Comparative Study of Dissuasive Emergency Signage

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Abstract
This thesis investigates dissuasive emergency signage conveying a message of not utilizing a specific exit door. The thesis analyzes and highlights which features of dissuasive emergency signage have the largest impact on observer preference, interpretation and noticeability of the signage, in addition to analyzing the possibility and effects of causing an increased sense of urgency amongst the observers. It is shown that features which clearly negate the original exit-message of the original exit signage are most effective, for instance a red LED (light emitting diode) X-marking placed across the entirety of the exit signage conveys a clear dissuasive message which is easily understandable by observers. Other features of note are red flashing lights and alternation of color. Affecting the sense of urgency of the observer results in faster decision making times and a mindset more prone to searching for and following signs and instructions, which is considered a positive effect. The sense of urgency is largely affected by sensory inputs such as red flashing lights or other features which cause the signs to break the tendencies of normalcy.

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Foreword

This thesis has been written for and with the Department of Fire Safety Engineering at Lund Institute of Technology (LTH), at Lund University. It encompasses a full 30 credits and is the final part of my Fire Engineering and Master of Risk and Disaster Management degrees. During the course of the thesis and entire education I have received help from a great deal of people. In particular Ronan Keating and his gentle music that has steadily helped me make it to the finish line. So please, kick back, relax, and enjoy this little piece of art (preferably to the tune of *When You Say Nothing at All*).

It's amazing that this,
education is done.
A lot of help I have had,
and thanks is to come.
As hard as I try, I could never explain,
how glad I am, for the help I have gained.

Enrico Ronchi,
supervising me clearly,
The *Daniel Nilsson*,
just grading me justly.
Your help and your guide says I'll do well, in the future to come.
Fire research, is best when it is with you.

Erik, *Sabine*, *Lisa*,
without you, I would fail (oooh-oooh-oooh-oooh-oooh).
With pilot testers like you,
what could ever go wrong. (ever go wrong).
And all of you, whom my survey took,
with your deeds, this thesis took to flight.

Results I have made,
with your help and none other.
Hope it will come to use,
otherwise what's the bother.
And last but not least, I say thank *Ulf*, for your help.
Cause fire research (fire research), is best when it is with you.

With this heartfelt song of a thank you I wish to thank the following people:

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Summary

At the time of writing this thesis the current state of research regarding emergency signage is focused on active and dynamic signage. Research and testing is being conducted in order to assess whether it is possible to affect egress route choice by utilizing different active features incorporated into emergency signage. Previously it has been shown that flashing lights of varying colors and the use of activated LEDs (light emitting diodes) have had positive effects on guiding egressing occupants along egress routes. When choosing between an egress routes provided with the above mentioned features and those not provided with such features, there is a tendency for the egressing occupant to follow the egress route marked by the activated features. Going forward, these findings may be utilized to create active dynamic signage systems which are capable of guiding egressing occupants along the paths best suited for egress, avoiding danger and areas where critical conditions may have been reached. In order for this to be possible, it must also be investigated how egressing occupants respond to signage telling them not to egress through a particular exit door and what features are best suited for an objective such as this.

This thesis aims to examine which features of emergency exit signage are best suited to dissuade observers from exiting through a particular exit door. In addition, the thesis also aims to examine the possibilities and effect of causing a greater sense of urgency and risk amongst observers through features which may be applied to current emergency signage. As a starting point, the thesis asks the following two questions:

- How should an emergency sign be designed to provide the largest likelihood of dissuading egressing occupants from the use of a certain egress route?
- How is it possible to affect the sense of risk and urgency amongst the observers through the use of emergency signage and additional features and what would be its gain?

To answer these questions the thesis proposes a paired comparison survey which will examine how observers react to different features by having them answer affordance based questions while viewing pairs of signage. Affordances are offered by the signs on sensory, cognitive, function and physical levels and intend to describe how observers perceive and interact with the signs on different levels. The signs ability to convey a sense of urgency is tested in a similar fashion for each pair of signage.

The results show that the most important factor when creating dissuasive emergency signage is the requirement to, in a clear way, negate the original *EXIT HERE* message of the original exit signage. As such, the cognitive affordance of the dissuasive emergency signage is of most importance when evaluating the signage's functional affordance and preference amongst observers. Sensory affordance also plays a key role in alerting observers of the signage and making them aware that the message of the original exit signage has changed. The following list highlights three features which were shown to together have a large positive effect on observers' preference of a dissuasive emergency sign:

- Green background with white text or pictogram.
- Red LED X-marking placed over entire sign.
- Red flashing lights placed adjacent to sign.

The results also show that increasing the amount of urgency felt by observers is most easily accomplished by providing heavy sensory output which conveys an alerting or warning message. An example of this is red flashing lights placed adjacent to signage, as red is commonly associated with warning or danger and flashing lights are usually associated with warning lights such as truck lights or restricted area lights. Causing observers to feel an increased sense of urgency and risk is expected to decrease decision making speed and cause observers to be more prone to search for and follow signs and instructions, which is considered a positive effect.

Sammanfattning

Vid tidpunkten för skrivandet av detta examensarbete behandlar den nuvarande forskingen kring utrymningsskyltning möjligheterna kring aktiv och dynamisk skyltning. Forskning utförs för att kunna undersöka huruvida det är möjligt att påverka vägval genom att använda diverse särdrag inkorporerade i utrymningsskyltning. Tidigare har det visats att användande av blinkande lampor av varierande färger samt användningen av aktiverande LED-markeringar har haft positiva effekter vad gäller guidandet av utrymmande personer längs utrymningsvägar. När val mellan utrymningsvägar görs finns en preferens att välja vägar som är försedda med liknande aktiverade system som nämns ovan. Om man blickar framåt kan dessa fynd användas för att skapa aktiva dynamiska utrymningssystem som är kapabla till att guida utrymmande personer längs med de utrymningsvägar som är bäst lämpade för situationen, vilka undviker områden där kritiska förhållande kanske redan råder. För att detta skall vara möjligt måste det även forskas kring hur utrymmande personer påverkas och reagerar på skyltning som säger åt dem att inte utrymma en specifik väg samt vilka särdrag som är bäst lämpad för ett sådant ändamål.

Detta arbete syftar till att undersöka vilka särdrag utrymningsskyltning kan nyttja för att bäst avråda personer från att utrymma genom en specifik dörr. Utöver detta syftar även arbetet till att undersöka de möjligheter som finns för att påverka känslan av brådska och risk hos iakttagare av skyltningen samt vilka särdrag som är bäst lämpat för detta. Som en startpunkt ställer arbetet följande frågeställningar:

- Hur bör en utrymningsskylt vara designad för att bäst förmedla ett avrådande budskap att använda en specifik utrymningsdörr till utrymmande personer?
- Hur är det möjligt att påverka känsla av risk och brådska hos personer under utrymningen genom användandet av utrymningsskyltning samt vad är effekterna?

För att besvara dessa frågor föreslår arbetet en parvis jämförelsestudie vilken skall undersöka hur personer reagerar på olika särdrag genom att be dem besvara *affordance*-frågor medan de iakttar utrymningsskyltning. *Affordances* ges av skyltarna på en sensorisk, kognitiv, funktionell och fysisk nivå, och ämnar beskriva hur personer iakttar och interagerar med skyltarna. Skyltens förmåga att förmedla en känsla av brådska testas på samma vis för varje par skyltar.

Resultaten visar att den viktigaste egenskapen vid skapandet av avrådande utrymningsskylten är behovet av att på ett klart och tydligt sätt negera det ursprungliga *UTRYM HÄR* meddelandet av den ursprungliga skylten. Därför är den kognitiva-*affordancen* av den avrådande skyltningen av störst vikt när man bedömer skyltens funktion och preferens bland iakttagare. Sensoriska-*affordancen* är också en nyckelpjäs vad gäller att uppmärksamma personer om skyltningen samt uppmärksamma dem om att meddelandet av ursprungsskylten har ändrats. Följande lista visar tre särdrag som har visat sig tillsammans ha en stor positiv effekt för personers preferens av en avrådande utrymningsskylt:

- Grön bakgrund med vid text eller piktogram.
- Röd LED-X-markering placerad över hela skylten.
- Röda blinkande lampor placerade intill skylten.

Resultaten visar även att en ökad känsla av brådska hos iakttagare uppnås enklast genom stora sensoriska intryck som på något vis meddelar ett varnande meddelande. Ett exempel är röda blinkande lampor placerade intill skylten, då rött ofta associerad med varning eller fara samt att blinkande lampor ofta associeras med liknande varningslampor så som lastbilslampor eller områdesvarningslampor. Att öka känslan av brådska och risk förväntas leda till en förkortad beslutstid och göra personer mera mottagliga till att både leta och följa skyltning och instruktioner, vilket anses vara en positiv effekt.

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1 Introduction

This section provides the background of the thesis, its purpose and presents its objectives and aims.

1.1 Background

In a society where complex and multifunctional buildings are becoming more commonplace and available to the general public, the requirements of a safe evacuation from these buildings are also becoming more apparent. It is not uncommon for buildings to be used in a manner they were originally not intended, such as interventions in historical buildings, renovations or changes of use. In cases such as these it is important for way-finding systems to be easy to understand as the preferred routes of egress may not be the most obvious (Vilar, Rebelo, Noriega, Duarte, & Mayhorn, 2014). As these buildings are often open to the public it is not uncommon for the occupants of the buildings to be unfamiliar with the environment. This further adds to the importance of an easy to understand and effective way-finding system.

An important step in the way-finding process is the use of emergency signage which indicates preferred routes of egress. It has been shown that egressing persons have a tendency to move towards the familiar, despite possibly seeing exit signs (Sime, 1985). However, evacuation experiments of occupants within buildings have yielded results which show that if an occupant sees an emergency sign during egress they are likely to proceed to follow the signage; however the signs are not always seen. For instance, in a study by Galea, Xie and Lawrence only 38% of people actually 'see' conventional static emergency signage, even if they are provided with unobstructed vision to signage directly in front of them (Galea, Xie, & Lawrence, 2014). It is therefore of importance to provide a means to make signage more visible and attractive to the occupants within the building, giving them a greater reason to follow it.

A possible way to alert occupants of the existence of emergency signage is the use of flashing lights in the immediate proximity of the emergency sign (Nilsson, Frantzich, & Saunders, 2005). This will alert occupants of the specific emergency sign and in most cases influence the occupants to use that particular path for egress making it possible to alter behaviors such as heading back down the known path. The use of for example flashing lights, or other dynamic features incorporated into emergency signage is frequently dubbed a dynamic signage system. In a study by Galea, Xie and Lawrence, when comparing dynamic signage systems to the more conventional static emergency signage systems an increase in the visibility of the signage could be observed, from 38% to 77% (Galea, Xie, & Lawrence, 2014). In other words, a larger portion of the egressing occupants are able to 'see' the sign and subsequently follow it. The process of measuring whether a sign has been seen or not is commonly done through observation during live trials, a method which has been utilized at the University of Greenwich (Galea, Xie, & Lawrence, 2014) when assessing visibility in normal conditions, and at Lund University (Ronchi, Nilsson, & Gwynne, 2012) when assessing visibility in smoke-filled conditions. Processes that subsequently impact observers' choice to follow signage are discussed frequently within relevant literature. One view includes a four step assessment: Is the sign visible to the observer, is the sign noticed by the observer, is the sign correctly interpreted by the observer, and finally does action occur due to the signage impacting the observer (Ronchi, Nilsson, & Gwynne, 2012).

The act of incorporating dynamic features into emergency signage has been researched in previous and ongoing research projects. The ongoing GETAWAY-project is evaluating if it is possible to address choice of egress route through the use of evacuation signage provided with lit green arrows or red crosses (Bryant & Giachritsis, 2014). A study at the University of Greenwich has examined if it is

possible to alert people of signage through the use of green LEDs within the evacuation signage, and also if it is possible to dissuade the use of certain exits through the use of an array of red markings (Galea, Xie, & Lawrence, 2014). A PhD thesis by Daniel Nilsson at Lund Institute of Technology has, amongst other things, highlighted that through the use of flashing green lights it is possible to alert people of the existence of an egress route or signage that they previously did not see or know about (Nilsson, 2009). This result is further enforced by a study showing that an egress route equipped with green flashing lights was used more frequently than one without (Fridolf, Ronchi, Nilsson, & Frantzich, 2013). A virtual reality study showed that it was not just possible to alert people of the existence of an egress route, but also affect choice of egress route through the use of different colored flashing lights and that the different colored lights convey different meanings to the observers (Johansson & Petersson, 2013).

By studying the results of the above mentioned research projects it is possible to draw the conclusion that dynamic emergency signage can be used to both alert occupants of existing signage and also affect their choice of egress path. A way to further improve way-finding systems is to incorporate active dynamic signage systems. These are systems capable of altering which path is shown as the preferred egress route by altering the meanings of the emergency signage (Galea, Xie, & Lawrence, 2014). This can be done by certain emergency signs within the system being altered to display a negative or dissuasive message, with the goal of dissuading use of a particular path, and hence leading occupants down the egress routes which are not marked as negative or dissuasive. This can be useful if coupled with a system capable of recognizing hazards along egress routes as occupants can then be dissuaded from utilizing these hazardous routes for egress.

Previous research projects have done testing on various types of color coding and signage to try to establish what kind of emergency signage may be utilized to dissuade occupants from certain egress routes. Two studies conducted at Lund University have come to the conclusion that occupants during egress observing green lights and colors are generally draw associations to safety, while orange lights and colors tend to indicate warning and red lights and colors convey a sense of danger (Frantzich, 2004), (Nilsson, Frantzich, & Saunders, 2005). A study at the University of Greenwich has also shown that by applying various types of red markings to emergency signs, they can convey a dissuasive message to not use a certain egress route which is generally understood by a large portion of persons that are egressing through unfamiliar spaces (Galea, Xie, & Lawrence, 2014).

This thesis aims to research and establish what type of emergency signage is best suited to convey a negative or dissuasive message to egressing occupants informing them that a certain egress route should not be used. By drawing inspiration from previous research projects and perception and interpretation theories a number of emergency signs will be tested alongside one another to examine which particular sign with a particular set of features, dynamic and static, is best suited for this goal. By doing this, this thesis aspires to become one with the current research and knowledge foundation required to correctly assess full scale active and dynamic signage systems.

1.2 Objectives

The purpose of this thesis is to examine the possibilities of dissuading egressing occupants of the use of certain egress routes by the use of negative or dissuasive emergency signage, and in turn examine what type of emergency signage is best suited to convey this message. An additional purpose of this thesis is for the results to be incorporated into the existing research and knowledge base allowing for further assessments into the use of intelligent and dynamic signage systems.

In order to establish what type of emergency signage is best suited to convey a negative or dissuasive message to observers, a series of questions are raised. The thesis' questions at issue can be summarized in the following bullet point list. The list is divided into two overall questions, with a few more limited guiding questions, which aim to be answered during the process of the thesis.

- How should an emergency sign be designed to provide the largest likelihood of dissuading egressing occupants from the use of a certain egress route?
    - What features of a sign are considered easy to interpret?
    - What type of emergency signage results in the correct dissuasive action?
    - How susceptible are observers to ambiguous messages?
- How is it possible to affect the sense of risk and urgency amongst the observers through the use of emergency signage and additional features and what would be its gain?
    - What features of a sign may be used to facilitate the sense of risk and urgency?
    - What are possible gains from facilitating risk and urgency amongst the observers?

1.3 Aim

The aim of this thesis is to compile the collected data and information to be able to draw a conclusion in regards to whether a certain type of emergency signage better conveys a dissuading message than other types of signage. Within this motivation the signage's ease of perception, understanding and preference will be included. In addition, an examination regarding the ability to affect observers' sense of risk and urgency and evaluate potential gains will also be included. The final aim is to leave a recommendation as to what type of signage is expected to be best suited to dissuade occupants from the use of a certain egress route during egress.

1.4 Limitations

The following limitations are imposed upon the thesis:

The thesis aims to examine emergency signage conveying a negative or dissuasive message only, presented in a comparative fashion. Therefore results will only be able to show if a certain configuration is preferred over another configuration presented within the survey.

The signage options presented within the survey of this thesis will be presented in a virtual environment. A further validation of the results would need dedicated real world testing.

1.5 Disposition

The disposition of the thesis is as follows, shown in figure 1:

Figure 1. Flowchart depicting the disposition of this thesis.

2 Literature and Theory Study

The literature and theory study serves as the knowledge base and starting point that the thesis builds upon. In order to maintain a systematic approach within the literature and theory study, guidelines have been adopted with influence from the methodology proposed by Khan in *Five Steps to Conducting a Systematic Review* (Khan, Kunz, Kleijnen, & Antes, 2003). The literature and theory study is divided into the following five steps:

> **Framing questions for a review:** A set of questions are asked which the literature and theory review aim to answer. These questions will serve as a starting point for the search of information. The questions will be chosen in a manner that the answers will provide the necessary knowledge required to provide the ability to answer the thesis' questions at issue.
>
> **Identifying relevant work:** Relevant work is primarily found by consultation with the thesis supervisor and through the searching of digital databases. Access to literature was gained primarily through the use of credentials gained from Lund University. Work was searched in two main fashions. Either by referencing *key words* related to the questions being reviewed or by referring to the list of references of other found literature to gain a more detailed understanding on certain subjects.
>
> **Assessing the quality of studies:** A source of literature was deemed acceptable if it contained relevant information to help answer the questions proposed for review and if it had been published by an established member of the scientific community, published within an established journal or was part of an approved research project.
>
> **Summarizing the findings:** The findings for each question proposed for review are summarized and relevant information is presented in the literature review.
>
> **Interpreting the findings:** The summarized findings are interpreted and a conclusion is put forth as to how the findings are relevant to the thesis and how they will be used for future development towards answering the thesis' questions at issue (included in section 4).

The questions proposed for review are chosen as follows:

1. How is it possible to affect observer's perception of emergency signage?
2. What features of emergency signage can increase a signs visibility?
3. How is it possible to affect people's egress route choice by the use of emergency signage?
4. How does risk perception alter action during egress and perception of signage?
5. Have similar studies been made previously?

How is it possible to affect observer's perception of emergency signage?

Gibson (1977) coined the term Theory of Affordances which offers a possible means of describing how observers perceive and understand objects. Affordances are properties of the perceived environment which provide probabilities for actions. Affordances help the observer understand what an entity or object is good for, what can be done with it and what utility it offers (Gibson, 1977). An example is a flat horizontal surface offering support for a second object. The horizontal surface affords support. A similar flat vertical surface does not offer support for a second object. The vertical surface does not afford support.

Affordances from entities or objects are static and need to be perceived by an observer. It is important to note that affordances can also be misinterpreted, that an observer interprets an affordance for something it is not (Gibson, 1977). An example of this is a closed clear glass door. The door offers the affordance of blocking the path, while the observer perceives the door as air and thereby perceives the affordance of passage. The result is that the observer walks into the glass door with a negative consequence due to a misinterpretation.

The term affordances may be further divided into four distinct categories, or types (Hartson, 2003):

Cognitive affordance: Design features that help users in knowing what to do.

Physical affordance: Design features that help users in doing a physical action.

Sensory affordance: Design features that help users sense something.

Functional affordance: Design features that help users accomplish a task.

The division into these four types of affordances offers an ability to alter an object to affect a certain facet of its affordance. An object may for example have an easily perceived physical affordance but a more difficult to perceive functional affordance (i.e. a door with a push plate that is only operable by pulling) (Hartson, 2003). Altering the objects physical attributes (i.e. adding a pull bar) will provide a physical affordance which matches the functional affordance creating a more easily correctly perceived object.

