emergency exit sign which was centered above the door with one flashing light of the same color at each side. The difference between the means of egress in each corridor was the color used for the emergency wayfinding systems, in other words, each corridor had a red emergency wayfinding system in one of the exits and a green system in the other one. The exit door and wayfinding systems used in the virtual reality environment can be seen in Figure 3 below.
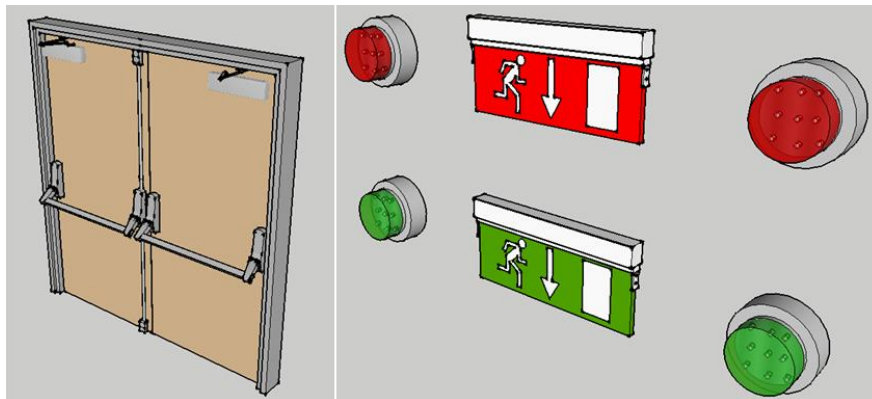
Figure 3: Components of the emergency exits

The exit signs in the virtual environment used the running man pictogram in accordance with the Council Directive of 1992 [17] of the European Parliament. As stated before in the literature review section, the background color for the emergency exit signs was green based on the considered codes [16] [17] [18]. The red exit sign was included in this case with the purpose of making a clear differentiation between the emergency wayfinding systems; this is, in order not to confuse the participants with the intended message.

The colors of the systems were alternated, this is, if the participant chose at the first corridor the exit with the green escape sign and flashing lights at the end of the right side of the corridor, the next room would have the green wayfinding system on the left side of the corridor and the red one on the right side and so on until reaching the outside of the building.

Distances were also taken into account in order to see if people would reconsider their choices when having their color of choice at a longer travel distance. As previously said, every path consisted in five different corridors thus, the subjects under study must have passed through five emergency exits before achieving their objective of arriving to a safe place outside the building.

The variation of the distances was made in the third and fourth corridor of each path, as seen in Figure 2. Once the person entered one of these corridors they would notice that their previous color choice would be now situated in the opposite side at a longer distance from the entrance. This was done in order to see if people would reconsider their previous choice when the distance to walk was longer. The front view of one of the corridors with the exits at the same distance from the entrance can be observed in Figure 4 below.
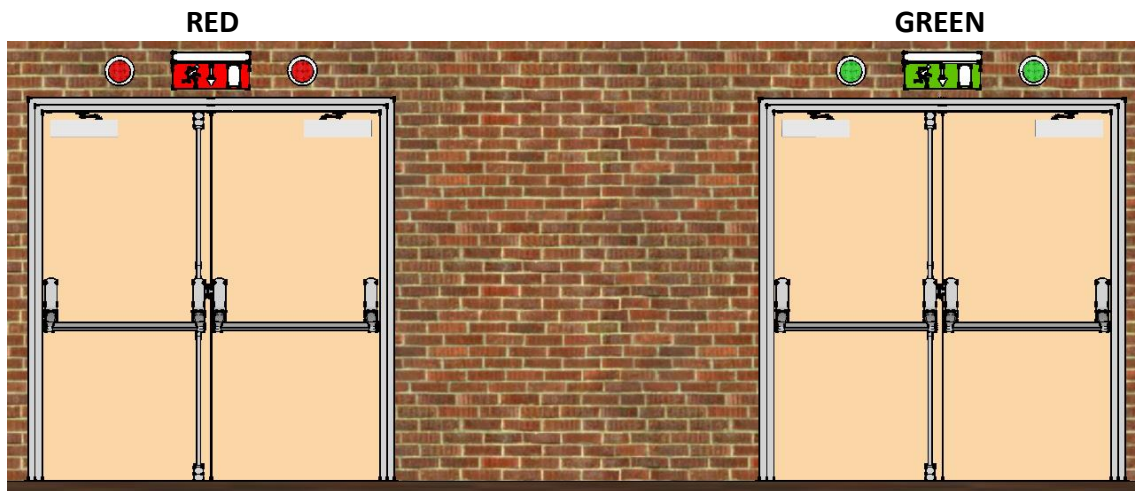
Figure 4: Front view of the emergency exit doors and wayfinding systems

Figure 5 shows a flowchart with the 32 possible corridor combinations in order to get to the outside of the virtual building in which case, each of the exits is enumerated. For each combination, it is also possible to observe the color of the emergency wayfinding systems, the relative direction of the chosen option (right or left) and the distance from the entrance until the exit of the corridors.
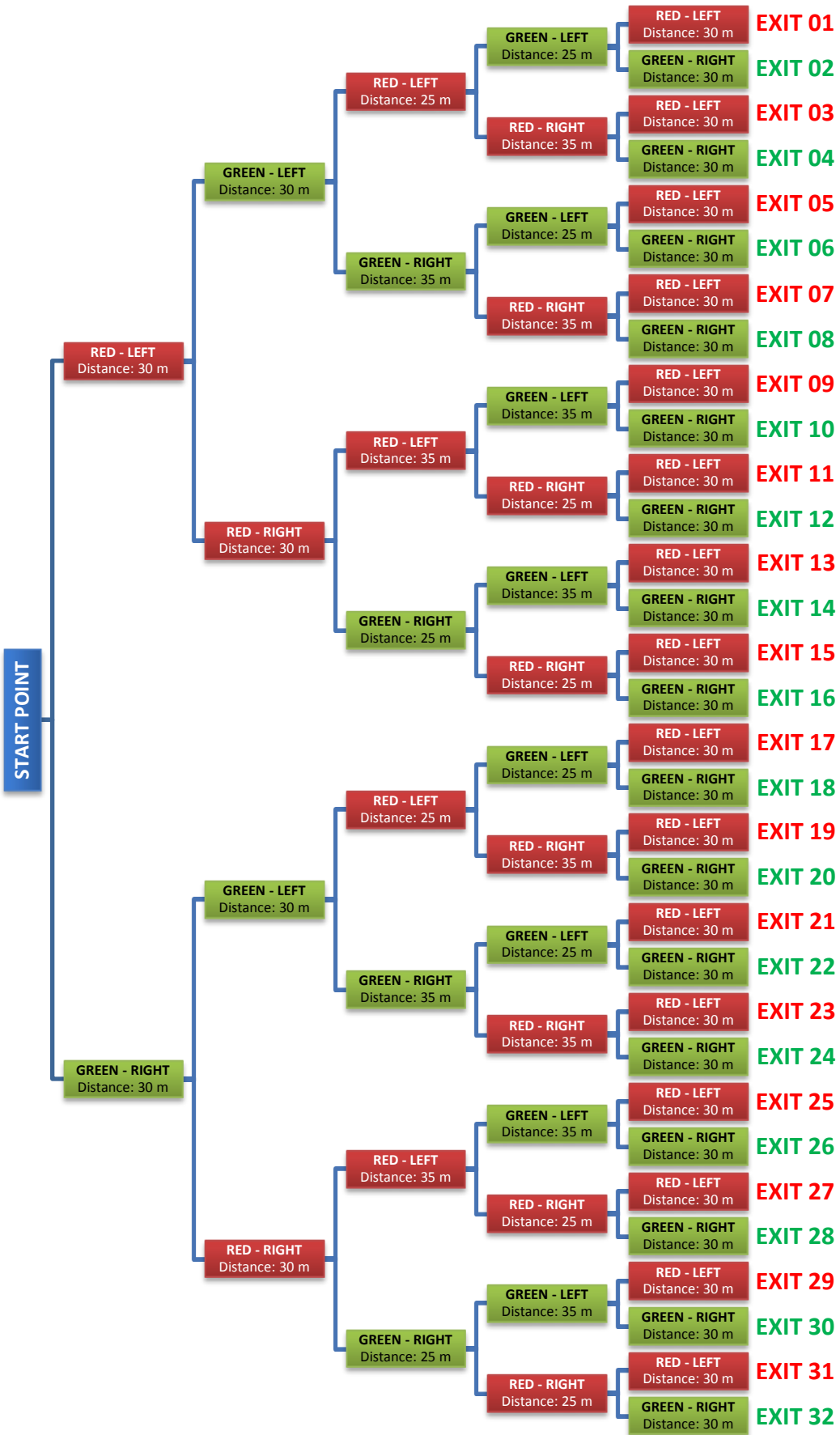
Figure 5: Flowchart with the possible paths for the virtual environment

