Warning citizens

Influencing self-reliance in emergencies

Simone Sillem

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1. Introduction

After Malta, The Netherlands is the most densely populated country in Europe (and the 23rd most densely populated country in the world) with almost 500 people per square kilometre (2007). The small space that The Netherlands provides, combined with the continued development of science, technology and the application thereof, does not go without a price. Our wealth is increased and the accommodation of a growing population is allowed, with increasing demands on goods and mobility. But, more people are living in a small area, which makes traffic busier and places more difficult to reach by emergency services. This causes an increased potential for an accident to become a large-scale disaster. Large accidents such as the explosion of a fireworks storage building in the city centre of Enschede (Oosting, 2001) and the fire on a ship in Velsen-Noord (ANP, 2007), in which citizens need to be warned about the danger they are in, will always remain to exist. Risk is everywhere, and always has been (Ale, 2009). Moreover, the danger of flooding increases in The Netherlands with the rising of the sea level (Poot and van Westen, 2006).

The above shows that research into accident prevention alone is not enough, as accidents will always happen. It is increasingly important to strengthen the response to and thereby to mitigate the consequences of disasters (ten Brinke, Saeijs, Helsloot and van Alphen, 2008), in order to save lives when an accident or disaster occurs.

An important part of the response to an emergency is making sure that people are able to take themselves and others to a place of safety. This is called self-reliance. In the next paragraph, the concept of self-reliance in an emergency will be explained, as well as its importance for human behaviour in emergencies. Then, the current warning system in The Netherlands will be discussed. Next, the problems with the current warning system and the need for additional warning methods will be discussed. This will lead to the research questions in paragraph 1.4 in which the question is raised how to investigate the effectiveness of new or existing methods for warning citizens.

1.1 Self-reliance

'Self-reliance' is related to individuals and is defined as: reliance on one's own efforts and abilities (Bandura, 1986). Self-reliance in emergencies specifically is defined as the reliance of building or area occupants on their own efforts and abilities in an emergency evacuation. For this study, this is further

specified as the behaviour that people present in a building or area show which is aimed at bringing themselves to a safe place (Ruitenberg and Helsloot, 2004) from the start of the emergency until the moment the fire fighting services arrive and take over the situation. Only means and people present at the scene at the time of the start of the emergency situation can be used. When the fire and rescue services from outside the building or area have arrived and have taken over the situation, the evacuees' actions are no longer called self-reliance, but this is then called rescue. Of course, the fire fighters cannot help everybody present in the building or area immediately, so not all self-reliance stops directly when the fire fighters arrive at the scene.

When a building or an area needs to be evacuated, or when all people have to go indoors, the first phases of the emergency response include warning people at risk and evacuating people from the building or area or making sure that everybody goes indoors. In many cases, the arrival of the rescue services (fire service, police or medical units) is not until after the start of the evacuation. It takes time for the rescues services to get to the scene and to prepare for action. This indicates the importance of people's emergency self-reliance, it takes time before the rescue services arrive and by that time it may be too late to be rescued. It is therefore of prime importance that citizens are able to rescue themselves as much as possible in the time that passes between the start of the emergency and the arrival of professional help. To a large extent, the effectiveness of an evacuation depends on the emergency self-reliance of the building occupants. Within the first minutes, a fire (or another situation) may quickly become life-threatening when remaining in the building.

This shows that warning citizens is very important in the first part of an emergency. People have to be informed and instructed, so that they can bring themselves and others to a place of safety without having to wait for actual physical help from the fire services. The time from the start of the emergency until people start taking action to go to a place of safety is called the pre-movement time. The goal of warning people about what is going on and what they should do is to minimize this pre-movement time, to make sure that people have enough time to rescue themselves. Research has shown, that this pre-movement time is a more important element of the required escape time than the actual time that is needed to move to a safe place (Bryan, 2002; Kobes, Helsloot, De Vries and Post, 2010).

According to the Dutch Building Regulation buildings should be designed in such a way that people can escape by themselves in case of a fire (Kobes, Oberijé, Rosmuller, Helsloot and de Vries, 2007). For example, people have to use the emergency exit signs in a building to find a safe way out in case of an emergency. Kobes et al indicate that research has shown that people are often found to be incapable of escaping in time. Incident evaluations indicate that the major fatalities occur in evacuations with a long pre-movement time, especially in hotels and apartment buildings. The pre-movement time covers the processes of perceiving and validating clues of danger and the processes of decision making before and during the actual movement. These processes are found to be more decisive influences on survival than the actual movement speed. Therefore, Kobes et al claim that it is better to let the fire safety of a building be based on actual human behaviour in fires, instead of assuming that people will comply with the technology based safety measures

To make people aware that there is an emergency and that immediate action is needed, they have to be warned by authorities (or by other people). The self-reliance of people in an emergency can then be increased when people are motivated to comply with instructions that are given in an emergency. This shows that self-reliance and compliance are very closely related to each other. Instructions can be given by a warning system to help people make a decision what they should do to get to a safe place. By giving warnings and instructions, people can be helped to be self-reliant from a distance, when there is nobody actually aiding them physically. When people respond quickly in an emergency and start acting immediately, the consequences of a disaster can be minimised. The information and instructions that people get through warnings have to be easily comprehensible, convincing, and feasible, to make sure that people will act upon them

There is however a field of tension between the two phenomena of compliance and self-reliance. On the one hand, people may be helped to be self-reliant by information and instructions from the authorities. On the other hand, this may not always be the case. The administrators may not always have a clear or complete view of what is the best behaviour in an emergency. The ultimate goal is not necessarily to make people comply with warning messages, but to improve their self-reliance in an emergency, to make sure that they bring themselves to a safe place as quickly as possible. So, information and instructions can be given to help people, but people have to decide for themselves whether this information is correct and whether the given course of action is indeed the best option for them. This issue will be discussed more in the paragraph that concerns the research questions.

There are many different ways in which people can be warned in an emergency. The next paragraphs will go into the current method of warning citizens in The Netherlands and the problems that this method encounters.

1.2 Current warning system

When there is an emergency, citizens in the exposed area and areas that may be exposed in the near future need to be warned, in order to give them the possibility to go to a safe place. As many people as possible need to be warned and they need to be informed about what is going on and what they should do. This can be done by several means, for example by sounding church bells, or by sending out sound cars with a pre-recorded or live message.

Figure 1-1 shows different possible warning methods and their ability to warn many people and to convey information to citizens. For example a town crier can give a lot of information (much more then the siren can), but only few people can be reached within a certain period of time, because the town crier has to go to all streets personally, the reach of his voice determines the number of people that can be reached. The siren has a very high reach and a high attention value, but a very low information conveying value, it can only give an alarming sound. The siren and its message originate from World War Two when it was used to warn for possible bombings by the 'Bescherming Burgerbevolking' (Protection Citizens). In that time only one message had to be conveyed: "There is an air attack and you have to hide". The equipment has been modernised since, but the message is still the same, although going inside may not always be the best option.

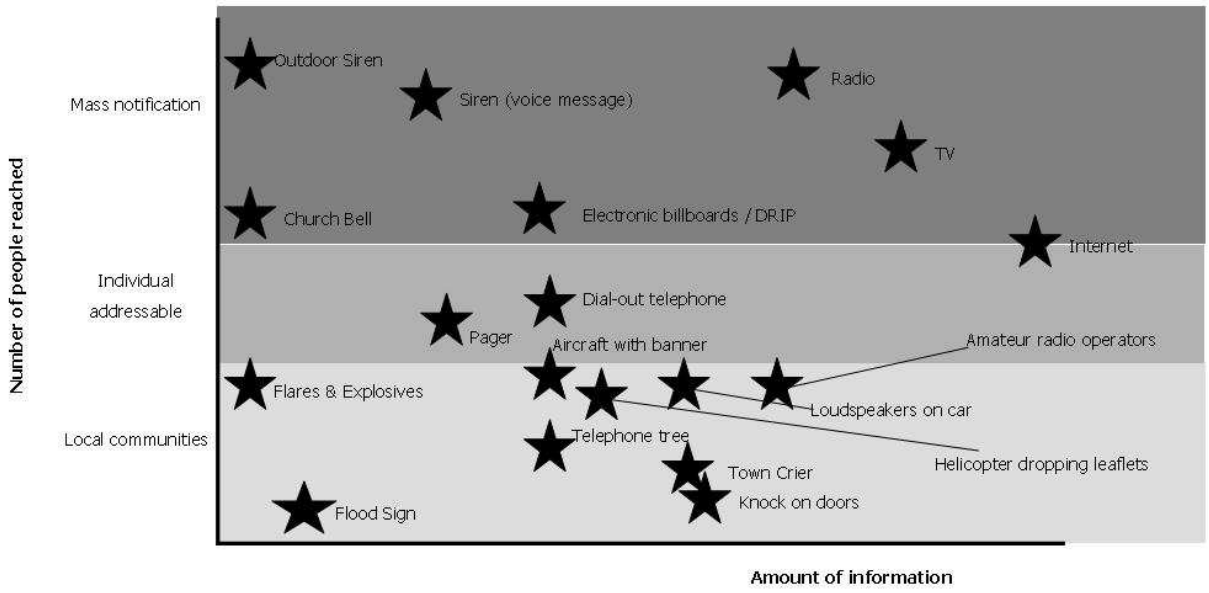

Figure 1-1: Palette of systems for warning citizens (Jagtman, 2008)

The siren can only give a tone and no information about what is going on and what should be done. The town crier and siren are active ways of warning people; people don't have to take a specific action to be warned, they will always be warned (provided that the sounds are loud enough) when there is an emergency and when these methods are used. Unfortunately, the more information these media give (for instance, the town crier versus the siren), the smaller the number of people that can be reached within a certain time.

Figure 1-2: Flood sign

Passive information carriers are information carriers that give information, but which do not actively warn you that something is going on. An example is the television. When you watch the news, you get information from your television, but when you are watching another channel, or do not have you television switched in at all, it does not alert you about an emergency. The known passive information carriers can give much more information (TV, radio or internet), but they cannot actively warn you that something is going on. This gives a problem in human information processing, as is demonstrable in the Human Information Processing model of Wickens and Hollands (1999) that will be discussed in paragraph 2.2.3.1, where the information has to come into the sensory processing system, before people know they have to pay attention to a message. A flood sign (a sign that is posted at the boundaries of an area that has been flooded, see Figure 1-2) is even less active. People have to physically drive by it, before the message can be read. This lack of information conveying capacity shows the need for alternative means of warning people that are both active an informative.

In The Netherlands, citizens are currently warned by sirens in case of a life threatening emergency The Dutch siren is tested every first Monday of the month at noon, to familiarize people with the sound of it. The warning signal of the siren is formed by a varying frequency. The frequencies are going up in 8 steps of 5.4 seconds each. The lowest step goes from 25 to 196 Hertz; the highest step goes from 392 to 784 Hertz. The frequency goes up for 4.8 seconds and then drops for 0.6 seconds. Figure 1-3 shows how the siren signal develops. When the siren sounds, this signal is sent out twice. This makes it a total of 88 seconds (with a short pause between the two signals).

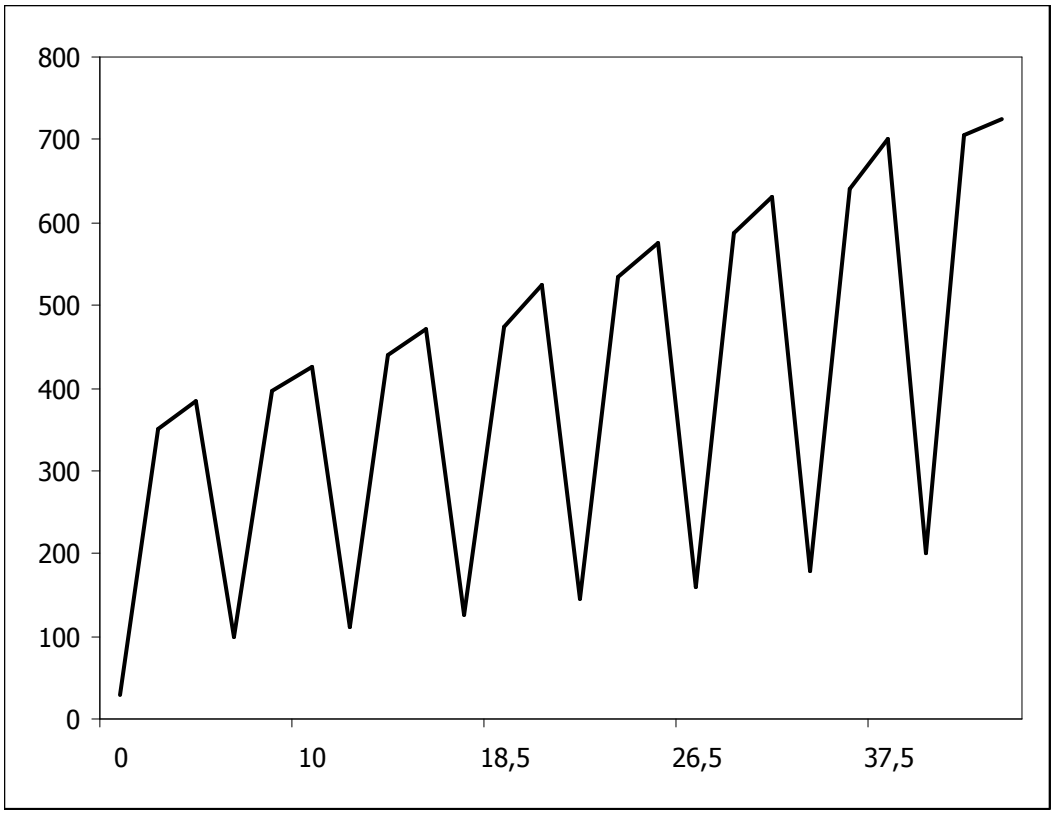

Figure 1-3: The siren signal (time in seconds on the X-axis and frequency in Hz on the y-axis).

From 1997 until 2003 the siren was only tested once a year. Unfortunately people no longer recognized the sound as being the national siren. In 2003, the monthly test, as was done with the old sirens before 1997, was re-introduced, by the Ministry of the Interior. They decided to sound that siren every first Monday of the at noon (Ministry-of-the-Interior-and-Kingdom-Relations, 2003), to ensure acquaintance with the sound and meaning of the siren. When the siren sounds at another time than the monthly siren test, people have to do three things: go indoors; close all doors and windows, and listen to local radio station. Next to the monthly siren test, there are national campaigns every few years to familiarize people with what they have to do when the siren sounds. Citizens then also get a card at home that specifies what they have to do when the siren sounds.

In this thesis, the warning systems that are discussed are the siren or warning systems that can serve as an addition to or replacement of this siren. The model developed and theory discussed however, is also applicable to other warning systems, such as Informative Fire warning systems in buildings.

1.3 Problems with the current siren

The purpose of the siren is to warn as many people as possible that something is going on and that immediate action is needed. Then, it should prompt immediate action. Next, it should initiate evacuation movement and finally, it should allow people sufficient time to evacuate (Proulx, 2000). Unfortunately, people tend to continue their activities and ignore the alarm signal (Proulx, 2000). Occasionally, when people have actually died in a fire, a statement is made that people panicked (Keating, 1982). This implicates that the situation could not have been prevented, as the people in the fire behaved irrationally. Research has indicated however that there is minimal evidence for the occurrence of panic in fires (Bryan, 2002; Quarantelli, 2002). In fact, what is found most of the time is altruistic, helping behaviour (Keating, 1982), especially among family members. There are of course several reasons why people do not start evacuating. First, it is possible that people believe it is a false alarm or a system test rather than a real one. The crying-wolf syndrome phenomenon has been

investigated by a number of researchers who have shown that under some circumstances, when alarms are very unreliable, people will stop responding to them completely (Edworthy and Hellier, 2006). It could also be that the signal is not loud enough, so that people don't hear the alarm in the first place.

In the Netherlands, there have been many complaints about the siren. If the sound of a siren is to be detected, the presence of other noise has to be overridden for detection of the tone to take place (Corliss and Jones, 1976). This mainly concerns the audibility of the siren indoors and in big cities with a lot of background noise. For example, Jansen (2003) has found that the sound of the Dutch siren is 5 dB lower than is specified by manufacturers. The sirens are not designed to be heard indoors; when the sirens were designed they were supposed to be heard outside, because they had to warn people to go inside, even though this does not warn people who are about to go outside). The audibility is however reason for many complaints (Vos, 2003). Moreover, in newly built urban areas, sirens are not always installed and sparsely populated areas may also be out of reach of the siren sound. Previous research shows that an average of 37% of people did not hear the siren on three different test occasions in 2004 (Sillem, Wiersma and Ale, 2005). Another limitation of the siren is its information conveying capacity. The only information the siren provides people with, is a warning that something is going on. People have to remember what actions they have to take to avoid being exposed to the risk for which the siren is sounded. A simple siren is not sufficient to get people to start moving (Bellamy and Geyer, 1990). Research has shown that it is necessary to give a lot of information about the situation to the occupants, to make it possible for the occupants to judge the situation themselves and make a correct decision (Proulx and Sime, 1991; Ramachandran, 1991; Partnership-for-Public-Warning, 2004). According to Ramachandran (Ramachandran, 1990), early behaviour is characterized by uncertainty, misinterpretation, indecisiveness, and seeking additional information. This gathering phase should be as short as possible, which can be done by giving the right kind and right amount of information in a warning (Bryan, 2001). There is a need to find out what is the best content and amount for the information that is given.

An example of the need to immediately convey information about what is going on is a large fire in a metal processing company in the city of Helmond, The Netherlands on April 15th 2007 (Vermeeren, 2007). The siren sounded in the area at risk, but little information was available on the local radio (an announcement was repeated every 5 minutes) and television (there was only message on teletext) station. This seems to be insufficient. 24% of the citizens did not hear the siren (de Gauw 2007). 62% of the total population in the area did follow one or more of the instructions that should be carried out when the siren sounds. Many people went inside and turned on their TV's to see what was going on. Nothing was broadcasted on TV, people had to listen to the radio (where a message was broadcasted every 5 minutes) or check teletext (where a message about the emergency and the sounding of the siren was posted), and so people weren't convinced of the need to stay inside and returned to their activities. Moreover, the siren sounded only once, which contributed to the fact that people thought there wasn't a real emergency. People indicated that they are very willing to comply with the instructions when the siren sounds, but that clear information needs to be broadcasted about the seriousness of the situation. This indicates that it is very important to fulfil peoples' expectations. The siren means that people have to watch / listen to local TV or radio stations, so when the siren does sound, something should really be broadcasted on those channels, to convince people that what they are doing is correct.

Another incident occurred in the city of Vlaardingen in The Netherlands (Temme, Bekkers et al. 2003) when a large amount of the chemical substance orthocresol was spilled from a chemical tank. Although the centre of Vlaardingen was outside of the area in which the orthocresol would have an effect on health, the strong smell and the possible effect of the strong smell on the perception of the seriousness by the citizens were reason for making the decision to sound the siren and to inform the citizens about the incident. Unfortunately, no information was broadcasted on the local radio or TV station. This, combined with the fact that the siren was sounded only once, made people do something else than what they were meant to do. There were people that sent their children back to

school after the lunch break. Other people were unsure about what to do, because no additional information was broadcasted. Shops in the centre had no procedures for what to do when the siren sounds. Some shops closed the doors and kept people inside, while other shops closed the doors and sent people outside. The evaluation of this incident (Temme, Bekkers et al. 2003) shows that many people do not know what to do when the siren sounds and that there are problems in communicating what is happening and what should be done during an emergency situation. This indicates that people need to be convinced of the need for an evacuation when a fire alarm is sounding. It is very important to provide information to people in an emergency that allows them to make a correct decision about getting control over the situation or bringing themselves and others to an area of safety (Proulx and Sime 1991). Humans are very capable receivers of information and usually use this information in accordance with the intentions of the supplier. However, they have to get the information to be able to do something with it. The successful design of warning messages maximizes the probability that each step on the warning process will be completed (Rousseau, Lamson et al. 1998). Moreover, people tend to seek information, primarily from radio and television, asses their personal risk and make independent evacuation decisions, rather than automatically following the requests of public officials (Dash and Morow 2001). This means that people have to be able to verify the information given, so that they can make a sound decision about the danger they are in and the actions that have to be taken.

The problems with the current siren as mentioned above, not being able to reach all relevant people and lack of possibility to inform people about what people should do, and the actual behaviour of people in emergencies, lead to the recommendation made by Temme et al (2003) to investigate the possibilities for alternative means of communication following the siren that can reach more people and are able to give more information than the siren does.

1.4 Research question

The preceding paragraphs show that it is important to influence and improve the self-reliance of people, so that more people can rescue themselves before the arrival of assistance in the form of rescue services when there is an emergency. The rescue services can then evacuate the people with a disability, those that are injured or people trapped. When the response to a disaster is optimised, because it is well organised and coordinated and citizens are self reliant, the consequences of a disaster can be minimised.

In order to follow the recommendations made by Temme (2003), to investigate the possibilities for alternative means of warning citizens, there is a need for a clear view on how to actually investigate whether and to what degree a new or existing warning system improves people's self-reliance in an emergency.

The objective of this dissertation is to determine how an overview of the influences on peoples' self-reliant behaviour in an emergency can be obtained, so that it is possible to determine the possible additional value of a certain warning system to the improvement of peoples' self-reliance. The meaning of warning effectiveness is a feature of debate. Some say that a warning is effective when it informs the public, while others say it has to actually alter their behaviour (Stewart and Martin, 1994). In this thesis a warning message is defined to be effective when it improves people's self-reliance, when it reaches as many relevant people as possible within a short period of time and when these people start acting immediately to bring themselves to a safe place after receiving the warning. This definition has two important implications. First, for a message to only reach a person is not enough, the warning message has to really come across. Second, the fact that people should start acting immediately after receiving a warning message does not necessarily mean that the instructions in the warning message have to be complied with exactly. Sometimes people may have better information about the situation or they may think of a better flight route. Moreover, sometimes the administrators may not have a clear or complete view of the best options for people. This means that the information given in the warning messages can possibly be incomplete or even incorrect. So, the goal is not that people necessarily comply with the message, but to support them to start acting immediately to bring

themselves to a safe place. Moreover, the effectiveness can be enlarged when people warn other people about the emergency after receiving a warning message.

Summarizing, this dissertation is about finding out what factors influence self-reliance in an emergency and how these influencing factors can be investigated so that the total effectiveness of a warning system on citizens' self-reliance can be determined. The research in this dissertation is not only purely scientific but also has a strong designing aspect to it, as it goes deeper into what information should be given to citizens and by what means. This fits the vision of Delft University of Technology (DUT, 2007) that states that Delft University of Technology should contribute to sound solutions for urgent social issues. In light of the aim stated the present research attempts to answer the following questions:

"How can the way in which a new or existing warning system effectively influences citizens' self-reliance in an emergency be investigated?"

In order to answer this main research question, several steps have to be taken. First, the available literature should be searched in order to determine what the steps in warning information processing are in which citizens' self-reliance in an emergency can be influenced. Then, this information has to be used to make a model that gives an overview of all the influences on citizens' self-reliance. Finally, for all the steps in this model, methods have to be given to investigate their effects on the self-reliant behaviour of people in an emergency.

The answer to the main question is thus to be found in answering the following three sub questions:

"What are the known steps in warning information processing in literature, in which self-reliance in an emergency can be influenced?"

"How should these steps be investigated?"

"What is the influence of each factor on citizens' self-reliance in an emergency?"

The answers to these questions should be useful when trying to determine the effectiveness of new or existing warning systems, whether this is a national warning system, or a system within a building or a limited area.

The next paragraph will explain how the answers to the research questions will be obtained.

1.5 The Research Approach

The research questions are answered through a series of steps. Although the research is theory-building in nature and synthesizes several existing models on human information processing and warning people, the steps taken resemble the phases of empirical research. This way of presenting the storyline of a dissertation is also found in the thesis of van de Riet (2003). In the 'cycle for empirical research', five phases are distinguished (Groot, 1961):

- Observation (collecting empirical data)
- Induction (developing theory)
- Deduction (Formulating hypotheses that can be tested)
- Testing (testing the hypotheses with new empirical data)
- Evaluation (evaluating the outcome of the testing in light of the theory developed)

In Step 1 of the present research (resembling phase 1 of the empirical cycle), literature on human information processing, human behaviour in emergencies and on warning citizens is studied to gain an overview of existing insights and models about the factors that influence human behaviour in general and self reliant behaviour in emergencies in specific. The literature consisted of many articles and

standard handbooks for warning citizens and human information processing. This will answer the first sub question.

In Step 2 of the research (resembling phase 2 of the empirical cycle) the insights found in literature were synthesized and structured into one model that will answer the first research question. This model shows the influences on the effectiveness of a warning system and thus the factors that are influencing peoples' self-reliance in an emergency. Chapter 2 starts with a description of the existing models on which the model that is constructed in chapter 3 is based. Next, the way in which these existing models are combined into one model that gives a complete overview of the influences on peoples' self-reliance. Finally, all influences that the model shows are explained.

In Step 3 of the present research (resembling phase 3 and 4 of the empirical cycle) the applicability of the theory developed is tested. In this part, the second and third sub question will be answered. The individual pieces of the theory (statements about the influence on self-reliance of each individual factor) are not tested because they are all supported as having an influence on self-reliance by literature, as is shown when building the model in Chapter 2 and 3. Thus, the literature sources used are guarantors for the individual pieces. The central question in the application is: "How should the influences on self-reliance of a warning system be investigated and what are their influences on self-reliance in an emergency" These questions will be answered by showing how all influences on self-reliance can be investigated, and by relating the influences of the separate steps to its implications for the whole model. This means that this thesis will look at the methodologies that can be used to determine the effectiveness of the warning system and the effects that the results have on the overall self-reliance. In this way, a judgement can be formed on the effectiveness of the warning system.

To test the applicability of the model developed, two warning system effectiveness studies were evaluated ex post using the theory. The vehicle of looking at these two warning system effectiveness studies was chosen because applying the theory requires deep insight into the ins and outs of a warning system effectiveness study. The nature of these studies is such that multiple sources of evidence are used, ranging from interviews, reaction time measurements and questionnaires to laboratory experiments. This makes these studies suitable for in-depth descriptions, interpretations and explanations of real-life phenomena. The vehicle of ex post evaluation of the studies was chosen because of the availability of these two recent studies for evaluation.

Examples of how the research was done in two different warning system studies are used to explain the way in which the factors can be investigated and what the influences on self-reliance are. Nonetheless, it is not the intention of the chapter to provide a complete listing of available methods and techniques. The specific methods or techniques mentioned are meant to illustrate the approaches used to investigate all factors. The methods and techniques that are used can vary depending on the characteristics of the warning system that is under study.

Chapter 4 describes the setup of the two warning system effectiveness studies that were evaluated. Chapter 5 then shows the application of the model using the two studies. This chapter is aimed at answering the second research question.

In the final step of the present research (resembling phase 5 of the empirical cycle), the study findings are evaluated and conclusions are drawn about the applicability of the model developed. Chapter 6, the final chapter, describes the outcome of answering the first sub question by doing literature research, of the second sub question which is discussed methodologically and of the third sub question which is answered by means of deduction, drawn from a combination of literature research and methodology, as well as recommendations for further research.

2. Theoretical Framework

Many aspects of warning people have been thoroughly researched and consequently many researchers have created models that attempt to describe human information processing and human behaviour in emergencies. These models and theories vary in their applicability to specific situations and aspects of warning people. Also, they vary in focus and intended use. As introduced in the previous chapter, the main focus of the research in this thesis is to determine how the way in which a new or existing warning method effectively improves citizens' self-reliance can be investigated. Therefore, this chapter will focus on finding all the steps in warning information processing in which self-reliance in an emergency can be influenced and finding or developing a model that shows all these steps. This will answer the first sub question "What are the known steps in warning information processing in literature, in which self-reliance in an emergency can be influenced?"

2.1 Criteria

When there is an emergency in which people have to be warned, there are three phases that have to be passed before people can follow the instructions in a warning and get to a safe place:

Warning: a warning that something is going on has to be sent to people.

Information Processing: after the warning has been sent, people have to perceive and process that warning, and decide whether and what kind of that action is needed.

Behaviour: finally, people have to perform the self-reliant behaviour so they can get to a safe place.

This sequence of warning, perception, processing (understand, believe and personalize) and responding (decide about alternative protective actions and perform them) has been discussed before (Mileti and Sorensen, 1990; Mileti and Peek, 2000). Self-reliance can be influenced in all of these three phases. A model that can help to explain how citizens' self-reliance in an emergency can be improved will thus incorporate these three phases.

Furthermore, the model should be helpful in determining the effectiveness of a warning method. In order to be able to determine the possible effectiveness of a warning system, it is necessary to know what the influences on the effectiveness are. This means that the model should show how these influences of a certain warning method on self-reliance can be investigated. When these issues are investigated, the results can give an indication of the effectiveness of that warning system. In order to determine possible problems with a warning system, the model should also show how the causes for ineffectiveness should be found, so that judgements can be made whether these problems can be solved, or whether the warning system will not be able to effectively warn citizens.

Taking this into account, a model that can be used to show how the way in which a new or existing warning method effectively improves citizens' self-reliance should be investigated should:

C1: include at least one of the three steps (warning, information processing and behaviour)
C2: be able to be used for describing the influences on citizens' self-reliance in an emergency
C3: incorporate determining the effectiveness of a warning on self-reliance
C4: incorporate determining the causes for ineffectiveness of a warning on self-reliance

This chapter of the thesis first presents models that were found in literature which incorporate one or more of these three steps. These models can help in determining what steps there are in warning citizens that can influence self-reliance in an emergency. The literature that was studies consisted of many articles and standard handbooks for warning citizens an on human information processing. Given the scope of the current research, the information from these sources was used to check the available models against the criteria mentioned above.

Models from various fields will be discussed, following Wogalters' (2006) indication that the multidisciplinary interest and relevance of warning has resulted in several separate bodies of literature related to the topic of warnings, including: human factors and ergonomics, communications, safety engineering, healthcare, marketing and law. The models that will be discussed concern human behaviour in emergencies and human information processing. They will be used to determine what the different phases are in communicating a warning message to citizens and the influences there are in these phase on self-reliance. The models that are discussed will be checked against the four criteria that can help indicate how helpful these models can be for the purpose of this thesis. These criteria concern the focus of the models on the influences on self-reliance in an emergency. After discussing the models available in literature, a model will be constructed that shows all steps in warning information processing and all the influences on self-reliance in an emergency in that model that should be investigated when trying to determine the effectiveness of a warning system. Finally, the theory that is found in literature concerning each of the steps in they model concerning the influences on self-reliance will be discussed. This will answer the first research question.

2.2 Modelling human information processing and human behaviour in emergencies

The goal of warning citizens in an emergency is to ultimately ensure that people get to a safe place, so that their lives are not at stake any longer. Hanea (2009) makes a distinction between three types of models that are used in the field of fire safety which are related to three main processes that take place during a fire in a building: fire (and its products') development, people evacuation process and the fire fighting process. In this thesis, only the middle process, the people evacuation is of interest. This evacuation process is broader than just the evacuation though. It encompasses the whole of human information processing and human behaviour in an emergency. Moreover, this people evacuation process can again be split into several types of models that describe this process. Some models focus on the response to a fire or chemical exposure. They take into account several aspects of the fire development and the fire fighting process and human behaviour to look at the outcome of the fire. Other models focus mostly on the evacuation that follows the event. These models show

what steps there are in an evacuation, but they are often mainly aimed at the behaviour stage of an evacuation, rather than the pre-movement phase in which people have to be motivated to start acting. Finally, there are models that focus on the communication of the warning and the way in which people process and react to this warning. This last type of models also includes models that do not consider an emergency, but focus on human information processing or communication in general. These three types of models will be discussed in the following paragraphs, to determine what parts of these models are useful for this thesis.

2.2.1 Evacuation models

Often, an evacuation is part of the process to get people to a safe place in an emergency. There are a number of evacuation models that show the three steps that are described in the previous paragraph. Two evacuation models are Bellamy and Harrisons evacuation model (1988) and Canters Informative Fire Warning System model (Canter, Powell and Booker, 1988).

The model proposed by Bellamy and Harrison (1988), is an evacuation model that shows the behaviour of people following a release of either toxic or radioactive material (see Figure 2-1). This is a time model; it shows how the different phases take place in time. The decision time starts at the moment a threat is identified and continues until the point at which it is considered serious enough to issue a warning (Bellamy and Harrison, 1988). The notification time lasts until the last member of the target population has been notified. Preparation time starts at notification, and it ends when evacuation commences.

Evacuation time ends when the evacuating population have left the area. This model is meant to give insight in the time issues. It shows the steps needed before people get into action. This model was later used by Ramachandran (1991) to evaluate the effectiveness of warning systems research. This model meets the first criterion that was set; it shows all three steps of the warning process. It does not however distinguish between the factors that are of influence on self-reliance. The whole influencing process is captured in one block 'perception of threat' and the block 'additional information acquisition'. The other three criteria are not met. Marsland (1999) developed a similar model concerning the alerting of building occupants.

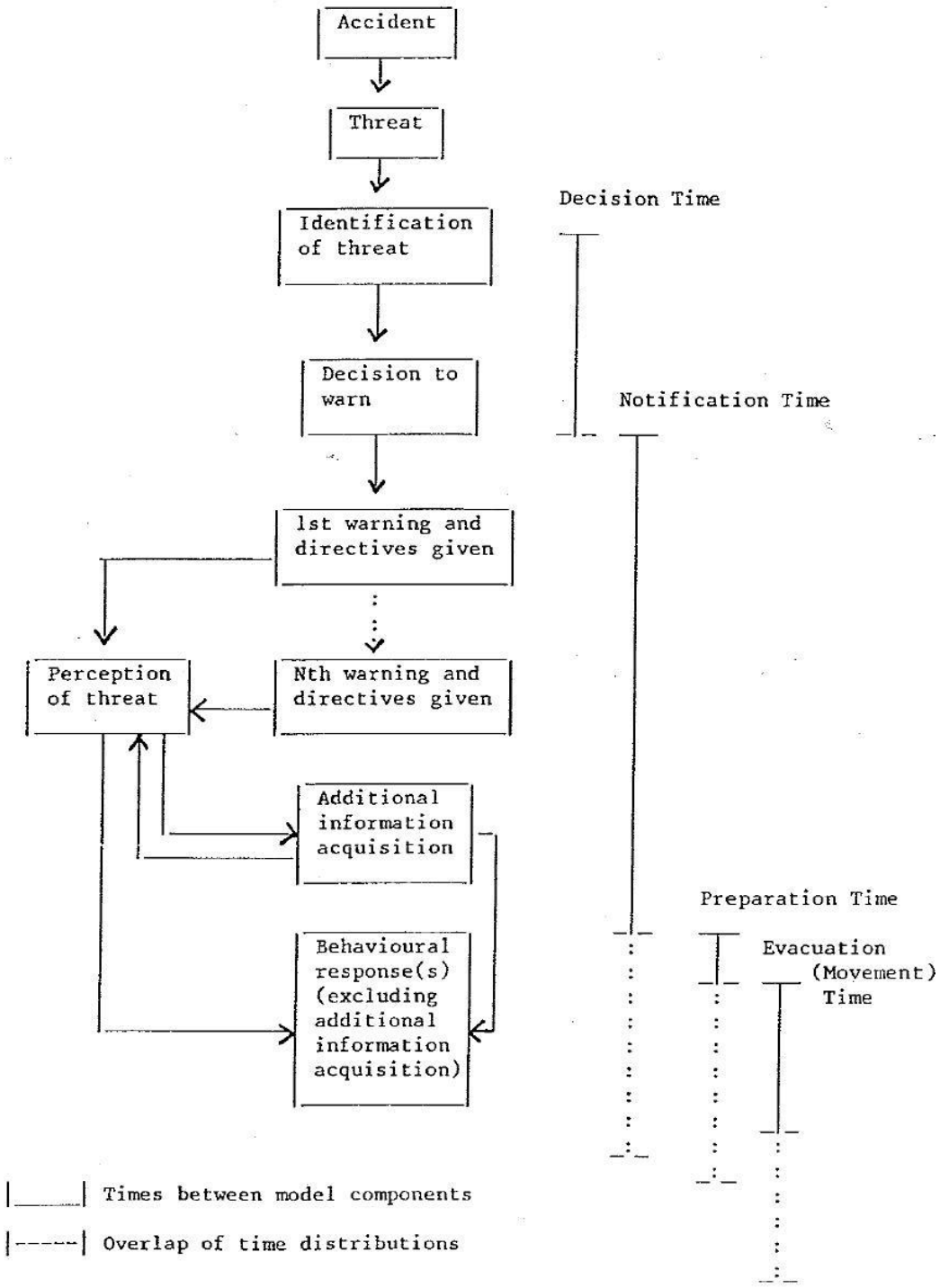

Figure 2-1: evacuation model Bellamy and Harrison

Canters, Powell and Bookers model (1988), describes the stages of an evacuation, and the possibilities to make an evacuation more effective by using an IFW (informative fire warning system). An IFW is a warning system that can provide specific messages at different stages of a fire. These messages would ensure that people have the information they need to enable them to complete the required stages in effective evacuation as quickly and safely as possible (Canter, Powell et al., 1988).

Cue reception -> seek additional information -> decide to evacuate -> choose exit route

v	v	v	v
Reduction of delays in definition of situation	reduction in time taken to decide on actions	reduction in time to begin evacuation	reduction in time to leave building

Figure 2-2 Contribution of IFW system in effective evacuation (Canter, Powell et al., 1988)

The model in Figure 2-2 shows what parts of the evacuation can be improved by using an IFW. This indicates possibilities for research into these issues. This model is therefore close to criterion number 3 which claims that the model should incorporate determining the effectiveness of a warning system. This model indicates where improvements in warning effectiveness can be made. The fourth criterion however is not covered. Ramachandran (1991) uses a similar model which is again based on the model by Bellamy and Harrison in his paper on informative fire warning systems.

The evacuation models discussed here show what steps there are in warning people when an evacuation is needed. These steps are useful to gain insight into the phases in which self-reliance can be influenced. These models do not however indicate how the self-reliant behaviour of people should be investigated. More information about this is needed from other fields.

2.2.2 Fire or chemical exposure related models

Next to the evacuation models mentioned in the paragraphs above, there are several models that look at the outcome of fires or exposure to chemical substances. These models usually take warnings and human behaviour into account, so they may be useful for the current purpose.

In the fire safety field for example, Hanea (2006) presented a schematic model that shows the BBN (Bayesian Belief Net) approach that can be used to estimate the human damage produced by a fire in a public building, see Figure 2-3. This model shows the influences on the outcome (human damage in this case) of a fire. In this model all the aspects that have to do with the human (the warning process, human information processing and behaviour) are captured in the evacuation-block.

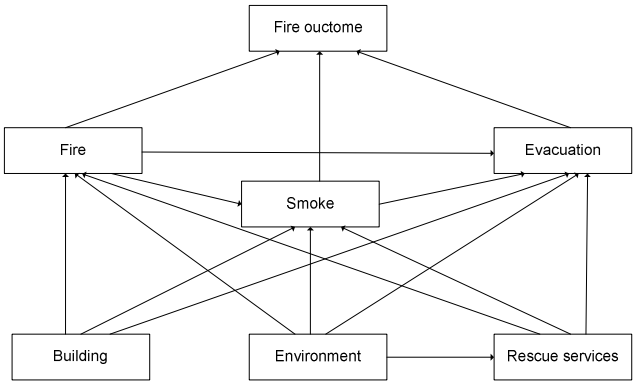

Figure 2-3: Schematic model for BBN approach to estimate human damage (Hanea, 2006)

This is of course a simplified view of the real BBN, in which all factors in each block have to be specified in order to calculate the outcome. Moreover, these specified factors can again have several causes that can be added to the model. An example of this can be seen in Figure 2-4.

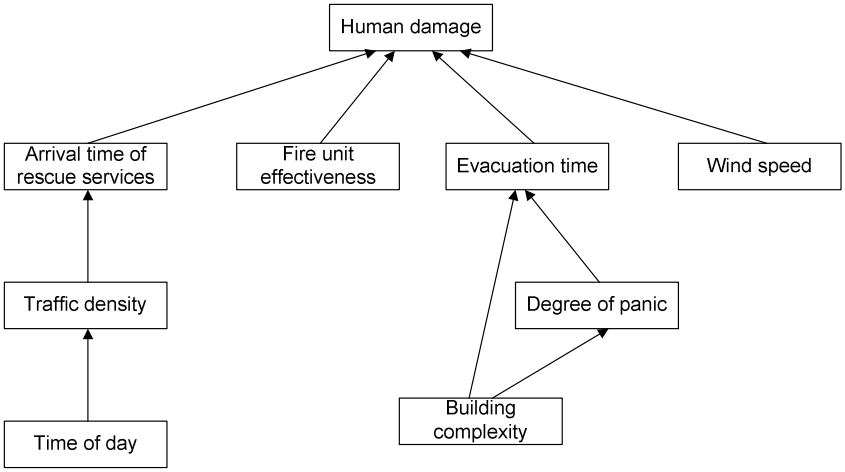

Figure 2-4: Human damage model – simplified structure (Hanea, 2006)

So, the model meets the first criterion, but as the model focuses to a large extent on the outcome of a fire and the influences on that rather than on the influences on the human behaviour, it is less useful for the current purpose, and the other criteria are not met.

Later, Kobes, Helsloot, de Vries, Oberijé and Rosmuller (2007) present a model similar to that of Hanea. They chose the human performance as the central aim, in stead of the human damage in Haneas' model. The model shows the critical influences on self-reliance in a fire. They have a different name for self-reliance in a fire, namely 'fire response performance', which refers to 'the ability of an individual to perceive and validate clues of danger and to make decisions that are effective with regard to survive a fire situation with none or little health complications subsequently' (Kobes, Helsloot et al., 2007). Their model, the fire response performance model shows five influencing factors on self-reliance in a fire: people (further split up into social features and individual features), the building and the fire. In a later publication (Kobes, Helsloot, De Vries and Post, 2009 (article in press)), this model is presented as is shown in Figure 2-5.

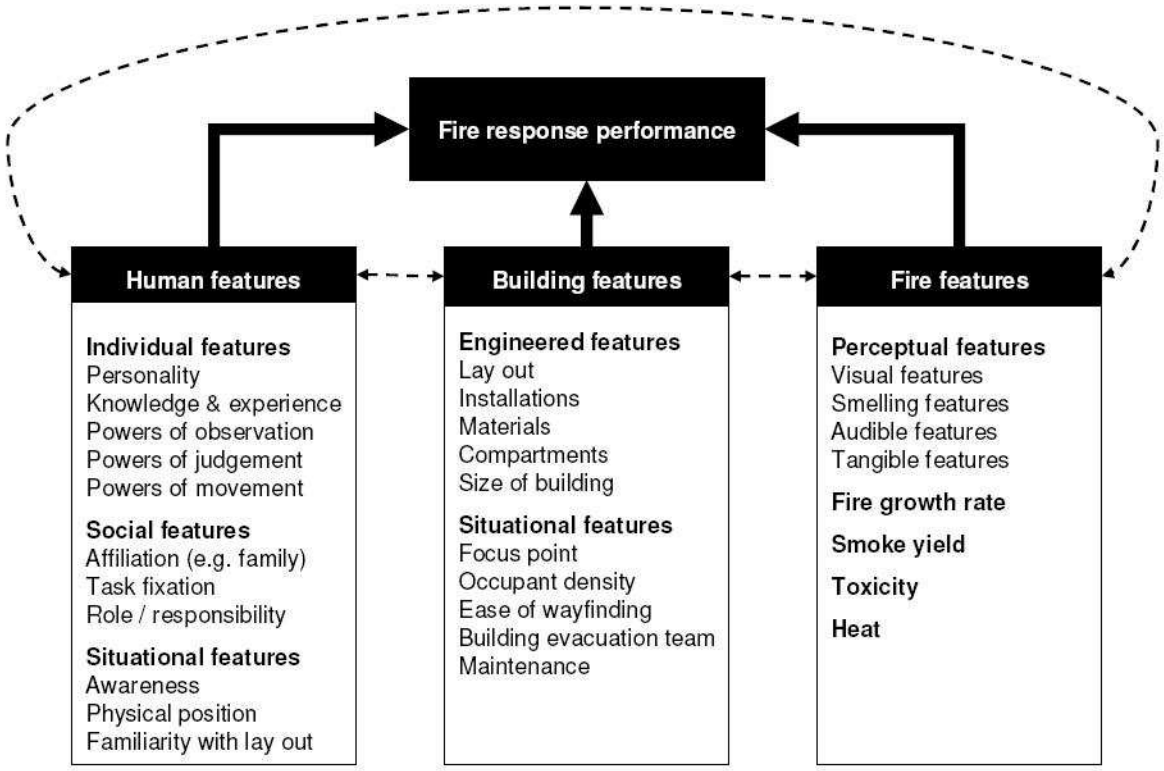

Figure 2-5: Fire response performance model (Kobes, Helsloot et al., 2010)

This model meets several criteria. First, it meets criterion 1 as it incorporates the behaviour. It also incorporates human information processing in the 'human features'. Moreover, it also involves warning messages in the description of the 'building features'. As it is about fires in buildings, it does not incorporate influences from outside the building like the siren or information from the media. Then, it also meets the second criterion as it shows the influences on the behaviour (the performance in this model). As this is meant as an overview of the influences that can be found in literature, the model and the description of the model don't go into how these influences should be investigated. This means that criterion 3 and 4 are not met in this model. Moreover, the model does not show in what way parts influence other parts.

A model similar to that of Hanea was presented by Dombroksi, Fischhoff and Fischbeck (2006). This model shows the critical variables after an RDD explosion (RDD stands for radiological dispersion device) and their effect on societal damage (deaths, economic impacts and quality of life). It takes into account physical as well as social processes believed relevant to predicting the associated health effects. These include time of day as well as compliance rates with official instructions and unofficial information. They create scenarios by giving values to each node in an influencing diagram. This model satisfies the first criterion, as it considers the warning and human behaviour. For the other criteria, the same arguments hold as for Haneas' model, the model focuses to a large extent on the outcome of a fire and the influences on that rather than on the influences on the human behaviour, it is less useful for the current purpose, and the other criteria are not met.

The last fire related model that will be discussed here, is the model of human behaviour in a fire emergency by Bickman, Edelman and McDaniels (1977). The individual is depicted in this model as a reactor to the environment with the emphasis upon the importance of perceptual stimuli and how they impact on the individual rather than the cognitive processes involved in interpreting the situation and driving behaviour (Saunders, 1995). This model assumes that when an individual fails to detect the fire, the behaviour will not be changed and that when the fire is detected, several types of behaviour are possible, such as suppress / contain fire, warn /rescues others, activate alarm system, seek

information, escape, etcetera. This model shows the possibilities that an individual has when there is a fire and when this fire is detected or not. The first criterion is met, the model considers both the warning and the human behaviour and to some degree it includes information processing. The steps that lead to behaviour are described minimally, so the second criterion cannot be met. The same holds for the third and fourth criterion.

The fire or chemical exposure related models show the influences there are on the outcome of an emergency event. They look at the even itself (fire or chemical exposure in these models), as well as the environment and the humans in the emergency situation. However, in most of the models human information processing is only a small part of these models. These models give a good idea where the influences of the human are in the whole model, but they focus less on how the human behaviour can be influenced. Kobes' model does give a rather extended oversight of human features that are of influence, but does not go into how these aspects should be investigated and what the implications of the results would be. More information about this is needed from other fields.

2.2.3 Warning process and human information processing models

This paragraph will discuss the models that have to do with communication and with the process of warning citizens. The process of warning citizens has a lot to do with the way in which people process information, whether this is in a normal or in an emergency situation. Therefore, the human information processing model is also discussed in this paragraph. The following model shows the steps of communication in an emergency (Wogalter, Dejoy and Laughery, 1999). This model shows that all communications (in this dissertation this will be warnings) are transferred from an originator (source) via a channel to a receiver. The emphasis in this model is largely on the transmission and reception of information in a strictly linear form. It looks at communication as a one-way process.

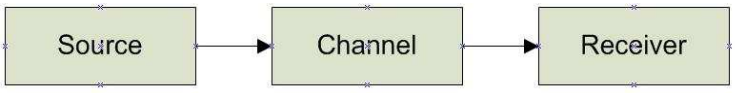

Figure 2-6: Communication model (Wogalter, Dejoy et al. 1999)

This model meets the first criterion as it shows how a warning travels from its source to the human. The other criteria are not met, as this model stops as soon as the warning has reached the receiver. However, the steps in this model can help determine in what phases self-reliance can be influenced. These different steps will now be discussed.

Source
According to Shannon (1997), all human communication begins with a source. The source of a message can be a person that has a certain reason for starting a communication. When people communicate, they usually want to convey information, instruct people to do something or persuade them to their point of view on a certain matter. The source expresses its purpose in the form of a message formulated in some kind of code. For a message to be received, it must be communicated through a channel that is interpretable by the receiver. The channel has to be adapted to the target group. For example, it is not possible to communicate with the blind through sign language. That specific channel is simply not usable for communicating a message to a blind person.

The source is the originator of the warning message. The characteristics of the source influence the number of people that will comply with the message. The source also selects the communication channel, the content and the format. This means that the source needs to adapt their output to what they know about the channel and the recipient. It is very important that the source characteristics are considered when trying to design an effective warning, because the receiver will combine the available information about the source with the information in the message when trying to determine the meaning of the message (Wogalter, Dejoy et al., 1999). Authoritativeness plays an important role in this (Baron, Byrne and Johnson, 1998). The credibility of the source will increase or decrease the degree to which people are willing to follow the instructions, and thus self-reliance with the message

that is sent (Williams and Noyes, 2007). Credible sources are known to produce more positive attitudes and motivate more behavioural change (Wogalter, Dejoy et al., 1999; Wogalter, Kalsher and Rashid, 1999). Cox and Wogalter (2006) pose that credibility is based on perceptions of the expertise and trustworthiness of the source. Expert sources are assumed to have special knowledge acquired through experience, education, and training. Sources are viewed as trustworthy when their communication appears to be legitimate and when there is no apparent conflict of interest.

Channel

The channel is the way in which the message is transmitted from the source to the receiver(s). The channel involves the sensory modality through which the warning is transmitted (visual or auditory) as well as the medium that is used to present the message (alarm bell, video message, text message). Each of the senses has its own characteristics that could be considered beneficial or disadvantageous for conveying the message, the environment and the tasks involved (Wogalter, Dejoy et al., 1999). For example, long and complex messages are not conveyed well through the auditory channel, they may be overwhelming and confusing, because people cannot remember the whole story. So, the channel is influencing the degree to which people are able to receive and understand the message, which of course influences the possibilities for people to comply with the instructions.

People experience a lot of noise when they receive communication. This means that if an auditory message is sent, the channel has to be audible over the background noise. According to the signal detection paradigm (Wickens and Hollands, 1999) this means that the channel has to be audible (or notable when using another sensory mode) over the background noise. There can also be visual noise. Visual noise is any extraneous element in a graphic that interferes with the user's perception if the intended message (Johnson, 2006). For example when there is a lot of smoke caused by a fire, it is possible that his makes it hard to determine where to go (Boer and Withington, 2004), as a warning has to be noticed and attended to before it can be processed and complied with (Vredenburgh and Helmick-Rich, 2006). Other visual noise can be caused by an overload of information. For example in a train station with a lot of colourful advertisements on the walls, an exit sign may also be very hard to locate. In these cases, other means of warning and directing people are necessary. This signal detection paradigm postulates that there may or may not be a signal (warning message in this case) in the real world, and this signal is detected or not by a certain person. The combination of these two categories produces a 2*2 matrix, as can be seen in Figure 2-7. 'Hit' means that there is a signal in the world and that this signal is noticed. A 'false alarm' is when someone thinks there was a signal, but there wasn't one. A 'miss' is when there was a signal in the real world, but it's not noticed, it's missed. A correct rejection is when there is no signal in the real world and when indeed no signal is noticed. When the channel performs perfectly, it will always be clear when a warning message is sent, so there will be no misses or false alarms made by the receiver. This does not however solve the problem of false alarms or misses at the part of the sender of course. A criterion for the minimum % of hits and correct rejection can be stated when testing a warning system. The criterion for accepting a signal as real against the noise can be shifted, but this means that there will also be more false alarms. On the other hand, more correct rejections, also means more misses.