The act of perceiving an affordance correctly is coined by Lu & Cheng (2013) as *the perceptible probability of affordance*. Correctly perceiving an affordance relies in large on three core aspects: The objects physical properties, the situation in which it is being perceived and the attributes of the person perceiving (Lu & Cheng, 2013). For instance, a Japanese texted sign (physical properties) may not allow a non-Japanese reader to perceive the message which the sign affords. However, if the observer is able to read Japanese (attributes of the observer) he will be able to perceive the message which the sign affords. Lastly, if the sign reads ‘only in case of emergency’ (situation) a person observing the sign would not perceive the message which the sign affords if not in an emergency.

Lu & Cheng (2013) also coin the term *perceptual threshold of affordance* relating to the ease of which an affordance may be perceived. Observers of an object experience perceptual thresholds while trying to perceive affordances. The thresholds can take different forms, for example language barriers, ambiguous signs and symbols not corresponding to the regular norm, and are all subjective to the observer (Lu & Cheng, 2013). Localizing these thresholds and altering them can provide a means to increase the ease of perceiving the affordances provided by objects.

Altering the perceptual thresholds can be done by the use of symbols and semantics. Symbols and semantics relating to an object differ from affordances in that affordances are provided by the object as a whole, while symbols and semantics are added to stimulate the cognitive perception of the observer to help them perceive the affordances of the object (You & Chen, 2007). An unmarked door leading to a stair case provides the affordance of passage, while the same door marked with a pictogram of a staircase provides the affordance of passage vertically, thereby helping the observer perceive that the door leads to a staircase.

What features of emergency signage can increase a signs visibility?

During a research project with particular conditions, utilizing conventional static emergency signage resulted in only 38% of people being able to adequately locate and interpret the signage during a presumed emergency evacuation. Out of the 38% who do locate the sign, 97% proceed to follow the signage's instructions (Xie, Filippidis, Galea, Blackshields, & Lawrence, 2012). Utilizing different types of dynamic emergency signage, the percentage of people able to locate the signage may be greatly increased to between 72% and 77% (Galea, Xie, & Lawrence, 2014). Therefore, increasing the visibility of emergency signage through the use of dynamic features may greatly improve their effectiveness.

A possible way to attract attention to emergency signage is by placing flashing lights adjacent to the signage (Nilsson, Frantzich, & Saunders, 2005), (Duarte, Rebelo, Teles, & Wogalter, 2013), (Johansson & Petersson, 2013). It has been shown that the placement of such flashing lights increase observers' awareness of the signage and are able to locate it with more ease. This is also applicable to signage that the observers previously did not know about (Nilsson, Frantzich, & Saunders, 2005). It is also believed that flashing lights placed adjacent to emergency signage may counter the effects of learned irrelevance, leading to observers recognizing signage they would otherwise ignore (Frantzich, 2004). In order to correctly counter the effects of learned irrelevance the flashing lights must only be active when an egress situation arises, preferably connected to the fire alarm, as they would otherwise quickly also succumb to the learned irrelevance of the observers and once again not be recognized for what they are (Nilsson, Frantzich, & Saunders, 2005).

Incorporating pulsing LED lights into the signage itself to highlight certain important areas, for example the arrow guiding the way in many pictogram style emergency signs, has been proven to have a positive effect on signage localization and interpretation (Galea, Xie, & Lawrence, 2014). LED incorporation into emergency signage has also been proven to increase the range of visibility of the signage and help in making it easier to read and interpret (Boyce, Shields, & Silcock, 1999), (Cook, Webber, Gillham, Le Scouiller, & Moseley, 2005).

Utilizing environmentally wide acoustic signals, specific to the emergency situation, engages the egressing people to more actively search for additional information during evacuation (Nilsson, Johansson, & Frantzich, 2009). It is noted that this result was gained from the egressing people not fully understanding the meaning of the acoustic signal, yet they interpreted it as an emergency signal and hence began searching for additional information by way of signage. Adding acoustic signals locally to signage, to draw attention to specific signage locations, has also proven to have a positive effect on locating signage (Withington, 2002), which was also tested within a smoke filled tunnel environment providing positive results on way-finding and egress time reduction (Boer & van Wijngaarden, 2004). Similar effects were observed when the signs co-located with acoustic signals were also provided with orange flashing lights drawing additional attention (Duarte, Rebelo, Teles, & Wogalter, 2013).

Static features that are able to be altered to increase an emergency signs visibility include, but are not limited to: size of the sign, size of the pictogram or text and choice of color for different elements of the sign. An increase in the size of the sign generally amounts an ease of attracting attentions and becoming more visible (Laughery & Wogalter, 2011), while an increase in size of the pictogram or text elements of the sign lead to it being easier to interpret in emergency, and possibly low light, conditions (Wong & Lo, 2007). It has also been found that colored sign content on a white background offers a high amount of visibility compared to other combinations (Wong & Lo, 2007), while it is also

important to keep in mind that the colors chosen must be distinguished from that of the surrounding environment and preferably chosen with the colors societal meaning in mind (Laughery & Wogalter, 2011). For instance, the color green is often considered a color of safety in the western world, but placing a green sign in a green room will drastically reduce the signs visibility as it does not stand out from its surroundings.

How is it possible to affect people's egress route choice by the use of emergency signage?

Egressing occupants have a tendency to attempt to egress via familiar routes (Sime, 1985). This typically results in people that are unfamiliar with the building they are in attempting to egress via the main entrance of the building as that is the route they know leads to the outside. This is further enforced by an evacuation experiment performed in an IKEA store where occupants unfamiliar with the store layout walked past certain egress routes without utilizing them and instead headed for the main entrance (Frantzich, 2001). The use of emergency signage is a way to alter this behavior, as people who see exit signage generally follow the signage's direction and may commence to follow a secondary egress route (Xie, Filippidis, Galea, Blackshields, & Lawrence, 2012). In the context of this thesis it is important to understand what features of emergency signage can affect egress route choice, both positively and negatively, as the aim is to have egressing occupants see the emergency signage and understand its dissuasive message.

Color coding is a possible option to apply different associations to certain entities. The use of color coding to convey information should be done with consideration to that different colors may have well established meanings for different populations (Wickens & Hollands, 2000). For instance, in the western world red is generally associated with stop or a negative, whereas green is associated with go or a positive, but this may not be the case throughout the world (Rasekh & Ghafel, 2011), (He, 2009). Furthermore, it is important to note that colors by themselves do not hold specific meaning, but may instead be used to enforce the meanings of other entities they are associated with or context in which they are viewed and it is therefore imperative that the colors chosen do not pose a conflict in meaning between the color and the entity it is associated with as this would lead to observer confusion (Wickens & Hollands, 2000).

During egress conditions, in certain parts of the world, green is most often associated with safety or exit, whereas orange is typically associated with warning and red generally associated with danger (Nilsson, Frantzich, & Saunders, 2005). Results from a similar survey concluded that when not in an egress situation people generally did not associate different colors with anything in particular although there was still a significant trend to associate green with safety and red with danger and to a lesser extent warning, but when asked in conjunction with performing an evacuation experiment the associations of green meaning safety and red meaning danger were much more clear while orange was slightly associated with warning (Frantzich, 2004). As shown in a study by Troncoso (2014), it is predominantly context and not culture which is of most importance when depicting the meaning of certain colors. When observing evacuation choices by persons identifying as Chinese or European similar choices were made due to participants noting that green was typically good in an emergency situation, as opposed to red, even though red is typically considered a good color in Chinese culture (Troncoso, 2014).

Providing flashing lights adjacent to emergency signage not only increases the signage's visibility, but also increases the proportion of people utilizing the marked egress route for egress when compared to egress routes marked with conventional static signage (Nilsson, Frantzich, & Saunders, 2005).

Explanations for this include that the activation of the flashing lights signal a change from passive to active indicating a certain egress route is of use (Nilsson, Frantzich, & Saunders, 2008) and that the emergency signage becomes easier to notice and hence egress routes become easier to locate (Nilsson, Frantzich, & Saunders, 2005). Context appears to play a significant role for the effectiveness of utilizing flashing lights to draw attention to and facilitate egress through certain egress routes. Occupants whom are familiar with the building layout, for instance office staff, tend to move along a pre-defined path and are not easily swayed to alter this path even if encountered by the flashing lights attempting to lead them elsewhere, while occupants whom are unfamiliar with the building layout, such as cinema visitors, to a larger degree accept and follow the signage leading them down an unfamiliar route once their attention has been drawn to it (Nilsson, Frantzich, & Saunders, 2008).

It has been shown through the use of virtual reality experiments that egressing people, when faced with the choice of egressing via a route marked with an exit sign coupled with green flashing lights and a route marked with an exit sign couple with red flashing lights predominantly chose the path indicated by green lights (Johansson & Petersson, 2013). It is also noted that during this experiment people were only given the chance to choose between routes with green or red flashing lights, and as such it is not possible to draw a conclusion as to how people would behave if faced with the options choosing between a route marked with red flashing lights or travelling down on unmarked corridor in search of a second currently non-visible egress route. A separate virtual reality experiment showed that dynamic emergency signage coupled with yellow flashing lights increased sign compliance, reduced decision time and reduced overall egress time when compared to conventional static signage (Duarte, Rebelo, Teles, & Wogalter, 2013), although orange is a color typically associated with warning.

An additional method of affecting people's egress route choice is by provision of various dynamic markings being activated on the signage when emergency conditions arise (Galea, Xie, & Lawrence, 2014). In order for these markings to be easily interpreted and of most effect it is of importance that well-known terms or symbols are used which convey a direct meaning, for instance a red X-symbol being used to negate a message, in conjunction with using a color for the markings that connote a correct meaning of what message is to be conveyed. It is also noted that people with familiarity of the environment do not heed warnings or markings to the same extent that people unfamiliar with the environment (Laughery & Wogalter, 2011), most likely due to a sense of security. An evacuation experiment at the University of Greenwich showed that incorporating markings into conventional pictorial exit signage, by locating pulsing green LED lights within the pictorial directional arrow, had a positive effect on interpretation, decision time and obedience of the signage. In addition, a questionnaire survey was issued where various negative markings, such as a red cross over certain areas of the sign, would be perceived as dissuasive (Galea, Xie, & Lawrence, 2014). The survey revealed that depending on marking placement and marking type the results varied significantly. The best results were found for markings consisting of a large red X-marking covering the entirety of the exit sign.

Utilizing directional acoustic signals coupled with emergency signage has been shown to increase the way-finding capacity of egressing occupants and also be able to convey directional messages by melodic scales moving up or down or through localized directional voice messages (Withington, 2002). It has also been shown that during evacuation experiments utilizing dense smoke conditions, directional bursts of sound have a tendency to lead egressing people to exits that are provided with the directional sound beacons as it becomes their only point of reference (Boer & van Wijngaarden, 2004).

How does risk perception alter action during egress and perception of signage?

There are several relevant models of risk perception covering the range from heuristic to systematic approaches to perceiving risk. A general consensus in regards to what factors potentially modulate risk perception include, amongst other things, the availability and intensity of fire cues, emotional states, previous experience and context (Kinateder, Kuligowski, Reneke, & Peacock, 2014). It is also of importance that the fire cues are of an unambiguous nature (Kuligowski & Mileti, 2009). This can be more tangibly explained as fire cues containing more sensory intense information that break the pattern of normality will generally result in a higher level of perceived risk. Breaking the tendency of normality, or normalcy bias, is imperative as it results in observers underestimating the risk of a situation if encountered with fire cues that are indicative of everyday events, such as a fire drill or general testing of systems (Kinateder, Kuligowski, Reneke, & Peacock, 2014).

Risk perception has been shown to function as a moderator of evacuation decision making and protective action (Kinateder, Kuligowski, Reneke, & Peacock, 2014). As shown in a study relating to the evacuation of the World Trade Center, people whom perceived a higher level of risk were more prone to seek out additional information and conform to the warnings within these messages (Kuligowski & Mileti, 2009). A separate study revealed that being confronted by a high perception of risk decreased the evacuation decision time and response time, while being confronted by an uncertain perception of risk caused an evacuation delay (Day, Hulse, & Galea, 2013).

During egress situations, red is commonly associated with danger and a higher level of risk and orange is commonly associated with warning (Frantzich, 2004), (Nilsson, Frantzich, & Saunders, 2005). As such, utilizing red and/or orange colors may cause observers to perceive a higher level of risk. It is important that the colors chosen are not ambiguous or in direct conflict in meaning, as the perceived hazard of the message being conveyed stands in direct relation to the likelihood that will be taken in (Laughery & Wogalter, 2011). Therefore, utilizing single-color schemes with colors generally associated with danger may likely produce the best results as the associations drawn in regards to the color will be unambiguous.

Have similar studies been made previously?

An international web survey, carried out by the University of Greenwich, has previously studied dissuasive emergency signage. The survey contained four types of dissuasive emergency signage that were varied by different types of markings placed upon regular exit signs with a *running man* pictogram and *fire exit* text combined. Within the survey respondents were asked to answer questions relating to interpretation of the signage, ranking their level of agreement with the signage's intended message and providing information on which of the four options was most preferred. The survey amassed 451 respondents, concluding that markings consisting of a large X, covering the entirety of the sign was most preferred (Galea, Xie, & Lawrence, 2014).

A virtual reality experiment, conducted at Lund University, has previously studied the effects of green and red flashing lights adjacent to emergency signage. The experiment consisted of participants equipped with virtual reality gear navigating a virtual corridor and being given choice to egress freely. It was noted that, while egressing, participants were drawn to the routes marked with emergency signage coupled with green flashing lights and generally dissuaded from using routes marked with emergency signage coupled with red flashing lights. A total of 30 and 40 participants participated in two separate trials. The pre-studies to the survey also concluded that humans typically make the same decisions in virtual reality as they would in real life (Johansson & Petersson, 2013).

The act of comparing different versions of signage is common practice within the advertisement industry. A survey, from the Wroclaw University of Technology, includes utilizing paired comparisons to determine which features of a signage are preferred amongst observers. Main benefits of using this method include the allowance of testing several different variants of signage against each other, each varying slightly from the other, in order to be able to pinpoint relevant features and finally recommend the most preferable signage (Grobelny & Michalski, 2011).

The author has not been able to locate any studies where specifically a comparison of different types of dissuasive emergency signage has been conducted.

3 Methodology

This section outlines the methodology chosen for the survey and aims to describe why certain methodological choices are made.

3.1 Survey Type

The survey aims to compare certain aspects and variations of dissuasive emergency signage in order to conclude what aspects and variations provide the most ease of interpretation of their dissuasive message and are generally preferred by observers. Therefore, the survey will take the form of a paired comparison survey as this allows for the comparison of variables and the ability to quantitatively score them against each other (David, 1960), (Brown & Peterson, 2009). The benefit of utilizing a paired comparison survey lies in that it produces a statistically robust result and is relatively easy to carry out (Noor & Aslam, 2013). Discrepancies of note related to paired comparison surveys include fatigue, which may cause respondents to become erratic during the end stages of the survey leading to enlarging error distributions, and the process of multiple valuations leading to respondents becoming more certain about their preferences and thus scoring these preferences with more weight later on in the survey (Brown & Peterson, 2009). By randomizing the sequence of presented pairs of items it is expected that an unbiased final result will be achieved.

In addition, it has been shown that in cases where respondents are not given sufficient background information and are not kept involved in the survey the effects of survey fatigue are enhanced and may result in an influx of erroneous standard deviation (Savage & Waldman, 2008). However, if respondents receive sufficient background information about the survey, chose to participate on their own accord, are kept involved throughout the time allocated for the survey and receive an incentive to continue, the effects of respondent fatigue are shown to be minimal (Hess, Hensher, & Daly, 2012). Due to respondents participating on their own accord, being kept actively involved throughout the survey and receiving an incentive (in the form of a cinema ticket), the effects of survey fatigue are expected to be small.

In the case of paired comparison surveys, respondents will be given the options to answer *closed* questions of an either/or type, with the addition of an indifference option. This utilization of *closed* questions is expected to result in an ease of interpretation and comparison of the results (Trost, 2012). However, it is recommended to provide at least one non-compulsory *open* question to give the participants the option of leaving any additional comments they may have had during the survey as it may provide valuable insight (Trost, 2012). This is offered in conjunction with each pair choice question in order to gain additional insight into why the participants choose as they do.

3.2 Study Sample

The sample size required for a comparative quantitative study, such as this thesis proposes, is largely dependent on what is to be studied and how many variables are included within the study (Trost, 2012), with more variables requiring a larger sample. Selecting a sampling method is dependent on the size and scope of the project and the amount of resources the author is able to allocate, where more resources usually results in a more correct sample (Marshall, 1996). Where time and resources are an issue, *convenience sampling* may be required. This entails acquiring a sample from where it is most convenient, for instance university students, or other easy to reach demographics (Trost, 2012).

Therefore, the study sample will be chosen with convenience in mind. Issues with utilizing a *convenience sampling* approach include not acquiring a sample that is representative of the population and the results lacking credibility (Marshall, 1996). However, due to time and economic constraints, this will be considered acceptable. As such the sample will be comprised largely of university students

with varying academic backgrounds. Within the survey questionnaire participants will be able to submit background information relating to themselves in order to gain an understanding of the spread of people within the survey. Similar choices of sample size have been utilized in similar testing scenarios (Nilsson, 2009), (Johansson & Petersson, 2013) and is as such deemed acceptable.

Persons with a background in fire engineering will not be allowed to participate in the survey as it is expected that their knowledge may affect their answers to a degree which does not correspond to that of the general population. The exact size of the study sample is not pre-defined but is governed by the amount of respondents the author is able to gather, however a study sample of approximately 45-55 persons is expected.

3.3 Compilation of Data

The survey will take the shape of repeated binomial testing as the aim of the survey is to test whether or not a deviation of statistical significance can be expected from a null hypothesis: that there is no preference of any one sign over another.

Data from the questionnaire survey is collected and statistical testing is performed on the results in order to test the null hypothesis:

H_o = There is no preferences of one specific feature or emergency sign over another.

In the event that H_o is rejected, a conclusion is drawn that the relevant variable affects the preference of one sign over another:

H_1 = A certain variable affects the preference of one emergency sign over another.

In addition to binomial testing, a scale test is also provided allowing participants to score the signage options individually. As a second level comparison of variables is performed, Bonferroni corrections are utilized to reduce the prevalence of type I errors, which could conclude that a significant preference is present when it in fact is not. It is a conservative method to control family-wise error rate (Dunn, 1961), (Armstrong, 2014).

Statistical significance will be controlled within a 95% confidence interval, resulting in $\alpha = 0.05$. For the second level comparison, the Bonferroni correction corrects the α-value to:

$$\alpha_i = {}^{\alpha}/_{n}$$

Where n = total number of comparisons performed.

3.4 Analysis of Data

Utilizing the compilation of data methods and the results showing the acceptance or rejection of the null hypothesis H_0, an analysis is made and conclusions are drawn in regards to any preferences to certain emergency signage certain variables could have imposed.

Discussions are held in light of the results as to what could have influenced the results, what the results mean and how they may be interpreted. Lastly, a conclusion is drawn as to whether a certain dissuasive signage variation is perceived as easier to understand and interpret and is generally more preferred in comparison to other dissuasive signage. Discussions are also held in regards to the possibilities and effects of increasing the sense of risk and urgency amongst the observers.

4 Survey

This section of the thesis details the paired comparison survey experiment carried out in order to determine if certain variables increase the preference for dissuasive emergency signage and attempt to recommend the most efficient signage option.

4.1 Survey Background

The following sub-sections depict the conclusions drawn from the literature review and outline why certain variations of dissuasive signage are chosen for further review.

