Multidimensional Emergency Signage Design

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ABSTRACT

Emergency signage plays an important role in helping building occupants find a safe route in both circulation and evacuation circumstances. During threatening emergencies and disaster events, most people experience high levels of stress and fear that adversely affect programs incorporating adaptive risk perception and decision-making. A currently problem exists in the fact that evacuation signage is often overlooked, and the misinterpretation of the meaning of signs is a problematic issue. Due to this, disaster incidents caused by signage's misconception have increased in recent years. During threatening emergencies and disaster events, most people experience high levels of stress and fear, which adversely affect programs incorporating adaptive risk perception, decision-making.

The important issues related to an emergency exit signage were studied by many researchers intended to improve the effectiveness of an information perceiving process to viewers. A majority number of related studied were focused on the visibility of the signage and the positioning and placement of the emergency exit signage respectively. Although these studies have useful examined visibility ability of an emergency exit signage, size and dimension of signage, and the positioning of exit signage, however the area of human behavior related to the process of perceiving a direction information were limited. For this

reason, the Research Question (RQ) we asked focuses on experiments to investigate how we can improve signage in an emergency situation: how accurate individuals accept information conceived by emergency signage? The aim of this study investigated how to make improvements of emergency signage located internally. This study aims to explore the influence of elements on existing signage due to the way-finding process accordingly.

This research study contained a series of continuous experiments related to information on direction conceived by emergency signage. In this study, we focused on the British format signage as a selected testing subject, due to the fact that British format emergency signage was presented and used in many continents around the world. The preliminary experiment of the research study was set up to test the efficiency and accuracy of the existing format of emergency signage. The preliminary experiment of the research study revealed that an average of 40.75 percent of participating participants were misled by the interpretation of emergency signage information, especially where the visual field or location of the sign is limited. Furthermore, the research discovered three primary factors that affect the occupants' perception when following instructions, which are i) the perception of direction, ii) signage positioning and placement, and iii) signage visibility. The overall results signify the need for emergency signage development to improve safety during emergencies and help save people's lives.

This study examined a comparison of emergency signage and alternative approach to an emergency signage design (Multidimensional Emergency Signage) under experimentation through a set of questionnaire responses, including an in-depth interview and the stimulation of emergency evacuation tests. Continuous experiments were conducted, and data were collected and analyzed to indicate and identify significant points for the improvement of emergency signage by using the visual detection method and additional analysis through the ANOVA and pairwise comparison methods. A series of experiments were conducted involving 127 participants, mixed in genders and nationalities to evaluate the accuracy and effectiveness of emergency signage in both British format emergency signage and the alternative approach on emergency signage.

The continuous experiments in this research including effectiveness information of direct guidance on signage and simulation of an evacuation task revealed that a multidimensional approach to emergency signage can decrease an error of wayfinding by 84.45%. The analyzed eye-tracking data showed that the multidimensional approach to emergency signage significantly decreased the time consumption participants needed to conceive the direction information. When this additional data was analyzed through the ANOVA method, we discovered that the multidimensional approach to emergency signage arrow positively benefits participants' perceiving directional information respectively.

Additionally, the proposed a new set of a pictogram on multidimensional design approach signage sets that included a representation of surrounding context not only able to imply the direction for viewers but also became a critical element assist their navigation process accordingly.

The overall results signify the need of emergency signage development to improve safety during emergencies and help save people lives. These findings lend valuable data that highlight how a multidimensional design approach to an emergency signage design has a greater impact on the general process of conceiving information and direction on signage respectively. Finally, a design reference for signage positioning and placement to improve occupants to be able to navigate and find a designated safe location thus decreasing evacuation time in any emergency situation is presented. In addition, results from the study can be apply as a design reference for signage development to improve occupants' ability to navigate and find a designated location; thus, the decreasing time consumption in their conceiving on direction information process is presented.

CONTENTS

LIST OF PUBLICATION AND CONFERENCES

Publication

Sopachitwatana, S. & Tanaka., T., Study on Improvement of Effective Emergency Signage, Asia Digital Art and Design Association, pp.29 -33, 2020

Sopachitwatana, S., Kaori, Y., Wang, Y., & Tanaka., T., Study of Multidimensional Design Approaches to Emergency Signage, International Journal of Asia Digital Art and Design Association, Vol.25, No.3, pp. 39-48, 2021.

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Conference in Japan

Sopachitwatana Supasumond & Takamitsu Tanaka: The Study of Directional and Arrow Design for Emergency Signage, The Society for Art and Science-Tohoku
（令和 3 年度 第 1 回芸術科学会東北支部研究会），January 2022

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Sopachitwatana Supasumond, Kaori Yamada, Takamitsu Tanaka: Psychological awareness study on improvement of effective signage, The Society for Art and Science-Tohoku（令和 2 年度第 1 回芸術科学会東北支部研究会），July 2020

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CHAPTER 1

INTRODUCTION

1.1 Research Background and Objectives

In emergency and disaster events, people can experience high levels of stress and fear that adversely affect our adaptive risk perception, our decision-making processes, and as a result attention is needed to implement plans to prepare and prevent for evacuation systems. One important aspect of the design of emergency signs is the message conveyed should be absolutely unmistakable and understandable to anyone at any time.

The installation of exit signs has been observed frequently in many built structures, and specifications have been a highlight in design guides and regulations. In the academic area, there are majority numbers of research focusing on the effectiveness of an emergency exit signage design, focused on the visualization ability [1], fonts and texts size imprinted on an exit signage [2], and positioning and placement of signage [3], [4]. In practice, much research has been devoted to an investigation through modeling and experiments, stimulating on how signage affects people's perception. [5], [6], [7].

However, although many studies have been published concerning emergency signage, data on how individuals accept information conceived by emergency signage is still limited. Experiments and studies have basically been done on an existing condition and environment, where the studies subjects were according to a simple assumption that occupants are familiar with (e.g. evacuation routes, signs, and way-finding information). Therefore, there is a lack of relevant data concerning the alternative approach to signage design and appearance that could possibly provide a significantly different perception in the way occupants see and interpret signage.

The evacuation timeframe for occupants to exit from the building in case of emergency was recommended at two minutes and 30 seconds [8]. Previous study showed that in Japan's emergency and disaster events, people could experience high levels of stress and fear that adversely affect our adaptive risk perception and our decision-making processes. Therefore, people's attention is needed to implement plans to prepare and prevent evacuation systems. Signage systems in the building are crucial in the possibility of a successful escape. Focusing the design on emergency exit signs, the message conveyed to the viewer is designed to provide a predominant meaning. As a regulatory and necessary obligation in many countries around the world, an exit sign is a safety device required in public facilities or buildings [9]. Emergency signage plays an

important role in helping occupants find a seamless way to orient toward a safe location and decrease the time that it takes to evacuate [10]. The objective of a previous study entails an important aspect of the design of emergency signs: the message conveyed should be unmistakable and understandable to anyone at any time. Emergency exit signs are usually a combination of arrows and pictograms in white and green colors. Pictogram has been considered one of the most efficient methods to convey information to the viewer's [11]. We recognize that translating the essential message into a form of imagery is easier to understand than a form of words.

However, we are also aware that the way people interpret, or process signage is different and directly related to personal experiences based on an initial study. A well-known example used in previous studies as well as in this follow-up study was that of the running man (Ota, 1979). One aspect of a pictogram design feature is that the imagery used in the sign can easily be interpreted and understood through recognition of our personal experiences. To assist in people's recognition processes, both the direction and directional signage and wayfinding information are embedded in the built environment around us [12], [13].

1.2 Thesis Overview

The purpose of the research is to explore a new, alternative dialogue and signage design approach to wayfinding that most effectively communicates and directs people to navigate themselves to safety. The purpose of the research is to explore the typical dialogue and signage that most effectively communicates and directs people in the way-finding process. How the implementation of information embedded into surrounding effect occupants during the actual event of evacuation. In this case, an analysis of people's awareness regarding existing signage must be determined to learn and understand the process from interpreting the meaning of a sign which leads to a specific action taken. More specifically, to what variation in signage design influences the way individuals read and respond information conceived by emergency signage. This study aims to explore the influence of elements on existing signage due to the way-finding process. For this reason, the Research Question (RQ) we asked focuses on experiments to investigate how we can improve signage in an emergency situation: how accurate individuals accept information conceived by emergency signage? This investigation leads to, what elements on existing emergency signage could affect people's interpretation of way-finding information. We believed that the results from this study would provide useful information to designers to be able to create the most effective signage design reference in relation to human

behavior. Specifically, these findings will also help designers and safety organizations to collaborate with each other to eliminate misinterpretation and solve other issues to promote a safety environment in the future.

Chapter 2 Literature review

In this chapter, we define and discuss similar previous studies that were performed related to our study. The data previously collected along with the parameters from other studies will be shown. In this chapter elements of an emergency signage will be defined, covering the area of colors of emergency signage and communication information respectively. Also, in this chapter presented the essential elements that affect the way in which people conceiving an information of direction interpreted from emergency signage.

Chapter 3 Research Methodology

In chapter 3, the methodology used for this research is clarified. The scope of the study and the experiments will be explained in this chapter. The emergency signage design samples used in this research is presented and explained. The further part in this chapter, explained the analysis procedure for the data collecting process.

Chapter 4 Analysis and Results

In chapter 4, the results from the experiments are shown. The results were analyzed through the ANOVA method. In this chapter, the analysis of the results provided valuable data leading to greater in-depth understanding of the multidimensional design approached to the emergency signage were clarified. In addition, the time consumption responds comparison among testing subject were displayed and analyzed.

Chapter 5 Conclusion and future works

Chapter 5 is the conclusion of this research. This chapter discussed potential use of the study results, providing a design reference for and emergency signage design and placement. These findings lend valuable data that highlight how multidimensional approached to the emergency signage design has a greater impact on general procedure of an information of direction information conceiving.

APPENDIX

This chapter is divided into sections as follow:

Appendix A – In this section, preliminary experiment A (an experiment on an evacuation tasks) and preliminary experiment B (Information on the emergency signage) were observed and analyzed.

Appendix B – In this section, the research survey, questionnaires and materials for the experiment were clarified. To be more specific, we investigated the different approaches of emergency signage design.

1.3 Definition and Terms

- *Emergency signage:* is a sign indicates the nearest location of emergency-related facilities including exits and safe locations. Emergency signage used in this study is featured with a white symbol with a green background
- *Pictogram:* In this study, a pictogram is an illustrated graphic that represents in a form of arrows and human figures, referred to as a picture or symbol that represents a word or phrase to indicate direction or exit feature
- *Conceiving:* is the experience of form, opinion, and ideas. In this study, conceiving is the visual interpretation of a particular direction and information presented by emergency signage
- *Multidimensional:* In this study, multidimensional represented and arrows or graphical elements in the emergency signage contained or involved several dimensions, including depth and perspective

CHAPTER 2

LITERATURE REVIEW

2.1 Previous study

This research focuses on the impact of exit signage placement in the internal environment and the investigation of human behavior during evacuation. To understand the necessary information needed to develop and solve problems. In preliminary experiments were conducted for the purpose of identifying aspects which affect the efficacy of signage so that we can provide way to improve emergency signage. First of all, we created two continual experiments which included a set of survey questions and an evacuation performing task 18 participants. Participants were from five different countries: Japan, Taiwan China, Mongolia, Indonesia and Thailand in order to acquire universal perceptions and interpretation, and the survey and task was administrated in a controlled location situated in the name laboratory. The age range of participants was from 18 to 47 years old, of which 61 percent of participants were female.