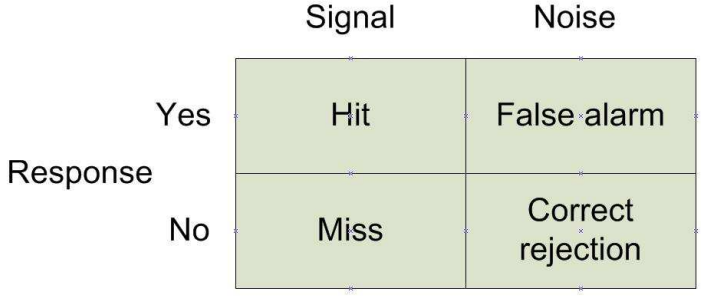

Figure 2-7: The four outcomes of signal detection theory.

In some contexts, it may be useful to use two modalities to deliver a message. This combination can allow the message to reach more people, for example people with a sensory deficit in one sense, or it can decrease the chance that a message is not received due to noise. This may decrease the number of misses. This can be done by combining a siren with a mobile phone text message. The siren can be heard, and the text message can be read by people that cannot hear the siren.

For others, receiving a message in two modalities or from two sources, may be reassuring that the information is correct and is of great importance. This leads to better remembering and complying with the warning (Cohen, Cohen, Mendat and Wogalter, 2006). Care should be taken that multiple types of warning messages do not interfere with each other. For instance, an alarm bell should not be so loud that a voice warning is no longer intelligible.

With any type of message, it is very important that the information reaches the people at risk. Warnings that do not arrive at the relevant people can result in people being in danger. Thus, knowledge about characteristics and efficacy of the warning channel benefits the communication of warnings (Cohen, Cohen et al., 2006).

The receiver part of the communication model is not described right here, as it will be described extensively in the paragraph on Human Information Processing, which is all about the receiver part of the communication model.

2.2.3.1 Human Information Processing model

An interesting model which shows the human information processing of a warning, is the Interactive Social-Cognitive (ISC) Model by Kalsher and Williams (2006) which can be seen in Figure 2-9. As this model is largely based on the human information processing model (Wickens and Hollands, 1999) that can be seen in Figure 2-8. Because it is necessary to understand how human information processing works to completely understand the ISC-model, Wickens and Hollands model of human information processing will now first be discussed.

The human information processing model provides a useful framework to analyze the different psychological processes that are used when interacting with systems. It can also be used when carrying out a task analysis (Wickens and Hollands, 1999). It shows that information processing can be represented as a set of phases whose function is to do something with the information, to make it usable for the human. The first criterion is met with this model, as it encompasses human information processing and behaviour. This model gives a clear view of all the steps in information processing in which self-reliance can be investigated. It does not however show how these issues should be investigated. Each block in the model will be explained. Later, literature will be used to determine how the influences on self-reliance can be investigated.

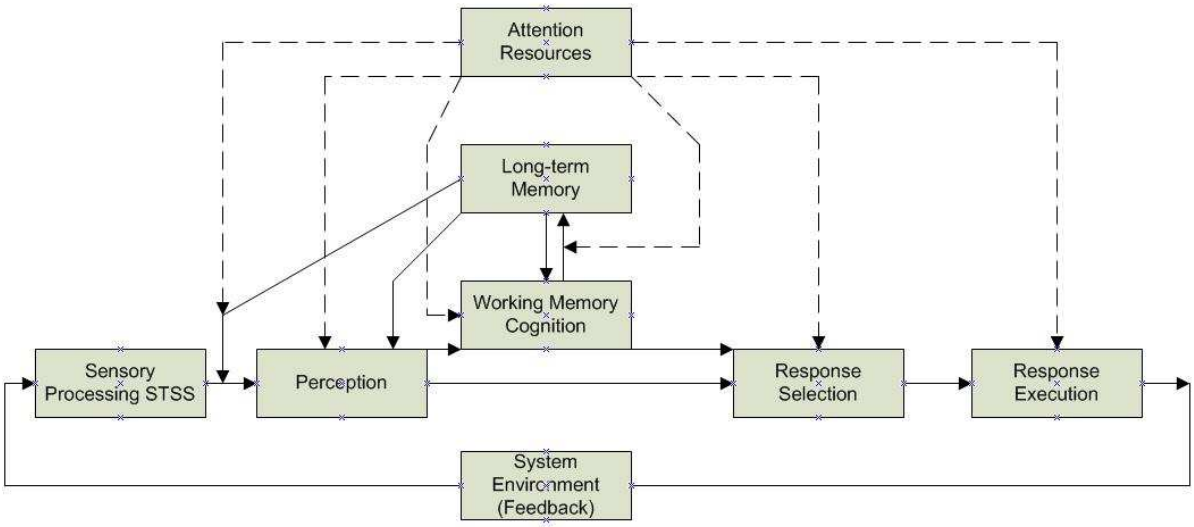

Figure 2-8: Human Information Processing Model (Wickens and Hollands, 1999)

Sensory Processing
Information that is transmitted must gain access to the brain before it can be noticed (Wickens and Hollands, 1999). The signal must be picked up by the sensory system. The attention must be switched to it and maintained long enough for the receiver to extract the necessary information (Wogalter, 2006). This means that for example an alarming sound has to be so loud that it can be heard over present environmental sounds before it can be received by the brain. In an emergency, people have to actively notice the warning message. The consciousness can only do one thing at a time, and that is what's called attention (Dijksterhuis, 2007). So, attention has to be switched from what people are doing towards the warning that is coming in. A message has to be processed by the senses, before it can be understood and acted upon.

Perception
Sensory processing is necessary but not sufficient for motivating people to start acting (Wickens and Hollands, 1999). The sensory data that comes into the brain must be interpreted and a meaning has to be given to it, through the stage of perception. For example, an alarming sound isn't just a loud sound, it also means that something is going on and that action is needed. Unfortunately, people may think the alarm is a test or a false alarm, or people may be so concentrated on their activities that they do not pay any attention to a warning message. Expectancy is an important issue in these kinds of situations. Houtenbos (2008) uses this phenomenon to describe the expectations that people have when interacting in traffic. She claims it not entirely clear yet how these expectations influence our behaviour or even how they are formed. In traffic, as in emergency situations, expectations of the outside world are especially important due to the time constraints in such situations. Actions are needed quickly, so it is important that the expectations of what is going to happen are correct. To achieve a certain level of anticipation of what is going to happen, adequate expectations are essential. When we know what to expect, we know what to anticipate for and therefore what to prepare for. This is one of the reasons why it is hard to convince people that something is going on when there is an emergency, something is happening that is outside their expectations. Unjustified expectations can lead to warnings not being perceived correctly, which has obvious implications for citizens' safety.

Close to the concept of expectancies, is the concept of situation awareness. Situation awareness is an active part of knowledge that is combined with current information about the environment. Situation awareness consists of three levels: the perception of environmental elements within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future (Endsley, 1995). This means that people have to be aware of what is happening around them and understand how information, events and your own actions will impact your goals and objectives, both

now and in the near future. For human behaviour in emergencies, this means that people have to be able to gather information from the environment about what is going on. This information has to be readily available and understandable, so that people can make a correct decision about what is going on and whether action is needed of them. Attention plays a big role in situation awareness. This will be discussed later in this thesis.

Concerning false alarms, there is a public belief that there is a cry wolf phenomenon, which means that people are desensitized by false alarms and will not react quickly during a real event. However, Gruntfest and Carsell (2000) state that false alarms do not severely reduce the publics' willingness to respond to warnings. But, although this may be true, the perception of people that a sounding alarm may be a false alarm or a test implies the need for people's attention to be drawn away from their normal activities and drawn towards the warning message.

Warnings need to give more information than only a sound, especially when the likelihood of false alarms is high (Papastavrou and Lehto, 1996), so that people can be informed correctly about the reason for the alarm. Proulx (2000) shows that encouraging an appropriate occupant response can be obtained by 'stopping the show', providing a sudden change in the environment. Preventing that people are able to continue their normal activities is an important option. For example, in a movie theatre, the lights can be turned on and the movie can be stopped; in an office building, all the computers can be turned off, or background music can be stopped. As long as 'the show goes on,' people are very reluctant to shift their attention to an unexpected or ambiguous event. When the show stops, this is a serious indication that something is actually different from normal and this will motivate information seeking behaviour. Then, after the attention is drawn, a voice communication system can be used to further inform people about what is going on and what should be done.

Moreover, the sound of a fire alarm is often misunderstood (Benthorn and Frantzich, 1996; Proulx, 2000; Proulx and Laroche, 2001). In the study by Benthorn and Frantzich, subjects were placed in the Helsingborg IKEA (in Sweden), in a position where they would normally pass by on the way through the warehouse. The subjects were instructed to do whatever they would normally do on whatever they heard. A ringing signal was provided to them. The alarm ring signal rang for 10 seconds. This was followed by 10 seconds of silence (to give the participants time to respond to the signal). After the pause, a pre-recorded message was transmitted stating that they should leave the building due to a technical failure. In Benthorns' research, 58% understood the ring signal as something rather unspecified and only 19% perceived it as a fire alarm. Many of the subjects did not understand that they should react physically by starting an evacuation. This shows the need for an intercom message clarifying what action should be taken.

Bellamy and Geyer (1990) did an experiment in which several display techniques for representing information about a fire were tested. They tested a 2D representation, a 3D representation, a regular fire bell, a display with a line of text and a speech message. On average only 59% of the participants interpreted the fire warning message they tested as a genuine fire irrespective of their accuracy in identifying the fire location. The worst result was obtained with the fire bell. Only 13% of the participants recognised this as being a genuine fire alarm. The most frequent interpretation was equipment test (28%). Only 14% reported interpreting the most recent alarm they heard outside this experiment as a genuine fire emergency. This shows a conventional fire alarm is insufficient in being able to convey an effective warning of fire. When a voice message was given, the time to arrive at a decision about what to do is very short, less than a minute. Other research (Wogalter, Rashid, Clarke and Kalsher, 1994) confirms the large effect of a voice warning. Wogalter et al did an experiment in which participants followed a set of printed instructions to perform a chemistry task that involved measuring and mixing disguised (nonhazardous) chemicals. Whether participants wore protective equipment was measured. In some conditions pictorials, a voice warning, and / or a flashing strobe light were added. The results showed that the presence of a voice warning produced a strong and reliable increase in compliance compared to conditions without a voice warning. In addition, compliance was positively related to remembrance of the warning, perception of hazard and reported

carefulness. They conclude that voice warning may be a very effective means of gaining behavioural compliance.

Summarising, compliance with a warning message depends for a large part on the meaning that can be given to the warning. This meaning has to be learned or has to become clear when perceiving the content of the message. So, perception is driven by sensory input as well as by inputs from the long-term memory.

Cognition and Memory

When enough information has been perceived, processes begin to operate in order to determine the appropriate action or response (Proctor and van Zandt, 1994). These processes can include the retrieval of information from the memory and comparisons among items in the message and the information in memory. People have limited abilities to attend to multiple sources of information, so the cognitive stage causes constraints in performance; it takes relatively more time to go through this stage than the stages before. This is because cognitive operations such as reasoning or image transformation are carried out by using the working memory. The working memory is a temporary store of activated information (Baddeley, 1997; Wickens and Hollands, 1999). In this phase, the message content and sender are compared with information in the memory. Is the sender credible, have similar messages been sent in the past, were past messages helpful and necessary. All this information is weighed in the cognition phase before starting to make a decision about whether to act and comply with the message.

Attention

Attention is part of the beginning of the cognition phase. Many mental operations are not carried out automatically but require attention (Wickens and Hollands, 1999). Attention has to be paid when listening to or reading the warning message. Attention is necessary for understanding the message and thus for being able to comply with the instructions given. Most situations require that people divide their attention among various stimuli and events (Wogalter and Vigilante, 2006). Wogalter and Vigilante indicate that according to most modern theories of attention, people have a limited capacity of attention or mental resources to be used for active processing. In most case, people cannot attend to everything in their surroundings; they have to make a selection. People are selective, they focus their attention, they filter the data that comes is. In general, people tend to look at, listen to, or think about the stimuli that are most salient or conspicuous, the stimuli that stand out in the background. Attention is generally given to the most conspicuous stimuli, and concurrent to the attention maintenance process, memories of that stimulus are produced. Internal mechanisms of expectancy or motivation can make different things conspicuous compared to their intrinsic conspicuity. This means that what is conspicuous to one person does not have to be conspicuous for another person. This makes this phenomenon subjective. As a memory is formed, the stimulus that activated it becomes less salient, and other stimuli start to attract the attention. This shows that there is a continuous process of focussing attention on one stimulus and then as it is becomes known, attention switches to new information. Thus, much of the information that reaches our eyes and ears, including also some safety information, is never processed at a conscious level, and may have no effect on our behaviour (Horst, McCarthy, Robinson, McCarthy and Krumm-Scott, 1994). An effective, well-designed warning attracts attention toward it. It also draws attention away from other stimuli and thoughts. This is the attention switch-stage (Wogalter and Vigilante, 2006). To cause this switch, the warning has to be relatively more conspicuous than other things. The second stage of attention is maintenance. To expedite information extraction, warnings should have certain characteristics such as being legible or intelligible and having content that readily is consistent with existing memories.

Factors that influence capturing and maintaining attention include the characteristics of the message itself and its immediate surroundings (Wogalter, Dejoy et al., 1999). Context or background factors are important because they enable or disable the warning to stand out in the environment. As soon as attention is captured, it needs to be maintained in order to extract information. Examples of factors

that influence the maintaining of attention are brevity (short message) and legibility (Wogalter and Vigilante, 2006).

Decision compliance or non-compliance

A number of factors are of influence on compliance. For example, source credibility is determined by the perceived trustworthiness and expertise of the source (Cox and Wogalter, 2006). Sources are judged as being trustworthy if their communication on a certain matter appears to be legitimate and if there is no apparent conflict of interest (Wogalter, Dejoy et al., 1999). Authoritativeness or power is also an important factor. Deutsch and Gerard (1955) indicated that social influence is achieved through so called information influence and normative influence. Information influence is inserted in the message content whereas normative influence is determined by the characteristics of the source and the relationship of the source with the receiver. The decision to comply with the instructions given in a message is dependant on all these factors and is based in the information retrieved from memory. The message has to be perceived by people, they have to pay attention to it, understand the message, and believe that the source and message are credible, powerful as well as authoritative. When one of these factors fails, this will have great influence on the effectiveness of the message. So, much attention has to be paid to make sure that all the demands are fulfilled. This is also the phase in which people can decide to deviate from the instructions given. When people feel that the instructions are incorrect, or they see other people do something else, they may not follow the given instructions but decide on taking another type of action or no action at all.

Response Selection and Execution

In this phase the actual response is selected after the decision to comply or non-comply is made. Understanding of a situation, which is achieved by perception and cognitive transformation, often triggers a response (Wickens and Hollands, 1999). The information that was retrieved from memory helps to make a decision about whether and how to act. A factor that plays a role in motivating a response is fear arousal. When the level of perceived hazard increases, people are more willing to look for and read warnings, people are better able to recall the content of warnings and people are more willing to comply with instructions (Wogalter, Dejoy et al., 1999). There is a strong positive relationship between perceived hazard and the intention of taking precautions (Lesch, 2006). Fear arousal is a major aspect of many learning theories and is closely related to other concepts such as anxiety, attention, agitation, stress, and motivation. The arousal level can be thought of as how much capacity you have available to work with. One finding with respect to arousal is the Yerkes-Dodson law (first observed by Robert M. Yerkes and John D. Dodson (Yerkes and Dodson, 1908). It predicts an inverted U-shaped function between arousal and performance. A certain amount of arousal can be motivating to change your thinking and behaviour. However, too much or too little arousal will certainly work negatively. A mid-level of arousal is preferred to provide the motivation to change thinking and behaviour. Too little arousal has an inert affect on the learner, but when levels of arousal become too high, performance decreases. Also, there are optimal levels of arousal for different tasks. The optimal level of arousal is lower for more difficult or intellectually (cognitive) tasks (the learners need to concentrate on the material) and higher for tasks requiring endurance and persistence (the learners need more motivation).

The selection of the response is not the same as the actual execution of the intended response, as environmental or physical factors may make it difficult or impossible to perform the behaviour that was planned.

Feedback

The last phase in the model is the feedback-loop (Wickens and Hollands, 1999). This indicates that actions that are performed are sensed by the human. This means that there is a flow of information and that the behaviour can be adjusted as the situation endures. Moreover, new information about the emergency can be of influence on the behaviour of citizens. Later stages in the model can influence how warning information is processed at earlier stages (Wogalter, Dejoy et al., 1999).

2.2.3.2 Interactive Social Cognitive model

A critical issue in the warning literature is that people do not always follow warnings and instruction that are given. A warning may be noticed, clear and understood, but this does not mean that the instructions will be followed. Non-compliance may occur for several reasons. People may fail to comply with instructions because of over exposure, this is a basic psychological process known as habituation (Kalsher and Williams, 2006). Another reason for non-compliance is when previous non-compliance has not had any negative consequences, has not lead to injury in the past, or when people do not think that the asked behaviour is necessary. The conceptual model from Figure 2-9 can be used to consider factors that potentially increase or decrease compliance to warnings. One purpose of introducing this model, is to consider theoretical perspectives from other fields, especially the social-cognitive research literature (Kalsher and Williams, 2006). This model is based on the human information processing model, and adds the warning that is sent, recipient characteristics and situational characteristics. The Human information processing part is split up into three parts that are considered important in processing warnings and determining the response to a warning. This model meets the first criterion; it incorporates warning, information processing and behaviour. The second criterion is also met; this conceptual model identifies specific points in the steps that have to be taken to warn people where breakdowns in behavioural compliance may occur. For example, in the phase in the model called perceived threat and course of action a breakdown may occur when a warning fails to adequately communicate the magnitude of the hazard to the citizens. Another possibility is that people do know how dangerous the hazard is, but they do not know that for example protective clothing can decrease the danger of the hazard. In each of the steps of this model, breakdowns may occur that prevent people from actually complying with the warning given. The third and fourth criterion are not met, this is again a model that shows the influences on self-reliance, but it doesn't go further to describe how these influences should be investigated. Literature has to be used to determine how each of these influencing factors should be investigated for a specific warning system.

In the Prefactual Thought-phase, the factor 'third person effect' is mentioned (Kalsher and Williams, 2006). This is an interesting issue. People are likely to believe that persuasive messages have a bigger effect on other people (the third person) than on themselves (Stewart and Martin, 1994). This also includes the likelihood of susceptibility to environmental influences such as illnesses or injury. This means that the effect of all general warnings can be decreased because of this effect. Making warnings more personal (for as far as this is possible in warning citizens), may help to counter this problem.

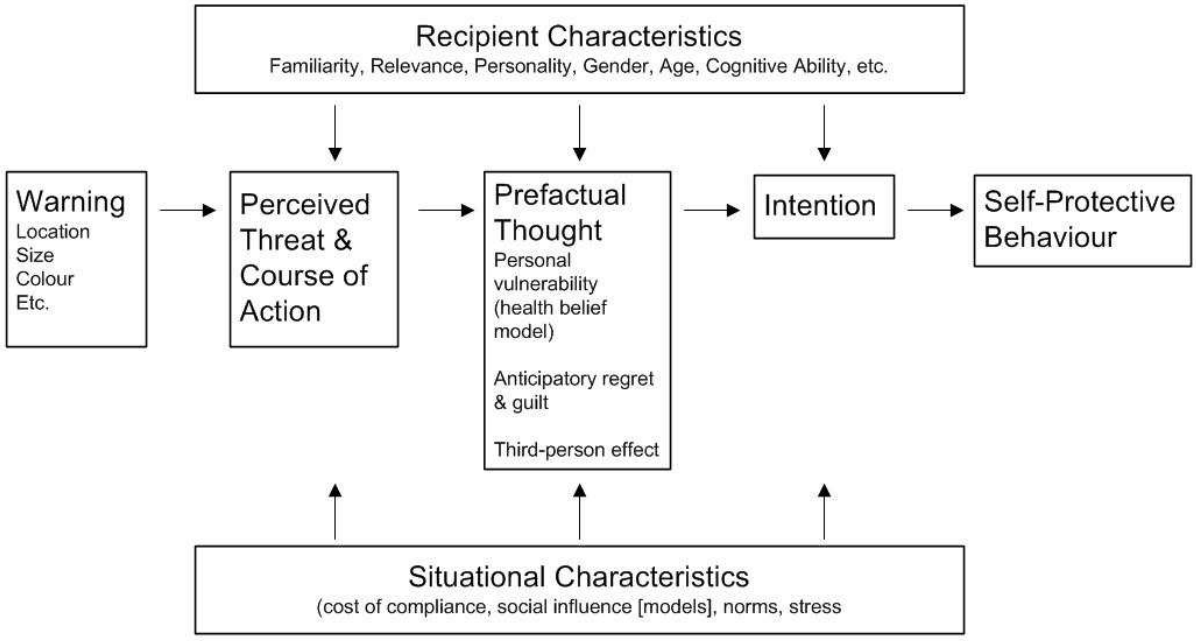

Figure 2-9: Interactive Social Cognitive Model (Kalsher and Williams, 2006)

In relation to warnings, it may occur that people feel that a certain warning is not especially meant for them, but for the 'third person'. This may decrease compliance rates. Personalisation of signs (for individuals or the group a person belongs to) may help in this case (Wogalter, Racicot, Kalsher and Simpson, 1994). Explanations of the other issues mentioned in this model can be read in the chapter by Kalsher and Williams (2006). Mileti and Sorensen (1990) developed a similar model years earlier which is a model of determinants and consequences of public warning response. In this model they include sender factors (message, channel, frequency and source attributes), receiver factors (environmental, social, psychological and physiological attributes) as well as information processing.

2.2.3.3 Other Human Information Processing models

Lehto and Papastavrou (1993) propose a level of performance model, which is based on Rasmussen's model of skills, rules and knowledge (Rasmussen, 1986). Lehto (1991) added a fourth level, namely that of judgement. This model is used to show that warning effectiveness is influenced by many factors at multiple stages of information processing. It can be used to clarify mixed results that are obtained during research into warning effectiveness. For example, a warning sign is likely to have the greatest influence when the behaviour is at a knowledge-based level, and may have little effect when used in a skill-based behavioural setting (Lehto and Papastavrou, 1993). This model satisfies the first criterion, but not the other three. It cannot be used to determine what issues have to be researched, and how their effectiveness of ineffectiveness can be researched. It can however be used when there are difficulties in explaining results obtained in this effectiveness research. Smith-Jackson and Wogalter (2004) also refer to a skills, rules and knowledge-model developed by Reason (1990) to explain and predict possible problems in warning effectiveness.

The models that have been shown in this chapter can, when combined, give a good overview of the influences on self-reliance in an emergency. However, the degree to which they indicate in what manner these influences should be investigated and what the implications of the resulting findings will be is not very high. In the next chapter, the discussed models will be used to form an overall model, showing the different phases in which self-reliance can be influenced and the factors that have to be investigated within these phases. Chapter 4 will then go into the ways in which these factors can be investigated and what the meaning of the results will be for the effectiveness of the warning system under examination.

3. Constructing a contextual model for human information processing in warning citizens

In this chapter, the useful parts of the models discussed in Chapter 2 are used to construct a model which shows all phases in which self-reliance plays a role in warning citizens in an emergency. This model can be used for all existing or new methods of warning citizens in an emergency, to determine whether the warning system will be effective. The model shows the influencing phases on the effectiveness of a warning message. These phases are split up in this chapter into factors that influence citizens' self–reliant behaviour in an emergency. The model can be used to determine what self-reliance issues need to be covered in the research and where improvements in self-reliance can be made. It will also show what parts are easy to investigate and what parts are more difficult or even impossible to investigate, what the implications of these difficulties are for investigating the effectiveness of a warning system, and what the influences of each factor are on the effectiveness of the whole system.

The model looks only at the part of the warning system that has to do directly with the citizens that have to be warned. It looks at direct influences on the citizens. The model does not go into organisational or purely technical issues. Evidently, the warning system has to work technically and the organisational issues concerning responsibilities for sending the warning messages are very important for the warning system to be effective, but these issues are outside the scope of this research. The present research will go into the issues that have to do with the psychology of influencing peoples' self-reliance.

3.1 Modelling influences on self-reliance

In self-reliance, not only the processes inside the human are important, the influences of the context on the human are very strong. That's why it is important to have a model that shows all possible influences on self-reliance. All steps of the model that will be constructed here have to be taken successfully, before the warning message can positively influence the self-reliance of people. A warning system is as effective as its weakest link. This new model is a contextual human information processing model for warning citizens. It will not only show the human information processing, but

also the contextual influences on this information processing. The steps that have to be taken before the self-reliance of people can be improved will be shown in this model.

The model is based mainly on three existing models that have been discussed in Chapter 2. These separate models show part of the whole chain in which self-reliance plays a part when warning citizens. The first model that this new model is based on is the human information processing model as can be seen in Wickens and Hollands (1999) (see Figure 2-8). The second model is the communication model as mentioned in Wogalter, Dejoy and Laughery (1999) which is shown in Figure 2-6. The last model is the Interactive Social Cognitive Model from Kalsher and Williams (2006) that can be seen in Figure 2-9.

3.2 Contextual human information processing model for warning citizens

The three described models are now used to construct the contextual human information processing model for warning citizens (Figure 3-1). When there is an emergency, the authorities will want to make sure that people take themselves to a safe place. They can do this by warning people and giving them instructions on what to do. This contextual model shows what influences there are between the intention of the authority and the actual self reliant behaviour of people. The model starts at the emergency and looks at all the steps that have to be taken to ultimately change the behaviour of the citizens, so that they will be safe. This model can be used to determine the possible effectiveness of a warning system. It shows what issues need to be taken into account when determining what means to use to warn people in an emergency.

The Human Information Processing model (HIP) is the centre of the contextual model. For self-reliance, the human information processing part is very important. This model shows how all incoming information is processed before an individual can use it to alter his behaviour. Around the HIP model, the contextual issues will be added, to show what external influences there are on the information processing of the individual.

First, the response execution part is taken out of the HIP model, as this is considered not to be part of the information processing anymore, but of the behaviour following the cognitive processes. It is an important issue for self-reliance however, so the response execution will remain in the model, it will now be called 'behaviour'.

The communication model is almost invisible in the contextual model. However, it is in there. It determines the order of the model. The source is part of the 'situational characteristics'. The channel is now the 'warning' block, and the receiver is the information processing part.

The third model, the Interactive Social Cognitive Model is used to build the contextual blocks around the HIP model. The 'perceived threat & course of action', 'prefactual thought' and 'intention' blocks are now part of the HIP model. Perceived threat, course of action and prefactual thoughts are part of cognition, they re formed by retrieving data from the long-term memory. Intention is formed in the response selection block, when the decision to comply or deviate has been taken. The situational characteristics and the recipient characteristics are present in a more obvious way. The result is the contextual human information processing model for warning citizens, as can be seen in Figure 3-1.

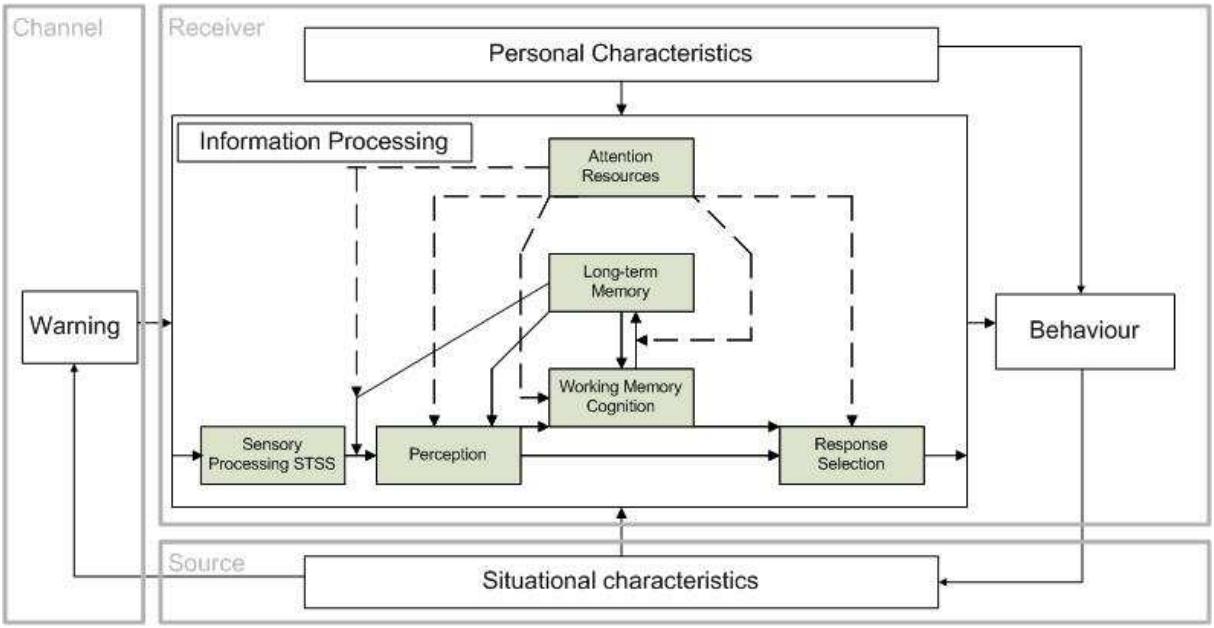

Figure 3-1: Contextual Human Information Processing model for warning citizens.

This contextual model tries to show the influences on self-reliance in terms of the interactions between cognitions, affective states and situational variables. This perspective suggests that critical issues that determine whether a person will alter their behaviour after receiving a warning message or not are dependent on a persons' cognitive or mental representation of the emergency and beliefs about the outcome of their behaviour. How people respond to an emergency, depends partly on their view of the situation, on their perceived vulnerability to negative outcomes of the emergency, on expectations about the effectiveness of the instructions that are given in the warning message, and on their perceived ability to perform the instructed behaviour. These issues are all part of the information processing part of the contextual model. People compare the warning and their perception of the danger to experiences from the past which they retrieve from their memory. All these issues have to be taken into account when determining what message should be sent through what medium. Wogalter (2006) has published a similar model that is aimed at warning messages in general as opposed to the model in this thesis which is aimed at warning citizens in an emergency.

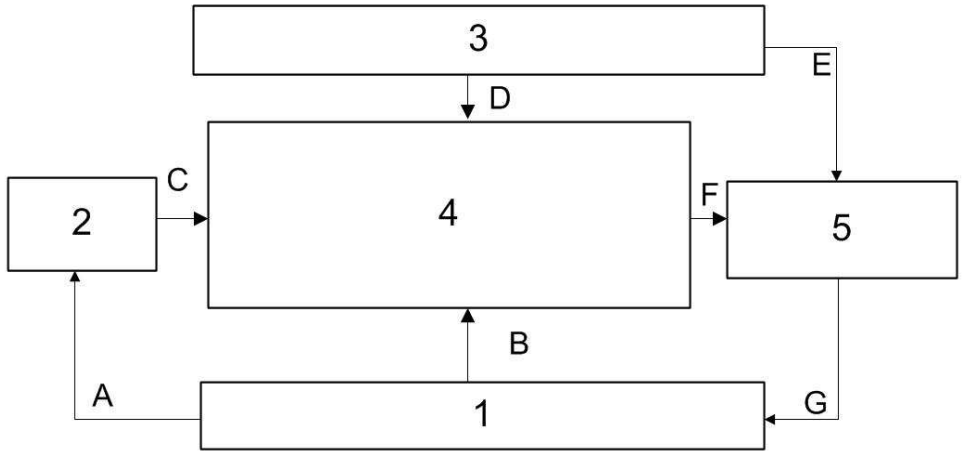

Figure 3-2: Numbered representation of the contextual model.

Figure 3-2 shows a numbered representation of the contextual model. This representation will be used as a whole and in small parts in the remainder of this dissertation to indicate what part of the model is discussed in each paragraph.

Apart from using this model for analysing the behaviour of individuals, this model also includes the behaviour of people when other people are around (which can of course be the case in many emergencies) and are influencing the behaviour of the individual. This model shows the human information processing, which is a model for individuals. However, when a person is in a group, these processes can take place differently, because the person is now influenced by the people around him. For example, when a family is in a house or a group of people is in a meeting when a warning comes in, group perception, group attitudes and beliefs need to be taken into account. A group to which an individual belongs, shapes the attitude and behaviour of people (Milem, 1998). According to Milem, the influence of the group will be proportional to the extent to which the individual seeks acceptance and approval from that group. This means that depending on the composition of the group, the influences of the group on the behaviour of the individuals may vary. These social influences are part of the situational characteristic, as they have to do with the information the individual gets from the environment. The contextual model can be used to investigate these influences.

The next paragraphs will discuss the different parts of the model and the steps that have to be taken to improve self-reliance. The description will show that investigating each step is necessary to improve self-reliance. In chapter 5, in which the model will be applied, the way in which to investigate all these factors and their influences on the whole model will be discussed.

3.2.1 Situational characteristics

The situational characteristics block consists of all the information that is present in 'the world' that can influence peoples' self-reliance in an emergency. This means that information about the emergency situation as well as other information that may influence peoples' self reliant behaviour in an emergency is a situational characteristic. Figure 3-3 shows that the situational characteristics have an influence on the warning that will be given and directly on the information processing of the individuals.

The information about the actual emergency situation (for example a fire and the smoke that comes from the fire) as well as possible information from media and disturbing factors such as conflicting information are situational characteristics. Information about the emergency situation itself, the so-called hazard is part of the situational characteristics, as mentioned before. In the case of warning citizens, a hazard is usually a dangerous situation or a threat of a dangerous situation that may emerge at a certain location, for example an explosion at a chemical plant, followed by a cloud of some dangerous substance. A consistent finding in warning research is that people's perception of the hazardousness of the situation is an important determinant of warning effectiveness (Laughery and Brelsford, 1994). This indicates the importance of communicating what is going on when there is an emergency. There is of course a trade off between giving information quickly and giving information accurately in an emergency. This may indicate that it is necessary to first warn people quickly, and with the information available at the start of the emergency, and later sending a following warning when more information is available. Research can be done into what is the optimum in this. Hazard perception may include notions on likelihood of an emergency as well as the severity of the consequences of the emergency. The greater the perception of a hazardousness, the more likely it is that peoples' self-reliance will be improved and that they will take safety precautions (Laughery and Brelsford, 1994). Unlike with product familiarity, familiarity with high-risk activities may increase compliance with warnings (Vredenburgh and Zackowitz, 2006). This means that when people live in an area with for example an industrial plant, and they know about the work that is done there and the risks it incorporates, people are more likely to act when they will get a warning message concerning the plant.

There are two ways in the model for information from the situational context to arrive at the individual. The first one is the warning that the authority gives to the individual to make him comply with their instructions (arrow A in Figure 3-3). This arrow shows the influence of the emergency situation and the information that the authorities intend to send out on the construction of the actual warning message. Moreover, this arrow also covers the information that citizens want and need to get from the authorities through a warning message in order to be able to improve their self-reliance and attitude towards the warning system. For example, the text in the warning is set up by the authorities and this text has to be legible, understandable and convincing for the receiver. So, the way in which the warning is set up, is of great importance for improving self-reliance.

Beside information through warnings, an individual will also get other information about the situation (arrow B in Figure 3-3). Flames or smoke may be visible for example. Or no signs at all of an actual emergency can be observed. There could also be conflicting information from the media or neighbours or rumours that go round. These situational factors are very hard to control in the warning process, but are of influence on the behaviour of the individual. Arrow B represents all other information about the emergency: direct information about the emergency, as well as information through the media or other people. All this information gives a certain picture of the actual emergency situation that is usually not complete (because not all the information is observed by the individual) and can even contain wrong information. Information from the media, other than the actual warning is an example of a situational characteristic that can be observed through arrow B. Information in the media can give information that is supporting the warning or that is conflicting with the information in the warning. This is of influence on the self-reliant behaviour of the individual.

Moreover, information that has nothing to do with the emergency, may also influence self-reliance through arrow B. Information, not related to the emergency, which is received by the individual, may interfere with receiving or understanding important information about the emergency. In the model, part of this last issue is dealt with in the warning and human information processing paragraphs, as these issues have a strong relationship with these blocks. For example background noise may interfere with people noticing a warning (in the warning paragraph) or work stress may blur a persons' judgement on the urgency of a warning (in the human information processing paragraph).

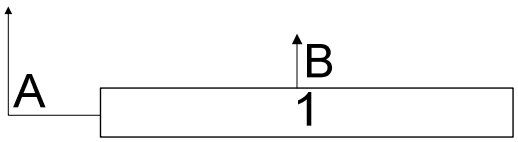

Figure 3-3: The influence of situational characteristics on compliance with warning messages.

Furthermore, social influences (how do other people act, how do other people feel about the warning information), stress and many more issues have an influence on how an individual will respond to an emergency. Social validation is of influence when the presence of other people serves as a model. This can affect the judgement and behaviour of people (Vredenburgh and Helmick-Rich, 2006). This phenomenon has also been found in research into compliance with warnings. The research (Wogalter, Allison and McKenna, 1989) suggests that if someone is observed heeding a warning, others are likely to do the same. The common finding in studies into social influence and compliance behaviour indicates that people are influenced by and follow the behaviour of others. Conformity often occurs when there is only one other person or when a majority of a larger group that show a certain behaviour (Vredenburgh and Helmick-Rich, 2006).

Summarising, the factors that have to be investigated from the situational characteristics part of the model are:

- Information through a warning message (Arrow A)
    - The situations in which people want to be warned

    - Information intended to be sent by the authorities
- Other information (Arrow B)
    - Direct information about the emergency (smoke / flames)
    - Indirect information about the emergency through media and other people (including social influences)
    - Information that has nothing to do with the emergency, but which may influence the self-reliant behaviour of people

3.2.2 Warning

The goal of a warning is to warn people that something is going on and that action is needed for them to stay safe / get to a safe place. Improving the ability of people to bring themselves to a place of safety, to improve their self-reliance, can be done by giving warnings and instructions during an emergency situation. Giving warnings to people has three main goals (Kalsher and Williams, 2006). Warnings are a method to communicate safety related information, so that people are able to make better decisions concerning their safety. Second, they can be used as a reminder to people who already know a certain danger, but may not be consciously aware of them. And third, warnings should motivate people to show safe behaviour and are ultimately intended to prevent injury or mitigate the consequences of a disaster. These warnings with instructions can be present in the building as flight plans, signs and emergency lighting. They can also be used by the building management to give extra instructions during an emergency, in intercom messages or mobile phone text messages. Intercom messages can be pre-recorded or 'live'. The advantage of live message is that new instructions can be given as the emergency situation develops. Also, the tone of the voice message can convey its urgency (Bellamy and Geyer, 1990; Burt, Bartolome, Burdette and Comstock, 1995; Proulx, 2000).

A warning message (the block in Figure 3-4 has to be constructed in such a way that it will reach as many relevant people as possible (Reach). Moreover, it has to be easily comprehensible, and likely to motivate people to start acting (Content).

3.2.2.1 Reach

The message has to be sent through a channel that ensures that people are actually exposed to the warning stimulus. As many relevant people as possible have to be reached. This means that a warning system should be used that is active; it actively warns people that something is going on. It should be able to reach many relevant people. This indicates that people should be able to hear or see the warning at all times in all places, either because it is visible or audible everywhere like a siren, or because there is a warning device (like a mobile phone) that people always carry with them, that can warn them. This also indicates that there should be a government or institution that is able to send out this message in a way that it can be reached by a large number of relevant people. Moreover, the warning has to be disseminated promptly by this organisation (Parker and Handmer, 1998; Samarajiva, 2005). This thesis will not go into the organisational part of sending warning messages, as has been explained before, but this is an important issue concerning the possibilities for a warning system to be effective.

Different experiments (Wogalter and Young, 1991; Wogalter, Kalsher and Racicot, 1993) have shown that voice warnings show greater compliance rates than comparable print warnings. Advantages of voice warnings are that they are attention getting and omni-directional. Moreover, reorientation of attention away from a visual task is not necessary. However, voice warnings are not appropriate for very long messages and they could be masked in a noisy environment. Furthermore, they cannot be heard by hearing impaired people. This shows that the optimal means of sending a warning message very much depends on the context in which it is sent. Selcon and Taylor (1995) showed that when high priority warning information is obtainable from more than one source for pilots, responses are significantly faster. This is the case between one or two sources, even up to the difference between 3 or 4 sources for the same information. This last difference is still significant.

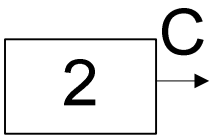

Figure 3-4: The influence of the warning on compliance with warning messages.

When determining the effectiveness in terms of reaching as many citizens as possible, two methods can be used. A criterion can be set, a percentage of relevant people that has to be reached. Another method is to compare the reach of the new warning method to the existing method. In this manner, an absolute reach can be determined as well as the profit of the new method. This profit exists if there are people that are warned by the new method, but that are not warned by the existing warning method. A criterion can also be set for this profit. Of course both methods can be used together.

Furthermore, besides determining the reach of a warning method, it is also important to determine the reasons for non-reach. Insight into the reasons why some people are not warned, can give implications for improvements and information on existing problems that may or may not be solved.

3.2.2.2 Content and Design

Finally, the content of the message is very important. The message has to contain the right amount and type of information. If the warning describes that character of the impending hazard well, people are better able to understand the logic of the instructions towards taking protective actions (Mileti and Peek, 2000). This will make it possible for people to judge the seriousness of the situation correctly and this will motivate them to start acting. Moreover, the warning should include information about the location of the hazard, as the degree of risk is a function of the proximity to the hazard (Mileti and Peek, 2000).

The text or other type of information has to be legible and easy to understand. The design of the warning also needs attention. Colour (Adams and Edworthy, 1995; Williams and Noyes, 2007), size (Adams and Edworthy, 1995), location (Wogalter, Kalsher et al., 1993; Frantz, 1994), conspicuousness (Jin, Yamada, Kawai and Takahashi, 1991), use of symbols (Stewart and Martin, 1994; Wogalter and Young, 1998) and proximity (Meyer, 2001) of the warning may be of importance for noticing, understanding and perception of relevance of warning messages (Wogalter, Kalsher et al., 1993). When all these issues are taken into account, many people will notice, read, understand and act upon the warning messages (Purswell, Krenek and Dorris, 1994).

Summarising, the factors in the warning paragraph that need to be investigated are:

- Reach
    - Reach (absolute values and values compared to current warning system)
    - Non-Reach (explain all cases of non-reach)
- Content
    - what information
    - length of messages
    - design of the warning (location, font, colour, size, medium)

3.2.3 Personal characteristics

Personal characteristics are factors within a person that may influence the self-reliance of that person directly or through the information processing block. This may be psychological factors as well as physical factors.

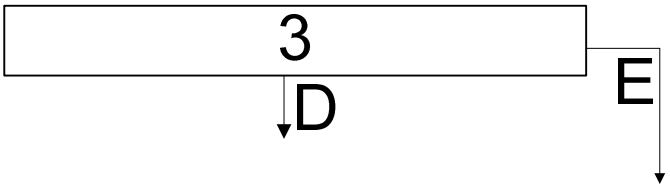

Figure 3-5: The influence of personal characteristics on compliance with warning messages.

Examples of personal characteristics are gender, age, level of education, physical ability, familiarity with the use of technology and so on. In this dissertation, these factors will be looked at in retrospect. When results of the research questions are known, there will be a check whether there are any differences for several personal characteristics, in order to check the representativeness and the generalisability of the studies. In this manner, the possible need for adjusted messages for certain groups of people can be determined as well. The influence of the factor physical ability is mostly through arrow E on the block behaviour in the contextual model, as people with physical disabilities may not be able to perform the instructed action.

The factors that need to be investigated from this paragraph are:

- Psychological factors
- Physical factors (disabilities)

3.2.4 Information processing

When a warning message is sent, it has to be noticed and processed by the individual; this is block 4 in the contextual model (see Figure 3-6). The warning has to be read or heard, understood and acted upon. There are many factors that can influence this process. First, there must be active processing of the warning message. The message has to gain access to the senses in such a way that the individual notices that a message comes in. This means that the warning should be noticeable over noise in the environment. Then, the importance of the message should be clear, so that the chances are increased that the individual will read or listen to the message immediately. This can be done for instance by a distinguishing sound. These factors are covered in the paragraph about warning, as the warning directly influences these issues.

3.2.4.1 Attitudes

After that, the subject must comprehend and agree with the warning message. This means that the warning should contain enough relevant information to enable the individual to make a correct decision about the situation. The message has to be easily understandable and legible / audible in the format that is used. This includes matching the expectations and mental models of the recipients. In this phase, the individual will recall warnings in the past as well as other information on emergencies that has been stored in the long term memory. Peoples' attitude towards the warning system has to be such that they are willing to use it. When the warning system includes an item that people have to carry with them, it has to be certain that people carry the warning device with them at all times in order to be able to reach them. In this last case, their attitude towards the warning system is very important. People have to be willing to carry the device with them and actually do so. Influences on peoples' attitude can be the opinion of people on the current warning system and connected to that the opinion of people on the need for a new replacement or additional method of warning. Also, the opinion of people on the authority that is sending the warning messages can be of great influence (Baron, Byrne et al., 1998). In 1987 there was a fire (in which 31 people died) in the King's Cross subway station (Crossland, 1992). At the time, this was the busiest and most complex station on the London Underground network (Turner, Thompson and Rosser, 1995). At the time of the fire, there were 250.000 passengers a day travelling through this station. There was a small fire that rapidly spread out of control on one of the wooden escalators, about one third up. The escalators (there were

three escalators next to each other) were then stopped and taped off, but some people continued to use them despite instructions by the staff not to. Research showed that people from the public tried to stop people from entering the main ticket hall, or from using the escalators, but they were ignored. The underground staff was also ignored, unless their instructions were backed by either the Fire Brigade or Police. Interviews afterwards showed that people do not expect much from the underground personnel, which makes them distrust their instructions (Donald and Canter, 1990). In contrast, as far as can be ascertained, everyone followed the instructions given by the uniformed police officers. This shows that authoritativeness is a very important factor in warning people.

According to Eagly and Chaiken (1993) "attitudes are evaluations of aspects of the social world". They refer to how positive or negative we are about some object or entity. The attitudes we have about subjects are evaluative associations that are stored in our memory (Fazio and Roskos-Ewoldsen, 1994). Attitudes are very important, as they influence social thought. It influences how we think about and process social information. Attitudes often work as schemas. Schemas are cognitive frameworks that contain and organise information about certain specific concepts or situations (Wyer and Srull, 1994). They influence what we notice, what enters the memory and what is remembered later (Baron, Byrne et al., 1998).

The information that plays a part in this phase, where memory and cognition based on situations in the past influence the behaviour, will be investigated in this block of the contextual model.

In this phase, the individual deliberates on the authority of the warning and other aspects that are important in deciding whether this message is credible and whether action is really needed. With the current siren, the individual has to remember what to do when it sounds from earlier media campaigns.

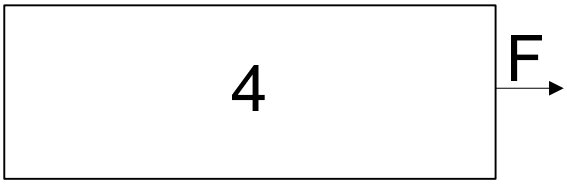

Figure 3-6: The influence of human information processing on compliance with warning messages.

Some of the main factors that can influence compliance behaviour are cost of compliance, severity of injury, social influence and stress (Kalsher and Williams, 2006). These are factors that people will take into account when in the information processing phase. They will deliberate on all these factors (consciously or unconsciously). Self-reliance requires people to take some sort of action, and this is usually accompanied by a certain cost. This cost may consist of extra time or effort to carry out this behaviour. When people feel that the cost of compliance is too high, for example when they believe that the proscribed behaviour will take too long, cause too much discomfort, or is too expensive, they are less likely to perform the behaviour they are instructed to perform (Kalsher and Williams, 2006). Warnings are most effective when the benefits associated with self-protective behaviour are heightened or the costs and barriers are reduced (Wogalter, Godfrey, Fontanelle, Desaulniers, Rothstein and Laughery, 1987). The cost should be as low as possible to achieve the highest possible compliance rate (Vredenburgh and Helmick-Rich, 2006). One way to reduce cost of compliance is to make the directed behaviour as easy as possible.

The cost of non-compliance can also have a great influence on the motivation of compliance. With warnings, this usually means that the consequences of noncompliance will be some sort of injury, fine or loss of a job. The perceived benefit of noncompliance is of particular concern, according to Clark and Lehto (1999). They hypothesise that operators may ignore warnings and intentionally enter hazardous work areas to save time and to avoid inconveniences, to search for children and other family members, or even just to collect their belongings. When people have a clear idea of the severity of injuries they might obtain, this has an effect on peoples' hazard perception and the

willingness to comply. When people perceive a greater level of hazard associated with using a product (and thus a high cost of noncompliance), they are more likely to search for and comply with warnings (Vredenburgh and Helmick-Rich, 2006). This shows that the safety can be improved by reducing the cost of compliance, increasing the cost of noncompliance, and emphasizing the negative consequences of product misuse (Zeitlin, 1994).

When the individual decides that there really is an emergency and that action is needed, the decision to comply is taken and a response will be selected. Whether this response will actually be executed, depends on several issues that will be explained in the next paragraph. In this phase, meaning is given to the warning message; is this really an emergency, is it important for me to act, and when contemplating an alternative warning system that can give textual messages: is the message clear on what to do, can I follow these instructions?

The factors from this paragraph that need to be investigated are:

- Attitudes towards
    - warning system / device
    - authority sending the warning messages (credibility, authoritativeness)
    - need for additional / replacement warning system
- Capacities that are needed to be self-reliant following a warning message, including: knowledge (hazard, protective action, plans), cognition and experience (type, recency)

3.2.5 Behaviour

When the decision whether or not to comply with the instructions in the warning message is taken, an appropriate response must be selected and this response must be performed (this is block 5 in the contextual model, see Figure 3-7). Whether this response is actually performed depends on several factors. Physical ability can influence the possibilities to follow the instructions in the warning message. For example, when people are told to leave a certain area on foot and to leave their car behind, this may be impossible to comply with by people with physical disabilities. New information from the situation can also make it impossible or irrelevant to perform the requested actions. For example an exit route can be blocked because of new developments in the emergency, or when a message is sent that there is danger of explosion, and later information informs people that there is a fire in stead if an explosion may render it unnecessary to still comply with the instructions to leave the area. Social influences can also have a great impact on the behaviour that is shown, even if people actually have other plans. When people see that other people do not respond to the warning, this may influence their behaviour. According to Dijksterhuis (Dijksterhuis, 2007), imitation is very important in social interactions. The more a person imitates another person or group of persons, the more this person is liked and the better they can cooperate with that group. Without knowing, we like people that imitate us more than those who don't. In an emergency this means that when people are part of a group, and the rest of the group doesn't start to act upon a warning message, individual members of the group are very likely to do the same. It is also possible that one person decides to act and that others decide to imitate this person, so imitation can have a positive as well as a negative influence in an emergency. On the other hand, when people in a group show the same behaviour, this is not always necessarily imitation, it is also possible that several individuals decide to show certain behaviour independent of each other.

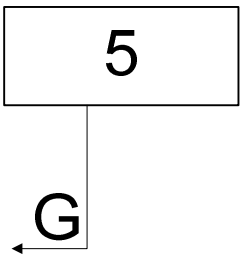

Figure 3-7: The influences on behavioural compliance with warning messages.

For ethical reasons, we cannot expose people to a real emergency on purpose; therefore it may be almost impossible to measure peoples' behaviour in an emergency. It is possible to conduct post-hoc studies to find out what people did (within the limits of their memory), but this may be coloured by information from the media, or discussions with other people in the emergency. It is also possible to try to approach the behaviour that people would show in an emergency. This may offer insight into possible responses of people in a real emergency. In order to test whether people understand the warning messages, several simple and more complex tasks can be given, to determine whether people notice the warning, read the warning and are willing to use the warning method and whether they are willing to perform the behaviour that is asked.

Willingness to comply with instructions given by authorities may differ between individualistic and collectivistic countries. According to Fukushima & Sharp (2009): "Individualism means placing a value on individual identity over group identity, individual needs and rights over group obligation, and individual pleasure over adherence to group norms. Collectivism on the other hand, grants priority to group identity over individual identity, shared in-group beliefs over unique individual beliefs, and cooperation with in-group members over maximizing individual outcomes". Their paper concludes that Japanese students are more compliant with norms than American students. This means that collectivistic countries may need a different type of warning message than individualistic countries. Further research needs to be done into what differences in warning messages are needed to obtain optimal responses for both types of cultures. This different response to compliance requests is backed up by a lot of literature. For example Cialdini (2005) distinguishes six different social influence principles: commitment / consistency, reciprocity, social proof, authority, liking and scarcity. People from more collectivistic countries are more likely to be persuaded by the social proof principle (this principle states that we view behaviour as more correct if we see other similar people perform the same behaviour), while people from a more individualistic country are more easily persuaded by the commitment / consistency approach (this approach is built on the knowledge that people want to be consistent with earlier choices or behaviour. Based on this study by Cialdini the conclusion can be drawn that collectivists are more willing to comply with a requests that is made by similar others, whereas individualists are more willing to comply with a request that corresponds with positions that they have committed to previously, as these positions reflect their personal attitudes (Schouten, 2008). Bond and Smith (1996) also indicate that individuals from collectivistic cultures should be more likely to yield to the majority, given the higher value placed on harmony in person-to-group relations.

