Fire alarm in a public building: How do people evaluate information and choose evacuation exit?

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1996

Brandteknik
Lunds tekniska högskola
Lunds universitet

Department of Fire Safety Engineering
Lund Institute of Technology
Lund University

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Research financed by the Swedish Fire Research Board (BRANDFORSK)

Lund, June 1996

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ISSN 1102-8246
ISRN LUTVDG/TVBB--3082--SE

Abstract: How people react on fire alarm have been studied in retrospect as well as in experiments. In the present study, the choice of exit was examined with respect to the distance to exits and open or closed emergency exit. The second part covers the question on how the subjects think and react in a situation having a small fire in the escape route. The third part deals with some communication aspects regarding identification of signs. It is shown that the subjects prefer a familiar ordinary cash exit even if the distance is longer to that exit than to the nearest emergency exit. However, if the emergency exit is open and the subjects can see the outside, the attractiveness becomes much higher for the emergency exit and most of the subjects choose the emergency exit.

The identification of alarm using a ring signal perceives often as a general warning or some kind of a conventional ring-signal such as telephone or school ring signal, and it is more seldom perceived as an evacuation signal. A spoken message, on the other hand, has a great impact on understanding what to do and gives a better and more appropriate behaviour for the evacuation of the building. The understanding of signs, important in a fire evacuation situation, is very good for signs such as emergency exit but rather low for signs not so frequently used, such as a sign for radioactive material.

Keywords: fire, evacuation, distance to exit, exit choice, fire alarm, signs, decision making, evaluation. The theory of choice by distance and familiarity, CDF, risk perception, feelings, emotions

Report financed by Brandforsk project No. 118-941

Illustrationer/Diagram: Lars Benthorn, Håkan Frantzich

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Summary

The report is presenting results from an experiment in which people were subjected to a fire alarm. The people participating in the test had to chose an evacuation exit and two different experiment positions were used in a public warehouse in Sweden. On the first position, the distances to the normal exit and the emergency exit were about the same. On the other position the distance to the normal exit was about twice the distance to the emergency exit. The emergency exits for the two test positions were located in the same way i.e. with the same distance and direction from the test position. One test person at a time participated in the experiment.

At each test position, the emergency exit was kept open for half of the test population and closed for the other half. This in order to see differences if preferred exit of the visual impression of the door was different. Of all the persons, about half the number were women and the age ranged between 16 and 75.

Apart from the exit choice experiment, two other tests were performed. In the second test, the persons were asked about their feelings and emotions if there was a fire in the pathway to the emergency exit and if that knowledge would have changed their exit choice. The last test was to identify six standard European Union signs used to inform about fire and other hazards.

The result from the exit choice experiment revealed that the normal exit is preferred to the emergency exit in all cases except one. If the distance to the normal exit was twice the distance to the emergency exit and if that exit also was open almost all the persons chose that exit. This result is in accordance with other findings in the literature.

On the condition that there was a fire in the evacuation route the persons were asked about their actions taken. The most frequent answer was to fight the fire, and that was also the most frequent male answer. Women preferred to ignore the fire and to run out to safety just passing the fire. The risk of passing the fire was judged by the subjects to be rather low. The height of the imagined fire was about 1 m and the closest passing distance was approx. 3 m.

Almost all the persons could identify all the six signs. The two signs indicating emergency exit were identified by all the subjects.

The information presented in this report could be used as a background document in the design process of the emergency routes in buildings. It could be used as a complement to computer simulation models to set up the movement pattern for the calculations.

Foreword

This work is part of a project with the objective of deriving the means for the planning of escape routes in buildings. The other two parts composing this project cover areas of both basic fundamental research and technical implementation of existing and new knowledge from the remaining parts of the project. The three parts are

Deriving data on movement on stairs (Frantzich 1996)
Studying human behaviour related to choosing escape route (this report)
Producing an escape model for design purposes (Thompson 1996).

The main outcome of the project from the designers point of view is the evacuation model, Simulex. This is the result from the third part. The necessary information for calculations in the model is provided from the two first parts. From a scientific point of view the two first parts will also provide new information to be used for other purposes.

The work on this project has been carried out by researchers at Lund University (parts 1 and 2) and at the University of Edinburgh (part 3). Project co-ordinator has been MSc Robert Jönsson at Lund University. The project has also been supervised by a reference group with the following members

Jan Blomqvist, Cerberus AB
Gun Hallberg, Royal Institute of Technology
Barbro Ahlén, The Swedish Fire Protection Association
Mette Lindahl-Olsson, The Swedish Rescue Service Agency
Tomas Rantatalo, The National Board of Housing, Building and Planning
Truls Paulsen, SINTEF, Norway
Sven Erik Magnusson, Lund University
Eric Marchant, University of Edinburgh

This work was financed, to a significant degree, by the Swedish Fire Research Board, BRANDFORSK, which is a joint state, municipal and industrial organisation for the initiation, funding and control of research within the field of fire safety.

The authors want to express their gratitude to the staff at IKEA in Helsingborg for permitting the experiment to take place at the warehouse.

Introduction

Research about how people react when they hear a fire alarm in a public building is of significant importance for the security and for the ability to save lives. Evacuation from a building in a fire situation is something that people are normally not used to. Furthermore, it has often to take place under considerable physical and psychological stress. It is therefore important to know how people behave during evacuation and which factors affect their behaviour. A number of investigations have been carried out within this area during recent years which have provided information on what people do after they have become aware that something unusual has happened. It is not always the case that a person seeing smoke interprets this as evidence of a fire, smoke from a restaurant kitchen may be quite a normal occurrence, for example. This means that certain signals are interpreted differently in different buildings. People do normally have schemata in their mind of what is normal in a special concept. Information on how people react and interpret a situation has been obtained through interviewing people who have experienced fires, both minor and extensive, such as the fire at the MGM Grand Hotel in Las Vegas in 1980 (Bryan, 1983), the Beverly Hills Supper Club in 1977 (Sime, 1980), both in the USA, and the Summerland leisure complex on the Isle of Man, UK (Sime and Kimura, 1988), which are described in the references quoted.

Others studies which are often referred to are ”Smoke as a Determinant of Human Behaviour in Fire Situations (Project People)” (Bryan, 1977) and ”The Behaviour of People in Fires” (Wood, 1972) These two studies were both carried out following relatively minor fires, mainly in private houses, but involving a large number of fires. Bryan interviewed 544 people who had been involved in 335 fires which occurred in the eastern USA at the beginning of the 1970s. Wood’s study included 2247 people involved in 952 fire situations which occurred in the UK at the end of the 1960s. The main purpose of these investigations were to determine the overall behaviour pattern of people subjected to a fire threat.