In a previous experiment, The Study on Improvement of Effective Emergency Signage [15], typical emergency signage was analyzed through a set of questionnaires,

including an in-depth interview, and the stimulation of emergency evacuation tests performed by 18 participants.

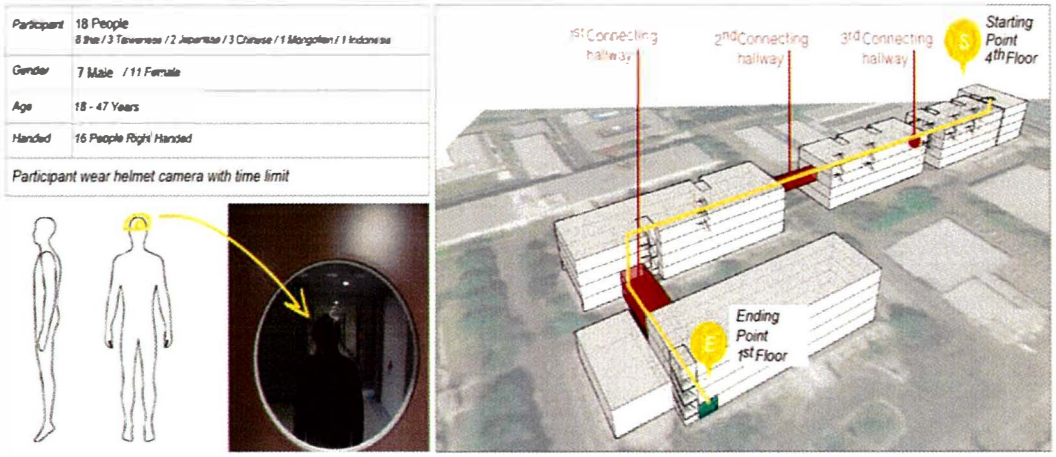


Figure 2.1 Experimental study on evacuation task

As result, an average of 40.75% of participants were misled by the interpretation of emergency signage information especially where the visual field or location of the sign was limited. In particular, the margin of error critically occurred when participants were asked to confirm the different direction of the arrows. In a specific case in a downward arrow emergency signage, in which case 27.7% of participants interpreted it as instructing to go back, 61.1% believed that the signage indicated going straight, and 11.11% believed that it indicated going straight and then up accordingly. The results suggested an issue of individual interpretation of signage and wayfinding from an arrow symbol. The results suggested issues with individuals correctly interpreting signage. In these cases, the arrow

was pointing to a different diagonal direction and recorded an average of 62.5% error rate, and the responses were mixed between going left, going right, and going up accordingly.

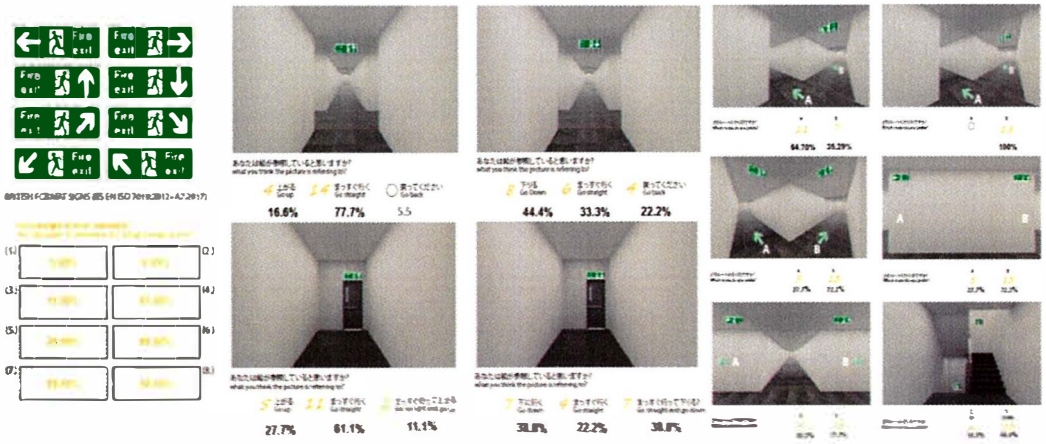


Figure 2.2 Set of emergency signage sample and simulation images (Preliminary experiment)

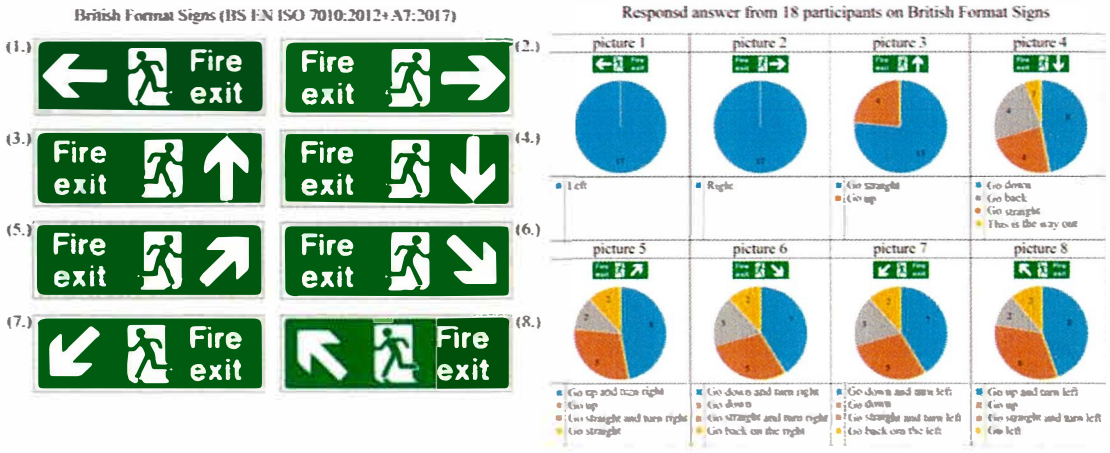


Figure 2.3 Result of direction interpretation response (Preliminary experiment)

These findings suggested that the two-dimensional design format of emergency exit signs was unclear and misled people in the navigation process. In conclusion, it was determined that in the area where the visual field was limited, such as in staircases and corridor junctions, current emergency signage was unclear and misleading, and therefore inaccurate.

2.2 Emergency signage development research studies

Edwin, Hui, and Peter discussed the effectiveness of dynamic signage systems in their study [3]. Their purposed system incorporates flashing lights into current standard signage, in order to investigate the differences between emergency signage and interactive signage in the participants' perceiving directional information process. Their purposed concept was to implement the electrical lighting systems into emergency exit signage. The detectability of the design was tested through the introduction of green and red flashing light components embedded in conventional signage. The flashing green confirmed the safety route suggested by the displayed signage arrow, while the red negated it.

In relation to emergency signage development research studies, Sonia, Alexander, and Sabina proposed alternative approaches to emergency signage based on a digital implementation system [16]. Their research adopted the new technology of on-screen

displayed signage, enhancing the way people perceived direction information with the aim to decrease wayfinding error and positively improve the participants' ability to perceive directional information. In their research, the temporal update information in text formed, along with conventional emergency signage, signage with a flashing light, and a crossed-out red x symbol was tested to measure the efficacy of a digital signage system. As a result, the digital signage can display updated information on safe escape routes and prohibited ones as well as provide a significant level of visual attention to viewers, respectively.

The digital and electrical signage design methods undoubtedly served the purpose of wayfinding; however, the requirements for its operation required consistency of power source and electrical supporting systems. In the second explanation, the proposed methods were considered suitable in a limited location and restricted context. Therefore, the present study focused on alternative dialogue and signage design approaches that are based on a conventional condition of emergency signage, which can be applied and used in spaces with and without electrical power sources accordingly.

2.2.1 Elements of emergency signage

Signage systems in the building are crucial in the possibility of successfully escape. Focusing on the emergency exit signs, the message conveyed to the viewer contains a predominant meaning. As a regulator and necessary obligation in many countries throughout the world, an exit sign is a safety device required in a public facility or building [17]. Emergency signage plays an important role in assisting occupants to be able to find a seamlessly way for orienting to a safe location and decreasing the time it takes to evacuate [10].

The ISO 7010 (International Organization for Standardization technical standard for graphical hazard symbols on hazard and safety signs), provides information and guidelines of signs and symbols and has been published respectfully in a two-dimensional design format. An example of this is the well-known pictogram sign known as "The Running Man" was created by Yukio Ota in 1979, and has been accepted as a standard sign in many countries. The ISO 7010 signs are illustrated in two parts: a legend (a man running through the door) and a directional arrow. The directional arrow may be up, down, left, right or diagonal. Another type of emergency exit signs equipped in many built structures is BS 5499 format signage, these signs are in three parts: the text (typically "Exit" or "Fire Exit") a legend (a man running through the door) and a

directional arrow. One of the other types of signage used in European countries known as the " Euro signs", these sign contained only the graphic indicating a man running towards a door and directional arrow (up, down, left, and right). All of the mentioned signage types are included a set of pictograms that indicating the directional information to the viewers. One aspect of a pictogram design feature is that imagery used in the sign can easily be interpreted and understood through recognition of our personal experiences [18].

Figure 2.4 British format emergency signage sample

2.2.2 Colors and elements of emergency signage

The color of emergency signage was assigned to distinguish it from another colored sign, which may distract the visual attention of the occupants when looking for safe exits [19]. Emergency exit signs have been considered important elements to help occupants find a seamless way to a safe location. In most public use spaces and buildings, safety

Figure 2.5 International Organization for Standardization, a technical standard for graphical hazard symbols on hazard and safety signs

regulations and specifications have been highlighted in design guides and regulations of emergency signage. The options of colors recommended by The ISO 7010 (International Organization for Standardization, a technical standard for graphical hazard symbols on hazard and safety signs), provide information and guidelines on signs and symbols and have been published in a two-dimensional design format for emergency signage are the green, red, blue and yellow [20, 21]. While the green was assigned for an evacuation route, location of safety equipment or safety facility, and safety action. The red color was presented for a piece of fire equipment and prohibition. Blue indicates a mandatory action and yellow for warning signs respectively. Reference to the International Fire Code, most international building codes prescribe green as the color for exit signs [22, 23]. The Department of Labor, Occupation of Safety and Health Administration recommended, that each exit sign must have the word "Exit" in a legible letter larger than 15.2 cm high, with the principal strokes of the letters in the word "Exit" not less than 1.9 cm wide. Furthermore, the recommendation for exit signage included a detail described in the placement, positioning, and visibility ability of an exit sign respectively [15]. In the specific case that the direction of travel to the exit or exit discharge is not immediately apparent, signs must be posted along the exit access indicating the direction of travel to the nearest exit and exit discharge [24].

2.3 The alternative dialogue and signage design approach

The purpose of the research is to explore a new, alternative dialogue and signage design approach to wayfinding that most effectively communicates and directs people to navigate themselves to safety. Regarding to previous experiment results, an arrow on emergency signage was represented in a two-dimensional form while indicating information within three-dimensional contexts. Generally, the two dimensions represented in 2D graphical signage were limited to width and height. These findings led us to believe that the depth of the represented context was unclear and overlooked [25].

