SAFE

OR

SORRY?

THE PSYCHOLOGY OF DOMESTIC PREVENTION BEHAVIOR

PATTY JANSEN

Safe or Sorry?

The psychology of domestic prevention behavior

Patty Jansen

Cover design: Sima Ipakchian Askari
Cover image: © copyright Brandpreventiewinkel.nl
Printing: ProefschriftMaken || www.proefschriftmaken.nl

ISBN 978-94-6423-242-4

Safe or Sorry?

The psychology of domestic prevention behavior

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de Technische Universiteit Eindhoven, op gezag van de rector magnificus prof.dr.ir. F.P.T. Baaijens,
voor een commissie aangewezen door het College voor Promoties, in het openbaar te verdedigen op vrijdag 2 juli 2021 om 16:00 uur

door

Patty Cornelia Petronella Jansen

geboren te Eindhoven

Dit proefschrift is goedgekeurd door de promotoren en de samenstelling van de promotiecommissie is als volgt:

voorzitter:	prof.dr. W.N. Houkes
1e promotor:	prof.dr. C.C.P. Snijders
copromotor:	dr.ir. M.C. Willemsen
leden:	prof.dr. M. Siegrist (University of Zurich)
	prof.dr. R.A.C. Ruiter (Universiteit Maastricht)
	prof.dr. W.J.W. Botzen (Vrije Universiteit Amsterdam)
	prof.dr. C.J.H. Midden
	dr. J.M.P. Gevers

Het onderzoek of ontwerp dat in dit proefschrift wordt beschreven is uitgevoerd in overeenstemming met de TU/e Gedragscode Wetenschapsbeoefening.

CONTENTS

1

Introduction

1.1 Safety does not happen by accident

Meet Alice. Thirty-one years old, single and she recently bought her first house in a popular neighborhood. She feels safe and happy there. In this house, and in her previous house also, she never experienced any problems: no burglaries, no house fires, nothing. Except perhaps for one minor incident: her bike, which she had forgotten to lock, was stolen from her front yard. Alice does not really contemplate or worry about risks in her life. She feels she takes the necessary prevention measures to protect herself. She always locks the doors when she leaves her home, blows out burning candles before she goes to bed, and makes sure she locks her new bike, especially after her old one was stolen.

Although or perhaps because Alice feels safe, some important prevention measures are lacking. For instance, she does not have a smoke alarm, which is widely considered as one of the basic prevention measures one should have. Since safety does not happen by accident, we want to incite Alice into preventive action. How can we motivate her to buy a smoke alarm? And once she has bought a smoke alarm, will she also install the device and at the appropriate location? It is also necessary to regularly test a smoke alarm to guarantee continued protection. This information is provided in the manual, but would that be enough to set her into action? And although she always locks her door when she leaves home, if we would want to motivate Alice to also close the windows every time she leaves home and install anti-burglar strips for even better burglary protection, how could we do that? Can we use the same approach that we used for buying a smoke alarm, or should we use a different motivational approach for each separate behavior? Suppose we have six prevention behaviors that we want Alice to consider: buy a smoke alarm, install the alarm, test it regularly, close windows when leaving home, and buy and install anti-burglar strips. Might there be a way to motivate her to perform all six, for instance by changing her attitude about risks and prevention in general? That would be very efficient, but can we pull this off? Or would it be better to start with promoting one specific behavior and if so, which one?

1.2 The human factor in preventing domestic risks

People's behavior has a major influence on our level of safety. Many fires, burglaries, thefts, and traffic accidents could have been prevented, or at least their consequences would have been less severe, if people had acted in a safer way or if more prevention measures were taken. Think about fire prevention measures such as a functioning smoke alarm, an escape plan, or closing interior doors, all of which can mitigate the consequences of a domestic fire (Institute for Safety, 2020, 2018). Also, burglary prevention measures such as certified locks on doors and windows, locking doors and

closing windows, interior lights on a timer, and exterior sensor-lightening are shown to be effective in reducing the likelihood of a burglary (Farrell, Tseloni, & Tilley, 2016; Vollaard & Ours, 2011). Although people can take actions to protect themselves against domestic risks, people do not necessarily act in a safe way or take these prevention measures. For instance, most domestic fires with a fatal outcome are caused by human actions, such as carelessness when smoking or cooking, and functioning smoke alarms are not always present (Ahrens, 2019; Institute for Safety, 2015, 2018). Also, in the case of burglary prevention, people do not always appropriately protect their homes, which results in 'easy' access for burglars (CBS, 2020; Van den Handel, Nauta, van Soomeren, & Nelissen, 2009).

Given that the behavior of humans does not seem to be optimally geared towards home prevention, the common belief is that great effort should be made to encourage prevention behavior. Various institutions such as insurance companies, the police, fire department, housing corporations and, other (non)governmental organizations deal with the consequences of these risks every day, and these organizations spend a substantial amount of attention on initiatives directed at behavior change. However, behavior change in the domain of domestic prevention behavior is a challenge, since we are dealing with a small likelihood of a negative event happening, and the benefits of prevention behaviors or measures are not always clear. For instance, burglars shying away from your house because it is well-protected is typically something that goes unnoticed. Moreover, the benefits of prevention might arise in the future or maybe even never at all, while the costs (either time, money, or effort) have to be incurred now.

1.3 Explaining prevention behavior

Before we can change behavior, we must first understand it. To better understand the processes that underlie behavior change, we can consult behavioral theories from the field of applied social psychology. Before we dive into the theories used in this thesis to explain and change prevention behavior, we give a short (non-exhaustive) outline of regularly used behavior change theories (for a more comprehensive overview see: Hagger, Cameron, Hamilton, Hankonenm, & Lintunen, 2020). Many behavior change theories are based on the social cognition approach, which focuses on individual attitudes and beliefs as key determinants for intentions and behaviors. Examples of these theories are the Social Cognitive Theory (Bandura, 1986), the Theory of planned behavior (Ajzen, 1991), Protection Motivation Theory (Rogers, 1975), and the Health Belief Model (Rosenstock, 1966). While in these theories 'intention' is often the end goal, intentions do not always result in the desired behavior (referred to as the "intention-behavior gap"). The so called "dual phase" theories address this gap by distinguishing a motivational phase and a volitional phase where intentions are put into action. Examples of these theories

are the Model of Action Phase (Heckhausen & Gollwitzer, 1987) and the Health Action Process Approach (Schwarzer, 2008). A theory that distinguishes five stages of change that people go through is the Transtheoretical Model, which facilitates the development of personalized interventions that target the specific stage someone is in (Prochaska & Di Clemente, 1982). Another line of emerging theories are the "dual processing theories" that argue that behavior is not only the consequence of a cognitive and deliberative process, but also of a more impulsive and unconscious process (Kahneman, 2011). Finally, another well-known approach that targets this unconscious process is "nudging", which refers to changing the choice architecture in such a way that people automatically and unconsciously change their behavior in the desired direction (Thaler & Sunstein, 2008).

Whereas most theories are general in the sense that they are supposed to apply to any kind of behavior, the Protection Motivation Theory (PMT) and the Health Belief Model (HBM) are two frameworks that are developed specifically to explain risk prevention intentions and behaviors. Both theories were originally developed for the purpose of explaining health related behaviors, but both have also been applied to other domains such as occupational injury and environmental risk. In this thesis we consult HBM and PMT for the explanation of domestic prevention behavior, instead of a more general theory of behavior change, anticipating that PMT and HBM themselves are tailor-made versions of these more general theories for the risk domain. PMT and HBM provide a systematic approach that includes a detailed analysis of the specific risk and the accompanying coping behavior. In the more general theories, such as for instance the Theory of Planned Behavior (TPB), specific details about the risk and the behavior are missing since attitudes are necessarily formulated on a more general level: the extent to which people have a favorable or unfavorable stance towards the target behavior. This however provides little information about the specific motives and barriers to engage in a behavior or not, which is necessary for the development of effective behavior change interventions. Although we still feel the initial focus on PMT and HBM is defendable and appropriate, we shall see that the subjective norm as mentioned in TPB (that is, the perception of what others do and think of the behavior) would in fact be a valuable addition to HBM/PMT, as we will see in chapter 5.

According to PMT and HBM, the likelihood of taking preventive action depends on several factors (referred to as "determinants" in this thesis). First, for someone to be motivated to take preventive action, someone must feel that there is a probability of being exposed to a certain risk (*perceived vulnerability*) that is paired with negative consequences that one wants to avoid *(perceived severity).* Second, an evaluation of the recommended behavior is made. Someone must perceive the behavior as effective in reducing the likelihood or severity of the risk *(response efficacy* or *perceived benefits)* and the financial and behavioral costs, for instance the effort needed or complexity, that are accompanying the behavior

should not be too high *(response costs* or *perceived barriers)*. Also, someone must have the belief that he or she can successfully perform the recommended prevention behavior *(self-efficacy).*

How these determinants are often used to explain and promote prevention behavior is explained in the following example. To make people aware of fire prevention behaviors and to promote these behaviors, the Fire Department decided to send out flyers. Alice received one of these flyers. She read that 1 in 65 households had dealt with a home fire in a year, of which most home fires were caused by smoking, cooking, and electrical appliances. The flyer explained that if a fire occurs, especially the smoke that you inhale is very dangerous for your health and that, in general, you will only have three minutes to escape your home. Although Alice never experienced a fire before and did not know anyone who did, this message scared her a bit. The flyer recommended various behaviors she could take such as: charge electronic devices with the original charger, do not charge them at night and unplug these devices when fully charged, formulate and practice an escape plan, and invest in measures such as a smoke alarm, a heat detector, and a fire extinguisher and also maintain them. After reading this flyer, Alice decided to only use the original charger for her smartphone, to not charge it anymore while sleeping, and to unplug it on time. She did not adopt any of the other prevention measures though.

According to both PMT and HBM, Alice's noncompliance with the other prevention behaviors can be explained because although there were some motivational factors addressed, there were still some barriers that inhibited her to take more action. Alice was motivated to perform some prevention behaviors because, after reading the flyer, she felt more vulnerable to fire and realized a fire was very severe. She adopted the behaviors concerning smartphone charging because she was convinced about the need of these behaviors in reducing the likelihood of a home fire, given the frequency of home fires caused by electrical appliances and the fact that she charges her smartphone daily. She also thought that these behaviors involved low financial and behavioral costs, and she knew she could perform them. However, Alice's perception of the other behaviors did not change enough to set her into action. Following these theories, better addressing these determinants (effectiveness, costs, self-efficacy) for the other behaviors, would increase the likelihood of Alice's compliance with the advised prevention behaviors.

1.4 Contribution of this thesis

Although these prevention behavior theories offer a useful framework to understand what drives people to take preventive action and offer guidance for behavior change, in this thesis we show that there are some issues that are neglected in the literature and need more attention for a better understanding of people's prevention behavior.

Alice's example is meant as an easy introduction into which issues are neglected or understudied:

I. There are different domestic risks for which someone can take prevention measures, and one can question whether people are consistent in their behavior across these different risks. Alice performs only a few fire prevention behaviors, does this imply she scores low on burglary prevention too? One can also question whether people are consistent in their behavior across different types of behaviors. We know that Alice always locks the doors when she leaves her home and checks for burning candles before she goes to bed. These are behaviors that involve no financial investment but need to be performed regularly. Does this mean she prefers these types of behaviors, and takes no or fewer prevention measures that require an investment? These issues have not been addressed in prevention literature before, since usually studies consider one specific risk and do not distinguish between different types of behaviors.

II. Individuals and prevention behaviors can differ. One can imagine that some individuals are more inclined to take prevention measures than others, and that some behaviors are more frequently performed than others. This might have implications for which behaviors we should advise to whom. For instance, Alice can be considered as someone not very likely to perform prevention behaviors in general. It would probably be easier to motivate Alice to buy a smoke alarm (a behavior frequently performed by many) than to let her formulate and practice a fire escape plan (which is rare behavior in any case).