In the next chapter, the possibilities for additional warning methods will be discussed. After that, the warning system effectiveness studies that have been chosen to be used as examples when applying the contextual model in this thesis will be explained.

The factors from this paragraph that need to be investigated are:

- Willingness to act
- What kind of behaviour do people actually show following a warning message?

4. Introduction to the warning system effectiveness studies

In order to test the applicability of the contextual human information processing model for warning citizens, two warning system effectiveness studies that were done by the author and colleagues (Sillem, Wiersma, Ale and Eysink Smeets, 2004; Jagtman, Wiersma, Sillem and Ale, 2008) were analysed in depth. This course of action was chosen because applying the theory requires deep insight into the ins and outs of a warning system effectiveness study. The nature of these studies is such that multiple sources of evidence are used, ranging from interviews, reaction time measurements and questionnaires to laboratory experiments. Using different sources enables triangulation of data, which improves the 'construct validity' of the results, that is, the establishment of adequate operational measures for the construct under study (van de Riet, 2003).

The case studies stem from the field of mobile phone technologies. Section 4.1 explains the possibilities for additional warning systems and the reason why the two studies that were evaluated in this thesis were chosen to be researched. Section 4.2 will go into the technologies that were investigated in the two studies. Section 4.3 explains how the warning cycle for these two technologies works. Section 4.4 shows the parameters that were studied in the two studies that will be evaluated in Chapter 5. Section 4.5 will show all the phases of research in the two studies.

This chapter is an introduction to SMS and cell broadcast, as well as an introduction to the case studies that were done. These SMS and cell broadcast projects did not have exactly the same research questions as this thesis. That is why some categorisations that are made in this chapter cannot be found in the contextual model (Figure 3-1). They are mentioned here however, because they are necessary to explain how the research in these projects was done.

4.1 Additional warning methods

Many aspects of a possible warning medium are important for the possibilities of using it for warning citizens. Figure 4-1 shows that there are two parts to the process of warning and informing the public in case of an emergency. The first part is to alert people that something is going on. The second part is providing further information once people are warned. This alerting of people should be done by a

medium that demands the user's attention, such as the siren does by giving a loud and alarming sound. This medium should be switched on (or stand-by) permanently, so that people can be warned at all times.

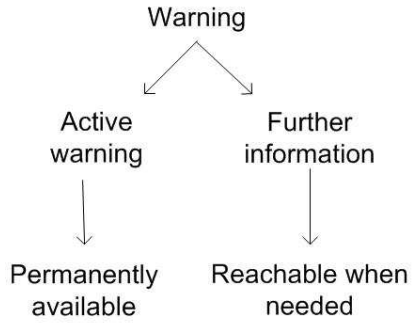

Figure 4-1: Warning and information facilities in an emergency

TV and Radio for instance, are not effective in alarming citizens, because they cannot reach people when they do not have the TV or Radio switched on. Moreover, when staying outdoors, people normally do not carry a TV with them. Recently, this issue is changing. More and more cell-phones have internet and TV available. This may improve the possibilities for warning through radio and TV in the future. On the other hand TV and Radio are very effective means of giving further information after people have received an initial warning.

Besides asking peoples' immediate attention, it is necessary that the warning medium can warn you at any time of day. This means that the medium has to be something like a siren or voice system that can be heard outside or an item that you carry with you at all times. A special item could be designed to carry with you at all times, but it is unlikely that this will be successful. Because the warning hardly ever sounds, it is a burden to carry something with you that will probably never be used. However, a mobile phone is something that most people already carry with them at all times and that can be used for many other things than just warning. Mobile phones are able to demand your attention, and because most people already carry a mobile phone with them, the possibilities for effectively using mobile phone text messages in citizens warning seem to be great. Mobile phone text messages can be used to give people information about an emergency. These facts make mobile phone technologies a very attractive option as an addition to the siren.

When the research for this dissertation had just started, the opportunity arose to investigate the effectiveness of two mobile phone technologies for warning citizens. These mobile phone technologies both use text messages. In a series of field and laboratory experiments in projects for the Ministry of the Interior, the safety region Rotterdam-Rijnmond and the city of Vlaardingen, the effectiveness of these two technologies were investigated in these studies. In this dissertation, the way in which these two technologies have been investigated will be compared with the contextual model, to see whether all aspects of the model are covered.

To reach an improvement in self reliance in an emergency, all steps of information processing as represented by the contextual model have to be taken successfully. To determine whether these empirical studies into using mobile phone technologies for warning citizens cover all the steps that have to be taken to achieve compliance, the studies that have been done will be fitted into the contextual model. In this manner, it will be made clear whether all steps are covered and where there are difficulties in researching the influences on self-reliance.

The next paragraphs will show how mobile phone technologies work and how they can be useful in warning citizens.

4.2 The field of mobile phone technology

GSM (Global System for Mobile Communication) is the most used standard for mobile phone technology in the world. It is used by over 2,6 billion people in 210 countries (Wireless-Intelligence, 2008). When a mobile phone is switched on, it starts searching for signals from available GSM antennas. Every antenna sends radio signals to all mobile phones in its area. This area is called a cell (hence mobile phones are also called cell phones). Based on the strength of the signals from the antennas (whereby the strongest signal is chosen, which is usually the closest antenna) and contract data (whether the phone is allowed to call through this provider, which is checked through the HLR, the Home Location Register), the phone makes a decision what antenna to connect with. This GSM mast (a BTS – Base Transceiver Station) has three antennas, together covering an area of 360 degrees. When a phone call is made, the antenna that the mobile phone is connected to, transfers the call to a central point, the BSC (Base Station Controller), from where the call is forwarded to the receiver.

Since the start of the GSM network in 1993, the use of mobile phones for text communication has grown explosively. Two billion text messages were sent in The Netherlands in 2002. This is an average of 125 messages for each inhabitant. In 1999, this number was only 500 million, so the amount of messages has increased by 400% in only 3 years (Consumentenbond 2003). In 2004, about 84% of Dutch society actively used a mobile phone (Derksen 2004). Worldwide this is 60% in 2009 (Barker, 2009). This market share will most likely continue to increase in the coming years. This high coverage in The Netherlands makes mobile phone technologies an interesting possible addition to the siren. Besides the high number of people that use a mobile phone, the mobile phone networks have coverage in at least 98,6% of the country (Groen 2006). However, the limitations of mobile phone technology, such as the possibility of a battery running out of power and not constantly carrying a mobile with them raises the question whether this technology can be used as a replacement of the siren, or only as an addition. The buddy-system, where people warn others after receiving a cell broadcast or SMS message can help decrease this problem. This will be discussed later in this dissertation.

Research by Vilella et al. (2004) in which patients were reminded by a mobile phone text message (known in The Netherlands as SMS, which stands for Short Message Service) about getting their second Hepatitis A vaccination before going on holidays, shows that SMS can improve the transmission of information. Their results show that SMS can be used to increase compliance with vaccination schedules and very probably with other preventive or therapeutic measures.

Mobile phone providers have the possibility to send large groups of identified users a specific message simultaneously. Advantages of mobile phone technology as an addition to the siren are:
Mobile phone text messages offer the opportunity to send more information than the siren can give. The siren is only an alarming sound without further information. Instructions can be added to the text messages
Mobile phone text messages offer the opportunity to send differentiated messages to different target groups. For example it is possible to differentiate between professionals that have specific roles in an emergency situation and the general public.
Mobile phones can be equipped with a vibrating alert. This is a possibility to inform the hard of hearing and deaf about an emergency situation through the use of text messages.
Mobile phone text messages offer the opportunity to inform other people that cannot hear the siren, such as people that live in remote areas.

There are two main technologies that can be used for sending a text message to large groups of mobile phone users: text messaging and cell broadcast. When using these technologies, a text message will appear on the screen of the mobile phone user. There is no difference in this part of the technology. There are, however differences between the two systems. These differences that have a bearing on its use for warning citizens will be explained in the next two paragraphs.

4.2.1 Text message function or SMS

The first technology, text messaging, uses the text message function, which is a well known mobile phone function. With the SMS service, a message is sent point-to-point to a specific predefined set of phone numbers (an example of an SMS message can be seen in Figure 4-2). This means that each message is sent separately to each receiver. In this case, the people that receive the message are known, but their location at the time of receiving is unknown. The fact that these messages are sent to a specific group of people means that the phone numbers of these people have to be known. Messages are stored in a buffer between the sender and the receiver, so that a message can also be received at a later point in time when the mobile phone of the receiver was switched off at the time of sending. However, using SMS also has some disadvantages:

Because of the technology used, the capacity of the network for SMS is limited; each message uses a certain amount of bandwidth. This could be a problem in a crisis-situation, when the network is easily overloaded in case of warning a large number of people in a limited-sized area (Cel@lert 2005). Research is being performed to find more intelligent and dynamic routing infrastructure in SMS networks and to find more efficient short message transmission (Naor 2004; Prieto, Cosenza et al. 2004; Prieto and Stadler 2005; mBalance 2006; NeoMatrix 2006).

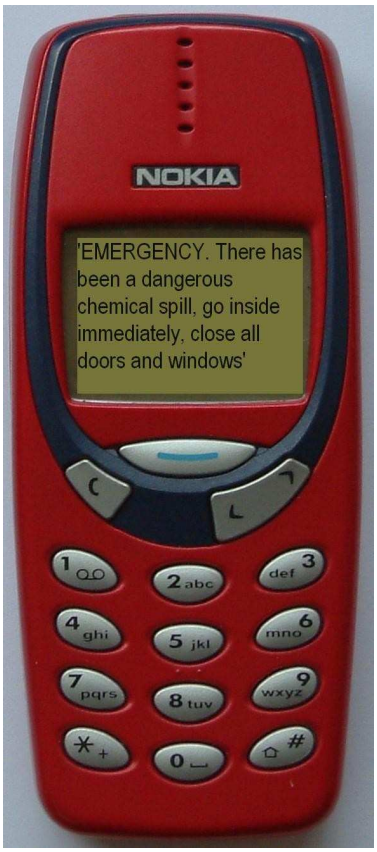

Figure 4-2: Example of an SMS message

Another problem is posed by the current privacy laws in The Netherlands. These forbid sending a message to a list of people or even having such a list without their permission. This means that a mobile phone user always has to apply for the SMS service before messages can be received. So, when people are visiting an area they don't usually go to, they will not receive a message.

Moreover, as an SMS message is sent to a specific person and not to people in a certain area, the location of people at the time of an emergency has to be known. Otherwise, an SMS message has to be sent to the whole country. So, to be able to know where people are, they can indicate, when they apply for the SMS service, a number of locations (for example zip code areas) that they regularly visit. The number of locations (zip code areas) can be chosen by the applicant. They will then receive messages when an emergency occurs in any one of those areas, irrespective of their actual presence in those areas. When something happens in a certain area, all users that have applied for that area are warned, even when the user is not in one of those areas. When people are in an area they did not apply for, they will not receive an SMS message in an emergency. In other words, SMS messages will be received independent of location.

To summarize, in order to be able to receive an SMS warning message, a mobile phone user currently has to:

- Apply for the SMS service
- Apply for the area for which the warning message is relevant;
- Switch on his mobile phone, and
- Be connected to a network that does not suffer from network congestion when the message is sent
- Not mind that they will receive a warning message regardless of their current location

4.2.2 Cell broadcast

The second alternative is cell broadcast. Cell broadcast uses a message service in which a message is sent point-to-area to all users within a certain cell. The term broadcast is used because of its similarity to radio broadcasting. It is a one way communication system. A message is broadcasted into the air and a mobile phone tuned to the channel that is broadcasting, can pick it up at the moment it is sent out only. It can not be traced back later as is possible with an SMS message.

Figure 4-3: A mobile phone antenna

A cell is a geographical area around a certain mobile phone antenna (an example can be seen in Figure 4-3) or a set of antennas. A mobile phone is always connected to one and only one antenna, the one that has the best reception at that moment. Every phone in contact with a certain antenna will receive the message that that antenna broadcasts. This means that it is possible that a certain mobile phone is inside the area that needs to be warned, but is still connected to an antenna outside the area, because of better reception, which results in not receiving the message. Using this technology, the warned geographical area is known, but the people that have received the message remain unknown, just like with broadcasting radio. This makes this service anonymous and free of charge for the receiver. It is however possible to equip mobile phone with software that sends back a message when a cell broadcast message is received, so this problem of not knowing how many relevant people received the warning message is solvable. With cell broadcast, again like with radio, the messages are not stored in a buffer before sending. They are sent out in real time and received by switched on mobile phones. If a phone is switched off, the message will not be received when the phone is switched on later. This problem can partly be solved by repetition of the message. The same message can be broadcasted a number of times with a certain repeat rate. The message should only be received by a mobile phone once. Unfortunately, because of lack of standardization at this moment, some mobile phones will also receive all the repeated messages.

A message can be sent to one cell, or to a set of cells within one area up to an entire network. With cell broadcast, a certain channel on each mobile phone has to be activated in order to be able to receive messages, just like tuning in to a radio station. Cell broadcasting places a very low load on the network; a cell broadcast message to everybody in the network is equivalent to sending an SMS message to a single phone (Cel@lert 2005). Network loading problems can cause severe problems in emergency situations when network usage is likely to be very high anyway and in these circumstances SMS messages can be delayed for hours or days or even be lost altogether. Cell broadcast messages are sent with a different technology. They can still be sent when the network is overloaded. To summarize, in order to be able to receive a cell broadcast warning message, a mobile phone user has to:

- Have predefined the channel of the message that is sent (citizens warning channel)
- Have his mobile phone switched on at the time of sending
- Have to be in the geographical area in which the message is sent at the time it is sent.

4.3 Warning cycle

Figure 4-4 shows the warning cycle (Jagtman, Wiersma et al. 2006) that has to be passed through when text messages (SMS or cell broadcast) are sent to warn citizens in an emergency. This cycle also fits into the contextual model in Figure 3-1. However, the alarming cycle is a bit more specific in terms of the steps that have to be taken before a message is actually sent (up until point B). These steps all fit into the situational characteristics part of the contextual model.

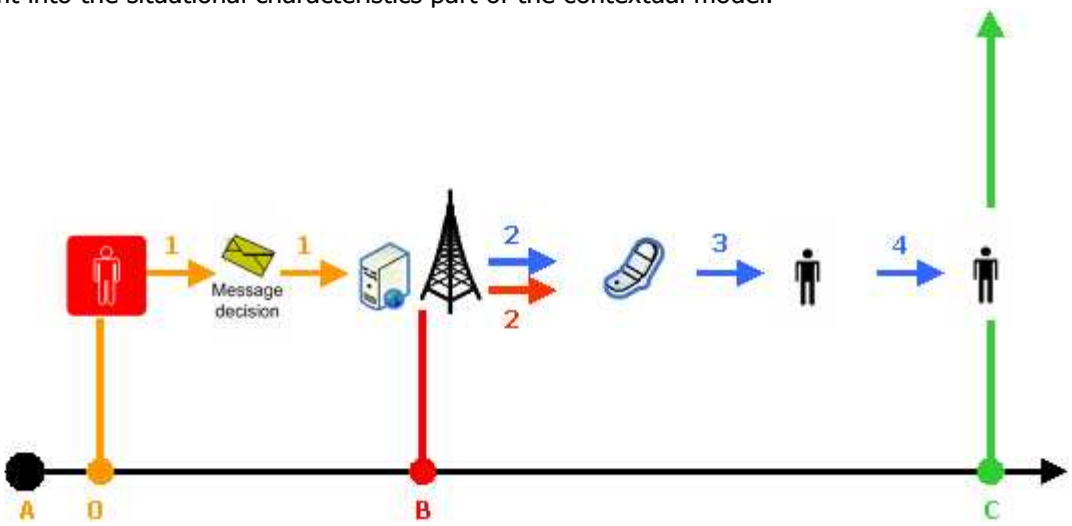

Figure 4-4: Operation warning cycle when using mobile phone technology for citizens warning (Jagtman, Wiersma et al. 2006)

The three general phases in this model are visualized by means of the letters A, B and C. The numbers 0 up to 4 further specify the phases when using mobile phone technology as a system to warn citizens. Phase A is the start of the event that causes the emergency. This can be something like a paper basket that starts burning, a short circuit in a meter cupboard, or a leakage of a chemical substance. The moment of the start of the emergency is usually unknown. At some point the fire or other event will be discovered by someone, but at that time, the time at which the emergency started is unknown. Point 0 is the identification of the emergency by a person or by a detection system. When the emergency is detected, the decision about the necessity to warn people and to send out a text warning message using a citizens warning system is made. After making the decision to send a message, the message has to be constructed or chosen from a list of messages that have been constructed earlier. This happens at point 1. The type and contents of the text message have to be chosen, based on the characteristics of the emergency at hand.

Then, in phase B, the alarm system is activated. In this phase, the messages are sent to the citizens mobile phones. At point 2, the messages are sent via the mobile phone antenna system of the mobile phone network to individual mobile phones (this is block 2 and arrow c in the contextual model). Next, the messages arrive at the mobile phones and they have to be noticed by the receivers. At point 3 the individual citizen has to read and at point 4 understand the text warning message. Then people have to make a decision whether to act upon receiving the warning message. These steps fall into block 4 and arrow F of the contextual model. The last phase is phase C, where the citizens act as a result of text warning message. This is block 5 and arrow G of the contextual model.

The next section will explain the way in which the effectiveness of SMS and cell broadcast for warning citizens has been investigated and how the experiments have been fitted into the contextual model. The aim and research approach of the SMS and cell broadcast research will also be given.

Then, in chapter 5, the way in which the contextual model should be applied will be explained thoroughly, using the research that has been done into SMS and cell broadcast as examples, to see how the effectiveness of these two technologies has been investigated and to determine whether all

parts of the model have been investigated thoroughly. In addition, the application of the model is described in such a way that it can be used for all new or existing warning methods, not only the ones that have been researched by the author.

4.4 Parameters and research approach of the SMS and cell broadcast studies

This section presents the parameters that were studied in the SMS and cell broadcast studies. As described in this section 4.5, several empirical studies were done into the effectiveness of SMS and cell broadcast for warning citizens. The SMS research was quite brief and not very complex. The cell broadcast research was very extensive and was spread over several phases and two years of research. The research that was done will be discussed per block of the contextual human information processing model for warning citizens.

SMS and cell broadcast will be dealt with together. So for each block and arrow in the contextual model, the parts of the SMS and cell broadcast research that have to do with these blocks will be discussed. Insight will be given into the research methods that were used in the SMS and cell broadcast research to investigate each block. Moreover, whether each issue was easy, difficult or even impossible to investigate will be discussed.

Attention will also be paid to issues that were not investigated in the SMS and cell broadcast research even though they are important issues in obtaining self-reliant behaviour. Explanations will be given why these issues were not investigated or why it was impossible to investigate these issues.

First, the goal and research approach of the cell broadcast and SMS research as they were performed will be discussed. Then, in chapter 5, the applicability of the contextual model will be tested describing the relationships of the results of the different SMS and cell broadcast empirical studies to the contextual model. The research performed will be discussed methodologically, and for the examples that are given, the results of the studies will be discussed in more detail, to give a clear idea of the analyses that were done and the results that were gathered in these investigations. Sometimes the same issues were investigated in both the SMS and the cell broadcast studies, or in more than one of the different cell broadcast studies. In these cases, the results of the studies that are most explanatory or clear will be discussed. This means that the results discussed in this thesis will not give a complete overview of all the studies that were done into SMS and cell broadcast. The discussion of the methodologies and the studies used as examples are meant to focus on giving a complete overview of the influences on self-reliance and how to interpret these. So, the influences on self-reliance will be discussed completely, but to get a complete overview of the SMS and cell broadcast studies, the reports on these projects have to be studied.

The goal of the SMS and cell broadcast studies was to determine whether these two mobile phone technologies can be used effectively and efficiently as an addition to the current siren system. To determine whether this is the case, the SMS and cell broadcast research was categorized into three main parameters:

- Reach
- Content
- Acceptance

These concepts were used to cover the most important issues to determine the possible success of these technologies in the SMS and cell broadcast studies. The meaning of these three concepts will be explained in this chapter and the research questions for the SMS and cell broadcast research within these concepts will be discussed. Later, these three topics were expanded to the contextual model, which gives a better overview of the possible influences and which is anchored in literature. As these three topics were used as the basis of the SMS and cell broadcast studies, they will be explained here.

In the next chapter, where the applicability of the contextual model is discussed, these three topics will be fitted into the contextual model. For example, acceptance is what is called attitude in the rest of this thesis.

4.4.1 Reach

Figure 4-5 shows where reach fit into the model. Reach can be seen as arrow C and block 4 of the contextual model. Reach has to do with the ability of the sent warning to be noticed and read by the receiver.

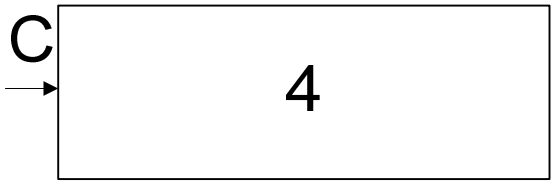

Figure 4-5: Influence of research area 'reach'

Reach has to do with reaching relevant people in an emergency. In order to warn people, it is necessary to reach as many of them as possible with the information that is sent. This part of the research looks into how many people can be reached by SMS and cell broadcast. Reach is part of the final goal of warning citizens in a threatened area when this is necessary (and not warning citizens outside this area unnecessarily). There is interdependency (see Figure 4-6) between reach and the other two parameters in the cell broadcast study (acceptance and content of messages). The technique used gives preconditions with respect to the content that can be given in a warning message, for instance the number of words that can be given in a message. An example for the current siren is the tone and the meaning thereof.

The most important part of the category reach is reaching the people that are present in the area at risk by means of SMS or cell broadcast. This is of great importance for increasing self-reliance. People have to be reached by a message before they can form their own opinion about the danger they are in and the action that is needed. In all experiments, the number of people that was reached by SMS or cell broadcast is determined. However, receiving an SMS or cell broadcast message is not enough to be warned. The message has to be noticed and read before people are actually warned. Moreover, people have to react adequately to a warning message. During the experiments, several methods have been used to determine the number of people that received and read the messages, such as reaction time measurements, questionnaires and calling participants.

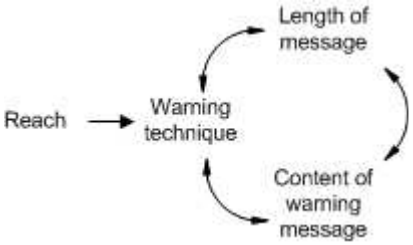

Figure 4-6: Interdependency reach and other parameters

When warning messages are sent out with SMS or cell broadcast right after the monthly siren test, the part of the relevant population of citizens that is actually reached by SMS and cell broadcast and what part of them is not reached by the siren can be determined. Determining the reasons for non-reach is an important issue in determining the reach and potential reach of a warning system. When the reasons for non-reach are determined, a judgement can be made about the degree to which this non-reach is a problem and whether the reach can be improved by solving these problems.

The research questions about reach are:

Question 1 "How many relevant people can be warned by SMS or cell broadcast within a certain time?"

Question 2 "How many people read the SMS or cell broadcast message within a certain time?"

The category Reach is also influenced by the technique that is used. This concerns several technical components that have to function as a precondition for cell broadcast or SMS to work. A number of technical problems occurred during the experiments. They will be discussed in the Reach chapter.

4.4.2 Content of messages

This part of the research is about determining what kind of information people need and want in order to motivate them to start taking action. What kind of information do people need in an emergency and how should this information be presented, in order to increase understanding and motivate action? The content then influences the response of the citizens.

The research area 'content' is part of block 2 'warning' and block 4 'human information processing'

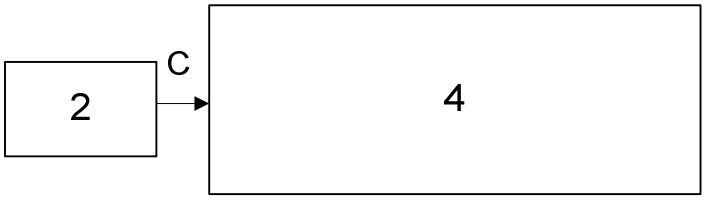

Figure 4-7: Influence of research area 'content'

The goal of sending people a warning message is to make sure that they take themselves to a place of safety, by showing self-reliant behaviour. But, when people receive an SMS or cell broadcast message, they have to read and understand the text in the message, before they can make a decision whether to comply with the instructions in the message, whether to do something else, or to not respond to the warning at all. This is where the category content starts. The warning message has to motivate people to start acting, before SMS or cell broadcast can be classified as being effective. The research questions in this category are:

Question 3 "What is the optimal length of SMS or cell broadcast messages, in order to maximise understanding and show a self-reliant response to that message?"

Question 4 "What information components should be given in an emergency SMS or cell broadcast message in order to maximise understanding and compliance (acting) to that message?"

In research for the optimal content of messages, it is not necessary to actually send out a cell broadcast message. This part can be effectively investigated by other means. So, contrary to the other parts of this study, the content part was investigated in a laboratory and a web-based experiment, where there is no dependency on the technical functioning of the cell broadcast infrastructure. The results from this research will be connected to the experiences gained from the field experiments wherever possible. This web-experiment was preceded by a laboratory study in phase 1b in which also deaf and hard of hearing people were investigated.

The research in this category was performed while people are in a non-emergency situation. This indicates the limitations of the results, especially for the question whether people will act following instructions to do so. From an ethical point of view, it is impossible to put people in a real emergency. That is why this study is only a first step in determining optimal content and investigating understanding of messages in a real emergency.

The next paragraph will explain the research into content in more detail.

4.4.2.1 Warning and content

The aim of warning in an emergency is to motivate people to undertake action to bring themselves and others to a safe place. To achieve this, citizens are currently being warned by sirens in the Netherlands. This siren system is called the WAS (warning and alarming system). It should be noted that the WAS in the Netherlands can only be used for a limited number of disaster and crisis scenario's. This is a consequence of the actions that the WAS prescribes when the siren sounds. Sounding the siren only indicates that something is going on. Citizens have to remember from earlier information what they have to do when it sounds: go inside, close all door and windows and tune in to the local TV or radio station for further information (Postbus51, 2010). Because of the lack of information conveying ability, it has been find that people are inclined to continue with the activities they were involved in before the siren sounded (Benthorn and Frantzich 1996). It is often thought that the siren is only a test or a false alarm. This shows that receiving sufficient and relevant information is of great importance for individual citizens to determine what is going on and whether it is necessary to act (Proulx and Sime 1991).

Proulx and Sime indicate that giving people information about the actions that are expected from them is effective, but that more research is needed into determining the optimal content of warning messages. Before people believe that something is really going on, they will always first try to gain information that confirms that something is going on. An alarming sound alone (like the siren) can never convey enough information to convince people that something is really happening (Bellamy and Geyer 1990).

By means of cell broadcast, a textual warning message sent to mobile phones can give direct instructions and information. People are not only warned that there is a disaster or threat (like the siren would do), but further instructions (although limited) can be given. This makes text messages more flexible than the siren. Text messages can also be used or scenario's in which the proper actions are different from the ones that the siren prescribes. Thin for instance, of danger of flooding, in which going inside and closing all doors and windows will not be the optimal response. Text messages can also convey information on the progress of the emergency and give additional instructions, if necessary. However, the space available in a cell broadcast or SMS message for clear and legible information is limited.

4.4.2.2 Understanding of messages versus action as a result of messages

For the eventual effectiveness of cell broadcast or SMS, it is of great importance that people show self-reliant behaviour following a message. The possibilities to investigate the behaviour of people in a real emergency are limited. Paragraph 3.6 will further elaborate on this issue. Whether people actually take the right action after reading a message depends on the correctly understanding of the message. It is easier to investigate the understanding of messages by people than it is to investigate the behaviour that they would show in a real emergency. In this former case, there is no need to put people in an emergency. Understanding messages in a stressful situation may be different from understanding messages in a non-threatening situation. However, it is hypothesized that the factors that negatively influence the understanding of messages in a normal situation, will also negatively influence the behaviour under stress, as decision making in stress is in essence the same as in non stressful situation, but there is usually premature closure (Janis, 1993), the decisional dilemma is terminated without generating and considering all alternatives and without seeking or judging the available information about the expected outcomes. It is of great importance that the messages are susceptible to only one interpretation. When people have to take a decision in a stressful situation, they see fewer alternatives, have less insight into the consequences of their behaviour, and are less efficient in searching for additional information (Goldberger and Breznitz 1993). This means that the

information in the warning messages needs to be unequivocal and provide sufficient information for immediate action. The messages that are understood best in a normal situation will also have an advantage in a crisis situation. A number of characteristics of the given text in cell broadcast or SMS messages are of influence on the understanding of the messages and on the possible actions following the messages. The content of the messages, which are shown on a small screen such as that of a mobile phone, are dependent on a number of factors. These factors have to do with:

- The threat or emergency that has to be warned for
- The individuals that read the messages
- The context that is given within the messages.

In the web-based experiment, the factor 'situation' was predefined. All messages were about emergencies that have to do with danger of explosion. Personal characteristics that are distinguished are age, sex and level of education. The laboratory experiment (phase 1b) also paid attention to people who were deaf and hard of hearing people. Parameters that are related to the context that is given within a message are expressed as the length of the message on the one hand and the content components on the other hand.

For the purpose of the category Content, the possible connections between the different factors were investigated. The messages used varied in length and content components. For instance, a description of the risk and the preferred action that should be taken was given, possibly completed with a reference to sources for further information. Possible differences between personal characteristics were investigated separately. The influence of length and content components on the understanding of the warning messages was investigated. As said earlier, understanding the messages will than influence the question whether people will take action after reading the message. Figure 4-8 shows the proposed relations between the influencing factors mentioned. This figure is the part of the contextual model that is relevant for the influence of understanding the messages on the behaviour. This figure also shows how the factors that are of influence on the understanding influence the possible action as a result of reading this message.

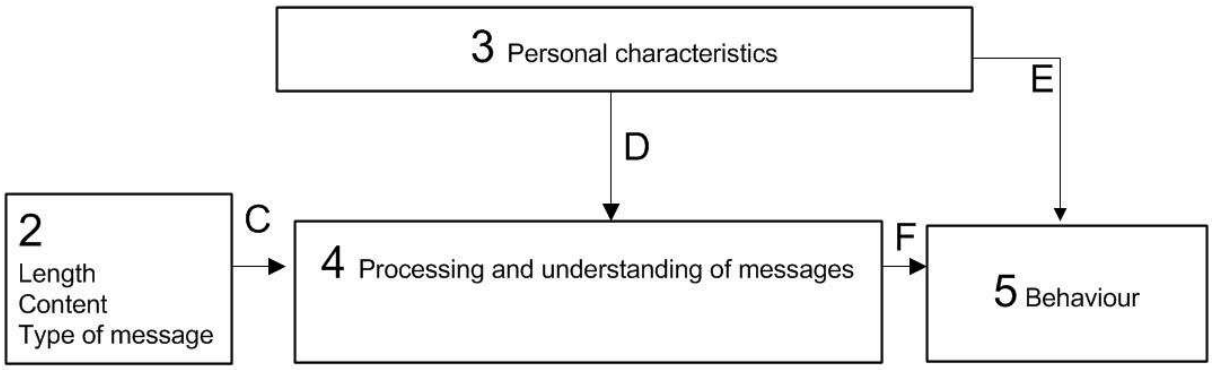

Figure 4-8: Connection between the factors that influence understanding of messages and taking action following these messages

All of these factors influence the understanding of messages. Both parameters length and content have an individual influence on understanding, but they also have a combined influence. For example, readers can get the feeling that a longer message with the same content components contains more information than a shorter message with the same information components. The factor 'type of warning' concerns both the situation and the timing of the message. In the web-based experiment, this factor was not manipulated. The laboratory experiment showed no difference in understanding of messages that contained information about different stages of an emergency. That is the reason why this variable was used in the web-based experiment that followed the laboratory experiment. The influence of personal characteristics (arrow D) on the understanding of messages was also investigated. Moreover, the extent to which understanding a message is an indicator of the degree to

which people indicate that they will act as a result of a message was also investigated. Paragraph 5.2.4 will discuss the supposed influence of each factor in the figure. This shows that the content part goes beyond answering research questions 4 and 5. It will determine all possible influences on the eventual action by the participants when receiving a cell broadcast or SMS message.

4.4.3 Acceptance

Acceptance is important for the possibilities for success for both SMS and cell broadcast. People have to accept a warning method for it to be successful. When SMS or cell broadcast are used as an addition to the siren, people need to carry their mobile phone with them at all times, and make sure that the battery doesn't run out of power. User friendliness is a big factor in acceptance. All these issues have to do with the acceptance of the system. People also have to see the source of the message as being credible before they will act when receiving a message. This acceptance plays an important role before there actually is an emergency, people have to accept it beforehand. Acceptance influences the number of people that will read the message that is sent to them and the number of people that will follow the instructions in the message. Acceptance is therefore of great influence on compliance or deviant action.

The technology used to send a message has to be user friendly if it is to be used by many people. The acceptance study in the SMS and cell broadcast research is a very important part of determining whether people are likely to comply with or otherwise act on the instructions given in an SMS or cell broadcast warning message.

The following questions are researched in the category acceptance:

Question 5: "What is the acceptance of people of SMS and cell broadcast as an additional means of warning in an emergency?"

This first question will give insight into whether people are willing to use SMS as an addition to the current siren. As cell broadcast and SMS are technologies that are not only used for warning messages, other messages that are sent may influence the number of people that will immediately read warning messages. The second question will determine what the influence is of other types of messages on the number of people that will read warning messages and the time it takes before they read the warning.

Question 6: "What is the effect of receiving non-warning messages on the notability of the warning messages and on the acceptance of cell broadcast as an additional means of warning citizens?"

In the SMS and cell broadcast studies, the acceptance research was split up into 3 main parts. The first studied the usefulness / desirability of SMS and cell broadcast as possible additional means of warning people. Do people feel that there is a need for an additional warning method or are they satisfied with the current warning system? The participants' perception is of great influence on the chance of success for cell broadcast or SMS as a means of warning citizens in an emergency. The perceived usefulness can depend for instance on the opinion of the citizens on the current means of warning people. Do they think that these techniques will be able to warn them better than the siren does? Is an addition to the siren needed at all?

Second, acceptance is influenced by participants' perception of the user friendliness of cell broadcast and SMS. How easy is it to use these technologies, will the system always work? Can people trust that they will always be warned by these technologies in an emergency? User friendliness has to do with the ease with which people can understand the cycle of warning citizens and the place that SMS and cell broadcast fulfil within this cycle. At this point, the user has to set his mobile phone to be able to receive cell broadcast messages. Investigating the user friendliness aims at finding out whether this setting of the phones has been done successfully by the participants, and what the possible problems were with setting the phone.

Thirdly, cell broadcast is a new and unknown technology. Warning citizens through SMS would be a new use of an existing technology. On the one hand, new technologies make people curious. On the other hand, people may have high expectations of the possibilities of a new technology. Depending on the experiences of the participants with these technologies, their opinion can change during the experiments. In this part, the effect of receiving additional non-warning messages on the acceptance of the cell broadcast technology (research question 6) was also determined.

The acceptance study in this research covers both the expectations (the ideas people have of the technologies before they have actually used it) and the experiences (the actual using of the technologies and the problems that arise when using it) of the participants. This gives a good insight into whether people will be likely to use the technology when it is implemented. Influences on acceptance are for example the receiving or not receiving of messages by the citizens during the test. The participant's expectations before the start of the experiment will be compared to their experiences with these technologies in the test period. To determine this, participants answered several questions before the test and answered the same questions again at the end of the test period.

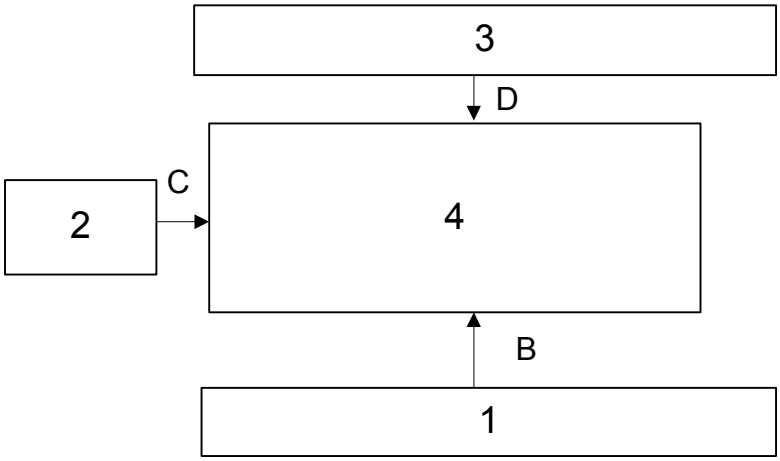

Figure 4-9: Connection between the factors that influence acceptance

The research area acceptance is an interdependent area. It is influenced by personal characteristics, situational characteristics as well as warning characteristics.

4.5 Overview Research Phases for SMS and cell broadcast

In this paragraph, a short description is given of all SMS and cell broadcast studies that were carried out and that will be used in this dissertation. The research from all these phases will be fitted into the contextual model. In this overview only short descriptions of the research done in each phase are discussed. When this research is explained in the application chapters, it will be discussed more thoroughly. An overview of the participants in each phase can be found in Appendix A and an overview of all the SMS and cell broadcast messages sent during the studies can be found in Appendix B.

4.5.1 Phase 0 Vlaardingen SMS

The SMS test was carried out in the city of Vlaardingen in The Netherlands. Three thousand randomly selected citizens of the city of Vlaardingen above the age of 16 were asked by a letter from the mayor, to apply for the SMS test. 605 Persons actually applied for the test. These people were split up into two groups. The largest group was the group of 'normal' citizens of Vlaardingen (568 persons). The other group consisted of auditory impaired citizens (37 persons).

This research involved two test methods. 6 SMS messages were sent to people to determine how many people would receive / read these messages and within what time they would do this. Four messages were sent at the same time as the monthly siren test and two messages at unexpected moments. People had to respond to these SMS messages as quickly as possible, so that the time it took before people read the message and the total number of people that read the messages could be determined. The messages sent right after the siren also made it possible to determine how many people received the SMS message but did not hear the siren.

Besides the messages, questionnaires before and after the sending of the SMS messages were used to determine the expectations of SMS before the start of the study and the experiences and opinions about the SMS service and the siren at the end of the study. Both test methods will be more thoroughly explained in chapter 5.

4.5.2 Phase 1 and 2 Zoetermeer cell broadcast

The cell broadcast tests were carried out in four different regions in The Netherlands: in the city of Zoetermeer, in the province of Zeeland, in the city of Amsterdam and on the islands Walcheren and Zuid-Beveland in Zeeland. For each phase, the specific goals of that test (next to acceptance and reach of cell broadcast, which were goals for all tests) are mentioned. The results for all phases of the cell broadcast studies were reported earlier (Jagtman, Wiersma et al., 2008; Jagtman, Wiersma, Sillem and Ale, 2008).

In the first area, Zoetermeer, the tests were split into two parts. The first part investigated two things: a first test with the cell broadcast technology with a limited group of participants (102 people, phase1a) and an investigation into the content of warning messages (44 people, phase 1b). Phase two encompassed a larger group of participants which increased the possibilities to effectively investigate the reaching of people. Besides knowledge about the technology and about the content of messages, attention was paid to the target group 'deaf and hard of hearing people'. Phase 1a mostly gave insight into the relationship that cell broadcast has to the warning cycle. In August and September of 2005, cell broadcast messages were sent to determine this relationship. The experiences gained were used in setting up phase 2. For phase 2, cell broadcast messages were sent from October until December 2005. Because of the small group of participants in phase 1a, the results discussed on Zoetermeer in this dissertation are mainly from phase 2 (1135 people). Both phase 1 a and phase 2 had a before and after-measurement (questionnaires) just like phase 0 of the SMS research, to gain insight into expectations, experiences and acceptance of the current siren and cell broadcast.

102, 44 and 1135 people respectively participated in phases 1a, 1b and 2. The number of deaf and hard of hearing in these phases was 6, 19 and 73 respectively. Unfortunately there were not enough deaf and hard of hearing participants in phase 2 to statistically determine whether they perceive citizens warning differently.

4.5.3 Phase 3 (and 6): Zeeland cell broadcast

In this phase, the province of Zeeland and the municipality of Woensdrecht were tested. These tests were set up just like the tests in Zoetermeer. Phase 3a was the application for Phase 3b. Phase 3b was a closed test (some phones will receive all cell broadcast messages, so during a test, there will be people who receive messages, and sometimes even reply to the questions in them, but thee peoples' answers were not analysed, only the known participants were analysed) with 391 participants; the focus in this test was in the technical possibilities and problems with the cell broadcast technique. Specific attention was paid to problems with setting the phones to receive cell broadcast and the reception of multi paging messages. A regular cell broadcast page consists of 93 characters. Messages that are longer are called multi paging messages, because they consist of two or more messages that are sent separately and that are combined again by the software in the mobile phone. Most of the sending dates and times of the messages sent in this phase were known by the participants. This

makes it impossible to determine the effective reach, as people knew when to expect the cell broadcast messages.

Phase 3c was an open test again, aimed at large scale citizens warning. 90.000 People were invited to participate in this phase and 6436 agreed to do this. The purpose of this phase was mainly to determine the range of people that can be reached, as well as the influence of different types of messages. Unfortunately, the possibilities to analyse the results were limited, because of technical problems with the sending of the messages. Cell broadcast messages for this phase were sent in March and April of 2006. After the test, all 6436 participants were sent a questionnaire (phase3d) covering the acceptance issues.

Phase 3c was extended for a project for the Ministry of Economic Affairs (known as phase 6). In phase 6 research was done into the effect of receiving informative cell broadcast messages on reading warning messages. In this phase, information messages (with information on for example weather or news) were sent in addition to the usual warning messages to which people had to respond. The purpose was to investigate the possible spam or synergy effects of sending different types of messages in various amounts per time unit (varying from 4 messages per week to 10 messages a day). The number of additional messages increased from the start of the experiment, to decrease again at the end of the study. Of the original 6436 participants, 1317 participated in this extended test. Warning and information messages were sent for this phase in June, July and August of 2006. At the end of the test, a number of participants joined several focus group sessions that were organised to gather more information about the experiences of the participants during this phase with additional cell broadcast messages.

Finally, an evacuation exercise was done in two holiday parks (phase 3e). A total of 196 participants were asked by a cell broadcast message at an unexpected moment to come to a certain location. The people that arrived at the specified location were asked some questions regarding the cell broadcast message and the time it took them to start acting. The people that did not come to the location received a questionnaire in their holiday home asking them some questions about the reasons for not coming to the specified location after the cell broadcast message was sent. These exercises were held on May 2nd and 3rd 2006.

4.5.4 Phase 4: Amsterdam cell broadcast

After phase 3, a test was done in Amsterdam. In this phase, only an open test was done. Contrary to the earlier tests, an open registration was used. The idea was to act as if the system was really implemented, to see how many people would apply for the test. People were informed about the upcoming test by messages in the (local) press. The open registration resulted in a total of 503 participants. These people are not a representative sample of the citizens of Amsterdam. This was partly because part of the participants were employees of one of the partners (for example LogicaCMG and SPMM) of the cell broadcast project. Moreover, the number of participants was very small, compared to the number of citizens that could have applied (all citizens of Amsterdam above the age of 16). Messages for this phase were sent in July, August and September of 2006. The main goal of this test was to again determine the reach of cell broadcast. Another goal was to determine the difference between immigrants and natives. Unfortunately the number of immigrant participants was too low to be able to analyse this. This phase was also followed by a questionnaire with questions regarding acceptance.

4.5.5 Phase 7: Walcheren en Zuid-Beveland cell broadcast

Because of the results of the previous test phases on the reach of cell broadcast, in which there were several technical problems concerning the sending of the cell broadcast messages, there was a need for an additional test. This phase was designed to provide insight into the loss, in other words into the reasons why some participants aren't reached. Should the reasons be found in the technology of the network, in the mobile phones or in the behaviour of the people (not responding)? For these tests, a

mobile phone with a special application was developed especially for this test. Among other features, this application sent back a message when a cell broadcast message was received. This created the possibility to gain more data about the different links in the warning cycle. These data can help indicate why participants didn't respond to messages. As was the case in Zoetermeer and Zeeland, phase 7b (phase 7a was again the application for Phase 7b) looked at the technique first. Delft University of Technology used 50 identical mobile phones with a special application that was used to directly observe whether messages were received. DUT was able to send messages themselves, so that the conditions under which the messages were sent could be controlled. Messages for this phase were sent in July, August and September of 2007.

Phase 7c consisted of a test with citizens. This test was carried out in part of the area of phase 3, namely the islands Walcheren en Zuid-Beveland in the province of Zeeland. Participants from the earlier test were asked to participate again. Moreover, a new random group of 4000 people in the 7 municipalities was asked to participate. Other people living in the area were also allowed to apply for participation in this test. A quasi-select group of 625 people was drawn from the group of interested people. This group was representative for the 7 municipalities for age and sex. All participants received an identical mobile phone with the special application. 8 Messages were sent in September and October of 2007. Afterwards, all participants were asked to fill out a questionnaire for the acceptance study.

4.5.6 Related test cell broadcast

An additional experiment was done outside the regional tests. This was a web-based experiment in which the content of messages was investigated. Participation in this experiment was open to everybody. A total of 418 people did the experiment on the website.

4.6 Limitations of research into understanding and action

With the different research studies that were performed, the goal was to encompass as many aspects as possible of understanding messages and motivating people to take action after reading a message. This can be used to give an indication of the degree to which people are inclined to take action in a non-threatening situation. It is important to note that all the content related experiments were performed under non-threatening conditions. Ethically seen, it is impossible to put people in a real emergency. This makes it very difficult to answer the actual research question "What message characteristics make people take action as a result of a cell broadcast or SMS warning message in an emergency?" In this paragraph the ecological validity of the research will be discussed, in order to determine to what degree the results from the non-threatening situation can be used as a guideline for emergencies. The ecological validity is the degree to which differences in a phenomenon (in this study the degree to which people are inclined to take action) are related to the situation and the conditions under which the experiment was done. This paragraph goes into a number of phenomena that are discussed in literature that have to do with the differences in understanding and taking action under stress.

In stressful situations, people take decision in a more basic way. People see fewer alternatives, have less insight into the consequences of their choices and people are less efficient in looking for additional information (Goldberger and Breznitz 1993). The information in warning messages should therefore be clear and univocal and give sufficient information to enable direct action. The messages that are well comprehensible in a normal situation will also be beneficial in an emergency.

Attention and perception are limited in an emergency. This is why people in a stressful situation cannot pay attention to given instructions for a long period of time. This indicates that the information given should be as short as possible. Warning messages that cause intense emotional reaction can cause people to judge a situation wrongly and can cause a wrong decision to be made (Goldberger and Breznitz 1993). This stresses the importance of the messages being clear, unequivocal and short and that different sources of information should not give inconsistent information.

Moreover, the techniques used in this research SMS and cell broadcast, also have to work in a clear and univocal manner. In a stressful situation, people are more likely to make mistakes. For example, they can accidentally delete a cell broadcast message. This message will have to be easily traced back, so that the information can be read again.

The effectiveness of a warning message depends on the extent of the possible consequences of an emergency. This concerns mainly the chance that the danger will have noticeable consequences and the chance that prescribed instructions will protect against these consequences. Realistic information about the possible negative consequences of the emergency will increase the likelihood of people taking the right decision, when it is indicated that the prescribed actions will have an effect on their safety. This effect will be reduced by earlier 'false alarms' (Bellamy and Geyer 1990)

The conditions under which taking action was researched in the experiments, is characterised by normal days without a direct threat to citizens. In the holiday park experiments (phase 3e) people received a cell broadcast message about a health risk (tuberculosis), while the participants were aware that this was not the case. In the web-based experiment (phase 4d) people answered questions about a location in which there was danger of explosion, while sitting behind a computer. Participants had to imagine that they were in this dangerous situation. The situation in which the research into taking action is performed differs so much from the real emergency that the results from this study can only give an indication of how people would react to such messages in a real emergency. It is important to ensure that the participants really imagine themselves in an emergency, in order to increase the validity. The cell broadcast study attempted to investigate as many aspects on taking action as possible. By using several research methods, the external validity of the results will be higher. In relation to action, the ecological validity of the experiments done in the cell broadcast study is limited. The results from that part cannot be translated with certainty to the behaviour people will show in an actual emergency. Nevertheless, it is interesting to see whether there are differences in the understanding of certain messages and peoples indicated degree to which they will act upon these messages.

4.7 Analysis of the warning system effectiveness studies

The purpose of evaluating the warning system effective studies was to assess the applicability of the model developed in Chapter 3. That model shows all the steps that have to be investigated in order to judge the effectiveness of a new or existing warning system. The central question is: How can the degree to which a new or existing warning method effectively improves self-reliance be investigated?" The key assumption is that all steps must be investigated before a sound judgement about the effectiveness can be made. This implies that omissions in the way the analysis is carried out have effects on the soundness of the judgements about the effectiveness of the warning system. The converse of this relationship should work as well: all unexplained variance should be traceable back to the way in which the study was carried out. Steps from the contextual model must have not been investigated (enough) if variance can be found that is not explainable. The next chapter describes the application of the model in which the two warning system effectiveness studies are used as examples to explain how the research was done, what is missing, and to explain the relationships of the separate steps to the whole model.

5. Application of the contextual model

In this chapter, the applicability of the contextual model will be tested. Each step of the model and each factor within these steps (as has been discussed in paragraph 3.2) will be discussed. For each factor that can be of influence on self-reliance, methods of investigation are given. These methods are applicable to all new or existing warning methods. For most of the factors, examples will be given on how this was investigated in the SMS or cell broadcast studies. Moreover, problems that can occur and possible solutions as well as improvements that can be done on the research that was done in the SMS and cell broadcast studies will be given. Attention will also be paid to issues that are difficult or maybe even impossible to investigate. Furthermore, attention will be paid to the internal and external validity of the tests described. Moreover, the relationship of the influences on peoples' self-reliance of each separate step will be related to the whole model.

In each paragraph, a small representation (as can be seen in Figure 5-1) of the contextual model will be given, and the part that is discussed in that paragraph will be indicated by a shaded area and bold arrows and text. In these parts, the results of the SMS and cell broadcast research that are relevant for that block and arrow will be explained thoroughly.

Not all aspects that were researched in the cell broadcast study will be discussed in this chapter. A number of issues have been investigated in several phases in more or less the same way. When this is the case, the results that are the clearest or that are a good example will be shown. Moreover, some issues that have also been investigated and discussed in the SMS research will be skipped as well. The example analyses from the SMS and cell broadcast research are used to clarify how the different issues that are of influence on self-reliance can be investigated. As these examples are samples drawn from all the different cell broadcast studies, the combination of all these examples will not give a complete view of the SMS and cell broadcast research, which means that they cannot be used to draw conclusions on the whole cell broadcast research. The complete results of the cell broadcast studies can be found in earlier publications (Jagtman, Wiersma et al., 2008; Jagtman, Wiersma et al., 2008).