4.1.1 The Theory of Affordances

The Theory of Affordances, as described by Gibson (1977) provides a basis of understanding human perception regarding the use of entities and objects. An advantage of the Theory of Affordances is that it focuses on what the emergency signage can provide to the observer to help them achieve their goal, thereby allowing the focus to remain on altering the emergency signage to best convey a message which will help the observer achieve their goal. This is a more realistic approach as opposed to informing and teaching the observer beforehand, which is not possible in a fire evacuation scenario. Coupled with the division into four affordance types: cognitive, physical, sensory and functional, the ease of altering an object for better functionality becomes clearer (Hartson, 2003). Therefore, within the thesis, the Theory of Affordances coupled with the four part affordance division will be used as a guideline to assess human perception and interaction with emergency signage.

In addition, the use of the terminology *perceptible probability of affordance* (Lu & Cheng, 2013), *perceptual threshold of affordance* (Lu & Cheng, 2013) and the relationship between affordance and symbols and semantics (You & Chen, 2007) will be utilized as a means to examine the possibilities of improving the affordance emergency signage in order to produce an acceptable dissuasive result which is easily understood by observers.

4.1.2 Dynamic Features

Incorporating dynamic elements to conventional static emergency signage greatly increases the signage's visibility (Galea, Xie, & Lawrence, 2014). This is considered to be of importance within the thesis as conveying the dissuasive message of the signage is not possible if the signage is not noticed. Also, if the signage is not noticed people may well continue to egress along a path that would prove hazardous because it is a path they know from previously and follow out of normality.

The dynamic features listed in the literature review include flashing lights adjacent to the emergency signage, pulsing LED lights incorporated into the pictograms or texts of the emergency signage and acoustic signals co-located with the emergency signage to draw attention to the signage's area. All these features have been proven to increase a signs noticeability and visibility (Nilsson, Frantzich, & Saunders, 2005), (Galea, Xie, & Lawrence, 2014), (Boer & van Wijngaarden, 2004). However, due to the nature of the survey that is to be performed within this thesis, the value of acoustic signals will not be able to be tested as this would require real life experiments to properly simulate the environment. Therefore, this thesis will attempt to incorporate, amongst others, flashing lights and LED lights in various abbreviations into the dissuasive emergency signage that is to be examined.

In addition to increasing the signage's visibility the addition of dynamic features may result in the signage conveying a more sensory intense message, resulting in a facilitation of observers risk perception increasing the likelihood of interpretation of the signage and protective action (Kuligowski & Mileti, 2009).

Although altering static features of emergency signage, such as text size and color (Wong & Lo, 2007) and overall sign size (Laughery & Wogalter, 2011), could prove to increase the signage's visibility this will not assessed further within the thesis. This is due to static features of signage in most cases being dictated by country specific building regulations or standards such as ISO-standard 7010:2011 (ISO, 2011).

4.1.3 Affecting Egress Route Choice

The tendency to egress along familiar paths within an otherwise unknown environment is a known phenomenon (Sime, 1985), (Frantzich, 2001). Even occupants whom are more familiar with an environment, for instance office staff, show a tendency to follow pre-defined paths they know lead to the outside instead of altering their route in accordance to exit signage (Nilsson, Frantzich, & Saunders, 2008). Therefore it is of importance to develop an emergency signage solution that offers a sufficient affordance to the egressing people in order to alter this behavior and affect their chosen egress route.

Surveys have shown that certain colors are associated with certain meanings during egress conditions (Nilsson, Frantzich, & Saunders, 2005), (Frantzich, 2004). Green is generally associated with safety, red is generally associated with danger while orange is generally associated with warning or nothing in particular (Nilsson, Frantzich, & Saunders, 2005). It is also important to note that the associations drawn from color are highly dependent on the context upon which it is viewed (Wickens & Hollands, 2000). A red wall tapestry will not signify 'stop', while the red light on a traffic light generally will. Therefore, within this thesis the color red will be further examined within various exit signage options to determine if it enhances the signage's meaning. As the color orange is most often associated with warning but also with nothing in particular, it is presumed that red offers better relation to the dissuasive message that is meant to be conveyed. This is further enforced by virtual reality experiments where only orange flashing lights were used to alert egressing people of emergency signage, which showed no dissuasive results or interpretation (Duarte, Rebelo, Teles, & Wogalter, 2013).

As the color red generally is associated with danger during egress conditions, emergency signage where the color is switched from green to red will be examined further. This is done to observe if this change in color causes observers to associate the signage with a dissuasive notion upon the switch in color. It is noted that as the colors in themselves do not hold a specific meaning unless they are coupled with another entity which does hold meaning (Wickens & Hollands, 2000), the observers may still only recognize the emergency signage as an exit sign, but of a different color. Another issue may be that as the change of features of the emergency signage is relatively small and not sufficient to break the tendencies of normalcy; people who are familiar with the environment will not take note of the change and proceed to ignore the signs intended message (Kinateder, Kuligowski, Reneke, & Peacock, 2014). However, due to the associations between the color red and danger and perception of risk it is believed this requires further investigation before dismissal.

Virtual reality experiments have also shown that when given the choice between an egress route provided with green flashing lights and an egress route with red flashing lights, egressing people generally chose the route provided with green flashing lights as it was perceived as safer than the one with red flashing lights (Johansson & Petersson, 2013). It should be noted that within these virtual reality experiments scenarios were only observed where the choice was between either a green marked route or a red marked route. No observations were made as to how people react if they must choose between a red marked route or 'nothing' (i.e. continuing down an unmarked path in search for further exit signage). Therefore, it may be that the red marked route only provides a sufficient dissuasive

message when coupled with a more lucrative alternative. However, as the participants noted that the green marked route was chosen due to a greater sense of safety, one can assume that the red marked route conveyed some form of negative message. Red flashing lights are also expected to provide a more intense sensory message than a static sign, which in turn may increase observers perception of risk and further dissuade from usage. Therefore, it is assumed that red flashing lights may be able to convey a dissuasive message when coupled with emergency signage and will be further examined within this thesis. It is noted that red lights coupled with a green sign may cause ambiguity and will also be examined further.

Providing emergency signage with dynamic markings in an attempt to further amplify its meaning, or change its meaning completely has been shown to work, depending on what type of markings are used (Galea, Xie, & Lawrence, 2014). Within the experimental survey four different markings were tested on pictorial exit signs depicting a directional arrow, a running-man exit and the text *fire exit*: an 'x-symbol' covering the entirety of the sign, an 'x-symbol' covering the directional arrow, an 'x-symbol' covering the running-man exit and lastly a common negation sign, a circle with a slash, covering the directional arrow and running-man exit. The results show that the marking consisting of the 'x-symbol' covering the entirety of the sign produced the best results and understanding that this egress route was not to be used. Other markings produced results such as the markings only negating certain parts of the sign, such as negating the directional arrow implied the exit was straight ahead and not in the direction of the arrow and negating the running-man exit implied that this was a fire exit, but do not run. It becomes clear that the markings must convey a clear message which is difficult to misinterpret in order to be of use, a finding which is further enforced by others (Laughery & Wogalter, 2011). With this in mind, it is expected that certain markings and perhaps alterations in text can help convey a dissuasive message to egressing occupants and will be further examined within this thesis.

Acoustic directional signals have been shown to produce positive results in way-finding, affecting egress route choice and total egress time (Withington, 2002). Difficulties with utilizing sound and voice signals are language barriers that may arise if linguistic message are utilized to convey information, such as 'exit here' or 'do not use'. In addition, providing a purely melodic signal (not utilizing voice) to convey a dissuasive message may prove difficult, as sound often draws attention to, and not from, objects (Duarte, Rebelo, Teles, & Wogalter, 2013). However, even though uses for acoustic directional signals can be seen, due to the nature of the survey that is to be conducted within this thesis, a correct environment cannot be produced to realistically simulate directional sound where results would be able to be gathered to be comparative to other dissuasive features. As such this will not be examined further within this thesis.

4.1.4 Selected Signage Variables for Review

In line with the conclusions drawn from the literature review the following dissuasive signage variables have been chosen for further review:

1. Flashing red lights.
2. Red LED X-markings.
3. Background color.
4. Pictogram / text.

4.2 Dissuasive Emergency Signage

In order to include the dissuasive features, as mentioned within section 4.1.4, into dissuasive emergency signage, two base designs are chosen and are later added to in order to test the features efficiency. The base designs are chosen as follows:

1. Green background, white markings, *running man* pictogram.
2. Green background, white markings, *EXIT* text.

Thereafter, layers of dissuasive features are added to the base designs. The efficiency of these designs are then qualitatively assessed with grounds in the Theory of Affordances and risk perception literature in a preliminary screening process, with the aim to determine which set of designs will be chosen for further experimental review.

Pictogram layout for signs including the *running man* pictogram is chosen to conform to the Swedish standards, set forth by Arbetsmiljöverket and recommended by Boverkets Byggregler (Arbetsmiljöverket, 2008), (Boverket, 2014). The choice to use the Swedish standard *running man* pictogram is largely due to the fact that this variation does not incorporate any text within the signage, which would allow for the comparison of text messages and pictogram messages within the experimental survey. Text layout for signs incorporating the *EXIT* text is chosen to conform with the text requirements of the New Zealand Building Code, as found in NZBC Clause F8 (NZDBH, 2012).

Red flashing lights are chosen to flash at a frequency of 1 hertz. All text and pictogram markings are done in white. See Table 1 for an overview of the chosen designs.

Table 1. Dissuasive emergency signage chosen for preliminary review.

Sign	Background Color	Markings	Additional Features
1	Green	*Running man* pictogram	-
2	Green	*EXIT* text	-
3	Green	*Running man* pictogram	Red flashing lights
4	Green	*EXIT* text	Red flashing lights
5	Green	*Running man* pictogram	LED lights, X-marking
6	Green	*EXIT* text	LED lights, X-marking
7	Green	*Running man* pictogram	Red flashing lights, LED lights
8	Green	*EXIT* text	Red flashing lights, LED lights
9	Red	*Running man* pictogram	-
10	Red	*EXIT* text	-
11	Red	*Running man* pictogram	Red flashing lights
12	Red	*EXIT* text	Red flashing lights

The following figures depict the dissuasive emergency signage chosen for preliminary review, see Figures 2 to 7.

Figure 2. Signs 1 and 2.

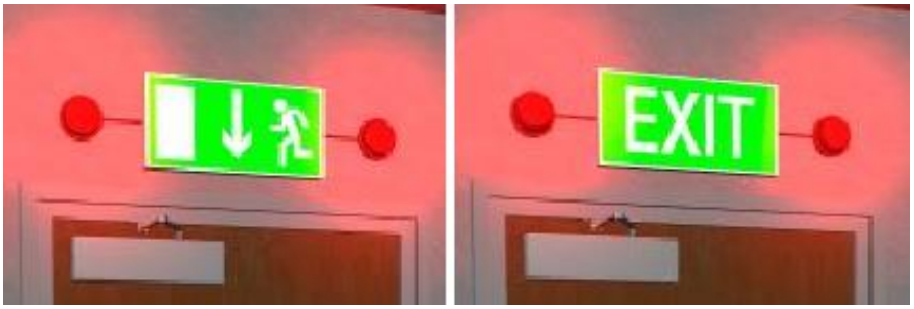

Figure 3. Signs 3 and 4.

Figure 4. Signs 5 and 6.

Figure 5. Signs 7 and 8.

Figure 6. Signs 9 and 10.

Figure 7. Signs 11 and 12.

4.2.1 Sensory Affordance

Sensory affordance of an entity help observers or users in noticing said entity (Hartson, 2003). It is essentially a measurement of the attractiveness of an entity and how easy it is to spot and read its message in regards to other surroundings. As highlighted within the literature and theory review, there are several features which are expected to contribute to the emergency signage's sensory affordance. Additional light sources, such as flashing lights or LED markings located on or adjacent to the signage have been shown to draw additional attention to the signs they are located adjacent to, and thus increasing the signage's sensory affordance. Given that all signs are of similar size and dimensions, assumed to be placed at a similar height, the differentiation between pictogram and text is not expected to attribute to the signage's sensory affordance in any significant way.

The perceptible probability of sensory affordance is expected to significantly increase when light sources are used, such as flashing lights or LED lights, due to breaking the tendency of normalcy bias and drawing additional attention to the signage. The perceptible threshold of sensory affordance is expected to heavily rely on the signage's ability to stand out from the environment and break the tendency of normality. Therefore, features that result in increasing the signage's visibility are expected to positively affect the signage's perceptible threshold.

Within the following table, each individual signs sensory affordance is qualitatively assessed, see Table 2.

Table 2. Review of sensory affordance of emergency signage.

Sign	Enhance Sensory Affordance	Impair Sensory Affordance
1	-	No additional features to break tendency of normalcy.
2	-	No additional features to break tendency of normalcy.
3	Red flashing lights draw attention. Dynamic features break tendency of normalcy.	-
4	Red flashing lights draw attention. Dynamic features break tendency of normalcy.	-
5	Red LED lights draw attention. Dynamic features break tendency of normalcy.	-
6	Red LED lights draw attention. Dynamic features break tendency of normalcy.	-
7	Red flashing lights draw attention. Red LED lights draw attention.	-
8	Red flashing lights draw attention. Red LED lights draw attention.	-
9	Altering colors draw attention.	No dynamic features to break tendency of normalcy.
10	Altering colors draw attention.	No dynamic features to break tendency of normalcy.
11	Red flashing lights draw attention. Altering colors draw attention. Dynamic features break tendency of normalcy.	-
12	Red flashing lights draw attention. Altering colors draw attention. Dynamic features break tendency of normalcy.	-

4.2.2 Cognitive Affordance

Cognitive affordance of an entity help observers or users in knowing what to do with said entity. It is essentially a measurement of how understandable an entity is and the entity's ease of interpretability (Hartson, 2003).

As noted within the literature and theory review, the cognitive affordance of emergency signage is expected to be affected by a number of variables. Utilizing the color red is expected to increase the cognitive affordance of the dissuasive emergency signage as it is commonly associated with danger, whereas utilizing the color green is expected to decrease the cognitive affordance of the dissuasive emergency signage as it is commonly associated with safety and as such conveys an ambiguous message. Incorporating descriptive markings is expected to increase cognitive affordance due to adding a further facet to the descriptive message of the signage.

The perceptible probability of cognitive affordance of the emergency signage when utilizing only the *running man* pictogram or *EXIT* text is expected to be low as the pictogram will convey an ambiguous message showing evacuation when the intended message is dissuasive. However, when LED X-markings are used to alter the meaning of the observed pictogram and text the perceptible

probability of affordance is expected to be high. It is also important to note that when utilizing the *EXIT* text, the English language has been chosen. This is expected to create a higher perceptible threshold of affordance due to requiring proper language skills in order to decipher the message, while a pictogram does not and thus provides a lower perceptible threshold of affordance. Due to the widespread use of the English language within Sweden (where this experiment is carried out) this is not expected to have a noticeable effect, but it will still be noted within the preliminary review of the signage.

Within the following table, each individual signs cognitive affordance is qualitatively assessed. See Table 3.

Table 3. Review of cognitive affordance of emergency signage.

Sign	Enhance Cognitive Affordance	Impair Cognitive Affordance
1	-	Green background conveying safety. Ambiguous use of regular pictogram.
2	-	Green background conveying safety. Ambiguous use of regular text. English text causing interpretation difficulties for non-English speakers.
3	Red flashing lights conveying danger.	Green background conveying safety. Ambiguous use of regular pictogram.
4	Red flashing lights conveying danger.	Green background conveying safety. Ambiguous use of regular text. English text causing interpretation difficulties for non-English speakers.
5	Red LED lights altering meaning of pictogram to dissuasive.	Green background conveying safety.
6	Red LED lights altering meaning of text to dissuasive.	Green background conveying safety. English text causing interpretation difficulties for non-English speakers.
7	Red flashing lights conveying danger. Red LED lights altering meaning of pictogram to dissuasive.	Green background conveying safety.
8	Red flashing lights conveying danger. Red LED lights altering meaning of text to dissuasive.	Green background conveying safety. English text causing interpretation difficulties for non-English speakers.
9	Red background conveying danger.	Ambiguous use of regular pictogram.
10	Red background conveying danger.	Ambiguous use of regular text. English text causing interpretation difficulties for non-English speakers.
11	Red background conveying danger. Red flashing lights conveying danger.	Ambiguous use of regular pictogram.
12	Red background conveying danger. Red flashing lights conveying danger.	Ambiguous use of regular text. English text causing interpretation difficulties for non-English speakers.

4.2.3 Physical Affordance

The physical affordance of an entity helps the users in performing physical tasks with said entity. As the sole intention of the dissuasive emergency signage is to convey a message through ocular examination, thus not being physically interacted with, the signs offer a low physical affordance. As

such, the physical affordance of the dissuasive signage will not be considered further within this thesis as it is deemed irrelevant.

4.2.4 Functional Affordance

The functional affordance of an entity relates to in what ways the entity helps the observer or user achieve its goals. In the case of dissuasive emergency signage, this goal is to not choose to egress via the marked path, but instead chose another path. The functional affordance of the dissuasive emergency signage is linked to the signs cognitive affordance due to the fact that the sole purpose of the signage is to convey a dissuasive message, which is done by transferring information through observation. Therefore, features that increase the cognitive affordance (as shown in Table 2) of the signage will in turn also provide an increase of the functional affordance.

Due to no specific features directly influencing the functional affordance of the dissuasive emergency signage, the functional affordance will instead be assessed as either positive or negative depending on if the cognitive affordance of the signage is ambiguous or not, i.e. helps the observer in understanding the correct course of action or not.

4.2.5 Facilitation of Risk Perception

The signage's facilitation of risk perception is interesting to note, as an egressing occupant who perceives an amount of risk is expected to make a decision to egress faster and amount to a shorter egress time as well as following instructions to a greater degree due to perceiving the seriousness of the situation. Features which are expected to facilitate the risk perception of the observer is the sensory intensity of the signage, the utilization of unambiguous and clear messages, the use of the color red and the signage's overall ability to break the tendencies of normalcy. Therefore, the utilization features which provide an increase in sensory affordance are expected to greatly increase the signage's ability to facilitate the observers risk perception due to these features breaking the tendency of normalcy and providing a sensory intense object. To a lesser extent, features which provide an increase in cognitive affordance are also expected to improve the signage's ability to facilitate the observers risk perception due to improving the ability to convey unambiguous messages.

As such, the facilitation of risk perception provided by the dissuasive emergency signage will be assessed as either positive or negative, depending to a large extent on the prevalence of features which increase the signage's sensory affordance, and to a lesser extent on the prevalence of features which improve the signage's cognitive affordance.

4.2.6 Preliminary Assessment

In order to summarize the preliminary assessment of the signs, the findings are presented in the Table 4 below. A justification of the scores is shown in Table 5. Scores for sensory and cognitive affordance are set as *low*, *medium*, *high* or *very high*, where *low* represents a lack of affordance and *very high* represents a large amount of affordance. Scores for the functional affordance and the ability to facilitate risk perception of the observer are set to either *positive* or *negative*. Scores are qualitatively assessed from the findings reported in Table 2 and Table 3 and the texts above.

Table 4. Preliminary assessment of emergency signage.

Sign	Sensory Affordance	Cognitive Affordance	Functional Affordance	Facilitation of Risk Perception	Preliminary Screening
1	Low	Low	Negative	Negative	Discard
2	Low	Low	Negative	Negative	Discard
3	High	Low	Negative	Positive	Discard
4	High	Low	Negative	Positive	Discard
5	Medium	High	Positive	Positive	Further Review
6	Medium	High	Positive	Positive	Discard
7	Very High	Very High	Positive	Positive	Further Review
8	Very High	Very High	Positive	Positive	Further Review
9	Low	Medium	Negative	Negative	Discard
10	Low	Medium	Negative	Negative	Discard
11	High	Medium	Positive	Positive	Further Review
12	High	Medium	Positive	Positive	Further Review

Signs 1, 2, 3, 4, 6, 9 and 10 have been discarded, while signs 5, 7, 8, 11 and 12 have been chosen for further experimental review. See Table 5 for further analysis and justification.