When dimensioning evacuation routes, one should already at the planning stage be aware of, how the routes are to be used. People usually choose to leave a building the same way they came in, even if this is a poorer alternative than other available. Within the field of behavioural science, it is pointed out that people often choose the known before the unknown, which would explain the above behaviour. Sime has presented a study of the use of evacuation routes, in which he arrived at the conclusion that knowledge of, and familiarity with routes are important if they are to be used. According to Sime, this is more important than the width or length of the routes. When leaving the bar in a large building, most of the guests preferred to leave by the same door as they had entered, Figure 1 (Sime and Kimura, 1988).

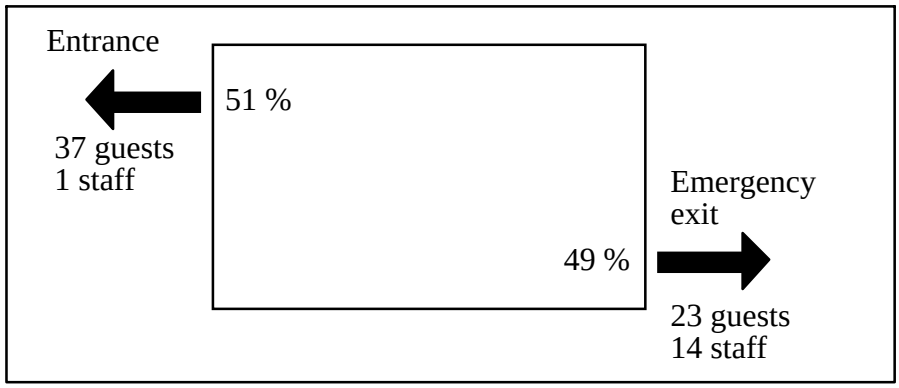

Figure 1. Evacuation of a bar at Summerland, Isle of Man, 1973.

The majority of the staff, however, chose to leave via the emergency exit, which they also had used to enter the hall. The fire had not reached the hall at this time. The location of exits is also important for their use. In an auditorium, it is better to have the emergency exits located at the front of the room so that they can be seen by the people sitting in the auditorium.

Sime gives another elucidating example of how evacuation routes are used in reality (Sime, 1989), in which it can be seen how customers and staff chose evacuation routes during a fire in a Woolworths store in Manchester, UK in 1979. The three floors were connected by two staircases intended for evacuation, as well as a central escalator, see Figure 2. The customers in the store used one of the staircases (A) and the central escalator to evacuate, while the staff mainly used the two staircases, in the proportions given in Table 1. The reason that so many customers used staircase A and that none used staircase B was that the first was used as a normal route up to the restaurant on the second floor. Staircase B was intended only for evacuation. The employees knew about it and therefore used it, together with staircase A, but only a few of the customers did so.

Table 1. Evacuation from the Woolworths store in Manchester.

Category	Escape route	Share, %
Public	Staircase A	71
	Escalator	22
	Window	7
Staff	Staircase A	27
	Staircase B	41
	Escalator	5
	Window	14
	Roof	13

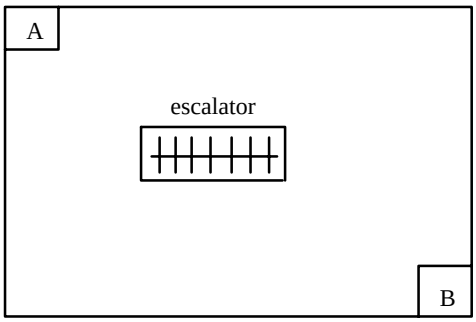

Figure 2. Sketch of the floor plans at Woolworths.

During the fire at the MGM Grand Hotel in Las Vegas 1980, most of the guests (on floors above where the fire was located) used the stairs in the building to evacuate. The building was constructed as a large T with evacuation stairways at both outer ends and at the cross of the T where the two main buildings met. A little more than 10% of the guests used the central staircase, while the others used the staircases at the ends of the building. This may be explained by the fact that in most hotels there is a staircase at the far end of the corridor, and most people therefore went in that direction. The staircases in the building were partly or totally filled with smoke during various stages of the fire.

Another case concerns a fire in a nursing home (Edelman, Hertz and Bickman, 1980). The staff led the patients (85 patients, corresponding to 95% of the patients on that floor) down one staircase, although there were another three available. The staircase used was the one normally used by patients as well as personnel, as a route between the two floors. The other three staircases were emergency routes, fitted with entry alarms, and were therefore not used. These staircases had negative associations for both the patients and the staff, and it was natural for them to use the normal staircase, even when evacuating the building. The evacuation, therefore, took longer time to perform than was expected by the building designer.

The psychological process in a fire evacuation situation might undergo several stages. At first the person will get some information about the change in the situation. It can be direct observations such as smell smoke, hear the sound of the fire, or see it. It can also be indirect information, such as a fire alarm. Anyway, when the persons become aware of the situation, the arousal level will probably increase, the body gets ready for a high impact action and the mind searches for more information in the actual situation as well as in his or her memory banks. The arousal level should have an ideal value, not to low, not too high. If it gets too high, the tendency of stop thinking and acting in panic rises. If it gets too low the subjects might ignore the danger and therefore increase the risk of harm.

Finally the person has to decide what to do. Two main alternatives might be fight or run. If the subject choose to fight he/she will search for the danger, in this case the fire, and fight it. On the other hand, if the decision is to run away the next action will be to get away from the danger as quickly as possible, as discretion is the better part of valour. Before the decision is made about fight or run, there has to be some evaluation of the danger. If the risk is low enough the person will fight it, otherwise, if it is to dangerous,

run away as quickly and safely as possible. To find the way out the person has to look around trying to find hints on where to go. Such a hint could be a sign for an exit.

As Sime clearly states, the knowledge of which exit route that will be chosen and used in an evacuation situation, is far more important, in the planning stage of the evacuation system, than the exits widths or lengths. Even though, the exit width and length of escape routes are the only parameters concerned in most present prescriptive building codes. However, in recent years, when performance based building codes are becoming more used, alternative design methods can be utilised. It is then possible to take the assumed use of the escape routes into considering in the design phase of a building. The question then arise on how the exits are used? How many persons will use a specific exit route and what are the factors determining the choice of a specific exit route?

In the design situation it is also important to take into account psychological factors involving the behaviour of the persons that have to evacuate from a building. A person who has to decide on how to get out from a building, and away from an uncontrolled fire, are under psychological stress. To improve fire evacuation it could be valuable to add important stress factors in models of human behaviour in fire evacuation. Such a stress model for humans facing a fire, has to define stages of control, how uncertainty and fear affects the decision process as well as how stress confusion could be reduced (Proulx, 1993). An attempt to make a decision making process model with probabilities and sequences of various actions has been proposed by Saunders at Victoria University of Technology in Australia (Saunders, 1995). It is also important to know about post decision processes, which have been shown to change the decision makers memory by increasing the difference between chosen and non-chosen alternatives on the most important attributes (Benthorn, 1994). In a decision making situation, the decision maker has at least two different alternatives to choose between. The alternatives (i.e. apples) can be described with some attributes (i.e. price, beautiful, taste, smell) which can be graded using a fact aspect (such as dollars) or an attractiveness aspect (such as 56 % of very good). The alternative that is best i.e. having the highest aspect value (for all or some of the attributes) is normally the chosen one. When, after some pre-decision differentiation, the difference between the chosen and non-chosen alternatives is large enough on the most important attributes, there might also be some further increase of the difference, due to a consolidation process after the decision is made.