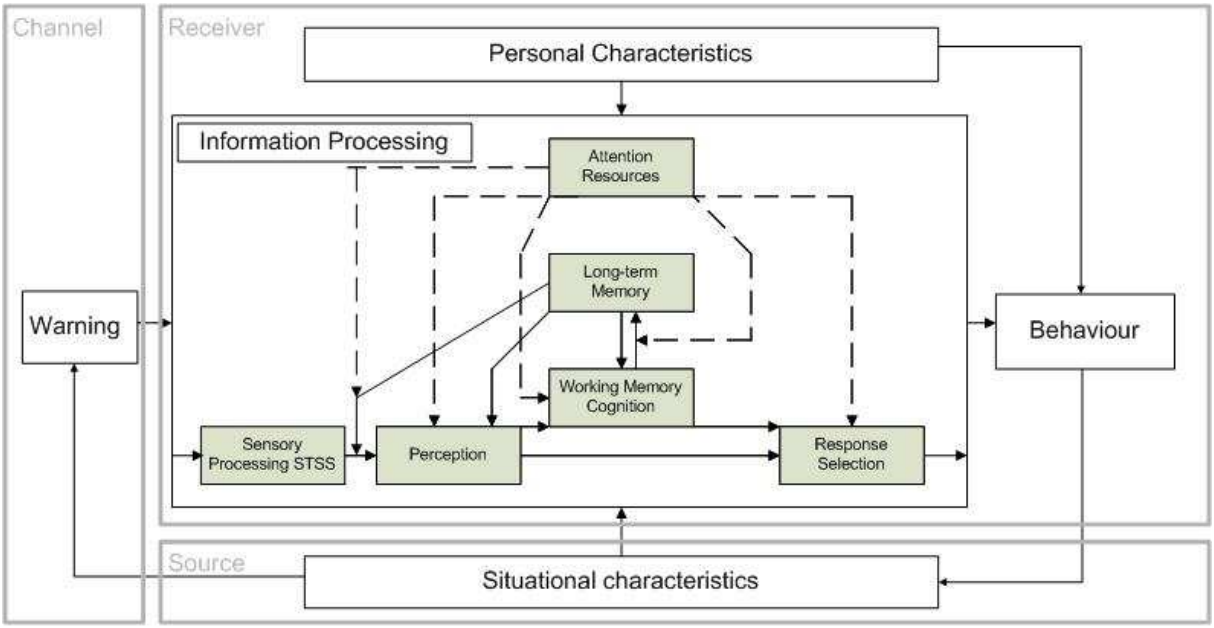

Figure 5-1: contextual human information processing model for warning citizens

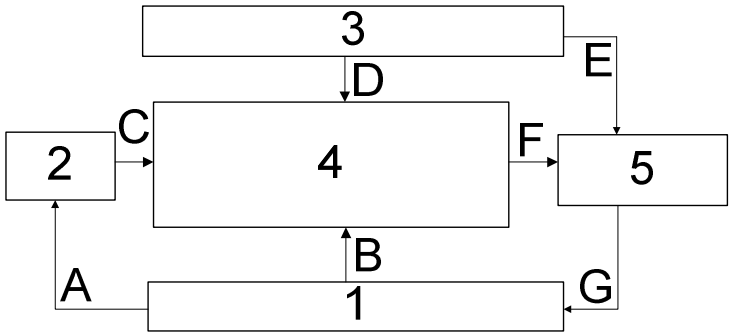

Figure 5-2: contextual model for human information processing model for warning citizens – numbered

The next paragraphs will show the research that has to be done in each of the blocks of the contextual model.

5.1 Situational characteristics

The situational characteristics are all the issues in 'the world' that can influence self-reliance in emergencies in specific situations. This is block 1 of the contextual model, the shaded part and the arrows A and B in Figure 5-3. For example, the emergency itself is a situational characteristic. When there is a fire in a building, there may be flames, smoke and heat that can be observed by a person. These issues have been explained in paragraph 3.2.1. The issues that have to be investigated in this part of the model are divided into two parts. The first part is arrow A, which consists of both the information that is sent out by the authorities through a warning message and the information that citizens want and need to receive in an emergency to improve their self-reliance. The second part is arrow B, all the other information that the citizens can receive about the world and the emergency and which can be of influence on self-reliance. This can be information through the media (from the authorities or other sources), direct information from other people (colleagues, family, neighbours), or direct information by personal observation (this can be observations of the emergency and it effects, but also the behaviour that other people show). Moreover, there may be disturbing or distracting information that is not about the emergency, but that does interfere with the effectiveness of the warning messages (such as messages sent through the same medium as the warning message).

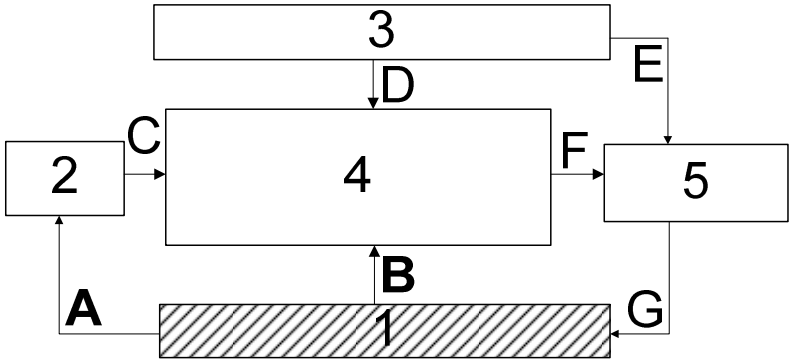

Figure 5-3: The influences of situational characteristics

At this stage of determining the effectiveness of a new or existing warning method, the issues in block 1 that are received by the individual through arrow A and B that are of influence on the self-reliance have to be determined. Moreover, a decision has to be made about what factors can be researched and how to do this. And of course, the influences of the factors that can or will not be investigated have to be discussed.

5.1.1 Direct information through a warning message (Arrow A)

Arrow A concerns the information about the emergency that is put into the warning message by the authorities and all the issues that have to do with this process. In this arrow, the information that people actually want to receive (in what type of situation do people want to be warned) in an emergency is investigated. The information that people need (content of messages) in order to be able to make the right decision (acknowledge that there is an actual emergency and that direct action is needed) will be discussed in the warning-paragraph. The reason for this is that the information that can be given in a warning message depends on the warning medium that is used.

5.1.1.1 Warning messages sent out by the authorities

Besides the information that people want and need, the information that the authorities intend to put in the warning message is also of importance in this arrow. On the one hand you have the information that the authorities want to put in a warning message. On the other hand you have the channel through which this information has to be sent. This means that the information that the authorities intend to send to the citizens has to be adjusted to be suitable for the channel used. There can be several influences on self-reliance when considering these issues. For example, the information that the authorities intend to send out may have to be shortened. The intended message has to be put into words and into a message that can be sent through the warning system that is in use at that time. This may lead to conversion errors. When designing warning messages for a new warning system, these issues have to be taken into account and research has to be done into how the information through a certain channel has to be presented in order to be able to influence the self-reliance of people in a desirable manner. Moreover, the information that the authorities intend to send may be based on wrong assumptions. This means that false information can be sent out through a warning system. This can be caused by several things. The authorities may not be well informed or they may accidentally send out wrong information. It is important to consider the possible influences of these issues when sending out a certain specific message. There is not much that can be done within the scope of this model to prevent the authorities from having wrong information, but it is something to bear in mind when designing warning messages. It is important to think about what the consequences may be when a message based on wrong information is sent to citizens. It may be that warning people per se is very important and that people will try to verify the information that they got in the warning. When it is possible for people to get correct information from either source available at the moment of the emergency, this may mean that the consequences of a wrong message may not

be very big. On the other hand, depending on the information and instructions that are given in the incorrect warning message, consequences may also be very large, if people follow the instructions that may put them in greater danger. Research into the possibilities of sending out false warning message texts and their consequences is needed when implementing such a system. This may be done by doing evacuation exercises in which people can get information from different sources, and vary the correctness of information given in the warning messages.

In the SMS and cell broadcast research, no attention has been paid to the information that is intended to be sent by the authorities as this was outside the scope of the research.

5.1.1.2 Situations in which people want to be warned & information wanted

It is important to determine in what situations people want to be warned by the authorities. When people receive warning messages about situations that they do not consider to be interesting or relevant to them, they may be less prone to pay attention to the warning messages, thereby decreasing the reach of the warning system. This can cause people to respond too slowly even when, on another occasion, it is relevant to them, which may put their lives in danger. People have to be ensured, that when they receive a warning message, it is relevant and important for them to pay attention to it and respond swiftly. The situations in which people want to be warned can be determined in several ways. It can be a multiple choice or open question in a questionnaire or a question in an interview or focus group. When the question is asked in a questionnaire that is answered by a large group of people, the external validity is enlarged, which makes it easier to generalize the found information found to the population. Interviews and focus groups can be used in advance to determine what issues are important to people in order to put them as options in the multiple choice question in a questionnaire.

The next paragraphs will discuss the study that was done in the SMS research (phase 0) into the information that people want to receive in an emergency situation.

In the SMS research, participants received two questionnaires; one at the start of the study and one at the end. This way, the expectations of the participants on several subjects before the start of the study could be compared to their experiences afterwards. Besides the comparison propositions, there were also some other questions in the questionnaires. In the questionnaire at the end of the study, people were asked in what type of situations they would like to be warned. In what situations would they prefer to receive information about the situation from the authorities? They could choose multiple options from the following list: disaster / progress disaster / smell inconvenience / threat of a terrorist attack / missing children / missing persons / weather alarm / child skipping school / disturbance in electrical, water or gas system / other situations. Of course, it is possible to add other situations to the list of choices, when these are relevant for the area or group of people that is given the questionnaire.

In the questionnaire sent at the end of the SMS study (Sillem, Wiersma et al., 2004) in phase 0, people were asked to indicate in what kind of situations they would like to receive a warning message from the authorities. This was a multiple choice question with an option for additions.

65 % Of the 605 questionnaires that were sent to the participants were filled out and sent back. This percentage was equal for both the questionnaire sent before the sending of the 6 SMS messages as the questionnaire sent afterwards. 74% of the participants that filled out the first questionnaire also filled out the second one.

Table 1 shows what percentage of people would like to receive information in different types of emergency situations. It is striking that not many people choose ‘smell inconvenience’, when the location of this test (the city of Vlaardingen, which is located close to a big chemical industry area) is a place where this type of announcements occurs quite often.

Table 1: Situations in which people want to be warned

Type of situation	
Life threatening disaster	98%
Progress disaster	42%
Smell inconvenience	25%
Threat of a terrorist attack	55%
Missing children	17%
Missing persons	9%
Weather alarm	55%
Own child skipping school	3%
Disturbance in electrical, gas or water system	59%
Other situation	2%

Participants indicate that they are mainly interested in announcements that have to do with disasters and threats of disasters, rather than police related subjects such as missing persons. As other situations, things like large traffic accidents that cause roads to be blocked are mentioned. Participants mention that when too many messages are sent, the attention value will decrease. People also fear SPAM messages on their phone. Research that was done into the influences of receiving other messages than warning messages through the same medium will be discussed in paragraph 5.4.1.3.1

These results show that people are very specific about what type of situations they want to be warned about. It has to be about a threat to their safety. This question gives insight into the information that people want to receive. This will have an effect on their attitude towards the warning system. When people receive information they are not interested in, this may decrease the attention value of the warning messages with information that they do want to receive. That will again have an influence on the time within which people will read the warning and thus the time before they will start acting. This shows that determining the information that people want to receive is an important issue increasing notability and self-reliant behaviour following warning messages.

Besides research into what type of information people want to receive, research has been done into what information people actually need to be able to make the right decision on what to do in an emergency. The results of this research will be discussed in the warning-paragraph (paragraph 5.2) of this chapter. In addition to these two issues, there are issues that have to do with situational characteristics through arrow B. These issues will be discussed in the next paragraph.

5.1.2 Other and indirect information (Arrow B)

Arrow B in Figure 5-3 is hard to research in a field experiment. As there is no real emergency in an experiment, there is no real information about the emergency in the real world. There are no flames or messages in the news that can confirm or contradict information about the situation. In an empirical study, the warning is usually the only information that the individual can base his behaviour on. It is unethical to put people in a real emergency to see what kind of information they use directly from the emergency in determining their behaviour. This means that in most cases it will be very difficult to investigate issues concerning this arrow, even though this arrow may be of great influence in a real emergency. It is however possible to look in retrospect at disasters that happened in the past, by doing interviews and looking at information that was available on the given warnings, available other information and the actual behaviour that was shown. Data obtained through this method may however be influenced by discussions people had with other people that were in the emergency, information from the media. Memories of the event can be influenced by the information obtained after the event. Moreover, people do not always remember or know the reasons for each action they performed in a certain situation (Dijksterhuis, 2007). This has a great influence on both the internal as well as the external validity of this type of research. In the SMS research, this part

could not be covered, as there have not been any emergencies in which people were warned by this warning system.

As is discussed in paragraph 1.4 for direct information through a warning system, indirect information from the media or other people may also pose people with incorrect or contradictory information. The influence of information from the media or other people can be examined in a way similar to the experiment described in paragraph 5.1.1 into determining the influences of possible false warning messages from the authorities. In such an experiment, people would get information about a fake emergency through a warning message and in which they would also find other information about the emergency. This may give more insight into the influences on decision making and the time it takes before people start acting, depending on the availability of additional information through other media that is either supporting or contradicting the warning message. As people are not in real danger in this type of experiments, there will be an influence on their behaviour and thus on the external validity. This has not been done so far in the SMS or cell broadcast studies due to time constraints. The Delft University of Technology Safety Science Group is however planning to do experiments as described here to gain more insight into the influence of additional information on the response to warning messages.

5.1.2.1 Social influences

Social influences, which are also part of arrow B, can be investigated in an experimental setting. These social influences are the influences of the behaviour that other people show on the behaviour of the individual, for example in an evacuation exercise. If this is done in an experimental setting, participants are put in a group of people that know about the evacuation exercise and you instruct them to show a certain type of behaviour. The participants do not know that the other people in the group are informed about the goal of the exercise and see how their behaviour is influenced by the behaviour of the other people. The results might be different for people that are familiar or unfamiliar to the subject, although it may be difficult to get together a group of people familiar to the test participant, without the participant knowing about the goal of the experiment. Moreover, the results may also be different for indoor and outdoor situations. Research into this issue will give insight into the influence of the behaviour of other people on the decision making of the individual after receiving a warning message. This is a direct influence on the human information processing block in the contextual model. This issue was researched in neither the SMS nor cell broadcast studies because of time constraints.

Besides the issues discussed here, there may be other situational issues that can be of influence on the effectiveness of a warning message. One issue is the fact that the medium that is used to send the warning messages can also be used for sending other types of messages. This can have a great influence on the attention value or attitude towards the warning device / warning system. This issue is dealt with in the paragraph about human information processing (paragraph 5.4.1), as its influence is mainly based on people's attitude towards a warning system. It is important to determine what kind of situational characteristics there are that can be of influence and to what degree.

Summarising the factors discussed in the situational characteristics block are:

- Information through a warning message (Arrow A)
    - The situations in which people want to be warned
        - In what situations do people want to be warned?
    - Information intended to be sent by the authorities
        - What are the consequences if the information that is sent in a warning is wrong?
        - What are the influences of the conversion of the warning information to the format of the warning system that is used?
- Other information (Arrow B)
    - Direct information about the emergency (smoke / flames)

- What is the influence of directly seeing (i.e. smoke or flames), hearing or smelling the emergency on the effectiveness of the warning?

o Indirect information about the emergency through media and other people (including social influences)
  - What are the influences of information through media?
  - What are the influences of information through of other people in the emergency?
  - What are the influences of the behaviour of other people in the emergency?

o Information that has nothing to do with the emergency, but which may influence the self-reliant behaviour of people
  - What are the influences of other messages sent through the same medium?
  - Are there other sources of information that are not about the emergency, but which could have an influence on peoples' response to a warning message?

5.2 Warning

In this paragraph, the influences of the warning on self-reliance will be discussed (Figure 5-4). A number of issues are of importance in this block. The warning has to reach as many relevant people as possible (Reach) and the content of the message has to be such that the message is easily comprehensible, to ensure that people understand its meaning (Content / Design).

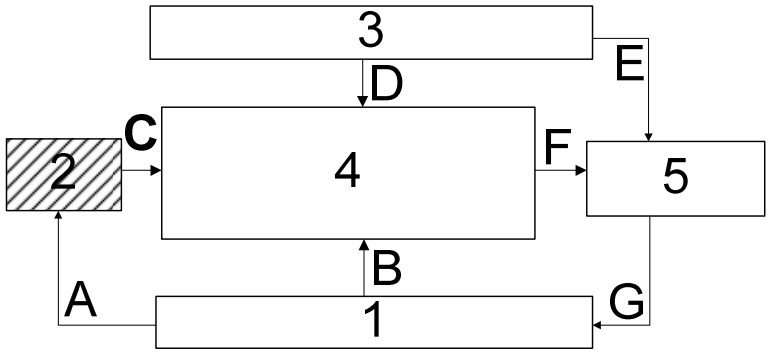

Figure 5-4: The influence of warning on self-reliance

5.2.1 Reach

It is important for a warning method to reach as many relevant people as quickly as possible (arrow C in the contextual model) in order to mitigate the consequences of an emergency. Furthermore, the time within which the citizens are warned is very important, as an emergency situation requires a swift response, as it often develops very quickly. Reach is not just the message being sent out, or the message being received by a certain warning device. The message actually has to be read and understood, before it can be said that the citizens are reached by the warning message.

When warning messages do not reach the citizens, their influence on peoples' self-reliance will be absent. Reaching citizens with a warning message is an essential part of influencing self-reliance in an emergency. When people are not reached by a warning message, the only information that people can get about an emergency is through arrow B. In the best case, when people are not warned by the warning system, they will be warned by other people in their surroundings who did receive the warning message. In this case, they have the same information at their disposal as the people who are warned by the warning message. This means that in principal, the reach of a warning system will be enlarged by the fact that a lot of people are in the vicinity of other people at most times of day, which ensures that when one or a few of these people are warned by the warning system, this information can immediately be spread to many more people. However, not being warned by the warning system can also mean that people don't get any information at all about the emergency. In this case, people have to rely completely on their own ability to notice the danger and to gain

information on what they should do. This is the same as when no warning message is sent out at all. This shows the importance of determining the reach of citizens with a warning system and the effect that this has on the total percentage of warned people. A reach of 100% is usually not necessary, as people that get a warning can warn other people (for example colleagues) about an ongoing emergency.

The next paragraphs explain how the reach of a warning system can be determined. Attention is also paid to checking whether people actually read and understand the warning messages and to determining the reasons for non-reach. Determining the non-reach is very important for determining the possibilities of the new warning system. When the percentage of non-reach is high, but the reasons for this are found, and the problems can be solved, the new warning system may still be very valuable. This shows the importance of explaining the variance. When all the cases of non–reach can be explained, a more accurate estimate of the additional value of a warning system can be given.

In the case of warning citizens in an emergency, a period of 7 minutes is an important time span. This is approximately the time it takes for the fire fighters to arrive at an emergency site in the Netherlands (arrival time) (Ministry-of-the-Interior-and-Kingdom-Relations-public-order-and-safety-inspectorate, 2007). Within these 7 minutes the siren has to warn all citizens in the area at risk. After these 7 minutes, the fire fighters have usually arrived and they can assist in evacuation and rescue. Because for example SMS and cell broadcast are meant to be an addition to the current siren, analysing the number of people that are reached within these seven minutes is an important indication of the additional value of these two technologies.

When other technologies of warning are used, or people have to be warned in another situation or another country, it is possible to look at a different period of time in which people should be warned. It may be that in other countries the arrival time for the fire fighters is later, because larger distances have to be covered, or that people have to be warned by a warning system that is not very fast in spreading warnings (such as sound cars). The time within which people have to be reached can differ per type of warning system, but has to be determined in advance, in order to be able to determine whether the criteria for reach are met.

The seven minutes that are used in this example are also an important time span because of the need to warn as many people as possible as quickly as possible, to be able to save lives. The disadvantage of the siren is that if somebody did not hear the siren in these first 7 minutes he will not know that the siren was sounding. Furthermore, when somebody is approaching a dangerous area he does not know the siren has sounded and that he should not enter the area. The advantage of additional warning systems such as SMS and cell broadcast is that the SMS message will stay on the screen of the mobile phone until the message is read, so people will always be warned eventually. This is the reason that attention will also be paid to how many people are reached within half an hour. Within half an hour it is probably still useful to warn people, as an emergency situation usually lasts longer than half an hour and more people will have read the warning message after half an hour than after 7 minutes.

This paragraph will show how the reach of a warning system can be determined. A test into the reach of a warning system can be done by sending people several warning messages at different times of the day, spread over a not too short period of time (preferably at least a few months, so that people will not expect messages coming in all the time). It is important that people are not in an experimental situation, but in their normal daily life, and that they do not know when the messages will come in. This means that will not be focused on receiving a warning message. The warning message really has to stand out before people will notice it when they are in their daily routine and not thinking about emergencies. This way, the situation that will exist when there is a real emergency will be approached as closely as possible. When there is a special device that people have to carry with them, this is also a good test to determine whether they are willing to actually do so in real life. People may think that they are willing to carry a special device with them at all times, but reality may

show that this is not very convenient. The next paragraph will explain how the experiment was done in the SMS and cell broadcast studies.

As the SMS service and cell broadcast are meant to be an addition to the siren, all participants were sent an SMS message a few minutes after the siren test (so that they could have heard the siren, before receiving the SMS message) at 12 o'clock (noon) on the first Monday of the month in March, April, May and June of 2004 to determine the reach of the SMS service. Besides these four messages connected to the monthly siren test, two SMS messages were sent at different times to determine the reach of the SMS messages at unexpected moments. One message was sent on a Friday evening at 21.00 and the other message on a Tuesday morning at 09.30.

Because it is not possible to get information on when people actually read an SMS message, participants were asked to send a reply as quickly as possible after reading the messages that they received. When people reply, the time at which they have approximately read the warning message is known, as well as the fact that they understood the instructions in the message.

By using this specific research method, a bigger part of the contextual model is tested. By asking people to respond to the warning SMS message, block 4 (human information processing) and 5 (behaviour) and their connecting arrows are also tested.

In the messages connected to the siren test people were asked to reply if they had heard the siren before they read the SMS message 'YES' or 'NO'. In the messages at unexpected moments they were asked to simply reply 'YES' as soon as they had read the message (Sillem, Wiersma and Ale, 2004).

The responses to the SMS warning messages are measured directly. This response consists of a time dependent part and a content part: the reaction time and the content of the reaction. The SMS messages contained an instruction. According to this instruction, people were supposed to send a reaction by SMS as quickly as possible. An example of the output is: "0031612345678,20409,YES,2006-03-16 19:45:59". This output consists of the following elements: participants' phone number, code of the provider, the text that was entered by the sender, the date and time at which the SMS message is received. The participants only had to enter the answer to the question (in the message shown this was 'Yes'); the other data (phone number, date etcetera) was automatically generated and added to the SMS message.

5.2.1.1 Reach expected versus unexpected moments

Within 7 minutes after sending the SMS messages, an average of 42 % of the participants have replied (measured over all sent messages). Eventually this number went up to a response of 74% within about 2 hours after sending. After these first two hours, only very few replies came in: about 2% of the total number of replies. In Figure 3, the speed with which the reply messages came in can be seen. The messages connected to the monthly siren test reached 50% of the total response within four and a half minutes on average after the message was sent. It took nine minutes to get 50 % of the response for the messages sent at unexpected moments. This shows that at the unexpected moments it took people longer to read the SMS message. People may be warned by hearing the siren that an SMS message is coming in. The rate at the unexpected moments is probably a better estimate of the reach in a real emergency, as the SMS message will then also be sent at an unexpected moment.

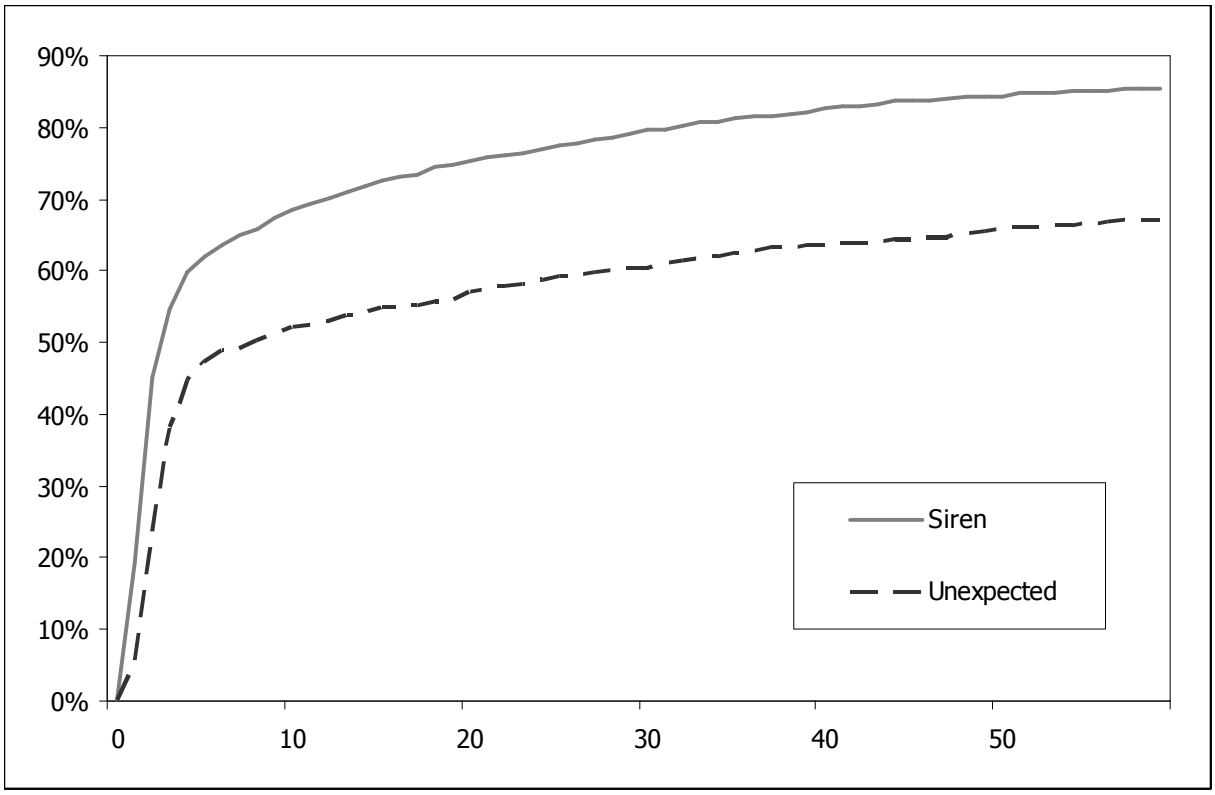

Figure 5-5: Reach of SMS for messages sent at the same time as the siren and at unexpected moments.

This analysis shows that the reach of SMS messages is high. Moreover, most people (50% of the total response) are warned within the first 4.5 (siren messages) to 9 (message at unexpected moments) minutes. This is very important as in an emergency people have to act quickly. The quicker people notice and read a warning message, the quicker they can evaluate the danger of the situation and the quicker they can start showing self reliant behaviour. Without a quick response, a warning system will not be very effective, which will have a very big effect on the outcome of an emergency.

The analysis also shows the importance of sending test messages at different times of the day (without people knowing when to expect the messages) during the experiment. This has great influence on the reaction time measurements and thus on the external validity of the test data. When people are in their normal routine and they don't know when to expect a warning message, the responses will give a more accurate representation of the response when the warning system is actually implemented.

In this study, people were asked to send a reply as quickly as possible after receiving a warning message. This means that the people that reply may not be all the people that have received, read and understood the message. Some people may have read the message, but did not send a reply for several possible reasons. So the actual reach of this warning message is always equal to or higher than the number of replies that come in. There may however be an effect of participants wanting to give a socially acceptable answer, which will make them indicate that they received the warning message, when they actually haven't. This effect is of course only possible when they have other people in their surroundings who did receive the warning message (otherwise, they wouldn't know when to send a reply that they did receive the warning message). This effect on the internal validity can be investigated by at one moment (preferably at the end of the stud, to minimise influencing the test) asking people (for example by giving them a phone call), whether they have received the message that was sent at a recent moment, when actually no message was sent out.

For other warning methods it may be easier or more difficult to determine the precise reach of the method. Attention has to be paid to determine the actual reach as accurately as possible, in order to determine the effectiveness of a new or existing warning method. For this reason, in the cell broadcast study, a sample of people that did not respond was called to determine if they really didn't receive the message. The results of the non-reach investigation will be discussed in paragraph 5.2.3.

5.2.1.2 Response to different types of messages

Different types of messages can be sent to test several aspects of the reach of a warning system. As shown in the previous paragraphs, messages can be sent at the same time as the siren or at unexpected moments to test the reach of the warning messages. It is however also possible to test other aspects of the warning system. Repeated sending of messages can be used to determine whether this will increase the number of people that are warned. Giving people a task in a warning message can help determine whether people read and understand the warning messages and whether they are willing to take action after receiving a warning message. Certain aspects of the correct functioning of the warning system may also be tested in some cases. In the case of the cell broadcast warning system for example, it is supposed to be possible to send quite long messages. To determine whether this works correctly, a number of long messages were sent to the participants in which the instructions were given at the end of the messages. In this way, the functioning of this part of the system can be checked. Sending these messages with different goals can help get a good view of the possibilities and impossibilities of the warning system.

In the cell broadcast studies, as in the SMS study, an important part is to determine how many relevant people can be reached using this new warning method. The goal is to reach more people than the siren reaches, or when cell broadcast is used as an addition to the siren, to reach the people that are not reached by the siren. Besides determining the reach, this chapter will also go into the reasons for non-reach. In the cell broadcast studies, several methods were used to determine how many people were reached and why some people were not reached. When it is known why people are not reached, solutions for the problems can be investigated, and the possible reach of cell broadcast when these problems are solved can be determined.

There are three ways of not reaching people: the warning message is not sent out correctly, the message is not received by the mobile phone or the message is received but not noticed or read by the receiver. There can be several causes for these failures. The next paragraphs will go into the research that was done in the cell broadcast study to determine the reach and non-reach of the service.

During the cell broadcast study, there were problems with the sending of cell broadcast messages. These problems mostly had to do with network problems from the providers and technical problems in the cell phone antennas. It is very important to find and recognize these problems for determining the effectiveness of a new or existing warning method. However, these problems cannot be influenced by the citizens that are warned by this method, so they will not be discussed thoroughly in this dissertation. The attention in these paragraphs is more focussed on the reasons for non-reach that can be influenced by the citizens, the reasons that are a consequence of the actual behaviour of the citizens, such as having their phone nearby, and switched on.

Like in the SMS study, the reach of cell broadcast is determined by sending people a message and asking them in this message to send a response back by SMS as quickly as possible. The reach of cell broadcast is determined in several research phases of the cell broadcast study. Two of these phases (3b and 3c) are chosen as examples in the following paragraphs because a lot of research is done in these phases to investigate the reasons for non-reach.

In phase 3c, 6436 people participated. The test had 7 test moments (cell broadcast messages to which the participants had to respond as quickly as possible). Before these test moments, 5 setting message were sent at known times, so that people could check whether their phone was set right. Table 2 shows the 7 test moments of phase 3c. The test area was split into two parts (part A with 3238 participants and part B with 3198 participants), so that two test methods could be tested at the same time for two different groups of people. The siren messages were the same as the SMS warning messages. These were messages asking people whether they had just heard the siren; these messages were sent right after the monthly siren test. When percentages are given, this percentage is based on the total number of participants (6436) and not on the number of participants in area A or B. The messages were sent out in area A and B, but it was not known how many participants were in those areas at the time of sending. It is possible that people who live in area A are in area B at the time of sending of a certain cell broadcast message. To be able to determine a good estimate of the difference between the different test messages, each type of message was sent out one time in both areas.

Besides the siren messages, there were 4 more types of messages that investigate the influences on the reach of cell broadcast. These test messages will be explained now.

Table 2: Test messages

Number	Message A	Message B	Date	Time
1	Direct	Teletext	March 16th	19:45
2	Teletext	Direct	March 23rd	11:00
3	Long	Short	March 30th	14:00
4	Siren	Siren	April 3rd	12:00
5	Short	Long	April 6th	19:45
6	Continuous	Repeat	April 20th	14:00
7	Repeat	Continuous	April 27th	19:45

In the direct versus teletext messages, participants' willingness to take action can be measured. In the direct messages, people are asked to send a certain response by SMS as quickly as possible. In the teletext messages, people have to check a certain teletext page, to see what their SMS response should be. The difference in percentage response and the difference in time of the responses give an indication of the willingness of people to take either simple or more complex immediate action after receiving a cell broadcast message in a non-emergency situation.

The long versus short messages are partly a technical test (whether longer messages are received correctly) and a test of whether people can read and comprehend the longer messages correctly. Longer messages can be useful. A standard cell broadcast message consists of only 93 characters (compared to 160 in an SMS message). More space may be needed to give people sufficient information to explain what is going on and what they should do. This may influence peoples' self-reliance, and thus makes it worth to test whether longer messages can be sent correctly.

Then the last test comparison was between repeat versus continuous transmission. This is also more of a technical test. A cell broadcast message is sent out a certain time. When a mobile phone is out of reach at that moment, the phone will not receive the message (as it would with SMS). Moreover, people may not notice every message that comes in. Both of these issues have a negative influence on reach. There are at least two solutions for these issues. In 'repeat', the same cell broadcast message is sent several times. A mobile phone should pick up this message only 1 time, because the phone recognizes it is the same message. The advantage of this method is that more people will receive the message. The disadvantage is that when you do not notice the warning coming in, you miss it, as the message only comes in 1 time. In the continuous mode, a new cell broadcast message

is sent out several times. Each phone should receive this message over and over again. The advantage of this message is that the message comes in several times, which improves the attention value. Disadvantage is that you get the message more times, even when you noticed it the first time, which may cause annoyance. Testing these to methods can determine which of these methods increases the chance of people receiving and reading a cell broadcast message most.

There were some problems with sending the cell broadcast messages in this phase. Although the number and percentages of the reach of cell broadcast are the actual test results for this study, they are not a good representation of the potential reach of cell broadcast when it will be implemented and when it will be working correctly technically. These results have also been published in the final report on cell broadcast (Jagtman, Wiersma et al., 2008).

5.2.1.3 Response to setting messages

As a reference for the test messages, several setting messages can be sent at the beginning of the study. Participants know when to expect these messages. Telling people when they can expect messages will improve the number of people that notice these messages. The reach therefore should be quite high for these messages.

5.2.1.4 Response to test messages

This paragraph gives an oversight of the responses to the different test messages. A distinction is made between the responses sent in areas A and B (the area in which the participants were living was divided into two geographical parts, area A and area B). Table 3 gives the responses by all participants and the responses by participants of which it is sure that they set their phone correctly (because they responded to at least one setting message). As mentioned earlier, the percentages in the table, are percentages of the total number of participants (so not of participants in area A or B), as it is not known whether people who are registered in area A or B were actually present in that area.

Table 3: Response by participants to test messages

Message	1		2		3		4	5		6		7	
Area	A	B	A	B	A	B	A+B	A	B	A	B	A	B
Participants	735	798	368	881	470	779	1344	407	473	380	440	397	553
Percentage	11	12	6	14	7	12		6	7	6	7	6	9
Overall	2%		19%		19%		2%	14%		13%		15%	
Set participants	625	667	316	729	365	613	1033	298	362	270	325	289	420
Percentage	25	26	12	29	14	24		12	14	11	13	11	16
Overall	51%		42%		38%		40%	26%		23%		28%	

5.2.1.4.1 Instruction direct or through Teletext

The message on March 16th for area B (message 1) and the message on March 23rd for area A (message 2) contained an indirect instruction ("Test: Immediately execute the assignment on Channel Zeeland Teletext page 120. Info: 0900-0922"). Participants were asked to consult a certain teletext page. The teletext page gives the right action (to send a text message with a certain text to a certain phone number). In the direct message, the instruction for the text and the phone number were given directly in the cell broadcast message ("Test. Immediately send a text message with the text 'tu alarm' to number 2020. Info: 0900-0922"). These participants did not have to consult the teletext page before they could send their response SMS message. For the first message, there is only a small difference between area A and area B (11.4% for direct versus 12.4% for teletext). The response for teletext is even bigger than the direct response. In the second message, however, the difference is much bigger (5.7 % versus 13.7%). The lower response for area A can be explained by the fact that only one of three providers sent out a message to this area. This shows the importance of collecting

data on both the sending as well as the receiving part. In this case, no judgement can be given on the difference between direct and teletext messages, because the disturbances in the sending process were too big.

5.2.1.4.2 Long or short cell broadcast messages

The message on March 30th for area A (message 3) and the message on April 6th for area B (message 5) were long cell broadcast messages ("Cell broadcast test. This message is part of the cell broadcast test in Zeeland. The government together with Delft University of Technology is investigating the possibilities to warn you in this manner in case of disasters. After reading this message, please send a text message with the text 'tu long' to 3111. Info"0900-0922"). The message on March 30th for area B (message 3) and the message on April 6th for area A (message 5) were short messages ("Test. Government investigates how to warn you. Text the text 'tu short' to 2020. Info: 0900-0922"). Message three to both areas was not sent out by provider 2. This gives less information, but the difference between area A and B can still be analysed. Message 5 was sent out by all providers, but the response for Provider 2 was very low. This is probably due to sending problems, so these results will not be analysed. For message 3, the difference between the long and short messages is substantial: 7.3% for the long message, and 12.1% for the short message. The assignment in the long messages is given at the end of the message. The fact that the number of response is so low is probably due to the bad reach of cell broadcast messages of more than one page. Cell broadcast messages of more than one page, are sent as separate messages of one page, which are connected together when they are received by a mobile phone. This probably is not working correctly yet. Further research needs to be done into this part of the cell broadcast technology.

5.2.1.4.3 Siren message

Message 4 on April 3rd was a siren message. This was a message that is sent right after the monthly siren test sounds (TEST: did you hear the siren? Text 'tu ja' or 'tu nee' to 2020. Info: 0900-0922"). This message was sent correctly by all providers and the response was 40.4% of the participants that have responded to at least one set message. This response is quite low compared to the response to the siren messages in the SMS study. This could be due to unknown problems with the sending of the cell broadcast messages. How this can be investigated will be discussed in the paragraphs about non-reach.

5.2.1.4.4 Continuous sending versus repeating of messages

The message on April 20th for area A (message 6) and the message on April 27th for area B (message 7) were continuously sent messages ("Test. Message to determine reach. Text 'tu proef' now to 2020. Do you want more information? Call: 0900-0922"). This message was sent out continuously for a certain period (6 times with a pause of 10 minutes between each message). This is the same message all the time. A mobile phone is supposed to pick up this message only one time. Because it is sent out continuously, the chance of receiving the message is bigger than when it is sent out only once, because it is received later when a phone is temporarily out of reach of an antenna. The other message ("Test. This message is sent out 6 times today. The first time you receive it, text 'tu herhaal' to 3111/ Do you want more information? Call: 0900-0922") was sent out repeatedly (6 times with a pause of 10 minutes between the messages). This is a new message each time, so each phone will pick it up 6 times (if within reach of the antenna, phone switched on, etc). Again, provider two had sending problems for both these messages, so the results cannot be analysed accurately. Expectation is that more people will respond in the repeat option, because people are alerted as a message is coming in more often.

These analyses show the importance of determining whether the sending of the messages was done correctly. Making sure that the technology works correctly in advance may save a lot of time when doing these types of field studies. The problems with sending in this phase, made the analysis of the data almost impossible in most cases. This analysis shows how influences on responses can be

investigated and also shows the problems that can occur while doing this. Furthermore, to determine more precisely the differences between two test methods, ideally these should both be tested in the two areas at comparable times. The times chosen in this schedule might not be ideal, because the sending times differ for the two test moments of a specific difference. For example the difference between short and long messages is first tested at 2 o' clock in the afternoon and the second time at 7:45 in the evening. There may be a difference between the number of people present in area A and B between these two times, which makes the analysis more difficult. It is better to keep as many variables the same when repeating a measurement.

When determining the reach of a new warning method, it is important to cover as many issues as possible that could be of influence on the reach, in order to determine a complete view of the possibilities. The last few paragraphs have shown that different types of messages as well as different sending times can have a great influence on the reach.

5.2.2 Reach compared to the siren

When determining the effectiveness of a new warning system, it is important to compare it to the current warning system, as the goal is to improve the number of people that are reached by the warning system. A criterion can be set in advance to indicate how large the improvement of the new or additional warning system has to be compared to the current warning system before implementation is useful. When more relevant people are reached by the new warning system, the influence on peoples' self-reliance will be bigger. It is however hard to compare two different warning systems. When an SMS warning message reaches more people than the siren, this does not automatically mean that an SMS warning message improves peoples' self-reliance. The information that is given in the warning is also of great influence on the degree to which self-reliance will be influenced. More reach alone is not enough to claim that a warning system is more effective in improving self-reliance.

In this paragraph the reach of a new warning system compared to the reach of the current warning system is determined. First, the reach of the current warning system has to be known. This can be determined in a field experiment when the warning system is actually used regularly. When the system is used at a set date and time (as is the monthly siren test in The Netherlands) the priming effect has to be taken into account. People know when to expect the siren to sound. This may cause more people to hear the siren. This means that when the siren sounds at an unexpected moment, less people may hear it. This has to be taken into account when comparing the current warning system with the new one. When the warning system is not used regularly, an experiment can be set up to determine the reach, although it may prove to be quite difficult to approach the situation of the real world in an experiment.

Subsequently, the reach of the new warning system has to be determined. Preferably, this is done in a way in which it is possible to determine how many people that are not warned by the current warning system are warned by the new warning system. In this way, the profit of the new warning system can be determined.

When these two measures have been taken, the two warning systems can be compared together and the additional value of the new warning system can be determined. The next paragraphs explain how the reach compared to the current warning system was determined in the SMS study (pahse 0).

The added value of the SMS service consists of two parts. First, the number of people that are reached extra by the SMS service, this is the number of people that read the SMS message but did not hear the siren. Second, SMS can give more information and instructions. This paragraph focuses on analysing the number of people that can be reached extra compared to the siren.

If the SMS service is implemented, the number of relevant people that can be reached is very important. Unfortunately, it was impossible in this test to determine the exact number of people that

read the SMS messages. The best estimate is the response; this is the number of people that send a reply SMS message, after reading the SMS message. The difficulty with this number is that there will be people who read the SMS message but who did not send a reply. Moreover, not everybody who sends a reply will do this immediately after reading the message. This again enlarges the difference between response and the actual reach figures. Because of these issues, the reach of the SMS service is always larger than the response figures that are shown in this thesis. In this study, people had to follow some simple instructions (send a reply). Further research is needed however, to determine how many people will actually comply with real instructions given in an SMS message in an emergency. This is of great importance, because if everybody is reached by SMS messages, the read and understands the message, but nobody acts upon the instructions given, then the added value of the SMS service is still nothing.

The next paragraphs (Sillem, Wiersma et al., 2004) will show how the measured reach is used to calculate the advantage of SMS and cell broadcast when they are used as an addition to the current siren.

The warning systems SMS and siren are both intended to warn people in case of an emergency. The additional value of the SMS service, next to the conventional siren for warning, can be expressed in terms of the reduction of the number of people that have been warned neither by the siren nor by SMS. In Table 4 the percentage of people that are not warned by either is given as I. The SMS test provides data on how many people are warned by means of SMS. These data provide details on (B) = the total percentage of people that replied to the SMS message, and (A) the percentage of these who had heard the siren.

To calculate the reduction in the percentage of people not reached by any means of warning system, data are also needed on the number of people that are currently, without the SMS service, not reached by the siren. Information on audibility of the siren from the questionnaire data can fill in the number of people that have not heard the siren on each occasion, marked (C) in Table 4. The questionnaire data can provide this information. Combining A, B and C, it is possible to calculate the number of people not reached. Namely, I = (C) – ((B) – (A)). The added value of the SMS service can be expressed in terms of the reduction of the number of people not reached: % advantage = ((C) – I) / (C).

Table 4: Calculating the advantage of SMS

		SMS		
		Yes	No	Total
Siren	Yes	(A)		
	No		I	(C)
	Total	(B)		100%

Using the data from this study shows the added value for the experimental group only. The respondents are different from the total population of the country, in that they all own a mobile phone. Moreover, they may have been primed for hearing the siren while participating in this study. The results in this section will present the added value in the experimental group only. If a choice had to be made between several different figures, the number that was most negative to the SMS service was chosen. This then indicates the minimum advantage of the SMS service, assuming that everybody has a mobile phone. Research shows that 84% of people in The Netherlands actively use a mobile phone (Derksen 2004).

Table 5 shows the number of participants that did and did not hear the siren and the SMS during this study. To determine the reach of the siren, the data collected at the end of this study were used. These data indicate how often the participants heard the siren during the last three months of the study. This number could have been influenced by priming, caused by the fact that the participants had heard the siren more often; this would give a more positive image of the siren and thus a more

negative image of the added value of the SMS service. On average 33% of the participants did not hear the siren.

The second known number is the mean percentage of reply messages, this is 74%. This percentage has to be corrected. 32% of the participants did not always send a reply message. If it is assumed that a participant did not send a reply only once (the actual number will be the same or higher), there has been a minimum under response of 5%; the total reach of the SMS message after correction is a minimum of 74% + 5% = 79%.

The test also shows that 72% of participants that sent a reply message did hear the siren. In Table 5 (A) is therefore 57%. Table 5 shows that for the test group, the number of non reached people is decreased from 33% to less than 11 %. This is an advantage of 67 %. Moreover, 57% was warned twice, they were not only warned by the siren, but SMS gave them more information and instructions on what to do.

Table 5: Response to SMS

		SMS		
		Yes	No	Total
Siren	Yes	(A) 57%	10%	67%
	No	22%	11%	(C) 33%
	Total	(B) 79%	21%	100%

In this study, combining questionnaires and SMS responses, it was possible to determine how many people are reached by SMS and by the siren and even how many people are reached only by SMS (advantage). Comparing these two methods is important to determine the additional value of the new (additional) warning system.

This analysis shows that the number of people that are not reached by a warning can be reduced from 33% to 11%. This is a large decrease. However, an important factor in warning citizens is time. It is important to warn citizens as quickly as possible. The next paragraphs will show the increase in the number of people that are warned within 7 minutes (Sillem, Wiersma et al., 2004).

42% of the participants replied to the SMS messages within 7 minutes. Table 3 shows that 9% of the total population responded to the SMS message but did not hear the siren. The number of people not reached by the siren is reduced by (9% / 33% =) 27%. Moreover, 33 % (A) of the participants were warned twice within that time period.

Table 6: Response within 7 minutes

		SMS		
		Yes	No	Total
Siren	Yes	(A) 33%	34%	67%
	No	9%	24%	(C) 33%
	Total	(B) 42%	58%	100%

This analysis shows that the reach of SMS is quite good and that most people that are warned are warned within the first 7 minutes. Even more people can be warned when warned people talk about the warning with other people who may not have received the warning (the so-called buddy effect). It is quite easy to determine whether people have received and read the SMS messages. A reply can be asked of them, it can be asked by a questionnaire, or people can be contacted by phone to ask whether they have received the messages.

Moreover, people that are warned twice now have information through two types of media. This helps convince people that there is a real emergency. When there is information that there is an emergency, people will start to search for more information, to confirm the information from the first source (Dash

and Morow, 2001). When the siren is heard and when this warning is backed up by an SMS message, this will be an indication that something is really going on and that action is needed. A disadvantage may be that people who did hear the siren, but did not get the SMS may think that the siren was therefore a false alarm. When they are used to this warning system, they will expect an SMS message with follow up information.

This analysis can be taken even further. The calculations in Table 5 and Table 6 assume that everybody uses a mobile phone. This is not really the case. In 2004, 84% of people actively used a mobile phone (Derksen, 2004). This figure will have probably gone up since. The tables can be adjusted by multiplying factor B (42% in Table 6) by the proportion of people that actively uses a mobile phone in a certain population (0.84 in 2004) and adjusting the rest of the table accordingly.

The advantage of cell broadcast as an addition to the siren was determined as well. The results of the siren message in phase 3c are used for this analysis. 1344 participants responded to the siren message. As in paragraph 5.2.1, the total percentage of people that did not hear the siren (68% in Table 7) is taken from questionnaires. In this case (Jagtman, Wiersma et al., 2008), the questionnaires from phase 2 are taken.

Phase 2 has a before and after measurement for the question how often people heard the siren during the previous 3 months. The before measurement gives an average of 64.8% of participants that heard the siren. In the SMS study, the result was 67%. In the after measurement of phase 2, the average was 67.5% of participants that heard the siren on each occasion. To be able to give a realistic impression of the advantage of cell broadcast as an addition, the worst (for cell broadcast) and highest number is used, rounded up to 68%. In phase 3c, this question about how often people had heard the siren was not posed anymore in the questionnaire. That is why the data from an earlier questionnaire is used.

Table 7: Advantage of cell broadcast as an addition to the siren

		SMS response		
		Yes	No	Total
Heard siren	Yes	14.8% (955)	53.2% (3421)	68% (4376)
	No	6.0% (389)	26.0% (1671)	32% (2060)
	Total	20.9% (1344)	79.1% (5092)	100% (6436)

Table 7 shows that when using cell broadcast as an addition to the siren, the percentage of people that is not warned, decreases from 32% to 26%. This is an advantage of 18.8%.

This advantage of 18.8% is calculated using the highest estimated percentage of people that do hear the siren, and is using the current cell broadcast reception, with all the sending problems that have occurred in this phase. Moreover, when somebody receives a cell broadcast message, this person can also warn other people that are around him. This indicates that the potential reach and advantage of cell broadcast are bigger than the numbers that these results show. This number is much lower than that of the SMS study. Unfortunately, there were many problems with sending and receiving of the cell broadcast messages due to technical issues(which will be discussed later) which makes it unfair to say now that SMS is better than cell broadcast in reaching people in an emergency. When the technology is working correctly, this improvement will go up for cell broadcast.

When using a warning method as an addition to the siren or another type of warning method, it can be useful to determine the advantage of this new method to the currently used method. In this way, it is clear how much more people can be reached when the additional method is used. In case of the siren, the advantage can be determined fairly easily, because the siren is tested every month. This may however give a slightly distorted view on the advantage, as the siren is tested every month at the same moment. The reach and thus the advantage may be different in a real emergency when the siren will sound at an unexpected moment.

5.2.3 Non-reach

The next paragraphs will go into determining the non-reach of a warning system. When the reasons for non-reach are determined, solutions for these problems can be looked for and the reach and the positive influences on peoples' self-reliance can be improved when adjustments are made, as the percentage of citizens reached can be increased. Determining the non-reach is increasing the internal validity. When the reasons for non-reach can be found, all influences on the reach can be found and the variance is explained.

The way in which the non-reach of a warning system is determined can vary depending on the research methods that were used to investigate the reach. When determining non-reach in a laboratory experiment for example, people can be interviewed or asked to fill out a questionnaire at the end of the experiment. When determining the reach in a field experiment, people can be called by phone some time after being sent a message, to ask them whether they have received the message, or they can be asked by questionnaire at the end of the experiment when it is important not to influence the participants during the experiment. When laboratory experiments are done into the audibility or notability of warning messages, the reasons for non-reach can be determined immediately. The next paragraphs explain how the non-reach was investigated in the cell broadcast study.

In phase 3c, a sample of about 400 participants were called after each message. This was a different sample after each message. In this paragraph, the reasons why people did not receive all messages are investigated. Data from phase 3b and 3c are used as examples (Jagtman, Wiersma et al., 2008).

Table 8: Message received?

	Number	Percentage
Yes	597	38.1%
No	971	61.9%

Table 8 shows that over all messages, an average of 38.1% received the cell broadcast message in phase 3c. This number is higher than the average response of 17.8% of participants that responded to the messages in Table 3. As not all people in these 7 samples of 400 were reached, it is possible that the people that answer their phone immediately are also the people that usually carry their phones with them, and that they have a higher percentage of receiving the cell broadcast message because they check their phone more often.

This shows it's very important to reach all the people in the sample, to get a representative view of the number of people that received the cell broadcast message. When only a selection of the sample is reached by calling them, this will probably be the people that have their phone close by and switched on all the time. This may give a much distorted view of reality. It is also important to determine the reach among people that do not always have their phones switched on and nearby. These results can have a great influence on the conclusions on the reach of cell broadcast. Carefulness in interpretation is very important when only a sample of the test population is tested on a certain issue. Moreover, it has to be taken into account, that this method may have an influence on the behaviour of participants and thus on the results of the test When people are called after each message, they may show other behaviour in the experiment than when they do not expect a phone call after each message. Whenever possible, it is best to consider this determining of the non reach by calling people as a separate technical test and to do this research on a separate sample of participants.

Subsequently, in the cell broadcast study, when the sample of people was called, for the people that indicate that they did not receive the cell broadcast message, the reason for this was determined. First, there was a check whether they were in the broadcasting area. If they were outside of the broadcasting area, than it is not a problem if they did not receive the cell broadcast message. In a real emergency only the people within the area at risk have to be warned.

Table 9 shows that over 75% of the people that did not receive the cell broadcast message were in Zeeland and had their mobile phone switched on (Jagtman, Wiersma et al., 2008). This means that they should have received the messages, if they had set their phones correctly. Not receiving the messages correctly could be due to not setting their phone correctly or to sending problems of the different providers. The government of the Netherlands indicates that they are trying to standardize the cell broadcast settings for all newly sold phones, when cell broadcast is implemented as an addition to the siren.