3.3 Experimental tools

Besides the physical space provided by the university in order to setup the equipment, a combination of software and hardware was utilized to perform the virtual reality experiments with the purpose of collecting observational data. This data was complemented by a questionnaire that was filled out by each participant after the experiment. A description of these tools is given in the subsequent sections.

3.3.1 Google Sketchup Pro

Google Sketchup Pro is a 3D modelling software developed for architectural, design and engineering purposes [20]. This software gives the possibility of recreating environments as they would look in real life by the use prefabricated and self-made textures and models.
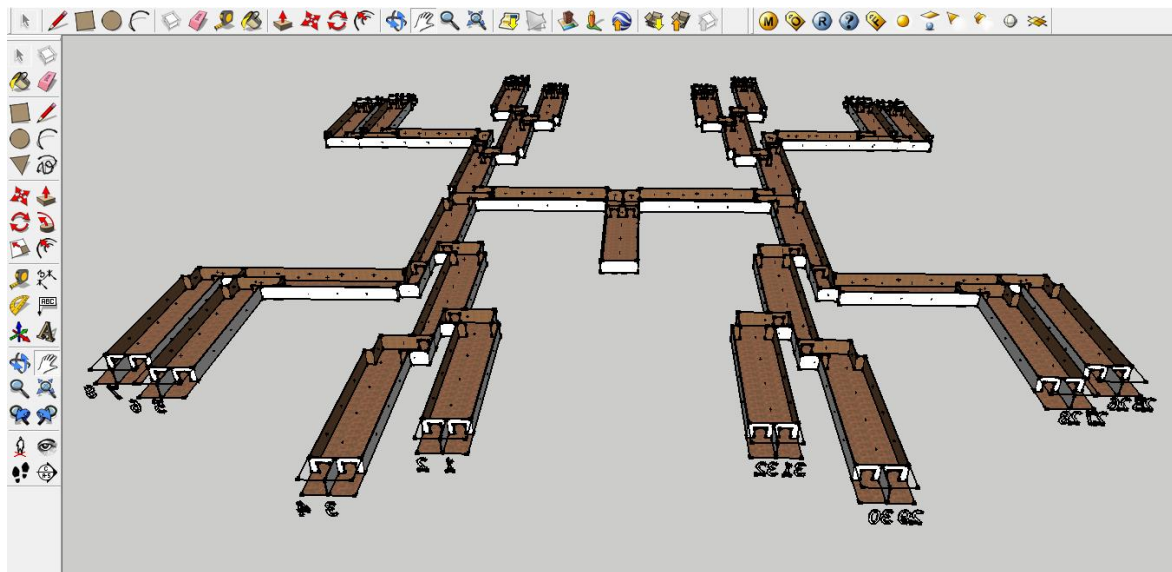
Figure 6: User interface in Google Sketchup 8 Pro

Google Sketchup 8 on its professional version was used for the development of the virtual reality environment on its first stage. The building, doors, exit signs, flashing light devices and the surroundings were created using this computer software.

The professional version of this software gives the option of exporting projects into a compatible format with Unity 3D, the software used in order to achieve the final version of the virtual reality environment.

3.3.2 Unity 3D Pro

Unity 3D Pro is a video-game development software for web, desktop, consoles and mobile platforms [21]. Due to all the tools it offers and the good quality of the graphics was considered as a suitable implement for its use in virtual reality experiments.
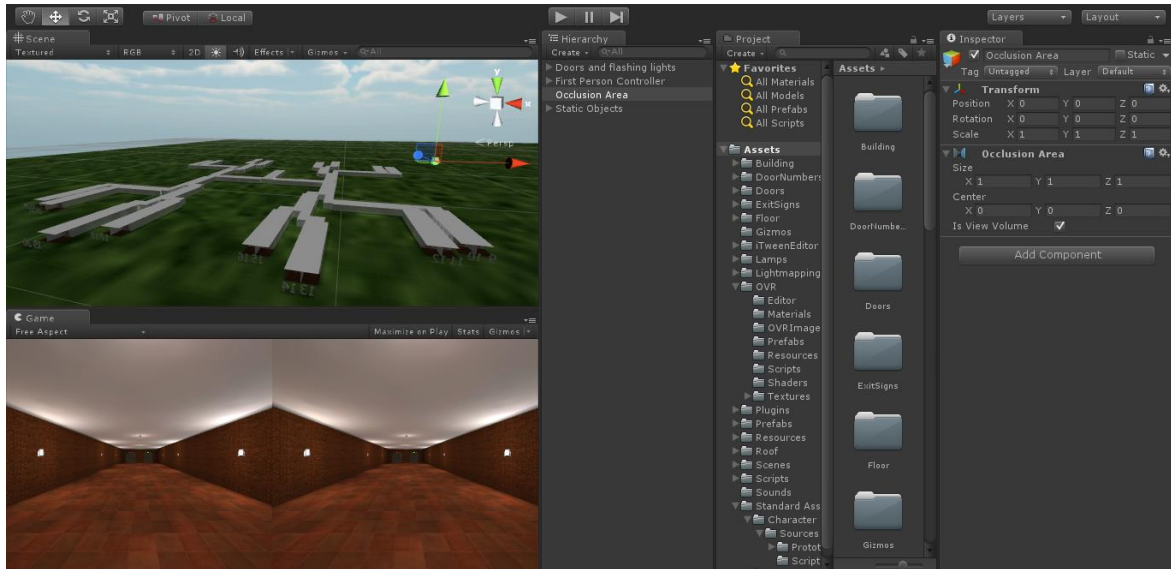
Figure 7: User interface in Unity 3D Pro

After importing the scenario built in Google Sketchup Pro, Unity 3D allowed to add all the features needed for the experiment. By the employment of programming knowledge, it was possible to add movement to the character besides special lighting and sounds effects. This software is compatible with the Oculus Rift device and therefore it was considered as a suitable tool for the purposes of the present study.