In the consolidation processes, the difference between the chosen and non-chosen alternative is increased in such way that the chosen alternative will be much stronger compared to the non-chosen alternative. This can be seen as a reduction of dissonance for the whole range of attributes, but can more often and more precisely be seen as a change of the most important attributes only. In an experiment the subjects rank the attributes according to their importance for the decision. The increase in difference of aspect value, between the chosen alternative and the non-chosen one, is made to make the difference large enough to prevent future threats from proposing that the decision was the wrong one. Such treats could be physical changes but also internal changes in our own value system (Svenson and Benthorn, 1992). Time pressure, which can be present in a fire evacuation situation, can start the consolidation processes, also in

decision situations that normally should not give any post decision consolidation (Benthorn, 1994).

The above mentioned post fire investigations show that the initial stage in the evacuation process is often characterised by uncertainty, misunderstanding and inefficiency. Common reactions are that people try to gain more information on what has happened and then decide what action to take. Among the actions commonly taken are: investigating what has happened, i.e. trying to gain further information, trying to combat the fire, helping or warning others, saving material objects, telephoning for the fire brigade and evacuating the premises. In some cases, the action taken can be to do nothing at all, or in other cases, although this is more rare, take some kind of action which increases the danger.

Studies have shown that if the people concerned are well informed about what has happened and what they are expected to do, the likelihood of a quicker and more successful evacuation is higher than other. This means that informative evacuation alarm systems reduces the time spent in the behaviour phase of the evacuation process. Other means of reducing this time is to have the building well lit or equipped with directional exit signs indicating the route to the nearest exit etc. If that exit will be used is another question but it must be better to indicate the way out than not doing so.

The problem for the designer of a building is then to determine how long time it will take before the persons in a building realises that they have to leave the building. Some studies that have been performed during the recent years show a better performance in using verbal messages, rather than a ring signal, in the evacuation alarm (Proulx and Sime, 1991). The data is of course very limited because of the rather extensive experimental set-up necessary for such a determination. The study is valuable as it is one of the few where the time for the reaction phase is measured and not just estimated afterwards.

In another study (Frantzich, 1993) a questionnaire procedure was used to get an estimate of the reaction time for different building types equipped with different alarm types. The median values from that investigation shows a good agreement with the data from Proulx and Sime (1991). But the authors still think that more information has to be collected to give a solid base of suggested design values of this parameter. In the present study the reaction time is measured to see if there are any similarities in the way people spent time during this simulation, with regards to the studies made by for example Proulx and Sime.

Purpose of the study

Since it is human beings that have to perceive, think and understand, it could be concluded that a successful evacuation from a building with uncontrolled fire is partly dependent on physical values such as distance, proportions of exits, and density of smoke and partly dependent on psychological values such as processes in communication, perception, conceptualisation, understanding, evaluating and decision.

The theory proposed in the present study is called the Theory of Choice by Distance and Familiarity, CDF. Regarding to this theory, there is a relationship between distance and familiarity in choosing an (emergency) exit at for example a fire alarm. If the distances to two different exits are the same, the decision maker will choose the most familiar one. By increasing the distance to the familiar one, the tendency to choose the other exit (i.e. emergency exit), is increased until we reach a ”break even point” in which both exits are equally often chosen. After that point, the emergency exit is increasingly more often chosen.

As also proposed by the CFD theory, an open emergency exit should be more attractive than a closed one. As mentioned above, distance to the exit is supposed to be of importance for which exit the subject will choose. The hypothesis is that the closer the exit is the more attractive it is. It is assumed that the subjects tend to choose a normal exit before an emergency one when the distance to the alternatives are about the same. When the distance to the normal exit is doubled, its attractiveness declines and the closer located emergency exit becomes more attractive and will be more often chosen.

The aims of the present study are to investigate which exit people choose and how they do it on a fire alarm i.e. to test the CFD theory. Do the subjects perceive and understand a ring signal and a spoken message? How well do people understand standard signs that are of importance in an evacuation situation. The hypothesis is that there should be a difference in perceiving the two different types of ”one way communication”, the ring signal and the verbal message. The latter is thought to be the best one in having the subjects to understand what they have to do and to start the evacuation. The variables in part I of the experiment are distance to exit and open or closed emergency exit. The hypothesis is that a familiar exit is more favourable in the decision about which one to choose.

The second part of the study looks into the problem of how a fire in the escape route affects the subjects actions and feelings. It is thought that a visible fire, in the pathway to the emergency exit, should make the subjects more afraid of walking that way out and therefore less frequent choose that exit. It seems reasonable that the subjects do perceive and understand the fire as a risk that they have to avoid. However, since we do not know how the subjects really will react on a fire (real or imagined) in the pathway to the exit, it is a goal for the study to ask the subjects how they would react and how they would experience such a situation.

In the final part of the present experiment, signs used as directional guidance in buildings are examined regarding the knowledge about their meaning. Designers and

building officials assumes that, if the signs used for marking the escape route are present in a building, the population is able to understand them and find the way out. The question then arises, are the signs we use interpreted in a correct way? Are there symbols used for fire safety reasons which are not good enough in informing about their meanings?

Method

The present investigation consist of three parts. The first part deals with the subjects reaction on alarm, how they choose an exit, and act on fire alarm. The second part is on investigation the feelings (i.e. fear) of passing a fire in the travel path to the exit. The third part is on investigation on the subjects knowledge about signs that could be important in evacuation and fire situations.

Subjects

In all three parts of the present study, the subjects were normally customers at an IKEA warehouse in Helsingborg in Sweden. All of them participated voluntarily in the experiment. The subjects got a small grant, a check of 25 Swedish kronor (about £2) to spend at IKEA. In total 64 subjects, males and females, participated in the experiment. The mean age was 43,7 years, ranging from 16 to 75. In the experiment 45.3 % were men and 54,7 % were women.

Material

A questionnaire form, presented in Appendix A, was used for all three parts of the experiment. It contained questions of two types. The first one contained ordinary questions that were answered by verbal answers. The second type was of the kind that had to be answered with a pencil mark on a line scale ranging from a low to a high value, such as from ”not important” to ”very important” or from ”not at all” to ”very large”. The latter were on questions like ”what feelings did you experience and how strong were they?”. Different feelings were mentioned.