Table 9: Conditions under which people did not receive

	Number	Percentage
Not in Zeeland	163	16.9%
In Zeeland, but phone switched off	71	7.4%
In Zeeland, phone switched on	729	75.7%

Determining the part of the participants that should have received a cell broadcast message (present in Zeeland and phone switched on) can give an indication whether there were problems in sending the messages. When using only the SMS responses, this doesn't provide a clear view. It is possible that people did not notice the messages immediately or that the message came in at an inconvenient moment. Calling a sample of people can give a better indication of whether there were sending problems. However, when each participant is called after each cell broadcast message, this can influence the behaviour of people, and thus the reach as well as the attitude towards cell broadcast. This means that it is very important to determine the goal of the study and to think carefully about the degree to which each intervention will influence the participants. A technical test can be done separately from the normal test. Then, the normal test can be used to determine the attitude towards the warning system and reach. This test will then have few interventions (contact with the test organisers). The technical test can be used to determine whether cell broadcast works correctly and to determine the reasons for non-reach by calling all participants after each message. Using two separate tests in this case will then give more complete and more valid results.

In phase 3b, the reasons for non-reach were investigated even more deeply. Every participant was called after each cell broadcast message. Not everybody was reached however; some people didn't pick up their phone despite being called several times, for other people the call came at an inconvenient time. People were asked in the calling sessions whether they had succeeded in setting their phones correctly, and if not, why not. This, in combination with the previous two questions, gives an even better indication of how many people should have received the cell broadcast messages (Jagtman, Wiersma et al., 2008).

Table 10: setting phone successfully?

	Number	Percentage	Letter clear
Yes	249	80.3%	219 (88%)
No	57	18.4%	27 (44%)
Not sure	4	1.3%	

391 People participated in phase 3b. 169 of them responded to at least one cell broadcast message. 310 participants were reached by calling them about setting their phone. Table 10 shows that 80% of the participants that answered the questions by phone were successful in setting their phone to receive cell broadcast messages. So, even though people received a letter about how to set their phone and with directions to the website with the instruction database for a lot of phones, still 1 in 5 participants could not or did not set their phone to receive cell broadcast messages. The following question was posed to the people that indicated in the phone call that they had not set their phone correctly or to those who were not sure. They were asked what the problems were that were encountered when setting their phone. Table 11 shows what these problems were. More problems could have occurred in each respondent.

Table 11: Problems in setting phones (number of participants)

	Set	Not set
Instructions were wrong / not clear	15	3
Type of phone was not mentioned	11	1
Email / phone not answered / busy	2	0
Other	7	28

This analysis shows that the interviewed people are not familiar with the use of cell broadcast and with setting their phone. It is important for a new or existing warning method that it is easy to use for everybody. The government is now working on standards for cell broadcast. This will make sure that in the future, cell broadcast will already be set on each new phone that is bought. In that case people don't have to follow the sometimes difficult instructions to set their phones. In this case, the results are also possibly influenced by the fact that not all participants had been reached to question them. It does give an indication of the reasons why people were not successful in setting their phones for cell broadcast.

At this moment there are several reasons for a cell broadcast message to not reach people that need to be warned. These reasons are mentioned below, as well as (in brackets) ways in which this data can be obtained. When these reasons are known, the problems causing the non-reach can be solved.

Reasons for not being warned by a cell broadcast message are:

- Outside of warned area (ask them by calling, or get data from network providers). This group is not a problem, as these people are not meant to be warned, as they are outside of the area at risk
- Mobile phone turned off (ask by calling)
- Mobile phone out of reach antenna (possibly this can be checked by network providers)
- Cell broadcast not set right on phone (check phone)
- Problems in phone with receiving cell broadcast messages (unclear how this can be checked)
- Message was not sent right by provider, so not received, or not received correctly/completely (data form network provider)
- Phone not nearby, so message received but not noticed (ask by calling)
- Sound of message not heard, so message received but not noticed (ask by calling)
- Message heard but not read (ask by calling)
- Message heard but not read immediately (ask by calling)

Investigating all these issues can give more insight into the problems with being warned by cell broadcast and into the possibilities for solving these problems and thereby increasing the reach and thus the number of people that will show self-reliant behaviour.

5.2.4 Content: understanding warning messages

The goal of sending warning messages is to influence the self reliant behaviour of people in an emergency so that they can take themselves to a safe place. In order to achieve this improving influence on self-reliance, people have to be able to understand the warning message when they receive it, and the information has to be clear, so that people know what they have to do, what kind of behaviour they are supposed to show in order to reach a safe place. Of course, understanding a warning message is not enough to ensure the proper action to be taken. The source has to be seen as credible and authoritative and many other issues are of influence. But understanding the warning message is a very important link in the chain that will influence peoples' self-reliance, as it is needed for the message to be able to increase self-reliance. Research is needed into what kind of information people want in an emergency. Research has been done into what kind of information they need to be able to judge the danger of the situation correctly and to be motivated to start acting and how this information should be given (OASIS, 2005). Furthermore, depending on the warning system that is used, the warning messages have to be designed in a certain format. A number of issues are

important in designing the warning messages, such as length of the text, the content components that are put in the messages, the font, the size of the text, the colour et cetera. Often there may be limited choice in how the warning message is presented because of the limitations of the warning system. For example, in most cases the length of the warning message will be limited. OASIS (2005) has designed a Common Alerting Protocol (CAP-protocol) which shows all subjects that should be mentioned in a warning message. The list of subjects is quite long and contains 44 issues like sender ID, message ID, sent date / time, scope, restriction, event category, urgency, severity, certainty, area description, etcetera (see Appendix E for a full list of the CAP protocol and the publication for an explanation of all the components), which makes it practically impossible to fit all of them in a warning message. Research is needed into what components are most important to be mentioned in a warning message of a specific format and which are of secondary importance. Of course, the message should be optimised within the limits given by the warning system at hand. The optimisation of the subjects that should be used in the warning message will vary over warning systems, as each warning system will have different limitations and possibilities. Therefore, each warning system will differ in the way that they influence peoples' self-reliance. This has to be looked at on a case to case basis.

The next paragraphs show how the content of warning messages sent through cell broadcast was studied in the cell broadcast studies. First, the information that people need / understand best in an emergency is investigated. Then, the information that people prefer to receive in an emergency is explained. In the cell broadcast study, only length and content of the message were varied. As cell broadcast messages are sent in a standard format (letter size, font, and colour) there are not many variables that can be tested / optimized except for length and content of the messages. In other warning systems it may be possible to change more variables.

The influences of the content of warning messages were investigated in a laboratory and a web-based experiment. This web-based experiment covered the issues as discussed in paragraph 4.4.2. Participation in this research was open to anyone. People did not have to have taken part in any of the other experiments. Moreover, advertisements were placed on several websites inviting people to take part in the experiment. 418 people completed the experiment.

In the web-based experiment, people were shown examples of warning messages, which can be seen in Figure 5-6. These warning messages varied in length and information content. Length is an important factor in warning messages. A warning system has a certain space for presenting warning messages, and as action is required quickly, the time it takes to read / listen to the warning message is also an important issue in conveying a warning message. For example in the cell broadcast study, the screen of a mobile phone is limited in the amount of text it can show at one time. Scrolling or changing pages is often necessary in order to read the whole cell broadcast message. Moreover, there is a maximum amount of text that people can still remember and understand, especially when fast action is required. On the other hand, a minimum amount of text is needed to explain the emergency situation and the need for immediate action. Optimising the length of warning messages can have an influence on peoples' self-reliance. The warning message has to be long enough, so that there is enough space to put al relevant information in the warning message. And the message has to be short enough, so that people can still remember the whole warning message, and make a correct decision about the possible danger they are in and the action that they have to take.

In the laboratory experiment (phase 1b), in which 44 people participated, 3 lengths of messages were offered. The messages had a length of about 150, 300 or 460 characters. The longest messages, with a length of 460 characters were chosen because this is the length of a teletext page. This length should provide enough space to tell almost anything you want to tell people. As a mobile phone has a limited screen size, the choice was made to use these 460 characters as the maximum length. The other two lengths were chosen by dividing 460 by 3 and by 2/3 and rounding off. In the laboratory experiment, for both understanding and preference, the messages of 460 characters scored worse than the other two lengths, so in the web-based experiment (Phase 4d), only two message lengths were used:

- Shorter messages: about 150 characters text
- Longer messages: about 300 characters text

Besides length, the content of the messages is considered to be an important factor. Starting with the results from the laboratory research in phase 1b, four types of information components were defined:

- Risk1: the emergency or threat
- Risk2: the location of the emergency or threat
- Action: the action that is needed
- Information: reference to other sources of information for further explanation and information

These components were determined before the publication of the CAP protocol was available. This is why the components are not copied exactly from the components found in this protocol. The 4 components used were determined by interviews with people that actually have to compose warning messages in an emergency. Further research can be done with the components from the CAP protocol, to see whether they will give the same results as this study.

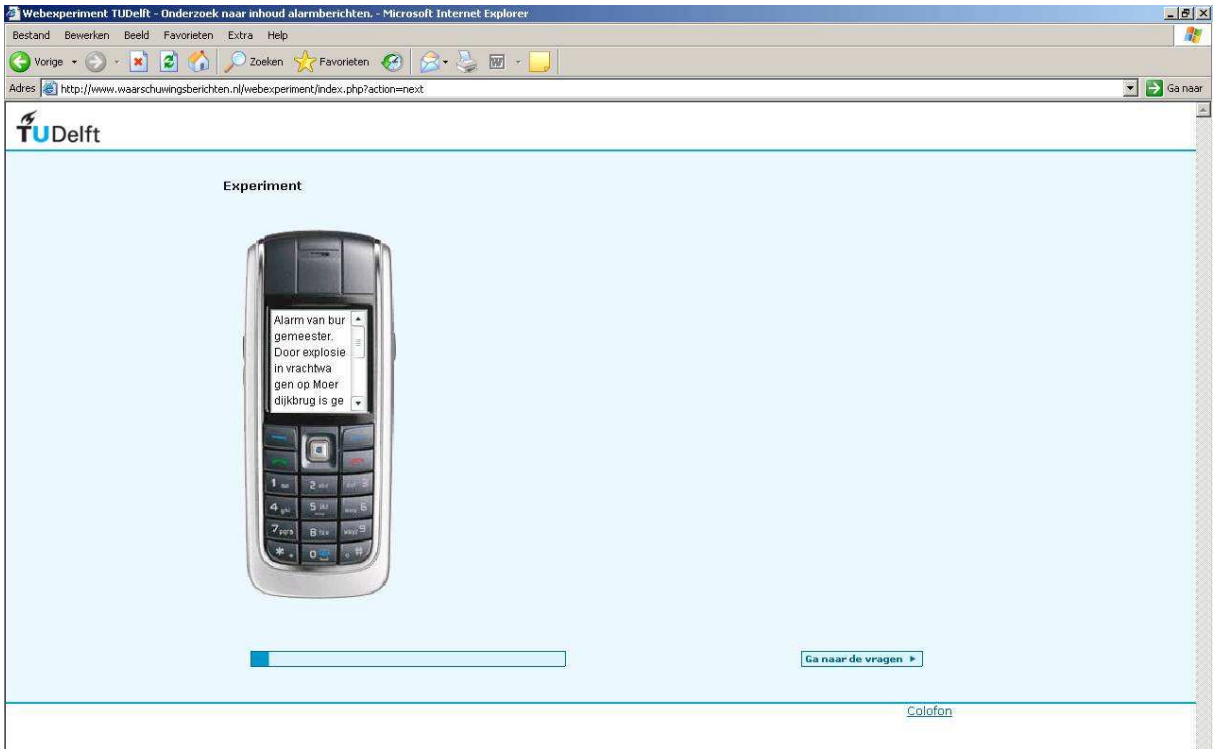

Figure 5-6: warning message in web-based experiment.

In an emergency, people need a certain degree of insight into each of these components. This information can be used by each individual to judge the situation, determine whether they really are in danger and what actions are needed to bring themselves and others to a place safe place. A minimum amount of information is needed to understand the importance of the message. Too much information on the other hand can lead to confusion. Just as for length, the influence of the factor content is not clear. Because a warning message without the two components Risk1 and Risk2 is not distinguishable from any other cell broadcast message, these two components were present in all test messages. The messages varied in the presence of the content components Action and Information. In total, three different types of message content combinations were tested:

- RA: messages with information on Risk1, Risk2 and Action
- RI: messages with information on Risk1, Risk2 and Information
- RAI: messages with information in Risk1, Risk2, Action and Information

Two different message lengths and three different types of content combinations led to a total of 6 different message configurations. For each of these 6 types, 3 messages were shown to the participants. So in total, each participant judged 18 messages. The tested messages can be seen in Appendix D.

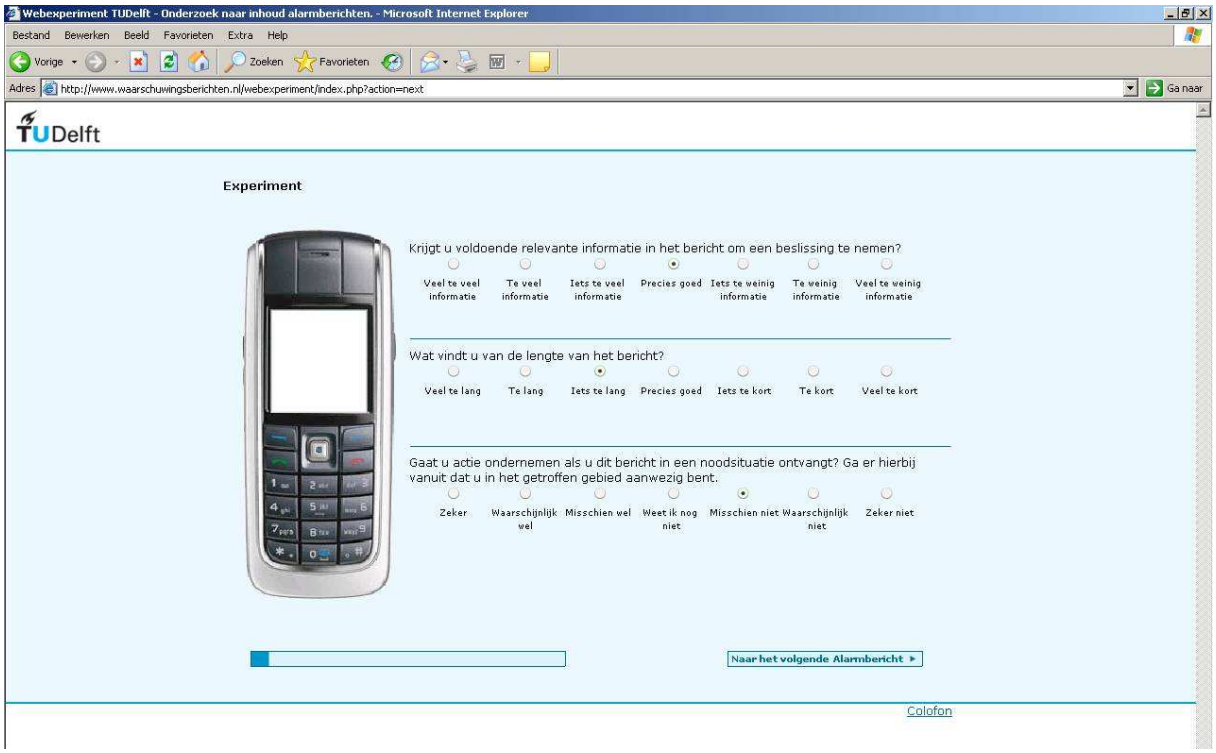

Figure 5-7: questions in web-based experiment.

After each warning message in the web-based experiments, the participants answered three questions. Two of these questions had to do with understanding the given message. These questions were:

- Do you get sufficient relevant information in the message to make a decision?
- What do you think about the length of the message?

Both questions had to be rated on a 7-point scale, going from 1 (much too much information or length) to 7 (much too little information or length). On this scale, the answer in the middle (4 = exactly right) is the optimal answer. The closer the answer is to 4, the better the message is judged by participants. A value higher than 4 means that the message is too short (length) or contains too little information (content). A value lower than 4 means that the message is too long (length) or contains too much information (content). The goal of these two questions was to determine what length is preferred and which messages are understood best, or in other words, what messages give the information needed to make a decision about the situation that they are in. It is difficult to truly operationalise the factor 'understand'. In this case the goal of understanding is that a decision can be made as to whether the person is really in danger and what action should be taken, so this is formed into a question to measure the factor of understanding.

Table 12 shows a summary of the results for the 6 different message configurations (Jagtman, Wiersma et al., 2008) that were used in the web experiment that was completed by 418 participants.

Table 12: Average judgement (and standard deviation) of tested warning messages

	Length		Content	
Type of message	Average	Stand. dev.	Average	Stand. dev.
RA150	4.0	0.79	4.3	0.87
RI150	4.3	0.92	4.9	1.11
RAI150	4.1	0.73	4.4	0.82
RA300	3.2	1.03	3.6	1.11
RI300	3.2	1.13	3.6	1.43
RAI300	3.2	1.01	3.5	1.01

For the averages, the table shows an expected pattern. The shorter messages are judged as being exactly right or a very little too short, whilst the longer messages are generally judged as being a bit too long. For the content of the messages, the values for the shorter messages show that they contain (a little) too little information. For the longer messages this is (a little) too much. The standard deviation of the shorter messages is generally smaller than with the longer messages. This means that the answers are scattered more over the different answer categories for the longer messages. The standard deviation for messages with content components Risk and Information (RI150 and RI300 messages) is striking. The next paragraphs show the statistical significance of the results for each factor (length and content). The answers of the participants to the three questions after each message were analysed using a General Linear Model (GLM, this is the same as an ANOVA) for repeated measures. The decision to use a GLM for repeated measures was made because the same participants judge several messages. The within-subjects differences were analysed. This GLM gives a main effect only. A Bonferroni post hoc test was used to determine the effects for each individual variable (when there were more then two in the analysis). As data points both the absolute score as well as in some cases the deviation from the optimal score were used.

The results of this analysis show how the differences in length of messages are judged and show whether a certain length is preferred. The next paragraph will go into the investigation of the length of the messages. The following paragraph will go into the content of the warning messages.

5.2.4.1 Preference for length of messages

As explained in the previous paragraphs, the optimal length of warning messages can be determined by giving people several warning messages of variable length and then asking them to judge these messages on a number of important issues. It is important to use a test interface that is similar to the one being used when the warning system is implemented, as this may have a great influence on the results. For mobile phone text messages for example, the amount of text that can be seen at one time is important. Most mobile phone screen have limited possibilities for showing large amounts of text at the same time. This mans that people have to remember the text in the warning message, because they can not see all the text at once. Not that this may change over time. More and more mobile phones are being equipped with larger screens. This means that the optimal warning message at this moment may be different from the optimal message in a few years, when more people have a mobile phone that can display a longer text.

The expectation was that, as in the laboratory experiment of phase 1b, participants would prefer a length of 150 characters. In order to answer this research question, the answers to the second research question (What do you think about the length of the message) were analysed. The answer to this question represents the judgement of the participants on the length of the messages. First, the differences between messages were determined. When there are differences, the type of message that was closest to the optimal score (4) was determined. In total, each participant judged 9 short and 9 long messages.

Figure 5-8 shows a histogram of the distribution of the judgements for the shorter and the longer messages (Jagtman, Wiersma et al., 2008).

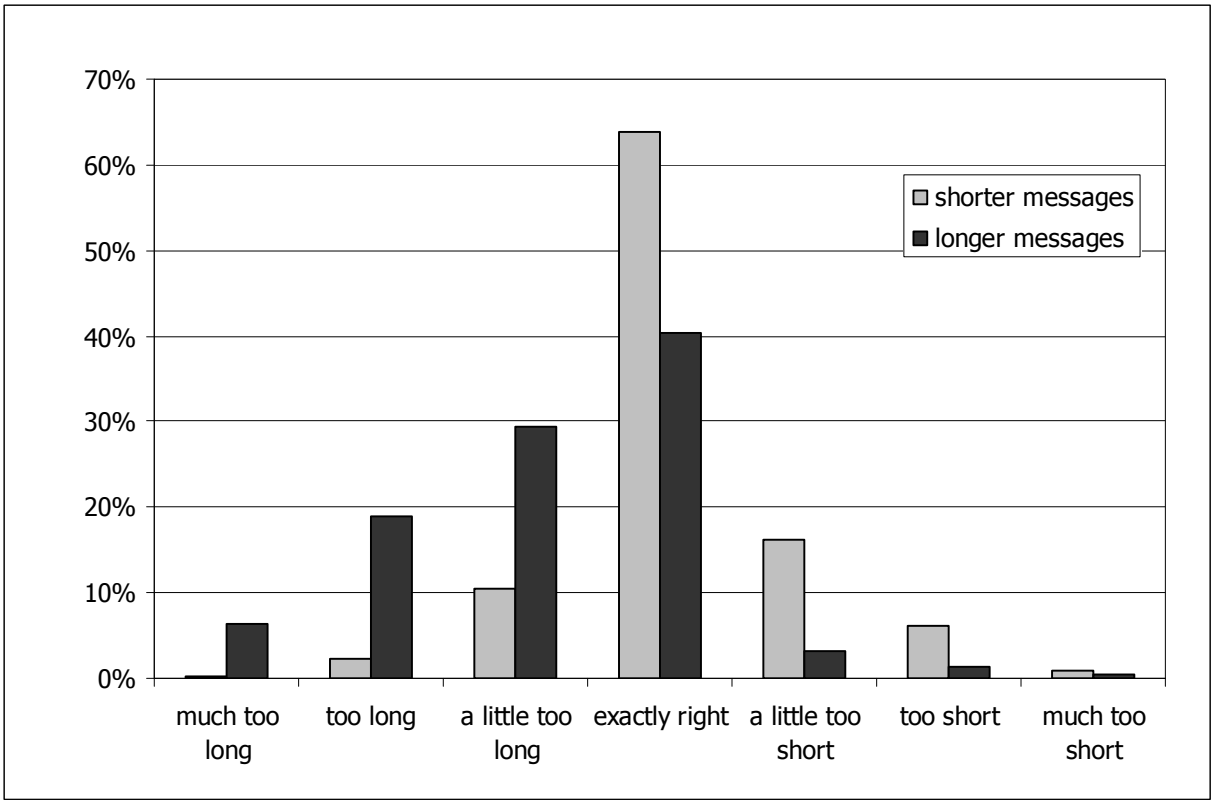

Figure 5-8: Judgement of length of messages (F=107.618; p < .001; df=373)

The Figure shows that the longer messages are mostly judged as being exactly right or too long. The shorter messages are mostly judged as being exactly right or too short. The GLM for repeated measures indicates that the distributions of the judgements for the shorter and the longer messages are significantly different. The Figure shows that the judgements of the shorter messages are closer to the optimal score of 4 than are those of the longer messages. So, for the length of messages, the shorter messages are preferred.

Summarizing, this analysis shows that when using cell broadcast for sending warning messages, the shorter messages are preferred. This does not mean that this can be generalized to other warning systems. When a larger screen is available, or when an auditory message is used, other lengths may be preferred.

A number of factors concerning warning messages can be investigated. It has to be taken into account that when there is an emergency, there is probably not a lot of time to compose a new warning message. When the decision is taken to sound the siren the warning message using SMS or cell broadcast goes out at preferably the same time or directly after. In order to do this, a standard message can be sent, followed later by a more specific message when a specific type of action is needed. Another possibility is to compose a number of warning messages in advance, for several possible scenarios. Then, a more specific message can be chosen directly when the siren is sounded.

Besides judging warning messages, some more issues concerning the length and content components of the warning messages were investigated in a questionnaire that was filled out by al the participants in the web-based experiment at the end of judging the warning messages. They were asked to

indicate what type of messages they prefer, the shorter or the longer messages. The results in Figure 5-9 show that 59% prefer the shorter messages.

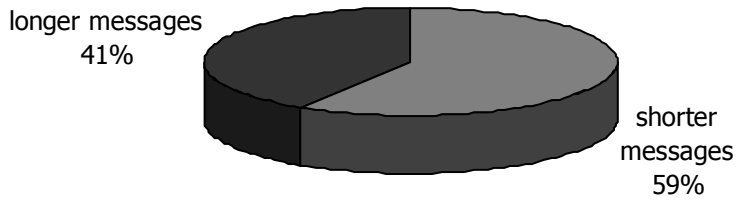

Figure 5-9:Preference of participants for length of messages (N=377)

This fits the results from the judgements of the warning messages, where the scores of the shorter messages are closer to the optimum of 4, so the understanding of shorter messages is closer to the optimal value.

5.2.4.2 Preference for content of warning messages

Next to the length of warning messages, the content is an important factor for understanding warning messages. Different content components can be investigated, depending on what information is available in an emergency and what kind of information is useful for citizens. As discussed in the paragraphs above, the web-based experiment looked at Risk1 (what is going on), Risk2 (location), Action and Information as possible content components.

The results from the cell broadcast study indicate what combination of content components contributes the most to understanding warning messages. The expectation is that participants will value highest messages that contain information on Risk, Action and Information (RAI). Based on this information, it is most likely that they will be able to correctly estimate the danger they are in and the actions that are expected from them. Moreover, it is expected that the participants will indicate that messages with information on Risk and Information only (RI) will be judged as containing too little information in order to take a decision. To answer this research question, the answer of the participants on the first question in the web-based experiment ("Did you get sufficient relevant information to make a decision") will be analysed. The answers to this question represent the judgements of the participants on the content of the warning messages. It indicates whether they feel the messages contain enough information to make a decision. Every participant judged 6 messages per combination of content, 6 messages with Risk and Action (RA), 6 messages with Risk and Information (RI) and 6 messages with all three content components (RAI) (Jagtman, Wiersma et al., 2008).

Figure 5-10 shows a histogram with the distribution of the participant's judgements of the three combinations of content components. The variance is larger than for the judgement of shorter and longer messages. This means that the participants are more divided in their opinion than they were for the length of messages.

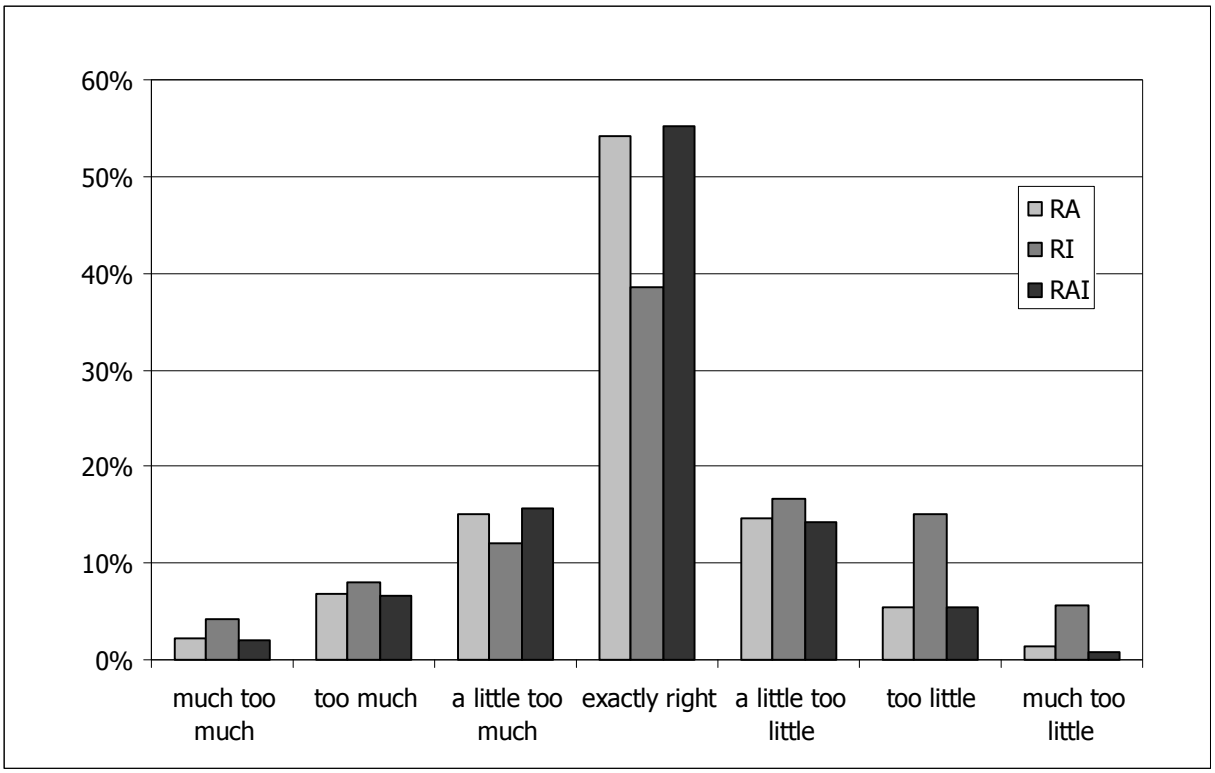

Figure 5-10: Judgement of content of warning messages (F=55.539; p < .001; df=372)

Figure 5-10 shows that the distribution of RI messages is deviating from the other two. In Table 6 this difference was especially seen for the shorter RI messages. This table also shows that the variance of the RI messages was considerably larger. The distributions differ significantly from each other. The Bonferroni post hoc test shows that the RI messages differ significantly from the other two types (RA and RAI). RA and RAI messages do not differ from each other. RA and RAI messages are significantly closer to the optimal value of 4. The messages in which no action component (A) is added are judged as being worse regarding content than the messages that do contain the action component (RA and RAI).

These results are in line with the results from Proulx (2000). This research shows that messages should at least describe the emergency and give instructions concerning the appropriate course of action. When these two content components are in a warning message, this will have a more positive influence on peoples' self-reliance than when one of these components is missing. People need this information to make a correct decision about the possible danger they are in and what they should do to make sure that they stay safe, and thus to show self-reliant behaviour.

It is important that people can find information about what is going on directly after the siren has sounded. People will want to validate that there is real danger and that the siren sounded for a good reason. When a warning message is sent directly, this will reassure people that something is going on and that action is needed. They will still probably seek for more information, but the siren and a warning message by SMS or cell broadcast are already two sources of information, and this will help people make a decision.

It has to be considered what message characteristics are of importance when investigating a new warning method. In this case, the goal is to warn more relevant people and to give them additional information to the siren. That is why the possible content components are investigated. This will give information into the needs of people in an emergency. Because of the limited size of most screens of mobile phones and the information processing capacities of people in an emergency, the length is also

of importance. In other warning media, other issues may also be of importance. These have to be determined, considered and investigated.

The questionnaire that the participants received at the end of the web-based experiment contained several additional questions about the content of the messages. One question concerned the order of importance of the content components. The second question encompassed the content components that are necessary in warning messages. The third question determined whether there are components that can better be left out of the warning messages. For the first question, all components had to be ordered. For the other two questions, more than 1 answer could be checked.

Figure 5-11 shows the participants' preference order of the content components (Jagtman, Wiersma et al., 2008). For this question, the Risk component was split in two parts, Risk1 = a description of the emergency and Risk2 = the location at which the emergency takes place. Most participants said that Risk1 was the most useful component, followed by Risk2 and Action. 74% felt that information is the least useful component. This fits earlier findings, where RI messages were judged as being the worst messages.

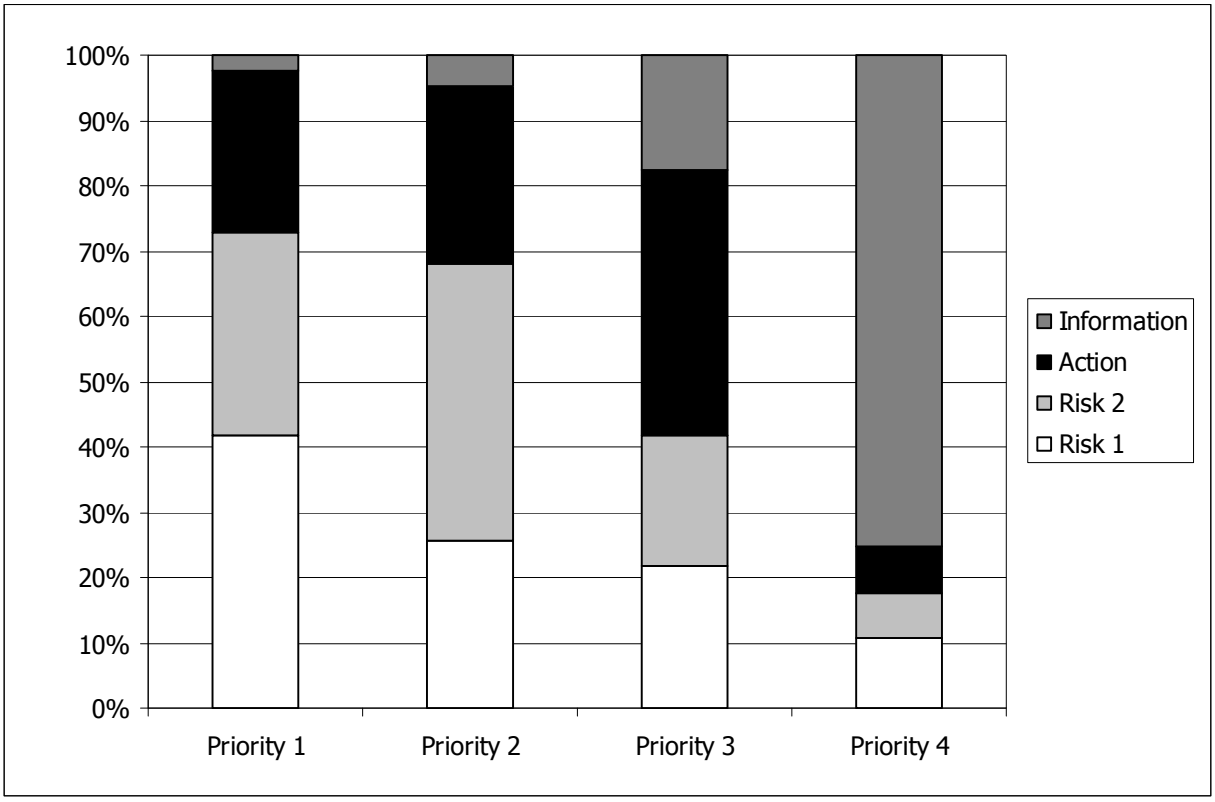

Figure 5-11: Preference order of content components for warning messages (N=377)

Figure 5-12 shows the components that were found to be necessary in a warning message. Information was least often indicated as being a necessary component. Action was the mentioned the most as being necessary. This fits with the results found earlier. However, this last finding seems to be contradictory to the findings in Figure 5-11; but if we add Risk1 and Risk2, people still prefer the Risk component in the warning messages. With 92% preferring the Risk component this is higher than the Action component. The inference must be that some of the people consider risk more in relation to the scenario and others more in the relation to the location of the emergency. 27% of the participants indicate that all 4 components should be in a warning message. Figure 5-13 shows what content components can possibly be left out of the warning messages.

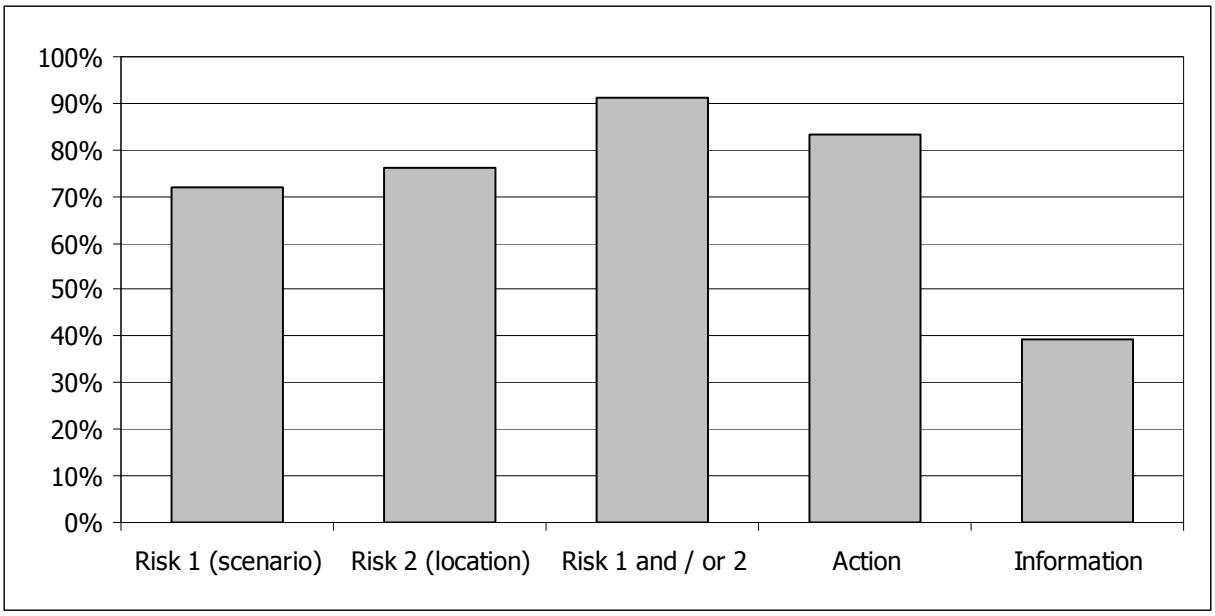

Figure 5-12: Content components that are necessary in warning messages (N=377)

Most of the participants (79%) do not declare themselves against any content components. In line with earlier results, the component Information is thought to be superfluous by 15% of participants. This may be caused by the fact that not all sources of information can reached at all times. The other three components are found to unnecessary in warning messages by less than 4% of participants.

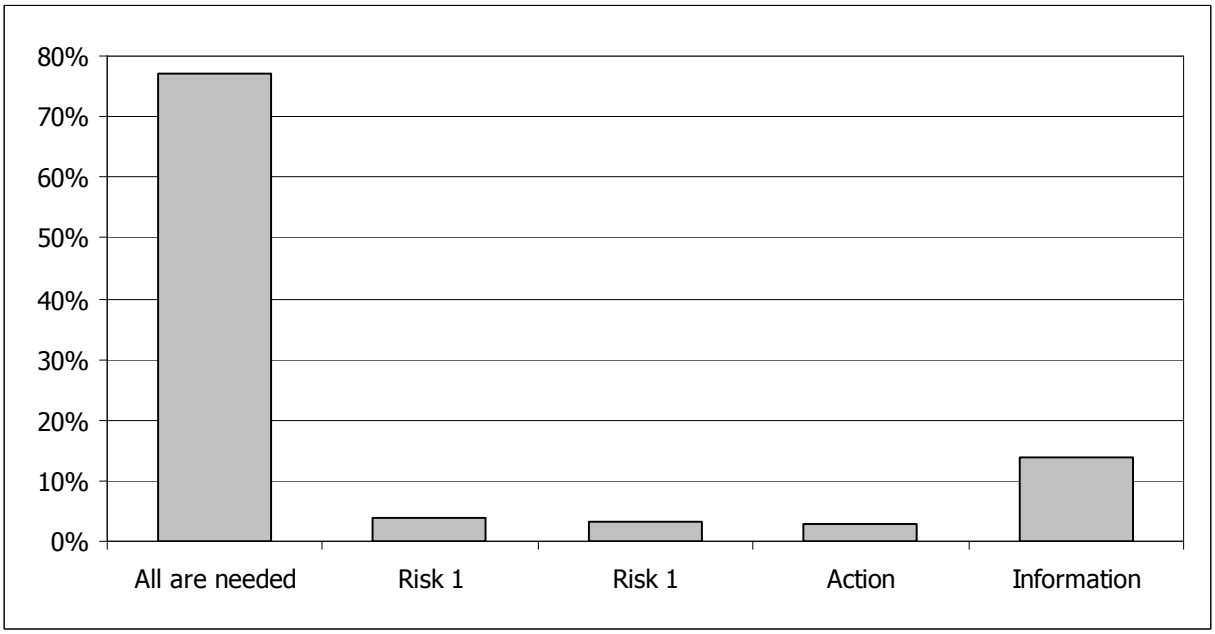

Figure 5-13: Content components that can be left out of warning messages (N=377)

The results for the three questions that are covered above give comparable findings. A significant difference is found between RI messages and the other two types of messages (RA and RAI). The messages containing only information on Risk and Information are judged as being worse. The direct questions in the questionnaire after the web-based experiment endorse the findings from the web-based experiment in which the participants had to judge 18 warning messages. What do these results

mean for formulating warning messages? As a result of the judged warning messages, the action component cannot be left out of warning messages. Risk1 and Risk2 are also very important and are often rated as being even more important than action. This indicates that a description of the risk has to be in the warning messages and preferably, but not necessarily, also information on what action to take.

Participants were given the chance to indicate whether there are other content components they would like to be warned about. They could also indicate other comments about the experiment and the messages.

Many people took the opportunity to stress the importance to use as many means as possible to warn people and that cell broadcast should always be an addition to the siren. A number of people were worried about the possibility of people sending warning messages as a joke. The possibilities for this should be taken into account when considering a new warning method.

Next, the participants have expressed a need for succession messages with new information and a message when the emergency is over. Suggestions were also made to number the messages, so that it is known when a message is been missed in an emergency.

The participants preferred short and concise messages. If necessary they could be in telegram style. A number of participants indicate that the need for certain actions should be explained, as they are sometimes counter intuitive. Also noted, is the fact that many people will not be at home when receiving a cell broadcast or SMS message, so that referring to a website for further information may be useless on many occasions. A phone number was mentioned most often as being useful, as is a radio frequency. Referring to a website of TV station was only considered useful when people are told to stay inside.

Finally, several comments were made on the sender of the messages that was used in these experiments. The text that was used "Alarm from mayor" was thought to be too long. A short sender would be sufficient according to many participants. Suggestions were made to use just "Alarm". A number of people mention that a specified sender was not necessary, because with a cell broadcast message the channel through which the message is sent is known.

These results show that it is important to give people a chance to express their opinions on a new warning method. In this case, some people showed concerns about this new method. These issues can be investigated or taken into account when implementing a new warning method.

5.2.4.3 Influence of length and content together in understanding messages

The preceding paragraphs have only looked at the direct influences of the variables on understanding warning messages. There may however also be interaction effects between the two variables. This paragraph will go into the effects of message length on the judgement of the content and the effects of message content on the judgement of length. These effects aim at the degree to which a certain length is needed to represent certain content and on the degree to which certain content is needed to fill up a certain message length (Jagtman, Wiersma et al., 2008). The combinations of variables together also have an effect on the design of the eventual warning message and thus on peoples' self-reliance. Two of these effects, as they were found in the cell broadcast studies, are discussed in the next paragraphs.

Figure 5-14 shows a histogram of the judgements of length on the three content combinations; the black columns represent the judgement of the length of the RA (Risk and Action) messages.

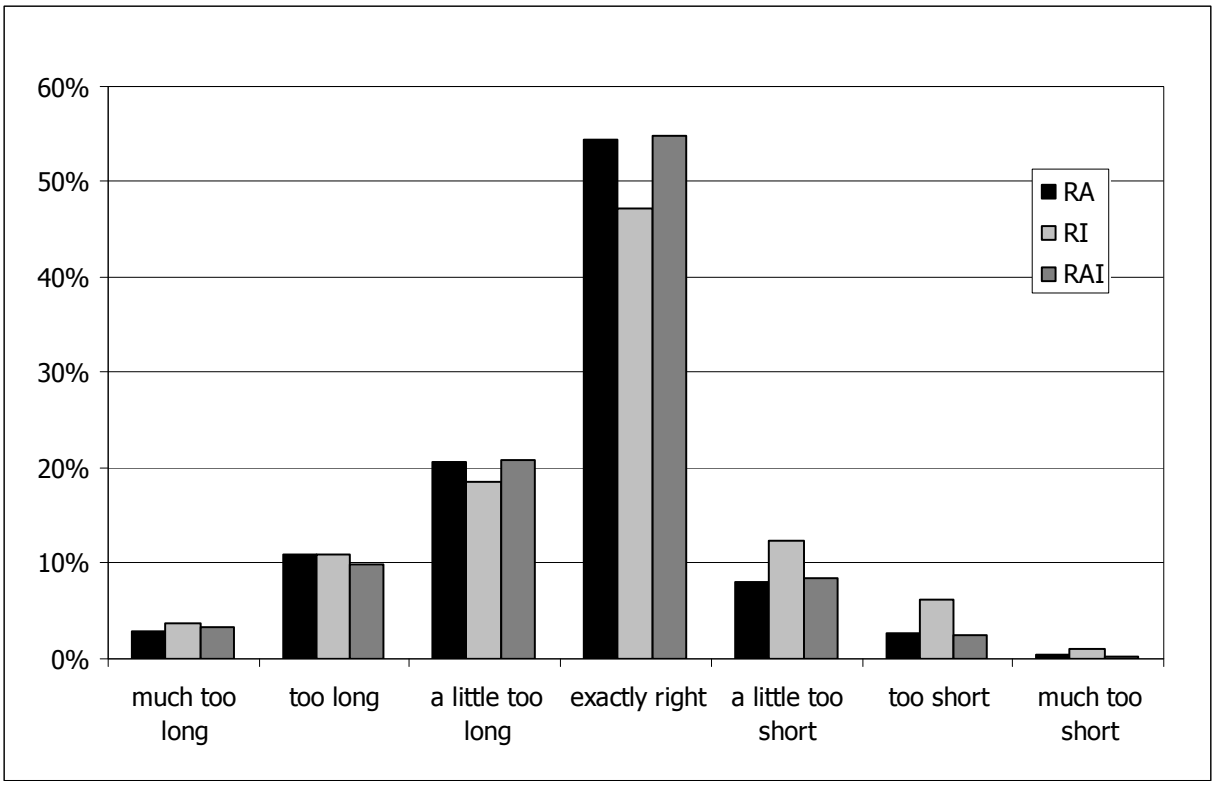

Figure 5-14: Effect of length through content on understanding – arrow 3b (F=21.212; p < .001 ; df=372)

Like the results of the effect of content on understanding, these results show that the RI messages score an average that is further away from the optimal value than the other two message types. This has again been analysed using a GLM for repeated measures. Again, the RI messages differ from the other two types, and RA and RAI do not differ from each other. The results indicate that especially in the shorter RI messages, people score the RI messages as being too short, because certain content is missing; the short RI message should have been longer and the preferred action should be described.

There are several effects of length through content on understanding. The effects especially point at the short messages, because people are expecting certain content in a message. They expect an action to be described, but this is not the case in the RI messages. So the question can be raised whether there also is an effect the other way around, of content through length on understanding (Figure 4-6)?

Figure 5-15 shows a histogram of the reactions of participants on the question that asks for a judgement on the content of the shorter and the longer messages (Jagtman, Wiersma et al., 2008). The grey columns show the judgement of the content of the shorter messages (150 characters).

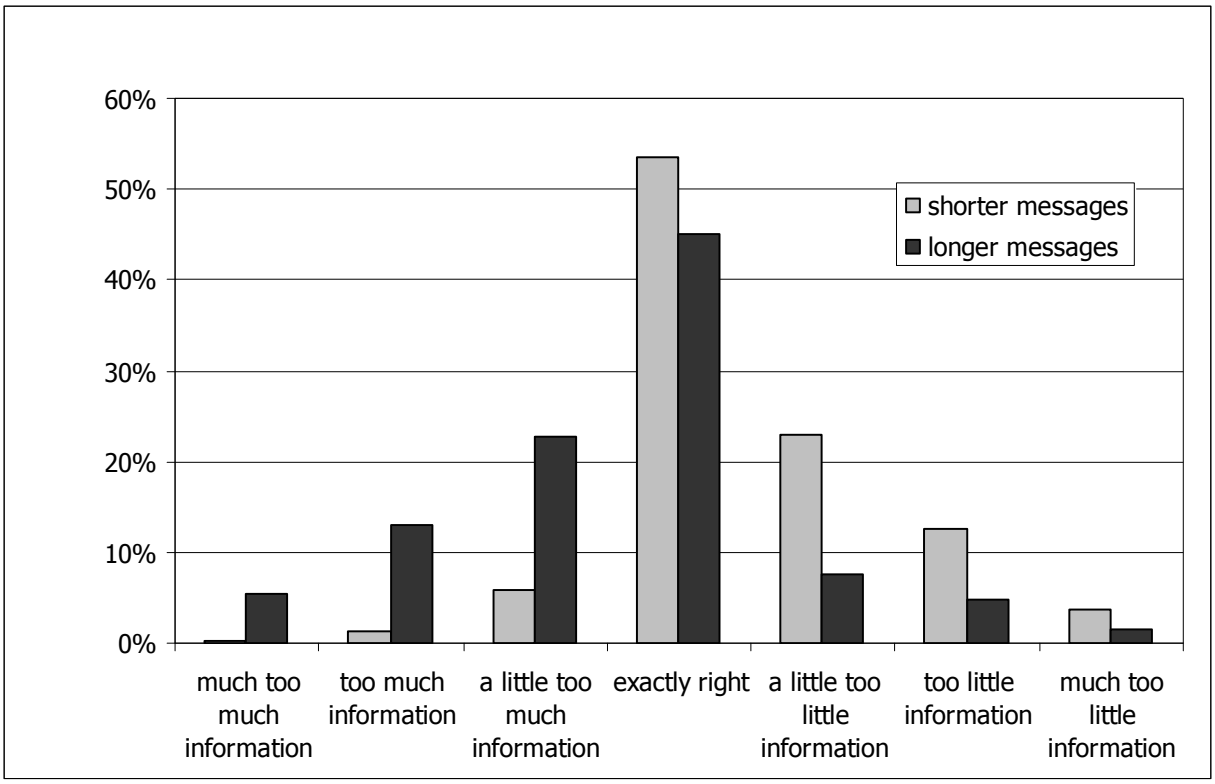

Figure 5-15: Effect of content through length on understanding (F=926.172; p < .001; df=373)

The two distributions in Figure 5-15 are significantly different from each other. The shorter messages are judged as containing less information than the longer messages and the other way around. The deviation from the optimal score of these two distributions is not different (F=.936; p=.33; df=373). This means that the shorter messages are just as much judged as containing less information than needed as the longer messages are being judged as containing more information then needed.

The effects found in the last two paragraphs again support earlier conclusions: shorter messages are preferred and the action component is needed for good understanding of a warning message. These last two figures show a way of determining the influence of the different variables on each other. In this case, the earlier conclusions are supported.

Summarising, the factors discussed in the warning block are,

- Reach
    - Reach (absolute values and values compared to current warning system)
        - What percentage of relevant people can be reached within a specific period of time at different times of day?
        - What is the improvement in reach that can be obtained by the new warning system when it is used as an addition to the current warning system or as a replacement?
    - Non-Reach (explain all cases of non-reach)
        - What are the explanations for the percentage of people that is not reached by any of the warning messages and can these problems be solved?
        - What is the influence of the explanations of the non-reach on the possible effectiveness of the warning system?
- Content
    - what information

- What information components are needed for people to understand the warning message and motivate them to start acting?
- What is the relative importance of these information components?

o length of messages
- What is the preferred length of messages for the warning system used?

o design of the warning (location, font, colour, size, medium)
- For as far as there is space for adjusting these issues, what is the optimal location, font, colour, size, medium, etcetera for the warnings sent through the specific warning system?

5.3 Personal characteristics

Personal characteristics can have an influence on peoples' self-reliance in several ways. Psychological factors have an influence on whether people understand warning messages, on whether they are willing to start acting after receiving a warning message and on many other aspects. Physical factors can also have an influence on whether people can read and understand warning messages. For example blind people, are able to hear a warning message come in, but they need special equipment to actually read the warning message. Moreover, physical factors can have an influence on whether people are able to perform the instructions given in a warning message. People in a wheelchair for example may be unable to evacuate a building when it is not allowed to use elevators. It is important when testing a warning system, to determine what physical and psychological factors are relevant for this warning system and what factors may be of influence on receiving and understanding warning messages and on following the instructions of a warning message and on how to overcome the arising issues. It is important that when there are groups of people whose personal characteristics have an influence on the self-reliance that they will be able to show when a warning message is sent out, that this is known, so that they can be taken into consideration.

Besides these two issues, personal characteristics can also be used to determine whether a test sample in a study is a representative sample from the population. The next paragraph goes into this aspect. Paragraph 5.3.2 will go into determining whether there are any special needs concerning warning messages through cell broadcast for certain types of people.