3.3.3 Oculus Rift device

The Oculus Rift virtual reality headset, on its development version, is a device designed for immersive gaming [22]. It consists on a headset which provides real-time ultra-low latency 360° head tracking allowing the subject to visualize and to move in the virtual reality environment as it would in real life.

Figure 8: Oculus Rift - Developer Version - Front (CC by 3.0)

Sebastian Stabinger - Own work

The Oculus Rift made possible the interaction between the subject and the virtual environment thanks to the head-tracking feature giving the participant the opportunity to have an immersive experience.

3.3.4 Questionnaire

Once the experiment was finished and before the purpose of their participation was explained to the participants, a questionnaire was filled out by each subject. The questions consisted of five main sections: personal information, previous experience, knowledge about emergency exit signs, feelings during the experiment and color preferences during the virtual reality session. The questionnaire included both open and closed questions. In most of the questions the participants had also the option to add an additional answer in case they did not find the appropriate one among the possible choices. The questionnaire is included in the Appendix 2.

The first section included basic personal information: age, gender, nationality, studies at the university, possible health conditions regarding vision deficiency and questions about the time the participants had been living and Sweden and/or in other countries. These questions were made in order to have a better idea of the possible cultural influence the subject might have experienced.

The second part incorporated questions about previous experience with real fires and fire drills and previous knowledge regarding education and/or training in fire safety. It also covered experience in virtual reality environments and gaming. The objective of this section was to analyze the level of knowledge people had about evacuation and if their performance during the experiments could be related with their previous experience.

The third part was devoted specifically to the emergency exit signs in order to know if people were aware of the colors used for these devices in their home countries and in Sweden.

The fourth part had questions about feelings during the experiment and the perceived level of these feelings. In this section people could mark their perception about red and green and also rank in a scale from 1 to 10 (low to high) the level of perception regarding different feelings during the experiments, namely reality, stress, haste and emergency.

The last section included questions about people's preferences concerning color and distance during the experiment. At the end of the questionnaire, the participants had the option to rank the importance of these variables according to their perception.

After the last questionnaire was filled out, all the data was gathered and analyzed in order to interpret the outcomes and compare them with the expected results.

3.4 Procedure

The preparation of the experiments started with the development of the scenario. Regarding the three objectives of the present study, the virtual reality environment was decided to have a labyrinth disposition as the most suitable way to observe the influence of the color of the emergency wayfinding systems and the distance to the means of egress when having this kind of systems on the exit choices of people with different cultural backgrounds.

As explained in section 3.1, the subjects were recruited using the social networks and by adds posted at the different faculties of the university and also at the various student accommodations. Sixty people took part of the virtual reality sessions, 30 of each group, namely subjects from China and from different European countries.

Each participant had to book a time depending on their time availability in a group scheduling system on the web. After this, every subject was contacted via private message in the social networks in order to confirm their assistance to the meeting. On the scheduled time, the experimenter waited for each participant at the entrance of the Kemicentrum building and, after their arrival, the participants were conducted to the room where the experiments took place. Each session lasted approximately one hour; this time was divided in four parts: a short briefing session, the experiment itself, the filling of the questionnaire and a short discussion about the session.

The briefing session aimed to illustrate to the participants the situation they would face, it included basic information about the employed tools, the utilization of the Oculus Rift device and the gamepad in order to interact with the environment. A short trial was performed before the experiment for the participants to get used to the Oculus Rift and to the controls. After this, a document was handed in to the participants with information about the experiment and possible risks and benefits. With their signature they gave informed consent as voluntary participants of the study.

Before starting with the experiment, they were told that an evacuation was taking place inside the virtual building and that their objective was to leave the place as soon as possible. No comments on the emergency wayfinding systems were mentioned in order not to bias their decisions during the experiment.

After arriving to the outside of the virtual building, the experiment finished and the subject under study had to remove the headset. In that moment, the questionnaire was handed in for them to fill out. After completing the questionnaire, the session finished with an explanation of the purpose of the study. In that moment, the objectives were exposed to the participants and a short discussion about their answers took place.

Once the virtual reality sessions finished the data was gathered and analyzed. In order to achieve this, the software IBM SPSS Statistics 20 [23] was used. First, a chi-square test was performed in order to analyze the possible relationship between the cultural backgrounds of the participants and their preferences during the experiments. Then, the Wilcoxon signed rank test was performed in order to see if on average the subjects ranked the perceived levels of importance of the considered variables in a different way, i.e. one higher than the other one. The considered variables were the color of the emergency wayfinding systems and the distance to the means of egress.

All questionnaires and observed results were subjected to analysis. Information related to the background of the participants, their preferences and perception concerning colors of the emergency wayfinding systems and distances to the means of egress were considered and discussed.

3.5 Ethical aspects

Ethics is an important aspect to consider when performing experiments with human beings. During World War II many experiments were performed in concentration camps in Europe forcing human subjects to take part on them, e.g. research exposing prisoners to malaria, hyperthermia, deadly gasses, viruses, bacterium and poison without any concern for scientific

principles and human rights [24]. Since then, ethical codes have been developed in order to protect people's basic ethical rights even though, thousands of humans were still utilized in experiments during the cold war era (between 1940 and 1974) without their voluntary consents or receiving little information about the possible consequences and risks involved. These experiments were conducted with national security purposes in the United States and they included radiological, chemical and biological research [25].

Ethical rights were stated first in the Nuremberg Code [26]. These rights were extended by the World Medical Association in 1964 and updated in 2004; the document is known as the Declaration of Helsinki [27] in which five ethical principles can be identified: restriction of harm and suffering, outweighing of risks by benefits, informed consent, right to terminate the experiment and protection of integrity. All these principles were considered for the present study.

Possible harm and suffering during or even after the virtual reality session was informed in advance, this is, potential side effects of using the Oculus Rift device. In 1998, a study made by McGee [28] showed that head tracking, a feature of the headset used for the experiments, produces negative effects on users. These side effects are nausea and motion sickness as a result of the perception of apparent motion. In order to minimize the possible side effects of the virtual reality experience, a pitcher containing water was prepared in advance for the participant to drink in case of feeling sick. Before the experiment, each participant was informed that, in case they feel nausea or motion sickness during the experiment, they should immediately remove the headset, remain in the seat and drink some water.

The main benefits of the experiments are the potential results. The direct benefit for the participants was the ticket for the cinema which also encouraged them to take part on the experiments, but most important, the chance of experiencing an evacuation, even if a simulated one, where the participants could practice and find out some facts they were not aware of until the moment of the experiment, namely the color used in Sweden for emergency exit signs and the difference between cultures regarding the different connotations given to colors. The risks, as cited in the previous paragraph, were explained to each subject in the informed consent. Therefore, every subject was aware of the possible consequences of taking part of the experiment.