III. Prevention behavior can be explained from two perspectives. The first is the perspective of the behavior itself, that is, why are some behaviors more often performed than others. The second is that of the individual, that is, why do some individuals perform more behaviors than others. This distinction has not been explicitly addressed in PMT or HBM, while it does have implications for behavior change attempts. When Jim, a friend of Alice, received the flyer of the Fire Department, he took almost all the advised prevention measures while Alice took only the behaviors related to smartphone charging. Why would that be? Perhaps (1) Jim's perception of fire and of all of the advised behaviors changed into the desired direction, or (2) Jim has a different outlook on risks and prevention behaviors in general than Alice, and the flyer prompted his generally more positive attitude towards prevention.

IV. The current prevention theories offer a framework for behavioral change, implying that desired changes in the prevention behavior determinants will result in a higher likelihood of adopting the recommended prevention behavior. One can of course question whether all prevention behaviors are affected by these determinants in

the same way, and hence, whether a change in one or some of these determinants necessarily results in a behavior change. If we want to motivate Alice to buy a smoke alarm, would it be enough if we increase her perceived vulnerability and severity of fire, together with the perceived effectiveness of a smoke alarm? Or should we also decrease the perceived response costs and increase her self-efficacy? And if so, should we reduce costs by giving a discount? Should we increase self-efficacy by recommending the most appropriate smoke alarm, or by offering a free-installation service? It could even be that other determinants are of importance here, such as social norms.

The aim of this thesis is to gain a better understanding of domestic prevention behavior. Our studies focus on domestic risk prevention, which includes prevention behaviors to protect oneself from the risks of fire, burglary, and water damage. In the paragraphs 1.5 - 1.7 we clarify the main issues that we address in this thesis in more detail and connect these to the academic literature.

1.5 Do all different domestic prevention behaviors stem from one underlying disposition?

To protect oneself and one's home and belongings, there is a range of prevention behaviors someone can perform, that can differ on various characteristics. We can distinguish prevention behaviors based on the type of risk, that is, take prevention measures to protect oneself for the risk of fire, burglary, or water damage as a result of leakage. Another distinction that can be made, as is typical in the energy domain, is based on the financial costs and frequency of performance and conceptualized as *efficiency behaviors* versus *curtailment behaviors* (Gardner & Stern, 2008; Karlin et al., 2012). Efficiency behaviors need a onetime investment, such as investing in an energy-efficient washing machine, or in the case of domestic risk prevention, investing in an alarm system. Curtailment behaviors usually involve no or low financial costs, but must be performed on a regular basis, such as switching off the lights every time you leave the room, or in the case of domestic risk prevention, lock the doors every time you leave your home. Given the fact that prevention behaviors can differ based on the risk it relates to or the type of behavior, one can ask himself if someone's prevention behavior in one category also says something about another category.

For instance, if we know that Alice only takes a few prevention measures to protect herself from burglary and fire, can we predict how much, and maybe even which measures she takes concerning water leakage? Her friend Jim takes almost all the advised prevention measures to protect himself against fire. How likely is it that he will also take many prevention measures concerning burglary and water leakage? Or, if we know Jim has

an expensive alarm system, how likely is it that he also switches on the exterior lights in the evening, and locks doors and closes windows every time he leaves his house? If people are consistent in their behavior across different risks and different types of behaviors gives an indication for the existence of an underlying general disposition (e.g. "domestic risk prevention"). Then Alice would have a low general disposition towards domestic risk prevention, and Jim would have a high general disposition.

The idea that a multitude of behaviors to prevent different domestic risks stem from the same underlying general disposition seems intuitively plausible. This idea, however, is not yet studied in the risk prevention literature, perhaps because most often one specific risk is studied and no distinction between different types of behaviors is made. In other multifaceted domains (e.g. energy, health, and ecology) this assumption of a general disposition has been tested before. For instance, a study concerning environmental behaviors showed that behaviors stemming from six different subdomains, that included both investment behaviors (e.g. solar panels) and curtailment behaviors (e.g. collect and recycle paper), all could be plotted on a one-dimensional scale, with the common underlying goal of environmental protection (Kaiser, Hartig, Brugger, & Duvier, 2011). The assumption of a general disposition can and has been tested by performing Rasch analysis on a multitude of behavioral self-reports (Bond & Fox, 2006). We explain this procedure by considering a "pyramid" of environmental behaviors. At the bottom of the pyramid the behaviors are positioned that are done by most people (e.g. reuse shopping bags), in the middle section of the pyramid the behaviors are positioned that are performed by approximately half of the people (e.g. use public transportation), and at the top of the pyramid the behaviors are performed that are only performed by a few very environmental-friendly people (e.g. do not own a car, use renewable energy sources). The individuals are likewise ordered on the basis of the number of behaviors they perform, which reflects their general disposition, or attitude, towards a specific goal. If this "pyramid model" of behaviors holds, then someone who performs the behaviors at the top, will most likely also perform the behaviors that are positioned in the middle and at the bottom of the pyramid. This would have several implications. First, we could determine someone's position in this "prevention pyramid" and accordingly advise targeted prevention behaviors, as has been done in the energy domain (Starke et al., 2020; Starke, Willemsen, & Snijders, 2017). One can imagine that suggesting an alarm system or practicing a fire escape plan to Alice, who does not even have a smoke alarm installed, would not be a very effective strategy. While behaviors such as informing the neighbors when she goes on holiday or regularly cleaning the dust filter of the dryer would better match with her safety attitude. Second, if we have information about someone's performance in one subdomain, for example we know which burglary prevention behaviors someone takes, we can predict which behaviors someone is most likely to perform in another subdomain (e.g. water leakage, fire). Third, the existence

of a general disposition opens perspectives to think about the possibility of influencing people's general disposition towards all domestic risks and prevention behaviors, so that someone will be motivated to take more prevention measures overall.

1.6 Explaining differences between persons and differences between behaviors

Not surprisingly, there are some prevention behaviors that are more popular than others, and there are individuals that perform more prevention behaviors than others (e.g. Lindell & Prater, 2002; Lindell & Whitney, 2000). For an explanation of why this is, we can for instance consult the determinants as described in PMT and HBM: perceived vulnerability, perceived severity, response efficacy, response costs, and self-efficacy. However, these theories do not make explicit claims about whether these determinants relate to differences between individuals (i.e. explain why some individuals perform more behaviors than others) or to differences between behaviors (i.e. explain why some behaviors are more often performed than others). It makes a difference whether the effects primarily run "within-persons" or "between-persons" and this has implications for how to influence people.

We explain this confusing difference by means of Alice's example. Alice decided from now on to only use the original charger of her smartphone, to not charge it anymore while sleeping, and to unplug it on time, because after she received the flyer she felt more vulnerable to fire, realized how severe a home fire can be, and of all behaviors she could perform, she perceived these as the most effective ones. So, Alice's perception of fire changed while the perception of other risks remained equal, and her perception of the safe charging behaviors changed while her perception of the other behaviors remained equal. In this case the characteristics of the behaviors as perceived by Alice were influenced. This explanation can be referred to as a "within-person effect" (Blalock, 1984; Enders & Tofighi, 2007) and potentially explains why some behaviors are more often performed than others. A different explanation would consider why some individuals perform more behaviors than other individuals. This is referred to as a "between-person effect". Such an explanation could run like this: Jim performs more prevention behaviors than Alice, because he has a different perception of risks and prevention behaviors in general. In this case the characteristics of both individuals differ. Jim perceives himself as very vulnerable (more than Alice) to the risks of fire, burglary, and water leakage and perceives all these risks as very severe (more than Alice). He is convinced about the effectiveness about almost all prevention behaviors, and because he is quite handy, he has a high perceived level of self-efficacy concerning all behaviors and does not perceive the performance of these behaviors as effortful (while Alice does not find all behaviors effective, effortless, and does not have a high general level of self-efficacy). When he received the flyer of the

Fire Department, some of the "basic" behaviors were not applicable to him because he already performed those, but he decided to adopt all of the behaviors he did not perform yet such as formulating and practicing an escape plan and buying a fire extinguisher. If Jim had received a flyer of the Police Department, suggesting a range of burglary prevention measures, he probably also would have adopted those recommendations, since Jim is more susceptible to prevention advice in general.

This example shows that besides influencing people's perception about one specific risk and corresponding behavior(s), it might be fruitful to change people's perception of all domestic risks and behaviors, so that people will be motivated to take more prevention measures in general.

1.7 Influencing domestic prevention behavior

In this thesis we also look at possible ways to increase prevention behavior. Our approach is to make an inventory of possibly relevant determinants that drive prevention behavior and address those in an intervention directed at behavior change. We then measure the effects of our interventions on observed behavior.

1.7.1 Influencing by simulating a risk experience in an IVE

One of the reasons why people are not motivated to engage in preventive behaviors is that "people tend to think they are invulnerable" (Weinstein, 1980, p. 806). People underestimate the likelihood of negative events happening to them such as being involved in a car accident, but also overestimate positive events such as success in the job market. The ruling thought is not that negative events won't happen, but that they won't happen to them (McKenna, 1993). This idea, referred to as *unrealistic optimism* or *optimism bias*, can be explained by people's perceived personal control over a situation (Weinstein, 1980). This tendency to underestimate risks has positive consequences for people as it reduces stress and anxiety and allows them to focus on the 'more important' things in life (Sharot, 2011). The downside is that it can result in more risky behaviors or might inhibit people from engaging in prevention behaviors (Weinstein, 1980). This optimism bias is often maintained because, luckily, often nothing bad happens. For instance, the probability of being confronted with a burglary in 2019 in the Netherlands was estimated at 1.7% (CBS, 2020). Studies showed that when people did experience a negative event such as a burglary, earthquake, or flood, they were more inclined to take prevention measures, because of an increased perceived vulnerability and feelings of worries (Siegrist & Gutscher, 2008; Weinstein, 1989; Zaalberg, Midden, Meijnders, & McCalley, 2009).

Obviously, we do not want to confront people with real negative experiences to stimulate prevention behavior. A potential solution can be the simulation of a risk experience in an Immersive Virtual Environment (IVE), also known as Virtual Reality (VR), as people often react to virtual experiences as if they were real (Fogg, 2003). Another benefit of risk simulation in an IVE is that the causal link between cause and effect can be made very clear, emphasizing the effectiveness of prevention behavior in controlling that risk.

Studies on the effects of simulated risk experiences (e.g. concerning flood, terrorism, aircraft evacuation) in IVE's have shown effects on important psychological determinants of behavior in the desired direction. While these effects give promising indications for behavior change, often the ultimate goal of actually influencing behavior remains untested. For instance, Chittaro (2016) has shown that a 3D serious game in which an aviation emergency landing was simulated, increased knowledge about safety procedures, increased feelings of self-efficacy, and made participants feel more in control when confronted with an emergency landing. However, one can wonder whether these desired changes in attitudes and feelings will result in the desired behavior change. Evidently, studying real behavior is not always that easy, especially if it concerns behaviors that can only be observed in high-risk situations such as an airplane evacuation.

We will show that studying both determinants and target behaviors gives more insight in the effect of an intervention on one or more behavior(s) and in the causal mechanisms that underlie these behavior(s). One can for instance imagine that people who experienced the evacuation game do not necessarily perform the safety procedures better when confronted with a 'real' evacuation situation than people who did not experience this game, but it might be that they are more likely to read the safety card next time they are in an airplane because of increased feelings of control and self-efficacy. For this reason, we study the effects of experiencing a virtual fire on two different behaviors and study the mediating effects of relevant determinants.

1.7.2 Influencing by first performing a thorough problem analysis

In the previous paragraph, we explored the idea of influencing behavior through the simulation of a risk by influencing relevant determinants such as risk perception. In this paragraph, we take another perspective: changing behavior by first defining the target behavior and all its potentially relevant determinants. To illustrate this point, we use the case of fire prevention behavior.