Table 5. Further analysis and justification of chosen signage.

	Sign	Justification
Further Review	**5**	Provides a high level of cognitive and functional affordance. Also expected to be able to facilitate the risk perception of the observer. In addition, signage type has previously been shown to be proficient (Galea, Xie, & Lawrence, 2014). Chosen to test dissuasiveness by use of no flashing lights versus red flashing lights.
	7	Provides very high levels of both cognitive and sensory affordance, in addition to a positive functional affordance. Expected to positively facilitate the risk perception of the observer. Chosen to test dissuasiveness by use of red LED x-markings versus red background, red flashing lights versus no flashing lights and pictogram versus text.
	8	Provides very high levels of both cognitive and sensory affordance, in addition to a positive functional affordance. Expected to positively facilitate the risk perception of the observer. Chosen to test dissuasiveness by use of text versus pictogram and dissuasiveness by use of red LED x-markings versus red background.
	11	Provides a medium level of cognitive affordance due to ambiguous pictogram use, but provides a high sensory affordance. Expected to provide both positive functional affordance and ability to facilitate the risk perception of the observer. Chosen to test dissuasiveness by use of red background color versus red LED X-markings.
	12	Provides a medium level of cognitive affordance due to ambiguous text use, but provides a high sensory affordance. Expected to provide both positive functional affordance and ability to facilitate the risk perception of the observer. Chosen to test dissuasiveness by use of red background color versus red LED X-markings.

Table 5 (cont.). Further analysis and justification of chosen signage.

	Sign	Justification
Discard	**1**	Discarded due to being a regular egress sign, not conveying a dissuasive message.
	2	Discarded due to being a regular egress sign, not conveying a dissuasive message.
	3	Discarded due to conveying an ambiguous message. Red flashing lights not expected to facilitate a change of interpretation of the observer resulting in interpretation as a regular egress sign.
	4	Discarded due to conveying an ambiguous message. Red flashing lights not expected to facilitate a change of interpretation of the observer resulting in interpretation as a regular egress sign.
	6	Discarded due to similar variables being tested by sign 5. Expected to achieve similar results.
	9	Discarded due to conveying an ambiguous message. Red background not expected to facilitate a change of interpretation of the observer resulting in interpretation as a regular egress sign.
	10	Discarded due to conveying an ambiguous message. Red background not expected to facilitate a change of interpretation of the observer resulting in interpretation as a regular egress sign.

The following figures depict the chosen dissuasive emergency signage chosen for further review. See Figures 8 to 12. These signs were chosen as a result of the preliminary review revealing their ability to convey a dissuasive message and be appropriately noticeable.

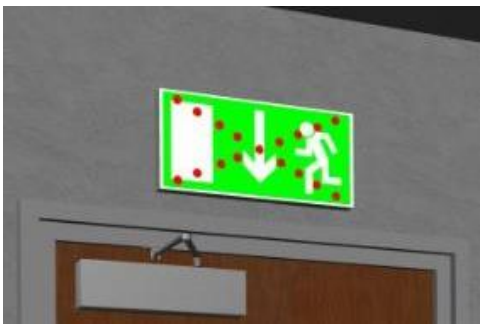

Figure 8. Sign 5: green background, *running man* pictogram, LED X-marking.

Figure 9. Sign 7: green background, *running man* pictogram, LED X-marking, red flashing lights.

Figure 10. Sign 8: green background, *EXIT* text, LED X-marking, red flashing lights.

Figure 11. Sign 11: red background, *running man* pictogram, red flashing lights.

Figure 12. Sign 12: red background, *EXIT* text, red flashing lights.

4.3 Experimental Setup

By utilizing paired comparison testing of the signage chosen for further review it is possible to give recommendations as to which designs work better than others. Table 6 shows the paired comparison tests that will be carried out in order to test the range of variables.

Table 6. List of tests and variables under consideration.

Test	Signs	Variable
1	5 versus 7	Assessing the impact of either providing red flashing lights adjacent to the dissuasive emergency signage or not.
2	7 versus 11	Assessing the impact of either providing a red background or a red LED X-marking to the dissuasive emergency signage with *running man* pictograms.
3	7 versus 8	Assessing the impact of providing a *running man* pictogram or *EXIT* text to the dissuasive emergency signage.
4	8 versus 12	Assessing the impact of either providing a red background or a red LED X-marking to the dissuasive emergency signage with *EXIT* text. This test is also provided to prevent inconclusive outcomes if participants provide a specific set of answers to tests A, B and C.

The order of tests 1, 2, 3 and 4 is randomized for the different survey trials. Also the order of which signage is shown on which screen is randomized for the different survey trials. This is done in order to minimize the effects that survey fatigue may have on tests placed towards the end of the survey.

Pilot testing was done in order to determine if future participants would have any issues with understanding the tests or questions asked. Comments from the pilot tests were taken and incorporated into the final testing setup.

4.3.1 Participants

Participants were recruited by the spreading of information of the survey through social media and social groups. Interested people were allowed to answer a sign-up-list giving the option of doing the survey on one out of three possible occasions:

Trial 1 – LTH, A-Building, Lecture Hall A:C, 2014-12-11, 15:15-16:00

Trial 2 – LTH, A-Building, Lecture Hall A:C, 2014-12-12, 12:15-13:00

Trial 3 – LTH, A-Building, Lecture Hall A:C, 2014-12-12, 15:15-16:00

In total, 46 participants were gathered. 16 during trial 1, 14 during trial 2 and 16 during trial 3. Participants consisted majorly of students with only one identifying as a worker. The age of the participants was on average 23 years old, with a minimum of 19 and a maximum of 40 years. A total of 29 participants identified as Swedish while the remaining 17 identified as people of other nationalities, with the second largest group being Germans with 6 participants. On a scale of 1 to 5, where 1 is low and 5 is high, the participants rated their own English skill as an average of 4.6, with a low of 3 and a high of 5. Previous fire emergency experience of the participants was largely made up of fire drills with a few participants also having experience real scenario evacuations.

Several participants noted eye-sight impairments such as near and far sightedness, however this was in all cases corrected by glasses or contact lenses. A single participants noted color blindness.

Participants were read an introduction text before the survey commenced. Refer to Appendix A for the introduction text.

4.3.2 Survey Room

Participants were seated in Lecture Hall A:C of the A-Building at LTH, facing two screens. On the screens were projected images of the dissuasive emergency signage that was to be compared. Refer to Figure 13 for an image of the survey room.

Figure 13. Picture showing setup of survey room with Screen A to the left and Screen B to the right.

During the survey the lighting in the room was dampened and turned off in order for the shown images to be clearer. Virtually modelled signs were shown in pairs on the screens. For information regarding modelling programs used, refer to Appendix E.

4.3.3 Questionnaire

The questionnaire administered to the participants during the experimental survey is designed to investigate the signage's efficiency. This is done by a set of five questions, assessing the efficiency of the signage, with grounds in the Theory of Affordances. Refer to Appendix B for the contents of the survey questionnaire.

The first question relates to sensory affordance. The aim of this question is to establish whether certain features provide a more noticeable sign, as in order to heed the signage it must first be noticed. The question is as follows:

*Which of the two signs is **easiest** to notice?*

The second question relates to sensory affordance. The aim of this question is to establish if any specific features enhance or diminish the ability to clearly distinguish the markings on the dissuasive emergency signage. The question is as follows:

*In which of the two exit signs is it **easiest** to distinguish the details?*

The third question relates to cognitive affordance. The aim of this question is to establish if any specific features increase the dissuasive emergency signage's ability to convey a dissuasive message causing observers to understand that evacuation should not occur via this specific route. The question is as follows:

*Which of the two exit signs best conveys the message of **not** using this exit route?*

The fourth question relates to functional affordance and provides information about which dissuasive emergency signage design is most preferred for use by the observer. The question is as follows:

*Which of the two exit signs would you prefer be used to advise you **not** to use an exit route?*

The fifth question relates to risk perception. The aim of the question is to establish if any specific features cause a greater sense of urgency or risk for the observer which would in turn cause observers to be more aware of the risk of the emergency situation. The word urgency was used instead of risk as it was expected that the meaning of risk varies greatly between participants. The question is as follows:

*Which of the two exit signs would result in the **greatest** sense of urgency of the situation?*

For all the above questions, participants are given the option to choose sign A, sign B or that sign A and sign B are equivalent, with the exception of the fourth question where only the option for sign A or sign B is given. Participants are also given the option to describe which features cause them to answer as they do.

In addition to these five questions, the participants are also given the option to rate the tested exit signage's functional affordance individually on a scale from 1 to 5, where 1 meant worse performance and 5 meant better performance.

The questionnaire also contains basic background questions to establish an understanding for who the participants are. These basic background questions highlight whether the participants age, gender, nationality, are color blind or have any eye-sight deficiencies and whether or not they have had previous experiences with fire drills or live evacuations.

4.3.4 Data Collection

Upon completion of the survey the questionnaire sheets were collected from the participants. Participants were thanked and compensated for their efforts.

Collected data was then input into spreadsheet programs in order to ease the analysis of the data.

4.3.5 Ethical Considerations

All gathered information is handled in a confidential manner where no information is able to be traced back to a specific individual. However, specific answers from specific survey sheets may be used within the thesis.

Participants of the survey were notified of their right to withdraw from the survey at the start of the survey procedure. Upon withdrawing, their survey sheet would be discarded and not used within the thesis. No participants chose to withdraw from the survey.

Contact information gathered upon recruiting participants was used only to remind participants of the time and place of the survey in the days leading up to the appointed time. This contact information was not shared and subsequently destroyed when the survey procedure was completed.

Participants of the survey received compensation for their efforts in the form of a free cinema ticket to a movie of their own choice. This compensation was given upon completion of the survey.

5 Results

This section provides the results gained from the paired comparison survey. For a full disclosure of the raw data, refer to Appendix C. For results of the individual statistical tests, refer to Appendix D.

5.1 Binomial Testing

The results of the experimental survey have been statistically analyzed by the use of binomial testing. The null hypothesis in this case is that there is no preference for any one sign over another, in other words, that the two signs of each test are expected to be preferred equally often.

Table 7 shows a summary of the binomial testing results of the survey questionnaire. Number of responses tested varies for questions 1, 2, 3 and 5 due to responses where no choice was made or where signs were considered equal have been removed.

n = frequency of answer
% = percentage of answer
p = probability of null hypotheses

Table 7. Summary of binomial testing results.

	Question 1			**Question 2**			**Question 3**			**Question 4**			**Question 5**		
	n	**%**	**p**	**n**	**%**	**p**	**n**	**%**	**p**	**n**	**%**	**p**	**n**	**%**	**p**
Test 1															
Sign 5	0	0	**0.000**	14	0.64	**0.286**	16	0.38	**0.164**	18	0.39	**0.184**	0	0	**0.000**
Sign 7	45	1		8	0.36		26	0.62		28	0.61		40	1	
Test 2															
Sign 7	9	0.26	**0.009**	7	0.17	**0.000**	34	0.79	**0.000**	34	0.74	**0.002**	6	0.25	**0.023**
Sign 11	25	0.74		34	0.83		9	0.21		12	0.26		18	0.75	
Test 3															
Sign 7	4	0.36	**0.549**	10	0.33	**0.099**	12	0.46	**0.845**	22	0.48	**0.883**	5	0.45	**1.000**
Sign 8	7	0.64		20	0.67		14	0.54		24	0.52		6	0.55	
Test 4															
Sign 8	11	0.3	**0.020**	5	0.12	**0.000**	37	0.86	**0.000**	37	0.8	**0.000**	8	0.23	**0.002**
Sign 12	26	0.7		37	0.88		6	0.14		9	0.2		27	0.77	

As statistical significance is checked within a 95% confidence interval a p-value lower than 0.05 results in a statistically significant difference from the null hypotheses, allowing the discarding of it and showing preference for a certain feature or sign. Statistically significant differences are found in 12 cases. Table 8 shows a brief of the statistically significant differences and a description of what this implies. The sign which contains the preferred feature or is generally preferred is for each case marked in **bold and underlined**.

Table 8. Brief of statistically significant differences and implications.

Case	Signs	Description
Test 1, Question 1	Sign 5 **Sign 7**	Sign with pair of flashing red lights placed adjacent to it is considered easier to notice than a similar sign not provided with flashing red lights.
Test 1, Question 5	Sign 5 **Sign 7**	Sign with pair of flashing red lights placed adjacent to it is considered to create a greater sense of urgency than a similar sign not provided with flashing red light.
Test 2, Question 1	Sign 7 **Sign 11**	Sign with red background and no additional markings is considered easier to notice than a sign with green background and red cross markings.
Test 2, Question 2	Sign 7 **Sign 11**	It is considered easier to distinguish the details of a sign with red background and no additional markings, as opposed to a sign with green background and a red cross marking. Comments from survey include that a red cross marking causes the pictogram of sign 7 to become difficult to distinguish.
Test 2, Question 3	**Sign 7** Sign 11	Sign with green background and red cross marking is considered more apt at conveying the message of not utilizing a specific exit door as opposed to a sign with red background and no additional markings. Comments from survey include that a red sign with no additional markings is easily mistaken for a regular but oddly colored exit sign.
Test 2, Question 4	**Sign 7** Sign 11	Sign with green background and red cross marking is preferred over a sign with red background and no additional markings to defer from exit use.
Test 2, Question 5	Sign 7 **Sign 11**	Sign with red background and no additional markings is consider to create a greater sense of urgency than a sign with green background and red cross markings. Comments from survey include that red is associated with danger and alarm.
Test 4, Question 1	Sign 8 **Sign 12**	Sign with red background and no additional markings is considered easier to notice than a sign with green background and red cross markings.
Test 4, Question 2	Sign 8 **Sign 12**	It is considered easier to distinguish the details of a sign with red background and no additional markings, as opposed to a sign with green background and a red cross marking. Comments from survey include that a red cross marking causes the text of sign 11 to become difficult to distinguish.
Test 4, Question 3	**Sign 8** Sign 12	Sign with green background and red cross marking is considered more apt at conveying the message of not utilizing a specific exit door as opposed to a sign with red background and no additional markings. Comments from survey include that a red sign with no additional markings is easily mistaken for a regular but oddly colored exit sign.
Test 4, Question 4	**Sign 8** Sign 12	Sign with green background and red cross marking is preferred over a sign with red background and no additional markings to defer from exit use.
Test 4, Question 5	Sign 8 **Sign 12**	Sign with red background and no additional markings is consider to create a greater sense of urgency than a sign with green background and red cross markings. Comments from survey include that red is associated with danger and alarm.

5.2 Scale Testing

The questionnaire also included the option for participants to rate the signage options individually on a scale from 1-5, where 1 was related to worse performance and 5 was related to better performance. These results are analyzed by utilizing Wilcoxon signed-rank tests in order to determine if any differences between the chosen baseline design and other options can be observed.

Table 9 shows a summary of descriptive statistics of the scale testing.

Table 9. Summary of descriptive statistics of scale testing.

	N	Mean	Standard Dev.	Min	Max
Sign 5	46	3.11	1.35	1	5
Sign 7	46	3.59	1.10	1	5
Sign 8	46	3.65	0.99	1	5
Sign 11	46	2.20	1.22	1	5
Sign 12	46	2.02	1.29	1	5

Table 10 shows the results of the Wilcoxon signed rank test, utilizing sign 7 as the baseline design.

Table 10. Wilcoxon signed rank test of scale testing.

Comparison		N	Mean Rank	Sum of Ranks	Z	p
Sign 7 VS Sign 5	Negative Ranks	14	18.86	264	-2.061b	**0.039**
	Positive Ranks	26	21.38	556		
	Ties	6				
	Total	46				
Sign 7 VS Sign 8	Negative Ranks	16	14.22	227.5	-0.224c	**0.823**
	Positive Ranks	13	15.96	207.5		
	Ties	17				
	Total	46				
Sign 7 VS Sign 11	Negative Ranks	7	13.29	93	-4.425b	**0.000**
	Positive Ranks	34	22.59	768		
	Ties	5				
	Total	46				
Sign 7 VS Sign 12	Negative Ranks	7	13.14	92	-4.665b	**0.000**
	Positive Ranks	36	23.72	854		
	Ties	3				
	Total	16				

Where: Negative Ranks: Sign 7 < Sign X
Positive Ranks: Sign 7 > Sign X
Ties: Sign 7 = Sign X
a: Based on negative ranks.
b: Based on positive ranks.

Bonferroni corrections are applied to the results of the Wilcoxon signed rank test due to the results stemming from a second level test carried out within the same survey. Therefore, the significance level to determine a statistical difference, originally $\alpha = 0.05$, is divided by 4, which results in a significance level of $\alpha_i = 0.0125$.

With Bonferroni corrections, a statistically significant difference may be observed in two cases. Sign 7 is rated to perform better than sign 11 and sign 12. In addition, a trend may be seen showing that sign 7 also performs better than sign 5, this can however not be proven as statistically significant. No statistically significant difference was found between sign 7 and sign 8.

5.3 Conditional Properties

In order to assess which affordance based features are most likely to affect the final preference of a certain sign and the perceived risk when viewing a certain sign, conditional probabilities analysis has was carried out. When analyzing the final preference of a sign three conditions are possible: agreement (same answer in both cases), disagreement (different answer in both cases) or uncertain (stating signs are equivalent). When analyzing the perceived risk three conditions are possible: agreement (same answer in both cases), disagreement (different answer in both cases) and non-relevance (specific answer on affordances while stating perceived risk is equivalent).

Figures 14 to 21 show the results of the conditional probability analysis on a per test and relation to question 4 and question 5 basis. Trends are defined as an arbitrary 75% rate of conformation to a single condition.

(Remainder of page left blank for ease of reading results on following pages.)

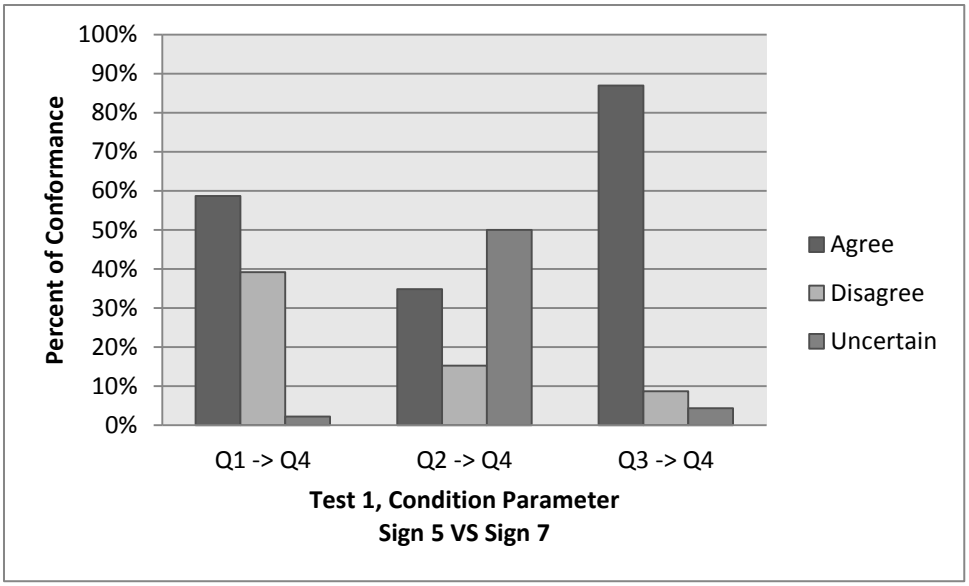

Figure 14. Conditional probability analysis results of question 4 of test 1.