Before starting the experiment, the informed consent was given to each participant for them to read. This document had a description of the experiment and the potential risks and benefits. In the description, some details about the experiment were avoided in order not to bias the participants' decisions, namely the study of the influence of red and green emergency wayfinding systems and the cultural backgrounds on their decisions.

The possibility to terminate the experiment at any moment, for any reason, was also included in the document as well as the protection of their personal integrity. Data as name and personal numbers was not considered for the study, just basic information in order to maintain the participants' privacy. With their signatures they agreed with the document and their informed consent was given as voluntary participants. This document is included in the Appendix 1.

4. Results

The outcomes of the experiments are presented in the subsequent sections. The data displayed is the result of the observed participants' behavior during the experiments, as well as information given by each subject in the questionnaires.

4.1 Exit choices

Previously, Figure 5 in section 3.1 presented all the possible corridor combinations in order to get to the outside of the building. Only 7 out of the 32 available paths were used by the participants during the experiments. A detailed flowchart of these 7 paths can be observed in Figure 9 below, in which case, the chosen colors of the emergency wayfinding systems, the relative direction of the chosen options (right or left) and the traveled distances for each of the corridors are shown.
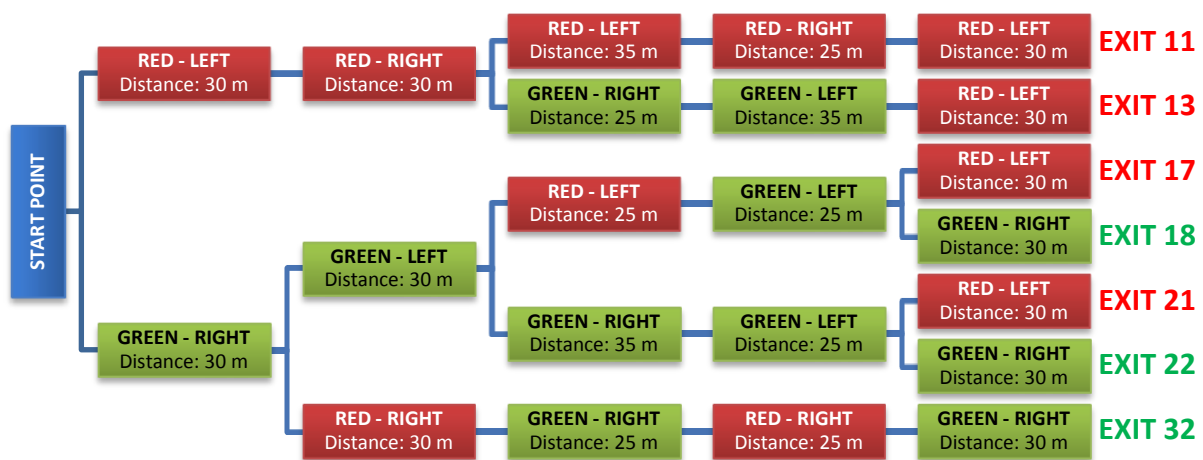
Figure 9: Flowchart with the chosen exits during the experiments

Table 3 displays the number of participants choosing each of the 7 paths presented in Figure 9. It can be also noticed that merely one person chose the path with the prevalence of the red wayfinding systems, namely the one leading to exit number 11. In the cases of exits number 13 and 32, 1 and 2 participants selected the paths leading to them, respectively. These 3 options were considered as special cases because of the quantity of participants making these choices and their explanations about their decisions during the discussion sessions; 6.7% of the studied sample went through these 3 exits.

As it can be observed, people chose green in a greater percentage than for the other options, followed by the choices where the shortest distance to the exits was present. The fact of having different colors at the emergency exits was confusing for some of the participants, in which case, they stood for a couple of seconds in front of the exits in order to analyze the difference between the emergency wayfinding systems before making a decision.

		EXIT CHOICE							
		Exit 11	Exit 13	Exit 17	Exit 18	Exit 21	Exit 22	Exit 32	Total
Nationality	Chinese	1	0	1	3	1	23	1	30
	% within nationality	3.3%	0.0%	3.3%	10.0%	3.3%	76.7%	3.3%	100.0%
	European	0	1	2	6	1	19	1	30
	% within nationality	0.0%	3.3%	6.7%	20.0%	3.3%	63.3%	3.3%	100.0%
	Count	1	1	3	9	2	42	2	60
Total	% within nationality	1.7%	1.7%	5.0%	15.0%	3.3%	70.0%	3.3%	100.0%

Solely 4 of the 7 chosen exits to the outside of the building, this is, exits number 17, 18, 21 and 22, were considered relevant for the analysis regarding the objectives of the present study, namely the influence of the color of the emergency exits signs in combination with flashing lights and the distance to the means of egress when having these wayfinding systems on the exit choices of people with different cultural backgrounds. Therefore, these four options were grouped into two categories: green wayfinding systems and distance.

The green wayfinding systems preference group considered the people selecting the green exit signs and flashing lights during the whole path no matter the distance to the exits in the cases in which the participants had to deal with it, namely on the third and fourth corridor of each path where the possible emergency exits were located at different distances from the entrance of the corridor. On the other hand, the distance preference group included the subjects which at the third and fourth corridor preferred to take the closest emergency exit reconsidering their previous color choice for the exit signs and flashing lights. Taking this into consideration, the subjects taking exits 21 and 22 were grouped into the green wayfinding systems preference group and the participants choosing exits number 17 and 18 were merged into the distance preference group. These rearrangements can be observed in Table 4 below, in which case, the participants choosing the remaining 3 paths were considered in the group categorized as "Other".

Table 4: Nationality by preference

			PREFERENCE			
			Green Wayfinding Systems	Distance	Other	Total
Nationality	Chinese	Count	24	4	2	30
		% within Nationality	80.0%	13.3%	6.7%	100.0%
	European	Count	20	8	2	30
		% within Nationality	66.7%	26.7%	6.7%	100.0%
Total		Count	44	12	4	60
		% within Nationality	73.3%	20.0%	6.7%	100.0%

Table 4 shows a positive trend in favor of the green wayfinding systems and distance groups. It can be noticed that 56 out of the 60 participants (93.3%) had a preference for these two groups. The remaining 4 participants (6.7%) were considered as "Other" or special cases; these cases are further treated in subsection 4.1.3.

4.1.1 Wayfinding systems preference

Forty-four participants (73.3%), 24 Chinese and 20 Europeans preferred the exits with the green emergency wayfinding systems. As it can be noticed in Figure 10, the participants made their choices in the third corridor no matter the distance, in other words, the subjects were prone to travel a longer distance in order to get to the exit with the green exit sign and flashing lights. Some of the subjects of this group expressed that, even though green was their color of choice, in case the distance to the means of egress was longer, they would probably have reconsidered their exit choices because, in that case, going for the option with their color of preference would

make their evacuation of the building longer. In the present study, the distance between the emergency exits in the third and fourth corridors was 1/3 of their total length. This distance was considered suitable in order not to biased people in their exit choices.