One way to protect oneself against severe fire consequences that receives a lot of attention are smoke alarms. Although this is a primary prevention measure in the case of

fire, still about 3% - 30% of the households does not own a smoke alarm[1], and if people do own one, about a quarter to one-third of the alarms does not appear to function properly, most often because of empty or missing batteries (Ahrens, 2019; Institute for Safety, 2015; Parmer et al., 2006). Although positive results to increase smoke alarm ownership have been reached with free-give-away programs (e.g. Jones, Thompson, & Davis, 2001; Omaki et al., 2018), there are also studies that show that even free smoke alarms are often not installed or maintained and that even free coupons for smoke alarms are often not exchanged (Diguiseppi et al., 2002; Ginnelly et al., 2005; Harvey et al., 2004; Jackson et al., 2010). A problem with these, but also with other fire prevention interventions, is that they are rarely based on a comprehensive problem analysis that includes behavior change theories (Eysink Smeets, Heijman, & Postma, 2016; Gielen & Sleet, 2003; Thompson, Waterman, & Sleet, 2004). Therefore, behavioral barriers that inhibit people to install, maintain or collect their smoke alarms are not appropriately addressed. Furthermore, while increasing the number of functioning smoke alarms at first sight might sound as aiming for just one target behavior, when looking more precisely, this involves different sequential behaviors. A smoke alarm needs to be bought, properly installed, regularly tested, sometimes dusted, and batteries need to be changed. All behaviors are necessary to end up with a functioning smoke alarm, but if someone is motivated to take one action, this does not necessarily imply someone takes all other necessary steps. All different steps need to be recognized, and motivations and barriers for each separate step need to be addressed.

Alice took the first step of adopting behaviors to safely charge her smartphone to reduce the likelihood of a fire. However, she also needs protection if, accidentally, a fire occurs. How can we stimulate her to buy a smoke alarm? After receiving the flyer of the Fire Department, she did feel more *vulnerable* to fire and realized the *severity* of a fire. Yet, this was not enough to motivate her to buy a smoke alarm. It might be that she is not convinced about the *effectiveness* of a smoke alarm, and we should perhaps make the benefits of a smoke alarm more explicit. Or maybe she perceives the financial *costs* as too high and a discount would work. Or maybe we should aim at increasing her level of *self-efficacy*. But what should we then actually address: her competency to buy the appropriate alarm, or her competency to correctly install an alarm? One can also wonder whether it is necessary to address all these factors, or would it be enough to address just one that will spark the desired action instantly? Moreover, it might be that other determinants than the ones prescribed by PMT/HBM matter in this case. Perhaps Alice finds a smoke alarm on her ceiling ugly, or is afraid that she will ruin her ceiling by drilling, or she is afraid that the smoke alarm will go off accidentally when she is not

1 In the Netherlands about 70% of the households reported to own (at least) one smoke alarm (Institute for Safety, 2015). In the U.S. 96 - 97% of households reported to own (at least) one smoke alarm. Of the U.S. households that experienced a home fire 76% reported to have a smoke alarm (Ahrens, 2019).

home and that will be annoying for her cat, or she has a smoke alarm on her to-do list for months but simply keeps on forgetting it. To attain that Alice buys a smoke alarm, we need to know exactly what motivates her and holds her back so these factors can be effectively addressed.

To increase prevention behavior, it is necessary to determine the specific target behavior, determine all potentially relevant determinants for this behavior, analyze which specific determinants influence this specific behavior, and address the relevant determinants in an intervention. In this thesis we run through this process for the specific behavior of smoke alarm ownership.

1.8 Thesis outline

This thesis addresses some relevant issues that, to our knowledge, have not been discussed in the existing prevention behavior literature. More insight into these issues leads to an improved understanding of domestic prevention behavior and can consequently result in designing better interventions for behavior change. For this aim a variety of methodologies are used, including theory review and integration, between- and within-subject experiments, survey research, and various statistical methods (e.g. Rasch analysis, multi-level regression analysis, Structural Equation Modelling). The work to fulfill our objective is reported in chapters 2 – 5.

In chapter 2 we test whether a diverse range of prevention behavior self-reports, that relate to different risks and that include different types of behaviors, form a one-dimensional scale. We test this by applying Campbell's paradigm using the Rasch model on survey data (n = 3,700). Our results show that all the prevention behavior self-reports can be plotted on a one-dimensional scale, when ranking individuals based on their prevention performance and ranking behaviors based on their prevalence. This is consistent with the idea of a general disposition towards domestic prevention behavior, of which some people have a higher general disposition than others.

In chapter 3 we apply the determinants of PMT/HBM to the context of domestic risk prevention behavior. More importantly, we test whether these determinants relate (more) to differences between persons or to differences between behaviors within persons. To test this, we designed a multi-level survey study (n = 263) in which between-person effects and within-person effects can be disentangled. Our results show that all determinants are relevant predictors for domestic risk prevention behavior, and that distinguishing within- and between-person effects explains the performance of prevention behavior in much greater detail.

In chapter 4 we study whether we can stimulate fire prevention behavior by the experience of a fire in an immersive virtual environment (IVE) in a between-subjects experiment (n = 242). We analyze the effects of experiencing a fire in an IVE (versus an information sheet) on psychological determinants of behavior, based mainly on arguments from PMT and HBM, and relate these determinants to actual prevention behavior. Our results show that although the IVE has the desired effects on the psychological determinants, these effects do not necessarily result in a change in behavior. Furthermore, our study shows that the two studied prevention behaviors were driven by different determinants.

In chapter 5 we aim to increase smoke alarm ownership by conducting a comprehensive problem analysis. We make an inventory of all potentially relevant determinants for smoke alarm ownership, making use of determinants from PMT and HBM but also including other possibly relevant variables such as social norms. We test the relationships of these determinants with smoke alarm ownership and intention of ownership using (logistic) regression analysis on survey data (n = 621). Results show that the determinants that drive smoke alarm ownership and intention are different from the determinants that are typically expected. Based on these results we developed two messages: one focused on these typically used determinants and one focused on the determinants we found to be strong predictors in the survey. We test the effects in a between-subjects field experiment with a control group, in which the target behavior was the order of a smoke alarm. Taken together, this study shows that conducting a comprehensive problem analysis for a specific target behavior can help us to better understand people's specific motivations and barriers, which gives a promising direction for developing interventions to increase smoke alarm ownership.

Chapter 6 provides an integrative view of the findings of the studies that were included in this thesis. We discuss the importance and implications of these studies for motivating Alice, and people in general, to take more prevention measures. In addition, implications for future research will be discussed.

Note

All chapters in this thesis are individual chapters that are submitted or published as journal papers. Therefore, all chapters can be read individually and in any order. This causes that introductions of different chapters sometimes have overlapping parts and terminology throughout the chapters can slightly differ.

2

Prevention performance through behavioral self-reports: an application of the one-dimensional Rasch model

2.1 Introduction

In 2013, insurers in the Netherlands paid out 8 billion euros in damage (Verbond van Verzekeraars, 2014b). There were, amongst others, 87,480 burglary related claims, which implies that one in every 95 homes was confronted with burglary (Verbond van Verzekeraars, 2014a). For fires, this number is even higher: 115,000 claims, which implies that one in every 65 homes was confronted with a fire (Verbond van Verzekeraars, 2015). From all advanced insurance markets in the world the Netherlands spends the most money per capita on non-life insurance (Swiss Re Institute, 2018). However, insurance does not take away the adverse consequences of occurrences. Prevention behaviors such as locking the doors when you leave the house or installing a smoke alarm do prevent risks or prevent them from getting more severe. Hence, with preventing more adverse occurrences, not only insurance premiums can go down, but losses and their associated emotions can be avoided. Therefore, it is relevant to research how to stimulate prevention behavior. Before we can stimulate this behavior, we must first better understand the underlying mechanisms that drive prevention behavior, and we start by measuring prevention performance. However, a generic scale to measure prevention behavior across domains (e.g. burglary, fire) does not yet exist.

Studies on prevention behavior that cross domains treat these domains often as separate factors. The underlying logic is that those who score high on, say, fire prevention are less likely to experience a fire. Instead, we analyze whether prevention behaviors from different risk domains can be mapped on a one-dimensional scale. The underlying logic here is that those who score high on fire prevention might not only be the ones who are less likely to experience a fire, but also the ones who are less likely to experience a burglary.

First, we consider how previous studies have measured prevention performance. Second, we considered studies in other similar domains that have successfully developed one-dimensional models. Then, we investigate to what extent we can create such a one-dimensional scale to measure prevention performance and investigate properties of the scale such as its robustness and the minimal number of items needed. Finally, we discuss how to interpret the finding of a one-dimensional scale for the measurement of prevention performance and its implications.

2.2 Theory and hypotheses

2.2.1 Prevention performance: a one-dimensional or a multi-dimensional scale?

Many, if not most, prevention related studies focus on a single aspect of prevention behavior, for example seat belt use (Bhat, Beck, Bergen, & Kresnow, 2015), or the presence of smoke alarms and fire escape planning (Harvey, Sacks, Ryan, & Bender, 1994). In studies that do cover multiple safety behaviors, measurement scales are typically restricted to a single domain such as work safety (e.g. Nielsen, Hystad, & Eid, 2016) or safe driving behavior (e.g. Newnam, Mamo, & Tulu, 2014). In fact, even within specific domains, for instance in studies on home safety, the measurement items in questionnaires are often analyzed separately without creating an index or scale score to represent an overall prevention performance for that specific domain (e.g. Kendrick et al., 2013; Robertson, Rivara, Ebel, Lymp, & Christakis, 2005).

Only a couple of studies on prevention behavior have crossed domains. In these cases, researchers typically consider prevention performance to consist of multiple factors: either one factor per domain or factors based on other a priori considerations. For instance Lund and Hovden (2003) distinguished two factors while studying safety behavior at home and during leisure time (primarily focusing on fire risks and transport accidents): safety behavior and emergency preparedness behavior. Safety behaviors are recommended behaviors to avoid an accident, such as keeping within the speed limit. Emergency preparedness behaviors are behaviors that reduce the consequences of a crisis, such as having prepared a first aid kid or having a fire extinguisher available. Although these two factors are obviously different from a theoretical perspective, the empirical support for a distinction between them is limited. In the three studies that Lund and Hovden performed, the reliability of the safe behavior items is sufficient but not high (between $\alpha = 0.60$ and $\alpha = 0.69$) and the same held for emergency preparedness behavior (between $\alpha = 0.57$ and $\alpha = 0.66$). Furthermore, no factor analyses were performed to explore the existence of other factors or to check for one-dimensionality.

In this respect, an interesting study was conducted by Blair, Seo, Torabi, and Kaldahl (2004). They did perform factor analysis to explore the existence of different underlying dimensions of safety related behavior (as part of a larger study on safety behavior and safety beliefs). Using a questionnaire developed by Crowe (1995) that included safety behaviors from multiple domains, Blair et al. (2004) identified four subscales for the safe behavior scale: (1) personal protective equipment or personal safety precaution, (2) seatbelt use or drinking and driving, (3) safe driving practices and (4) home safety practices. Nevertheless, in the remainder of their paper they combined the total scores on

these subscales into a single 'safe behavior' score, implicitly suggesting that this combined score can function as a unidimensional construct of safety-related behavior.