All lines in the questionnaire form were 89 mm long, except those explicitly stated shorter. Other examples of questions were: How did you judge the risk for the chosen exit if it had been a real situation?

The material used for part I of the experiment with decision making and actions after hearing an alarm signal were: wireless head phones, tape recorder for the verbal message, freestyle tape recorders for the interview, video camera, and sets of questionnaire forms. The headphones had an infrared transmission system which permitted wireless transmission. The message could then reach the subject independent of its location.

The material used for part II of the experiment was only a red jacket. It was hanging on a shelf in the direction of the emergency exit. Questions about feelings of passing the simulated fire (the red jacket) was asked. Typical questions were ”If there had been a fire on that place where you see the red jacket, a fire with about the same size as the jacket, would that have changed your decision?”, ”What about your thoughts?” and ”What would you have felt?”.

The material used for part III was a set of standard emergency signs. Five of the six signs are standard EU signs used in the European council directive on safety at work. The last symbol is an old symbol indicating emergency exit route used in Sweden until

December 1995. The signs were placed on a board and questions were asked about their meanings. The standard signs used in this part of the experiment were:

1.) Smoking and naked flames forbidden.
2.) No smoking.
3.) Radioactive material.
4.) Emergency exit route.
5.) Fire hose.
6). Emergency exit route.

Signs 1 and 2 are red with black illustration and white background. Sign 3 is yellow with black illustration and border. Signs 4 and 6 are green with white illustrations. Sign 5 is red with white illustration.

Figure 3. Symbols used for identification. The word "UTGÅNG" means exit.

Procedure

All three parts of the experiment took place at the IKEA warehouse in the city of Helsingborg, Sweden. Normally visitors (customers) were asked whether they would like to participate in an experiment determining the effect of PA-messages. Nothing concerning fire or evacuation was mentioned to the subjects prior to the test. The subjects participated one at the time in the three parts of the experiment. No social effect was studied.

In part I, the subject was placed in a position where he/she would normally pass by on the way through the warehouse. The subject was provided with a set of wireless headphones and was instructed to act as he or she normally would do on whatever heard in the headphones, just as if the sound come from the normal equipment in the warehouse.

After the subject was placed in position, the video camera started as well as the verbal message tape recorder. At first, the subject heard a ring signal in the head phones. The alarm ring signal sounded for 10 seconds. Then followed a silent pause for 10 seconds (to give the opportunity for the subjects to react to the signal). After the pause a pre-

recorded message was transmitted for approximately 45 seconds with the following wording: ”Important message to all our customers. Due to a technical failure we kindly ask you to leave the building. Use those exits marked with symbol for exit or emergency exit. Proceed to the street and please leave the area. Follow the instructions. Those children left in the child care have already left the building and are now at the shop EXPERT on the other side of the parking place. I repeat”...(repeated a second time).

During this sequence the subject was recorded with the video camera and observed by the research staff. After the subject had chosen an exit the recording stopped. The subject was then interviewed about feelings and reactions and the questionnaire covering the first part was answered. The answers were recorded on tape for later analysis.

The verbal message used differed from the original IKEA message by not having any information telling that the personnel should help the customers getting out. This information is included on the tape that IKEA uses.
Two different test positions were used with different distances to the normal exit, see Figure 4. At the first point (B) the distance to the cash exit was about the same as to the emergency exit. At this position, 31 subjects participated. At the other position (A) the distance was twice as long to the cash exit as to the other main emergency exit. In this experiment position, 33 subjects participated. In both positions the subject could see the cash exit as well as at least one emergency exit. For half of the subjects in each position the emergency exit was closed and for the other half it was open (this means that the subjects could see the outside). The emergency exit was painted with a bright red colour and the door width was approximately 1.6 m. Above the door a backlit emergency sign was located with a pictogram as symbol 4 in Figure 3.

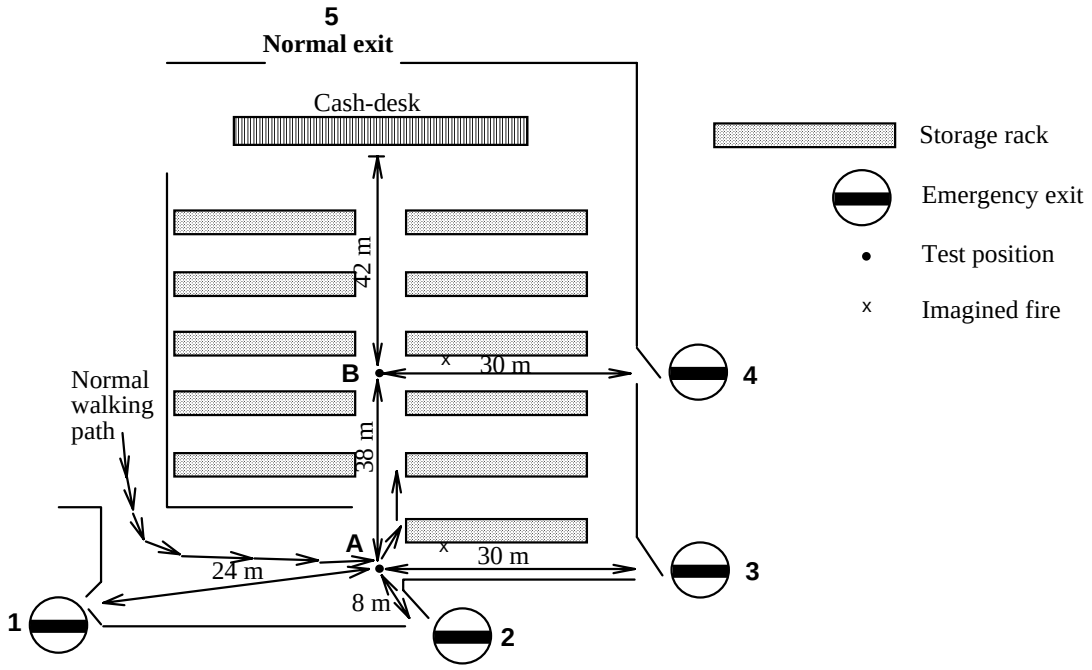

Figure 4: Plan over the experiment area. The positions of the imagined fire used in part II are also marked in the figure

In part II, the subject was instructed to look in the direction of the emergency exit and observe an red jacket hanging on some packages. The subject was told that the red jacket symbolised a fire of about the same size as the jacket (flame height of about one meter). Questions were asked about feelings and fear which were recorded on tape for later analysis.
Finally, in part 3, the subject had to identify six symbols associated to fire, evacuation or danger at a place of work. Each symbol was presented and the subject was asked to describe its meaning. The answers were recorded on tape to make the procedure shorter since the subjects were not willing to spend too much time in the experiment.