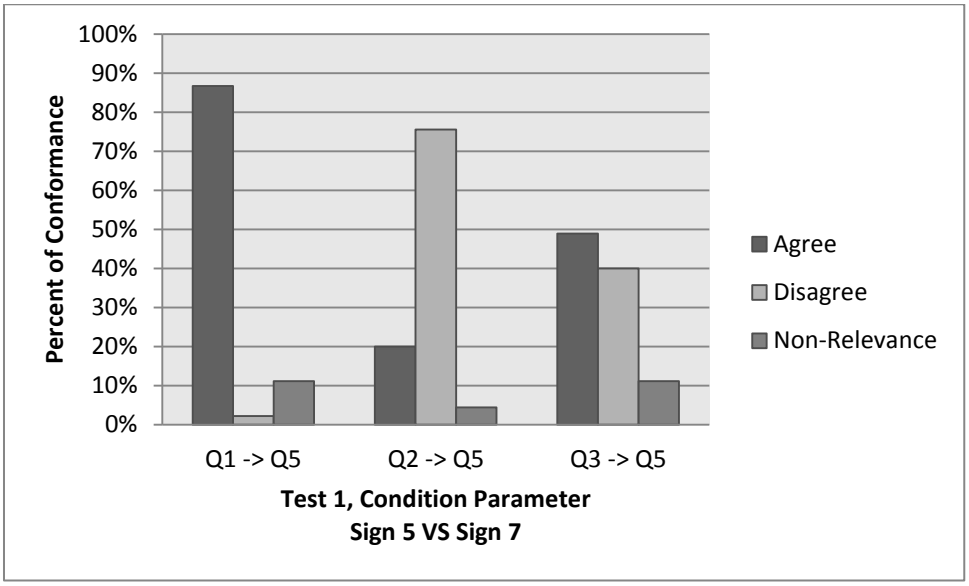

Figure 15. Conditional probability analysis results of question 5 of test 1.

Where: Q1: Sensory Affordance (visibility)
Q2: Sensory Affordance (detail)
Q3: Cognitive Affordance (message)
Q4: Functional Affordance (preference)
Q5: Risk Perception (urgency)

As per figure 14, a trend of agreement is seen between question 3, relating to which sign best conveys the message of not utilizing an exit door, and question 4, relating to which sign would be preferred in use (87%).

As per figure 15, a trend of agreement is also seen between question 1, relating to which sign is easiest to notice, and question 5, relating to which sign conveys the greatest sense of urgency (87%). A trend of disagreement is seen between question 2, relating to in which sign it is easiest to distinguish details, and question 5 (76%).

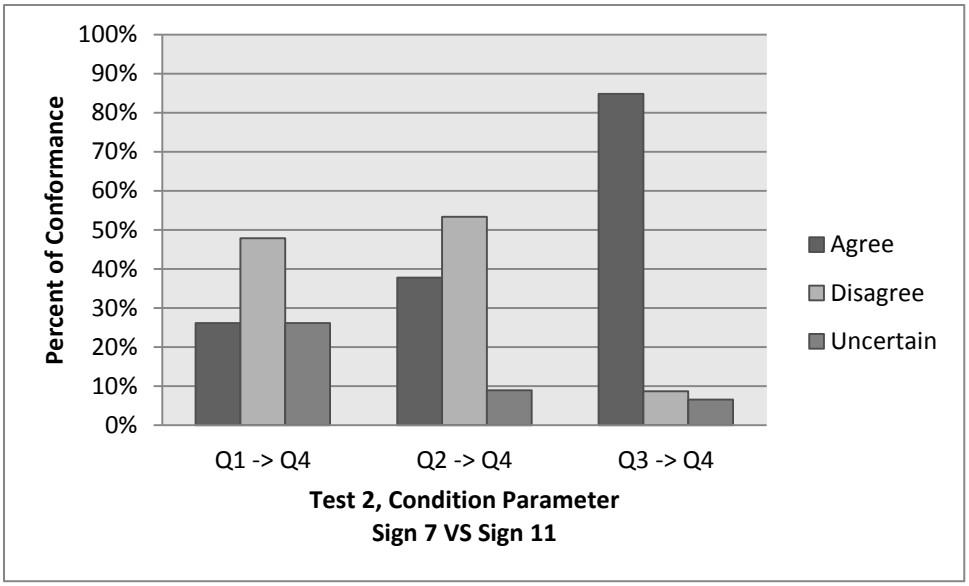

Figure 16. Conditional probability analysis results of question 4 of test 2.

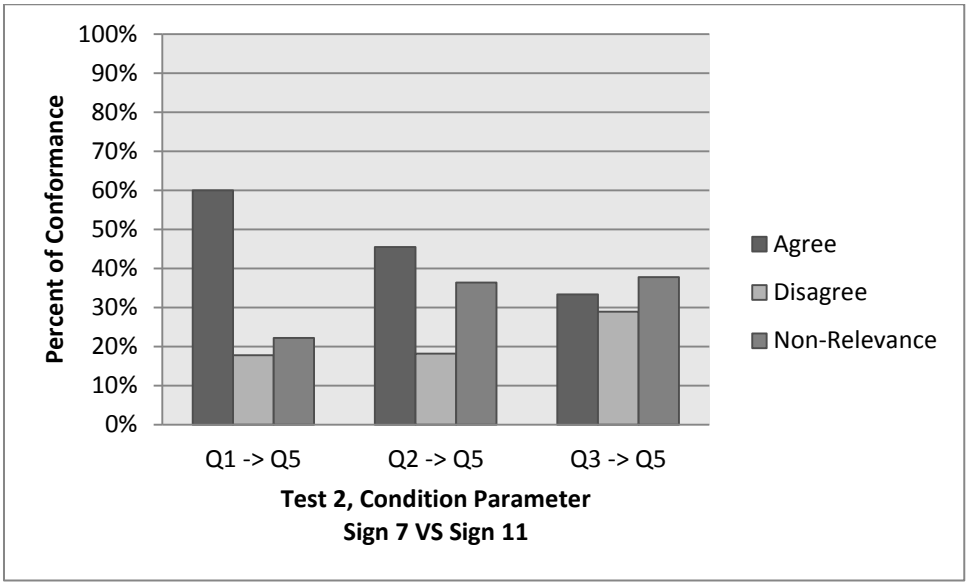

Figure 17. Conditional probability analysis results of question 5 of test 2.

Where: Q1: Sensory Affordance (visibility)
Q2: Sensory Affordance (detail)
Q3: Cognitive Affordance (message)
Q4: Functional Affordance (preference)
Q5: Risk Perception (urgency)

As per figure 16, a trend of agreement is seen between question 3, relating to which sign best conveys the message of not utilizing an exit door, and question 4, relating to which sign would be preferred in use (85%).

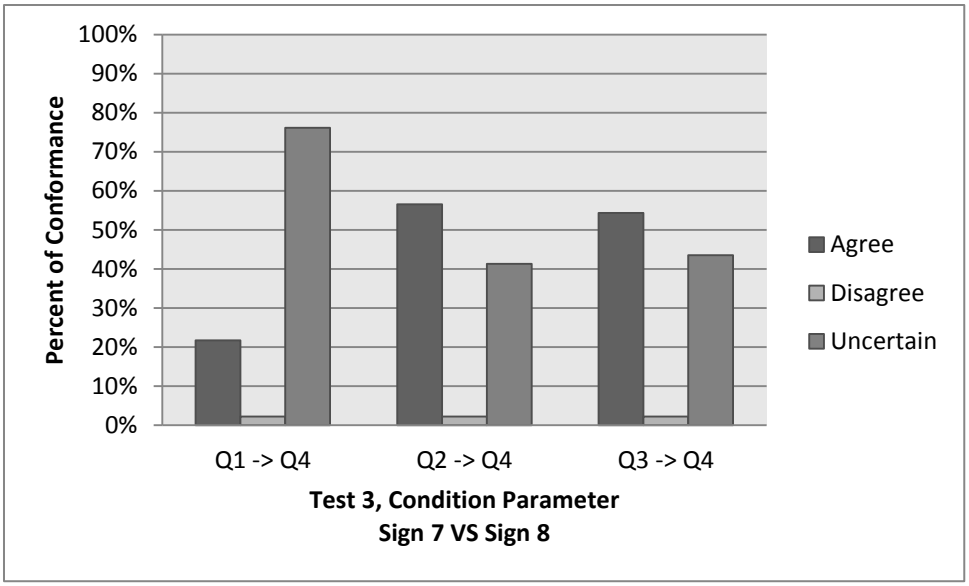

Figure 18. Conditional probability analysis results of question 4 of test 3.

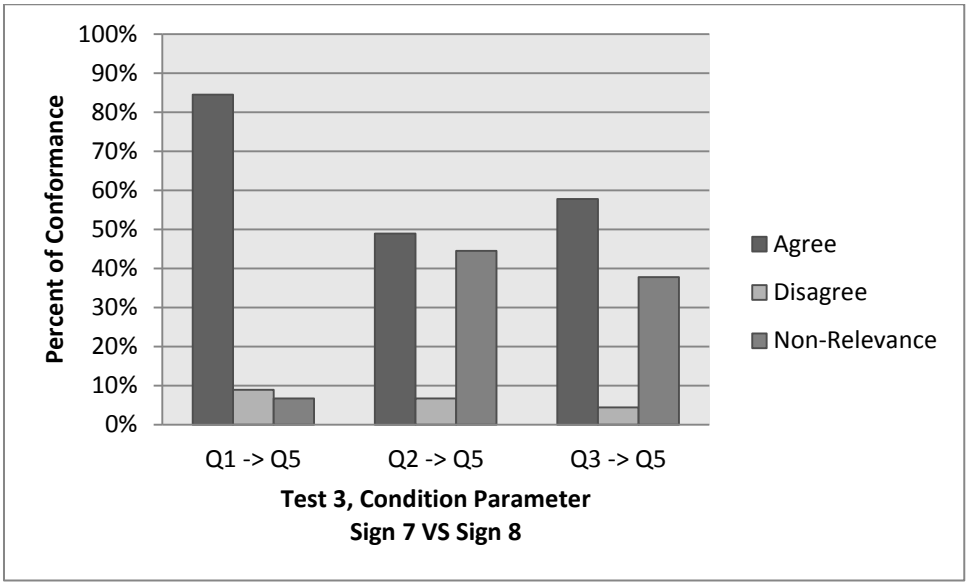

Figure 19. Conditional probability analysis results of question 5 of test 3.

Where: Q1: Sensory Affordance (visibility)
Q2: Sensory Affordance (detail)
Q3: Cognitive Affordance (message)
Q4: Functional Affordance (preference)
Q5: Risk Perception (urgency)

As per figure 18, a trend of agreement is seen between question 1, relating to which sign is easiest to notice, and question 5, relating to which sign conveys the greatest sense of urgency (84%).

As per figure 19, a trend of uncertainty is seen between question 1, relating to which sign is easiest to notice, and question 4, relating to which sign would be preferred in use ((76%).

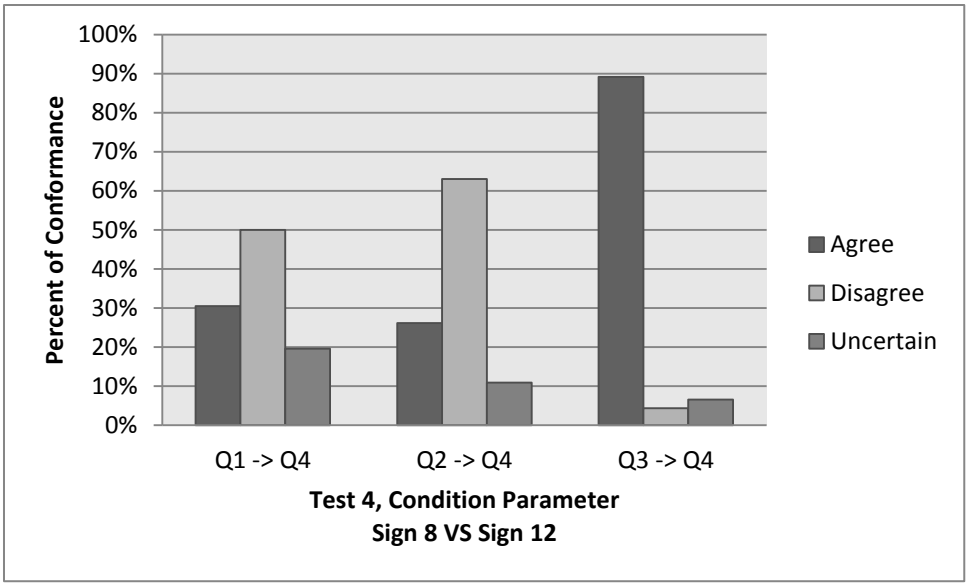

Figure 20. Conditional probability analysis results of question 4 of test 4.

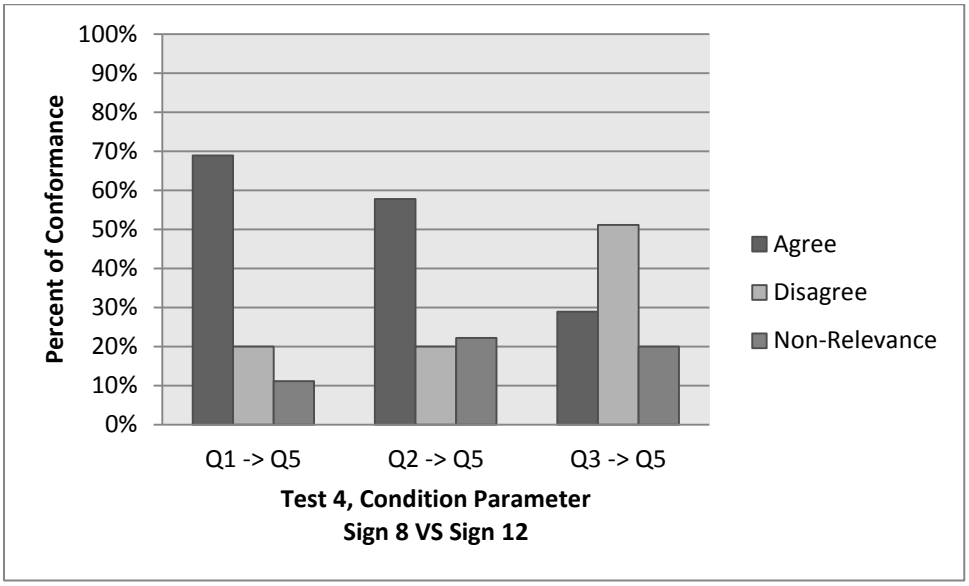

Figure 21. Conditional probability analysis results of question 5 of test 4.

Where: Q1: Sensory Affordance (visibility)
Q2: Sensory Affordance (detail)
Q3: Cognitive Affordance (message)
Q4: Functional Affordance (preference)
Q5: Risk Perception (urgency)

As per figure 20, a trend of agreement is seen between question 3, relating to which sign best conveys the message of not utilizing an exit door, and question 4, relating to which sign would be preferred in use (89%).

6 Analysis

This section provides an analysis of the results gained from the survey.

6.1 Binomial Testing

The binomial testing of the results provided 12 cases where a statistically significant difference was shown and the null hypothesis could be discarded. These 12 cases can be put in relation to the affordance and risk perception based questions of the questionnaire as follows:

Q1. Sensory Affordance (visibility): Providing red flashing lights adjacent to signage makes it easier to notice as opposed to similar options not provided with red flashing lights. In addition, a sign with red background is easier to notice than a sign with green background.

Q2. Sensory Affordance (details): It is easier to distinguish the details of a sign with red background and no additional markings as opposed to the details of a sign with green background and a dotted red cross marking. This is true for both text and pictogram use.

Q3. Cognitive Affordance (message): The message to not use an exit door is better conveyed by a sign with green background and a dotted red cross marking as opposed to a sign with red background and no additional markings. This is true for both text and pictogram use.

Q4. Functional Affordance (preferred for use): A sign with green background and dotted red cross markings is preferred for use over a sign with red background and no additional markings.

Q5. Risk Perception (urgency): A greater sense of urgency is achieved by the use of flashing red lights placed adjacent to exit signage, as opposed to not providing flashing lights at all. In addition, a greater sense of urgency is provided by the use of signs with red background as opposed to signs with green backgrounds and dotted red cross markings.

In addition to the above results the following statistically significant preferences for certain signage options may be observed:

- Sign 7 is preferred over sign 11.
- Sign 8 is preferred over sign 12.
- Sign 7 is considered equal to sign 8.

There is only a trend towards sign 7 being preferred over sign 5. This may be an issue associated with the limited sample size under consideration, but this cannot be confirmed.

With this in mind, a conclusion may be drawn that the cognitive affordance of a sign is the main factor of influence for participants when choosing a preferred signage option. Even if signs with red backgrounds were considered better in both sensory affordance categories (questions 1 and 2), participants consistently preferred signs with green backgrounds and red cross markings which were considered better in the cognitive affordance category (question 3).

While observing results of the binomial testing relating to risk perception (question 5) and if the shown signage conveyed a sense of urgency, a clear statistically significant difference may be observed during Test 1. Sign 7 was preferred over sign 5 for this question, which draws the conclusion that red flashing lights placed adjacent to exit signage cause a greater sense of urgency for the observer.

Additionally a statistically significant differences relating to risk perception may be observed for signs 7 and 8 when compared to signs 11 and 12 respectively, in signs 11 and 12's favor. Comments provided from the participants show that this is supposedly due to the presence of more red colored features, as they generally relate the color red with danger or warning. Also, as a major portion of the participants were from countries who generally use exit signs with green backgrounds, signs with red backgrounds were considered something out of the ordinary and extra attention was given to the signs.

Several participants provided comments relating to the importance of cognitive affordance and the need for a clear message which is not easily misinterpreted.

"Since 'EXIT' is clearly crossed over I wouldn't wanna use that exit route."

Comments included that red flashing lights may only serve to draw attention to the sign but distract from the signs details, and thus resulting in observers using the exit despite the sign attempting to tell them not to.

"The light would draw me to sign B [sign 7] and think that it was an emergency exit."

Words of caution were also raised in regards to using signs with red backgrounds only, as this did not fully convey the dissuasive message but could instead easily be misinterpreted as a regular exit sign, but with an uncommon color.

"I would think that B [sign 11] was an exit route that I should use despite it being red."

Additionally comments regarding the red LED X-markings made note of that a fuller or completely drawn cross marking would convey the message in a better way, as the cross marking would then become even more visible. With this in mind, the importance of the cognitive affordance of the dissuasive exit signs becomes clearer and the need for an easy to understand but difficult to misinterpret message is paramount.

6.2 Scale Testing

For the Wilcoxon signed rank test, sign 7 is chosen as the baseline design for two main reasons. Judging from results of the binomial testing and the descriptive statistics of the scale testing, the top performers are signs 7 and 8. When comparing these two they perform very similarly. Therefore choosing either of these as a baseline design is expected to provide similar results within the Wilcoxon signed rank test. However, choosing sign 7 as a baseline design will allow for further investigation as to whether sign 7 performs better than sign 5, which was not able to be statistically proven within the binomial testing.

The Wilcoxon signed rank test allows for the following observations:

- There is a statistically significant difference between the performance of sign 7 and signs 11 and 12, where sign 7 is preferred.
- A trend may be observed showing that sign 7 is preferred over sign 5, however this cannot be statistically proven.
- Signs 7 and 8 perform very similarly.
- The Wilcoxon signed rank test gives similar results as to the preferences stated within the binomial testing.

The results of the Wilcoxon signed rank test agree largely with those of the preferences shown in the binomial testing. Sign 7 performs better than signs 11 and 12, and a trend shows it may also perform better than sign 5. While once again confirming that sign 7 and sign 8 are considered equal in performance. With this in mind, the results and arguments gained from the binomial testing are considered further enforced by these scale test findings.