Figure 10 also shows the difference between the merged paths leading to exits number 21 and 22. This difference was in the participants' final exit choice in which case the one leading to exit number 21 had the red wayfinding system while number 22 had the green one. The participants choosing exit 21 expressed making this decision at the final exit because, after exiting through 4 consecutive corridors, they were not sure about the possibility of leaving the building, therefore their reconsideration at the final exit choice and, after this, their inclusion in the green wayfinding systems preference group. Exit 21 was chosen by 2 subjects (3.3%) meanwhile 42 participants (70.0%) went for exit number 22.
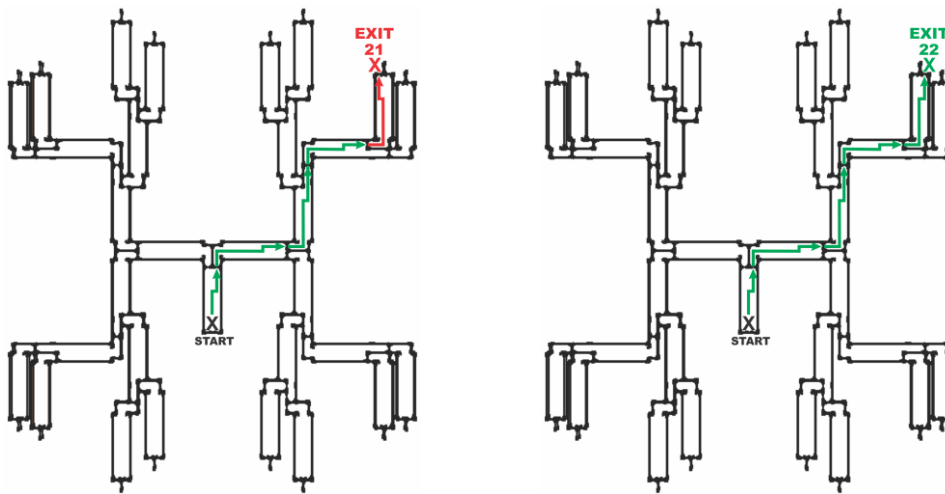
Figure 10: Floor plans showing the paths leading to exits number 21 and 22

In the questionnaire, there were questions concerning people's color preferences for the emergency wayfinding systems during the experiment. For the participants choosing the green exit signs and flashing lights, Table 5 shows that, 37 subjects (61.7%) had a preference for a specific color during the experiments, namely green, while 3 participants (5.0%) did not have any preference for a particular color. The rest of the subjects choosing green as the color of preference, namely 4 subjects (6.7%), expressed that they did not care about the color of the wayfinding systems.

Table 5: Preferences concerning color during the experiments

			Any color preference during the experiment?				Total	If yes. Which one?	
			Yes	No	I did not care	Other		Green	Red
Nationality	Chinese	Count	18	3	3	0	24	18	0
		% within nationality	60.0%	10.0%	10.0%	0.0%	80.0%	60.0%	0.0%
	European	Count	19	0	1	0	20	19	0
		% within nationality	63.3%	0.0%	3.3%	0.0%	66.7%	63.3%	0.0%
Total		Count	37	3	4	0	44	37	0
		% within nationality	61.7%	5.0%	6.7%	0.0%	73.3%	61.7%	0.0%

4.1.2 Distance preference

Twelve participants (20%), 4 Chinese and 8 Europeans, had their preference on the shortest distance to the means of egress rather than the color of the emergency wayfinding systems in those exits. As it can be noticed in Figure 11, in the third and fourth corridor, the participants decided to go for the closest emergency exits, first going by the one with the red emergency wayfinding system and then through the exit with the green exit sign and flashing lights. During the whole path, the subjects had a clear preference for the color green but, when they got into the third corridor, they changed their minds and went for the closest exit with the red emergency wayfinding system.
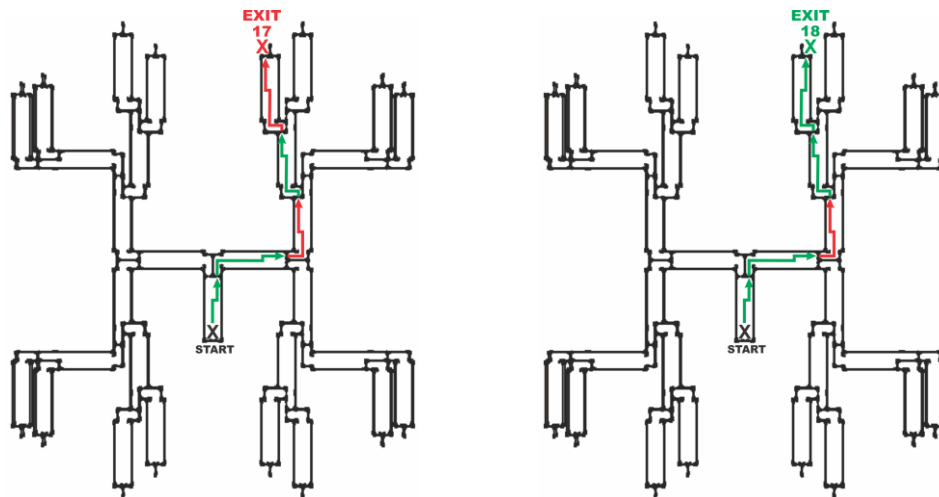
Figure 11: Floor plans showing the paths leading to exits number 17 and 18

As observed in Figure 11, the only difference between the paths leading to exit number 17 and 18 was, as for the wayfinding systems preference, in the participants' final exit choice, in which case, number 17 had the red wayfinding system and number 18 the green one. The participants choosing exit 17 expressed making this decision at the final exit because, after exiting through 4 consecutive corridors, they were not sure about the possibility of leaving the building, therefore their reconsideration at the final exit choice and, after this, their inclusion in the distance preference group. Exit number 17 was chosen by 3 subjects (5.0%), whereas 9 participants (15.0%) went for exit number 18.

In the questionnaire, there were questions concerning the participants' preferences in the third and the fourth corridor when dealing with the different distances to the means of egress. For the participants choosing the shortest distance to the means of egress in these corridors, Table 6 shows that, 7 subjects (11.7%) stated taking the closest door meanwhile 4 participants (6.7%) answered that they continued using the same color for the wayfinding systems at the emergency exits. The European subject choosing the "Other" option expressed a preference for the exits with the green emergency wayfinding systems but, when realizing that the evacuation was not successful after two corridors, this person decided to go for the closest exit which had the red exit sign and flashing lights.

Table 6: Preferences concerning distance during the experiments

| | | | Any distance preference during the experiment? | | | |
			I continued using the same color	I preferred to use the door that was closer to me	Other	Total
Nationality	Chinese	Count	2	2	0	4
		% within nationality	6.7%	6.7%	0.0%	13.3%
	European	Count	2	5	1	8
		% within nationality	6.7%	16.7%	3.3%	26.7%
Total		Count	4	7	1	12
		% within nationality	6.7%	11.7%	1.7%	20.0%

4.1.3   Special considerations

Four participants (6.7%) were considered as special cases and categorized as "Other" in the observed results because of their exit choices during the experiments. This group of four persons consisted in two Chinese and two Europeans.