The idea that behaviors to prevent a burglary from happening and behaviors to prevent a fire stem from the same general disposition ("prevent risks/be safe") seems legitimate. A single scale that crosses several (or all) prevention domains would obviously allow us to use someone's prevention performance in a specific subdomain (say, fire prevention) to assess a disposition to prevention behavior in this particular domain. More importantly, given suitably chosen measurement items, it would also allow us to assess someone's prevention performance in another subdomain (say, burglary). Though previous research in the prevention domain has hardly considered this possibility, in other similarly complex multifaceted domains such one-dimensional scales have been developed successfully. Kaiser (1998) developed a one-dimensional scale in the ecological domain that consists, as does the prevention domain, of a multitude of behaviors and different subdomains. Kaiser (1998) argued that there were two measurement problems in the ecological domain: the fact that behaviors vary according to how easily they are performed and the fact that situational conditions can influence the difficulty level of the behaviors. The solution for this problem is found in what is generally referred to as "Campbell's paradigm"[2] (Kaiser, Byrka, & Hartig, 2010). The basic idea of this paradigm is that one can rank order behaviors (based on behavioral self-reports) according to their prevalence and can likewise order individuals according to their disposition to perform certain behaviors. For example, to prevent burglary many people will lock their doors when they leave their home, but only few people own an alarm system. In the literature the prevalence of behaviors is often referred to as the "difficulty" of the behaviors. In the remainder of this paper we will likewise use the term "difficulty" for behaviors, even though the term itself can also refer to for instance how expensive a given behavior is, how time-consuming it is, or how much effort is involved (as opposed to being literally difficult to carry out). The higher the general disposition of someone towards a domain, the more obstacles someone will be willing and able to overcome to perform specific behaviors that contribute to this domain. In terms of our prevention behavior domain, someone with a strong general disposition towards the prevention domain is likely to perform both more and more difficult behaviors than someone with a weaker general disposition towards prevention. The aim is to find behaviors so that the difficulty of the specific behaviors is roughly equal for everyone, so that the

2 Campbell's paradigm builds on earlier work of Campbell (1963) that aimed to explain the attitude-behavior gap. Campbell argued that both verbal declarations and actions stem from the same underlying disposition. However, in order to perform an action someone must overcome more situational thresholds compared to with verbal declarations. Consequently, consistency is found when taking the accompanying thresholds into account. Multiple studies in the health- and environmental domain provide empirical support for the consistency between general attitudes, verbal declarations and actual behaviors (Byrka, 2009; Kaiser, Byrka, & Hartig, 2010; Kaiser, Hartig, Brugger, & Duvier, 2011). Consequently, someone's general disposition towards the health- and environmental domain can be measured with behavioral self-reports and is also referred to as a "behavior-based disposition".

behaviors can be transitively ranked. Ultimately, the question is whether this assumption of a specific transitive order of the behaviors can indeed be used to define the general disposition (Byrka & Kaiser, 2012).

Campbell's paradigm can be empirically measured using the "Rasch model", which is one specific psychometric flavor of item-response theory (Baker, 2001). Studies in the area of traffic safety and occupational health and safety performance in organizations using this approach have indeed shown that behaviors could be mapped on a one-dimensional scale and that the behaviors could be (transitively) ordered from easy to more difficult (Davis, Conlon, Ownsworth, & Morrissey, 2016; Kay, Bundy, Clemson, & Jolly, 2008; Shea, De Cieri, Donohue, Cooper, & Sheehan, 2016). In the domain of ecological behavior this transitive ordering of behaviors was also found, and furthermore all ecological self-reports from seven substantively different subscales appeared to fall on a one-dimensional scale when accounting for the varying difficulty levels of the behaviors (Kaiser, 1998). In such a setup collecting and recycling used paper falls on the same scale as not using chemical toilet cleaners; the only difference is that the latter behavior is harder to perform and in that sense on the far end of the scale. Byrka and Kaiser (2012) later showed, using the same analytical setup, that health-related behaviors across subdomains (sustenance, hygiene, stress recovery, risk prevention, and physical exercise) can also be understood to fall on one general health performance scale.

Since the prevention domain is similar to the ecological and health domain in that it includes multiple behaviors and different subdomains, and perhaps an underlying general disposition towards prevention, we therefore consider the following research question:

Can prevention behaviors be mapped on a one-dimensional scale (using Campbell's paradigm)?

To answer this research question, we made use of an existing dataset of an insurance company situated in the Netherlands. The dataset contained survey data collected among 3,700 customers. The prevention behaviors queried in the survey crossed different domains: they were related to different prevention domains within the home (e.g., fire, burglary, water damage) and related to car possession (prevention of car theft and/or accidents).

2.2.2 The Rasch model

Campbell's paradigm can be mathematically described by the Rasch model. The analytical details of the Rasch model are covered in more detail in the *Results* section, but we briefly introduce the main principles here. The philosophy of the Rasch model

is as follows: "A person having a greater ability than another should have the greater probability of solving any item of the type in question, and similarly one item being more difficult than another one means that for any person the probability of solving the second item correctly is the greater one" (Rasch, 1960, p.117). The Rasch model is a measurement model within the tradition of item response theory (IRT) and is one option in the repertoire of a researcher's search for a reliable and valid measurement tool (Green & Frantom, 2002), although its application seems to be limited to specific research domains. The idea behind the model is that a positive answer to an item ("I use this", "I do that", etc) depends on two parameter estimates: a person's ability (the "person logit") and an item difficulty (the "item logit"). One often speaks of the "difficulty" of items and the "ability" of individuals because the Rasch model has been and is being used most frequently in the domain of educational attainment, where the behaviors are test assignments and the individuals are pupils. For prevention performance this implies: whether a person performs a specific prevention behavior depends on: a person's general disposition towards prevention and the difficulty related to perform that specific behavior. Mathematically the Rasch model can be described as follows (cf. Kaiser et al., 2010):

$$P\{\text{Person n showing behavior i}\} = P(x_{ni} = 1) = \frac{e^{\theta_n - \delta_i}}{1 + e^{\theta_n - \delta_i}}$$

Or, stated differently, that

$$\ln\left(\frac{P(x_{ni} = 1)}{1 - P(x_{ni} = 1)}\right) = \theta_n - \delta_i$$

In this model, the natural logarithm of the ratio of the probability (P) of performing behavior i by person n ($x_{ni} = 1$) relative to the probability of not performing the behavior (-P [$x_{ni} = 1$]) (i.e., the odds) is given by the difference between a person n's ability (θ_n) and the item difficulty i (δ_i). A logarithmic transformation of the odds of success is used since this way relative distances are more easily represented. For example, moving from a 90% score to a 95% score represents a bigger increase in ability than moving from 50% to 55% (Bond & Fox, 2012). When the item difficulty is equal to a person's ability the probability of performing that behavior is 50%. If a person's ability is 1 logit higher than the item difficulty, the probability of performing that behavior increases from 50% to 73.1%.

The Rasch model is a probabilistic model in the sense that inconsistency in behavior is allowed to a certain extent: irregular personal and contextual factors can for instance influence item difficulties (Kaiser et al., 2010). A discerning feature of the Rasch model is its unidimensionality: every item must contribute to the total list of items in the abovementioned way (Bond & Fox, 2012). Moreover, responses are assumed to follow

a hierarchical pattern. That is, the data should be consistent in the sense that persons with a higher ability should have a greater likelihood to have more positive answers to difficult items, and in addition the more difficult items should occur more frequently for persons with a higher ability. Persons and items that deviate from the expected response patterns are identified by the values of certain fit statistics. This is one way in which we assess the appropriateness of the Rasch scale (more on this in the *Results* section).

2.2.3 Defining subgroups

We assess the unidimensionality of the scale also in a different way, namely by calculating the Rasch scale for several subdivisions of items and individuals and comparing the consistency of the scale between them. By definition of the Rasch model, the scale should not be strongly dependent on the chosen items or the specific individuals.

2.2.3.1 Curtailment versus investment behaviors

Prevention behaviors can vary from matters someone can do, such as cleaning the gutter, to matters one can purchase or possess, such as buying or owning an alarm system. In the energy conservation domain, a similar distinction is made between *curtailment behaviors* and *efficiency behaviors*. Curtailment behaviors are considered behaviors someone has to perform regularly in order to conserve energy, and efficiency behaviors are considered behaviors that, in general, require a one-time action such as an investment or the purchase of an energy-efficient appliance (Karlin et al., 2012). The two main attributes that distinguish curtailment and efficiency measures are costs and frequency: curtailment behaviors are repetitive and involve low or no costs while efficiency behaviors are one-time investments (Karlin et al., 2012). Most studies in the energy domain treat curtailment and efficiency behaviors as two separate dimensions, and do not consider the possibility that they can be mapped on a one-dimensional scale (cf. Sütterlin, Brunner, & Siegrist, 2013).

Kaiser and Keller (2001) also included energy conservation behaviors in their General Ecological Behavior Measure, of which some could be typified as curtailment behaviors ("I wash dirty clothes without prewashing") and some could be typified as efficiency behaviors ("I own energy efficient household devices"). Their results show that all ecological behaviors, and so also the energy conservation behaviors, could be mapped on a one-dimensional scale based on their difficulty level. This contradicts the general idea that curtailment and efficiency behaviors should necessarily be treated as two separate dimensions.

In the domain of risk prevention, this distinction between curtailment and efficiency has not yet been made in the literature as far as we know, but straightforwardly applies. For example, for burglary there are behaviors someone has to perform on a regular basis in order to be effective (locking the door when you leave the house), and behaviors that require a one-time investment (buying certified locks). As in the ecological domain we label the first type of low costs and high frequency behavior 'curtailment behavior'. The second type (high costs, low frequency) we label 'investment behavior' rather than 'efficiency behavior' since this term applies better to the prevention domain (efficiency behavior might mistakenly be connected to energy efficient appliances). Hence, one subdivision of items we consider is the subdivision between curtailment and investment behaviors.

2.2.3.2 Groups of individuals

Apart from different classes of items that might lead to separate scales, different groups of individuals might also behave differently across the Rasch scale. For instance, Scheuthle, Carabias-Hütter, and Kaiser (2005) have established an influence of situational conditions by comparing self-reports on ecological behaviors between two countries. They found that the country of origin influenced the order of the behaviors: 47 of the 65 behaviors differed significantly with respect to their difficulty level, for example not using a tumble drier appeared to be easier in Spain than in Switzerland due to climate differences. Other factors that influenced these differences were affluence, availability of alternatives, and cultural beliefs. Based on these results, they concluded that a single (Rasch) scale is not appropriate across diverse social cultural contexts. Another study of Kaiser and Keller (2001) has established the influence of an urban versus a rural environment on the difficulty levels of ecological behaviors, due to transportation possibilities and social climate.

In the prevention domain, it is similarly likely that situational factors can hinder or facilitate the difficulty level of specific prevention behaviors. Subgroups might exist for which the difficulties of certain prevention behaviors differ. In the prevention domain the year of construction of a house can be such a situational factor. As of 1999, Dutch law requires new houses to be equipped with specific prevention measures, such as certified locks on doors and windows, and as of 2003 also smoke alarms are required. So, people who live in a house built after that date simply have these measures, whereas it is a matter of choice only for those who live in older houses. The type of home might also have an effect on difficulty thresholds: people who live in an apartment building would in all likelihood state more often that they have a fire escape plan or a lightning conductor than people living in a (semi)detached or terrace home. Another factor of influence might be whether someone owns or rents a home. According to Vollaard

(2014) an often mentioned reason why people do not take more preventive measures is because they rent a house, which implies that for them preventive measures are more costly relative to home owners since renters carry the costs of the preventive measure but do not enjoy all benefits. We will examine whether the one-dimensional prevention performance scale that arises from our Rasch model is robust in the sense that the scale functions the same across these different subgroups.

2.2.4 Scale reduction

In general, a desirable measurement instrument is one that has high reliability and validity and is short, as this is more convenient for participants and as a consequence will cause fewer dropouts (Green & Frantom, 2002). The Rasch model is based on the principle of person and item invariance which implies that the relative item difficulties should be equal for a different, but similar, group of people (Bond & Fox, 2012). Moreover, the scale is relatively insensitive to the set of items used, since the items chosen are just a fraction of all possible items on the same dimension. So, if the test group would randomly get half of the items, the persons should have the same relative ability scores as they would have had with the full set (albeit with a lower resolution). A unique property of the Rasch model thus is that certain items can be removed from the scale without influencing the point estimates of the ability scores. Therefore, after analyzing whether a (unidimensional) Rasch scale can be established, we consider to what extent we can decrease the number of items in the Rasch scale without losing (too much) precision.