It is noted that if Bonferroni corrections had not been used, a statistical difference would have been observed between the preferences of sign 5 and sign 7. However, as Bonferroni corrections are used this is not the case. A larger sample would likely result in a statistically significant difference being observed in this case, but for the purpose of these results it will be referred to as a trend towards preference of sign 7 over sign 5, thus showing that red flashing lights placed adjacent to similar signage options would likely provide a better dissuasive message than if no red flashing lights are present.

6.3 Conditional Properties

The conditional properties testing is used to gain insight as to which affordance based questions have the highest impact on preference of a specific sign or on the sense of urgency a specific sign conveys. A trend is in this case defined as an arbitrary 75% conformation to a single condition.

In tests 1, 2 and 4 a trend of agreement may be observed between answers to question 3, regarding cognitive affordance, and question 4, regarding functional affordance. In test 3 there is a trend of participants being noted as ‘uncertain’ when observing the relation between questions 3 and 4, meaning that they consider both signs similar from a cognitive affordance perspective and thus the cognitive affordance should have no impact on final preference choice. It is also noted that in the binomial testing of test 3 no statistically significant difference was observed between the preferences of the signs tested (sign 7 and sign 8). With this in mind, it is assumed that the driving force for preference and functional affordance is the ability to understand what the sign is trying to say. In conclusion, a high level of cognitive affordance results in a high level of functional affordance. This enforces the previous results gained from both binomial testing and scale testing in regards to how preference is chosen.

In tests 1 and 3 a trend of agreement may be observed between answers to question 1, regarding sensory affordance, and question 5, regarding the sense of urgency caused by the sign. For tests 2 and 4 there is still a strong bias towards agreement, but not significant enough to be considered a trend within this thesis. Similarities can be seen for tests 2, 3 and 4 while observing the relationship between answers to questions 2, sensory affordance, and question 5 as there is a bias towards agreement but not significant enough to be considered a trend. Similar relationships cannot be observed for answers to questions 3, cognitive affordance, and question 5. Therefore, it is assumed that the sensory affordance of the signs, most notably the visibility of the signs, is of most importance when attempting to convey a sense of urgency to the observer.

A trend of disagreement is only found in a single case, which is in regards to the relationship between answers of question 2, sensory affordance, and question 5 of test 1.This shows that for this particular test, although participants were not able to clearly distinguish the details of a particular sign, they still felt it caused a greater sense of urgency than the easier to depict sign. Results show that for test 1 sign 7 causes the greatest sense of urgency among the observers, while sign 5 is dubbed as easier to depict. This further enforces the conclusion that the visibility of the sign is of more importance than the ability to see all the signs details when attempting to convey a sense of urgency. In the case of test 1, this was achieved by providing red flashing lights to sign 7.

6.4 Recommended Signage

Through an assessment utilizing the Theory of Affordances and risk perception literature as well as a questionnaire study resulting in an analysis of binomial testing, Wilcoxon signed rank testing and testing of conditional properties, the following features are recommended for use together in signage to dissuade from use of a specific exit door.

- A green background with white markings.
- Markings of either pictogram or text nature.
- Red X-marking over signage. Preferably a full line or clearly visible dots.
- A pair of red flashing lights placed adjacent to sign.

With these features in place, it is believed the signs will achieve the needed dissuasive function while also making observers aware of the urgency of the situation with the least amount of room for misinterpretation of the dissuasive message. Figure 22 shows an example of how signs such as these may look.

Figure 22. Examples of dissuasive emergency signage which was preferred among the participants of the survey.

7 Discussion

This section contains the author's discussion and personal thoughts about different areas of the thesis.

7.1 Choosing of signage

During the preliminary assessment of the twelve different signage variations seven out of the twelve signs were discarded due to different reasons.

The first phase of the screening related to the cognitive and functional affordances provided by the signage, i.e. if the signage conveyed the intended dissuasive message or not. This was deemed as most important, as if the sign does not convey its intended message, further examination of the sign would be irrelevant. Signs, which received low scores for cognitive and functional affordance, were typically of an ambiguous nature showing either a regular *running man* pictogram or *exit* text accompanied by either no additional features, or features which did not alter the meaning of the pictogram and text. Therefore, it was expected that signs such as these would lead to confusion, and more importantly misinterpretation, leading to observers making an erroneous decision and exiting via a door that is deemed unsafe. This first phase of the screening resulted in signs 1, 2, 3 and 4 being discarded.

The second phase of the screening process involved assessing how noticeable the signs are expected to be in their natural environment and their ability to break the tendencies of normality, i.e. an assessment of the sensory affordance provided by the signage. This was deemed important, as shown in the study by Galea, Xie and Lawrence (2014); if the signs are not noticeable observers would simply walk past them and follow their regular paths to the outside, even if this meant egressing via a potentially dangerous route. Features that provide additional sensory input, such as flashing lights or LED markings being turned on, are expected to provide a relatively large increase in sensory affordance. In addition, features which provide a change in appearance are also expected to provide an increase in sensory affordance due to them causing an alteration of the norm and thus possibly breaking the tendencies of normality. Subsequently, signs that were not provided with these features, or only to a small amount, were discarded as it was expected that other signage options provided a much better starting point. This second phase of the screening resulted in signs 9 and 10 being discarded, and it further increased the reasoning behind discarding signs 1 and 2.

The third, and final, phase of the screening process revolved around choosing signage options that could be tested against each other to test certain variables. This lead to certain signage types being discarded, not because they were deemed inefficient at conveying a dissuasive message, but because other signs were chosen to test similar variables in a better fashion. This third phase of the screening resulted in sign 6 being discarded due to sign 5 being used instead to test the efficiency of LED X-markings. The entire screening process resulted in signs 1, 2, 3, 4, 6, 9 and 10 being discarded.

Subsequently, signs 5, 7, 8, 11 and 12 were chosen for further review. These signs were chosen due to receiving high scores throughout the preliminary review and deemed to be the most effective at conveying the intended dissuasive message. In addition, comparison of these signs allowed for the testing of different variables: red flashing lights, LED X-markings, background color and text or pictogram use.

Additionally, thought was given to the actual feasibility of implementing said signs into real world circumstances, by way of making the designs incorporable into existing exit signage. The chosen signs have the feature in common of all being regular exit signs at their base, with additional features added. This takes the form of LED lights which can be turned off and on at will much akin those used in other research projects (Bryant & Giachritsis, 2014), colored background lights which can be altered

between green and yellow or features added next to existing signage, such as flashing lights. As a result of this, the chosen signage is limited by the fact that signage options that would require a different set of signs were disregarded. This would include, for instance, signs with the lettering "*NO EXIT*" and signs with altering pictograms.

7.2 Limitations of study sample and sample size

The study sample for the survey experiment was largely made up of students of Lund University, with the odd working or PhD person. This was considered acceptable for a number of reasons. As the thesis is written at Lund University it was considered convenient to choose study subjects in the immediate geographical vicinity. This also allows for an ease of recruitment for the survey, both in regards to location and timing, as most students operate on a similar schedule throughout the day. It has also been noted from other similar experiments that the response rate is high among students when provided with adequate incentive, like a cinema ticket. An effort was made to limit the amount of participants within the survey having a fire engineering background, due to this possibly increasing their knowledge of dissuasive emergency signage and thus providing slightly biased results as they may answer on a knowledge base instead of a perception base (i.e. answering the survey in a biased manner relating to previous knowledge detailing what should be considered preferred or not).

This comes with a set of limitations. Due to the study sample used within the survey experiment being chosen by convenience it is not expected to accurately represent any known population. The majority of the study sample was within a narrow age gap, a majority had similar occupation and a large portion of the sample came from a single country. However, given the study samples size and the relatively small amount of variables being tested, it is expected that trends seen within the study sample relating to the experiment may be used as guidance for future research. Although it should be noted that large scale testing on a statistically fit population should be considered.

It should be noted however, that the fact that the participants of the survey were all similar in that they share similar features regarding age, work status, living conditions and so on, could also be seen as a strength of the survey sample. As the testing is comprised of relative testing, not absolute testing, the similarities of the participants may serve to enhance the validity of the results as their judgments might be made with a similar bias. This hinges on the assumption, that for instance age or work status would not greatly affect the choices made when observing the dissuasive signage relative to one another and should as such only be regarded as a note for further discussion.

7.3 Pictogram, Text and Language

Within the survey study both emergency signs containing a *running man* pictogram and *EXIT* text were used. It is noted that the usage of such emergency signs varies throughout the world. *Running man* pictograms are largely used throughout Europe, whereas *EXIT* text is largely used in the Americas. Therefore, it must be considered that the results given in this thesis could vary depending on where in the world the respondents of the survey have received the most input from emergency signage. A respondent whom has spent a substantial amount of time in the Americas, where red and white emergency signage with *EXIT* text is common, might not interpret the use of the color red as an attempt to negate the message of the sign, whereas a respondent whom has spent a substantial amount of time in Europe, where emergency signage is typically green, might do so. It is important to note though that this might not always be the case, as presented in a study be Troncoso, showing that context had more impact than culture when it came to interpreting colors in an emergency situation (Troncoso, 2014). Upon completion of the survey it was noted that the majority of respondents came from countries within Europe and were as such expected to assume that the signs with a red background and white text or pictogram were of a negating nature. A single participant had spent a

substantial amount of time in North America and it was noted that the participant questioned the use of red signs with white markings as dissuasive within the survey. With this in mind it is if importance to see the results of this thesis in the correct context, as they were produced on a European style population, even though the impact of this may not be sizeable.

The survey study contained participants of both Swedish and international backgrounds. All participants completed the survey in English. Also, select signs utilizing *EXIT* text in English were presented to the participants. Within the survey the participants were allowed to score their own English skills. Unsurprisingly, on a scale from 1 (bad) to 5 (good) the lowest recorded score was 3, with a mean value of 4.63. It is widely known that people most often rate their own skills higher than what is actually the case, but the results speaks for participants having at the least a basic understanding of English. The survey sheets were also constructed in a fashion to be easy to understand. English skill was also a requirement for participation, as noted on the survey invitation. With this in mind, it is expected that all participants understood all text presented to them throughout the course of the survey.

7.4 What Makes a Good Dissuasive Emergency Sign

In short, the ability of an exit sign to dissuade from using the exit it is marking should be considered the definition of a good dissuasive emergency sign. In addition to this, in order to be considered a feasible design, the dissuasive emergency signage must also be able to display a regular exit sign when required, in order to allow its implementation into new sophisticated fire alarm systems. Within this thesis the Theory of Affordances was used to discern which features of an exit sign caused different types of reactions amongst the observers.

Given the results of the thesis it was noted that the cognitive affordance of the dissuasive signage was of most importance as it directly influenced the functional affordance (i.e. whether you use the sign as intended or not) and the final preference of signage amongst participants. Therefore, features which increase the cognitive affordance of the signage should be considered top priority when producing a dissuasive emergency sign. This is in agreement with the findings of Galea, Xie & Lawrence (2014) who found that signs with dissuasive markings which were not able to convey a sufficient enough cognitive message were misunderstood by observers (i.e. only crossing out certain areas of a sign only negated certain parts of it, such as direction or movement speed). This can also be seen from a reasoning perspective, if one choses to disregard the statistical results of the thesis. Since the whole act of creating a dissuasive emergency signage starts with the use of a regular exit sign, the most important factor becomes making observers understand that the sign no longer conveys an "*EXIT HERE"* message, but instead is supposed to convey a "*DO NOT EXIT HERE"* message. If one does not provide sufficient alteration to the sign to alter this conveyed message, the sign will not work in its intended fashion, and as such it will not dissuade anyone from using the marked exit door no matter how visible it becomes. Therefore, once again, the cognitive affordance of the sign is proven to be of great importance when designing a dissuasive emergency sign.

However, the need to also provide a sufficient amount of sensory affordance to the dissuasive signs must not be disregarded. People become blind to the signs they see in their everyday life. Couple this with the urge to exit via familiar paths in case of an emergency and you have a group of people egressing through a specific route without paying any heed to available signage as they already know the way leads to the outside (what they don't know is if the way is safe or not). In order for dissuasive emergency signage to also be effective the signage must in some way break the tendency of normality to become visible to the passing would-be observers. As such, one can also see the importance of sensory affordance affecting the functional affordance and preference of certain signage, although it

does take a back seat to the importance of cognitive affordance. This is further confirmed by the thoughts of Frantzich (2001), relating to how occupants of a department store fail to notice exit signs and instead follow known paths.

Within the thesis, an attempt was made to increase the cognitive affordance of the signage options in three different ways: The incorporation of a red LED X-marking over the signage, the use of a red background instead of a green background and the use of red flashing lights adjacent to the signage. The option which resulted in the greatest boost in cognitive affordance was the red LED X-markings. This is believed to be the case due to it providing the most clear and unambiguous message. By providing an X-marking over the signage (be it *running man* pictogram or *EXIT* text) the *EXIT HERE* message of the original exit signage is negated in a way most people would understand. Comments within the survey revealed that quite a few participants would have wanted the red LED X-markings to be more full, or even fully drawn lines over the signs for increased visibility and understanding. However, in an attempt to design a feasible solution for real dynamic signage the 'dotted' LED X-marking was chosen, due to the possibility to actually incorporate this into real current exit signage without reducing their primary objective of showing current exit routes. Providing fully drawn lines may cause the original message of the sign to be obscured even when the dynamic portion of it is not activated.

Only providing a red background instead of a green background or only providing red flashing lights adjacent to the signage seem to cause observers to rethink the message of the sign but the final results vary heavily. This is thought to be because signs only provided with these features have not properly negated the original *EXIT HERE* message and are instead providing an ambiguous message, stating either *danger* or *warning* while at the same time still stating *EXIT HERE*. A few participants also noted that this configuration caused them to believe that the exit sign was urging them to exit through the door faster, which is the opposite of what was intended.

The sensory affordance of the signs was attempted to be increased by the use of red flashing lights placed adjacent to the signage. It was quickly established that the red flashing lights did a good job of this and really seemed to bring attention to a sign provided with them as opposed to a sign not provided with them. There does seem to be a double edged blade here, as the flashing lights are good at catching attention and causing the signage to break out of its normal form and appearance it is of outmost importance that the sign they are placed adjacent to is able to provide a clear message of what to do. Comments within the survey described that the red flashing lights were great at catching attention, but that in doing so also drew attention away from actually attempting to discern the information of the sign. This was not able to be statistically proven, but may still be worth to bear in mind. Results also show that a sign provided with a red background instead of a green background provided an increase in sensory affordance due to being both more noticeable and easier to see details. It should be noted that this does not conform to the findings of Wong and Lo (2007) who found that a green and white sign was more visible than a red and white sign. It may be the result of the red LED X-markings causing observers to have a more difficult time viewing the green sign, than if these LED markings would not be present. However, due to providing an unambiguous message this signage option was quickly discarded as a preferred option for use, once again enforcing the notion that cognitive affordance is of the most importance for discerning functional affordance and preference of use.

With the above in mind, it comes as no surprise that signs 7 and 8 were the overall preferred signs within the survey, as they both incorporate the red LED X-marking and have flashing lights placed

adjacent to them. This result is in agreement with both the statistically tested results and the general reasoning of the author.

A note should also be made about the possibilities of utilizing for instance LCD-screens to provide a different set of messages, removing the need to negate an original "*EXIT*" message and instead only providing an already dissuasive message by way of for example a dissuasive pictogram or a *"NO EXIT*" text. As most of the results point towards unambiguousness being a key factor in providing a dissuasive message, the option of not having to negate an already existing message may prove to give very positive results. Additionally, the act of using such a dissuasive message could serve to break the tendencies of normalcy, as the observers of the sign would notice a change in signage and pay more heed to the new message. As discussed previously in this thesis, such signs were chosen to be discarded and as such this is considered a separate area for future research and will not be discussed further.

Additionally, the dissuasiveness of a certain sign must also be looked at in comparison to the persuasiveness of a certain sign. Within the survey the dissuasive signs were only tested relative to one another, and as such the observers were never presented with the possibility of observing a dissuasive and a persuasive sign simultaneously. This could have additional, unknown, effects on the perceived dissuasiveness of the signage. When being presented with a persuasive option the dissuasive properties of a dissuasive exit sign might be enhanced, as they would in a way become clearer when comparing to a persuasive sign. For instance, a red cross marking might more clearly mark a negation when compared to a sign that does not have a red cross marking. Additional thought must also go into the sensory affordances of both signage options, as providing a too heavy sensory affordance to the dissuasive signage might cause observers to disregard the persuasive sign as it is deemed less important. This reasoning however could work to a positive effect of leading observers towards the persuasive signage if this signage is provided with the increased sensory affordance.

7.5 Why Causing a Sense of Urgency is Important

The survey also took the time to ask participants what signage options created the greatest sense of urgency. This was done for several reasons, mostly revolving around the efficiency of evacuation. As the literature study has shown, providing an increased sense of risk or urgency will cause reactions amongst the observers which are generally of a good nature.

For instance, observers whom perceive a greater sense of risk are more prone to following given instructions and signs. As previously stated, this is considered a positive response in the case of this thesis because the need to interpret and follow the directions of the dissuasive emergency signage is of great importance as it is what determines if the signage can be considered to meet its objective or not. If causing an increased sense of risk or urgency would facilitate this behavior it is considered positive.

In addition, increasing the sense of risk or urgency of the observers has been shown to decrease the time required to make decisions in an emergency situation. These two positive effects combined are expected to lead to an overall decrease in evacuation time which, quite frankly, should never be considered a negative occurrence.

The results show that the facilitation of the feeling of risk and urgency is closely tied to the sensory affordance of the signage options, with the provision of red flashing lights being the main feature which gives a positive effect. Others include the utilization of a red background instead of a green background and to a very small extent the red LED X-markings were also mentioned. What all these features have in common is that they break the tendency of normalcy of the signage which conforms

to the findings of Kuligowski and Mileti (2009), who state that such cues would cause a greater sense of risk. They turn the signage into something new and 'activate' the signage making it both more interesting and also possibly more convincing to follow. The red flashing lights provided the largest increase in the sense of urgency. This is not surprising as comparisons can be drawn to similar warning lights placed on trucks or in areas which do not allow admittance. Therefore it seems reasonable that a similar line of though went through the observers minds when observing these red flashing lights.

The color red was also mentioned as a good projector of the feelings of urgency, danger and warning. Though it should be noted that within the survey only the colors red and green were utilized and there were no questions specifically related to the color of the signs or lights. These comments were instead comments made by the participants themselves and should as such be taken as only that, comments with no proven statistical value. Previous literature within the literature survey do back these comments up, such as the tests performed by Nilsson, Frantzich and Saunders (2005), showing that tests have shown that red is commonly associated with warning and danger, as opposed to green which is generally associated with safety . Therefore, utilizing a change from green to red within the signs may prove an effective manner of causing a greater sense of urgency amongst the observers as the signs are actively changing from showing safety to showing danger.

A general conclusion may be drawn stating that providing red flashing lights adjacent to signage will increase the sense of urgency for people observing the area and the sign, which should lead to a decrease in decision making time and an increase in the ability to take in and follow directions.

While the thesis predominantly investigates the positive effects of feeling a stronger sense of urgency it should also be noted that negative effects might occur. The thesis has not gone into depth on the subject but a note should be made nonetheless. Negative effects that might occur could be rasher decision making. The positive effects include a faster decision making process, but it could be that since the observer is feeling more urgency the final decision made might not be given as much thought as it would have been otherwise. It should also be noted that the thesis has not examined this in depth, and as such this is only mentioned as a note for future discussion.

7.6 Survey Questionnaire

The survey questionnaire designed to reduce the effects of fatigue and to make it easily understandable for all participants. An "easy to read" language was used excluding overly long or complicated words and all questions were presented in a short and consistent manner.