In both groups of participants there were subjects choosing exit number 32. One Chinese and one European had this preference. As seen in Figure 12, door 32 represented a preference for the closest doors on the way to the outside of the building. During their evacuation, the participants also chose an exit with the red lighting system in the second corridor where the exits were at the same distance from the entrance of the corridor. These two participants expressed after the experiments that they wanted to see what they could find behind the door with the red sign and flashing lights. Therefore, these subjects were excluded from the main groups under consideration.
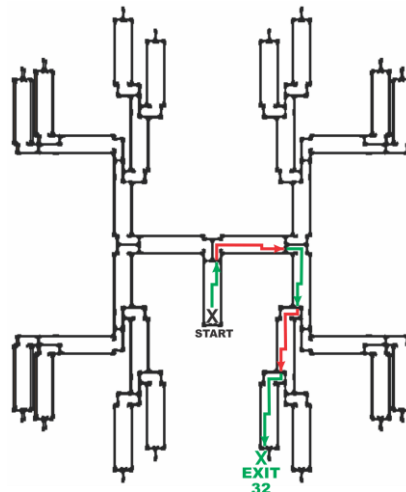
Figure 12: Floor plan showing the path leading to exit number 32

Only one person of the European group chose exit number 13. As observed in Figure 13, this path included three exits with the red emergency wayfinding systems and two with the green exit signs and flashing lights. In three of the five corridors, where the exits were at the same distance from its entrance, this person chose the exits with the red signs and flashing lights. The green emergency wayfinding system was chosen in the corridors where the distances to travel to the exits were different; in other words, in one case the emergency exit was closer to the entrance of the corridor and in the next one was further away. This participant stated focusing on finding the way out of the building rather than in the colors of the exit signs and flashing lights or the distances to the means of egress. Therefore, this subject was considered as an isolated case.

Figure 13: Floor plan showing the path leading to exit number 13

Merely one person from the sample chose the path with the red wayfinding systems during the whole path. This person belonged to the Chinese group and argued making these choices based on the fact that red was the catchiest color at the starting point and, once making the first decision, this person preferred to keep using the same color for the following emergency exits in order to find the way out. This subject chose the red emergency wayfinding systems relating this color with the one used for fire extinguishers and fire trucks. Figure 14 below illustrates the path followed by the subject.

Figure 14: Floor plan showing the path leading to exit number 11

4.2 Relationship between cultural backgrounds and preferences

The chi-square test was applied in order to verify the relationship between the considered variables, namely the nationality of the participants and their preferences during the experiments. The preferences, as stated in section 4.1, included the green emergency wayfinding systems at the different emergency exits and the shortest distance to the means of egress when having this kind of systems. The special cases considered as "Other", were not relevant for the purpose of the present study and therefore, they were excluded at the moment of performing the chi-square

test. This test indicates if there is an association between the variables but not the degree or the kind of association in case the relationship exists.

Table 7 presents the crosstabulation of the nationality by the preference of the studied sample. The SPSS software [23] was used in order to get the results displayed in this section.

Table 7: Nationality by preference crosstabulation for the Chi-Square test

| | | | PREFERENCE | | Total |
			Green Wayfinding Systems	Distance	
Nationality	Chinese	Count	24	4	28
		Expected Count	22.0	6.0	28.0
		% within Nationality	85.7%	14.3%	100.0%
	European	Count	20	8	28
		Expected Count	22.0	6.0	28.0
		% within Nationality	71.4%	28.6%	100.0%
Total		Count	44	12	56
		Expected Count	44.0	12.0	56.0
		% within Nationality	78.6%	21.4%	100.0%

The null-hypothesis in this case was "there is no relationship between the nationalities of the participants and their preferences for the green emergency wayfinding systems or the shortest distance to the means of egress when having this kind of systems during the experiments" and therefore, no significant association between people's cultural backgrounds and their exit choices can be shown. For this case, the level of significance was considered to be 5.0%.

The results of the Chi-Square test, χ^2 (1, N = 56) = 1.697, p = .193 show that, there was no statistically significant association between the participants' nationalities and their preferences during the experiments, in other words, no difference could be observed between the preferences for the green exit signs in combination with flashing lights and the shortest distance to the means of egress when considering Chinese and European subjects in Sweden. Therefore, it could be said that, according to these results, the null hypothesis presented in the previous paragraph is not rejected.

4.3 Perceived importance of color and distance

Tables 8 and 9 show a summary of the participants' answers regarding the importance given to the color of the wayfinding systems and to the distance to the means of egress when having this kind of systems, respectively.

It can be observed in Table 8 that, for the proposed scale, more than half of the subjects rated the color of the wayfinding systems with a high score, namely 32 participants (53.3%). On the other hand, concerning distances to the means of egress (Table 9), the group of participants rated distance in a similar distribution, being the high score the most chosen option; 14 participants (23.3%) considered this variable as highly important.

Table 8: Perceived importance of the color

| | | | IMPORTANCE OF THE COLOR | | | | | |
			Low	Medium Low	Medium	Medium High	High	Total
Nationality	Chinese	Count	3	1	2	9	15	30
		% within Nationality	10.0%	3.3%	6.7%	30.0%	50.0%	100.0%
	European	Count	2	3	1	7	17	30
		% within Nationality	6.7%	10.0%	3.3%	23.3%	56.7%	100.0%
Total		Count	5	4	3	16	32	60
		% within Nationality	8.3%	6.7%	5.0%	26.7%	53.3%	100.0%

In a scale from 1 to 10: 1-2=Low; 3-4=Medium Low; 5-6=Medium; 7-8=Medium High; 9-10=High

Table 9: Perceived importance of the distance

| | | | IMPORTANCE OF THE DISTANCE | | | | | |
			Low	Medium Low	Medium	Medium High	High	Total
Nationality	Chinese	Count	5	6	7	4	8	30
		% within Nationality	16.7%	20.0%	23.3%	13.3%	26.7%	100.0%
	European	Count	7	5	5	7	6	30
		% within Nationality	23.3%	16.7%	16.7%	23.3%	20.0%	100.0%
Total		Count	12	11	12	11	14	60
		% within Nationality	20.0%	18.3%	20.0%	18.3%	23.3%	100.0%

In a scale from 1 to 10: 1-2=Low; 3-4=Medium Low; 5-6=Medium; 7-8=Medium High; 9-10=High

The Wilcoxon signed rank test was performed in order to see if on average the subjects ranked the perceived levels of importance of the considered variables in a different way, i.e. one higher than the other one. The considered variables were the color of the emergency wayfinding systems and the distance to the means of egress shown in Tables 8 and 9. The level of significance was considered to be 5.0%. Tables 10, 11 and 12 show the results of this test performed using the SPSS statistical software [23].

In this case, the entire sample was included in the analysis because the participants' performance during the experiments was not considered to play an important role in the perceived level of importance they might have had about the color of the emergency wayfinding systems and the distance to the means of egress in case of an evacuation.

As observed in Table 10, for the proposed scale (from 1 to 10) the mean value for the color of the wayfinding systems was 7.87 (Medium high) and for the distance 5.55 (Medium) with a standard deviation of 2.600 and 3.078, respectively.