2.3 Method

2.3.1 Participants and procedures

Our analyses are based on data that were collected from customers of an insurance company in the Netherlands who either had a home insurance and/ or a contents insurance. The data was collected by the author of this thesis as part of a project of the insurance company (prior to the start of the PhD project). The questionnaire was sent out per e-mail to 20,000 customers, of which 3,700 responded (18.5%) within two weeks. To stimulate the response rate, three iPads were raffled. In the invitation it was made clear that the questionnaire was about prevention behaviors and that the goal of the study was to gain more knowledge about the effects of prevention to improve customer service. To avoid social desirability, it was stressed that there were no correct or wrong answers. The modal group of the 3,700 respondents was 55 years or older (44.4%), followed by those between 36 and 54 years (36.1%) and between 18 and 35 (19.4%). There were 65% men in the study versus 35% women. With respect to education, 45.3%

of our respondents had completed a BSc. level education or higher, 28% completed a secondary vocational education, 9.0% completed secondary education (i.e. high school level), 15.1% completed preparatory vocational education and 2.3% of our respondents had a primary education as their highest educational level. Concerning household composition, most people belonged to the category 'married/ living together, kids living at home' (29.2%) followed by 'married/ living together, no kids' (26.5%) and 'married/ living together, kids not living at home' (16.9%). The majority of participants owned the house in which they lived (78.9%), the remaining (21.1%) rented their home. The most prevalent type of homes were terrace homes (29.7%), followed by detached homes (20.9%) and semi-detached homes (19.0%), and apartments/studios (17.5%). Most houses (77.3%) were constructed before the year 2000. In 20.1% of the cases they were constructed after 2000 and 2.7% of participants did not know the date of construction.

2.3.2 Measures

The questionnaire comprised 11 background questions and 48 prevention behavior self-reports. The background questions included gender, age, education, household composition, residence, ownership home, date of construction, type of home, presence thatched rooftop, presence of a fireplace and car ownership. All prevention behavior self-reports were selected by damage-claim experts of the insurance company and include a wide range of behaviors that can prevent or mitigate risks that are covered by insurance policies. The prevention behaviors were related to the domestic risks of fire, burglary, and water damage, which are covered by the home and contents insurance (together "domestic risk prevention", as defined in this thesis). These prevention behavior self-reports were extended with behaviors related to the prevention of car theft and car accidents. The prevention behavior self-reports included investment behaviors and curtailment behaviors. The investment behavior self-reports were all dichotomous ("yes/no" format). The curtailment behaviors were measured on an ordinal scale, for which the number of levels depended on the specific behavior that was asked. Some behaviors were hard to quantify and therefore only had a three point scale with answer possibilities (almost) always/ sometimes/ (almost) never, for example "How often do you lock the door when you leave the house?". Other questions were easier to quantify for example 'How often do you clean the roof gutter?'. These scales included specific quantities: "at least twice a year/ yearly/ every two to three year" etc. The options "I do not know" and "not applicable" were included in the questions when this was appropriate.

2.3.3 Statistical analysis

We tested the one-dimensionality of the scale with the Rasch model for binary data. Accordingly, we coded all behavioral self-reports into 0 ("no") and 1 ("yes"). For recoding the curtailment behaviors advice was used from prevention experts of the insurance company to determine whether an answer should be coded 0 or 1: when the scale consisted of the answer possibilities "(almost) always/ sometimes/ (almost) never" the most strict answer "(almost) always" was given code 1 and the others were given code 0. The answer possibilities "I do not know' and "not applicable" were treated as missing values.

2.4 Results

We report our findings in four sections. In the first section we will answer the main research question: can prevention behavior self-reports be mapped on a one-dimensional scale (using Campbell's paradigm)? In the second section, we test the robustness of the scale by showing whether curtailment and investment behaviors in the prevention domain can be mapped on a one-dimensional scale. In the third section, we further test the robustness of the scale by showing whether the scale significantly differs for subgroups. The final section shows whether we can construct a scale with fewer items, while obtaining similar reliability and validity.

2.4.1 A one-dimensional scale

The data from the behavioral self-reports were analyzed in Winsteps® (Linacre, 2015a) with the Rasch model. The results show how well each individual item and individual persons fits. Furthermore, the Rasch model rank orders the items and persons based on, respectively, the estimated item difficulties and person abilities. In Figure 1 the item-person map is introduced, which is the heart of the output of the Rasch model. The distribution of the persons is shown at the left side of the map and the distribution of the items is shown at the right side. The higher the position on the logit scale, the more difficult the item or the higher the ability of the person. The person ability depends on how many positive answers a person gives and the item difficulty depends on how many persons give a positive answer to a certain item (Bond & Fox, 2012).

```
 3              .  +  44
                   |  12     4
                .  |
                .  |
                .  |
                .  |
                .  |
 2              .  +  10     28     45
                .  |  5
                .  |  22     9
                .  |S 46
                # T|  18     3
               .#  |  1      23     38
              .##  |
 1            .##  +
            .####  |  39
         .#######  |
         .####### S|  11     8
       .#########  |  25     42     6
       .#########  |
      .##########  |
 0 .############  +M 30
   .############ M|  24
   .############  |  21     27     34     43     7
   .############  |  40
    .###########
       .########  |  29
         .###### S|  16
-1       .######  +  19     41     47
            .###  |  17
           .###   |  13     26
           .###   |
            .##   |S 2      35
             .# T|
             .#   |  20     33     36     37
-2            .  +  32
              .  |
              .  |
              .  |  48
              .  |  31
              .  |
              .  |
-3            .  +
                 |T
                 |
                 |
                 |
                 |  15
                 |
-4               +
```

Figure 1: Item-person map.
The distribution of the persons is shown at the left side of the map. Each # represents 23 persons and a dot represents less than 23 persons. The distribution of the items is shown at the right side. The estimated person abilities and estimated item difficulties are mapped on a logit scale.

Consequently, the behavior that is most often answered positively is located at the bottom of the map (item 15: burning clean and dry wood when using fire place) and the behavior that is least often answered positively (item 54: track and trace system) is located at the top of the map. To give an indication: of the people that had a fireplace 96.9% stated that they burn clean and dry wood when using the fire place. Of the people that own a car, 5.5% stated they have a track and trace system in their car. For all item labels and difficulties see Appendix A.

The item-person map (Figure 1) gives information about the transitive order of the items and persons, and on how well the items are targeted at the person abilities. For instance, the map shows that a person who is positioned next to item 44 (track and trace system) has a 50% chance of having a track and trace system in his or her car and a 73.1% chance of performing a prevention behavior that is one logit easier (Bond & Fox, 2012). So, having a fire ladder (item 10, a fire hazard item) can be mapped on the same scale as having a track and trace system (item 44, a car theft related item). The difference is that the former is just easier to perform. The test was neither too difficult nor too easy for the sample. This is confirmed by the person mean measure, which was M = -.15: the closer this score is to zero gives an indication that the items were well targeted at the ability of the sample, because the Rasch model sets the mean item estimates at zero logits (Bond & Fox, 2012). The map furthermore shows a normal distribution of person ability showing a good spread of persons on the scale. The items cover almost the whole range of person abilities: there are only a few persons at the extremes of the distribution. The ability of those persons cannot be measured as accurately as that from the persons in the middle. Most items are centered in the middle where most items are needed to differentiate between person abilities.

The fit statistics and reliability information that are provided by the Rasch model show how well the data fits the expected model. We briefly reiterate the meaning of the main statistics to be calculated. Fit statistics are presented for persons and for items. The person fit is a measure for the consistency of the respondents' answers and the item fit shows how well the items form a continuum to measure an ability (Green & Frantom, 2002). The Rasch model presents two chi square ratios for this: "infit" and "outfit" mean square (MNSQ) statistics. When the data fits the model perfectly, the infit and outfit mean square values are equal to 1.0 (Bond & Fox, 2012). The mean square values are also reported in their standardized form as z-scores (equivalent to a t-statistic) to be able to assess the statistical significance of the mean square statistic. The mean standardized infit and outfit values (ZSTD) are expected to be 0.0 (Bond & Fox, 2012). Items or persons can "underfit" when there is more variation than expected, defined by a MSNQ > 1.3 and a ZSTD > 2.0 (Bond & Fox, 2012). This is the case when "a capable person gets easier items unexpectedly wrong (e.g., 0010011110, where items are ordered from easiest to most difficult), or a less able persons gets harder items unexpectedly correct (e.g., 1101000110)" (Bond & Fox, 2007, p.239). In our case: a person that performs many prevention behaviors but misses several of the easy ones, or a person that performs just a few prevention behaviors but several of the more difficult ones. Observing less variation than expected (the answers are too perfect, so to speak) is referred to as "overfit" which is defined by MNSQ < .75 and a ZSTD < -2.0 (Bond & Fox, 2012). The fit statistics can be seen as a measure for validity, since they identify items that do not fit on the scale (Green & Frantom, 2002).

The reliability scores were calculated for persons and items. The person reliability shows whether the person ordering would be the same when the same persons were given a similar set of items (Bond & Fox, 2012). The item reliability shows whether the item ordering would be the same when the same items were given to a comparable sample (Bond & Fox, 2012). The person reliability was α = .66. This can be considered acceptable since the reliability as presented by the Rasch model can be interpreted much in the same way as Cronbach's Alpha (Bond & Fox, 2012). The item reliability was α = .97.

All items, except item 14, fit the model sufficiently with MNSQ values between .75 and 1.3 (see Appendix A for all estimated item difficulties and the accompanying fit statistics). Item 14 (spark-catcher on chimney when having a thatched roof top) had a too large standard error (S.E. = 1.84) which indicates that its position could not be estimated precisely. This due to the small number (n = 35) of observations for this item. After deleting item 14, the item reliability increased to α = 1.0. The person reliability remained α = .66. To determine how many persons had an acceptable fit, we considered all mean squares ≤ 1.3 as acceptable since an overfit (< 0.75) is not really a problem but an underfit (> 1.3) is, since this indicates unusual or inappropriate response patterns (Bond & Fox, 2012). There were 195 persons (5.3%) with a significant misfit. Deleting these persons from the dataset, increases the person reliability to just α = .67. Since the person reliability barely improved, we kept these persons in the dataset.

To explore multidimensionality, we used Principal Component Analysis. Empirically the Rasch model explained 36.4% of the variance in the data and the modeled variance was also 36.4%. An additional factor would result in an increase of explained variance of 2.7%.

To further test our scale, we performed the "Ben Wright's Challenge" (Bond & Fox, 2012). This test includes testing person and item invariance, a requirement of the Rasch model. Invariance means that the ability of the persons is independent of the test, and the difficulty of the items is independent of the persons (Bond & Fox, 2012). To test the person invariance we divided the test into two scales, based on the item difficulty order (easiest items versus most difficult items). Person reliability of the dataset with the easiest items was α = .47 and of the dataset with the most difficult items α = .46. The correlation between the person abilities was r = .42. However we have to correct for the measurement error (that is, low person reliability) by applying correction for attenuation since measurement error diminishes the correlation (Jensen, 1998). The deattenuated correlation was r = .90. Thus, the person abilities remained stable across different subsets of items, which implied that the person abilities were indeed independent of the given items. To test the item invariance, we split the sample in half according to the person abilities (low versus high ability). The correlation between the item difficulties of the two samples was r = .98, which implied the item difficulties were indeed independent of the persons. Here, correction for attenuation was not necessary since item reliability was high.