In general, signs can have two-dimensional, three-dimensional, or digital forms [12]. The use of a three-dimensional approach in signage design can be found in a scope of commercial purposes, usually presented in a form of 3D letters. The presence of depth in that dimensional sign creates a natural attraction and draws people's attention [26]. However, there is a lack of relevant data concerning alternative approaches to conventional emergency signage design and appearance that could possibly provide a significantly different perception in the way occupants see and interpret signage in wayfinding. For this reason, this study explores the benefits of multidimensional arrow signage connected with the perception of the wayfinding process; in addition, it introduces an alternative set of pictograms in emergency signage to eliminate the

misinterpretation that occurred from existing signs and to decrease evacuation time accordingly.

One of the most frequent uses of directional signage is traffic signage. Traffic signs serve as critical information media to provide safety, efficiency, and road continuity [27]. Evidence of traffic signage is embedded in most built-in environments around us,

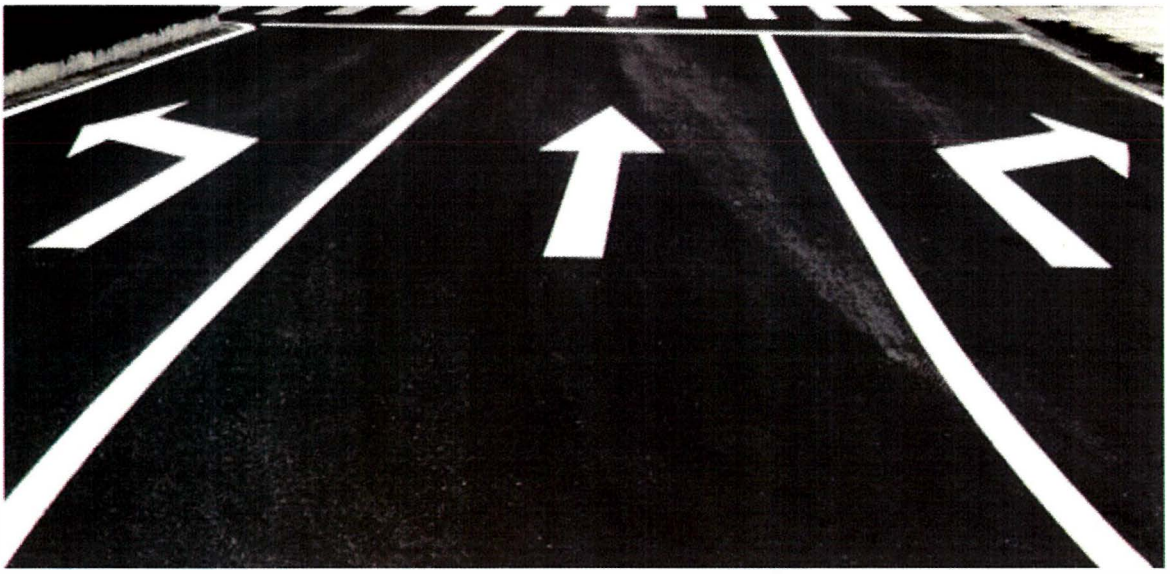


Figure 2.6 Sample of the depth dimension in traffic direction information signage

and the interaction between pedestrians and drivers and traffic signage is unavoidable. People experience and interpret the meaning of traffic signs on a daily basis [28]. For this reason, the research focused on the possibility to implement traffic signage design elements into emergency signage to improve the viewers' wayfinding ability as well as on how the implementation of multidimensional design embedded in emergency signage affects occupants during the actual event of an evacuation.

In this case, a comparative analysis of people's awareness regarding existing signage to propose a multidimensional design must be determined to learn and understand the process of interpreting the meaning of a sign, which leads to taking a specific action more specifically, to what variation in signage design influences the way individuals read and respond to information conveyed by emergency signage. This study aims to explore the possibility of multidimensional signage elements in the wayfinding process. For this reason, it focuses on experiments investigating how we can improve signage in an emergency situation, i.e., how accurate individuals accept information conveyed by multidimensional emergency signage.

This investigation leads to an essential design element in emergency signage that could affect people's interpretation of wayfinding information. We believed that the results from this study would provide useful information for designers to be able to create the most effective signage design reference in relation to human behavior. Specifically, these findings will also help designers and safety organizations collaborate with each other to eliminate misinterpretation and solve other issues to promote a safe future environment.

CHAPTER 3

RESEARCH METHODS

3.1 Procedure

This research focuses on the impact of the exit signage design approach on the internal environment and the investigation of human behavior related to evacuation. To understand the necessary information needed to develop and solve problems, in this research, experiments are conducted for the purpose of identifying design aspects that affect the efficacy of signage so that we can provide a way to improve emergency signage and decrease the time necessary for evacuation to occur.

First, we created two continual experiments that included a set of survey questions and the evacuation simulation task. Participants were from three different countries, namely Japan, China, and Thailand, to acquire universal perceptions and interpretation, and the evacuation simulation tasks were administered in a controlled location situated in the Design and Media Technology Laboratory, Faculty of Science and Engineering, Iwate University.

3.2 Information of multidimensional design approach to emergency signage design

To test the efficiency of the alternative dialogue and signage design approach to wayfinding that most effectively communicates and directs people to navigate themselves to safety. We created two continual experiments namely Experiment A: (Effectiveness information of direction guidance on signage) and Experiment B: (Simulation of an evacuation task experiment). In order to understand the effectiveness of an emergency signage the experiments were created to test in two majority criteria of the information of direction conceiving by emergency signage including the accuracy of direction and the time consumption upon the information perceiving accordingly. A large number of cases related to an emergency incident and disaster, an accuracy and effective direction information for evacuation considered as an essential element to determined safety. As a regulation and recommendation of public safety around the world, the British format emergency signage were recommended as a standard procedure [29] in the case of an emergency. One of the essential elements presented on British format emergency signage is the arrow. The arrow represented as a guideline for direction information to its' viewer [30]. In reference to previous experiment (Chapter 2), the problematic of direction guidance from British format signage were found in the of diagonal arrow signage and the

downward arrow signage. For this reason, the research aimed to test on an effectiveness information of direction guidance on signage as a priority. Another factor that critically affect the effectiveness of direction information of signage is the time required to perceive the information of direction. To understand the effectiveness of an emergency signage, the Simulation of an evacuation task experiment were created to test in two majority criteria, including the accuracy of direction and the time consumption upon the information perceiving accordingly.

3.2.1 Experiment A:

Effectiveness information of direction guidance on signage. In this research, the set of online-based questionnaires, which stimulate different types of emergency signage, were created using Google Form, Google Sketch Up, Adobe Illustrator, and Adobe Photoshop to be used for study as testing subjects as shown in Figure 3.1 and 3.2. One-hundred participants were asked to provide short explanations that match the direction and meaning of given sample images in the form of open-ended questions. The responses will be analyzed to investigate the accuracy of direct guidance from typical emergency signage and the proposed methods of multidimensional emergency signage design accordingly.

(British format emergency signage)

Figure 3.1 Set of Emergency Signage Samples for Experiment A (A1-A8)

(Depth dimension signage)

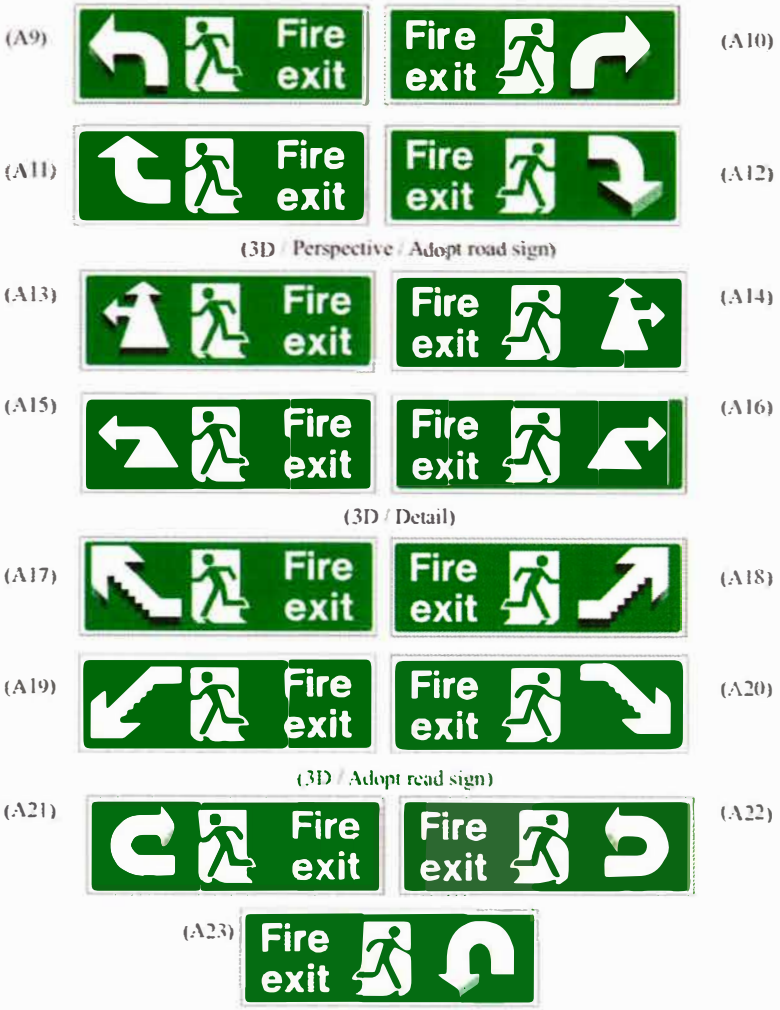


Figure 3.2 Set of Emergency Signage Samples for Experiment A (A9-A23)

3.2.2 Experiment B:

Simulation of an evacuation task experiment. In this experiment, 27 participants were asked to perform a simulation of an evacuation task. First, we created two continual tasks for this experiment, which included the descriptive response of signage meaning (Task A) and direction selecting (Task B).

Task A: In this part of the experiment, participants were asked to describe the meaning of a sign to test their understanding by giving a short description of the perceived information. The testing samples included four images and represented an interior space with emergency signage displayed as shown in Figure 3.3. The performing tasks were recorded and analyzed through a visual detection method in order to clarify various noticeable actions of participants regarding their process of determining the information of different samples. The processing time taken by participants will be later analyzed using the visual attention method and the ANOVA method.