Table 10: Descriptive statistics for the Wilcoxon Signed Rank test

	N	Mean	Std. deviation	Minimum	Maximum
Wayfinding Systems' Color	60	7.87	2.600	2	10
Distance	60	5.55	3.078	1	10

The ranks in Table 11 show clearly that more participants gave a higher score to the color of the wayfinding systems, namely 37 participants (61.7%). On the other hand, 15 subjects (25%) gave more importance to the distance to the means of egress and 8 participants (13.3%) considered the color and the distance equally relevant at the moment of choosing an evacuation route.

Table 11: Ranks for the Wilcoxon Signed Rank test

		N	Mean Rank	Sum of Ranks
Distance – Wayfinding Systems' Color	Negative Ranks	37[a]	29.42	1088.50
	Positive Ranks	15[b]	19.30	289.50
	Ties	8[c]		
	Total	60		

a. Distance < Wayfinding Systems' Color
b. Distance > Wayfinding Systems' Color
c. Distance = Color

Table 12 presents the outcomes of the test statistics for the Wilcoxon signed rank test. It can be observed that, the value for the asymptotic significance is below the considered level of significance of .050; therefore, a clear significant difference between the scores given to the color of the wayfinding systems and the distance to the means of egress was present.

Table 12: Test statistics for the Wilcoxon Signed Rank test

	Distance - Green Wayfinding Systems
Z	-3.647[a]
Asymp. Sig. (2-tailed)	.000

a. Based on positive ranks

For this case the trend shows that, in case of evacuation, the color of the exit signs and flashing lights is more important than the distance to the means of egress; in others words, the participants will be prone to walk more if their color of choice for the wayfinding systems is at a longer distance when having to choose between two different exit options.

5. Analysis and discussion

The present study displayed results concerning the influence of the color of the emergency wayfinding systems and the distance to the means of egress when having these systems on the exit choices of people with different cultural backgrounds. Observed behavior during the experiments and data gathered from the questionnaires were used in order to present the results.

This section includes a discussion on the previously presented results. The participants' behavior was analyzed taking into account their individual characteristics and their preferences concerning the variables under study. Ethical aspects were also considered during the whole data collection process in order to protect the participants' integrity and rights.

As expressed in section 3.1, all the participants stated being aware of the color used for the emergency exit signs in their home countries; therefore, the color green was supposed to be familiar to the subjects under study when considering emergency exit signs. This could explain their choices in the corridors where distances were different. On the other hand, the trend indicates that, the distance to the emergency exits might be less important when the green wayfinding systems are at a longer travel distance from the entrance of the corridors. As expressed by Sime [29], in some occasions people can be attracted by an exit at a longer travel distance in case they feel more familiar to it as for the present study, where most of the participants felt more familiar with the emergency exits with the green wayfinding systems located further in the third corridor of the selected path.

The distance between two possible exit options might play a role in the cases where this one is greater compared to the total length of the corridor. In this case in particular, in the third and the fourth corridor of each possible path the difference between the two emergency exits was 1/3 of the total length of the corridor. As expressed in section 4.1.1, some of the participants stated that they would have reconsidered their choices in case the distance between the exits was longer.

When having to choose between red and green emergency wayfinding systems at the means of egress, the subjects preferred the green ones because of the feeling of safety. This situation agrees with the study made by Johansson and Petersson [8], in which case, the majority of the participants consistently preferred the exits with the green flashing lights rather than the ones with red because of the perception of being the safest choice.

Having different colors at two emergency exits in the same location might become a bit confusing for people due to the fact that, in real life, this situation is not normally given. This was observed during the experiments in the cases in which the participants stood for some seconds in front of the exits before making a decision. They stated that, first they compared the exit signs in order to find any other difference besides the color of the signage. After confirming no other difference, they decided which exit to take.

The results show that green was the color of preference despite the different connotations this color might have from culture to culture. Green was perceived by most of the participants as meaning safety in case of an emergency. Most of the experiments analyzed in previous sections [2] [4] [5] [8] showed this perceived feeling of safety the color green gives to people in case of an emergency. Only one person (1.67% of the sample) had a clear preference for the red emergency

wayfinding systems. This case was considered as an isolated one. Therefore red, as observed in studies performed in exit choices [1] [2] [8] is considered as a color with a negative perception in case of emergencies.

Exit choices might be different in the case where the subjects under study come from countries in which, considering the safety codes, the color used for emergency wayfinding systems is red, i.e. United States and Canada. Further research could be made considering participants from these countries.

The consideration of merging groups of participants exiting the building through four different exit doors into two groups was made based on the subjects' statements. Participants said that they decided to go for the exit with the red lights in the last corridor due to the fact that, after passing through four consecutive corridors without succeeding on their goal of evacuating the building, they decided to investigate what they could find behind the exit with the red wayfinding system; they also stated that, in another case, they would just continue using the green exit signs and flashing lights because they considered them as the safest options. These situations can be observed in the paths having exits number 17 and 21 merged with 18 and 22, respectively. These paths were fused into the green wayfinding systems and distance preference groups.

Some of the answers given by the participants in the questionnaires are not fully consistent with the actions performed by them during the experiment. It could be observed that, some of the subjects under study did not realize what they had chosen during the experiments and their answers about these choices in the questionnaire. In the observed behavior during the experiments, 12 persons (20.0%) were considered to have chosen the closest exit and 44 persons (73.3%) to have continued using the same wayfinding systems' color. The answers of these participants in the questionnaire showed first that, 7 out of the 12 subjects cited before were aware of choosing the closest exit. For the second case, 37 out of the 44 subjects stated using the same color of the exit signs and flashing lights during the whole path. Therefore, a difference of 41.6% and 15.9% respectively could be observed between the observed and perceived behavior for these two items.

The chi-square test showed no statistically significant association between the participants' cultural backgrounds and their exit choices during the experiments, meaning that, knowing the nationality of the participants would not give much confidence about their preferences during the experiments.

In general and taking into account the three objectives of the present study, the most relevant result would be the influence of the color of the wayfinding systems in people's exit choices. People with different cultural backgrounds, namely Chinese and Europeans in Sweden, tend to have the same perception for the colors red and green in case of an emergency and, as observed during the experiments, in most of the cases the participants went for green as the color of preference, the safest one according to their perception. This statement can be reinforced with the results obtained in the Wilcoxon signed rank test, in which case, a significant difference between the scores given by the participants to the color of the wayfinding systems and the distance to the means of egress could be noticed. The outcomes of this test showed that, more

participants gave a higher level of importance to the color of the exit signs and flashing lights than to the distance to the emergency exits.

As the experiments were performed with one participant at a time, the implication of social influence was not considered. The participants might have behaved in a different way in a situation with more people present due to the possible influence of their behavior in the decisions of the subjects under study, as suggested in a previous study performed by Nilsson and Johansson [30]. It is difficult to know to which extend this situation might have biased the participants' exit choices using virtual reality due to the fact that, having more than one participant at a time was limited by the technology used for the experiments.

6. Conclusions

The present study suggests that having red and green emergency wayfinding systems as options at the means of egress influences people's choices. The trend showed that, even though some subjects doubted before making their decisions, most of them would go for the green emergency wayfinding systems. In both groups, the majority of the participants considered this color as the most suitable option due to the meaning the color green had for them in case of an emergency. Participants were aware that green, as when used in traffic lights, means go and safety and red, stop and danger.