2.4.2 Curtailment and investment behaviors

In this second section, we further test the robustness of the scale. We checked if we could map investment and curtailment behaviors on a one-dimensional scale or if they should be treated as two separate dimensions. For this, we analyzed the items of these two dimensions in two separate analyses and then calculated the correlation between the two sets of person measures. The correlation between the two dimensions was .37. After correction for attenuation (because of low person reliability) the correlation equaled r = .70. The person reliability for *investment behaviors* was r = .56 and for *curtailment behaviors* r = .49. Since the correlation was sufficient and the reliability was higher of the one-dimensional scale than of the two separate dimensions, we conclude that investment and curtailment behaviors can be mapped on a one-dimensional scale. Although the two types of items are both well spread along the continuum, curtailment behaviors appear easier to perform (M = .59, SD = .12) than investment behaviors (M = .39, SD = .15; $t(3234) = 71.51$, $p < .001$).

2.4.3 Subgroups

In this third section we show whether the scale functioned significantly different for subgroups. We used Differential Test Functioning (DTF) to check whether the test functioned the same way for persons living in: a.) rental homes versus owned homes, b.) new homes (built after the year 2000) versus old homes (built before the year 2000), c.) detached homes versus semi-detached homes, d.) detached homes versus terrace homes, e.) detached homes versus apartments/ studios, f.) semi-detached homes versus terrace homes, g.) semi-detached homes versus apartments/ studios, and h.) terrace homes versus apartments/ studios. With Differential Item Functioning (DIF) we checked for significant differences on an item level. DIF differs from DTF since with DIF the interaction of the subgroups with each item separately is investigated, while holding all other item and person measures constant (Linacre, 2012).

In general, the scale functioned the same way for different subgroups since the correlations between the item measures were all high (see Table 1). This supports the robustness of the finding that a single (Rasch-) dimension is underlying the different prevention behaviors. This does not imply that on an individual item level no significant differences can exist. Guidelines to determine if an individual item functions differently across groups: the difference in difficulty between groups must to be big enough (size > 0.5 logits) and the difference needs to be significant (Linacre, 2015b). The DIF impact on person ability depends on the number of items of a test. The same logit bias will have a larger impact on the person ability in a 10-item test compared to a 100-item test (Linacre, 2012). Since we have quite a large test the DIF impact on the person ability

(prevention performance in this case) is limited, we therefore considered a size > 1 logit as a difference that is not desired. In total there were 17 unique items that functioned differently across all defined subgroups. In Appendix B all the items are shown that functioned significantly different between subgroups. For example, table B1 shows that people that live in a new home more often have certified locks and a smoke alarm. This was expected beforehand since certified locks and smoke alarms are required by law for homes built after 1999 and 2003, respectively. Furthermore, Table B3 and B4 show that people that live in a detached home more often have an alarm system, compared to people living in a terrace home or an apartment. In terms of the Rasch method, we would say an alarm system is *easier* for people that live in a detached home. A possible explanation is that people in a detached home have a higher burglary risk and have more financial resources to afford an alarm system. That some behaviors are typified by various difficulty levels (or "item logits") in different subgroups is not problematic since in general the test functions the same across subgroups. In In section 2.4.4 we used the information of the deviating items as a criterion for item reduction.

Table 1: Correlation coefficients between item measures across subgroups.

Subgroups	r
rental vs owned homes	.94
new vs old homes	.91
detached homes vs semi-detached homes	.98
detached homes vs terrace homes	.94
detached homes vs appartments/studios	.85
semi-detached homes vs terrace homes	.98
semi-detached homes vs apartment/studios	.88
terrace homes vs apartments/studios	.90

2.4.4 Scale reduction

One of the appealing characteristics of Rasch is that it enables us to check whether we can construct a scale with fewer items, without sacrificing much in terms of reliability and validity. There are no set rules how to create a smaller scale, however we predetermined some guidelines upfront based on Rasch model considerations. Items can be taken into consideration to be dropped from the scale when one or more of the following factors are present: items that have a large error estimate, since these item estimates are not accurate. Items that have poor fit statistics since these items do not fit on the continuum. Items that have a lot of missing values since information is missing there. Items that have the same difficulty level as other items (especially on the top or bottom of the item-person map) since items with equal difficulty estimates target the same ability. Items that are answered by (almost) everyone by "yes" (that is: on top of the map) or "no" (that is: at the

bottom of the map), since these items do not separate persons well. Or items that function differently across subgroups, since these biases can affect person abilities, especially in a smaller scale. We reduced the scale in steps since the structure of the person-item map changes every time when items are deleted. Also, this allows us to carefully (re)view the consequences of every decision. Table 2 shows the items that were deleted in every step together with the accompanying reliability statistics.

Other than item 14, which we already deleted because of a large standard error, there were no items with bad fit statistics. In step 1 we deleted all items with more than 50% missing values. These were all conditional items (e.g. items about the fireplace, which someone only had to answer if he owns a fire place). Person reliability reduces to α = .65. After deleting these items, we produced the person-item map again. When inspecting the newly produced person-item map, in step 2 we considered dropping several items that had the same difficulty level (since these items measure the same ability level) and at the same time were located at the top or bottom of the map (since these items target just few persons). To decide which specific items could be dropped we looked at the percentage of missing values and their functioning across subgroups. For example: in step 2 we considered dropping item 1 or 38 because they had the same difficulty level and were on top of the map. We decided to drop item 11 because it had most missing values and functioned differently in the subgroup new homes versus the subgroup old homes.

This step-by-step analysis shows that it is possible to reduce the scale to 27 items and still obtain reliability above α = .60. In this smaller scale item fit statistics were all acceptable according to the norms. In Figure 2 the map is shown with 27 items. To place the reliability score of α = .61 in perspective we calculated some other person reliability statistics when we reduce to 27 items in different, less informed, ways: when a.) randomly deleting 21 items, the reliability reduces to α = .51, b.) deleting the 21 items with the most missing values, the reliability reduces to α = .56, c.) deleting all items that functioned differently (17 items) the reliability was α = .55 , d.) deleting all items that functioned differently (17 items) and 4 items with the most missing values the reliability was α = .55, e.) randomly selecting 5 items reduces the reliability to zero. (In all these approaches item 14 was taken out of the analysis). These results indicate that reducing the scale by applying our predetermined guidelines produces a better scale than randomly selecting items or using simpler rules. To check the robustness of this smaller scale of 27 items we performed Differential Test Functioning. The dataset is randomly divided into a test set (n = 1854) and a training set (n = 1846). The correlation between the item difficulty estimates of the two sets is perfect (r = 1.00). Also, the person reliability is similar to the total dataset (.60 respectively .61). In conclusion we can state that, by using legitimate pre-determined guidelines, we were able to create a smaller scale of 27 items and still have a reliable and valid measurement tool for prevention

performance (which works better than randomly selecting items).

Table 2: Reliability statistics after item reduction.

Step	Items deleted	Person reliability	# items measured	Reason
0	14	.66	47	large standard error
1	9, 12, 13, 15, 16, 29, 30, 39	.65	39	> 50% missing values
2	44, 45, 46, 1, 36, 37, 20	.63	32	similar difficulty estimates at top and bottom of map, deletion based on % of missing values and/ or DIF[1]
3	10, 22, 48	.63	29	similar difficulty estimates at top and bottom of map, deletion based on % of missing values and/ or DIF
4	3, 11	.61	27	similar difficulty estimates, deletion based on % of missing values and/ or DIF
5	4, 31	.59	25	most top at most bottom item
6	35, 41, 27, 8	.54	21	similar difficulty estimates, deletion based on % of missing values and/ or DIF
7	21, 43	.51	19	similar difficulty estimates, deletion based on % of missing values and/ or DIF
8	38, 42, 47	.50	16	similar difficulty estimates, deletion based on % of missing values and/ or DIF
9	28, 18, 32, 2, 17, 40	.40	10	position in item-person map so that items are well spread across continuum
10	5, 6, 33, 19, 7	.19	5	position in item-person map so that items are well spread across continuum

[1]Note. DIF = Differential Item Functioning.

```
 4              .  +
                .  |
                   |
                   |
                   |
                .  |
 3              .  +  4
                   |
                .  |T
                .  |
                .  |
                .  |  28
 2              .  +  5
                .  |
               .# T|  18
                .  |  38
            .###   |S 23
           .####   |
 1          .###   +
        .####### S|
      .#########  |  42      6      8
      .#########  |  25
    .###########  |
          .######  |  24
 0 .############ M+M 43      7
    .###########  |  21      27     34
    .###########  |  40
      .#########  |
          .#####  |
        .####### S|  19      41     47
-1        .#####  +  17
            .###  |  26
             .##  |S
             .##  |  2       35
              .# T|  33
               .  |  32
-2             .  +
               .  |
               .  |
               .  |  31
               .  |T
               .  |
-3             .  +
               .  |
                  |
                  |
                  |
```

Figure 2: Item-person map with 27 items.
The distribution of the persons is shown at the left side of the map. Each # represents 28 persons and a dot represents less than 28 persons. The distribution of the items is shown at the right side. The estimated person abilities and estimated item difficulties are mapped on a logit scale.

2.5 Discussion

The present study shows that self-reported prevention behaviors can be mapped on a one-dimensional scale, when ranking the behaviors according to their difficulty level. The results support a clear transitive ordering, which implies that people who for example own an alarm system (high difficulty level), most likely also have a fire blanket (lower difficulty level). The one-dimensionality indicates that people act consistent regarding

their prevention behavior across subdomains, and that therefore prevention behavior in a given subdomain is predictive of prevention behavior in another subdomain. This result is similar to what Byrka and Kaiser (Byrka & Kaiser, 2012; Kaiser, 1998) have found in the domains of ecological behavior and health behavior. Our results show that Campbell's paradigm, operationalized by the Rasch model, also works in the prevention domain. In addition, the finding of a one-dimensional scale gives an indication for a general disposition towards prevention performance that is underlying the prevention behaviors.

The results of this study further suggest that curtailment behaviors and investment behaviors can be mapped on a one-dimensional scale. That is, when taking the difficulty level of the behaviors into account, people do not behave differently regarding matters that they have to do regularly to be safe (e.g. locking the doors) as opposed to matters they can purchase to be safe (e.g. a smoke alarm). Nevertheless, our results do show that curtailment behaviors are more often performed (and are, in the Rasch terminology, "easier") than investment behaviors. An explanation could be that the curtailment behaviors are often habits, such as locking the doors, closing the windows, informing your neighbors when going on holiday, and not leaving valuables in the car. Instead, investment behaviors often lead to substantial costs and involve some amount of effort, such as the installation of a smoke alarm, alarm system, or locks on windows and doors.

Furthermore, this study demonstrates that, in general, the relative ordering of the behaviors does not change across subgroups of people, which further corroborates the one-dimensionality. Scheuthle et al. (2005) argue that contextual differences, such as country of origin, affect behavior by constraining or facilitating behavior. Whereas we were not in a position to analyze the effect of sociocultural conditions, we did consider the effect of other contextual factors (rental versus own home, date of construction, type of home). There were some behaviors that were easier or more difficult for specific groups, but generally the test did not show substantial differences across subgroups. This is a promising finding, as it is consistent with the idea that the results of the diverse subgroups are comparable, and no separate scales have to be developed for specific subgroups. Items that functioned differently across subgroups can however be taken into consideration to be dropped from the scale.