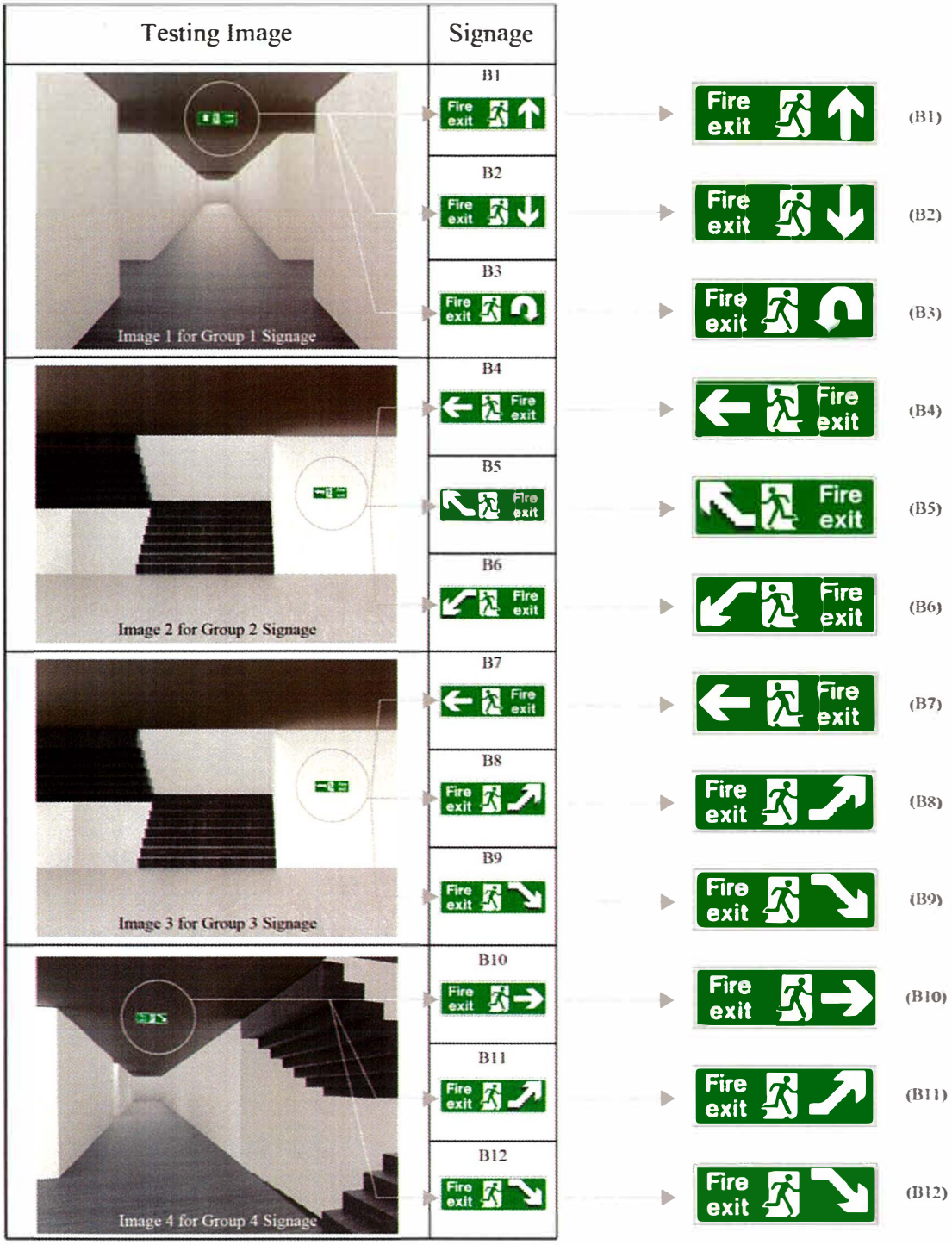


Figure 3.3 Set of Emergency Signage Sample for Experiment B (Task A: B1- B12)

Task B: For this part of the experiment, participants were asked to select the option of direction A or B provided in the testing images. These presented different approach methods to emergency signage design, including existing emergency signage and multidimensional emergency signage. (Figure 3.4 and 3.5) The experiment was created to test the efficiency of signage in wayfinding interpretation. Time consumption for each sample was recorded and analyzed with an eye-tracking device. A comparison to evaluate the difference in time consumption of each sample and the most effective samples will later be analyzed.

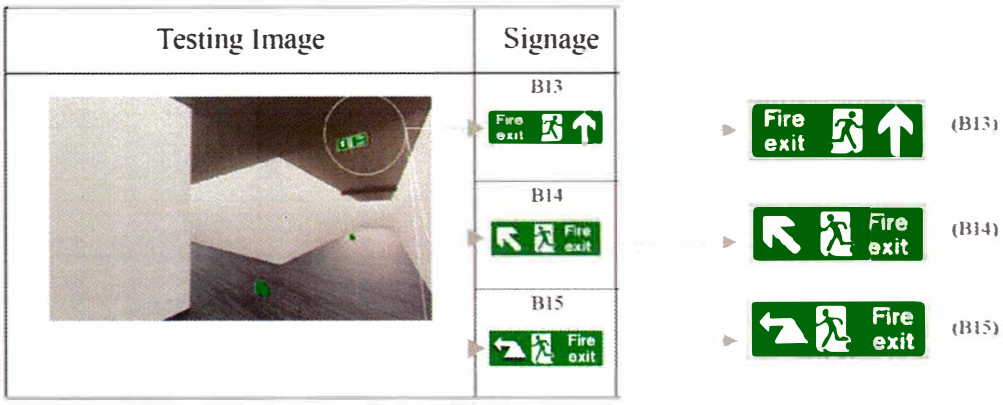


Figure 3.4 Set of Emergency Signage Sample for Experiment B (Task A: B13- B15)

Performing task (A) and (B) were recorded and analyzed through a visual detection method, in order to clarify the noticeable action of participants regarding their process to determine the information of provided samples and the decision time. A proposed in-depth

interview was later set up as a qualitative measure to expand our scope of participants' interpretation of directional information on the emergency signage tested, including the decision-making related to the graphics and installation location of the exit signage. In order to further investigate the way in which individuals perceive information conveyed by emergency signage, this study focused on recording the participants' actions.

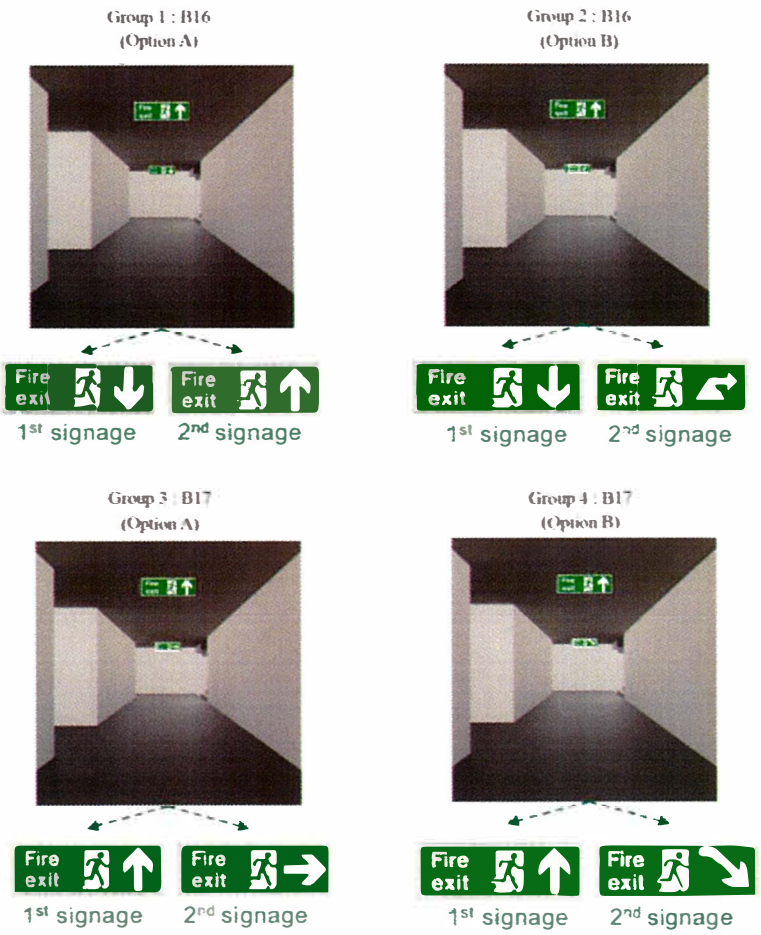


Figure 3.5 Set of Emergency Signage Sample and Image of an Interior Space for Experiment B (Task B)

3.3 Data Collection

3.3.1 Experiment A Data Collection

For the collection of data collection in experiment A, one hundred participants were asked to provide a short explanation of information conceived by the given sample images. The data obtained from experiment A results were analyzed to investigate the accuracy and comparison of direct guidance from typical emergency signage and the multidimensional emergency signage design.

3.3.2 Experiment B Data Collection

Figure 3.6 Performing Tasks of Participants equipped with eye-tracking device

In process of the data collection of experiment B, recorded a total of 27 simulation evacuation tasks (A) and (B), which were analyzed through (a) an eye-tracking device, and (b) an in-depth interview regarding the participant's selection. During the experiment, the differentiation between focusing time and visit count for each sample was recorded by the eye-tracking device and later analyzed using the visual attention method and the ANOVA method regarding the evaluation process performed by each of the participants. A comparison to evaluate the difference in time consumption of each sample upon the decision-making regard to the preferred direction was analyzed.

CHAPTER 4

ANALYSIS AND RESULT

4.1 Results and Analysis of Experiment A

The results from the survey questionnaires, investigating the accuracy of direct guidance from emergency signage and multidimensional signage among 100 participants, were analyzed with regard to their response shown in Figure 4.1. The overall results revealed that some problematic issues emerged due to inconsistent answers concerning the directional guidance of emergency signage, as shown in Figure 4.1. In particular, the margin of error critically occurred when participants were asked to confirm the different direction of arrows. For example, all participants accurately responded to signage sample A1 and A2, indicating that left and right arrows represent the correct intended direction. The results from A3 sample indicated that, 70% of participants interpreted the sign as indicating going straight, while 29% interpreted it as going up. In A4 sample results, 45% of participants interpreted the sign as going down, while going back and going straight recorded 20% and 14 % respectively.

The later signage samples additionally revealed a critical point of directional misinterpretation for signage sample A5, A6, A7, and A8. In general, a diagonal arrow

signage was typically displayed to indicate the staircase and change in an oblique direction. In these cases, the arrow was pointed in a different diagonal direction and recorded an average of 26.75% misinterpretation, as shown in Figure 5. The multidimensional design signs A9, A10, A11, A12, A21, A22, and A23 were designed based on the design elements of daily basis signage to test the accuracy of direct guidance from the proposed signage. The results from A9 and A10 suggested that 42% of participants interpreted the signs as indicating going straight then turning in the direction of the arrow, while 50% were recorded as going in the assigned direction. The results from the A11 sign reported that 27% of participants interpreted its information as going straight then left; 27% interpreted it as going up on the left, and 20% as going left. The results from A12 showed that, 37% of participants interpreted its information as going backward then right, while 32% interpreted it as going down on the right. Regarding A23, 83% of participants interpreted its information as going backward.

The multidimensional design approach methods were designed and tested in signage samples A13 to A16. The depth dimensions were implemented into an arrow symbol for testing samples to measure the efficacy of the participants' direction information perception. The results from the A13 sample shows that 94% of participants interpreted the information as going straight and left, while 2% interpreted it as going left.