Distance might not play an important role in people's decisions when the color of the wayfinding system they consider as safe is at a longer travel distance. Results indicate that more people give a higher importance to the color of the emergency wayfinding systems than to the distance to the means of egress; in other words, the considered subjects will be prone to walk a longer distance in order to reach the exit with the color of choice.

The study also shows that, considering Chinese and European subjects in Sweden, no influence of the cultural backgrounds can be observed concerning people's exit choices in case of a simulated evacuation. Although traditions and culture might play an important role on the participants' ways of thinking and behaving, it could be noticed that the meaning they give to a certain color seems to depend more on the situation. Even when red has a very positive meaning for the Chinese culture, the participants made a differentiation in case of emergency; for them red means danger, keep away and keep out, as it was for the case of the European subjects.

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Appendix 1 – Informed consent for experimental participants

Informed Consent for Experimental Participants

Please read the following information carefully. If you have any doubts, do not hesitate to ask the person in charge of the experiments.

Experiment: Response to evacuation systems.

Person in charge: Jorge Troncoso. Erasmus Mundus master student.

Institution: Faculty of Engineering - Lund University.

DESCRIPTION: You were invited to participate in an experiment that uses virtual reality in order to study the response of people to certain aspects in a virtual environment. You will be asked to move around this environment in order to find the way out in case of a simulated emergency. After the virtual reality session is finished, you will be asked to fill out a questionnaire. Your integrity and privacy will be maintained during the study.

POTENTIAL RISKS AND BENEFITS: During the experiment you could experience some nausea and motion sickness due to the immersive experience the Oculus Rift device offers. In case this happens, we advise you to remain in your seat, take off the headset and drink a glass of water. Benefits of your participation will be getting a ticket for the cinema in Lund.

TIME INVOLVEMENT: Your participation in this test will take approximately 30 minutes.

SUBJECT'S RIGHTS: Your participation in this experiment is voluntary. You have the right to withdraw from the study at any moment without fear of retribution. This means that in case you feel like terminating the experiment for any reason, you can do it. For your participation you will get a cinema ticket.

In case you agree with all the information stated above, please sign below. With your signature you confirm the following conditions:

- You have read this informed consent document, understood it and agreed to it.
- You are willing to take part as a volunteer of the present experiment.

Name: _____

Date: _____ Signature: _____

Appendix 2 – Questionnaire virtual reality experiments

<table>
<tr>
<td rowspan="2">QUESTIONAIRE VIRTUAL REALITY EXPERIMENT</td>
<td>SUBJECT CODE: ☐ EU ☐ CH _____</td>
</tr>
<tr>
<td>CHOSEN EXIT NUMBER: _____</td>
</tr>
<tr>
<td colspan="2">PERSONAL INFORMATION</td>
</tr>
<tr>
<td>Age:</td>
<td>Gender ☐ Male ☐ Female</td>
</tr>
<tr>
<td>Nationality:</td>
<td>Studies:</td>
</tr>
<tr>
<td colspan="2">Do you have color vision deficiency? (i.e. color blindness) ☐ Yes ☐ No

If yes. Which kind of color blindness? ☐ Total ☐ Red-Green ☐ Blue-Yellow ☐ Other: _____</td>
</tr>
<tr>
<td colspan="2">IF YOU ARE NOT ORIGINALLY FROM SWEDEN</td>
</tr>
<tr>
<td colspan="2">How long have you been living outside your home country? ☐ 1 semester ☐ 1 year ☐ Other: _____

Have you lived in another country before living in Sweden? ☐ Yes ☐ No

If yes. Where? _____ For how long? _____</td>
</tr>
<tr>
<td colspan="2">PREVIOUS EXPERIENCE</td>
</tr>
<tr>
<td colspan="2">Do you have any previous experience with evacuation drills? ☐ Yes ☐ No

If Yes. With which frequency? ☐ Every year ☐ Every six months ☐ Other: _____</td>
</tr>
<tr>
<td colspan="2">Do you have any previous experience with real fires? ☐ Yes ☐ No

If yes. Describe the situation: _____</td>
</tr>
<tr>
<td colspan="2">Do you have any training or previous education in fire safety? ☐ Yes ☐ No

If yes. Which kind of training? ☐ Fire Safety training ☐ Other: _____</td>
</tr>
<tr>
<td colspan="2">Do you have any previous experience in a virtual reality environment? ☐ Yes ☐ No

If yes. Describe the situation: _____</td>
</tr>
<tr>
<td colspan="2">What is your experience with gaming? ☐ Computer games ☐ Video games (Playstation, Nintendo, etc) ☐ None

If some previous experience. For how long? ☐ Less than 1 year ☐ Between 1-5 years ☐ Other: _____</td>
</tr>
<tr>
<td colspan="2">KNOWLEDGE ABOUT EMERGENCY EXIT SIGNS</td>
</tr>
<tr>
<td colspan="2">Do you know the color of exit signs in your home country? ☐ Yes ☐ No

If Yes. Which one? ☐ Green ☐ Red ☐ Blue ☐ Yellow ☐ Other: _____</td>
</tr>
<tr>
<td colspan="2">Do you know the color of exit signs in Sweden? ☐ Yes ☐ No

If Yes. Which one? ☐ Green ☐ Red ☐ Blue ☐ Yellow ☐ Other: _____</td>
</tr>
<tr>
<td colspan="2">FEELINGS DURING THE EXPERIMENT</td>
</tr>
<tr>
<td>What is your perception when you see RED exit signs and lights?</td>
<td>☐ Safety ☐ Danger ☐ Warning keep away

☐ Warning keep out ☐ Nothing in particular</td>
</tr>
<tr>
<td>What is your perception when you see GREEN exit signs and lights?</td>
<td>☐ Safety ☐ Danger ☐ Warning keep away

☐ Warning keep out ☐ Nothing in particular</td>
</tr>
<tr>
<td>Which level of reality did you perceive during the experiment?</td>
<td>Low | Medium | High
1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>Which level of stress during the experiment?</td>
<td>Low | Medium | High
1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>Which level of haste during the experiment?</td>
<td>Low | Medium | High
1 2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>Which level of emergency during the experiment?</td>
<td>Low | Medium | High
1 2 3 4 5 6 7 8 9 10</td>
</tr>
</table>

COLOR PREFERENCES DURING THE EXPERIMENT
Did you have any preference concerning the color of the emergency exit signs and lights during the experiment? ☐ Yes ☐ No ☐ I did not care about it ☐ Other: _____ If yes. Which one? ☐ Red ☐ Green
When referring to the exits where you had to choose between the distances you had to travel ☐ I continued using the same color ☐ I preferred to use the door that was closer to me ☐ Other: _____
Two of the rooms in the building, the third and the fourth, were situated at different distances. One was closer than the other one. What is the importance of the distance to the door when choosing an emergency exit?

For the distance question:

Low				Medium					High
1	2	3	4	5	6	7	8	9	10

The disposition of the lights in the building was alternated. In the first room the green lights were at the right side of the corridor and the red ones at the left side. In the next room they were at opposite sides, and so on with the following rooms.

What is the importance of the color of the exit sign and the lights at the door when choosing an emergency exit?

Low				Medium					High
1	2	3	4	5	6	7	8	9	10