As the survey consisted of four similar tests, consisting of five similar questions per test, it is possible that towards the end of the survey the participants became bored or tired of answering the same questions repeatedly. This may have resulted in less effort being put into answering in a serious manner. This was countered in two ways: the test rotation was randomized for each survey trial in an attempt to spread the fatigue (if any presented itself) evenly among the tests and an incentive was given to do a good job (the cinema tickets). In addition, the important parts of the survey were placed at the start while the more informational sections such as background information of participants were placed at the end of the survey. As the information gained from the four tests was to be used for statistical testing and analysis it was deemed as more important than the background information, which would mostly be used to gain an overview of the participants.

During the course of the survey any questions participants had regarding the survey sheet were answered directly. This occurred on two occasions. The first being a question as to whether

participants had to choose either sign A or B for question 4, or if they could answer that the signs were equivalent in this question also (Note: question 4 was only supplied with options for A or B, not equivalent). The answer to this question was "*Yes, you must choose either sign A or B.*". The second being a question as to whether participants were to complete all five questions on the test sheet for the shown pair of signs. The answer to this question was "*Yes, please answer all five questions on the page while viewing these two signs.*".

Considering questions only appeared on two occasions and that they were related to survey layout and not survey contents, it is believed that the survey sheet was understood by the participants. As such, no information from any of the survey sheets has been discarded due to misunderstanding or failure to answer in a serious manner.

7.7 Realism in Modelling

The signs shown within the survey were all of a virtually modelled nature, i.e. no signs shown were actual real signs. An attempt was made to make these models as realistic as possible, given the time frame of the project and the skill of the author. Suitable programs were used to build a virtual environment and implement this environment into a program capable of rendering lights in a realistic fashion.

In an attempt to make the environment seem more natural the signs were placed above a door in what could be described as an office. Observers were also able to see a desk, some boxes, a couple of shelves, a fire alarm and a plant. This was done in order to not create a sterile unrealistic environment.

When modelling, the red flashing lights were rendered light sources which gave off a shine on nearby textures. This was considered more realistic than only providing red textures which would alternate between red and black. The light render provided an increased sense of reality as it caused the light to act more like light would act in a real life situation. It is noted though that shadows were never able to be incorporated into the model, which would be the next step in creating a more realistic environment.

On a whole, utilizing the modelled environment is not expected to have a negative effect on the results. The main focus of the survey was to determine how different features added to the signs would affect the observers' perception of the signs. These features were made clearly visible in a manner which is deemed realistic enough in order to produce useable results. In addition, the findings of Johansson and Petersson (2013) show that persons act very similarly in a virtual environment as they do in the real world. A single participant noted that the render should have been more realistic to produce a better result, and although the author agrees that the more realism the better, both time and skill constraints prevented this from being possible.

7.8 Future research

In order to move the area of evacuation signage research forward several areas of future research are proposed based on the findings of this thesis and other relevant literature assessed during the literature review.

A proposition for future research is to incorporate the use of both regular and dissuasive signage into evacuation experiments to assess if the availability for observers to observe both types of signage simultaneously has any impact on their ability to interpret and correctly follow the signage. Research within this area is already underway, but the research is sparse and the combined effect of utilizing both regular and dissuasive signage has not yet been fully tested in large-scale realistic evacuation scenarios.

Further areas of future research may include research relating to the utilization of acoustic signals to convey dissuasive messages. It has been shown that acoustic signals offer a high level of sensory affordance to the entity they are attached to, given that the observer is able to hear the acoustic signal. Acoustic signals may be difficult to tailor to specific needs such as dissuasion and may instead only be interpreted as a feature to gain attention, as such the impact on cognitive affordance is questionable, even though some research points to this being possible also. In addition, the type of environment the acoustic signals are used in may have an impact on their effectiveness, for example in a cluttered environment it may be more difficult to locate the source of the signal. Therefore, it is recommended that further research into this area be done as it may result in an even more effective dissuasive emergency signage design.

It was found during the literature review of this thesis that the capability of incorporating intelligent active dynamic signage systems into real buildings is not a too far off endeavor. The ability consists to in real time predict and assess people's egress movements, the knowledge of how to make egress routes seem both preferred and not-preferred is available and the ability to incorporate dynamic signage to fire alarm systems is available. Combining this knowledge and technical know-how allows for the creation of intelligent active dynamic signage systems which are able to react to and direct egressing occupants from hazards within the environment. However, for these systems to become plausible solutions to evacuation problems more studies must be done where all these different parts are combined in order to assess their effects on one another when working together. When this has been done, the future development of intelligent active dynamic signage systems may commence.

8 Conclusions

To draw a conclusion, the two main questions asked by the thesis are answered:

How should an emergency sign be designed to provide the largest likelihood of dissuading egressing occupants from the use of a certain egress route?

As shown in the results of the survey within this thesis, a statistically significant preference was able to be observed for sign 7 and sign 8. These signs both include white text or pictogram on green background, red flashing lights placed adjacent to the sign, a red LED X-marking placed over the signs. Therefore, incorporating the following list of items will produce an emergency sign capable of dissuading observers from the use of a certain egress route:

- Green background with white text or pictogram.
- Red LED X-marking placed over entire sign.
- Red flashing lights placed adjacent to sign.

In addition to the above points, there are also points to be made as to the importance of not providing an ambiguous message within the dissuasive emergency signs. The single most important feature required for the dissuasive emergency signage to work is that observers understand the dissuasive message; otherwise observers will only see a regular exit sign with strange features attached and proceed to exit. This is best done by providing features which heavily negate the original *EXIT HERE* message. The above example includes providing a red LED X-marking over the entire sign in order to negate the message of the *EXIT* text or *running man* pictogram. Other options could include altering text from *EXIT* to *NO EXIT* but this has not been covered within this thesis and would require additional testing.

How is it possible to affect the sense of risk and urgency amongst observers through the use of emergency signage and additional features and what would be its gain?

It is judged as possible to affect the sense of risk and urgency amongst the observers through the use of red flashing lights placed adjacent to the emergency signage. Observers' feeling of risk and urgency are largely affected by sensory inputs to a greater extent than other things, such as cognitive input. In addition the flashing color red results in ties to other warning features, such as flashing lights on trucks or areas of restriction. The utilization of the color red in other features of the signage also has a tendency to cause observers to feel urgency, although to a lesser extent than that registered for active components such as red flashing lights.

By imbuing observers with a greater sense of urgency and risk of the situation it is expected that this will result in the observers making faster evacuation decisions and be more prone to see and follow signage and instructions while egressing. This is considered a positive effect, especially while attempting to affect egress route choice amongst observers, as this will increase the likelihood of observers heeding both regular and dissuasive signage.

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10 Appendix A

The text contained within Appendix A is a transcription of the text participants of the experimental survey were read upon commencement of the survey. The text serves to increase immersion and create an understanding of what is being observed.

Hello,

Welcome and thank you for coming here to participate in this experimental study of dissuasive emergency signage, which is signage that tells you to not use a particular exit door. Please take a minute to read the first page containing information about the survey. The survey sheet contains separate pages for tests 1 to 4 which we will work our way through throughout the survey. You will be shown two exit signs per test, each shown on these separate screens and provided with a letter for recognition (Point to screen A/B). The goal of the survey is for you to answer the questions in relation to the shown signage. If you wish to withdraw from the survey please notify me now or at the end of the survey.

Now, let's get started. Please turn to Test 1.

(Told during Test 1):
Imagine yourself being within a building. Suddenly the fire alarm is activated and you smell smoke. You make a decision to evacuate the building. Making your way towards an emergency exit you encounter the following exit signs telling you to not use this exit door.

On the screens in front of you, you will see two exit signs placed above doors within an office environment. Please fill out the Test 1 page of the survey while observing these signs.

(Repeated for Test 2):
On the screens in front of you, you will see a new couple of signs located above the doors. Please fill out the Test 2 page of the survey while observing these signs.

(Repeated for Test 3):
On the screens in front of you, you will see a new couple of signs located above the doors. Please fill out the Test 3 page of the survey while observing these signs.

(Repeated for Test 4):
On the screens in front of you, you will see a new couple of signs located above the doors. Please fill out the Test 4 page of the survey while observing these signs.

(Told at end of survey):
The final question of the survey allows you to rate all the tested signage individually on a scale from 1 to 5, which means that different signs can receive the same score. Please do so in regards to how you consider the signs will perform in advising you to not use an exit door.

When you have done this, please also answer the background questions located at the end of the survey sheet and I will then proceed to collect them.

Thank you for you participation in this experimental survey! Please do not forget to receive your cinema ticket as thanks for the help before leaving. If you have any questions relating to the survey or are curious about anything, do not hesitate to come and ask.

Good-bye!

11 Appendix B

Appendix B presents a representation of the questionnaire participants were asked to complete upon observing the paired comparisons of dissuasive emergency signage.

The questionnaire is split into four parts:

The first containing information relevant to the participants. The second containing the repeated affordance and risk perception based questions relating to the shown dissuasive emergency signage. The third containing a scale test allowing for the individual rating of all signage options. The fourth containing background information questions relating to the participant.

The survey sheet in its entirety is as follows:

Survey

Dissuasive Emergency Signage

LTH, A-Building, A:C

<Date, Time>

The following document contains a survey questionnaire relating to dissuasive emergency signage and is part of a thesis (VBRM10) on the subject, being prepared by Joakim Olander.

Survey: Dissuasive Emergency Signage

Welcome to this survey on dissuasive emergency signage, a type of signage which is to tell you as an observer to NOT use a specific exit door during an emergency. Please read the following information before awaiting further instruction from your interviewer.

The Questionnaire

You will be asked to fill out a questionnaire which is part of an experimental survey on the effects emergency signage. The relevant signage options will be shown on the screens in front of you. The questionnaire contains a repeat set of 5 questions for each pair of signs shown during the experimental survey, a sheet where you rate different signage options on a scale and a final open discussion question where any thoughts you may have about the survey are greatly appreciated. In addition, at the end of the questionnaire you will be asked to fill out 10 questions relating to background information about yourself. The survey is expected to take 40 minutes to complete.

Confidentiality

All answers will be treated confidentially and it will not be possible to relate specific answers to specific persons. Data gained from the experimental survey will be stored for research purposes and may be published to be accessible to the public.

Right to Withdraw

You reserve the right to withdraw from the experimental survey at any point in time. To do this, please contact your interviewer now or directly after the survey has been completed and your responses will be discarded from the survey.

A Small Thank You

As a thank you for participating in the experimental survey you will be awarded a free cinema ticket upon its completion.

Agreement

With the following signature you agree to participate in this survey on dissuasive emergency signage given the information provided on this page. The survey will take place in low light conditions and flashing lights will be prominent.

Sign: _____

Please await an introduction from your interviewer before commencing to fill out the survey.

Test 1 / 2 / 3 / 4

1. Which of the two exit signs is **easiest** to notice?

A ☐ B ☐ A and B equivalent ☐

Please describe which features are easy to notice:

_____

_____

2. In which of the two exit signs is it **easiest** to distinguish the details?

A ☐ B ☐ A and B equivalent ☐

Please describe why the details are easy to distinguish:

_____

_____

3. Which of the two exit signs best conveys the message of **not** using this exit route?

A ☐ B ☐ A and B equivalent ☐

Please describe which features best convey the message:

_____

_____

4. Which of the two exit signs would you prefer be used to advise you **not** to use an exit route? (Only chose A or B.)

A ☐ B ☐

5. Which of the two exit signs would result in the **greatest** sense of urgency of the situation?

A ☐ B ☐ A and B equivalent ☐

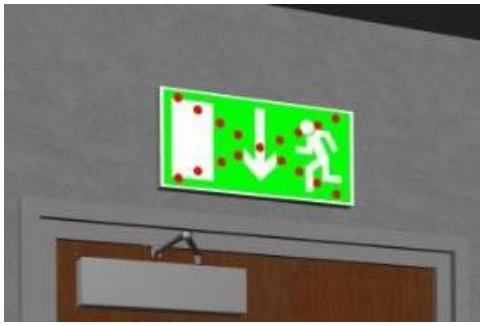
Please describe which features result in the greatest sense of urgency:

_____

_____

Rate the Signage

Please rate the signage options from 1-5 based its ability to tell you to **not** use an exit door (note that multiple signs may receive same score).
1 = worse, 5 = better.



1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Open Discussion

Do you have any additional comments you wish to add regarding the signage shown or the survey?

_____

_____

Background Information

1. Age: _____
2. Nationality: _____
3. Sex: Male ☐
   Female ☐
   Other ☐
4. How do you rate your English understanding (1 = low, 5 = high):
   1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
5. For how long have you been in Sweden: _____
6. Have you spent months/years in North or South America:
   Yes ☐
   No ☐
   If yes, please state time and occupation: _____
7. Are you colorblind (see a difference between red and green etc.?):
   Yes ☐
   No ☐
   If yes, please describe what type: _____
8. Do you have an eye-sight impairment (near or far sighted, partially blind etc.?):
   Yes ☐
   No ☐
   If yes, please describe it: _____
9. What is your occupation: _____
10. Previous experience with emergency situations (cross all that apply or leave blank):
    Fire drills ☐
    Real evacuation ☐
    Fire service work ☐
    Other (please elaborate): _____

Thank you for your participation in this survey regarding dissuasive emergency signage! Please do not forget to collect your complimentary cinema ticket before leaving.

12 Appendix C

This appendix contains the raw data collected from the survey.

Test 1 – Sign 5 (A) VS Sign 7 (B)					
Trial	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
1	B	AB	B	B	B
1	B	AB	AB	A	B
1	B	A	A	A	B
1	B	A	A	A	B
1	B	A	A	A	B
1	B	AB	B	B	B
1	B	A	A	A	B
1	B	A	B	A	B
1	B	B	AB	A	B
1	B	A	A	A	B
1	B	AB	B	B	B
1	B	AB	B	B	B
1	B	A	B	B	B
1	B	AB	B	B	B
1	B	A	A	A	B
1	B	B	B	B	B
2	B	AB	B	B	B
2	B	AB	B	B	B
2	B	AB	A	A	B
2	B	A	B	B	B
2	B	A	B	B	B
2	B	AB	B	B	B
2	B	B	B	B	B
2	B	AB	B	B	AB
2	B	A	B	B	B
2	B	AB	A	A	B
2	B	AB	A	A	AB
2	B	A	A	B	B
2	B	A	A	A	B
2	B	AB	AB	B	B
3	B	AB	B	B	B
3	B	AB	B	B	AB
3	AB	AB	B	B	B
3	B	AB	A	A	B
3	B	A	A	A	B
3	B	B	B	B	B
3	B	AB	A	A	B
3	B	B	B	B	AB
3	B	AB	A	A	-
3	B	AB	A	A	B

Test 1 – Sign 5 (A) VS Sign 7 (B) (cont.)					
Trial	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
3	B	AB	B	B	B
3	B	B	B	B	AB
3	B	AB	B	B	B
3	B	B	B	B	B
3	B	B	B	B	B
3	B	AB	AB	B	B

Test 2 – Sign 7 (A) VS Sign 11 (B)					
Trial	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
1	B	B	A	A	B
1	B	A	A	A	B
1	A	A	A	A	AB
1	B	B	A	A	B
1	AB	AB	A	A	AB
1	AB	AB	AB	A	B
1	A	AB	B	B	B
1	B	B	A	A	B
1	A	B	AB	B	AB
1	AB	B	B	B	AB
1	AB	B	A	A	AB
1	AB	B	A	A	AB
1	AB	B	A	A	AB
1	A	A	A	A	AB
1	B	B	A	A	AB
1	AB	B	A	A	AB
2	A	A	A	A	A
2	AB	AB	A	A	AB
2	AB	B	A	A	A
2	B	B	B	A	B
2	A	B	A	B	B
2	AB	B	B	B	AB
2	B	B	A	A	A
2	AB	-	B	B	B
2	B	B	A	B	B
2	B	B	A	A	AB
2	B	A	A	A	A
2	B	B	AB	A	B
2	A	A	A	A	A
2	B	B	A	A	B
3	B	B	A	A	AB
3	B	B	B	B	B
3	AB	B	A	A	A

Test 2 – Sign 7 (A) VS Sign 11 (B) (cont.)					
Trial	**Trial**	**Trial**	**Trial**	**Trial**	**Trial**
3	B	B	A	A	B
3	A	B	A	A	A
3	B	B	B	B	B
3	B	B	A	A	AB
3	A	A	A	A	AB
3	B	B	A	A	-
3	B	B	A	A	AB
3	B	B	B	B	B
3	B	B	A	B	AB
3	B	B	A	A	B
3	B	B	A	A	B
3	B	B	A	A	B
3	B	B	B	B	B

Test C – Sign 7 (A) VS Sign 8 (B)					
Trial	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
1	AB	AB	AB	A	AB
1	AB	AB	AB	A	AB
1	AB	B	B	B	AB
1	AB	B	B	B	AB
1	AB	AB	B	B	AB
1	AB	AB	AB	B	AB
1	B	AB	B	B	B
1	AB	B	B	B	B
1	AB	AB	AB	B	AB
1	AB	AB	B	B	AB
1	AB	A	A	A	AB
1	AB	A	AB	A	AB
1	AB	AB	A	A	AB
1	AB	A	AB	A	A
1	AB	A	A	A	AB
1	AB	A	AB	A	AB
2	AB	B	AB	B	AB
2	AB	A	AB	A	AB
2	AB	A	A	A	AB
2	A	B	A	A	A
2	AB	B	B	B	AB
2	AB	AB	AB	B	AB
2	AB	AB	AB	A	AB
2	AB	AB	A	A	AB
2	AB	B	AB	B	AB
2	AB	AB	A	A	AB

Test C – Sign 7 (A) VS Sign 8 (B) (cont.)					
Trial	**Trial**	**Trial**	**Trial**	**Trial**	**Trial**
2	AB	A	AB	A	AB
2	B	B	B	B	B
2	AB	AB	A	A	AB
2	A	B	B	B	AB
3	AB	B	AB	A	AB
3	B	B	B	B	B
3	AB	AB	A	A	AB
3	AB	AB	B	B	AB
3	A	A	A	A	A
3	B	B	B	B	B
3	AB	B	B	B	B
3	B	B	B	B	AB
3	AB	AB	AB	B	-
3	AB	B	AB	B	AB
3	AB	B	AB	A	AB
3	A	A	AB	A	A
3	AB	B	A	A	AB
3	B	B	A	B	A
3	B	B	AB	B	AB
3	AB	B	AB	B	AB

Test D – Sign 8 (A) VS Sign 12 (B)					
Trial	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
1	B	B	A	A	B
1	B	A	A	A	B
1	B	B	A	A	B
1	B	B	A	A	B
1	AB	B	A	A	B
1	B	B	A	A	B
1	AB	B	A	A	B
1	B	B	A	A	B
1	AB	B	AB	A	AB
1	B	B	A	A	AB
1	AB	B	A	A	AB
1	AB	B	A	A	AB
1	AB	B	A	A	AB
1	B	B	A	A	B
1	B	B	A	A	AB
1	A	AB	A	A	B
2	A	A	A	A	A
2	B	B	AB	B	B
2	A	B	B	B	B

Test D – Sign 8 (A) VS Sign 12 (B) (cont.)					
Trial	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
2	A	B	A	A	A
2	B	B	A	A	B
2	AB	B	B	B	AB
2	B	AB	A	A	B
2	AB	B	B	B	B
2	B	B	A	B	B
2	B	B	A	A	AB
2	A	AB	A	A	A
2	A	B	A	A	B
2	A	A	A	A	A
2	B	B	AB	A	B
3	B	AB	A	A	B
3	AB	B	A	A	B
3	A	B	A	A	A
3	B	B	A	A	B
3	A	B	A	A	A
3	A	B	A	B	B
3	B	B	A	A	A
3	A	A	A	A	A
3	B	B	A	A	-
3	B	B	A	A	AB
3	B	B	B	B	B
3	B	A	B	B	AB
3	B	B	A	A	B
3	B	B	A	A	B
3	B	B	A	A	B
3	B	B	B	B	B