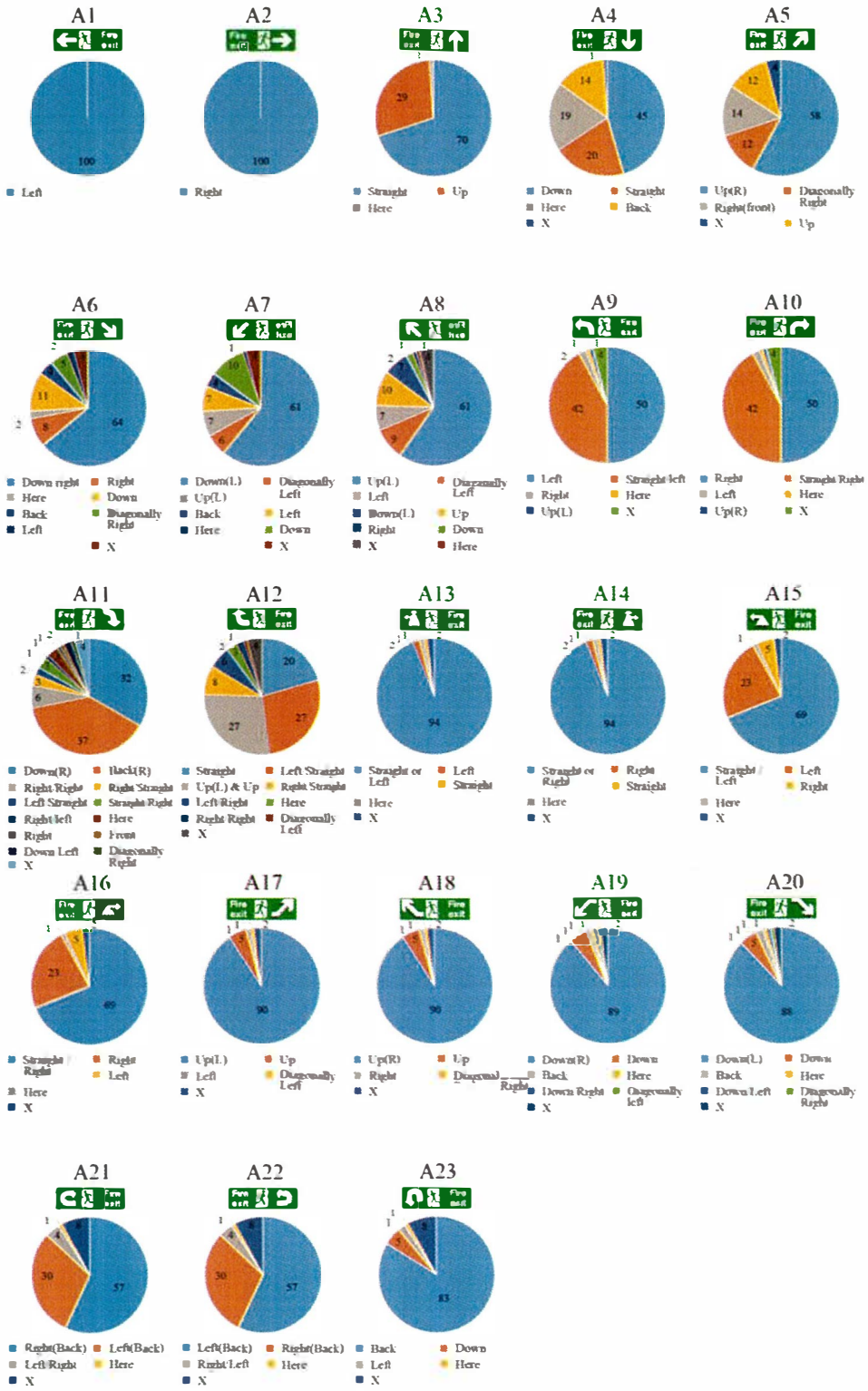


Figure 4.1 Results of Effectiveness information of direction guidance on signage (Experiment A)

The results from the A14 sample show that 94% of participants interpreted the information as going straight and right, while 2% interpreted it as going right. Regarding A15, the results showed that 69% interpreted as going straight then left, and 23% as going left. In A16 results, 69% interpreted it as going straight then right, while 23% interpreted it as going right. These findings on testing samples indicated that multidimensional design signage significantly affected the participants in their perceiving information process. The depth dimension in multidimensional signage conveyed an absolute sequence of suggested directions to participants.

The later signage samples A17, A18, A19, and A20 were designed with a multidimensional pictogram design approach to test the efficacy of additional information on signage. With regard to the A17 and A18 samples, 90% of participants interpreted them as going upstairs in the assigned direction, while 5% interpreted them as going upstairs. Regarding the A19 and A20 samples, 89% of participants interpreted them as going downstairs in the assigned direction, while 5% interpreted them as going downstairs. The results from the multidimensional pictogram design approach suggested that the multidimensional pictogram on signage optimally improved the way in which participants' perceived information and how they navigated their direction with an accuracy rate of 94.25 % respectively.

4.2 Results and Analysis of Experiment B

4.2.1 Results and Analysis of Experiment B: Task (A)

Experiment B: Task (A) was created to test the efficiency of emergency exit signage and the multidimensional approaches used in signage as a method to indicate wayfinding. The testing results from 27 participants were analyzed by the visual detection method to identify whether there was a significant point related to a design reference that noticeably affected participants in their evaluation process. The analysis of time consumption for the perceived information from different approach methods design included arrow signage, and contextual signage was analyzed through a one-way analysis of variance (ANOVA) model with a significance of 0.05.

One-way ANOVA was used to analyze whether significant differences existed in the average time consumption of participants' perceived information on testing samples B1, B2, and B3, as shown in Table 4.1. The comparison of results showed no significant difference in average time consumption: B1 (M = 6.033, SD = 2.887), B2 (M = 6.069, SD = 3.799), and B3 (M = 5.775, SD = 3.240), $F(2,78) = 0.070$, $p = .932 > 0.05$. However, in the descriptive response of signage meaning for sample B2, the downward arrow emergency signage was placed in the middle of a corridor intersection. Here, the statistics of an evaluation process showed statically significant differences in direct guidance

results: 14.82% of participants interpreted the information as going down, 22.22% as going straight, and 62.96% as going back.

Table 4.1 One-way ANOVA Analysis for B1, B2, and B3

Type B1.B2,B3		N	M(s)	SD	df	F	p-value
Time	B1	27	6.033	2.887			
	B2	27	6.096	3.799	2, 78	.070	.932
	B3	27	5.775	3.240			

N: Number of participants; M:Mean, s=second(s); SD : Standard Deviation; df: degree of freedom; p-value: Significance

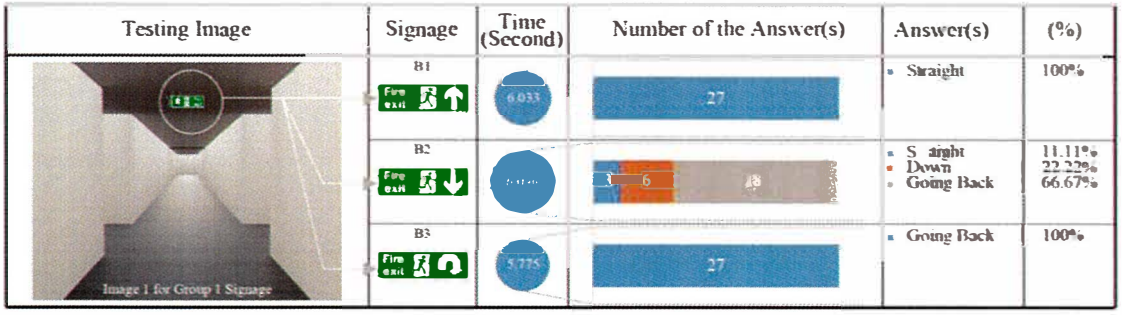


Figure 4.2 Results of Simulation of an evacuation task (Task A, sample B1,B2, and B3)

In the comparison of results from experiment B, Group 2 samples revealed an average mean in the time to perceive information from testing images B4, B5, and B6 (Table 4.2). A statistically significant difference was found in the average time: B4 (M = 8.668, SD = 3.067), B5 (M = 5.111, SD = 1.859), and B6 (M = 4.404, SD = 1.962), $F(2, 78) = 25.297$, $p = 0.001 < 0.05$.

Table 4.2 One-way ANOVA Analysis for B4, B5, and B6

Type B4,B5,B6		N	M(s)	SD	df	F	p-value
Time	B4	27	8.668	3.067	2, 78	25.297	<.001
	B5	27	5.111	1.859			
	B6	27	4.404	1.962			

N: Number of participants; M:Mean, s=second(s); SD : Standard Deviation; df: degree of freedom; p-value: Significance

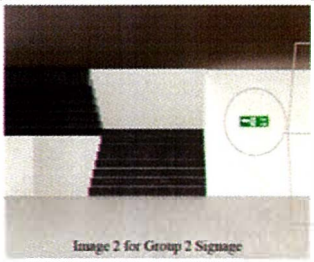
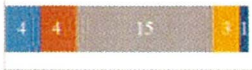
Testing Image	Signage	Time (Second)	Number of the Answer(s)	Answer(s)	(%)
 Image 2 for Group 2 Signage	B4 	 8.668	 4 4 15 3 1	Down/Stairs Left/Stairs Left Stairs Up	14.81% 14.81% 55.55% 11.11% 3.70%
	B5 	 5.111	 20 3 4	Up/Stairs Stairs Left/Stairs	74.04% 11.11% 14.85%
	B6 		 25 1	Down/Stairs Back Left/Down	92.60% 3.70% 3.70%

Figure 4.3 Results of Simulation of an evacuation task (Task A, sample B4,B5, and B6)

Continual analysis on the multiple comparison results displayed in Table 4.3 illustrates the difference in time consumption among the samples. The results indicate a significant difference in the comparison of average time consumption for the existing signage B4 and the multidimensional signage B5 and B6: (B4–B5, Md = 3.557, $p = 0.001 < 0.05$), (B4–B6, Md = 4.264, $p = 0.001 < 0.05$). The results indicated a reduction of average time consumption to perceive information from B5 and B6 to B4 by 45.09%.

Table 4.3 Multiple comparison of average time for B4, B5, and B6

Post Hoc Tests (Multiple Comaparisons)					
Dependent Variable: Time					
(I)Type	(J)Type	Mean difference (I-J)	p-value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
B4	B5	3.557*	<.001	2.278	4.836
	B6	4.264*	<.001	2.985	5.543
B5	B4	-3.557*	<.001	-4.836	-2.278
	B6	.707	.275	-.572	1.986
B6	B4	-4.264*	<.001	-5.543	-2.985
	B5	-.707	.275	-1.986	.572

p-value: Significance; *.The mean difference is significant at the .05 level.

The ANOVA analysis on testing sample Group 3 showed a significant difference in the average time consumption, with B7 (M = 6.672, SD = 2.913), B8 (M = 4.603, SD = 1.512), and B9 (M = 4.245, SD = 1.430), F(2, 78) = 10.843, p = 0.001 < 0.05 (Table 4.4). This finding suggests that multidimensional approach design method signage significantly affects the way individuals perceive information conveyed by emergency signage; as a result, the highest mean rate for time consumption was 6.672 seconds for signage B7, and the lowest time recorded was 4.245 seconds for B9.

Table 4.4 One-way ANOVA Analysis for B7, B8, and B9

Type B7,B8,B9		N	M(s)	SD	df	F	p-value
Time	B7	27	6.672	2.913			
	B8	27	4.603	1.512	2, 78	10.843	<.001
	B9	27	4.245	1.430			

N: Number of participants; M: Mean, s=second(s); SD : Standard Deviation; df: degree of freedom; p-value: Significance

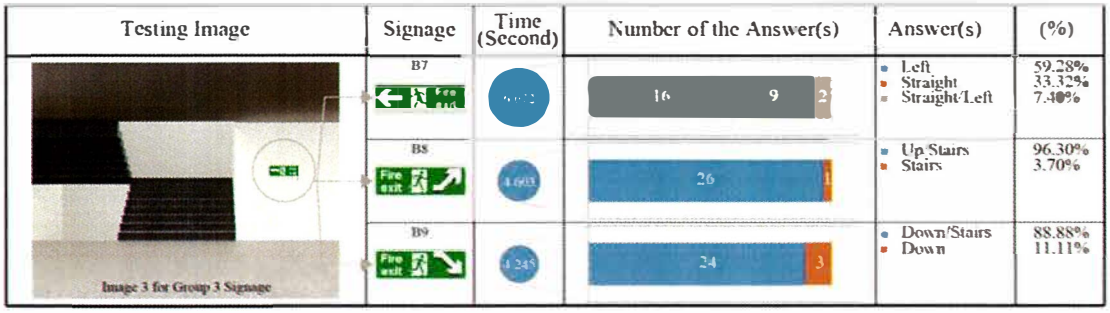


Figure 4.4 Results of Simulation of an evacuation task (Task A, sample B7,B8, and B9)

The multiple comparison analysis revealed a significant difference in time consumption to perceive information between B7 and B8, and B7 and B9, namely (B7–B8, Md = 2.068, $p = 0.001 < 0.05$) and, (B7–B9, Md = 2.427, $p = 0.001 < 0.05$), as shown in Table 4.5. However, the analysis on B8 and B9 showed no significant difference ($p = 0.526 > 0.05$). This finding suggested that participants comprehensively identified an information reference to their surrounding environment with the information represented on the signage. The results showed that time consumption on B8 and B9 decreased by an average of 2.25 second.