5.3.1 External validity

It is important to determine whether the sample of people that is tested is representative for the population it represents, before generalisations to the population can be made. This is the external validity of the research that is done. Some general characteristics such as age and gender can be used for this. There may be other variables that are of importance when testing a certain warning method, such as familiarity with technology, already using the technology or the area where people live and its susceptibility to disaster. In that case, these variables should be tested too if it is possible, if there are data available about the population. In the SMS study, the personal characteristics (age, gender, distribution over area codes and frequency of sending SMS-messages) were mainly looked at to determine the representativeness of the participants for the population.

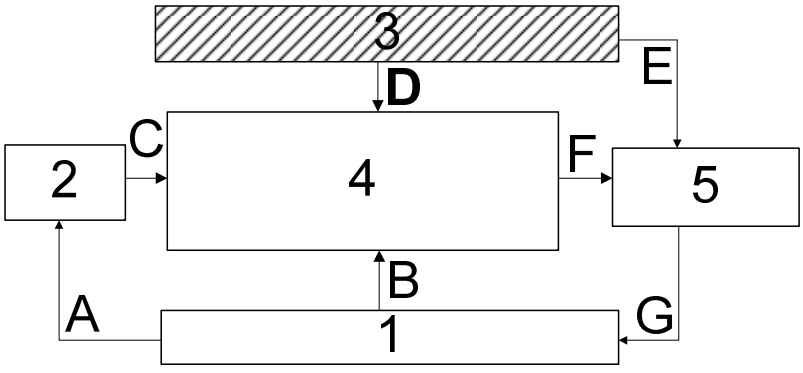

Figure 5-16: The influences of personal characteristics on compliance behaviour

To determine the representativeness of the test sample, its personal characteristics can be compared to the total population from which the sample is taken in order to determine how representative they are for the population. Whenever possible, it is useful to choose characteristics that may be of influence on the results of the research. When the sample is representative for the population for that characteristic, this makes it easier to generalise the data to the population.

In the SMS research, the sample was compared to the population for three personal characteristics: gender, age and distribution over zip code areas. This last characteristic is important in the SMS research as part of the research is the audibility of the siren. The siren may be easily audible in one part of the city, but not very audible in other parts of the city. In order to compare the audibility of the siren from the sample to the population, it is important that the participants are a representative sample of the distribution over the zip code areas of the city of Vlaardingen.

The following distributions have been tested with a Mann-Whitney-U-test to determine whether the sample differs from the population (citizens of the city of Vlaardingen in The Netherlands) (Sillem, Wiersma et al., 2004).

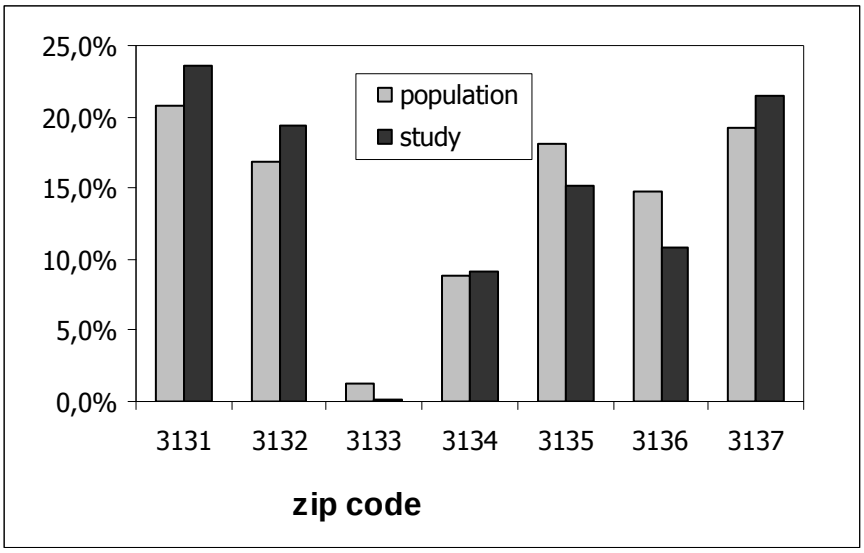

Figure 5-17: Distribution over zip code areas

Figure 5-17 shows that the distribution of the participants in the SMS research does not differ significantly from the distribution of the population ($p = .725$).

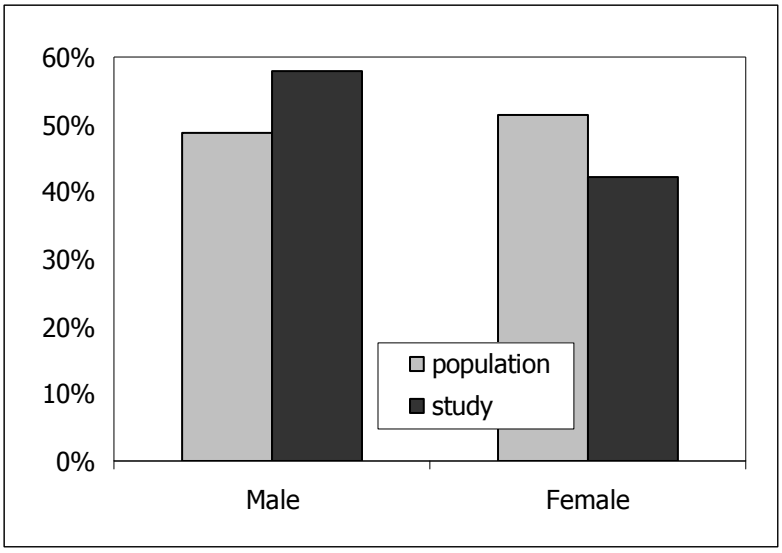

Figure 5-18: Distribution of gender

Figure 5-18 shows that the number of men and women that participate in the SMS research is representative for the population of the city of Vlaardingen (p = .203).

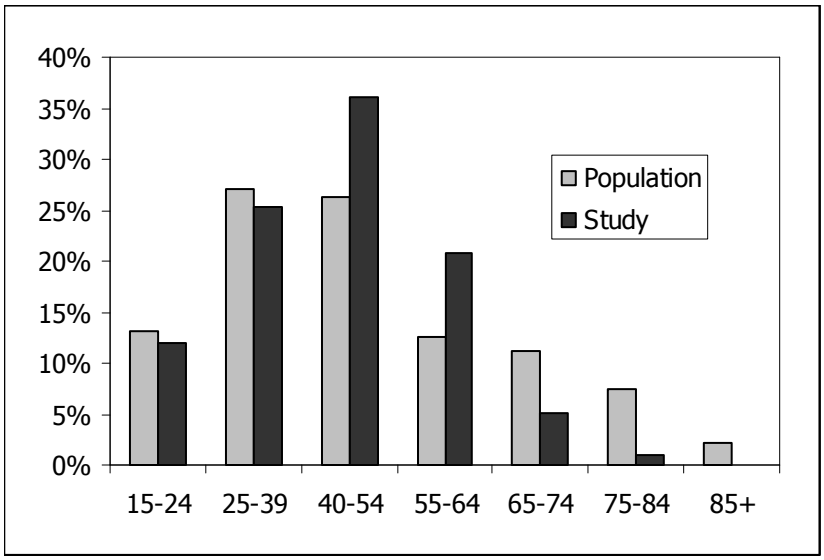

Figure 5-19: Distribution of age

Figure 5-19 shows that the distribution of the age of the participants is representative for the distribution of the citizens of the city of Vlaardingen (p = .746), even though the participants had to be at least 16 years of age.

Determining the representativeness of the research sample is important when determining whether results found can be generalised to the population from which the sample is drawn.

5.3.2 Possible need for different types of mobile phone text messages

This paragraph will show the personal and psychological factors that were investigated in the SMS and cell broadcast studies. Several personal characteristics may have an influence on the understanding of warning messages. For example, because deaf and hard of hearing people are unable to hear the

siren, an additional means of being warned such as SMS or cell broadcast is very important. Deaf people often have a lower than average level of understanding written language. This may also be a problem for people with a lower education. This may indicate that there is a need for different kinds of messages for these groups of people. It is important to determine what type of people can be warned by a new warning method and what the needs of these people are.

In analysing the data of the SMS study (phase 0) the difference between people with normal hearing and deaf people and those hard of hearing people was determined. Because the deaf and hard of hearing are unable to hear the siren, it was important to determine in what ways they prefer to be warned and to see what the difference was between them and the normal hearing people. This has an influence on the possibilities to process the warning information, and can give an indication of what type of warning people are able to process best and whether different types of warnings are necessary for different types of people.

The next paragraph shows the way in which the deaf and hard of hearing are warned in the current situation, with the siren system warning citizens that something is going on (Sillem, Wiersma et al., 2004).

The auditory impaired were asked in the questionnaire if and how they are now warned in case of an emergency. 56 % said that they are not warned at all. The rest of the participants said in the questionnaire that they are able to hear the siren. This may be caused by their lower degree of auditory impairment. Only 1 participant said that he has made arrangements about being warned by other people when the siren sounds

This analysis shows that personal characteristics can have a great influence on the effectiveness of warning messages. It is important to investigate whether all relevant groups of people are warned by the new warning method.

In phase 1b (in the city of Zoetermeer), a laboratory study was done into the content of cell broadcast warning messages. This experiment investigated whether a different type of message was needed for the deaf and hard of hearing and for people with a lower level of education.

Paragraph 5.2.4 shows the research approach for the web-based experiment. This experiment was preceded by the laboratory experiment of phase 1b. The set-up was the same as the one in the web experiment. In the laboratory experiment, people were also shown examples of warning messages. These warning messages varied in length and information content. In this laboratory experiment, 3 message lengths were offered: 150, 300 or 460 characters. The maximum message length of 460 characters was chosen because this is the length within which a teletext page has to fit its complete news message. This seems to be long enough to convey almost any relevant message. The shorter messages are chosen because the possibilities for showing a lot of text are limited on a mobile phone screen, so the shorter the message, the better. One page of cell broadcast can show only 92 characters.

Besides length, the content of the messages was varied. Three types of information components were defined as:
- Risk: what is going on and where
- Action: the action that is needed
- Information: reference to other sources of information for further explanation and information

Not all combinations of these content components seem to be logical. Information about the Risk is always necessary for people to be able to make a decision about whether they are in danger and whether action is needed. The following combinations of content components will be tested:
- A = Risk
- B = Risk + Action

- C = Risk + Information
- D = Risk + Action + Information.

Three different message lengths and four different types of content combinations lead to a total of 12 different message configurations. For each of these 12 types, 3 messages were shown to the participants. So in total, each participant judged 36 messages. The tested messages can be seen in Appendix C.

After each warning message in the web-based experiments, the participants answered four questions.
- What do you think about the information that you get?
- What do you think about the length of the message?
- How clear do you think the message is?
- Would you take action when you would receive this message in an emergency?

All questions had to be rated on a 7-point scale, going from much too much information (or length) to much too little information (or length). On this scale, for question 1 and 2, the answer in the middle (4 = exactly right) is the optimal answer. The closer the answer is to 4, the better the message is judged by participants. A value higher than 4 means that the message is too short (length) or contains too little information (content). A value lower than 4 means that the message is too long (length) or contains too much information (content). For the last 2 questions, answer 1 is the optimal answer, which stands for 'very clear' and 'very likely'.

Because of the limited sample size of 44 participants (25 normal hearing and 19 deaf and hard of hearing, matched by gender and age, with some reserve participants in the normal hearing group), the results in this section are only indications. First, the results for the deaf and hard of hearing compared to the hearing participants will be discussed. Then, the differences for level of education will be discussed.

Because there are various types of deafness, which do not all have an effect on understanding messages, the expectation is that there will be a bigger effect for level of education.

For question one, the judgment on the length of the messages across the types of content, the chi-square test is not significant for the hearing people (see Table 13). The chi-square test for the deaf and hard of hearing is significant, probably because of the greater variance in the scores on the 'Risk only' messages (see Table 14). The difference between the average values for each message type of the two groups is not significant (df = 3, $\chi 2$ = .01, p = .999). The preference orders for the types of messages (R, R+A, R+I, R+A+I) are the same for the hearing people and the deaf and hard of hearing. This indicates that according to this limited data set, there is no need for a different choice of messages for the deaf and hard of hearing; they prefer the same content of messages.

Table 13: Judgment of content by hearing people

Number	R	RA	RI	RAI	Total		%	R	RA	RI	RAI	Total
1	23	21	28	23	95		1	3%	2%	3%	3%	11%
2	19	18	23	19	79		2	2%	2%	3%	2%	9%
3	31	22	20	30	103		3	4%	3%	2%	3%	12%
4	81	113	87	103	384		4	9%	13%	10%	12%	43%
5	27	19	18	25	89		5	3%	2%	2%	3%	10%
6	28	23	32	18	101		6	3%	3%	4%	2%	11%
7	16	7	15	6	44		7	2%	1%	2%	1%	5%
	225	223	223	224	895			25%	25%	25%	25%	100%

Chi-square test: df = 18, $\chi 2$ = 26.65, p = .086, optimal score = 4

Table 14: Judgment of content by deaf and hard of hearing people

Number	R	RA	RI	RAI	Total		%	R	RA	RI	RAI	Total
1	25	14	23	23	85		1	4%	2%	4%	4%	13%
2	12	12	5	13	42		2	2%	2%	1%	2%	7%
3	11	16	8	20	55		3	2%	3%	1%	3%	9%
4	51	83	69	75	278		4	8%	13%	11%	12%	43%
5	17	17	14	11	59		5	3%	3%	2%	2%	9%
6	15	6	18	5	44		6	2%	1%	3%	1%	7%
7	30	12	24	11	77		7	5%	2%	4%	2%	12%
	161	160	161	158	640			25%	25%	25%	25%	100%

Chi-square test: df = 18, $\chi 2 = 48.00$, $p < .001$, optimal score = 4

The chi-square tests for the difference between the ratings across content types in both the lower and higher level of education are both significant, but they both give the same preference order (see Table 15 and Table 16). The variance is somewhat higher for the higher educated; they agree less with each other. People with a lower level of education, judge the messages as being 'exactly right' more often. In other words, people with a higher level of education are more critical. The difference between the two groups is not significant (df = 3, $\chi 2 = .00$, $p = .99$). Attention was only paid to the differences in preference order. This also indicates that within this small sample, there is no apparent reason for different messages for different levels of education.

Table 15: Judgment of content by lower educated people

Number	R	RA	RI	RAI	Total		%	R	RA	RI	RAI	Total
1	21	11	18	19	69		1	3%	1%	2%	2%	9%
2	8	13	7	10	38		2	1%	2%	1%	1%	5%
3	13	18	14	23	69		3	2%	2%	2%	3%	9%
4	84	110	92	100	386		4	11%	14%	12%	13%	49%
5	21	19	19	22	81		5	3%	2%	2%	3%	10%
6	21	11	24	8	64		6	3%	1%	3%	1%	8%
7	29	14	23	12	78		7	4%	8%	33%	2%	10%
	197	196	197	194	784			25%	25%	25%	25%	100%

Chi-square test: df = 18, $\chi 2 = 34.13$, $p = .012$, optimal score = 4

Table 16: Judgment of content by higher educated people

Number	R	RA	RI	RAI	Total		%	R	RA	RI	RAI	Total
1	27	21	33	27	111		1	4%	3%	4%	4%	15%
2	23	17	21	22	83		2	3%	2%	3%	3%	11%
3	29	20	14	27	90		3	4%	3%	2%	4%	12%
4	48	56	64	78	276		4	6%	11%	9%	10%	37%
5	23	17	13	14	67		5	3%	2%	2%	2%	9%
6	22	18	26	15	81		6	3%	2%	3%	2%	11%
7	19	5	16	5	43		7	2%	1%	2%	1%	6%
	189	187	187	188	751			25%	25%	25%	25%	100%

Chi-square test: df = 18, $\chi 2 = 40.25$, $p = .002$, optimal score = 4

Possible differences in judgements of the tested messages have also been determined for gender and the age of participants of the web-based experiment. For these tests, only the results will be discussed briefly, the research method used is the same as the one for hearing and level of education

as shown in the last few paragraphs; a chi-square test is done followed by an analysis of the preference order (Jagtman, Wiersma et al., 2008)

For both personal characteristics, the judgements across the 12 message types differ from each other significantly. As is concluded earlier, not all message types are desirable. For age, the preferred message types (RA and RAI) do not differ across age groups significantly. The effect for sex is about the same as that for age: the preferred messages (the shorter RA and RAI messages) do not differ from males to females. The rating of the other message types does differ across gender groups. This indicates that there is something about the RI messages that makes people disagree with each other. The variance in the judgement on this message type is higher than for the other two message types.

For a sample like this, this is a method that can be used to determine whether there is a need for adjusted messages for certain personal characteristics. A chi-square test can be done to determine whether there are differences in the judgement of the different message types. In this case this is followed by an analysis of the preference order of the types of message by the participants. Where, as the case for hearing and level of education, this order is the same across the groups with different personal characteristics, the conclusion can be drawn that there are no differences in the needs of the different participants based on these characteristics.

Several personal characteristics can be of influence on self-reliance. When the relevant characteristics are determined, their influence can be investigated. When differences are found for certain personal characteristics, these can be taken into account when designing the warning messages that will be used when there is a real emergency.

Summarising, the factors discussed in the personal characteristics block are:

- Psychological factors
    - What relevant psychological factors may be of influence on the understanding or ability to act upon the warning messages?
- Physical factors (disabilities)
    - What relevant physical factors may be of influence on the ability to act upon the warning messages?
    - What is the representativeness of the participants on the relevant demographical factors for the population?
    - Are there relevant groups of people that may need adjusted types of messages?

5.4 Human Information processing

This paragraph is about the influence of human information processing on self reliance (see Figure 5-20). A great influence in this block is memory. People have all sorts of memories about warnings in the past and about the authorities that are sending out the warning messages. False alarms in the past for example will influence compliance behaviour in the future (Edworthy and Hellier, 2006). These memories of past events and experiences form attitudes towards certain issues. According to Eagly and Chaiken (1993) "attitudes are evaluations of aspects of the social world". They refer to how positive or negative we are about some object or entity. The attitudes we have about subjects are evaluative associations that are stored in our memory (Fazio and Roskos-Ewoldsen, 1994). Attitudes are very important, as they influence social thought. They influence how we think about and process social information. Attitudes often work as schemas. Schemas are cognitive frameworks that contain and organise information about certain specific concepts or situations (Wyer and Srull, 1994). They influence what we notice, what enters the memory and what is remembered later (Baron, Byrne et al., 1998). These attitudes are of great influence on how people will respond to warning messages.

Attitudes can be learnt by classical or instrumental conditioning. Classical conditioning can occur below conscious awareness. This can explain why people often have quite strong opinions on certain subjects, but it is quite hard to find out why these opinions are so strong or where they come from.

Instrumental conditioning has a lot to do with an individuals' environment or social context. In this case, people learn what the 'right' opinion is by being rewarded by peers.

Attitudes can influence thoughts and behaviour in several ways. The stronger attitudes are, the greater their impact is on behaviour. The strength of an attitude is determined by its specificity, extremity, the knowledge of an individual about the subject, and the importance of the attitude to the individual, for example because friends or other valued reference persons or groups, have the same opinion. Attitudes that are formed by experiences have more influence on behaviour than those formed by hearsay (Regan and Fazio, 1977). When people make a decision on what kind of behaviour they are going to show, their intentions are influenced by three factors, their attitude towards the planned behaviour, their beliefs about how other people will evaluate this behaviour and their perceived behavioural control; how hard is it to show this behaviour, how much control do I have over the outcome?

Changing existing attitudes can also take place in several different manners. First there is systematic processing. This means that an individual carefully considers new information on a subject. There is also heuristic processing. In that case learned short cuts are used to decide whether to agree with a message. Motivations for processing and thinking about new information that might change attitudes are accuracy, defence and impression. Accuracy consists of gaining more information, because people want their opinion to be accurate and up-to-date. Defence is when people look for new information because they want to maintain their own attitude (Zuckerman and Chaiken, 1998), so they search for information that justifies not changing their attitude. The last case is impression, which is about a socially optimal opinion (Zuckerman and Chaiken, 1998). This refers to an attitude that will be approved by for example peers.

In this block, issues are studied that are influenced by peoples' memories of past events, information that people have about the environment that they are in, or attitudes toward being warned and authorities. These past events may be of great influence on self reliance. The events may be media campaigns in the past about what to do in case of a disaster or other information that people got about emergency situations or dangerous situations or companies in their surroundings. Attitudes can be ones that people have towards the authorities that are sending out the warning messages or attitudes towards warning systems in buildings (do they often give false alarms?).

Besides attitudes, human information processing also has to do with peoples' mental capacities. A warning message can contain clear information, but when an individual does not understand the information, or is not capable of following the instructions given, self-reliance is still not improved. Information about the environment can be used to determine what information people need and what information people can use in a warning message. For example, are people able to determine a direction of flight when it is important that people move away from an emergency site? It is important to investigate whether people are able to understand the warning message and whether they are able to follow the instructions that are given in the warning message.

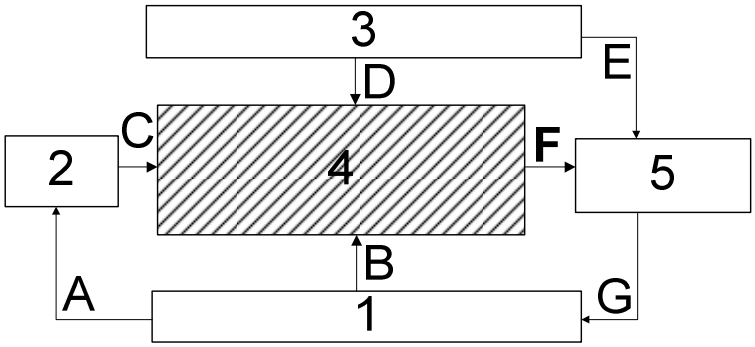

Figure 5-20: Influence of human information processing on compliance behaviour.

5.4.1 Attitude

A positive attitude towards a warning system is very important. People have to be willing to act when they are warned by a certain warning system. Moreover, attitudes can even have an influence on the reach of a warning system. When a warning system includes a device that people have to carry with them, it has to be certain that people carry the warning device with them at all times in order to be able to reach them. In this last case, acceptance of the warning system is very important. People have to be willing to carry the device with them at all times and actually do so.

Influences on attitudes can be the opinion of people on the current warning system and connected to that, the opinion of people on the need for a new, replacement or additional method of warning. Furthermore, as explained earlier in paragraph 3.2.2, the opinion of people on the authority that is sending the warning messages can be of great influence. This means that the attitudes of people cover the following issues:

- Attitudes towards the source of the warning message
- Attitudes towards the current warning system
- Attitudes towards the need for a new replacement or additional method of warning
- Attitudes towards the actual new warning channel / device

These aspects will be investigated in this paragraph. Of course, the content of the warning messages is also of influence on the attitudes towards the warning system. This is part of the new warning channel, but this issue has been discussed in paragraph 5.2.4.

5.4.1.1 Attitude towards source of warning message

The source of a warning has to be accepted for the warning system to be effective. People have to feel that the source is credible and authoritative. If not, they are less likely to follow the instructions in the warning message, which will result in less improvement in self-reliance. Research into the attitudes towards the source of warning messages can be done by questionnaires or interviews in which the attitudes can be determined. It is also possible to design an experiment in which people get messages from different sources to determine what sources are seen as being most credible. In the SMS and cell broadcast research, this part of the attitudes issue was not covered. For warning in the Netherlands, there is no choice for the sending authority. The mayor of a city is always the person that is responsible for sounding the siren and sending out the warning message. This is why this part was not covered in the SMS and cell broadcast studies. When there is no choice for the authority that is sending out the warning messages, attention can be paid to improving the image / credibility / authoritativeness of the sending authority when this is needed to improve the effectiveness.

5.4.1.2 Attitude towards current warning system and need for replacement / additional system

When the attitude towards and degree of satisfaction with the current warning system is low / negative, it may be the case that people feel the need for a replacement or additional warning system, to make sure that they are warned adequately in the case of an emergency. It is important to determine how satisfied people are with the current siren in order to be able to determine what the needs for the replacement or additional warning system are. When these needs are met in a new or additional warning system, this gives people more possibilities to improve their self-reliant behaviour when receiving a warning message.

The opinion of people about the current warning system can be determined by a questionnaire consisting of open or multiple choice questions or propositions. This can give an overview of the general opinion on the current warning system. Interviews can also be used to obtain more in-depth information on the reasons for people's opinions on the current warning system.

In the SMS and cell broadcast studies, the participants were posed several propositions about the current warning system (the siren in The Netherlands) and the new possible warning systems (SMS or

cell broadcast). The participants had to give their opinion on a 7-point scale in order to make it easy to analyse the large number of answers. These propositions were posed in the before and after questionnaires of the SMS and cell broadcast research, so that expectations in advance could be compared to experiences at the end of the studies. This gives insight into the attitudes of people after having some experience with the new warning system. The degree to which their expectations were met can be determined.

The questionnaire that was sent before the start of the SMS study, aimed at the experiences of participants with the current siren and the expectations that they had regarding the new method, SMS. This meant that the questionnaires before the experiment looked at the influence of the issues in the long term memory of the individual about warnings in the past, the experiences with the current siren and the expectations of the new use of the SMS technology. This was designed to give an indication of the degree to which people would accept the new method as being a good addition to the siren.

The questionnaire that was sent at the end of the studies aimed at investigating the experiences with both the siren during the test period as well as with SMS. People had now experienced the warning SMS messages and were able to give a judgement about how quickly they noticed the messages and whether they missed warnings. In order to compare the expectations of the participants with their experiences at the end, a number of propositions were posed in both questionnaires. These propositions were used in all questionnaires in the SMS and the cell broadcast phases, so that the results between studies could be compared.

All participants were asked as part of both questionnaires how often they had heard the siren in the past 3 months, what they were supposed to do when the siren sounds and how satisfied they were with the audibility of the siren.

- How often did you hear the monthly siren test the past three months? (0, 1, 2 or 3 times)
- About the audibility of the current siren I am… (rated on a 5-point scale from very satisfied to very dissatisfied)

These first two propositions have to do with the participants' perception of the current warning system and the need for an alternative means of warning. This has an influence on the attitudes and the reach of the new means, SMS. This influences the actual use of the new technology, and thus arrow C in the contextual model, the part where the warning has to reach the person. If this technology is not perceived as being an important additional means of warning people, people may not make sure that they carry their mobile phone with them at all times, which is necessary for them to be reached.

In Figure 5-21 the number of times the participants have heard the siren the 3 months previous to the study and the last three months of the study can be seen (Sillem, Wiersma et al., 2004). A large number of participants (80%) did not hear the siren every time during the three months previous to the start of the study. 52% have only heard the siren once or not at all. On average, 49% of the participants did not hear the siren on each occasion. The results of the after questionnaire show clearly that during the SMS test the participants heard the siren more often than before the test. Now only 27 % of the participants that have sent a reply SMS message have heard the siren only once or not at all. On average 33 % did not hear the siren on each occasion, compared to 49% before the study. This difference is significant ($z = -7.662$, $p < .001$). This may have been caused by priming. By participating in this study people seem to have paid more attention to hearing the siren.

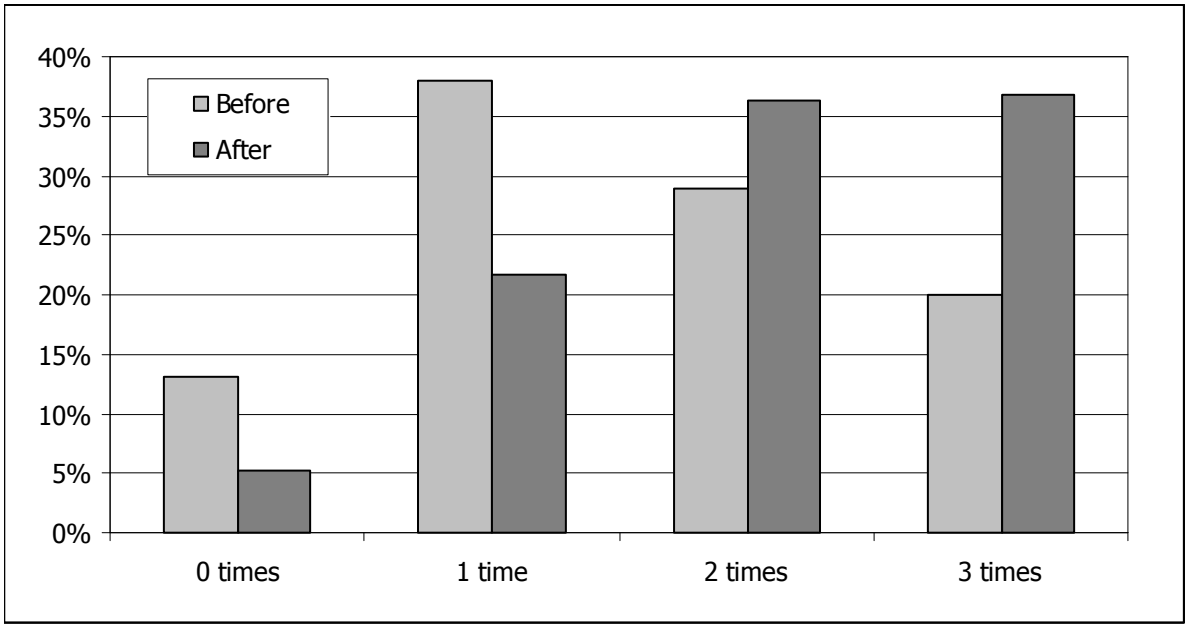

Figure 5-21: How often did you hear the monthly siren test the past three months?

Figure 5-22 shows how satisfied the participants in the SMS research were with the siren, previous to and at the end of the study. 42% of the participants are very or somewhat satisfied and 47% are very or somewhat dissatisfied about the audibility of the current siren at the start of this study. At the end of this study 55 % is very or somewhat satisfied and 30 % is somewhat or very dissatisfied. This shows that after the test people are more satisfied with the audibility of the siren. This difference is significant ($z = -4.884$, $p < .001$). This may partly be caused by priming. By participating in this study, people may pay more attention to hearing the siren. This causes them to actually hear the siren more often, which makes them feel more positive about the audibility of the siren.

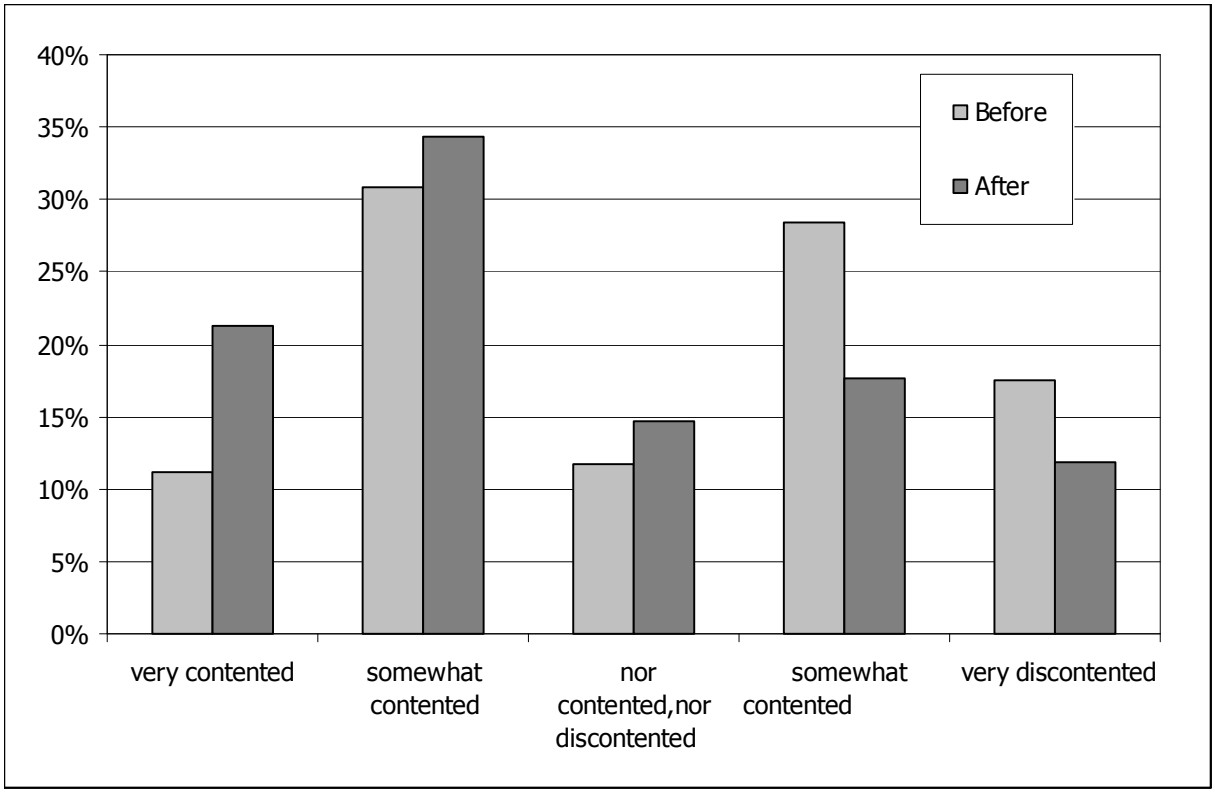

Figure 5-22: Reaction to proposition: "About the audibility of the siren I am..."

This analysis shows that it is quite easy to investigate how satisfied people are with the current means of warning. When using a questionnaire, the number of times that people hear the siren can be determined and people's opinion on the siren as a warning method can easily be determined as well. This would be a different story if the siren was not tested monthly. With this monthly test it is easy to determine how many people actually hear the siren. When there is no test of the warning system, the audibility cannot be tested in a field experiment. However, this can be tested in a laboratory and people's opinions on the warning system and whether they know what to do when they are warned can still be tested in a questionnaire. When investigating the effectiveness of a new warning method, it is important to determine people's opinions on the current warning system, in order to determine the need for a new or additional method and to determine the issues that need to be improved for the warning method to be more effective.

The opinion about the current siren can give an indication whether people feel that there is a need for a replacement or additional warning system. More information on the exact opinion of people on replacing or adding to the siren can be obtained by some more specific questions or propositions.

In the cell broadcast studies, the above two questions / propositions were also posed to the participants. Moreover, two propositions were added to the ones from the SMS research. One of these two is relevant for this paragraph, the other one will be discussed in the next paragraph. Participants were asked at the end of the study whether they thought the siren could be replaced by cell broadcast. The results from this proposition will be discussed now (Jagtman, Wiersma et al., 2008).

Table 17: "I feel that cell broadcast can replace the siren"

	Number	Percentage
Agree very much	65	1.6%
Agree	275	6.7%
Neither agree, nor disagree	544	13.3%
Disagree	1862	45.4%
Disagree very much	1112	27.1%
I don't know	241	5.9%

This shows that most participants (72.5%) feel that cell broadcast cannot replace the siren, but that it should be used as an addition to the current siren instead.

These results show that it is easy to determine whether people feel that a new warning system can replace an existing warning system, after they have had some experience with the new warning system. When they did not have any experience with the new system, they will still answer the question, but the results are then not likely to be a good predictor of actual attitude once the system is implemented. This gives an indication of the trust people have in the new warning system. In the case of cell broadcast, people think it should be used as an addition and not as a replacement at this moment. This may be caused by technical problems during the tests, which caused people to miss some cell broadcast messages. It may also be caused by the fact that people do not always have their mobile phone switched on or within reach, which will cause them to possibly miss important warning messages if cell broadcast were to be the only means of warning citizens.

5.4.1.3 Attitude towards new warning system

Finally, when it has been determined that there is a need for replacing a current warning system or introducing an additional one, the best warning method has to be determined and this method has to be accepted by the citizens. To determine what method is best to be used as an addition, several methods can be used. People can be asked in a questionnaire what type of existing warning system they would prefer. Moreover, several warning methods can be tested more thoroughly, as has been done with the SMS and cell broadcast technologies that are used as examples in this thesis. Furthermore, the effectiveness of a single method can be investigated after some sort of evaluation of the possible additional or replacement warning methods. When a new method is only a possibility and not yet implemented, it is more difficult to ask people what method they would prefer, as they have no experience with the method. In that case, an experiment or a set of experiments may give better results.

Expectations and attitudes at the start of the introduction of a new technology may not last. Attitudes can change over time, when there is more experience with the technology or the new use as a warning system of the technology. First people become aware of the new technology. Than, they get more information about how it works and what it does. Then comes the evaluation stage, where people determine whether this system will be useful for them, if it will warn them better than the old system. Then there is the trial stage, where an individual gets a first impression of the system and they evaluate that first impression. The final stage is the adoption phase in which the warning system is characterised by a large-scale continued use. The tests are done in a different phase than the one on which the warning system has to operate eventually. This may have an influence on the representativeness of the results of the studies into the warning system.

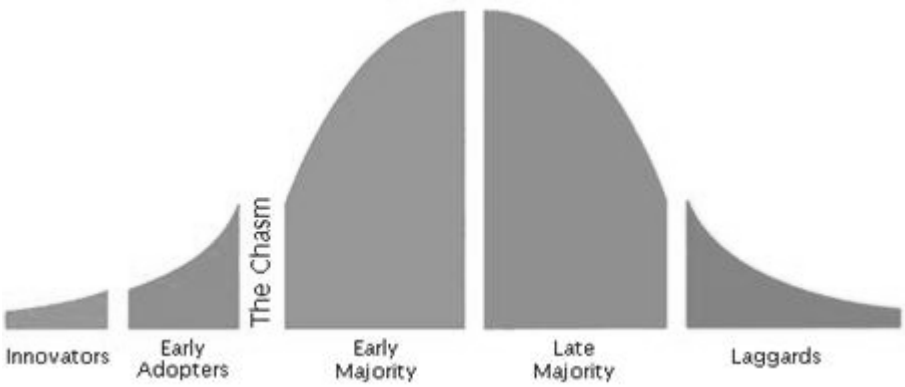

Figure 5-23 Technology adoption life cycle (Beal and Bohlen, 1981)

Be aware however, that when dealing with the implementation of new technologies, one has to do with the technology adoption life cycle (Beal and Bohlen, 1981). The people that will usually start to use a new technology are called innovators. They adopt ahead of other people (see Figure 5-23). The early adopters are the next to adopt the new technology. They are usually young people with a higher education than those who adopt more slowly (Beal and Bohlen, 1981). They are well informed. There are differences in the characteristics of these groups of adopters. This will have an influence on the results when a new warning system has just or has not yet been implemented. That shows it is also important to do some follow-up and evaluation research when a system has been implemented, to determine whether the results from the field studies still hold.

At the start of the SMS study, the possibilities for other warning systems were determined by asking people how they would prefer to be warned when there is an emergency. This was actually a kind of combination of reach and attitudes. People were asked what means they prefer, i.e. what means they trust, and what means they think that they would be reached by best. This way, people's preferred means of warning could be determined. Moreover, the difference between people's opinions before and at the end of the study could be obtained. This was done through a multiple choice question in the SMS study (Phase 0). In the questionnaire at the end of the study, the participants were asked about the best way to be warned at several moments of the day (work hours / free time / at night). They could choose from: siren / SMS / radio / TV / normal phone / e-mail / other. The post-study questionnaire also had the option sound car (Sillem, Wiersma et al., 2004).

Table 18: Preference of warning method

before		SMS	siren	radio	TV	Normal phone	e-mail	other	
		91%	81%	63%	40%	23%	10%	10%	
after		SMS	siren	radio	Normal phone	Sound car	e-mail	TV	Other
	Work	78%	70%	16%	13%	13%	6%	3%	2%
		SMS	Siren	Radio	Sound car	TV	Normal phone	e-mail	other
	Free	81%	74%	12%	12%	9%	9%	2%	1%
		siren	Normal phone	SMS	Sound car	TV	other	e-mail	Radio
	At night	79%	43%	39%	31%	2%	2%	1%	1%

Table 18 shows the responses of participants from both questionnaires. From left to right the most preferred means of warning are shown.

Most people indicated at the start of the study that they want to be warned by SMS (91%) and by the current siren (81%), although a number of people indicate that the siren should be louder than it is

now. In the category 'other', in the questionnaire before the start of the study, some people proposed the additional option of sound cars that broadcast what is going on and give instructions. This option may not always be usable, because then, people have to be sent into an area that is possibly life threatening. In addition, a clearly audible siren or a national radio broadcast that overrules all other radio traffic are mentioned in the 'other' category as possible means of warning citizens. In the questionnaire at the end of the study, the category 'other' mentioned a better audible siren, the fax for doctors during work hours, and at night emergency services that come to peoples houses to knock on the doors. This last option is difficult for the same reasons as the sound cars that were mentioned in the first questionnaire.

The interviewed who were deaf and hard of hearing indicated that SMS is a good way of being warned for them, especially during the day and at work. At night they prefer a combination with neighbours ringing their door bells, which activate the flash lights in their homes. Table 19 shows the preferences of the deaf and hard of hearing. Striking is the fact that many of the deaf and hard of hearing indicate the siren as a preferred means of being warned. Perhaps some of the hard of hearing can still hear the siren. Or maybe, they expect that they will be warned by other people when the siren sounds.

Table 19: Preference of warning method for deaf and hard of hearing people.

SMS	TV	Siren	Normal phone	e-mail	Other
76%	65%	59%	47%	6%	6%

Because of the differences in answer possibilities between the two test moments, a statistical test was not carried out. However, the trend is that having experience with a method for warning can change the preference order for warning methods. Experience with a method gives people more insight into the usefulness for a certain purpose. However, for work time and free time, the first three preferred methods are the same before and after the study. The situation at night is different. People may not have their mobile phone near their beds, or even turned on at night. This decreases the preference for SMS and shows that at night, the siren and a normal phone may be more effective means of warning people. Deaf people prefer SMS over TV or the siren, as these are auditory methods which are probably not very good at warning deaf and hard of hearing people. The siren cannot be heard, and the deaf need a deaf interpreter to understand the information on the TV, unless it is written information.

This analysis also shows that it is quite easy to investigate what kind of means of warning people prefer in different situations. This can help to determine what method of warning citizens can be effective in several situations and in what situations additional means may be needed.

To gain more insight into whether and how well people accept a new warning method, propositions can be posed concerning the added value of the warning system. When these propositions are posed at the start and at the end of the study, the expectations of people in advance can be compared to the experiences they had with the system during the study.

In the SMS study, several propositions were posed to the participants. The first one asked whether people felt that SMS could be a valuable addition to the current siren. This was designed to give an indication of the expectations people had about the new use of SMS warning messages. The second proposition asked people whether they thought that they would be reached better when SMS is used as an addition to the siren:

- I consider SMS to be a good addition to the current siren (5 point scale from agree very much to disagree very much)
- With SMS, I am… (1 = warned better than by the siren alone, 2 = warned equally well as by the siren alone, 3 = warned worse than with the siren alone)

These two propositions go into the attitudes towards SMS as an addition to the siren. This will influence the human information processing in block 4 of the contextual model. The degree of positive attitudes will influence the likelihood of people to actually take action when receiving a warning message (Sillem, Wiersma et al., 2004).

Figure 5-24 displays the participants' expectations about the usefulness of SMS as an addition to the siren.

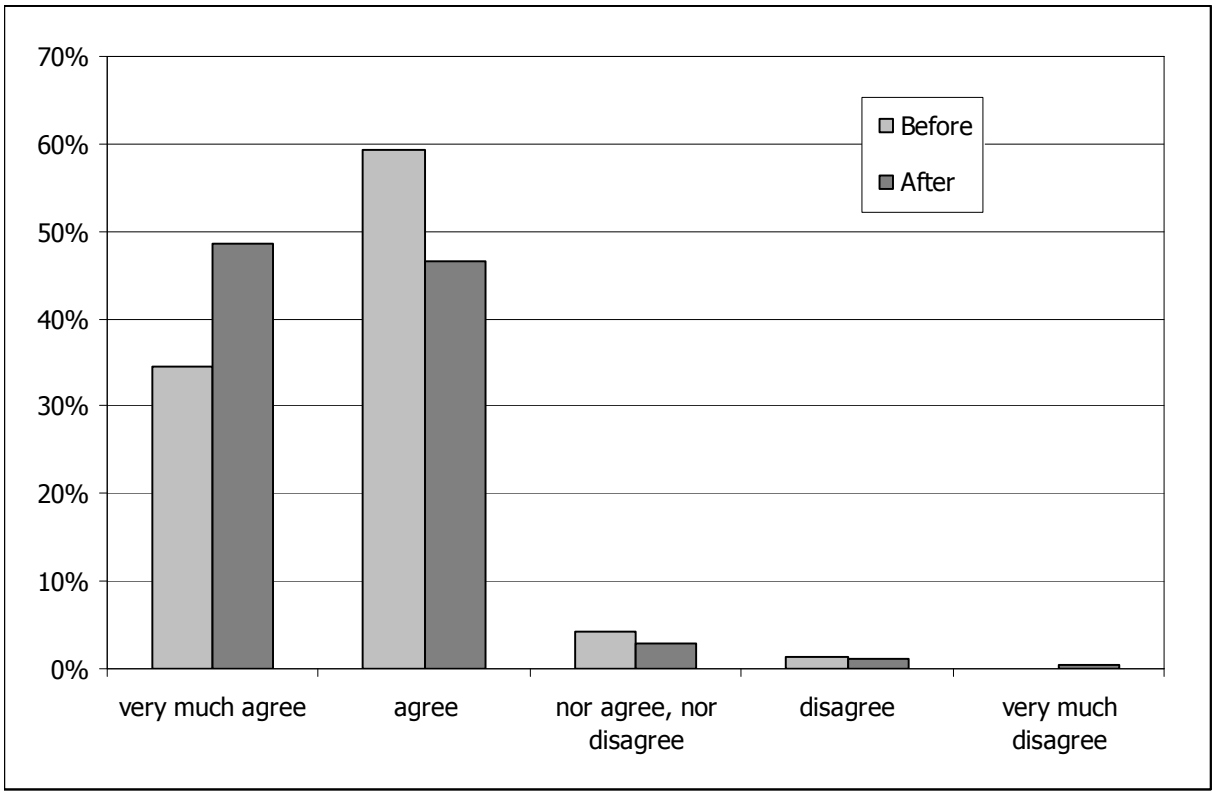

Figure 5-24: Good addition to the siren

At the start of this study most people agreed very much (35.5 %) or agreed (58.8 %) that SMS would be a good addition to the current siren. The questionnaire that was sent at the end of the study showed an increase in people that very much agree (49 %). There was a small decrease in the number of people that disagree. The difference between the two questionnaires is significant ($z = -2.437$, $p = .015$). The auditory impaired also said that SMS was a good addition, 80% very much agreed with this proposition at the end of this study. None of the deaf were neutral or disagreed.

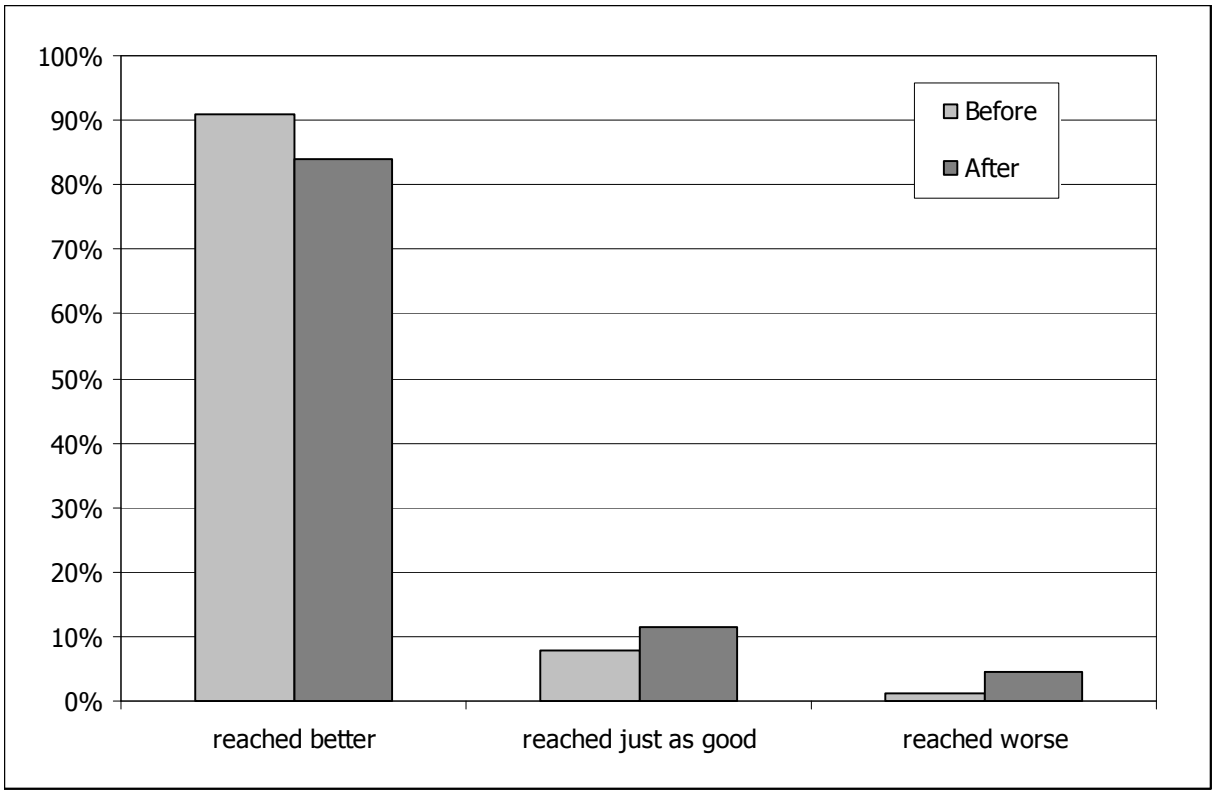

Figure 5-25: Siren compared to SMS

Figure 5-25 shows that most people that filled out the questionnaire that was sent before the start of the study indicated that they would be reached better with SMS as an addition than by the siren alone (91 %). In the questionnaire at the end of the study, this was the case as well. Now, 84 % still feels that they would be reached better by SMS than by the siren alone. The difference between these two measurements is significant ($p < .01$). This difference could be explained by the fact that people expected to be warned in 100% of the cases, and they may not have noticed one or more of the messages immediately.

This analysis shows that by giving people propositions, you can determine how people's opinion about a new technology changes between before and after they have had some experience with this new technology. The difference between these two questionnaires shows whether people's expectations have been met. The results show whether and to what degree people are interested in and are willing to use a new warning method. Determining whether people are willing to use a new warning method is very important. People have to be interested in using a new warning method before it can be effective. People have to be willing to fulfil the conditions that have to be met in order to receive the warning messages. In this case this means that they have to carry their mobile phone with them at all times and that the batteries should be charged. The more conditions people have to fulfil in order to receive a message, in other words, the more people have to change their behaviour to receive a warning message, the bigger the chance of disruptions of a decrease in the number of people that are reached. Asking people to carry a special device with them at all times with a very small chance of it actually being of any use, is not very likely to be successful. Fortunately, most people already carry a mobile phone with them, which makes the behavioural changes needed for this specific warning method limited. For other warning methods, the behavioural changes that are asked from people have to be considered.

In the cell broadcast studies, the above two propositions were also posed to the participants. Moreover, one more proposition on this topic was added to the ones from the SMS research. Participants were asked whether they would switch on cell broadcast on their mobile phones if it were

to be implemented. This not only gave participants the opportunity to indicate whether and to what degree they were content about the siren and about cell broadcast, they could also indicate whether they were content to such a degree, that they would actually use the new system if it were to be implemented (Jagtman, Wiersma et al., 2008).

Table 20 shows the number of people that would set their phones to receive cell broadcast warning messages if the government were to decide to implement this service for warning citizens. This percentage of 88.9% is quite high, considering the technical problems that arose during this test (as discussed in paragraph 5.2.1).

Table 20: "When the government decides to implement cell broadcast, I will …"

	Numberl	Percentage
Set my phone for sure	3630	88.9%
I may set my phone	383	9.4%
I will not set my phone	70	1.7%

5.4.1.3.1 Influence of additional messages on reach of warning messages

When a certain warning system is also used for sending other types of messages than only warning messages, these messages can possibly influence the notability and attitude towards the warning messages. When other messages come in often that are not of great importance, messages may be read later or missed altogether; which will have a big influence on peoples' self-reliance in an emergency. When other messages are sent through the same medium which come from a different authority or have completely other content, this may also influence peoples' attitude towards the medium, and thus have an influence on self-reliance.