Results

The investigation was divided into three different parts: I) decision making, II) what to do if there is a fire in the evacuation route, and III) understanding the meaning of standard signs. In these three parts communication aspects, and feelings in different conditions (in such an evacuation alarm as examined in the present study) were studied.

Part I; exit choice

Familiarity and distance

The first part covers the question of decision making, i.e. the subject has to choose an exit. The main differences between the alternatives were (1) familiarity with the exit (cash exit and emergency exit) and (2) distance to the exit. From the hyphotesis it was presumed that the more familiar an exit is, the more attractive and more often chosen it becomes. It is also presumed that the shorter the distance to the exit is, the more attractive it will become and therefore more often chosen. The distance to the emergency exit is the same in all cases.

As illustrated in Table 2 and Figure 5, the results indicate that the cash exit, at the same distance as the emergency exit, seems to be the most popular one. It was 22 subjects who chose the cash exit, while only 9 chose the emergency exit, resulting in a difference of 13 subjects ($p= 0.00196$, $\chi 2 = 5{,}45$). The contrary is the seen when the distance to the cash exit is the double as to the emergency exit distance. Only 11 subjects chose the cash exit while 19 chose the emergency exit. It is about twice as many that chose the emergency exit when cash exit is at about the double distance as the emergency exit. This difference is however not significant ($p= 0.14$, $\chi 2 = 2{,}1$).

Table 2. Chosen exit depending on distance to cash exit.

	Cash exit	Emergency exit	Difference
Same distance to cash	22	9	13*
Double distance to cash	11	19	-8

* significant on $\alpha = 0.05$ on $\chi 2$ test

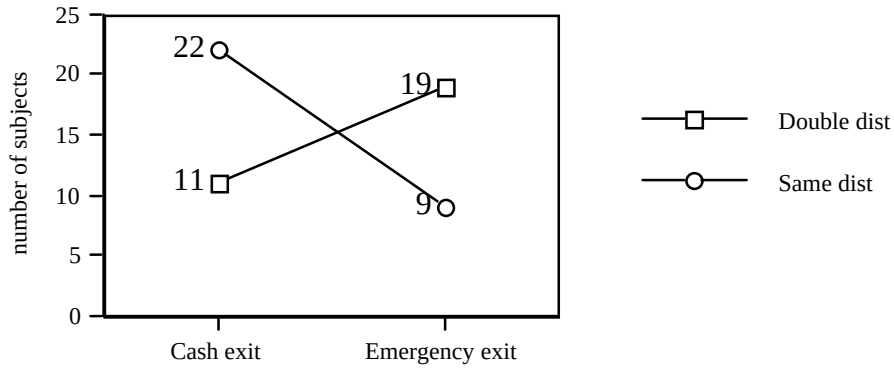

Figure 5. Chosen exit depending on distance to cash exit.

Increasing the distance to an exit should, according to the hypothesis, decrease its chances to be chosen as an exit in an evacuation situation. This seems therefore to be true.

Emergency exit door open or closed

The hyphotesis is that an open emergency exit should be more attractive and thereby more often chosen than a closed emergency exit. This hypothesis seems to be confirmed. It was 22 subjects that chose the emergency exit when it was open but only 6 subjects chose it when it was closed (p= 0.0025, $\chi 2 = 9.1$). This is further illustrated by those who chose the cash exit. When the emergency exit was closed 23 subjects chose the cash exit but when the emergency exit was open only 10 subjects chose the cash exit (p= 0.0236, $\chi 2 = 5.1$, Table 3 and Figure 6.

Table 3. Chosen exit when the emergency exit is open or closed.

	Cash exit	Emergency exit	Difference
Closed emergency exit	23	6	18**
Open emergency exit	10	22	-12*
Difference	13*	-16**	

* significant on $\alpha = 0.05$ $\chi 2$ test, ** significant on $\alpha = 0.01$ $\chi 2$ test.

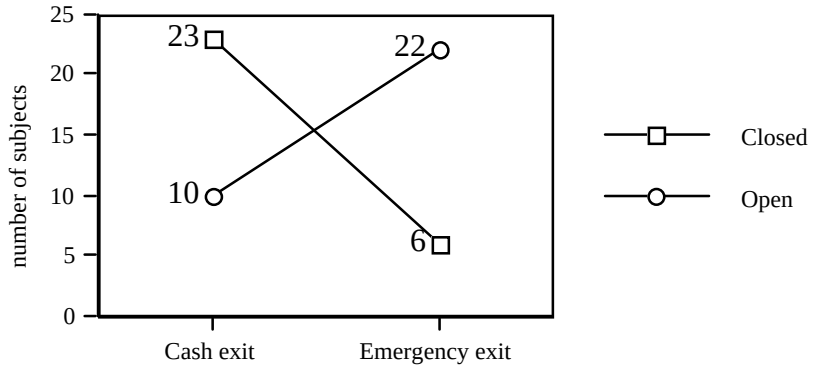

Figure 6. Chosen exit at open or closed emergency exit.

Combination of conditions

The three variables, familiarity, distance to exit and open or closed emergency exit, seems to interact with each other in such a way that even if the familiarity is preferred, this preference is weakened by increasing distance and having the emergency exit open. This is illustrated in Table 4 and Figure 7. The slope of the lines, which connect measure values for familiar and non familiar exits, are changing. The curves have slopes varying from negative (short distance and closed door) to positive (long distance and open door). The familiar cash exit is chosen by less and less subjects depending on supposed reduced attractiveness, with increased distance to and with increasing attractiveness for the emergency exit while it becomes open. In the first situation (with closed emergency exit and close to the cash exit) 13 subjects chose the cash exit and 2 subjects chose the emergency exit (p= 0.0045, $\chi 2 = 8.06$). In the condition ”open emergency exit and the cash exit at a long distance” only 1 subject chose the cash exit

while 15 chose the emergency exit, which means a difference of -14 and a significant level of 0.0005 and
$\chi 2 = 12.2$.

Table 4. Numbers of subjects that chose the cash-exit or the emergency exit.

Condition		Chosen exit			
Emergency exit	Distance to cash exit	Cash exit	Emergency exit	Difference	Total number of subjects in each condition
closed	short	13	2	11**	15
open	short	9	7	1	16
closed	long	10	7	3	17
open	long	1	15	-14**	16
Total		33	18	-15	

** $p <= 0.01$ on $\chi 2$ test

It seems that most of the subjects prefer to go to the cash-exit even when the distance is the double compared to the emergency exit. The only exception is when the emergency exit is open.