Table 4.5 Multiple comparison of average time for B7, B8, and B9

Post Hoc Tests (Multiple Comaparisons)					
Dependent Variable: Time					
(I)Type	(J)Type	Mean difference (I-J)	p-value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
B7	B8	2.068*	<.001	.948	3.189
	B9	2.427*	<.001	1.306	3.547
B8	B7	-2.068*	<.001	-3.189	-.948
	B9	.358	.526	-.762	1.478
B9	B7	-2.427*	<.001	-3.547	-1.306
	B8	-.358	.526	-1.478	.762

p-value: Significance; *.The mean difference is significant at the .05 level.

Table 4.6 showed that significant differences were recorded in the average time consumption of B10, B11, and B12: B10 (M = 7.158, SD = 2.619), B11 (M = 5.087, SD = 2.354), and B12 (M = 3.871, SD = 1.278), F(2, 78) = 15.929, p = 0.001 < 0.05. The multiple comparison analysis revealed significant difference between B10 and B11, and B10 and B12, namely (B10–B11, Md = 2.070, p = 0.001 < 0.05), (B10–B12, Md = 3.286, p = 0.001 < 0.05) as shown in Table 4.7. The descending order of the timeframe for perceived information based on direction can be placed in order as B10, B11, and B12, respectively. This finding suggested that the representation of a multidimensional arrow signage presented in sample B11 and B12 improved the time taken for participants to perceive the signage information by 37.48%.

Table 4.6 One-way ANOVA Analysis for B10, B11, and B12

Type B10,B11, B12		N	M(s)	SD	df	F	p-value
Time	B10	27	7.158	2.619			
	B11	27	5.087	2.354	2, 78	15.929	<.001
	B12	27	3.871	1.278			

N: Number o fparticipants; M: Mean, s=second(s); SD : Standard Deviation; df: degree of freedom; p-value: Significanc e

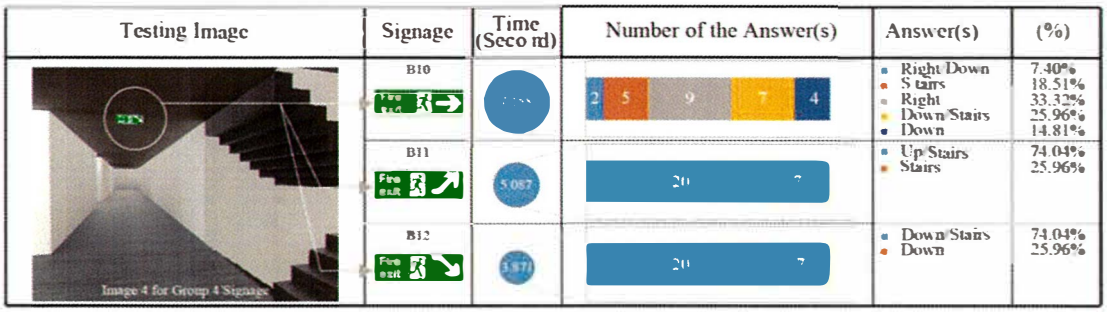


Figure 4.5 Results of Simulation of an evacuation task (Task A, sample B10, B11, and B12)

Table 4.7 Multiple comparison of average time for B10, B11, and B12

Post Hoc Tests (Multiple Comaparisons)					
Dependent Variable: Time					
(I)Type	(J)Type	Mean difference (I-J)	p-value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
B10	B11	2.070*	<.001	.898	3.242
	B12	3.286*	<.001	2.114	4.458
B11	B10	-2.070*	<.001	-3.242	-.898
	B12	1.215*	.042	.043	2.387
B12	B10	-3.286*	<.001	-4.458	-2.114
	B11	-1.215*	.042	-2.387	-.043

p-value: Significance; *.The mean difference is significant at the .05 level.

4.2.2 Results and Analysis of Experiment B: Task (B)

Experiment B: Task (B) was created to test the efficiency of a multidimensional approach to signage design for wayfinding interpretation. The time that the participants needed to determine the information of provided samples, which led to their final decision were recorded and analyzed. The testing results from the 27 participants were analyzed by the visual detection method to identify whether there was a significant point related to a design reference that noticeably affected participants in their perception of the information process. In general, direction information on emergency signage is presented in the form of a two-dimensional arrow. In this study, the multidimensional design approach method signage represented additional information regarding the environment context and was tested in continual questions part (1) and (2) as shown in Table 4.8 and Figure 4.3. The results illustrated the importance of such type of signage for the participants' time consumption to perceive wayfinding information. In this experiment, the time span for each sign's interpretation was recorded and analyzed.

The results and analysis of Experiment B: Task (B) Part (1), shown in Table 4.8, suggest that a comparison of the average visual attention time span was conducted. The average focus time on existing emergency signage for 27 participants were recorded: B13 ($M = 2.721$, $SD = 1.302$) ,B14 ($M = 4.343$, $SD = 3.657$), and B15 ($M = 1.277$, SD=.995),

Table 4.8 One-way ANOVA Analysis for B13, B14, and B15

Type B13,B14,B15		N	M(s)	SD	df	F	p-value
Time	B13	27	2.721	1.302			
	B14	27	4.343	3.657	2, 78	11.865	<.001
	B15	27	1.277	.995			

N: Number of participants; M:Mean, s=second(s); SD : Standard Deviation; df: degree of freedom; p-value: Significance

Table 4.9 Multiple comparison of average time for B13, B14, and B15

Post Hoc Tests (Multiple Comaparisons)					
Dependent Variable: Time					
(I)Type	(J)Type	Mean difference (I-J)	p-value	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
B13	B14	-1.621*	.012	-2.875	-.368
	B15	1.444*	.025	.190	2.698
B14	B13	1.621*	.012	.368	2.875
	B15	3.066*	<.001	1.812	4.320
B15	B13	-1.444*	.025	-2.698	-.190
	B14	-3.066*	<.001	-4.320	-1.812

p-value: Significance; *.The mean difference is significant at the .05 level.

F(2, 78) = 11.865, p = 0.001 < 0.05. The multiple comparison analysis revealed a significant difference between B13, B14, and B15, namely (B13–B14, Md = -1.621, p = .012 < 0.05), (B13–B15, Md = 1.444, p = .025 < 0.05), and (B14–B15, Md = 3.066, p = 0.001 < 0.05), as shown in Table 4.9. The result suggested that multidimensional design approach

method signage in B15 positively affected wayfinding interpretation. In comparison, a secondary sample recorded a reduced time to perceive and interpret the signage by 63.84%.

Figure 4.6 displays the comparison of recorded time responses in Experiment B: Task

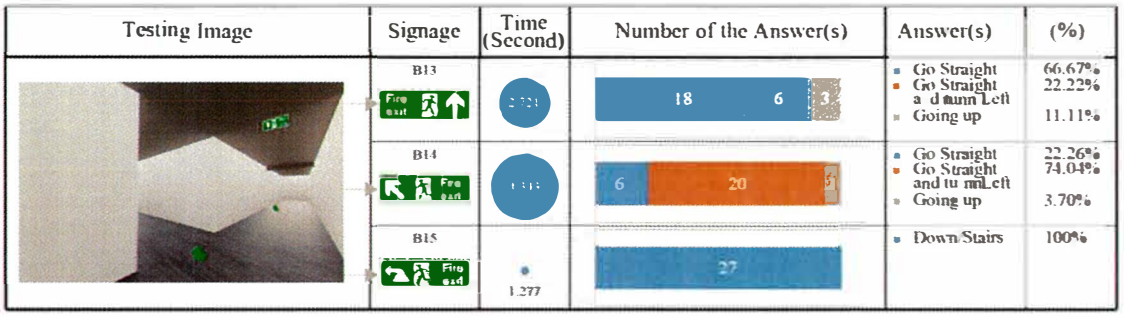


Figure 4.6 Results of Simulation of an evacuation task (Task B, sample B13, B14, and B15)

(B) Part (2). For this part of the experiment, a comparison of time spans for emergency signage included four pairs of wayfinding signage samples, namely upward arrow and downward arrow: B16 (A), upward arrow and multidimensional straight right arrow B16 (B), upward arrow and right arrow B17 (A), and upward arrow and multidimensional stair-right arrow. Throughout the analysis procedure from the eye-tracking data of 27 participants, the average focused time duration were recorded as B16 (A); 3.445, B16 (B); 2.661, B17 (A) 3.226, and B17 (B) 2.286, respectively.

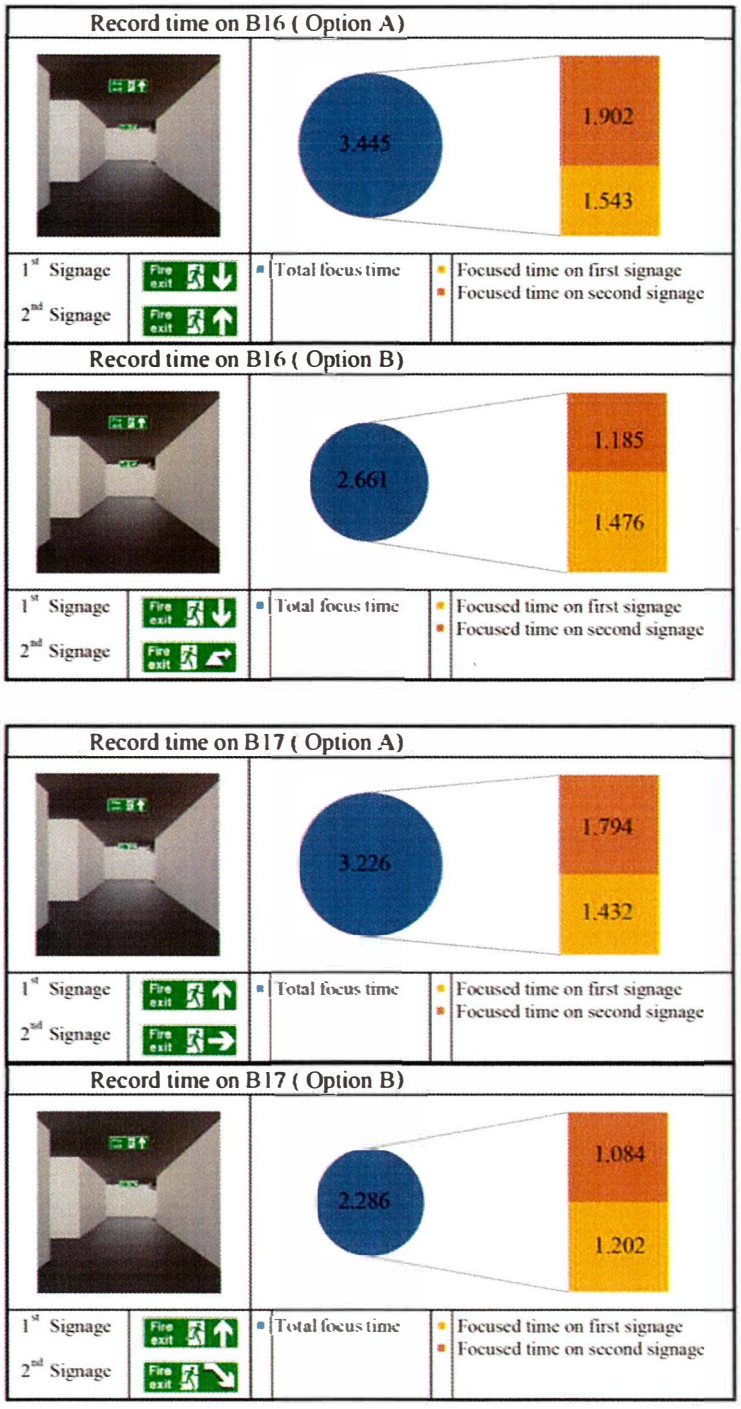


Figure 4.7 Results of Simulation of an evacuation task (Task B, sample B16, and B17)