Scale Testing					
Trial	**Sign 5**	**Sign 7**	**Sign 8**	**Sign 11**	**Sign 12**
1	3	4	4	2	1
1	3	2	4	1	1
1	4	3	5	2	1
1	3	4	5	2	3
1	5	3	4	2	2
1	1	4	4	3	3
1	3	2	3	2	1
1	2	2	4	1	1
1	2	1	1	1	1
1	2	2	5	3	3
1	4	5	5	2	2
1	4	5	3	2	2

Scale Testing (cont.)					
Trial	**Sign 5**	**Sign 7**	**Sign 8**	**Sign 11**	**Sign 12**
1	3	5	3	3	2
1	4	5	4	1	1
1	4	4	2	1	1
1	2	5	4	3	3
2	4	5	5	2	2
2	1	5	4	3	4
2	5	4	2	2	2
2	3	4	5	1	1
2	2	2	3	1	1
2	1	2	2	2	2
2	3	4	4	1	1
2	1	2	2	4	4
2	2	3	3	4	5
2	5	4	3	1	1
2	5	3	3	2	1
2	3	4	5	4	4
2	4	5	3	2	2
2	4	4	5	1	1
3	2	4	4	1	1
3	1	2	4	2	3
3	5	5	4	1	1
3	5	3	4	1	1
3	5	4	3	2	1
3	1	3	4	5	2
3	3	2	3	1	1
3	4	5	4	2	2
3	5	4	4	2	1
3	4	3	3	2	2
3	1	4	4	5	5
3	3	4	4	5	5
3	3	4	2	2	2
3	5	4	5	1	1
3	2	4	4	3	1
3	2	3	3	5	5

	Average	**Min**	**Max**
Age	23,22	19	40
English Skill	4,63	3	5

	Male	**Female**	**Other**
Sex	28	17	1

	Student	PhD	Working
Occupation	44	1	1

	Yes	No
Colorblind	1	45
Eye-Sight Impairment	16	30

	None	>3 months	>1 year
Time in Sweden	0	13	33
Time in N/S America	39	5	2

	Fire Drills	Real Evacuation	Other
Experience	37	13	5

	Amount
Swedish	29
German	6
Russian	1
Polish	1
Moldavian	1
English	1
Spanish	1
Finnish	1
Pakistani	1
Bulgarian	1
Nigerian	1
USA	1
Slovenian	1

Participants Comments (summary)	
Q1. Sensory Affordance (Visibility)	
Pros:	Red flashing lights.
	Red background color is more noticeable.
	Green background color is more noticeable.
	Color of sign does not matter, only flashing lights.
Cons:	Random complaints about render not being realistic enough.
Q2. Sensory Affordance (Details)	
Pros:	Red on white easier to distinguish.
	When a sign is clear of markings it is easier to read/distinguish details.
	Red flashing lights may help illuminate details.
Cons:	Red cross markings make details more difficult to see.
	Red flashing lights cause disturbance when viewing the sign.
	Red cross should be full as it was difficult to distinguish.
Other:	Text is easier to read than pictogram when crossed over.
	Random complaints about render not being realistic enough.
Q3. Cognitive Affordance (Message)	
Pros:	Red cross.
	Flashing red lights make exit seem dangerous.
	Red is relatable to "do not use".
Cons:	Red cross should be more visible.
	Red background with no cross is easily mistaken.
	Flashing lights draw people to the exit making them use it. (When paired with sign 5.)
	Crossing over a known sign (pictogram) does not convey the message well enough.
Other:	Crossed out text conveys message better than crossed out pictogram due to strong association.
	Red cross should be full for better understanding.
	Easier to understand cross out pictogram than cross out text, as you don’t have to read the text.
	Pictograms should be used over text, as pictogram provides an "international language".
Q5. Risk Perception (Urgency)	
Pros:	Red flashing lights.
	The more red, the more urgent it feels. Red signals danger.
	Red lights = urgency, if flashing this feeling is enhanced.
	Impression that it is burning behind door with red flashing lights.
	Flashing lights, due to feeling extraordinary, cause a sense of urgency.
	Crossing over the regular exit sign (pictogram) makes it feel more urgent as it is an alteration of something common.
Cons:	Red sign with red flashing lights conveys a sense of urgency in a wrong way, a sense to USE the exit.

13 Appendix D

This appendix contains information gained from binomial testing of the preferences of signs observed from question 4 of the survey sheets and information gained from Wilcoxon Ranked Sign Testing of the scale test provided within the survey sheets. Binomial testing and Wilcoxon Ranked Sign testing were performed in IBM SPSS Statistics Data Editor, provided by IBM.

A test proportion of 0.50 is chosen to resemble a H_0 = there is no preference of one emergency sign over another.

Table 11 shows a legend for the statistical testing.

Table 11. Legend for statistical testing.

TestNUM1		**TestNUM2**		**TestNUM3**		**TestNUM4**	
Sign 5	A	Sign 7	A	Sign 7	A	Sign 8	A
Sign 7	B	Sign 11	B	Sign 8	B	Sign 12	B

Tables 12 – 16 show results of binomial testing of questions 1 to 5 of the questionnaire.

Table 12. Results of binomial testing for Q1.

Binomial Test – Q1

		Category	**N**	**Observed Prop.**	**Test Prop.**	**Exact Sig. (2-tailed)**
TestNUM1	**Group 1**	B	45	1.00	.50	.000
	Total		45	1.00		
TestNUM2	**Group 1**	B	25	.74	.50	.009
	Group 2	A	9	.26		
	Total		34	1.00		
TestNUM3	**Group 1**	B	7	.64	.50	.549
	Group 2	A	4	.36		
	Total		11	1.00		
TestNUM4	**Group 1**	B	26	.70	.50	.020
	Group 2	A	11	.30		
	Total		37	1.00		

Table 13. Results of binomial testing for Q2.

Binomial Test – Q2

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
TestNUM1	**Group 1**	A	14	.64	.50	.286
	Group 2	B	8	.36		
	Total		22	1.00		
TestNUM2	**Group 1**	B	34	.83	.50	.000
	Group 2	A	7	.17		
	Total		41	1.00		
TestNUM3	**Group 1**	B	20	.67	.50	.099
	Group 2	A	10	.33		
	Total		30	1.00		
TestNUM4	**Group 1**	B	37	.88	.50	.000
	Group 2	A	5	.12		
	Total		42	1.00		

Table 14. Results of binomial testing for Q3.

Binomial Test – Q3

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
TestNUM1	**Group 1**	B	26	.62	.50	.164
	Group 2	A	16	.38		
	Total		42	1.00		
TestNUM2	**Group 1**	A	34	.79	.50	.000
	Group 2	B	9	.21		
	Total		43	1.00		
TestNUM3	**Group 1**	B	14	.54	.50	.845
	Group 2	A	12	.46		
	Total		26	1.00		
TestNUM4	**Group 1**	A	37	.86	.50	.000
	Group 2	B	6	.14		
	Total		43	1.00		

Table 15. Results of binomial testing for Q4.

Binomial Test – Q4

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
TestNUM1	**Group 1**	B	28	.61	.50	.184
	Group 2	A	18	.39		
	Total		46	1.00		
TestNUM2	**Group 1**	A	34	.74	.50	.002
	Group 2	B	12	.26		
	Total		46	1.00		
TestNUM3	**Group 1**	A	22	.48	.50	.883
	Group 2	B	24	.52		
	Total		46	1.00		
TestNUM4	**Group 1**	A	37	.80	.50	.000
	Group 2	B	9	.20		
	Total		46	1.00		

Table 16. Results of binomial testing for Q5.

Binomial Test – Q5

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
TestNUM1	**Group 1**	B	40	1.00	.50	.000
	Total		40	1.00		
TestNUM2	**Group 1**	B	18	.75	.50	.023
	Group 2	A	6	.25		
	Total		24	1.00		
TestNUM3	**Group 1**	B	6	.55	.50	1.000
	Group 2	A	5	.45		
	Total		11	1.00		
TestNUM4	**Group 1**	B	27	.77	.50	.002
	Group 2	A	8	.23		
	Total		35	1.00		

Tables 17 and 18 contain the results of the Wilcoxon Sign Rank test.

Table 17. Results of Wilcoxon Sign Rank test for scale testing.

Wilxocon Sign Rank test

		N	Mean Rank	Sum of Ranks
Sign7 - Sign5	Negative Ranks	14[a]	18.86	264.00
	Positive Ranks	26[b]	21.38	556.00
	Ties	6[c]		
	Total	46		
Sign7 - Sign8	Negative Ranks	16[d]	14.22	227.50
	Positive Ranks	13[e]	15.96	207.50
	Ties	17[f]		
	Total	46		
Sign7 - Sign11	Negative Ranks	7[g]	13.29	93.00
	Positive Ranks	34[h]	22.59	768.00
	Ties	5[i]		
	Total	46		
Sign7 - Sign12	Negative Ranks	7[j]	13.14	92.00
	Positive Ranks	36[k]	23.72	854.00
	Ties	3[l]		
	Total	46		

a. Sign7 < Sign5
b. Sign7 > Sign5
c. Sign7 = Sign5
d. Sign7 < Sign8
e. Sign7 > Sign8
f. Sign7 = Sign8
g. Sign7 < Sign11
h. Sign7 > Sign11
i. Sign7 = Sign11
j. Sign7 < Sign12
k. Sign7 > Sign12
l. Sign7 = Sign12

Table 18. Results of Wilcoxon Sign Rank test for scale testing.

Test Statistics[a]

	Sign7 - Sign5	Sign7 - Sign8	Sign7 - Sign11	Sign7 - Sign12
Z	-2.061[b]	-.224[c]	-4.425[b]	-4.665[b]
Asymp. Sig. (2-tailed)	.039	.823	.000	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

14 Appendix E

Appendix C contains information regarding 3D modelling, program usage and software setup for the experimental survey.

Producing the images shown during the experimental survey was a three-stage process. A 3D-model, incorporating the dissuasive emergency signage under examination and a suitable environment was modelled in the program SketchUp Make 2015. This is a free software package from Trimble which allows for simple 3D-modelling and texture rendering. The environments modelled included the dissuasive emergency signage, an egress door, a fire alarm sounder and push button and environmental scenery, all placed within the corner of an imaginary office space. Refer to Figure 23 for an example of the SketchUp Make model window. For dissuasive emergency signage variants including red flashing lights, the base of these were also modelled. For signage incorporating LED X-markings, these were prepared within SketchUp Make by locating red circular textures in an X-marking over the signage. SketchUp Make was utilized due to its ability to export models in a COLLADA format (.DAE).

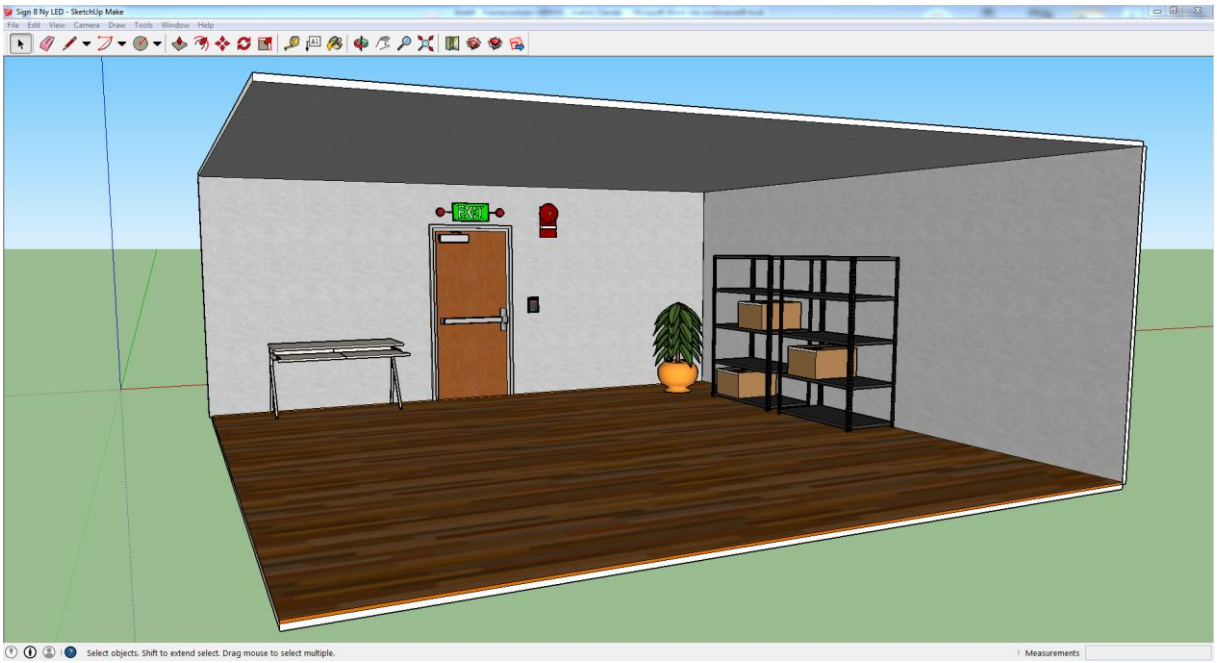


Figure 23. SketchUp Make 2015 model showing sign 8 within a modelled environment.

Models produced in SketchUp Make 2015 were then exported as .DAE files and subsequently loaded into the program Unity (version 4.5.5.f1). Unity, provided by Unity Technologies ApS, is a game creation software program capable of, amongst other things, incorporating lighting into 3D-models. For work within this thesis a free, scaled down, version of Unity was utilized. Unity was used to incorporate the lighting aspects of the signage. Refer to Figure 24 for an example of the Unity model window. Red flashing lights were modelled as point lights with a lighting area of 20 meters and an intensity of 8 with *Draw Halo* active. Signage backgrounds (green and red) were also applied with the *Self-Illumin/Bumped-Diffuse* shader in order to create the image of a back-lit self-illuminated sign.

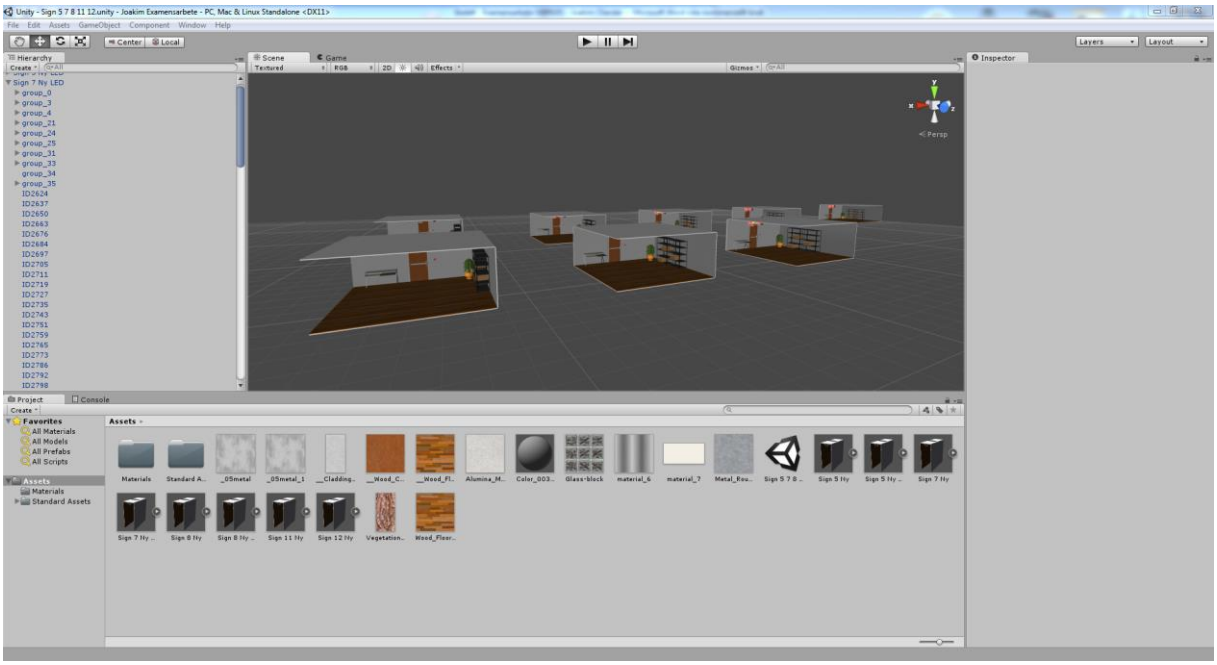


Figure 24. Unity model showing an overview of the scenario created.

Footage of the signage options shown within the Unity software was taken via the use of screen dumping. Footage showing both activated and deactivated lighting options was taken. Windows Movie Maker 2012, provided by Microsoft, was then utilized to create a stream of the activated and deactivated images allowing for movies to be created where the lights were flashing at a frequency of 1 hertz. Refer to Figure 25 for an example of the Windows Movie Maker process used when creating the final versions of the rolling images shown to the participants of the experimental survey.

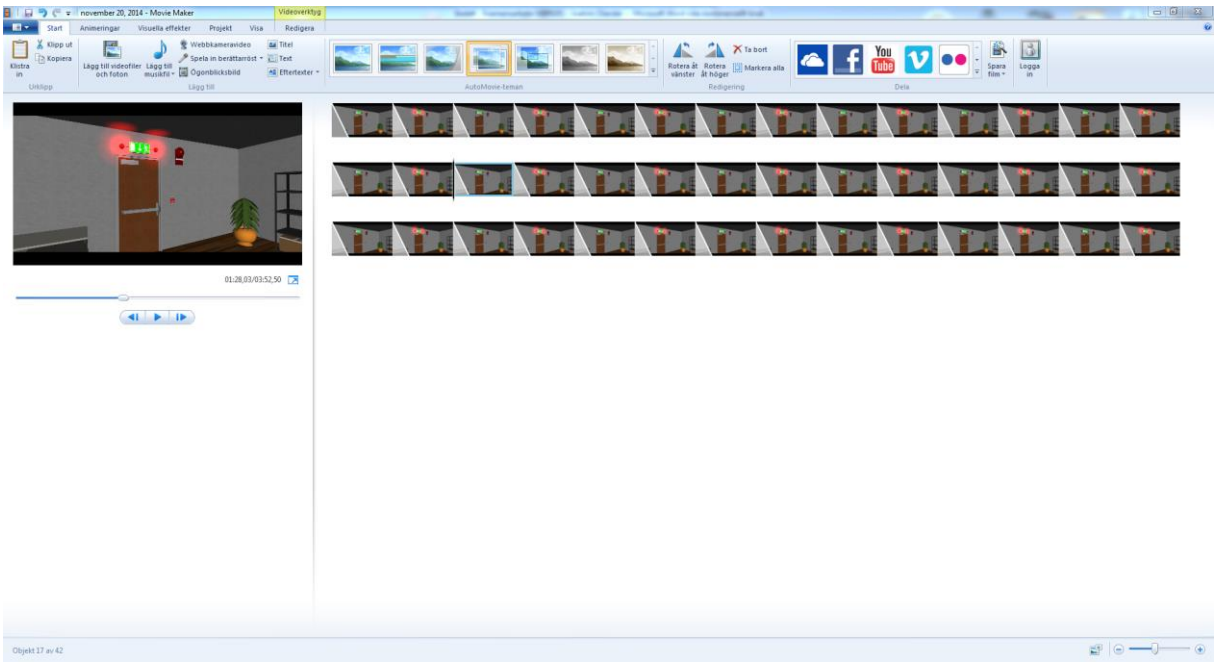


Figure 25. Windows Movie Maker window showing setup of sign 7 rolling image.