Finally, we created a smaller scale (from 48 to 27 items), while maintaining sufficient reliability and validity, to measure prevention performance. The results of the Rasch analysis facilitated the item reduction process by identifying poorly functioning items, items that functioned differently across subgroups and by providing a person-item map that gives clear indications of where on the difficulty scale an item reduction was feasible (particularly at the top and bottom of the map). When reducing the scale, it is important

to consider the goal of the measurement instrument. In our study we developed the scale for the measurement of a person's individual prevention performance. A related but different possibility is to develop a scale to measure the prevention performance (or: safety) of the home. For example: for newly built houses a smoke alarm is required by law in the Netherlands since 2003. Therefore, this item says nothing about the general disposition towards prevention of a person in such a home. However, this item does say something about the safety of the home itself. So, it depends on the goal of measurement which items have to be excluded from the scale, and it would in fact require an additional analysis to consider whether cross-domain consistency also holds in that case. Finally, it is important to realize that we considered just one possible way to reduce the scale. There are certainly other ways to do this, and obviously one could consider further reduction to fewer items at the expense of precision and reliability.

As we mentioned before, our results indicate that to measure prevention performance, it is not necessary to measure all the separate subdomains, because when we know someone's ability on the prevention performance scale, we can predict his or her score on other items of which we know the difficulty estimate. This implies that, in principle, asking for only items related to, say, the fire domain, could be enough to estimate general prevention performance. This however requires that the items of the fire domain are well spread along the prevention performance continuum to be able to measure every person's ability.

The results of this study give rise to implications for personalization of prevention advice since the specific transitive ordering of the behaviors can be seen as a predictor of which behaviors people are most likely to be performed next. People with a low general disposition towards prevention performance, would probably be more inclined to engage in prevention behaviors that are ranked lower on the scale (that is, are considered "easier"), such as installing a smoke alarm or informing the neighbors when going on a holiday, compared to behaviors ranked higher up in the scale. While people with a high general disposition probably already have a smoke alarm installed and inform their neighbors when going on a holiday. Hence, prevention behaviors that are ranked higher on the scale will be more fruitful for them. Although it is a common approach to give general prevention advice to society as a whole or to specific target groups, personalization of prevention advice will probably be more effective than non-personalized approaches, as has also been shown in the energy domain (Starke et al., 2020; Starke, Willemsen, & Snijders, 2017).

There are also some limitations of the present study. The questionnaire was sent out by an insurance company, which may have resulted in some social desirability bias. On the other hand, given that the insurance company was the obvious sender of the

survey, one could also argue that this is particularly likely to lead to honest answers, as participants might consider the possibility of their answers being checked. In addition, in the invitation that was sent out the subject of the survey was made clear beforehand (as per company policy). Consequently, actual respondents may have had a higher interest in prevention than non-respondents or were more comfortable about giving information about their prevention behavior to their insurance company (or both). As a result, the average prevention performance of this sample could be higher than the average score of the total population. Further analyses should show whether our results generalize to other populations. A limitation concerning investment behaviors is that we do not know if the participant actually bought the prevention measure or if the measure was already present in the house. When investment measures were already present in the house and the respondent would not have bought this measure had he or she have to do this, this might result in an undeserved high ability score viewed from a behavioral perspective. In addition, our study did not include all possible domestic prevention behaviors (e.g. injury prevention, cybercrime) since solely prevention behaviors related to risks covered by damage insurance policies were included. Consequently, results can strictly speaking not be generalized to other risks not studied. Then again, following the argument of a general disposition towards risk prevention, the idea that also other (domestic) risk prevention behaviors can be plotted on this one-dimensional scale seems plausible.

Conclusion

The present study shows that self-reported prevention behaviors can be mapped on a one-dimensional scale, by transitively ranking those behaviors according to their difficulty level. That is, we can distinguish a single ranking of prevention measures according to their prevalence that is consistent across subdomains (e.g. fire versus burglary) and across types of behaviors (e.g. curtailment versus investment) in the sense that respondents who participate in more difficult behaviors, are likely to participate in (all) easier behaviors. This implies that to measure someone's general disposition towards risk prevention it is not necessary to measure all prevention behaviors: prevention in one domain can be predictive of that in another domain, as long as the prevention items are carefully chosen across the whole range of difficulties.

The results of this study give rise to implications for personalization of prevention advice, which is probably more effective than the general advice that is often offered by insurance companies or the government. Thus, recommending people which prevention behaviors to perform next on the basis of our scale is a promising practical application of our findings. In addition, the general disposition as measured here allows for instance insurance companies to better and more efficiently examine the relationship between prevention performance and claim behavior (frequency and amount of claims).

3

Determinants of domestic risk prevention behavior: the importance of separating effects within-persons and between-persons

This chapter is published as a journal paper:
Jansen P.C.P., Snijders, C.C.P. & Willemsen, M.C. (2020).
Determinants of domestic risk prevention behavior: the importance of separating effects within-persons and between-persons. *Risk Analysis.*
https://doi.org/10.1111/risa.13632

3.1 Introduction

People are susceptible to various risks that can bring damage to their homes, the content of their homes, and themselves. The consequences of risks such as fire damage, water damage, and burglary can be covered by insurance policies, although not always completely. Taking measures to prevent a risk or mitigate the consequences of a risk is preferred over the more passive approach of repairing and claiming the damage after the fact, as it can save people a lot of hassle, money, and emotional losses. Even in a country such as the Netherlands, where 98.3% of the households has a home and/or contents insurance, there is still a lot to gain in terms of the number and quality of prevention measures that people could take to protect their homes (CBS, 2016; Janssen, Van Den Berg, & Tieben, 2009).

Two frequently applied theories that consider how people deal with risks and risk prevention are the Protection Motivation Theory (PMT; Rogers, 1975) and the Health Belief Model (HBM; Rosenstock, 1966). The basic idea behind PMT and HBM is that the perceived likelihood of a risk and its perceived consequences create a motivation for self-protection, and a (perhaps implicit) cost-benefit analysis that results in taking action or not. The determinants[3] derived from PMT and HBM, vulnerability, severity, costs, effort, and effectiveness, have been extensively tested in various areas of prevention behavior research. Most studies consider the health domain but other domains such as environmental risk and traffic safety have also been studied (Bubeck, Botzen, & Aerts, 2012; Floyd et al., 2000; Janz & Becker, 1984; Milne, Sheeran, & Orbell, 2000, Bamberg et al., 2017). The general conclusion in the literature is that these hypothesized determinants are indeed relevant predictors for prevention behavior albeit with varying degrees of importance (Bamberg, Masson, Brewitt, & Nemetschek, 2017; Floyd et al., 2000; Janz & Becker, 1984). In this chapter we test whether these determinants are relevant predictors in the domestic risk prevention domain.

In addition, the more important contribution of this chapter is a methodological one: we want to address the importance of separating between-person and within-person effects when testing the effects of prevention behavior determinants. Suppose that one finds that the perceived effectiveness of a behavior correlates with the probability that someone indeed performs this behavior, as several researchers have found (Floyd et al., 2000; Janz & Becker, 1984; Milne et al., 2000). This could mean on the one hand that persons who find prevention behaviors in general more effective than other persons, are more likely to perform prevention behaviors, a “between-persons” effect. On the other hand, it could mean that for a given person, prevention behaviors that are

3 Other labels for the term determinants in the literature are: components, (explanatory) factors, variables, and antecedents.

perceived as more effective than other behaviors are more likely to be performed, an effect "between behaviors within-persons". Although these two interpretations are not the same, the literature on PMT and HBM does not make this distinction explicit. In fact, most studies do not clearly state which interpretation is more appropriate, although the (mostly implicit) general argument made seems to be on the within-person level. If, say, the perceived effectiveness of a prevention behavior would become higher for a given person and everything else remained equal, then that person would be more likely to perform that behavior. Although the general argument is on the within-person level, correlational studies perform analyses solely between-persons, perhaps mistakenly thinking this allows testing a within-person effect (Chatterjee & Mozumder, 2014; Jayanti & Burns, 1998; Lindell et al., 2009; Martin et al., 2007; Zaalberg, Midden, Meijnders, & McCalley, 2009). This is a common problem in psychology, and also addressed as such by several scholars (Collins, 2006; Curran & Bauer, 2011; Fogg, 2003; Molenaar, 2004; Mroczek, Spiro, & Almeida, 2003).

Whether the effects are primarily within- or between-persons has important implications for initiatives directed at influencing prevention behavior. When effects are mainly between persons and hence depend on personal characteristics (e.g. on a person's general perception of the effectiveness of prevention behaviors, socio-demographics, etc.), it would make sense to direct general prevention initiatives at specific target groups with the appropriate characteristics, or to try to influence people's general perception of all risks and behaviors. However, when effects are mainly between behaviors within persons, it would make more sense to focus on a general audience and try to influence their perception of the characteristics of specific risks and behaviors (relative to other risks and behaviors). This is typically the way both theories are interpreted, and hence, how behavior change attempts are designed (see for instance Cismaru & Lavack, 2007). We discuss this subtle but crucial issue in more detail in the 'Theory and hypotheses' section.

This study contributes to the existing literature in several ways. First, we apply and test arguments as put forward in PMT and the HBM in a context in which they have not been tested before: the domestic risk prevention domain. That is, we consider which of the determinants - vulnerability, severity, costs, effort, effectiveness, and awareness - determine domestic risk prevention behavior, and to what extent. Second, and most important, our research design allows us to evaluate which differences in the performance of domestic prevention can be attributed to differences between persons or to differences between behaviors within persons. This gives a more thorough understanding of the prevention behavior decision making process and has direct implications for the choice of possible interventions. Third, we test the robustness of our findings by considering whether the determinants that drive prevention behavior

differ across persons and types of behaviors. We discuss our findings and conclude with implications for policy makers and others interested in motivating people to increase their (domestic) risk prevention behavior.

3.2 Theory and hypotheses

Both PMT (Rogers, 1975) and HBM (Rosenstock, 1966) provide a framework to explain why individuals do or do not engage in actions to prevent or mitigate the consequences of risks. While PMT was originally developed for the explanation of fear appeals, it has later been revised into a more general theory for prevention behavior (Rogers, 1983). Both PMT and HBM originate from applications in the health domain, for example to explain smoking behavior (Maddux & Rogers, 1983; Mantler, 2013), HIV prevention (Bengel, Belz-Merk, & Farin, 1996; Rosenstock, Strecher, & Becker, 1994), and breast cancer prevention (Wiegman, Taal, van den Bogaard, Gutteling, 1992; Yarbrough & Braden, 2001), and have later been applied to other areas of risk, such as earthquakes (Mulilis & Lippa, 1990), floods (Ejeta, Ardalan, Paton, & Yaseri, 2016; Zaalberg et al., 2009), wildfires (Martin et al., 2007), and burglary prevention (Wiegman, Taal, van den Bogaard, & Gutteling, 1992).

Although the specific behaviors under study can be different, the general arguments why people engage in prevention behaviors are similar. According to both PMT and HBM the desire to avoid or mitigate a negative outcome creates motivation for self-protection. This desire is based on the perceived likelihood that the risk will materialize and the perceived severity of the consequences if it does materialize. In order to act, someone must feel that the prevention behavior is effective in reducing the likelihood or severity of the risk, and this benefit must outweigh the costs, such as time, effort, money, and inconvenience. Both theories make the assumption that the behavioral determinants relate to the subjective perceptions of a person and not to the objective state of a risk or behavior. Although the theories share more similarities than differences, the main theoretical difference is that PMT attributes the prevention behavior determinants to two cognitive processes ("threat appraisal" and "coping-appraisal") while HBM is organized as a catalog of variables (Floyd et al., 2000; Rosenstock, 1966).

In line with arguments in these previous studies, we expect that vulnerability, severity, costs, effort, and effectiveness influence domestic risk prevention behavior. Furthermore, we expect awareness, the extent to which one is familiar with the specific prevention behavior, to play a role. We now discuss the potential determinants of domestic risk prevention behavior in some detail.