These results indicated that the signage sets represented with multidimensional design approaches found in B16 (B) and B17 (B) provided a significantly lower time for the participant to perceive the information from signage in an average of 0.861 seconds throughout the evaluation process. In addition, when participants were asked which signage they preferred, 100% of participants selected option B16 (B) and B17 (B) as their preferred directions. An in-depth interview regarding their evaluation process revealed that the multidimensional design approach to emegency signage efficacy conveyed essential wayfinding information to the viewer. The depth dimension of multidimensional emergency signage significantly affected their ability to understand direction information. The pictogram applied on multidimensional emergency signage samples not only benefited the way in which participants perceived the indicated direction, but it also cohesively instructed information regarding the surrounding context, which critically assisted their navigation process.

These findings identified such points and revealed that multidimensional approach design method signage significantly decreases time consumption for participants to perceive direction information in both descriptive responses to signage and select the respective direction option tasks.

CHAPTER 5

CONCLUSION AND FUTURE WORK

5.1 Conclusion

The goal of the study was to investigate the accuracy of individuals' perception of information conveyed by multidimensional emergency signage. The study results and significant findings have provided valuable data, leading to a greater in-depth understanding of the interpretation of information factors in the current design of existing emergency signage. An important component of this study included an experiment conducted on emergency signage and multidimensional emergency signage. The results from Experiment A suggested that existing emergency signage and the ability to find its correct interpretation throughout the entire process is limited due to the misinterpretation of the intended direction. Our findings suggested that, overall, two- dimensional displayed emergency signs influence and affected the participants' ability to correctly interpret directional meaning for an average of 37% of them. In particular, the diagonally oriented arrow on emergency signage critically contributed to a misunderstanding of direction and overall interpretation. In comparison, the multidimensional emergency signage approach can decrease errors made in the wayfinding process and positively

benefit participants' perception of directional information. We found that the depth dimension of multidimensional signage promotes a successful rate of information perception and comprehension correctly by 94.25%, as shown in Experiment A.

In addition, the results from Experiment B showed that the time consumption recorded for participants to perceive the meaning of signage significantly decreased. An additional in-depth interview and analysis on eye-tracking device data indicated that the multidimensional approach signage design positively benefits participants' perception of directional information in the situation where visual perception is limited and obstructed, as shown in results from Experiment B. The proposed new pictogram on emergency signage sets included a representation of context not only to imply the direction for viewers but also to critically assist their navigation process. However, it is important to note that, this study's setup and experiments were conducted in simulated conditions that would not be possible in a real-world environment. The test was conducted without a limitation of time length, and this would not be possible in reality for example, smoke and fire development, which would directly affect the participants' physical and psychological perception.

5.2 Future work

In this study, experiments were conducted to investigate the benefits of multidimensional emergency signage for participants' perception of direction information. Our experimental findings revealed a misinterpretation of the meaning occurring in two-dimensional emergency signage. However, the depth dimension proposed in multidimensional emergency signage and the implementation of traffic signage design elements can further promote the occupants' ability to be able to navigate and find a designated safe location. These experimental results can help designers and safety organizations collaborate with each other to eliminate misinterpretation and solve other issues to promote a safe environment in the future. In addition, experimental results recorded from conducted tests can be used as a design reference to develop signage design in buildings as well as promote and assist viewers in their wayfinding process. In summary, simulation and experimental results demonstrated significant benefits for the implementation of the multidimensional signage approach into the wayfinding process and evacuation time, and further developments reflecting this approach will be conducted.

APPENDIX A

PRELIMINARY EXPERIMENT

A.1 Preliminary experiment A (Experiment on an evacuation tasks)

In order to understand the relationship between the evacuation process and the interpretation of information from emergency signage, a preliminary experiment on an evacuation task was created. In this experiment, 18 participants were asked to perform a task that resembles a real-life evacuation, by relocation from an assigned location to another assigned exit point as shown in Figure A.1. While elevators and personal communication devices were prohibited throughout the time of the experiment. Each individual was equipped with a headband camera recording the performing assigned task.

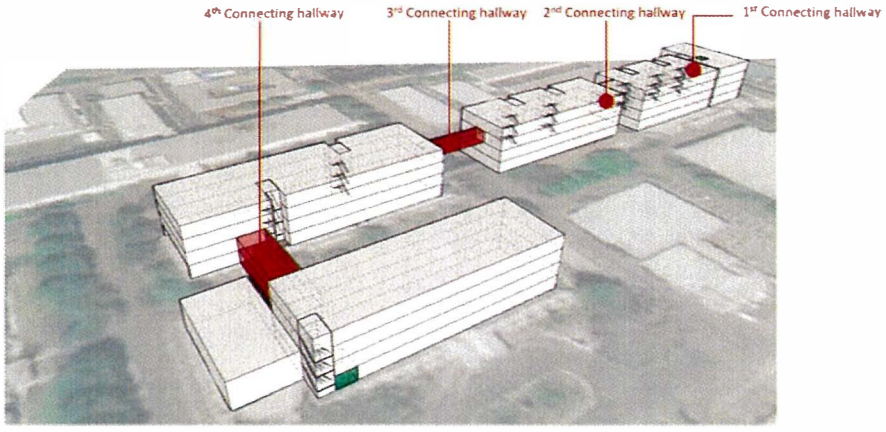


Figure A.1 Experimental Studies on Evacuation Task in a controlled environment

The performing tasks were recorded and analyzed through a visual detection method, in order to clarify the noticeable action of participants regarding their process to find a way to the designated safe location (Figure A.2). A proposed in-depth interview was later set up as a qualitative measure to expand our scope of participants' interpretation of directional information on the emergency signage tested. In order to further investigate the way individuals, accept information conceived by emergency signage and record their actions. The testing results from 18 participants were analyzed by the visual detection method to identify if there was a significant point related to human behaviors during the evacuation that noticeably affected participants in the way finding process. In this experiment, the participants' performed tasks resemble a real-life evacuation.

Figure A.2 Headband camera image recorded from a performing task of an real-life evacuation task

Referred to the universal fire safety regulation, the maximum time consumption for evacuation are 2 minutes and 50 seconds; no records from a participated participant were relocated on the assigned time period. The average time consumption for evacuation was 4 minutes and 40 seconds; the minimum evacuation time consumption recorded was 3 minutes and 40 seconds and the maximum was 6 minutes and 7 seconds as shown in Figure A.3.

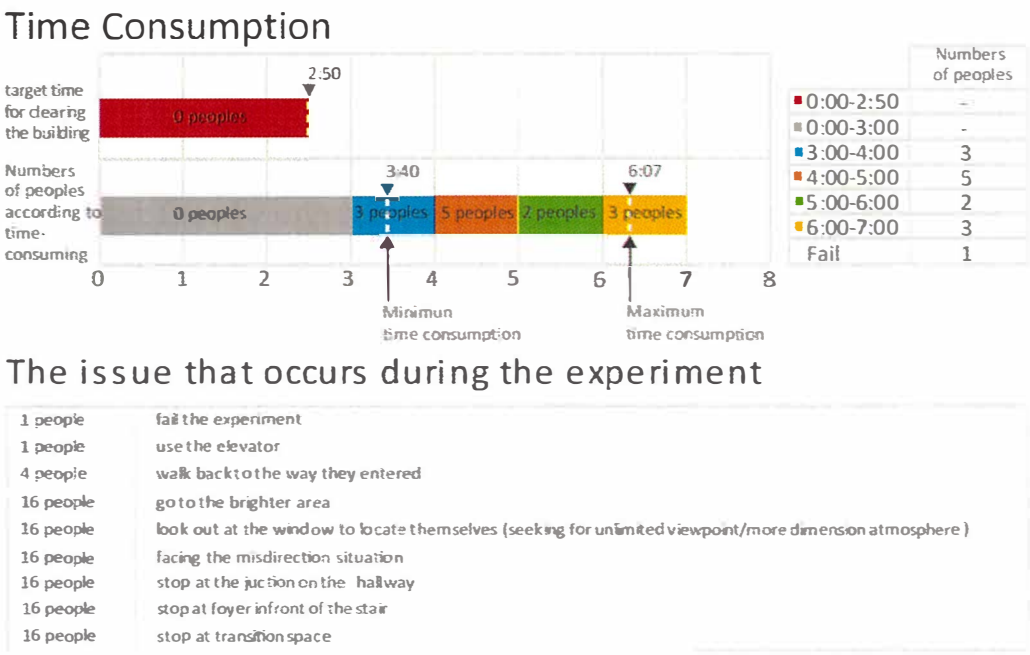


Figure A.3 Analysis results of an evacuation tasks experiment

Throughout the analysis procedure from the visual detection data of 18 participants, 100 percent of participated participants stopped at the corridor intersection, where their visual field was complicated. In this experiment, all of the participants navigated themselves to the area, where the illumination of the light level was greater. The result from an investigation on

a visual detection data revealed, all participated participants inspected their location referenced to the outside environment and exterior surroundings through the windows and building facade opening in order to reference their position.

The overall results revealed emergency signage contained a misinterpretation in directions where the visual field was limited. Our finding suggests three primary factors which directly related to the perception of participants, which are positioning of signage, placement of signage, and the visibility ability of signage respectively. Simulation and experimental results demonstrated the problem of exiting signage, which still interpreted a large number of a misunderstood or misled the viewers.

A.2 Preliminary experiment B (Information on the emergency signage)

In this research, the set of survey questionnaires, which stimulate an interior atmosphere, were created using Google Sketch Up, Adobe Illustrator and Adobe Photoshop to be used for study as testing subjects as shown in Figure A.4. In the form of multiple-choice questions, participants were asked to select an answer from provided options that matched the directional provided in sample images to a short explanation. This experiment was created to test the accuracy of the information of direction conceived by the viewers. In this study, the sample of 8 British format emergency signage was selected as testing subjects. The

experiment was set up with no limitation of time for responding, to ensure that participants can be interpreting information of direction from the provided sample without a time factor.