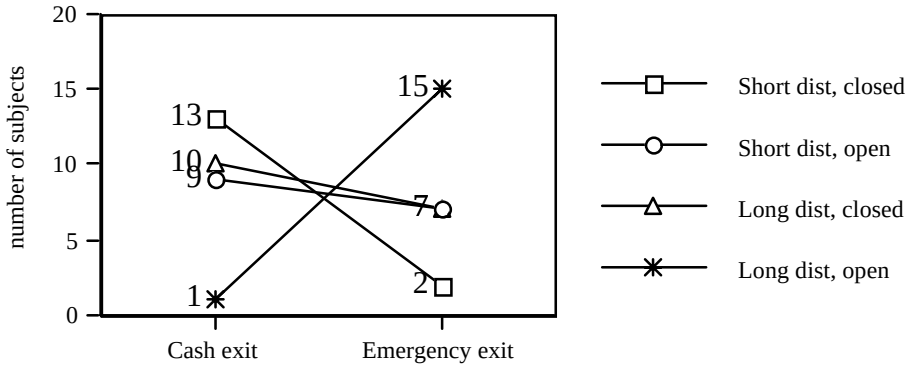

Figure 7. Subjects that choose the cash exit respective the emergency exit.

Communication aspects

The questions of how the subjects perceived and understood the meaning of the alarm signal and the spoken message gave support to earlier findings (Proulx and Sime, 1991). Most of the subjects, 41 %, perceived the ring signal as if it was an ordinary unspecified alarm or warning signal and 17 % as if it was some other kind of alarm such as telephone. It means that 58 % understood the ring signal as something rather unspecified and maybe more associated with things in a home schemata such as telephone. An other quite familiar ring signal is the school ring signal which 6 % said it sounded like. About one of five or 19 % perceived it as a fire alarm. It seems that the ring signal is perceived and understood as a general unspecified warning signal by most of the subjects.
This result could be because the low sound level in the head-phones. If the sound level was higher it could be assumed that more subjects could think of the ring signal as a fire alarm. Still, other investigations such as the one made by Bellamy et. al. 1990 indicate

that a low share of individuals interpret a ring signal as a fire alarm. The sound level was not measured so a more general interpretation of this result should not be made.

The spoken message, on the other hand, is more specific from the information point of view. Most of the subjects could memorise the main parts of the spoken message correctly. Therefore, it is not surprising that many subjects did refer its contents as it is a serious problem or evacuation alarm. Still, the spoken message is quite unspecified, because it is designed for several different kinds of situations, such as a bomb threat or a fire evacuation. The message tells the subjects to go to the nearest exit or emergency exit but does not specify any. This means that the fire alarm, regardless if it is a bell or a voice, does not give any clue for the decision about which exit that should be chosen. What is a little worrying is that 5 subjects did not understand the message or did not relate it to fire or evacuation. It seems like direct perception of the area compared with long term memory, for specific exits or schemata for buildings are the main guidelines in the decision process. In Table 5 and 6 the associations of the subjects are shown regarding the ring signal and the spoken message.

Table 5. How subjects perceived and understood the ring signal.

Association	1st association no of subjects	1st association percent	2nd association no of subjects	3rd association no of subjects
1. Fire alarm	12	19	4	-
2. Evacuation	3	5	2	1
3. School bell	4	6	-	-
4. Alarm by mistake	2	3	1	-
5. Warning or general alarm	26	41	4	-
6. Did not hear it	6	9	-	-
7. Other	11	17	2	-

Table 6. How subjects perceived and understood the spoken message.

Association	1st association no of subjects	1st association percent	2nd association no of subjects	3rd association no of subjects
1. Serious problem	28	44	3	-
2. Evacuation	24	38	21	1
3. Fire	4	6	2	1
4. Test	2	3	-	-
5. Other	5	9	1	-
	1	missing	-	-

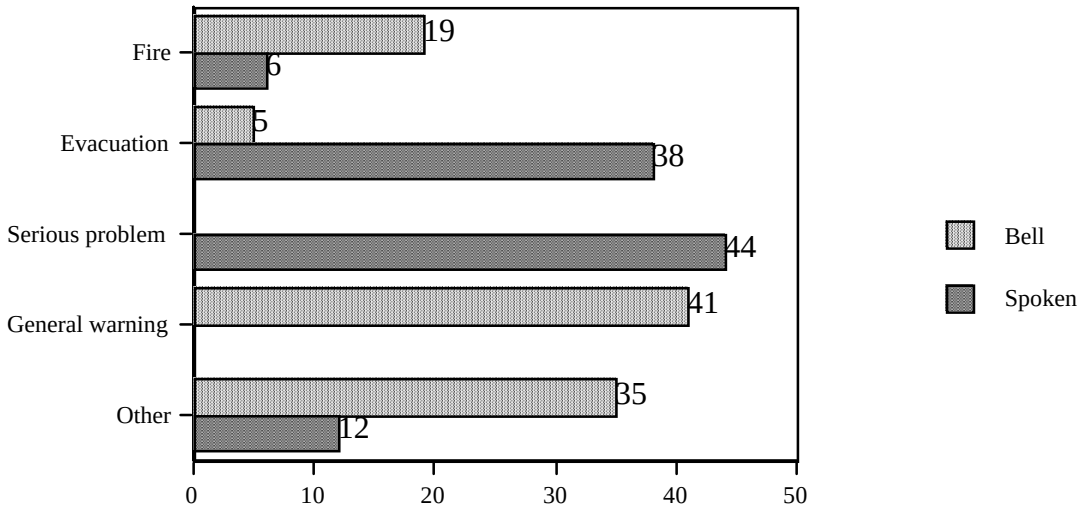

Figure 8. First association in perceiving ring signal and spoken message in per cent.

Time for the reaction phase

Since many of the subjects did not understand that they should react physically on the fire alarm, they stood still waiting and started to act first after that the research leader had proposed the subjects to act. It might be that the instruction was not clear enough of what was expected from them. Clearly, the message was understood by most of the subjects. The absence of action could also depend on, which is quit likely, the hesitation of doing something that is not normal. The person is then risking to loose his/her face if the action was not the expected one. This is probably a very important factor to consider in designing evacuation routes from public buildings. Totally, it was 31 % of the subjects that did not spontaneously react at all. The rest of the subjects acted at the ring signal or the spoken message as they were expected to. Of those who behaved accordingly, the mean reaction time was 35 seconds and the standard deviation was 22 seconds. These times are rather short compared to other studies. This might be due to the fact that the subjects believed it to be some kind of test or drill and acted as quick as possible. Short times are expected but these seems to be too optimistic. The uncertainty is also rather large with a c.o.v of 0.6.

Exit choice motivation

When subjects were asked about ”why did you choose the exit you went to?”, they often seemed to be surprised of the question and answered, after a short moment of hesitation, ”well it was close”. When asked for more detailed explanation they typically answered ”it was there” or ”I saw it and started to walk in that direction”. It therefore seems as they where not aware of the reason of the choice. It could be that the decision process was more on an unconscious level and therefore not easy to answer questions about. It could also be that the decision was on a level 2 of decision making. This means that only one or very few attributes (such as distance or familiarity) of the alternatives (cash exit or emergency exit) were evaluated prior to the decision.