For both SMS and cell broadcast, other messages can be sent through the same medium. Therefore, the influences of additional messages through these media had to be investigated. For these warning systems that can also be used to send out other information, the question arises whether and to what degree offering several types of messages has an influence on the effectiveness of warning citizens with cell broadcast. On the one hand, offering several services on one device can enhance the familiarity of people with the service. It may also positively change the attitude towards using the device and increase the time that people carry the device with them. On the other hand, an overdose of messages may lead to people ignoring incoming messages and thus possibly missing warning messages. The goal of warning citizen is of course to warn as many relevant people in the shortest time possible. Therefore, the important issues for warning citizens are:

- What is the influence of additional messages on the response times?
- What is the influence of additional messages on the number of replies to warning messages?

The first question is aimed at determining whether the response times get longer or shorter when more messages per week are sent and to determine whether there is an optimum in the number of additional messages per week. This information can be used to optimise the reach of the warning messages of a certain warning system.

The second question aims at determining whether more or less responses come in when the number of additional messages increases. When people receive a lot of messages per week, the chance increases that people will not read all messages (immediately). This means that there is a chance that people will miss a warning message or that they may read it at a later moment. In other words, it aims to determine whether and when there is synergy between the warning messages and the additional messages and whether and when people start perceiving it as spam and stop reading all of the messages.

To answer these research question for cell broadcast, a test was done with 1317 people on the islands of Walcheren and Zuid-Beveland in the Province of Zeeland (phase 6). This study into the influences

of additional messages has been reported earlier by Jagtman, Wiersma and Sillem (2006). The next paragraphs will show the results of this study.

The test that was done was a relatively short test, so no clear indications can be given for long term effects of sending several types and amounts of messages.

During the test, additional messages in the form of messages with information on news or weather issues were sent in addition to the 'normal' warning messages that were also sent in the other tests. The number of additional messages that were sent per week varied from four per week to 10 messages per day. People were asked to respond only to the warning messages by sending an SMS message. They did not have to respond to the two other types of messages (about news or weather).

Participants knew there would be a variation in the number of messages sent per week, but they did not know the exact amount. Table 21 shows the amount of additional messages that were actually sent. The number of messages sent per week was almost constant for two weeks at a time (3 weeks when the most messages were sent per day). Besides these news and weather messages, 8 warning cell broadcast messages were sent. One of these warning messages was sent at the same time as the monthly siren test (the message on August 7th) and 7 messages were sent at unexpected moments.

There was one test group in this study, people that wanted to receive additional messages, and a control group of people who did not want to receive additional messages (Wiersma, Jagtman and Sillem, 2007). The influence of people wanting or not wanting to receive additional messages was not considered to pose a self-selection bias of importance, as all people were asked to respond to the alarm messages. If there would be a bias in this test, the expectation is that it would be that people, who do want to receive additional messages, are also the people who have their phone close to them and use it more. This would mean that the influence of more messages would probably have a less disturbing effect on their replying to alarm messages than it would on people who do not want to receive additional information.

Table 21: Number of additional messages that were sent per week (Monday-Saturday).

Week	23	24	25	26	27	28	29	30	31	32	33
Date warning message	June 6	June 15	June 22		July 6	July 14		July 27		August 7	August 17
Number of additional messages	5	4	12	11	36	36	55	58	54	11	12

Table 21 shows the dates on which the warning messages were sent and the number of additional messages that were sent each week in the test period to the test group.

In order to indicate the effect of the additional messages, this paragraph describes the responses to the warning that came in within the first 120 minutes after sending the warning message.

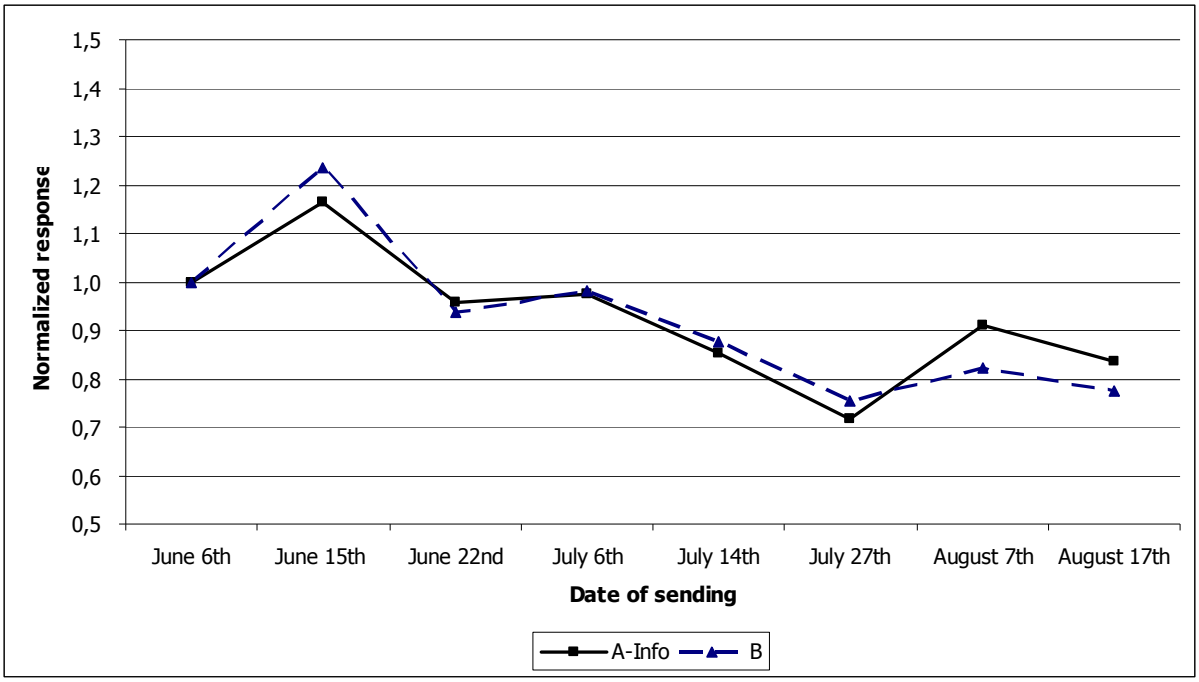

Figure 5-26: SMS response within 2 hours, normalized for response received on June 6th (Wiersma, Jagtman et al., 2006)

Figure 5-26 shows the results for both the test group (group A) and the control group (group B). This figure has been normalized to the response on the 6th of June, as '1'. The figure shows that the number of responses within 120 minutes hardly differs between the test and the control group. There is however a difference in the speed with which the responses come in. Figure 5-27 shows the responses within 7 and within 120 minutes, normalized for the control group B that did not receive any additional messages. This means that the number of responses for control group B are set to 1 for each of the broadcast moments. When the line for 7 or 120 minutes is higher, this means that more messages have come in than in the control group; if it is lower, less messages have come in than in the control group.

Figure 5-27 shows that the number of responses that came in for the test group within 120 minutes hardly differed from the number of responses that came in for the control group. This means that after 2 hours, there is no effect of sending additional news and weather messages, the number of responses after two hours remains the same. There is however a difference for the number of responses that came in within the first 7 minutes. On June 22nd, and August 7th and 17th, the number of responses that come in within the first 7 minutes is higher than for the control group, but on July 6th, 14th and 27th, the number of responses that came in within the first 7 minutes is lower than that of the control group. This difference was significant ($df = 7$, $\chi 2 = 16.67$, $p = .019$). Table 21 shows the number of news and weather messages that were sent each week of the study and the dates on which the warning messages were sent.

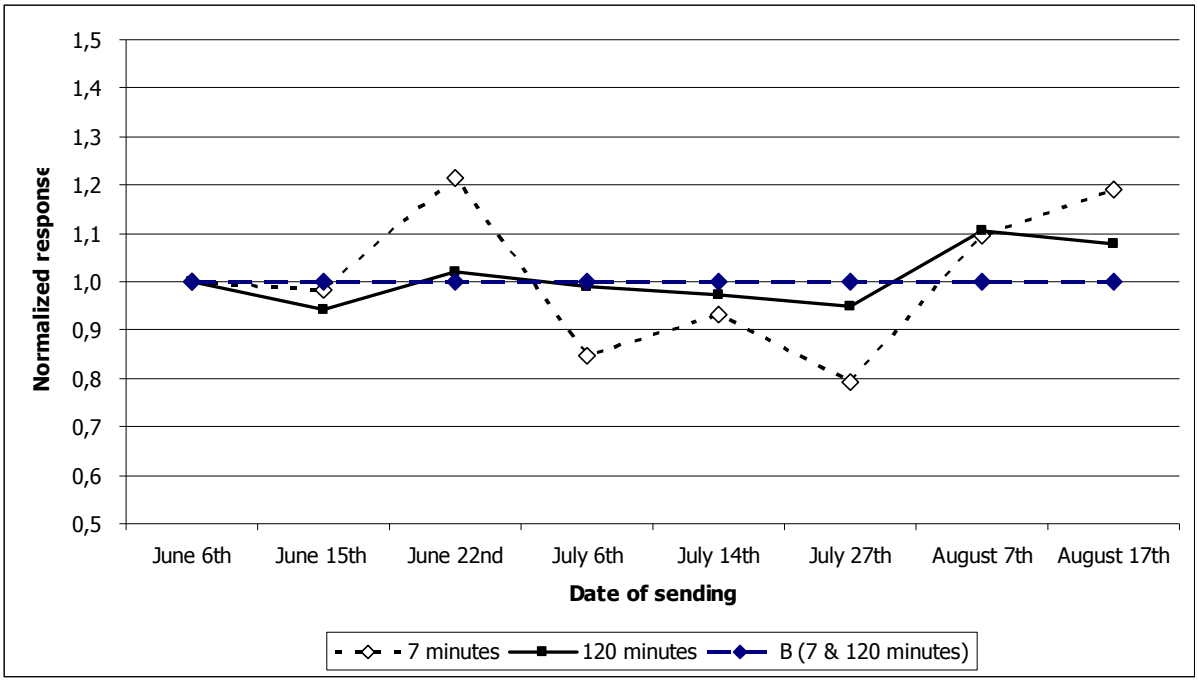

Figure 5-27: SMS response of A-info normalized for control group B (Wiersma, Jagtman et al., 2006)

During the test, the number of additional messages sent per week increased over the weeks. At the end of the study, the number of additional messages decreased again. Figure 5-27 shows that when a few additional messages are sent, people respond faster to the warning messages (see for example the number of responses in the week of June 22nd). Later on, when more additional messages are sent (for example in the week of July 27th, in which 58 additional messages are sent), they respond slower to warning messages than the control group. At the end of the study, when the number of additional messages decreases again, people start responding faster again. So, there is no effect after two hours, but within 7 minutes there is an effect of the additional messages on the speed with which people respond to the warning messages. People respond slower when more than 36 or more additional messages are sent per week. Numbers of messages between 12 per week and 36 per week were not tested. The number of messages at which the responses start to get slower will be between these two numbers.

The number of fast responses (within 7 minutes) decreases when the number of additional messages increases. The number of eventual responses to a warning message is not influenced by the number of additional messages that are sent, the responses are just slower.

For warning citizens through cell broadcast, this is an important result. It means that if cell broadcast is also used for commercial purposes, and these commercial messages are sent 36 or more times a week, people will respond slower to warning messages. This may be caused by the fact that people expect to receive a number of weather and news messages all the time. They may consider these messages as not having direct priority, which may cause people to decide to ignore the messages and to read the messages at a later moment in time. This means that people may not directly read all messages, and then later, when they find a convenient moment, they read all the messages that have come in. So, eventually they will read the warning messages as well, but in this manner, they may read important warning messages too late.

This problem could possibly be solved by giving the warning messages an alarming or at least distinctive sound, so that they can be distinguished from other incoming messages, either SMS or cell

broadcast. This makes it possible to discriminate between several types of mobile phone text messages.

These results show that when determining the effectiveness of a new or existing warning method, it is important to investigate the possible influence of other messages sent through the same medium. There may be an influence of these messages on the effectiveness of the method.

The effect of additional messages on the behaviour of people can also be investigated in other and additional ways. Questionnaires can be used to investigate whether people are interested in receiving additional messages and how they think that this will affect their behaviour. Moreover interviews or focus group sessions can be used to get more insight into why people do or don't like to receive additional messages and in what amount. A field study as was done in the cell broadcast study can be used to obtain objective data of the influences on response times and number of responses, and the questionnaires and interviews can be used to determine the way that people feel about the additional information and the reasons for the differences in response times and number of responses.

Within the cell broadcast study into the effect of sending additional cell broadcast messages, 9 focus group sessions were organised with a total of 36 participants, to ask participants about their experiences with cell broadcast warning and the effect of receiving additional messages. These participants also filled out a small questionnaire (Wiersma, Jagtman et al., 2007).

The number of additional messages varied during the test period. First the number increased, at the end it decreased again, as can be seen in Table 21. During the discussions, participants indicate that the number of messages was very big at a certain time. They did read the messages and they did not turn the service off. They indicated that they did not do this, because they were in a test. Otherwise, several people would have turned the service off, because too many messages were being received. Not all messages were read immediately. Figure 5-28 shows that, according to their responses to the questionnaire, if more than 2 messages per week are sent, people start to find it uncomfortable. This is a very low number of messages.

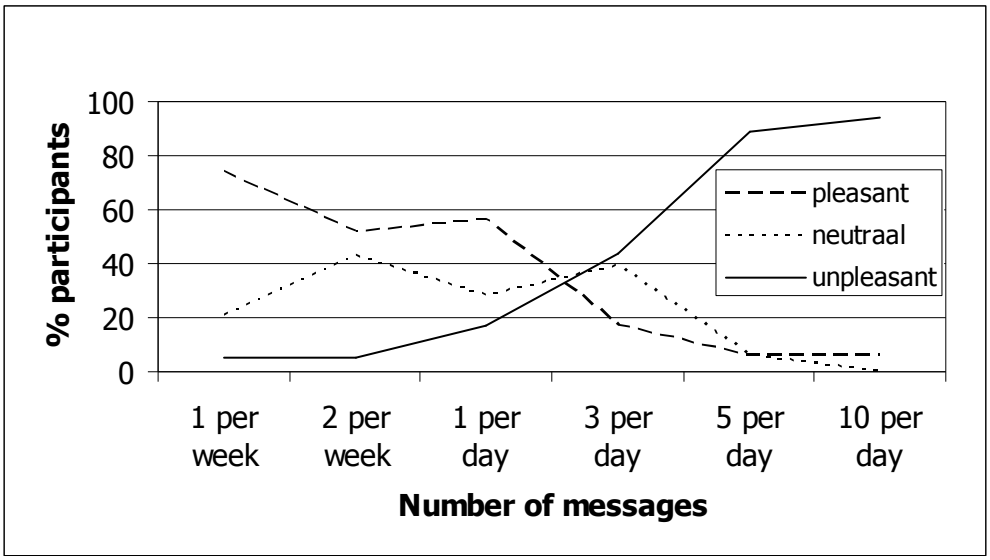

Figure 5-28: Preference for number of messages.

The results from this last paragraph endorse the results from the responses to the cell broadcast messages that more additional messages make responses to the alarm messages slower. However, the influence of the additional messages indicated in the questionnaires is a lot bigger: when more than two messages per week are sent, people indicate that they start to think this is unpleasant. This differs from the data from the experiment, in which people start responding slower when 36 or more

messages are sent per week. This difference may be caused by the fact that people already get annoyed at 2 additional messages per week, but actually start adjusting their behaviour (by not reading all incoming messages) at 36 or more messages per week. As people indicate that they do not like getting more than two messages per week, this may mean that the long-term effects of sending a lot of additional messages per week may be that people stop reading incoming messages less (quickly) at a lower number than 36 messages per week.

This again shows the importance of investigating the influence of other messages sent through the same medium as the warning messages. In this study it was easy to investigate this influence in two different ways. First, simply by asking people how many messages they would like to receive and when the number of messages starts to annoy them. Second, by actually analysing when the number of messages starts to influence their behaviour.

These types of questions can give a better insight into how content people are with a new warning method and whether it met their expectations of it. Several other questions about what people prefer and (type of sound or loudness of sound used to warn, whether the warning system can be replaced by the new system or serve as an addition) how they would act in certain situations (although what people say about how they will act in a certain situation may not always be very close to what they will actually do in such a situation) can be thought of to determine the attitudes towards the warning system. When the attitudes are more positive after the test, people were probably reached better than they had expected in advance, which made their attitude more positive. When the attitude is more negative at the end of the study, this can be caused by two things. People may have been reached worse than they had expected, or they may have encountered unexpected troubles in using the warning system.

People may be very willing to use a method (as Table 20 shows), but they may have some doubts about the effectiveness or reliability of the new warning system, because they don't think cell broadcast can be used as a replacement of the siren at this moment. It is important to use several methods or questions to determine how content people are with the new method and whether they will use it if it is implemented. When more questions are asked, and the outcome is about the same for each question or method, a statement about the opinion on the new method as a replacement or addition can be made with more certainty and the validity is larger. This analysis shows that people do not think that cell broadcast can be used as a replacement of the current siren, but still almost everybody would set their phone for receiving cell broadcast warning messages if it is implemented. This indicates that people see the possibilities and additional value of cell broadcast as a means of warning citizens in an emergency, but that they need more proof that it will actually work as an effective warning system.

5.4.2 Capacities: do people know what to do?

During the SMS study, people were asked whether they know what they are supposed to do when the siren sounds. People are supposed to remember this from earlier media campaigns. The next paragraph will show whether people know what to do when the siren sounds (Sillem, Wiersma et al., 2004).

It seems that people are not very familiar with what they have to do when the siren sounds; the questionnaires that were sent at the start of the study showed that 61 % of the participants did not mention all three things that need to be done when the siren sounds (go inside, close all doors and windows an tune to the local TV or radio station). This is almost the same as the 60% of people that do not know what to do when there is a power outage, as was investigated by Helsloot and Beerens (2009).

This analysis shows that most people do not know what to do when the siren sounds. The siren will not tell them what to do, as it is only a warning sound. The behaviour that is expected has to be remembered from earlier information. An advantage of SMS in this situation could be that it is possible

to give instructions about what people should do during an emergency situation. People will then always know what is expected of them. Sometimes, for example when there is an explosion or a bomb threat, people in the surrounding area should not go inside, but go outside or to a basement / shelter instead. The siren cannot convey this change of information. SMS could help give alternative information. It is important to investigate whether a new means of warning can convey the warning information. When the warning method includes text, the desired behaviour can be given in the warning message. However, when the warning means is only a sound or another type of sensory warning that does not include the specific behaviour that is desired, it should be investigated whether people know what to do when they are warned in this manner.

This paragraph will go into the influences of human information processing on compliance behaviour. When people receive a warning, they will start comparing this warning with information they have received in the past. They try to remember what they have to do when the siren sounds, whether there have been previous warnings from this source, whether those previous warning turned out to be useful. Moreover, the information in the warning message is evaluated. Is this really a threat to me? Do I understand what is expected of me? Can I perform the behaviour asked from me? What do other people do?

In this paragraph, two of these issues will be discussed. First, whether people know what to do and second, a small part of the content of the messages will be discussed in which people have to use knowledge about their environment. The other issues have been discussed in the warning paragraphs.

At the start of phase 2 (in the city of Zoetermeer), participants were asked whether they knew what behaviour was expected from them when the siren sounds. The results for this question indicate whether there was a need for more information when the siren sounds.

The results showed that 7% of 448 participants indicate that they did not know what to do. The other 93% said that they did know what to do. However, only 56% of them recall all three things that needed to be done (go inside, close all doors and windows and tune in to the local radio or TV channel) when the siren sounds. This means that based on the phase 2 questionnaire in Zoetermeer, 48% (7% + 56% of the other 93%) of the participants needed more information on what to do when the siren sounds.

This data indicates that many people do not know exactly what they are supposed to do when the siren sounds. This shows that people need more information when there is an emergency. When many people do not know what to do when the siren sounds, this is a good reason for using an additional warning method that can give them this information.

For a number of types of disasters, evacuation may be the optimal response. To steer an evacuation in the right direction, instructions can be added to cell broadcast or SMS messages. A difficulty is that most directional aids require knowledge of the area. People have to have a map in their memory of the area where they are, and of where north or the city centre. The expectation is that it is almost impossible for people to use a warning message with concrete directional instructions, because of difficulties for people to understand these instructions, as well as the fact that directional instructions, as for example go south, are only applicable to people that are south of the emergency. This type of concrete messages could possibly send people towards the emergency by accident, because a cell is quite big and it can never be guaranteed that people will not get a message that is not meant for them.

In the questionnaire that participants answered at the end of the web-based experiment, a number of directions of flight were presented. Participants were asked whether they could use these instructions to determine in which direction to flee. The results (see Figure 5-29) give an indication of the familiarity of people with several locations and directions in a city.

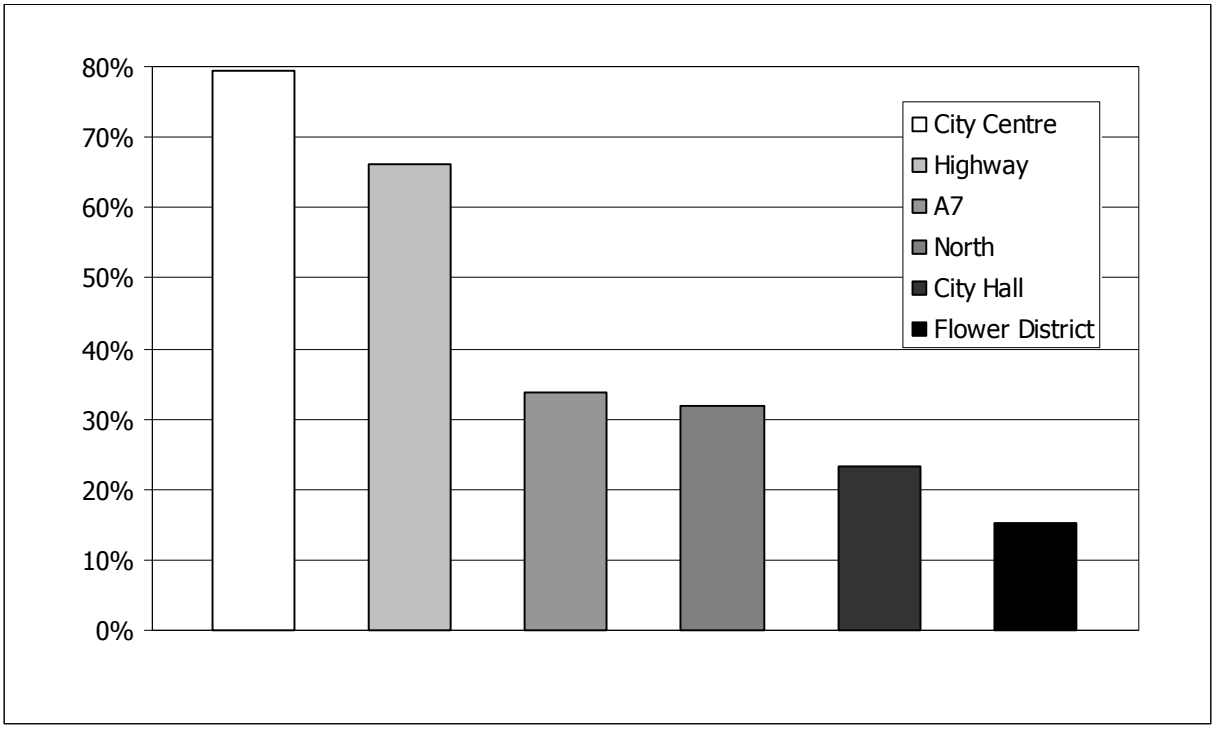

Figure 5-29: Familiarity with directions of flight

The figure shows that only very few possible directions of flight would indicate a clear and know direction for participants. 80% of the participants knew what to do with the direction 'city centre'. Also, 66% knew their position in respect to the highway. The other directions were clear for les than half of the participants. Even a general indication such as north was a clear indicator for only a third of the participants.

This means that participants find it difficult to understand a direction of flight in a cell broadcast or SMS message. The possibilities of giving a univocal direction of flight are limited because of this. This indicates the importance of giving specific information in warning messages, information that people can easily understand and that everybody can follow, without needing to have prior knowledge of the surroundings.

Summarising, the factors discussed in the human information processing block are:

- Attitudes towards
    - warning system / device
        - What warning system do people prefer for different times of day?
        - Do different groups of people prefer different types of warning systems?
        - Is the new warning system a good addition to the current system?
        - Will people use the new warning system if it is implemented?
        - What are the influences of other messages sent through the same medium?
    - authority sending the warning messages (credibility, authoritativeness)
        - Is the authority sending the warning messages perceived as being credible and authoritativeness and if not, what is the influence of this and how can it be improved?
    - need for additional / replacement warning system
        - How satisfied are people with the current warning system (if available)?
        - What is the attitude of people towards the new warning system?

        - Do people think the new warning system should be used as an addition or can it replace the old system (if available)?
- Capacities that are needed to be self-reliant following a warning message, including: knowledge (hazard, protective action, plans), cognition and experience (type, recency)
    - Do people know what to do when specific instructions are given in the warning messages?
    - What is the influence of prior experiences and knowledge of hazards in the area on the effectiveness of the warning system?

5.5 Behaviour

In this block, the actual behaviour that people show after receiving a warning message in several situations will be investigated. This is the eventual self-reliant behaviour that people may or may not show after receiving a warning message. It is of course very difficult to approach a real emergency situation, as you cannot put people at risk deliberately. It is however possible to investigate peoples' intention to act, and it is possible to do small experiments into whether people will act in a real emergency. Moreover, different types of messages can be compared so that a preference order can be determined.

In the SMS and cell broadcast studies, each SMS or cell broadcast message contained an instruction in which the participants were asked to send a response by SMS as quickly as possible. Usually this instruction was a question that had to be answered. The answers could be used as input for the analysis. This analysis consisted of two parts: did the answer match with the question and what information that could be taken from the correct answers. The first part gave an indication of how well people understood the questions and whether they act according to the instructions. The second part can gave insight into numerous issues. In the SMS experiments for instance, the question that was sent directly after the monthly siren was sounded asked the participants "Did you just hear the siren?" This question gave insight into the added value of SMS and cell broadcast, namely the people that did receive and read the SMS or cell broadcast message but who did not hear the siren.

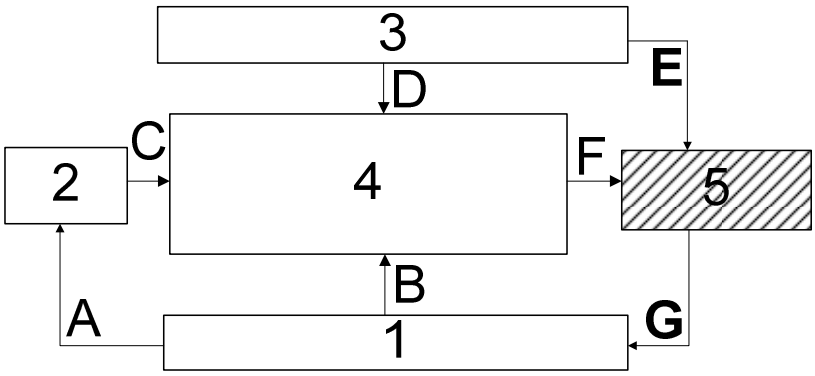

Figure 5-30: Influences on behaviour

5.5.1 Content of reactions

This part concerns block 5 of the contextual model. The answers given in the response SMS messages indicate whether people understood the message and the question in the message correctly (Sillem, Wiersma et al., 2004).

In the messages that were sent with the siren test, the participants were asked if they had heard the siren before they received the SMS message. There was a separate message for the auditory impaired people, asking if they had been warned about the siren going off before they read the SMS message, as they (probably) could not have heard the siren.

The number of people that reply that they have not heard the siren before receiving the SMS message is a very important group. This is the group that was only reached by SMS; these people would not have been warned if it had not been for the SMS service. On average 28 % of the participants that sent a reply SMS message said that they did not hear the siren previously to receiving the SMS message. The number of NO-replies was looked at per postal code region. The difference between the best and the worst postal code region is almost a factor 2 (20 % compared to 37 % that did not hear the siren), so the audibility of the siren is very much dependent on location. Further research is needed to determine in which areas or types of areas the sirens audibility is bad. Examples of areas could be newly developed urban areas (as sirens have not been placed yet), noisy areas (i.e. close to highway), houses that are very well insulated, rural areas etcetera. People in these areas could especially benefit from the SMS service, as the coverage for mobile phones is very good in the Netherlands.

This analysis showed how many people understood (and obeyed) the meaning of the SMS message they received, because they sent back the requested response. This may not be the required behaviour in an actual emergency, but it does show that in this case, instructions given through an SMS message were followed. It is important to investigate whether people are willing to take action following a warning message through a new or existing warning method. In many cases it will be difficult or impossible to investigate whether people will act by following the instruction from the warning message in a real emergency. It is unethical to put people in real danger. It may however be possible to simulate an emergency by doing an evacuation exercise or to test people by putting them in a situation that is as similar as possible to the situation they would be in in a real emergency. This can be done for example by putting people in a group (of actors) and seeing how they respond to the warning, depending on what the rest of the group does. This may however be a very costly experiment. The closer the real situation is approached, the more likely it is that the behaviour that is shown will also be shown in a real emergency, and thus the better this behaviour can be predicted and influenced.

An important issue in this part of the contextual model is the difference between intention and the actual behaviour that people will show. Of course, people can always be asked how they will respond in a certain situation. But this is not always the way that they will actually act in an emergency. Partly, this is caused by the fact that when asked about this, we all start thinking about what we would do in a certain situation. People think that the consciousness directs behaviour and that our behaviour starts with consciously taken decisions (Dijksterhuis, 2007). However, in reality, the largest part of our decisions to start showing certain behaviour are taken unconsciously and the reasons for this behaviour do not always reach our consciousness. According to Dijksterhuis, the unconsciousness takes a decision or forms an opinion, but the conscious creates the illusion afterwards that there were all sorts of reasons for this opinion or behaviour. When asked for their opinion on something, people use other arguments to give their opinion than the (unconscious) reasoning they would use without thinking about it. When they start thinking about the reasons for doing or not doing something, people tend to use arguments that are easily put in words. This makes the arguments that are easily put to words more important than they actually are. This makes it really difficult to predict your own behaviour in a certain situation.

The next paragraph discusses the degree to which people are willing to take action after receiving and reading a cell broadcast or SMS message. First, the results from the experiments in two holiday parks, in which participants actually had to act, will be dealt with. Then, the question from the web-based experiment on the degree to which people are willing to take action after reading a warning message will be discussed.

Two experiments were done in two holiday parks in which a real emergency was simulated. These experiments differ from a real emergency on several crucial points. Participants were asked in advance whether they wanted to participate. For participating they received a refreshment coupon of € 10,-. This meant that people already knew an evacuation exercise was going to be done. They also

knew it was a test and not a real emergency, so that there would be no consequences if they would not act. This makes it very difficult to translate the results from the test to the behaviour of people in a real emergency situation. The results can therefore only be seen as an indication of the real behaviour of people in an emergency. Moreover, some other occurrences during the test make interpreting the results more difficult. Because of troubles with sending the cell broadcast message in the second holiday park, only the results from the first park (Hof Domburg) will be analysed.

The message that was sent in the holiday park was: "Experiment. This is a message from the mayor of Veere. Come to the Theater in the Parel in Hof Domburg. Possible outbreak of open tuberculosis in holiday park. Info:: 0900-0922". For the German visitors in the park, this message was also sent in German.

In Hof Domburg, 492 people from 98 holiday homes applied to participate in the experiment. 93 of these participants actually came to the instructed location (19%) (Jagtman, Wiersma et al., 2008). Besides the applicants, 5 people (this makes a total of 98 persons that answered the questionnaire) came to the location. 3 of these people were from two different holiday homes that had not applied to participate; the other two were from outside the park. These last two received the cell broadcast message when they were outside the park and they decided to come to the location.

49% of the 98 people that reported in indicated that they had received the message themselves. 48% were warned by somebody else. The other 3% accidentally walked past the location when the experiment took place. This shows that the reach can be much higher than the number of people that actually receive the message on their phone. In this experiment it was almost twice as high. This so called buddy-effect appears to be especially effective among people in the very near surroundings of participants: 95% of the people questioned indicated that they didn't warn anybody from outside their own holiday home. The degree to which this would also be the case in a street or a company environment, or somewhere else where people know other people in the neighbourhood, needs further investigation.

The participants that did not show up at the instructed location received a questionnaire in their holiday home. The response rate for the questionnaire that was sent to people who did not show up was 58%. 70% of the participants who filled out this questionnaire, indicated that they had not received the message at all. The other participants had three reasons for not showing up: 1 time the message came at an inconvenient time, 1 time a participant was outside the park and the other 7 participants noticed the message too late.

This shows that almost all participants that received and noticed the message, came to the location. This indicates that given the experimental conditions, people were very wiling to take action. This shows that people do read the messages when they come in, they understand the text in the message and they are willing to act upon the messages in the circumstances as given in the holiday park (people would get a financial reward in return for showing up). This can give an indication of the willingness of people to use cell broadcast message in an emergency. However, only very general conclusions can be drawn as to the behaviour of people in a real emergency situation.

The web-based experiment (phase 4 d) not only looked at understanding of messages, participants were also asked after each message whether they would take action after reading that message, if they were to receive this in an actual emergency (also judged on a 7-point scale). The question was: "Will you take action when you receive this message in an emergency? Imagine you are in the area at risk".

Contrary to the other two questions that were posed after each message in the web-based experiment, in this case the optimal answer is the answer at the extreme: "I will act for sure" (7). The answers indicate what messages are most likely to motivate action. Because this is a direct question to the participants, this reflects the opinion of the participants. This does not mean that they will

actually follow the instructions when they are in a real emergency. Table 22 gives an overview of the results for the 6 message types (Jagtman, Wiersma et al., 2008).

Table 22: Average judgement (and standard deviation) of judged warning messages

	Action	
Type of message	Average	Stand. dev.
RA150	6.3	0.85
RI150	5.5	1.34
RAI150	6.2	0.92
RA300	6.2	0.90
RI300	5.6	1.23
RAI300	6.4	0.83

The table shows that participants are motivated less to take action after reading a message that does not contain the action component (RI150 and RI300). The variance is also larger for these messages than for the other types. Because the analysis of understanding warning messages indicates that the messages containing only Risk and Information are not appreciated, they will be left out of the remainder of the analysis of taking action. The other four message types do not show a distinguishing pattern. Differences in degree to which the 4 message types motivate action were also determined, in other words, the message type that is closest to the optimal score of 7. Figure 5-31 shows a histogram of the distribution of the judged willingness to take action after reading warning messages.

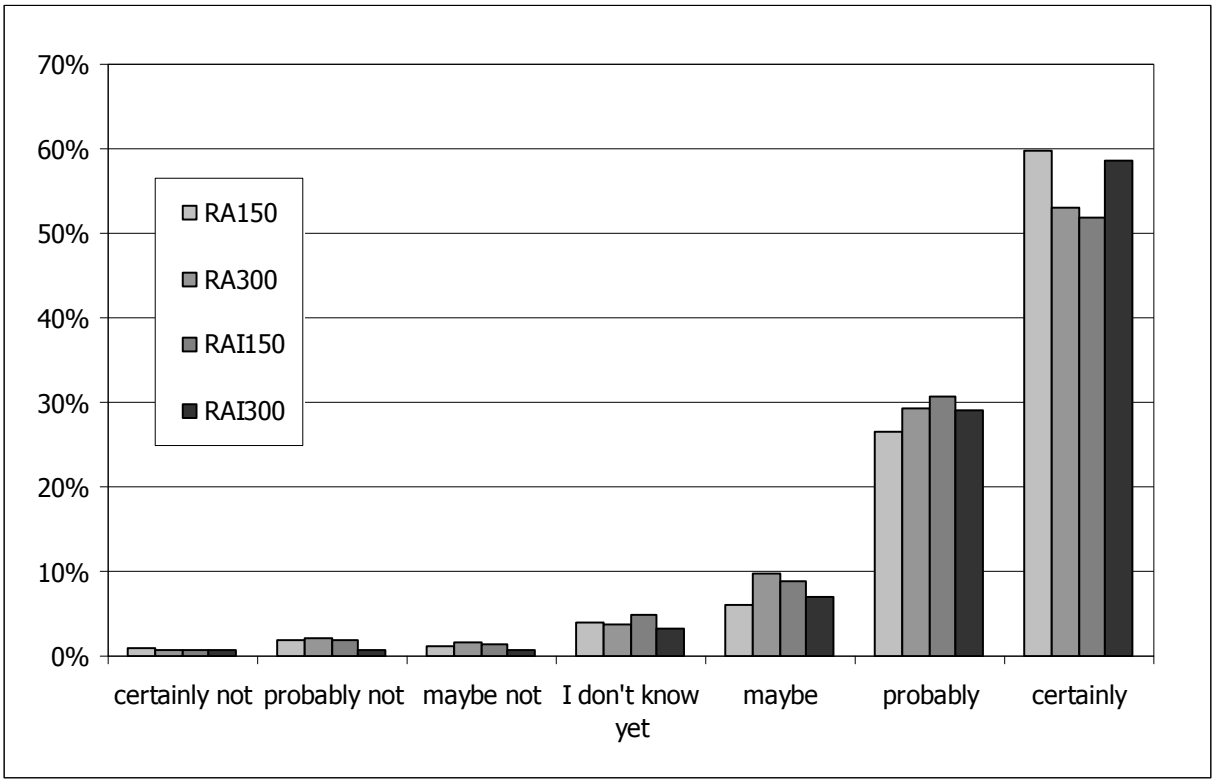

Figure 5-31: Willingness to take action (F=9.705; P=.000; df=372)

For most types of the messages, people are very willing to take action (81 tot 86% will probably or certainly take action). The difference between RA 150 and RAI300 as well as the difference between RA300 and RAI150 are not significant.

In predicting whether people will really act upon a warning message in a real emergency, several issues are important. First, the situation in which the field experiments are done should resemble the real emergency as much as possible in order to be able to draw conclusions on the behaviour of people in a real emergency. Second, different research methods should be used (such as was done in the cell broadcast research by doing a field experiment as well as a laboratory experiment) to be able to judge whether people show consistent responses. In this block of the contextual model, much attention should be paid to issues such as socially desirable behaviour / responses in a test environment, as when people are participating in an experiment, they want to help the experimenter and they think about what the experimenter wants from them.

Summarising, the factors discussed in the behaviour block are:

- Willingness to act
    - Are people willing to act upon warnings sent through this warning system?
- What kind of behaviour do people actually show following a warning message?
    - Will people act upon the warning messages sent through a specific warning system?

6. Conclusions and recommendations

The study presented in this thesis was based on the following main research question:

"How can the way in which a new or existing warning system effectively influences citizens' self-reliance in an emergency be investigated?"

This main question was divided into further sub-questions:

"What are the known steps in warning information processing in literature, in which self-reliance in an emergency can be influenced?"

"How should these steps be investigated?"

"What is the influence of each factor on citizens' self-reliance in an emergency?"

The research related to each of the questions is presented as follows: chapter 2 and 3 deal with the first sub-question. Chapter 4 is an introduction to the research project that served as examples in chapter 5, which deals with the second research question. This chapter discusses the main findings of the research conducted and described in this thesis and answers the research question mentioned above.

6.1 "What are the known steps in warning information processing in literature, in which self-reliance in an emergency can be influenced?"

The challenge of warning system effectiveness studies is to judge whether a warning system will be effective, whether it can actually improve self-reliant behaviour, and to do this in a scientifically valid and relevant way. There are three steps in warning citizens in an emergency that have to be taken before people can follow the instructions in that warn and get to a safe place: there has to be a warning that something is going on, people have to perceive and process that warning, and finally,

people have to perform the self-reliant behaviour that will get them to a safe place. In each of these three steps, several issues have an influence on self-reliance. Literature has been studied to determine what the steps are that have to be taken in warning information processing and to determine what factors within these steps can have an influence on self-reliance. Three main types of models were considered: evacuation models, fire or chemical exposure related models and warning process and human information processing models. All models discussed look at part of the process relevant in this thesis. Combining parts of the models discussed, a model was constructed that shows the steps of warning information processing in which self-reliance can be influenced. This model is called the contextual human information processing model, as it shows the influences on self-reliance in terms of the interactions between cognition, affective states and situational variables. Figure 6-1 shows the model developed. The development of the model was discussed in chapter 2 and 3.

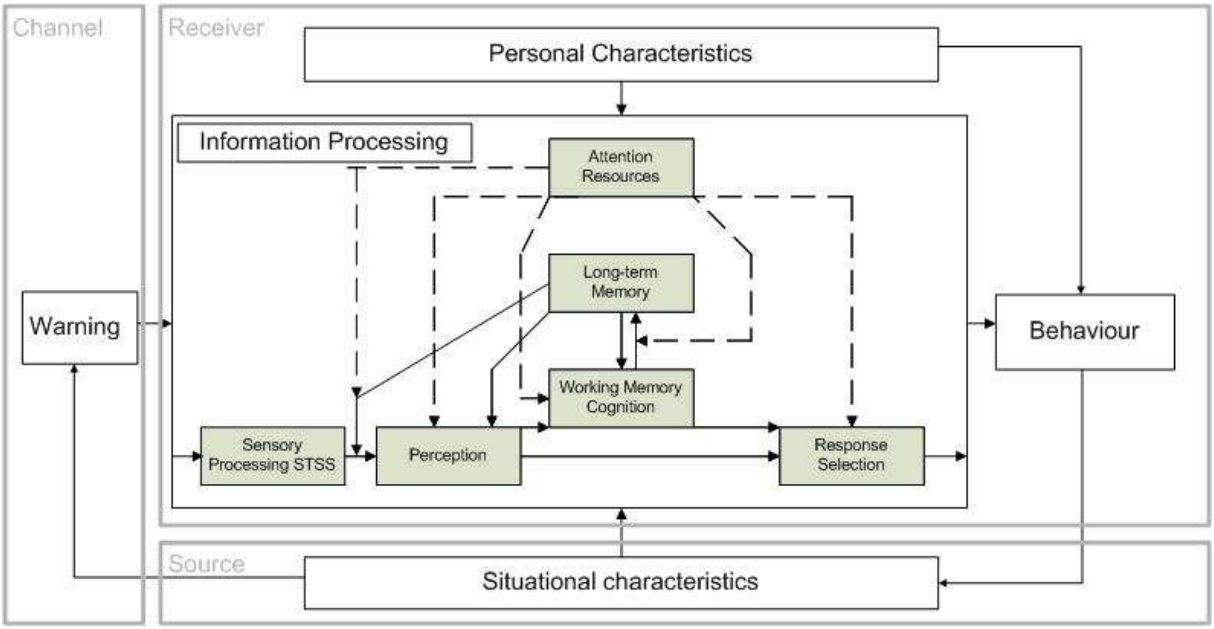

Figure 6-1: Contextual human information processing model for warning citizens

The model looks at issues inside (HIP, Personal characteristics and behaviour) and outside (situational characteristics and warning) the human. Each of the steps in the model is a necessary factor to investigate. The necessity of the individual factors in the contextual model is supported by literature sources, which show a remarkable agreement. What factors need to be investigated depends on the warning system under investigation. Not all factors and issues may be relevant for all warning systems. The examples and descriptions in chapter 5 try to cover how to determine what factors have to be investigated for a specific warning system. The model and the following list of factors following from the model provide a checklist that helps analysts make informed choices about the effectiveness of a specific warning system. An elaborate consideration of each factor can be found in chapter 5.

Situational characteristics

- Information through a warning message (Arrow A)
    - The situations in which people want to be warned
        - In what situations do people want to be warned?
    - Information intended to be sent by the authorities
        - What are the consequences if the information that is sent in a warning is wrong?
        - What are the influences of the conversion of the warning information to the format of the warning system that is used?
- Other information (Arrow B)

- Direct information about the emergency (smoke / flames)
  - What is the influence of directly seeing (i.e. smoke or flames), hearing or smelling the emergency on the effectiveness of the warning?
- Indirect information about the emergency through media and other people (including social influences)
  - What are the influences of information through media?
  - What are the influences of information through other people in the emergency?
  - What are the influences of the behaviour of other people in the emergency?
- Information that has nothing to do with the emergency, but which may influence the self-reliant behaviour of people
  - Are there other sources of information that are not about the emergency, but which could have an influence on peoples' response to a warning message?

Warning

- Reach
  - Reach (absolute values and values compared to current warning system)
    - What percentage of relevant people can be reached within a specific period of time at different times of day?
    - What is the improvement in reach that can be obtained by the new warning system when it is used as an addition to the current warning system or as a replacement?
  - Non-Reach (explain all cases of non-reach)
    - What are the explanations for the percentage of people that is not reached by any of the warning messages and can these problems be solved?
    - What is the influence of the explanations of the non-reach on the possible effectiveness of the warning system?
- Content
  - what information
    - What information components are needed for people to understand the warning message and motivate them to start acting?
    - What is the relative importance of these information components?
  - length of messages
    - What is the preferred length of messages for the warning system used?
  - design of the warning (location, font, colour, size, medium)
    - For as far as there is space for adjusting these issues, what is the optimal location, font, colour, size, medium, etcetera for the warnings sent through the specific warning system?

Personal characteristics

- Psychological factors
  - What relevant psychological factors may be of influence on the understanding or ability to act upon the warning messages?
- Physical factors (disabilities)
  - What relevant physical factors may be of influence on the ability to act upon the warning messages?
  - What is the representativeness of the participants on the relevant demographical factors for the population?
  - Are there relevant groups of people that may need adjusted types of messages?

Information processing

- Attitudes towards
  - warning system / device

        - What warning system do people prefer for different times of day?
        - Do different groups of people prefer different types of warning systems?
        - Is the new warning system a good addition to the current system?
        - Will people use the new warning system if it is implemented?
        - What are the influences of other messages sent through the same medium?
    - authority sending the warning messages (credibility, authoritativeness)
        - Is the authority sending the warning messages perceived as being credible and authoritativeness and if not, what is the influence of this and how can it be improved?
    - need for additional / replacement warning system
        - How satisfied are people with the current warning system (if available)?
        - What is the attitude of people towards the new warning system?
        - Do people think the new warning system should be used as an addition or can it replace the old system (if available)?
- Capacities that are needed to be self-reliant following a warning message, including: knowledge (hazard, protective action, plans), cognition and experience (type, recency)
        - Do people know what to do when specific instructions are given in the warning messages?
        - What is the influence of prior experiences and knowledge of hazards in the area on the effectiveness of the warning system?

Behaviour

- Willingness to act
        - Are people willing to act upon warnings sent through this warning system?
- What kind of behaviour do people actually show following a warning message?
        - Will people act upon the warning messages sent through a specific warning system?

6.2 "How should these steps be investigated" and "What is the influence of each factor on citizens' self-reliance in an emergency?"

Answering this second and third sub question was done in chapter 5 by a methodological discussion followed by examples of performing this research as was done in the two warning system effectiveness studies. Possibilities and impossibilities in researching each factor are discussed in that chapter. For each factor the ways to investigate this factor and the influence it has on citizens' self-reliance is discussed. It is not possible to give a short summary or general conclusion of that chapter here. What can be said here is that most difficulties in indicating how to research factors and what their influence on self-reliance is can be found in determining the actual behaviour that people will show. All steps before the actual behaviour takes place can be investigated with quite a good external validity, but when it comes to the actual execution of the desired self–reliant behaviour, the estimations become more imprecise. As people cannot be put in a real emergency because of ethical reasons, other ways of testing the influences of self-reliance have to be thought of. This issue is discussed thoroughly wherever it is important in the model in chapter 5. In some cases, to be able to make statements about certain influences on self-reliance, experiments have to be thought of that can simulate an emergency, either by making a task stressful by giving people other tasks to do during an experiment, or by causing distractions in the performance of a task. This will be an issue for further investigations.

6.3 The relevance of the model developed

In this paragraph, relevance of the contextual model is discussed. This thesis does not show a complete validation of the model developed. It does however show an overview of what the methodological issues are that have to be taken into account and what the influences on self-reliance

are for each factor, for as far as this can be determined. Some direction for development and further research are given in the final paragraph of this chapter. Together with the application chapter, the model forms a guide for investigating the (possible) effectiveness of warning systems. It does this by showing what factors are of influence on self-reliance, how to investigate these factors, and by showing what the results mean for the effectiveness of the whole model.

The contextual model can be used in any stage of developing or implementing a new or replacement warning system. Not all issues may be researchable at each stage, but insights can be gained into what factors are of importance and what issues have to be taken into mind when thinking about using a certain warning system to warn citizens'. The model can give directions and requirements as to what are important parts of a warning system, and the design of specific warnings. The model is meant to be useful for anyone involved in designing, testing, analysing or using a system for warning citizens in an emergency. It is meant to be a guide in setting up the structure of such an analysis. The model provides a checklist that helps analysts make informed choices about the effectiveness of a specific warning system. The model outlines the demands that a warning system effectiveness study puts on the analysis. The model structures the process that constitutes a successful warning exercise. The present research to a large extent validates the model. The model gives a set of factors and issues that need to be investigated when evaluating a potential (new) warning system and shows how this can be done. It does not prescribe how to fulfil all the requirements. It does not prescribe the methods and techniques that should be used in the analysis. These may differ for different types of warning systems. In short, it is a guide and not a ready to cook recipe. In describing the model in the application chapter, examples of specific methods and techniques were given. These were meant as an illustration of how the analysis can be done. In practice, there is a wide variety of ways to deal with the different factors. The methods and techniques most suitable will depend on the warning system that is analysed.

The model is built using literature. The methodological discussion shows how each of the factors can be investigated. However, the model itself is not yet validated. There is no proof that the model gives a complete list of all factors of influence. The studies that are used for showing how the different factors can be investigated provide some evidence that the model developed forms an applicable framework of the demands that an investigation into the effectiveness of a warning systems puts on the number and type of factors that have to be investigated regarding their influence on self-reliance. In both of the studies, the model is enabling to develop a good insight into the factors of importance and the way in which to investigate them. For example, in determining the non-reach of cell broadcast, a lot of variance and omissions in the results could be traced back and explained by research needed within the factors of the model.

Nevertheless, the studies also show that not meeting all the demands (not researching all the factors of the model (enough), won't necessarily make a study a complete disaster. The relationship between the way the warning system effectiveness study was carried out and the extent to which a sound judgement about the effectiveness of the warning system can be made, is not an all-or-nothing relationship. Even when not all factors are researched enough, the study can provide an important contribution to the judgement about the effectiveness. For example, the reach and non-reach in both the SMS and cell broadcast studies has been investigates thoroughly. Combined with the attitude related questions, a strong general statement can be made about the possible additional value of SMS and cell broadcast. However, to be precise about the effectiveness of these methods, the factors that were missing in theses studies have to be investigated as well. If the remaining factors were also investigated, the contribution would be greater. Than for example, statements could be made about the influence of possible wrong information sent through these media. This is an important issue, as it is a clear difference between these two technologies and the current siren. The siren can only convey one message, so the chances of sending out a wrong message are much smaller than that are possible in SMS and cell broadcast. In other words, in such cases, parts of the studies are useful. However, the cell broadcast study clearly shows that when for example the non-reach would not have been researched, the additional value of this system would probably have been rated as very slim.

However, as the reasons for the low reach in the early stages of the study were found and in principle solvable, the additional value became much more interesting. This shows that it is possible to miss essential findings when not all factors are investigated. These misses may not come up until the system is implemented when not all factors of the model are investigated. Therefore it is important to state what kind of information is needed from a warning system effectiveness study before a decision about implementation can be made. The influences of the different factors on the total effectiveness were discussed in Chapter 5.

Both cases are good illustrations of this notion. In neither of the cases all of the factors were investigated enough, but in both cases the studies provided important contributions. The major contribution of the SMS study was to show that when reach and attitude are researched, a great deal can be said about the possible effectiveness of the warning system. The field studies gave the participants enough information to form an informed opinion about the possible additional value for SMS as a warning system. The most important value of the cell broadcast study was the insight that investigating the reasons for non-reach can give an enormous amount of information on the possible additional value of the warning system. The cell broadcast research also showed the importance of research into the content of warning messages and the influences of additional messages sent through the same medium.

Of course not every factor has the same importance of being investigated when trying to obtain a complete view of the influences on self-reliance for the whole model. Some issues are more important to gain information on. The factors that will have the least effect on self-reliance are considered to be the personal characteristics. These characteristics are the issues outside the normal human information processing that are of influence on self-reliance. These issues are relevant for groups of people that have special needs. These groups are by definition limited in number, which makes these factors less important for general warning systems. The effect of these groups on self-reliance of the total population will be relatively small. The other issues are however considered to be of great importance on citizens' self-reliance in an emergency. Based on the three phases of warning people, as mentioned in paragraph 2.1, the issues from the list in paragraph 6.1 that can give a quick first insight into the possibilities of a certain warning system are can be seen as the three issues that can make sure that these three phases are passed:

- Warning: determining the reach and non-reach of the warning
    - This issue can help determine whether the warning system under investigation has the potential to warn a lot of people
- Information processing: degree of understanding of the content of the messages
    - This issue can help determine what messages should be sent
- Attitude: willingness / citizens attitude towards the warning system and the authority sending the message
    - This issue can help determine whether people would accept this warning system would it be implemented.