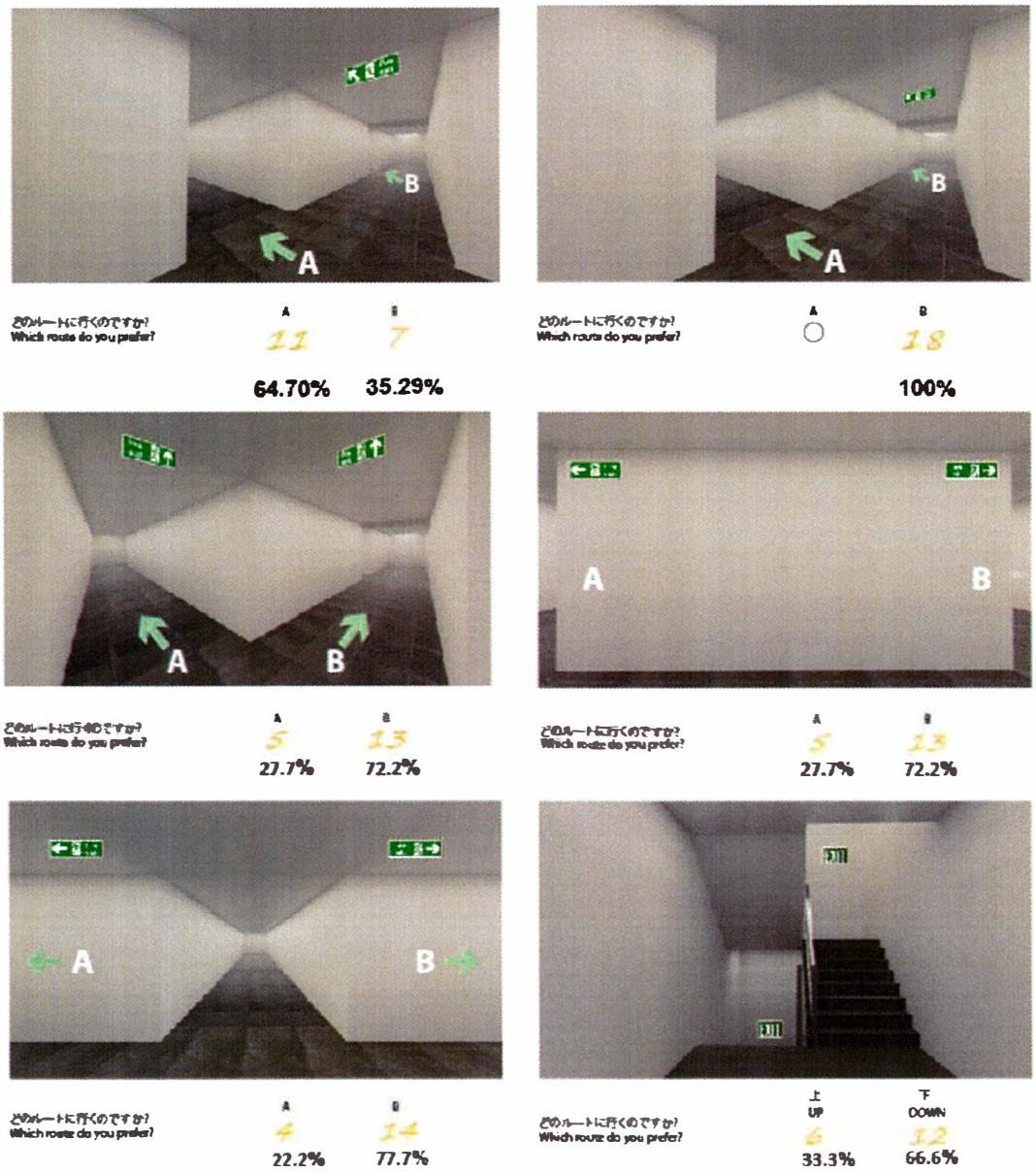


Figure A.4 Results from survey questionnaire on stimulated interior atmosphere with signage placement

The responses will be analyzed in order to investigate the accuracy of direct guidance from emergency signage, and which determined the effect on decision making of the exit signage's graphics and the signage's installed location. These responses were collected and allowed the interviewer to ask more in-depth questions regarding the participant's selection; as intended, this help collate why participants selected their answers to understand their interpretation of both information and overall emergency signage design.

The results from survey questionnaires, investigating the accuracy of direct guidance from emergency signage from 18 participants were analyzed. The results revealed the problematic issues lead by imprecise directional guidance that occurred on emergency signage. The results indicated the margin of errors critically occurred from the emergency signage, where the directional arrow was complicated. Participants' responses were a hundred percent accurate in the picture sample, where the left and right arrows are absolutely represented in direction. In the picture sample, where the arrow was pointed upward, participants' responses were errors by 11 percent and 65 percent on an image of a downward arrow accordingly as shown in Figure A.5. The research revealed a critical point of directional interpretation on sample pictures, where the arrow pointed toward a diagonal direction, with an average of 62.5 percent error rate.

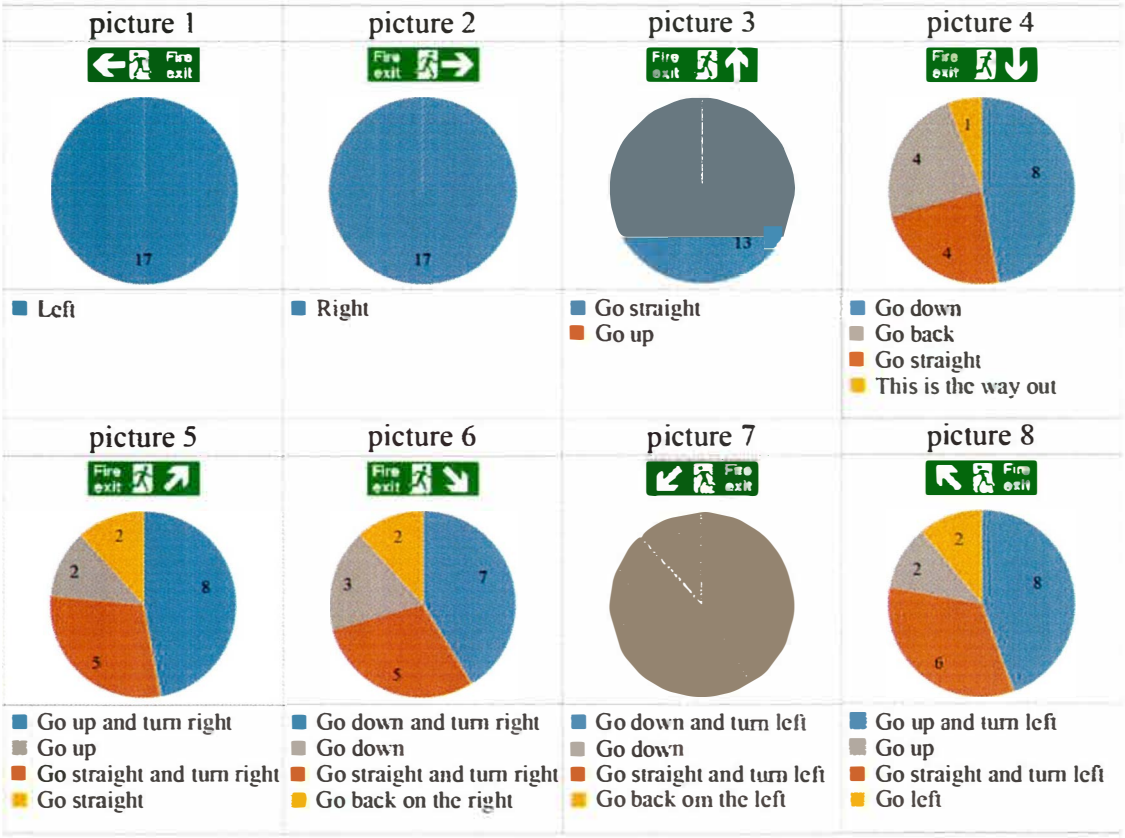


Figure A.5 Results from an investigating on the accuracy of direct guidance from emergency signage

APPENDIX B

THE RESEARCH QUESTIONAIRE

B.1 Criteria for evaluation

To acquire how accuracy participants conceive an information methods and essential information of direction relate to the emergency signage, we created a survey form to evaluate the accuracy of individuals' perception of information conceived by emergency signage. The experimental survey questionnaire results were in a form of short explanation format. We believed that in the case of an emergency, there are no option in a direction information, on the other hand the information of direction interpreted by participants must originally create in the way participants conceive information on their own methods.

To test the efficiency of the graphic design approach on an emergency exit signage design, the performing tasks of 27 participants were recorded and analyzed through a visual detection method, in order to clarify the action of participants regarding their process of information conceiving and time consumption. The evaluation of results was focused on the accuracy of an individual's response to the direction information and the recorded time length required for the interpretation process (referred to as methodology in chapter 3).

B.2 Multidimensional design approach

To regulate laws in many countries around the world, including Japan, emergency signage has become standardized for public safety. Focusing on the emergency exit signs, the message conveyed to the viewer contains a predominant meaning. As a regulator and necessary obligation in many countries throughout the world, an exit sign is a safety device required in a public facility or building. One important aspect of the design of emergency signs is the message conveyed should be unmistakable and understandable to anyone at any time. Despite that, the research aims to provide an alternative approach to emergency signage design that transfers the essential information of the direction into the form of multidimensional signage design as shown in figure B.1.

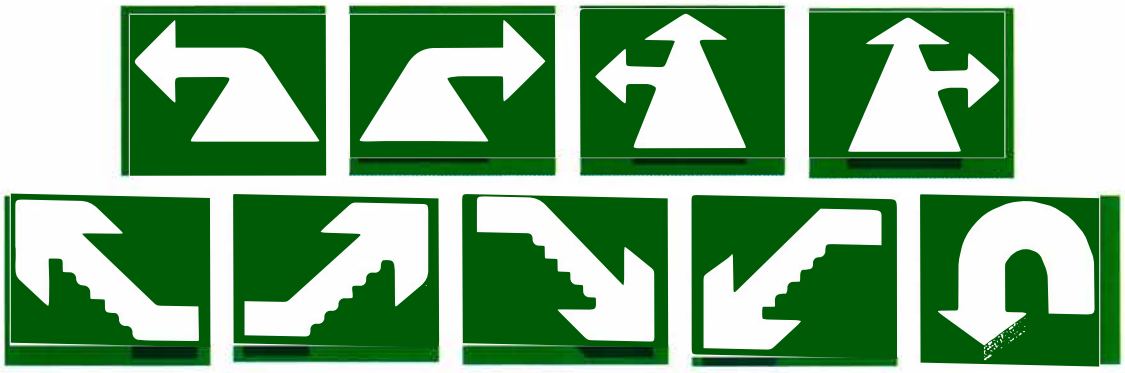


Figure B.1 A sample of multidimensional design signage

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IMAGE REFERENCES

Figure 2.4 (British format emergency signage sample)

Source 1: *https://www.safelincs.co.uk/euro-vs-bs-signs/* (Accessed, May 2022)

Source 2: *https://www.dreamstime.com/standard-emergency-exit-sign-designs-may-be-used-text-format-can-be-used-building-iso-graphical-symbols-image134997283* (Accessed, May 2022)

Figure 2.5 (International Organization for Standardization, a technical standard for graphical hazard symbols on hazard and safety signs)

Source: *https://www.conceptdraw.com/examples/safe-condition-sign-meaning* (Accessed, May 2022)

Figure 2.6 (Sample of the depth dimension in traffic direction information signage)

Source: *https://medium.com/walmartglobaltech/data-science-in-walmart-supply-chain-technology-bdb5d6b4105c* (Accessed, May 2022)