Questions were also asked about how important some aspects were in choosing an exit. The attributes to grade were closeness to an exit, safe way out, known way out, to go where others are going and finally if it was possible to see the outside. The aspect value for each attribute was marked on 82 mm long lines and the mean and standard deviation for each attribute are presented in Table 7.

Table 7. Importance of conditions for choosing an exit.

Condition	Units of max. 82	Standard deviation	%, from ”not important” to ”very important”
Closeness to an exit	64	16	78
Safe way out	68	15	83
Known way out	54	26	66
Where others are going	26	18	32
Possible to see out	48	24	59

The result shows that an exit shall first of all be safe to use and secondly it shall be close to the exit. These conditions are quite well understandable. What is more surprising is that the subjects do not think they will follow others in choosing an exit. Evacuation studies have shown that the social behaviour is very strong and people do not tend to take own actions unless they are forced to do so. This makes the validity of the estimations a little doubtful.

Risk perception

The subjects perception of the risk associated with the different exits were also studied. It seems that the subjects react accordingly to the previous believes i.e. that the chosen exit is associated with the less risk than the non-chosen exit, Table 8. The estimation of the risk associated with the chosen exit is only 16 units on a 89 units long scale, or about 18 % of maximum. The risk associated with the non-chosen exit is higher, 42 units of 89 or 47 % of maximum. Since the difference in perceived risk is so high between the chosen and non-chosen exit, the assumed risk seems to be an important attribute in deciding what exit to choose.

Feelings in the situation

On the question ”If this had been a real situation, what feelings do you think you would have had, and how strong would those feelings be?” The subjects made a mark on a line ranging from ”not at all” to ”very much”. The lines were 89 mm long. Table 8 shows the mean values and the standard deviations for the different attributes. The main feelings, they thought they would experience, were to be worried, insecure and afraid. This is quite obvious as the situation is new and happens without any warning. From that point of view it is still more important to provide good information on a fire alarm. However, in the present experiment it seems that the subjects did not feel they were in much lack of information. This might be because of the information in the verbal message. It is not possible to tell if the verbal message has had the effect of reducing the ‘lack if information’. Therefore the results in the present study about feelings and risk perception, should rather be seen as indicators which has to be further investigated in future studies.

Table 8. The subjects estimation of risk and feelings.

Attribute	units of max. 89	standard deviation	%, from ”not at all” to ”very large”
The risk to go to the chosen exit	16	21	19
The risk to go to the non-chosen exit	42	25	47
Joy	16	23	18
Worry	40	27	45
Angry	11	14	12
Insecurity	32	24	37
Fear	31	26	35
Lack of information	19	22	22
Stimulus	22	23	24

Differences due to sex

Do men and women act and perceive the emergency situation in different ways? From the point of view that women and men are very unlike it could be presumed that there should be many differences between men and women in their perception, emotion and decision making in choosing an exit at an alarm. However, in the present study, almost non of the differences in response due to differences in sex, are statistically significant. The only exception was in the estimation of ‘Worry’ or to be afraid, in which there was a significant difference ($p=0.028$, t-test) between men and women. Women were more afraid than men.

Part II; fire in the evacuation route

In the second part of the study, the subject was instructed to look at a red jacket in the pathway to the exit and then answer questions from the questionnaire (see Appendix A). The red jacket should symbolise a fire. The result indicate that the subjects don't perceive a fire of that size as dangerous. The subjects estimated the risk of passing the fire to be rather low. Their comments could be that they thought that such a small fire (the size of a jacket) could not be so dangerous. Still they are to some degree afraid, Table 9.

Table 9. The subjects estimation of their own feelings if it had been a real emergency situation.

Attribute	units of max. 89	standard deviation	%, from "not at all" to "very large" or "very afraid"
Risk to pass the fire	24	25	27
Afraid to pass the fire	30	24	34

There was no difference due to sex, in risk to pass the fire (p= 0.18, t-test) but however, on the attribute 'afraid to pass the fire' the difference was statistically significant (p= 0.028, t-test). Women were more afraid than men.

Regarding the actions taken by the subjects, as many as 37.3 % of the subjects said that they would try to fight the fire and only 2 % should raise the alarm. About one third, should just ignore the fire, while one of four, should run out or do something else, Table 10.

Table 10. What to do if there was a fire in the pathway to the exit.

Type of action	No of subjects	Male	Female	Difference
Fight the fire	19	14	5	9*
Make an alarm	1	0	1	-1
Ignore it	17	7	10	-3
Run out	13	2	11	-9**
Other	1	1	0	1

*p< = 0.05 on $\chi 2$ test, ** p< = 0.01 on $\chi 2$ test.

Quite many subjects have the intention to fight the fire. They commented their intention with phrases as "such as small fire" or "if it isn't bigger than that". Others, not as brave, said that they should just ignore the fire and pass it on their way out. The third major action was to hurry up and run towards the exit. The differences in actions taken between men and women shows the same pattern as other investigations performed by Wood, 1972, Bryan, 1977 and others. Men are more likely to fight the fire. Women are more likely to take actions such as evacuating and rescuing others.
The large number of subjects telling that they should ignore the fire are very likely to also run out passing the fire. They probably mean that they would run out without taking any other actions. It is not likely that they should just stand still doing nothing.

Part III; the meaning of standard signs

The third part of the study investigated the ability to describe the meaning of six different signs, from knowledge in the long term memory. As seen in Figure 9 the subjects are fairly well identifying the signs. Three of the six signs (the no smoking sign and the two emergency exit signs) were identified by all the subjects. One sign, naked flames forbidden, was identified by almost all of the subjects (92%). Most difficult to identify seems to be the warning for radioactivity as well as the information of fire hose. These latter two, are relatively uncommon in the daily life.

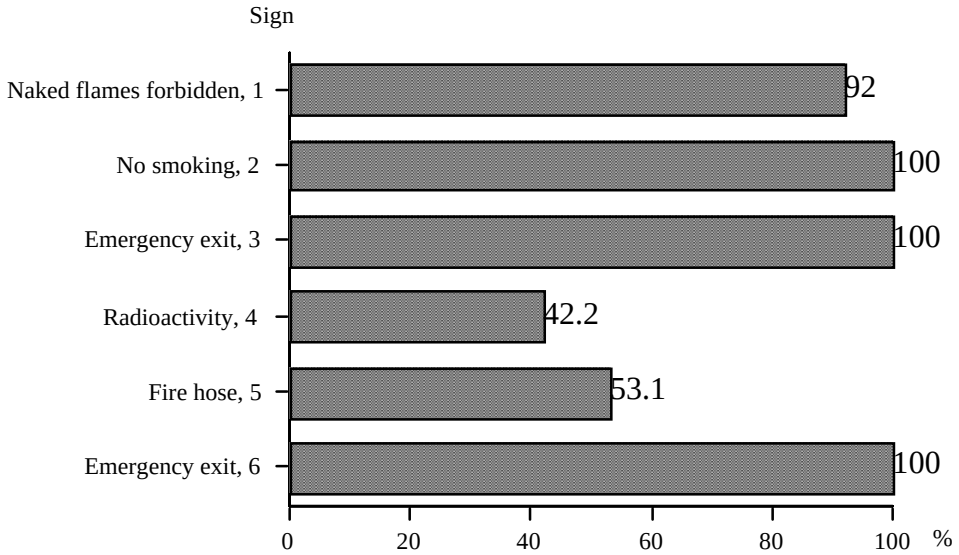

Figure 9. Subjects ability to understand the meaning of standard signs (in per cent of all the subjects).