The reach and non-reach give insight into how many people can be reached with the warning system. Without reaching people, a warning system is of no use. Research into the non-reach shows the problems there are with the warning system and can help determiner whether these problems are solvable. The understanding of the content of messages helps to determine what information people need in a warning message top make sure that they can make an informed decision about the danger they are in and what they should do to stay safe. This will greatly improve peoples' self-reliance. Finally, peoples' attitude towards a warning system will determine whether and how it will be used. This is a big condition to make a high reach possible.

When one of these three issues fails, the chances of success for the warning system can be considered limited.

To be able follow the demands of the model, there should be possibilities to take a broad scope and to investigate all factors of the model in depth. Time and money issues may render it impossible to investigate all factors as deeply as may be desirable. Moreover, there may be pressure to implement a new technology quickly. It is essential that the analysis of the warning system effectiveness be tailored to the needs of the analysers, since limitations imposed on the scope of the analysis may decrease the analysts' possibilities to obtain a complete view of the effectiveness of the warning system. Cutting corners on the evaluation of a warning system is asking for trouble. It is important to try to stretch the limits and meet the demands of the model as much as possible, since a complete view of the effectiveness is a necessary condition to make sound judgements about this warning systems additional value for warning citizens.

6.3.1 Recommendations

Despite the two cases, the study findings cannot be considered definitive. First, the fact that both cases are from the mobile phone technology field raises the question of whether the findings would also hold for other types of warning systems, such as dedicated devices, or voice systems. Given the similarity in findings in these two studies, however, there is good reason to believe that other fields would render similar findings. This is something to research further in the future.

As has been described in chapter 5 as well as in this chapter, most difficulties in indicating how to research factors and what their influence on self-reliance is can be found in determining the actual behaviour that people will show. As people cannot be put in a real emergency because of ethical reasons, other ways of testing the influences of self-reliance have to be thought of. This will be an issue for further investigations.

The warning systems studied, were both meant as public warning system, as an addition to or replacement of the siren. However, the model also aims at being applicable to other warning systems, such as warning systems in buildings. The description of investigating the factors in chapter 5 makes it possible to determine what factors could be of importance for more local warning systems.

Next, the limitations of the studies to the Netherlands pose another question, as to whether other countries need to put the same demands on factors that have to be investigated. For instance because of cultural differences in the attitude of people towards authorities. These may be issues that have to do with trusting authorities or with willingness to comply with requests made by authorities.

Finally, it would be interesting to dig deeper into the interrelationships between the different factors. Which factors are depending on each other and to what degree? What are the most important factors, and which factors have less influence? If a person does not trust the authority sending out the warning message, the message that is received from this authority will be seen as irrelevant. In such a situation, the warning system may be very good in reaching people, but the effect will not be optimised. Trust issues are very important when considering trust in the authorities that are sending out the warning messages. This is an issue that may be different for different countries and which also may change over time. Dalton (2004) and Bovens and Wille (2008) show that in the Netherlands, there has been a decrease of confidence in government and politicians. People seem to be dissatisfied with the way the democratic institutions function (van der Burg and van Praag, 2007). This may change the response to a warning message received from the government and thus influence the resulting self-reliant behaviour.

A lot remains to be developed for dealing with human behaviour in emergencies and making sure that people respond immediately and act self-reliant.

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Appendix A

Participants SMS and cell broadcast studies

SMS

Name test	Phase	invited	participants
Test Vlaardingen	Phase 0	3000	726

Cell broadcast

Name test	phase	invited	participants
Closed test Zoetermeer	phase 1a	1.000	102
Laboratory experiment	phase 1b	Open	44
Open test Zoetermeer	phase 2	12.000	1.135
Zeeland – Technology (closed)	phase 3b	4.200	391
Zeeland (open)	phase 3c	91.000	6.436
Zeeland – holiday parks	phase 3e	Open	196
Amsterdam – citizens	phase 4b	Open	503
Web-based experiment	phase 4d	Open	418
Zeeland – Additional messages	phase 6b	2555*	1.317
Walcheren en Zuid-Beveland	phase 7c	about 6500**	621

* All participants from phase 3c that reacted to at least 1 setting message, were invited to participate
** Participants from phase 3c that reacted to at least on message and that are living in Walcheren or Zuid-Beveland were invited. Moreover, 4000 extra citizens were invited and all citizens in the area could also apply to participate.

Appendix B

Messages sent to citizens

SMS

Date	Message
Phase 0	
20040301	ALARM: Dit is de maandelijkse alarmtest. Stuur zo snel mogelijk 'JA' naar 5100 zodra u dit heeft gelezen. Dank voor uw medewerking.
20040205	ALARMTEST. Heeft u de sirene horen loeien voordat u dit bericht ontving? Stuur 'JA' of 'NEE' naar 5100. Dank u wel.
20040423	ALARM TEST. Dit is een bericht om het bereik van de alarmberichten te bepalen. Wilt u zo snel mogelijk 'JA' naar 5100 sturen? Dank u wel.
20040503	ALARMTEST. Heeft u de sirene horen loeien voordat u dit bericht ontving? Stuur 'JA' of 'NEE' naar 5100. Dank u wel.
20040511	ALARM TEST. Dit is een bericht om het bereik van de alarmberichten te bepalen. Wilt u zo snel mogelijk 'JA' naar 5100 sturen? Dank u wel.
20040607	ALARMTEST. Heeft u de sirene horen loeien voordat u dit bericht ontving? Stuur 'JA' of 'NEE' naar 5100. Dank u wel.
20040607	De SMS-test in Vlaardingen is beëindigd. U ontvangt volgende week de laatste vragenlijst en wordt daarna automatisch afgemeld. Dank voor uw medewerking!

Cell broadcast

Datum	Bericht
Fase 1	
20050818	cell broadcastproef: Stuur NU een SMS met de tekst 'TU ja' naar 3111. (Info 0900-0922)
20050823	cell broadcastproef: Stuur NU een SMS met de tekst 'TU ja' naar 2020. (Info 0900-0922)
20050829	cell broadcast: Voer NU opdacht op TV West Teletekstpagina 112 uit. (Info 0900-0922)
20050910	cell broadcastproef: Stuur NU een SMS met de tekst 'TU ja' naar 2020. (Info 0900-0922)
fase 2	
20051003	PROEF: Dit is een bericht van de cell broadcastproef. Heeft u om 12:00 uur de sirene gehoord? Stuurt u alstublieft zo snel mogelijk een SMS
20051011	PROEF: Bent u buiten? SMS nu "TU ja" of "TU nee" naar 3111. (info 0900-0922)
20051026	Cell broadcast: Voer NU de opdracht op TV West Teletekstpag. 112 uit. (Info 0900-0922)
20051107	PROEF: Heeft u de sirene gehoord? SMS 'tu ja' of 'tu nee' naar 3111. (info 0900-0922)
20051116	PROEF: Bericht om het bereik te testen. SMS nu 'tu ja' naar 2020. (info 0900-0922)
20051117	Cell broadcast: Voer NU de opdracht op TV West Teletekstpag. 112 uit. (Info 0900-0922)
20051123	Cell broadcast: Voer NU de opdracht op TV West Teletekstpag. 112 uit. (Info 0900-0922)
20051129	PROEF: Bent u buiten? SMS nu "tu ja" of "tu nee" naar 2020. (info 0900-0922)
20051205	PROEF: Heeft u de sirene gehoord? SMS 'tu ja' of 'tu nee' naar 2020. (info 0900-0922)
20051207	PROEF: Bericht om het bereik te testen. SMS nu 'tu ja' naar 2020. (info 0900-0922)
20051213	Cell broadcast: Voer NU de opdracht op TV West Teletekstpag. 112 uit. (Info 0900-0922)
Fase 3b	
20060130	Cell broadcastproef. Dit is een instelbericht. SMS de tekst tu ja naar 2020. Info: 0900-0922
20060131	Cell broadcastproef. Dit is een instelbericht. SMS de tekst tu ja naar 2020. Info: 0900-0922
20060201	Cell broadcastproef. Dit is een instelbericht. SMS de tekst tu ja naar 2020. Info: 0900-0922
20060202	Cell broadcastproef. Dit is een instelbericht. SMS de tekst tu ja naar 2020. Info: 0900-

	0922
20060203	Cell broadcastproef. Dit is een instelbericht. SMS de tekst tu ja naar 2020. Info: 0900-0922
20060203	Cell broadcastproef. Dit is een instelbericht. SMS de tekst tu ja naar 2020. Info: 0900-0922
20060207	Dit is een proef. Als u dit bericht niet geheel ontvangt, SMS dan 'tu gedeelte' naar 2020, ontvangt u het bericht wel helemaal, SMS dan 'tu helemaal' naar 2020. Er is in de provincie Zeeland een dreiging van een grieppandemie. Zorg ervoor dat u zo snel mogelijk naar uw stadhuis komt voor een inenting. Voor meer informatie kunt u terecht bij: 09000922
20060209	Dit is een proef. Als u dit bericht niet geheel ontvangt, SMS dan 'tu gedeelte' naar 2020, ontvangt u het bericht wel helemaal, SMS dan 'tu helemaal' naar 2020. Er is in de provincie Zeeland een dreiging van een grieppandemie. Zorg ervoor dat u zo snel mogelijk naar uw stadhuis komt voor een inenting. Voor meer informatie kunt u terecht bij: 09000922
20060216	Proef: voer nu de opdracht op Omroep Zeeland Teletekstpagina 120 uit. Info 0900-0922
20060223	Proef. Stem nu af op Radio Omroep Zeeland: FM 87.9 of 98.4; kabel FM 87.6 Info: 0900-0922
Fase 3c	
20060316	Proef. Stuur nu een SMS met de tekst 'tu alarm' naar nummer 2020. Info 0900-0922
20060316	Proef: Voer nu de opdracht op Omroep Zeeland Teletekstpagina 120 uit. Info 0900-0922
20060323	Proef: Voer nu de opdracht op Omroep Zeeland Teletekstpagina 120 uit. Info 0900-0922
20060323	Proef: Voer nu de opdracht op Omroep Zeeland Teletekstpagina 120 uit. Info 0900-0922
20060323	Proef. Stuur nu een SMS met de tekst 'tu alarm' naar nummer 2020. Info 0900-0922
20060323	Proef. Stuur nu een SMS met de tekst 'tu alarm' naar nummer 2020. Info 0900-0922
20060330	Cell broadcastproef. Dit bericht maakt deel uit van de cell broadcastproef in Zeeland. De overheid onderzoekt samen met de TU Delft de mogelijkheid om u op deze manier bij rampen te waarschuwen. Stuur nadat u dit bericht heeft gelezen een SMS met de tekst 'tu lang' naar 3111. Info: 0900-0922
20060330	Proef. Overheid test hoe u te waarschuwen. SMS de tekst 'tu kort' naar 2020. Info: 0900-0922
20060403	PROEF: Heeft u de sirene gehoord? SMS 'tu ja' of 'tu nee' naar 3111. Info: 0900-0922
20060406	Proef. Overheid test hoe u te waarschuwen. SMS de tekst 'tu kort' naar 2020. Info: 0900-0922
20060406	Cell broadcastproef. Dit bericht maakt deel uit van de cell broadcastproef in Zeeland. De overheid onderzoekt samen met de TU Delft de mogelijkheid om u op deze manier bij rampen te waarschuwen. Stuur nadat u dit bericht heeft gelezen een SMS met de tekst 'tu lang' naar 3111. Info: 0900-0922
20060420	Proef. Bericht om het bereik te testen. SMS nu 'tu proef' naar 2020. Wilt u meer informatie? Bel dan met: 0900-0922
20060420	Proef. Dit bericht wordt vandaag 6 keer gestuurd. SMS de eerste keer 'tu herhaal' naar 3111. Wilt u meer informatie? Bel dan: 0900-0922
20060427	Proef. Dit bericht wordt vandaag 6 keer gestuurd. SMS de eerste keer 'tu herhaal' naar 3111. Wilt u meer informatie? Bel dan: 0900-0922
20060427	Proef. Bericht om het bereik te testen. SMS nu 'tu proef' naar 2020. Wilt u meer informatie? Bel dan met: 0900-0922
Fase 4b	
20060724	PROEF: bericht van alarmkanaal! SMS nu de tekst 'pk kort' naar 3111. Info: 0900-0922
20060801	Proef. Bericht om het bereik te testen. SMS nu 'da proef' naar 3111. Wilt u meer informatie? Bel dan met: 0900-0922
20060807	PROEF: Heeft u de sirene gehoord? SMS 'al ja' of 'al nee' naar 2020. Info: 0900-0922
20060815	Cell broadcastproef. Dit bericht maakt deel uit van de cell broadcastproef in Amsterdam. De overheid onderzoekt samen met de TU Delft de mogelijkheid om u op deze manier bij

	rampen te waarschuwen. Stuur nadat u dit bericht heeft gelezen een SMS met de tekst 'da lang' naar 2020. Info: 0900-0922
20060822	PROEF: bericht van alarmkanaal! SMS nu de tekst 'pk kort' naar 3111. Info: 0900-0922
20060829	Proef. Dit bericht wordt vandaag 6 keer gestuurd. SMS de eerste keer 'da herhaal' naar 3111. Wilt u meer informatie? Bel dan: 0900-0922
20060904	PROEF: Heeft u de sirene gehoord? SMS 'al ja' of 'al nee' naar 3111. Info: 0900-0922
20060907	PROEF: SMS zo snel mogelijk 'pk ja' naar 3111. Info: 0900-0922
20060914	PROEF: SMS zo snel mogelijk 'da ja' naar 2020. Info: 0900-0922
20060919	PROEF: SMS zo snel mogelijk 'al ja' naar 3111. Info: 0900-0922
20060926	PROEF: SMS zo snel mogelijk 'jl ja' naar 2020. Info: 0900-0922
20061002	PROEF: Heeft u de sirene gehoord? SMS 'al ja' of 'al nee' naar 2020. Info: 0900-0922
20061005	PROEF: SMS zo snel mogelijk 'pk ja' naar 3111. Info: 0900-0922
20061011	PROEF: Bent u nu in A'dam? SMS zo snel mogelijk 'tu ja' of 'tu nee' naar 3111. Info:09000922
20061017	PROEF: SMS zo snel mogelijk 'au ja' naar 3111. Info: 0900-0922
20061026	PROEF: Bent u nu in A'dam? SMS zo snel mogelijk 'tu ja' of 'tu nee' naar 3111. Info:09000922
20061106	PROEF: Heeft u de sirene gehoord? SMS 'al ja' of 'al nee' naar 2020. Info: 0900-0922
Fase 6b	
20060606	PROEF: Heeft u gister de sirene gehoord? SMS 'si ja' of 'si nee' naar 3111. Info: 0900-0922
20060615	PROEF: bericht van alarmkanaal! SMS nu de tekst "si kijk" naar 2020. Info: 0900-0922
20060622	PROEF: bericht van alarmkanaal! SMS nu de tekst "si loop" naar 2020. Info: 0900-0922
20060703	PROEF: Heeft u de sirene gehoord? SMS 'jl ja' of 'jl nee' naar 3111. Info: 0900-0922
20060706	PROEF: bericht van alarmkanaal! SMS nu de tekst "si kijk" naar 2020. Info: 0900-0922
20060714	PROEF: bericht van alarmkanaal! SMS nu de tekst "si deur" naar 2020. Info: 0900-0922
20060727	PROEF: bericht van alarmkanaal! SMS nu de tekst "si zoek" naar 2020. Info: 0900-0922
20060807	PROEF: Heeft u de sirene gehoord? SMS 'au ja' of 'au nee' naar 2020. Info: 0900-0922
20060817	PROEF: bericht van alarmkanaal! SMS nu de tekst "si auto" naar 3111. Info: 0900-0922
Fase 7c	
20070927	Proef: Stuur nu een SMS met tekst 'bruin' naar nummer 1111. Info 0900-0922
20071001	Proef: Sirene van gemeente gehoord? SMS 'ja' of 'nee' naar 1111. Info: 0900-0922
20071003	Proef cell broadcast burgeralarmering: Dit bericht maakt deel uit van de cell broadcastproef in Walcheren en Zuid
20071006	Proef: Is alarmtoon op toestel goed? SMS 'wel OK' of 'niet OK' naar 1111. Info: 0900-0922
20071008	Proef: Stuur nu een SMS met de tekst 'groen' naar 1111. Info 0900-0922
20071011	Proef: bericht wordt vandaag 6 maal gestuurd. SMS 1e keer 'paars' naar 1111. Info 0900-0922
20071012	Proef cell broadcast burgeralarmering: Dit bericht maakt deel uit van de cell broadcastproef in Walcheren en Zuid
20071003	Proef: Stuur nu een SMS met de tekst 'blauw' naar het nummer 1111. Info: 0900-0922

Appendix C

Messages sent in laboratory experiment (phase 1b)

A1 – 150 Risico
Alarm van burgemeester: om 10.30 uur tankwagen met benzine gekanteld op A12, afslag Zoetermeer-Centrum, hectormeterpaal 112,5. Explosiegevaar. – 144 char

A1-150 Risico
Alarm van burgemeester: brand bij LPG-station langs A27 richting Utrecht, afslag Bilthoven. Hectometerpaal 321,3. Explosiegevaar. - 131 char.

A1-150 Risico
Alarm van burgemeester: brand in chemische fabriek Cindu Uithoorn, vlakbij N241. Explosiegevaar. Gevaar tot 5 kilometer van fabriek. - 132 char.

A1 – 300 Risico
Alarm van burgemeester: om 10.30 uur goederentrein ontspoord bij station Rotterdam-Lombardijen. Zeer giftige stof ontsnapt. Stof is onzichtbaar en nauwelijks te ruiken! Gaswolk trekt langzaam over wijk IJsselmonde naar Rotterdam centrum. Gevolgen voor gezondheid na enkele uren merkbaar. – 287 char.

A1-300 Risico
Alarm van burgemeester. Hoogste alarmfase gemeente. Om 4.30 uur chloortrein ontspoord tussen station Hilversum-Noord en station Bussum-Zuid. Wolk chloorgas trekt over Mediapark richting Hilversum-centrum. Chloor is onzichtbaar en reukloos. Inademen chloor is levensgevaarlijk. – 276 char.

A1-300 Risico
Alarm van burgemeester: onbekende vloeistof lekt uit wagon op station Amersfoort CS. Gevaar nog niet bekend. Mogelijk explosiegevaar en gevaar voor gezondheid. Wagon staat op perron 1 naast stationshal. Tot 500 meter rond wagon scherpe zoete lucht. Lucht veroorzaakt rode, prikkende ogen. – 289 char.

A1 – 460 Risico
Alarm van burgemeester. Hoogste alarmfase gemeente. Om 10.30 uur goederentrein ontspoord bij station Rotterdam-Lombardijen. Grote hoeveelheid zeer giftige stof ontsnapt. Stof onzichtbaar en nauwelijks te ruiken. Gaswolk trekt langzaam over wijk IJsselmonde naar Rotterdam centrum! Wolk vanaf 12.00 uur in centrum. Gevolgen voor gezondheid na enkele uren merkbaar. Mogelijke gevolgen: misselijkheid, buikkrampen, ademnood, hoofdpijn en bloedplassen. – 448 char

A1- 460 Risico
Alarm van burgemeester. Hoogste alarmfase gemeente. Levensgevaarlijke chloorwolk op Mediapark. Om 4.30 uur chloortrein ontspoord tussen station Hilversum-Noord en station Bussum-Zuid, op 400 meter van station Hilversum-Noord. Uit wagon is chloor ontsnapt. Chloor is onzichtbaar en reukloos. Inademen is levensgevaarlijk. Wolk hangt vanaf grond tot 1,50 meter hoogte. Chloorwolk gaat met 500 meter per uur richting wijk Trompenberg. Sinds 5.45 uur is chloorlek gedicht. – 468 char.

(bij bovenstaande lange melding van levensgevaarlijke situatie lijkt het goed direct de situatie te schetsen (Levensgevaarlijke chloorwolk op Mediapark) en niet de oorzaak (OM 4.30 chloortrein ontspoord)

A1-460 Risico

Alarm van burgemeester. Gevaar van terreuraanslag in openbaar vervoer Rotterdam. In metrostation Rotterdam-Blaak is om 7.45 uur man gearresteerd met explosieven op het lichaam. Hij wilde zichzelf opblazen. Politie denkt dat meer terroristen actief zijn. Gevaar in metro, tram, bus en trein. Gearresteerde man was ongeveer 20 jaar. Hij had onopvallend uiterlijk. Centrum Rotterdam wordt afgesloten tot 1 kilometer rond Centraal Station. – 435 char.

B1 – 150 Risico en handeling
Alarm van burgemeester. Brand in chemische fabriek Cindu. Gevaarlijke chemische stof vrijgekomen. Ga direct naar binnen! Sluit deuren en ramen. – 144 char

B1-150 Risico en handeling
Alarm van burgemeester. Gevaar van terreuraanslag Rotterdam. In metrostation is man met bom gearresteerd. Ga niet in metro, tram, bus of trein! Ga weg uit stations. – 164 char.

B1- 150 Noodoproep
Noodoproep Samenwerkende Hulp Organisaties. Voor 2 miljoen slachtoffers aardbeving Pakistan dreigt hongerdood. Met uw geld kan voedsel worden gebracht. Stort op giro 555. – 170 char.

B1 – 300 Risico en handeling
Alarm van burgemeester: om 10.30 uur tankwagen met benzine gekanteld op A12, afslag Zoetermeer-Centrum. Explosiegevaar. Blijf minimaal 1 kilometer bij afslag vandaan. Als u op snelweg bent, laat auto achter en loop weg. Bewoners binnen 1 kilometer van afslag moeten huis verlaten.
280 char

B1- 300 Risico en handeling
Alarm van burgemeester. Chloorwolk op Mediapark. Inademen chloor is levensgevaarlijk. Aanwezigen op Mediapark moeten binnen blijven. Houd ramen en deuren dicht. Voor omwonenden: ga minimaal 2 kilometer bij Mediapark vandaan. Als dat niet kan, blijf dan binnen en houd ramen en deuren dicht. – 290 char

B1-300 Noodoproep
Noodoproep van de Nederlandse regering. Door de ramp in de kerncentrale Borssele zijn 2 miljoen inwoners van Zuid-West-Nederland tijdelijk dakloos. De regering vraagt inwoners van de rest van Nederland woonruimte aan te bieden. U kunt woonruimte aanmelden op gratis telefoonnummer 0800-1351. – char 289

B1 – 460 Risico en handeling
Alarm van burgemeester. Explosiegevaar door bom uit Tweede Wereldoorlog. Bom op vliegveld Zestienhoven bij Rotterdam-Overschie blijkt zeer gevaarlijk. Explosieven Opruimings Commando is gestopt met opgraven bom. Verlaat direct omgeving vliegveld. Iedereen binnen 3 kilometer van het vliegveld moet weg. Ga naar buiten en volg aanwijzingen autoriteiten op. Controleer of uw buren ook gewaarschuwd zijn. Verlaat het gebied lopend of met fiets, niet met auto. – char 456

B1- 460 Risico en handeling
Alarm van burgemeester. Bij uitslaande brand in opslagloods in Tynaarlo komt veel asbest vrij. Loods staat aan A28 bij afslag Tynaarlo, hectometerpaal 183,3. Brandweer heeft brand nog niet onder controle. Het asbest is zeer kankerverwekkend. Adem het niet in. Wolken met asbest trekken richting Assen. Voor iedereen in Assen, Tynaarlo, Zeyen, Balloo, Rolde en Loon: blijf binnen. Houd deuren en ramen dicht. Waarschuw bekenden in het gebied. – char 440.

B1-460 Risico en handeling
Alarm van burgemeester. Explosiegevaar in Amsterdam Arena. Politie heeft dreigmail ontvangen over aanslag. Politie neemt dreiging serieus. Volgens dreigmail zal een terrorist zichzelf in het stadion opblazen tijdens Ajax-Sparta Praag. Plaats terrorist in stadion onbekend. Ook tijdstip aanslag

onbekend. Toeschouwers in stadion moet wachten op aanwijzingen autoriteiten. Ze zullen vak voor vak stadion verlaten. Buiten stadion moeten ze lopend in aangegeven richting naar bussen gaan. – char 483

C1 – 150 Risico en info
Alarm van burgemeester: Door explosie in vrachtwagen op Brienenoordbrug is gevaarlijke stof vrijgekomen. Omvang gevaar nog onbekend. Meer informatie op www.crisis.nl . – 174 char

C1 – 300 Risico en info
Alarm van burgemeester: In kerncentral Borssele zijn om 15.05 uur drie explosies geweest. Oorzaak is nog niet duidelijk. Mogelijk komen radioactieve stoffen vrij. Wij houden u op de hoogte via nieuwe cb-berichten. Voor meer informatie: Radio Zeeland, 88,6 FM. en www.crisis.nl. – 285 char

C1 – 460 Risico en info
Alarm van burgemeester: Explosiegevaar door verdacht pakket. Verdacht pakket is na telefonische waarschuwing gevonden langs A12 bij Prins Clausplein. Pakket ligt bij munitiedepot TNO. Dreiging zeer ernstig. Prins Claus Plein wordt afgezet. Daarna zal het leger omgeving binnen 2 kilometer van pakket ontruimen. U bent in dit gebied. Wij houden u op de hoogte via nieuwe cb-berichten. Voor meer informatie: Radio West, 89.3 FM. En telefoonnummer 0800-1351 – 456 char

C2 – 150 Risico en info
Alarm van burgemeester: Gifwolk trekt vanaf Brienenoordbrug over Rotterdam-Zuid richting Hoogvliet. Meer informatie op www.crisis.nl . – 139 char

C2- 150 Risico en info
Alarm van burgemeester: Sinds 14.30 uur lekt gevaarlijke stof uit wagon op Amersfoort CS. Meer informatie op www.crisis.nl en Radio Utrecht, 87.7 FM. – 157 char

C2- 300 Risico en info
Alarm van burgemeester: In de Leeuwenhoekstraat in Laakkwartier houdt politie sinds 4.30 uur huis omsingeld. Er zitten vermoedelijk terroristen in. Bewoners hebben granaat gegooid. Wijk wordt afgezet door ME. Voor meer informatie: Radio West, 89,3 FM. En telefoonnummer 0800-1351.
– 278 char.

C2 – 300 Risico en info
Alarm van burgemeester: Over Rijswijk en Delft trekt gifwolk. Het gif kwam vrij door explosie in vrachtauto op A13 bij Afslag Delftse Hout, hectometerpaal 13,3. Het gas stinkt naar rotte eieren. Het kan gevaarlijk zijn voor mensen met hartklachten. Meer informatie op Radio West, 89.3FM. Telefonische informatie via 0800-1351 – 277 char

C2- 460 Risico en Info
Alarm van burgemeester: Explosieven Opruimings Commando onderzoekt verdachte pakket bij munitiedepot langs de A12. Explosiegevaar blijft groot. Dreiging is zeer serieus. Prins Clausplein is afgezet. Leger begint met ontruiming van de omgeving. Binnen half uur krijgt u aanwijzingen van de militairen. Wij zullen meer cb-berichten sturen. Informatie krijgt u ook via Radio West, 89,3 FM, TV West teletekstpagina 112. En telefoonnummer 0800-1351. -445 char

C2- 460 Risico en info
Alarm van burgemeester: Explosiegevaar op Westerschelde. Uit vastgelopen schip in Westerschelde bij Terneuzen lekt gevaarlijke vloeistof. De stof kan exploderen. Het schip vervoert 300 vaten met dit gif. Het dreigt in tweeën te breken. Daardoor kunnen gifvaten in Westerschelde terechtkomen.

Waarschijnlijk geen groot gevaar voor bevolking Terneuzen. Wij houden u op de hoogte via nieuwe cb-berichten. Voor meer informatie: Radio ZeelandRadio, 88,6 FM. en www.crisis.nl. – 479 char

D1 – 150 Risico, handeling en info
Alarm van burgemeester. Grolsch-fabriek Enschede dreigt te exploderen. Verlaat omgeving onmiddellijk. TV Oost voor meer informatie. – 131 char

D1 – 150 Risico, handeling en info
Alarm van burgemeester. Dreiging gasexplosie in centrum Delft. Ga direct ergens naar binnen. Open alle ramen en sluit gordijnen! TV-West voor meer informatie - 157 char

D1 – 300 Risico, handeling en info
Alarm van burgemeester. Explosiegevaar bij Knorrfabriek Loosdrecht. Door brand dreigt fabrieksketel te ontploffen. Ga onmiddellijk weg uit omgeving fabriek. Ook omwonenden tot 2 kilometer van fabriek moeten direct weg. Waarschuw uw buren. Voor meer informatie: TV-Utrecht en Radio Hilversum, 92.2 FM. – 300 char

D1- 300 Risico, handeling en info
Alarm van burgemeester. Hoogste alarmfase gemeente. Explosiegevaar in de wijk Oud-West in Amsterdam door brand in opslagloods vuurwerk. Vuurwerk ligt midden in de wijk. Levensgevaar. Ga direct weg richting centrum. Blijf niet kijken. Laat ramen en deuren open staan. Meer informatie: TV AT5 en www.crisis.nl - char. 308

D1 – 460 Risico, handeling en info
Alarm van burgemeester. Explosiegevaar en mogelijk giftige dampen in woonwijk Hesseler As in Hengelo. F-16 gevechtsvliegtuig om 11.35 uur neergestort in wijk. Vliegtuig ligt op veld tussen huizen Jaap Burgerstraat en Elco Brinkmanlaan. Bewoners Hesseler As moeten binnenblijven. Houd ramen en deuren dicht. Schuil onder tafel. Wacht op aanwijzingen politie. Meer informatie: TV Oost en teletekst pagina 112 van TV Oost. Radio Oost, 91.4 FM en 0900-0922. – char 453

D1- 460 Risico, handeling en info
Alarm van burgemeester. In Eindhoven en omgeving is radioactief stralingsgevaar. Radioactieve straling is ernstig verhoogd. Oorzaak verhoogde straling is onbekend. Ook op andere plaatsen in Nederland en buitenland verhoogde radioactiviteit. Buitenlucht kan gevaarlijk zijn voor gezondheid. Blijf binnen. Houd ramen en deuren dicht. Meer informatie: Omroep Brabant Radio, 87.7 FM, Radio 1 98.9 FM, TV Brabant en Nederland 2. Ook pagina 101 NOS Teletekst. – char 453

D2- 150 Risico, handeling en info
Alarm van burgemeester. Explosies in metrostations Blaak en Coolsingel en in bus op Coolsingel. Verlaat lopend metrostations en centrum Rotterdam. Meer informatie: TV Rijnmond en Radio Rijnmond 95.4 FM. - char 173

D2-300 Risico, handeling en info
Alarm van burgemeester. Vuurwerkopslagloods in Oud-West Amsterdam geëxplodeerd. Meer explosiegevaar. Ook Amstelfabriek dreigt te ontploffen. Verlaat onmiddellijk Oud-West richting centrum. Ga te voet of met fiets. Niet met auto. Laat deuren en ramen open staan. Meer informatie: TV Oost en www.crisis.nl. – char 304

D2-460 Risico, handeling en info
Alarm van burgemeester. Explosiegevaar vliegtuig Zestienhoven blijft groot. Explosieven Opruimings Commando hervat opgraven bom uit Tweede Wereldoorlog. Bom kan elk moment ontploffen. Het is een zware bom, die in groot gebied schade kan veroorzaken. Omgeving tot 3 kilometer van vliegveld blijft afgezet. Als u nog in gebied bent, moet u dat NU verlaten. Meer informatie: TV Rijnmond en Radio Rijnmond 95.4 FM. Ook informatie op 0800-1351. – char 438

Appendix D

Messages sent in web-based experiment (phase 4d)

RA150
Alarm van burgemeester. Brand in chemische fabriek Cindu. Gevaarlijke chemische stof vrijgekomen. Ga direct naar binnen! Sluit deuren en ramen.

RA150
Alarm van burgemeester. Gevaar van terreuraanslag Rotterdam. In metrostation is man met bom gearresteerd. Ga niet in metro, tram, bus of trein! Ga weg uit stations.

RA150
Alarm van burgemeester. Gevaar voor gasexplosie op de markt in het centrum van Middelburg. Verlaat zo snel mogelijk te voet het centrum van de stad.

RA300
Alarm van burgemeester. om 10.30 uur tankwagen met benzine gekanteld op A12, afslag Zoetermeer-Centrum. Explosiegevaar. Blijf minimaal 1 kilometer bij afslag vandaan. Als u op snelweg bent, laat auto achter en loop weg. Bewoners binnen 1 kil ometer van afslag moeten huis verlaten.

RA300
Alarm van burgemeester. Chloorwolk op Mediapark. Inademen chloor is levensgevaarlijk. Aanwezigen op Mediapark moeten binnen blijven. Houd ramen en deuren dicht. Voor omwonenden: ga minimaal 2 kilometer bij Mediapark vandaan. Als dat niet kan, blijf dan binnen en houd ramen en deuren dicht.

RA300
Alarm van burgemeester. Er is gevaar voor een gas explosie in een woning aan de Beestenmarkt in Delft. Bent u op de Beestenmarkt, gaat u dan naar binnen, open de ramen en sluit de gordijnen tegen mogelijke glasscherven. Voor mensen in de buurt van de Beestenmarkt: blijf minimaal 2 straten uit de buurt.

RI150
Alarm van burgemeester. Door explosie in vrachtwagen op Moerdijkbrug is gevaarlijke stof vrijgekomen. Omvang gevaar nog onbekend. Meer informatie op www.crisis.nl.

RI150
Alarm van burgemeester. Een gifwolk trekt vanaf de Lekbrug bij Vianen richting Utrecht. Voor meer informatie kijkt u op www.crisis.nl.

RI150
Alarm van burgemeester. Sinds 14.30 uur lekt gevaarlijke stof uit wagon op Amersfoort CS. Meer informatie op www.crisis.nl en Radio Utrecht, 87.7 FM.

RI300
Alarm van burgemeester. In kerncentrale Borssele zijn om 15.05 uur drie explosies geweest. Oorzaak is nog niet duidelijk. Mogelijk komen radioactieve stoffen vrij. Wij houden u op de hoogte via nieuwe cb-berichten. Voor meer informatie: Radio Zeeland, 88,6 FM. en www.crisis.nl.

RI300
Alarm van burgemeester. In de Leeuwenhoekstraat in Laakkwartier houdt politie een huis omsingeld. Er zitten vermoedelijk terroristen in. Bewoners hebben gezien dat er een granaat werd gegooid. Wijk wordt afgezet door ME. Voor meer informatie: Radio West, 89,3 FM. En telefoonnummer 0800-1351.

RI300
Alarm van burgemeester. Over Eindhoven trekt een gifwolk. Mogelijk door explosie in vrachtwagen op A2/ A67 bij Afslag Waalre. Het gas stinkt naar rotte eieren. Het kan gevaarlijk zijn voor mensen met hartklachten. Meer informatie op Omroep Brabant radio, 94.1FM. Telefonische informatie via 0800-1351.

RAI150
Alarm van burgemeester. Grolsch-fabriek Enschede dreigt te exploderen. Verlaat omgeving onmiddellijk. TV Oost voor meer informatie.

RAI150
Alarm van burgemeester. Dreiging gas explosie in centrum Zeist. Ga direct ergens naar binnen. Open alle ramen en sluit gordijnen! TV-Utrecht voor meer informatie.

RAI150
Alarm van burgemeester. Explosie in metrostation Blaak. Verlaat lopend metrostation en centrum Rotterdam. Meer informatie: TV Rijnmond en Radio Rijnmond 95.4 FM.

RAI300
Alarm van burgemeester. Explosiegevaar bij Knorrfabriek Loosdrecht. Door brand dreigt fabrieksketel te ontploffen. Ga onmiddellijk weg uit omgeving fabriek. Ook omwonenden tot 2 kilometer van fabriek moeten direct weg. Waarschuw uw buren. Voor meer informatie: TV-Utrecht en Radio Hilversum, 92.2 FM.

RAI300
Alarm van burgemeester. Hoogste alarmfase gemeente. Door een gaslek bij DSM Geleen is er explosie gevaar. Levensgevaarlijk. Ga direct weg richting centrum. Blijf niet kijken. Laat ramen en deuren open staan. Voor meer informatie stemt u af op L1 radio of L1 TV teletekst pagina 112 en www.crisis.nl.

RAI300
Alarm van burgemeester. Vuurwerkopslagloods in Amsterdam Oud-West geexplodeerd. Meer explosiegevaar. Ook Amstelfabriek dreigt te ontploffen. Verlaat onmiddellijk Oud-West richting centrum. Ga te voet of met fiets. Niet met auto. Laat deuren en ramen open staan. Meer informatie: TV Oost en www.crisis.nl

Appendix E

Message components from the CAP protocol. See reference for full description (OASIS, 2005).

Alert

- alert
- identifier
- sender
- sent (time and date)
- status
- msgType
- source
- scope
- restriction
- addresses
- code
- note
- references
- incidents

Info

- info
- language
- category
- event
- responseType
- urgency
- severity
- certainty
- audience
- eventCode
- effective
- onset
- expires
- senderName
- headline
- description
- instruction
- web
- contact
- parameter

Resource

- resource
- resourceDesc
- mimeType
- size
- uri
- derefUri
- digest

Area

- area
- areaDesc
- polygon
- circle
- geocode
- altitude
- ceiling

Summary

Warning citizens
Influencing self-reliance in emergencies
Simone Sillem

As accidents will always happen, it is important to mitigate the consequences of these accidents. An important part of the response to an emergency is making sure that people are able to take themselves and others to a place of safety. This is called self-reliance. When there is an accident, it takes time before the rescue services arrive and within the first minutes, a fire (or another situation) may quickly become life threatening. This indicates the importance of peoples' self-reliance. To a large extent, the effectiveness of an evacuation depends on the self-reliance of the building occupants. To make people aware that there is an emergency and that immediate action is needed, they have to be warned by authorities (or by other people). Self-reliance can be increased when people are motivated to comply with instructions that are given in an emergency. Instructions can be given by a warning system to help people make a decision about what they should do to get to a safe place. When people respond quickly in an emergency and start acting immediately, the consequences of a disaster can be minimised.

There are many different ways in which people can be warned in an emergency. In the Netherlands, people are warned by the siren. The siren however, can only give a tone and no information about what is going on and what should be done. This indicates the need for alternative means of warning citizens. This thesis is about finding out what factors influence self-reliance in an emergency and how these influencing factors can be investigated so that the total effectiveness of a warning system on citizens' self-reliance can be determined. The research question is:

How can the way in which a new or existing warning system effectively influences citizens' self-reliance in an emergency be investigated?

The challenge of warning system effectiveness studies is to judge whether a warning system will be effective, whether it can actually improve self-reliant behaviour, and to do this in a scientifically valid and relevant way. There are three steps in warning citizens in an emergency that have to be taken before people can follow the instructions in that warn and get to a safe place: there has to be a warning that something is going on, people have to perceive and process that warning, and finally, people have to perform the self-reliant behaviour that will get them to a safe place. In each of these three steps, several issues have an influence on self-reliance.

The second chapter of this thesis focuses on the first sub question which deals with finding all steps in warning information processing in which self-reliance in an emergency can be influenced and finding or developing a model that shows all these steps. A literature study was doing using four criteria to judge the usefulness of the found models for the purpose of this thesis. Literature has been studied to determine what the steps are that have to be taken in warning information processing and to determine what factors within these steps can have an influence on self-reliance. Three main types of models were considered: evacuation models, fire or chemical exposure related models and warning process and human information processing models. All models discussed look at part of the process relevant in this thesis. Combining parts of the models discussed, a model was constructed in chapter 3 which shows the steps of warning information processing in which self-reliance can be influenced. This model is called the contextual human information processing model, as it shows the influences on self-reliance in terms of the interactions between cognition, affective states and situational variables. The model looks at issues inside (HIP, Personal characteristics and behaviour) and outside (situational characteristics and warning) the human. Each of the steps in the model is a necessary factor to investigate. The necessity of the individual factors in the contextual model is supported by literature sources. What factors need to be investigated depends on the warning system under investigation.

Not all factors and issues may be relevant for all warning systems. The examples and descriptions in chapter 5 try to cover how to determine what factors have to be investigated for a specific warning system. The model produces a list of influencing factors that have to be investigated when determing the effectiveness of a warning system.

Answering the second sub question ('how should the steps in warning information processing in which self-reliance in an emergency can be influenced be investigated') and third sub question ('what is the influence of each factor on citizens' self-reliance in an emergency') was done in chapter 5 by a methodological discussion followed by examples of performing this research as was done in two warning system effectiveness studies. Possibilities and impossibilities in researching each factor are discussed in that chapter. For each factor the ways to investigate this factor and the influence it has on citizens' self-reliance is discussed. It is not possible to give a short summary or general conclusion of that chapter here. What can be said here is that most difficulties in indicating how to research factors and what their influence on self-reliance is can be found in determining the actual behaviour that people will show. All steps before the actual behaviour takes place can be investigated with quite a good external validity, but when it comes to the actual execution of the desired self–reliant behaviour, the estimations become more imprecise. As people cannot be put in a real emergency because of ethical reasons, other ways of testing the influences of self-reliance have to be thought of. In some cases, to be able to make statements about certain influences on self-reliance, experiments have to be thought of that can simulate an emergency, either by making a task stressful by giving people other tasks to do during an experiment, or by causing distractions in the performance of a task. This will be an issue for further investigations.

This thesis does not show a complete validation of the model developed. It does however show an overview of what the methodological issues are that have to be taken into account and what the influences on self-reliance are for each factor, for as far as this can be determined. Together with the application chapter, the model forms a guide for investigating the (possible) effectiveness of warning systems. It does this by showing what factors are of influence on self-reliance, how to investigate these factors, and by showing what the results mean for the effectiveness of the whole model.

Of course not every factor has the same importance of being investigated when trying to obtain a complete view of the influences on self-reliance for the whole model. Some issues are more important to gain information on. The reach and non-reach give insight into how many people can be reached with the warning system. Without reaching people, a warning system is of no use. Research into the non-reach shows the problems there are with the warning system and can help determiner whether these problems are solvable. The understanding of the content of messages helps to determine what information people need in a warning message top make sure that they can make an informed decision about the danger they are in and what they should do to stay safe. This will greatly improve peoples' self-reliance. Finally, peoples' attitude towards a warning system will determine whether and how it will be used. This is a big condition to make a high reach possible. When one of these three issues fails, the chances of success for the warning system can be considered limited.

Samenvatting

Warning citizens
Influencing self-reliance in emergencies
Simone Sillem

Omdat er altijd ongevallen zullen blijven gebeuren, is het belangrijk de gevolgen van deze ongevallen zoveel mogelijk te beperken. Een belangrijk deel van de reactie op een noodsituatie is het zorgen dat mensen in staat zijn om zichzelf en anderen in veiligheid te brengen. Dit wordt zelfredzaamheid genoemd. Wanneer er sprake is van een ongeval, kost het altijd tijd voordat de hulpdiensten ter plaatse zijn en juist binnen die eerste minuten kan een brand (of een andere noodsituatie) kan een situatie al levensbedreigend worden. Dit geeft het belang van zelfredzaamheid. De effectiviteit van een evacuatie is voor een groot deel afhankelijk van de zelfredzaamheid van de mensen in een gebouw of gebied. Om mensen ervan bewust te maken dat er sprake is van een noodsituatie en dat zij direct actie moeten ondernemen, moeten zij eerst gewaarschuwd worden door de autoriteiten (of door andere mensen). De zelfredzaamheid kan verhoogd worden wanneer mensen gemotiveerd zijn om de instructies die worden gegeven in een noodsituatie op te volgen. Instructies kunnen door een alarmsysteem gegeven worden om mensen te helpen een beslissing te nemen over wat ze moeten doen om zichzelf in veiligheid te brengen. Als mensen snel reageren in een noodsituatie en direct actie ondernemen, kunnen de gevolgen van een ramp worden geminimaliseerd.

Er zijn veel verschillende manieren waarop mensen kunnen worden gewaarschuwd in geval van nood. In Nederland worden mensen gewaarschuwd door de sirene. De sirene geeft echter alleen een geluidssignaal en geen informatie over wat er aan de hand is en wat er gedaan moet worden. Dit geeft aan dat er aanvullende methoden nodig zijn om deze informatie wel te geven. Dit proefschrift gaat over het vinden van factoren die de zelfredzaamheid in een noodsituatie kunnen beïnvloeden en over hoe deze beïnvloedende factoren zo kunnen worden onderzocht dat de totale effectiviteit van de invloeden van een waarschuwingssysteem op de zelfredzaamheid kan worden bepaald. De onderzoeksvraag is:

Hoe kan de wijze waarop een nieuw of bestaand waarschuwingssysteem effectief de zelfredzaamheid van burgers in een noodsituatie beïnvloed worden onderzocht?

De uitdaging van onderzoek naar de effectiviteit van waarschuwingssysteem is om te beoordelen of een waarschuwing systeem in staat zal zijn de zelfredzaamheid te verbeteren, en om dit te doen op een wetenschappelijk valide en relevante wijze. Er zijn drie stappen in het waarschuwen van burgers in een noodsituatie die moeten worden genomen voordat mensen de instructies die gegeven wroden op kunnen volgen en zichzelf in veiligheid kunnen brengen: er moet een waarschuwing zijn dat er iets gaande is, mensen moeten deze waarschuwing kunnen waarnemen en verwerken en ten slotte moeten mensen zelfredzaam zijn en zichzelf in veiligheid brengen. In elk van deze drie stappen zijn er verschillende onderwerpen die van invloed zijn op de zelfredzaamheid.

Het tweede hoofdstuk van dit proefschrift richt zich op de eerste deelvraag die gat over het vinden van alle stappen in het verwerken van waarschuwingsinformatie waarbij zelfredzaamheid in een noodsituatie kan worden beïnvloed en het vinden of ontwikkelen van een model dat al deze stappen laat zien. Er is een literatuurstudie gedaan waarbij vier criteria gebruikt zijn om de bruikbaarheid van de gevonden modellen voor het doel van dit proefschrift te beoordelen. De literatuur is onderzocht om te bepalen wat de stappen zijn die genomen moeten worden om een waarschuwing te verwerken en om te bepalen welke factoren binnen deze stappen van invloed kunnen zijn op zelfredzaamheid. Drie typen modellen werden beschouwd: evacuatie modellen, modellen over brand of blootstelling aan chemische stoffen en modellen over het verwerken van (Waarschuwings)informatie. Alle besproken modellen werpen een blik op een deel van het proces dat relevant is voor dit proefschrift. Door delen

van verschillende besproken modellen te combineren is in hoofdstuk 3 een model geconstrueerd waarin de stappen van het verwerken van waarschuwingsinformatie waarbij de zelfredzaamheid kan worden beïnvloed zijn verwerkt. Dit model heet het contextuele informatieverwerkingsmodel omdat dit de invloeden op zelfredzaamheid in termen van de interacties tussen cognitie, affectieve toestanden en situationele variabelen beschrijft. Het model kijkt naar problemen binnen (informatieverwerking, persoonlijke kenmerken en gedrag) en buiten (situationele kenmerken en de waarschuwing) de mens. Elke stap in het model is een noodzakelijke factor om te onderzoeken als men een compleet overzicht van de invloeden op de zelfredzaamheid wil verkrijgen. Welke factoren onderzocht moeten worden is afhankelijk van het waarschuwingssysteem dat wordt onderzocht. Niet alle factoren en aspecten hoeven voor elk type waarschuwingssysteem van belang te zijn. De voorbeelden en beschrijvingen in hoofdstuk 5 proberen aan te geven hoe bepaald moet worden welke factoren onderzocht moeten worden voor een specifiek waarschuwingssysteem.

In hoofdstuk 5 worden de tweede ('hoe moeten de verschillende stappen van het verwerken van waarschuwingsinformatie waarbij zelfredzaamheid in een noodsituatie beïnvloedt kan worden, worden onderzocht') en derde deelvraag ('wat is de invloed van elke factor op de zelfredzaamheid van burgers in een noodsituatie') beantwoord door een methodologische discussie gevolgd door voorbeelden van het uitvoeren van het onderzoek dat gedaan is in de twee onderzoeken naar de effectiviteit van waarschuwingssystemen. Mogelijkheden en onmogelijkheden bij het onderzoeken van elke factor worden in dat hoofdstuk besproken. Voor elke factor wordt aangegeven op welke wijze deze factor onderzocht kan worden en wat de invloed is van de factor op de zelfredzaamheid van burgers wordt besproken. Het is niet mogelijk om hier een korte samenvatting of algemene conclusie van dat hoofdstuk te geven. Wat wel kan worden gezegd is dat de meeste problemen bij het aangeven hoe factoren onderzocht moeten worden en wat hun invloed op zelfredzaamheid is, te vinden zijn in het vaststellen van het feitelijke gedrag dat mensen laten zien. De meeste stappen die plaatsvinden voordat het feitelijke gedrag uitgevoerd moet worden, kunnen worden onderzocht met een hoge externe validiteit, maar als het gaat om de feitelijke uitvoering van het gewenste zelfredzame gedrag, worden de schattingen minder nauwkeurig. Om ethische redenen kunnen mensen niet in een situatie geplaats worden die echt gevaar voor hen oplevert. Daarom zal het gedrag van mensen naar aanleiding van een waarschuwingsbericht op andere wijzen onderzocht moeten worden. Om uitspraken te knnen doen over het invloeden op het daadwerkelijk gedrag van mensen na een waarschuwingsbericht, zouden experimenten opgezet kunnen worden die een noodsituatie simuleren, bijvoorbeeld door mensen een stressvolle taak te laten uitvoeren tijdens een experiment, of door voor afleiding tijdens het uitvoeren van een experiment te zorgen. Verder onderzoek zal aan moeten tonen of dit soort experimenten het gedrag van mensen in een noodsituatie beter zal benaderen.

Dit proefschrift geeft geen volledige validatie van het ontwikkelde model. Het toont echter wel een overzicht van wat de methodologische kwesties zijn die moeten worden onderzocht, en wat de invloeden op zelfredzaamheid zijn voor elke factor, voor zover dit kan worden bepaald. Samen met het toepassingshoofdstuk, vormt het model een leidraad voor het onderzoeken van de effectiviteit van waarschuwingssystemen. Het doet dit door te laten zien welke factoren van invloed zijn op zelfredzaamheid, hoe deze factoren onderzocht kunnen worden en door te laten zien wat de resultaten betekenen voor de effectiviteit over het gehele model.

Niet elke factor uit het model is even belangrijk om onderzocht te worden wanneer men een compleet beeld probeert te krijgen van de invloeden op de zelfredzaamheid voor het hele model. Het bereik en niet-bereik geven inzicht in hoeveel mensen bereikt kunnen worden met het waarschuwingssysteem. Zonder mensen te bereiken, een alarmsysteem is van geen enkel nut. Onderzoek naar het niet-bereiken geeft aan wat de problemen zijn met de waarschuwingssysteem en kan helpen om te bepalen of deze problemen op te lossen zijn. Het onderzoeken van het begrip van de inhoud van de berichten helpt bij het bepalen welke informatie mensen nodig hebben in een waarschuwing, om ervoor te zorgen dat zij een weloverwogen beslissing kunnen nemen over het gevaar dat ze lopen en wat ze moeten doen om veilig te blijven. Dit zal de zelfredzaamheid positief beïnvloeden. Ten slotte zal de houding van mensen ten opzichte van een alarmsysteem bepalen of en hoe het systeem zal

worden gebruikt. Dit is een belangrijke voorwaarde om een hoog bereik mogelijk te maken. Wanneer het waarschuwingssysteem op één van deze drie punten faalt, kan de kans op succes voor het waarschuwingssysteem als beperkt worden beschouwd.

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About the author

Simone Sillem was born on January 24th 1979 in Rotterdam, The Netherlands. After obtaining her high school (vwo) diploma from Libanon Lyceum in Rotterdam in 1997, she attended Leiden University and Utrecht University to study Psychology. She got her Masters degree in Psychonomy (specialisation Cognitive Ergonomics). She did the research for her Masters thesis at TNO Human Factors in Soesterberg where she investigated the colour blindness simulator that TNO developed. In September 2003 she started her PhD at Delft University of Technology, at the faculty of Technology, Policy and Management, where she was appointed to the Safety Science Group. From January 1st 2009, she is appointed as an assistant professor at the Safety Science Group.