Discussion

Earlier findings about exit choice indicate that people prefer to leave by the same door as they had entered (Sime and Kimura, 1988). That is leaving by a familiar exit. Such a familiar exit is the cash exit in the present case. The fact that the normal way out is preferred by occupants who have to evacuate is confirmed in this report. It is also important to give appropriate information to the customers in a public warehouse when they have to evacuate the building, for instance because of an uncontrolled fire. A ring signal might be a first alarm and attention-maker but it might not be enough. There are many associations linked to the ring signal and only a few people are expected to choose evacuation as the alternative. At the IKEA warehouses, the normal procedure is to initiate the alarm with a ring signal and then, after a short pause, send a message via the loudspeakers. The message tells the customers to leave the warehouse through the normal exit or emergency exits. In addition to this, the personnel are instructed to open the emergency exits and guide the customers to the outside.

It is also likely that the people tend to continue ”on the same road”. This means that if they have passed throughout the entire warehouse and have the cash exit in front of them, it is not likely that they will run all the way back to the entrance. Anyone understands that such a long way back would take much longer time and also increase the risk of running into the fire and thereby also increase the risk of getting hurt or even die. Despite such a disadvantage of running back there could be situations when it happens. Such a situation is when a subject tries to reach another person, such as a child. To prevent such behaviour, a spoken message tells the customers that the children left in the children care centre at the warehouse are already outside the building. If the customers really follow this instruction is another question.

The results from the present experiment show that an open exit is much more attractive and more often chosen as an exit than a closed one. It therefore seems to be a good information strategy used at the IKEA warehouses to open up the exits if the alarm starts. Furthermore, the spoken verbal message is important because it directly tells the customers to go out. A problem will however occur if a customer does not understand the language in the message.

On the question about how the subjects did perceive and evaluated an imagined fire, it is interesting to note that they were very unaware about why they chose a specific exit. This is interesting because it points to the assumption that the decision making is made on quite a low level, maybe level one or two on the model by Svenson (Svenson 1992). It seems like the subjects based their conscious decision on one or two attributes and on a simple decision rule. It does not seem to be a trade off between several attributes and their aspects (i.e. how good each attribute is on each alternative). Still the proposed theory of Choice by Distance and Familiarity seems to be approved by the results in this study. However, this does not mean that the subjects have to be consciously aware of it. It would be reasonable to believe that on a real fire alarm the decision making will be quicker and still more simple. Since there will not be much time for problem solving, it is important to note that the subjects will use ordinary knowledge and behaviour patterns. It therefore seems to be important to make the emergency exits very well

visible and to make them look like those exits that normally would be used. It could also be important to educate and train people in how to behave on a fire alarm.

The results in this study could be used as a rule of thumb in designing evacuation exits. Important variables are the familiarity with the exit and if the exit is open or not. Normal occupants do prefer a normal exit such as the cash exit if the distances to the available exits are the same. Even when the normal exit is at the double distance compared to the emergency exit many subjects do prefer the normal one, except when the emergency door is open. Therefore, it seems to be important to have a normal exit available for the occupants to evacuate through at a fire alarm. It is probably also important that the exit is visible from many points. If the emergency exit is to be used, it seems to be important that it is open or in some other way is made to look more like a normal exit. However, more research is needed to be sure about the behaviour upon such a stimuli. It has to be explored how subjects perceive and understand emergency exits depending on variables such as brightness, colour, contrast, pictures, motion (e.g. induced movement by successive lighting of lamps) and signs.

The results could also improve use of computer simulating models of human evacuation behaviour, such as the evacuation model Simulex (Thompson et al, 1994). The program shows how average occupants (symbolised with dots) are moving towards an exit. Each ”person” in such a program moves with a speed, assessed by the circumstances, to the closest exit. However, in real life, not all people are acting with the same robotlike behaviour. To make the simulation more realistic, the ”persons” can be assessed with individual characteristics. If taking some behaviour differentiating aspects into consideration, the program could even better simulate a real life evacuation.

Further research is needed to clarify the questions raised in this report. A lot of variables could be further studied such as the distance dependence. How will, for instance, the subjects choose between the cash exit in front of them and the entrance behind them if the distances were about the same? It could also be interesting to measure emotional variables when the subjects have additional information such as ”possibility to see the fire” or ”smell the smoke”. It would be interesting to know more about if subjects overestimate their braveness in an abstract situation compared to a real fire. The psychological issues are of great importance in fire safety research and there are many questions that still have to be answered.

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Appendix A

Interview form for part 1.

Condition of door:
Sex:
Age:
Person no:

Questions
How did you recognise the alarm bell and how did you interpret the signal?
How did you recognise the verbal message and how did you interpret that?
Do you remember the message? Can you repeat it?

Why did you choose the exit you walked to?
What attribute does that exit represent?
Did you see other exits?
What attribute does those exits represent?

If this had been a real situation, how do you think you would have reacted?
How would you have experienced that?

Are you familiar with the premises?

Mark by indicating on the line how important you think the below conditions are
(lines were 82 mm on the original form)

Closeness to an exit	not important_____	very important
Safe way out	not important_____	very important
Known way out	not important_____	very important
Where others are going	not important_____	very important
Possible to see out	not important_____	very important

How did you judge the risk for the chosen exit if it had been a real situation?
very small_____very large

How did you judge the risk for the not chosen exits if it had been a real situation?
very small_____very large
(lines were 89 mm on the original form)

What feelings did you experience and how strong?
Joy
not at all_____very large
Worry
not at all_____very large

Anger

not at all_____very large

Insecurity

not at all_____very large

Fear

not at all_____very large

Lack of information

not at all_____very large

Stimulus

not at all_____very large

Other feeling_____

not at all_____very large

(lines were 89 mm on the original form)

Interview form for part II

Judgement of risk looking at a simulated fire (red jacket).

How would a fire on the position indicated affect your decision?

What about your thoughts?

What about your feelings?

What exit would you have chosen if there was a fire at the indicated position?

How do you value the risk of passing the fire to reach the exit on the other side of the fire?

very small_____very large

How afraid do you think you would be?

not at all_____very afraid

(lines were 89 mm on the original form)