3.2.1 Evaluation of risk: vulnerability and severity

According to both PMT and HBM, the motivation to take preventive action arises from the evaluation of the risk (referred to as threat appraisal in PMT, and perceived threat in HBM) (Maddux & Rogers, 1983; Rogers, 1975; Rosenstock, 1966). Someone must feel that there is a probability of being exposed to the risk: the *perceived vulnerability* (or perceived likelihood, or perceived susceptibility). The second factor for the evaluation of the risk is the *perceived severity* (also referred to as perceived seriousness): the more severe the expected consequences, the higher the motivation to take action to reduce the likelihood of the risk (e.g. do not use candles) or to mitigate the consequences in case of the risk materializing (e.g. buy a fire blanket).

Multiple studies have found positive effects of perceived vulnerability and severity on prevention behavior (Bamberg et al., 2017; Bubeck et al., 2012; Floyd et al., 2000; Janz & Becker, 1984; Milne et al., 2000; Valkengoed & Steg, 2019). With respect to determinants that influence prevention behaviors in the areas of domestic fires, burglary, or water damage, there is much less literature available. The one study that we found concerning burglary showed a small impact of perceived severity on burglary prevention, but perceived vulnerability did not affect prevention behavior (Wiegman, Taal, van den Bogaard, & Gutteling, 1992).

Although positive relations of vulnerability and severity with prevention behavior have been found, correlations tend to be small, which might be explained by measurement problems (Bubeck et al., 2012; Milne et al., 2000; Weinstein, Rothman, & Nicolich, 1998). Most studies are cross-sectional and investigate the performed prevention behaviors of individuals at the same time point as their perceived vulnerability and severity level. This can result in less strong, absent, or even negative correlations as someone might no longer feel vulnerable to the risk or will perceive its consequences differently after the prevention measures have been incorporated (cf. Milne et al., 2000). This issue is also addressed by Siegrist (2013) who emphasizes the need for experimental and longitudinal studies in order to test the 'true' causal relationships of risk perception variables with prevention behavior.

In line with the literature, we expect that perceived vulnerability and severity are relevant determinants for prevention behavior.

3.2.2 Evaluation of prevention behaviors: awareness, effectiveness, financial costs, and effort

Before even considering a specific prevention behavior, one must first be aware of the behavior and its preventive aspects. Although awareness of the (preventive aspects of the) behavior is not officially operationalized as a determinant for prevention behavior in PMT or HBM, it is a commonly studied determinant, for instance in cyber security prevention (Hanus & Wu, 2016; Talib, Clarke, & Furnell, 2010), earthquake prevention (Vincente, Ferreira, Maio & Koch, 2014; Yang, Gao, Liu, He, & Fan, 2010), and health risk prevention (Tenkorang, 2018). For domestic risk prevention we argue that people are more likely to perform a behavior, if they are aware of the behavior and its preventive aspects. Some behaviors might be not so well known, such as the fact that a smoke alarm needs to checked on a regular basis (Clark & Smith, 2018), while other behaviors might be known but its preventive aspects might be unknown (for instance knowing that cleaning the kitchen hood prevents a grease fire from getting bigger).

PMT and HBM also contend (Rogers, 1975, 1983; Rosenstock, 1966) that the motivation to take preventive action depends on an evaluation of the benefits and costs of the different prevention behaviors (in PMT this is referred to as the coping appraisal, which includes self-efficacy). We will label the benefits as the *perceived effectiveness* (referred to as response efficacy in PMT, and as perceived benefits in HBM) of the behavior: the perceived extent to which the behavior reduces the probability of the risk or mitigates the consequences of the risk. The *perceived costs* (referred to as response costs in PMT, and perceived barriers in HBM) refer to the potential negative aspects that are attached to the prevention behavior and for example include one or more of the following aspects: financial costs, time, effort, discomfort, painfulness, and unpleasantness, depending on the type of behavior (Floyd et al., 2000; Rosenstock, 1966). In HBM the costs of behavior are reflected by one single item, while in PMT the various type of costs are represented by multiple items (Weinstein, 1993). In the domain of domestic risk prevention behavior, especially *financial costs* and *effort* seem important, similar to findings in the domain of environmental risk prevention (Lindell et al., 2009; Poussin, Botzen, & Aerts, 2014). We follow PMT in this respect and include both type of costs in our study.

Meta-analyses have shown that both the perceived costs and the perceived effectiveness are important predictors for preventive behaviors, and in general, have stronger effects than the perceived vulnerability and severity (Bamberg et al., 2017; Bubeck et al., 2012; Floyd et al., 2000; Janz & Becker, 1984; Milne et al., 2000; Valkengoed & Steg, 2019). A study in the burglary prevention domain also found a small effect of perceived effectiveness on burglary prevention, but perceived costs were not included in this study (Wiegman, Taal, van den Bogaard, Gutteling, 1992). In line with the literature,

we expect the perceived effectiveness and perceived costs (more specifically: financial costs and effort) to be relevant determinants for performing domestic risk prevention behaviors.

A concept that has later been added to the original versions of PMT and HBM is self-efficacy (Rogers, 1983; Rosenstock, Strecher, & Becker, 1988), which refers to "the conviction that one can successfully execute the behavior required to produce the outcomes" (Bandura, 1977, p.193). Empirical evidence shows that this determinant is an important predictor in the domains of health risk and environmental risk (Floyd et al., 2000; Milne et al., 2000; Valkengoed & Steg, 2019), although there are also studies that show no effects of self-efficacy (Lindell & Prater, 2002; Lindell & Whitney, 2000; Zaalberg et al., 2009). A possible explanation might be that self-efficacy can be very closely related to the costs or barriers of a behavior, so that the effect of self-efficacy on top of the other variables is limited (Weinstein, 1993; Zaalberg et al., 2009). Because we expect that self-efficacy is largely reflected by the perceived costs (financial costs and effort) in the domain of domestic risk prevention, we excluded self-efficacy from our study.

3.2.3 Separating effects within-persons versus between-persons

Although there are differences with respect to the way in which previous studies have been conducted, several research design choices are common. Often, researchers test the determinants of prevention behaviors by performing regression type analyses on cross-sectional survey data. Most studies cover one particular risk, and ask people to indicate whether they (intend to) perform a specific behavior for a given risk (e.g. Chatterjee & Mozumder, 2014), or which behaviors from a set of behaviors they (intend to) perform (e.g. Martin et al., 2007; Zaalberg et al., 2009). When studying multiple prevention behaviors, these are often transformed into a single scale score measuring "the extent to which someone performs prevention behavior". A further difference between studies is whether the determinants are evaluated at the level of the requested prevention behaviors ("what is the effectiveness of behavior X") (e.g. Dang, Li, Nuberg, & Bruwer, 2014; Lindell et al., 2009; Lindell & Prater, 2002; Martin et al., 2007; Zaalberg et al., 2009) or on a more general level (e.g. "what is the general effectiveness of prevention behaviors", as in e.g. Jayanti & Burns, 1998). Although in the former case every determinant is being evaluated for every behavior, the scores are typically aggregated in a single scale score per determinant per person and analyzed as such.

What these research designs have in common is that between-person effects (some persons tend to perform more prevention behaviors than others) cannot be

distinguished from within-person effects (a person finds some prevention behaviors more attractive to perform than other behaviors), as either the data considers a single prevention behavior for a single risk, or scores have been aggregated per individual and can therefore only be analyzed at the between-person level. This is peculiar, as the (often implicit) argument of these underlying theories seems to be a within-person argument, where a change in an independent variable will result in a change in a dependent variable for a given person. This issue does not only relate to PMT and HBM but is a common problem is psychology, where typically psychological theories make intrapersonal inferences while these inferences are tested on a interindividual level (Collins, 2006; Curran & Bauer, 2011; Molenaar, 2004; Mroczek et al., 2003). An example explained by Curran and Bauer (2011) that makes the importance of separating the within- and between-person effects clear is the following: people are more likely to have a heart attack during or directly after exercising compared to less strenuous activities or no activity at all (a within-person effect), while at the same time, people that exercise more than others have a lower likelihood on having a heart attack (a between-person effect) (Curfman, 1993; Mittleman et al., 1993). Distinguishing both effects results in a more complete understanding of the true nature of the relationships. Moreover, it would be an error of inference to generalize the between-person effect to the individual level (Collins, 2006).

The within-person argument for prevention behavior can be described as follows: if an individual does not perform a specific prevention behavior, then affecting a characteristic of this behavior, such as increasing its perceived effectiveness, will cause that particular individual to become more likely to perform this prevention behavior (see e.g. Cismaru & Lavack, 2007; Maddux & Rogers, 1983; Sheeran, Harris, & Epton, 2014). This "within-persons between-behaviors" type argument is explicitly mentioned in Rosenstock (1966, p. 7): "The direction that the action will take is influenced by beliefs regarding the relative effectiveness of known available alternatives in reducing the disease threat to which the individual feels subjected. His behavior will thus depend on how beneficial he thinks the various alternatives would be in his case." The comparable but different "between-persons" argument is that persons who consider prevention behaviors in general as more effective (compared to other persons) are more likely to perform prevention behaviors. Both arguments assume that the perceived effectiveness of the behavior affects the likelihood of the performance of the behavior, but there is a crucial difference, as illustrated by the following hypothetical case (see Table 1). Suppose individual A considers prevention behavior P not effective at all and prevention behavior Q a bit more effective than P. Instead, individual B considers prevention behavior P quite effective and, similar to individual A, also finds prevention behavior Q a bit more effective than P. Using the logic of the "between-persons" argument, type B individuals are more likely than type A individuals to perform any of these prevention

behaviors because they find both behaviors more effective than type A individuals considers them. The logic of the "within-person" argument suggests that prevention behavior Q will be preferred over P and hence that Q will be executed more than P. The "within-person" argument concerns the characteristics of the behaviors (independent of the person), while the "between-persons" argument concerns the characteristics of the person independent of the behavior (i.e. a person finds all prevention behaviors effective, expensive etc). However, it may well be that there is a within-person effect for a given variable, while there is no between-person effect (or vice versa), as illustrated in Figure 1. In such a case, failing to disentangle and hence averaging out both effects might cause misleading results.

Table 1: Hypothetical scores of effectiveness of two individuals (A, B) for two prevention behaviors (P, Q).

	Prevention behavior P	Prevention behavior Q
Individual A	1	2
Individual B	4	5

Note. 1 = not effective at all; 5 = very effective.

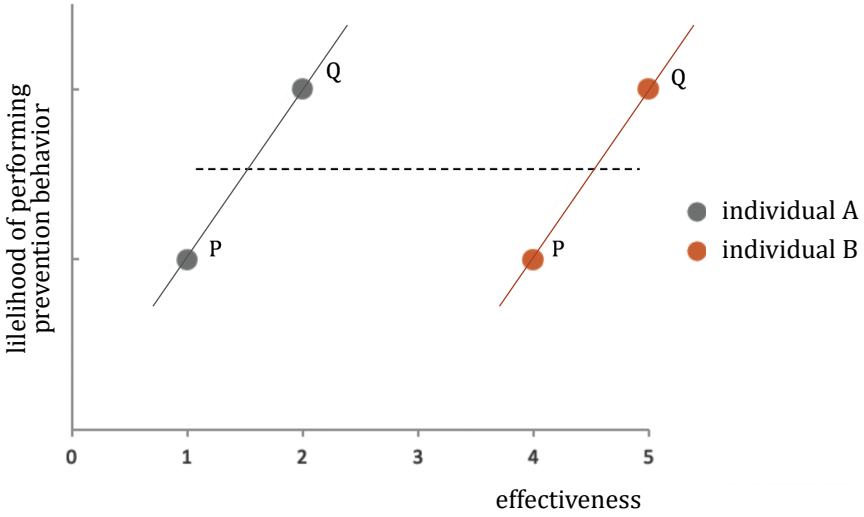


Figure 1:
Graph to illustrate the difference between within-person effects and between-person effects. While a within-person effect holds for individual A and B, there is no between-person effect (the dotted line is horizontal). The dots represent two different prevention behaviors: P and Q.

Note that although this distinction is rare in the PMT/HBM literature, it is a common approach in research that employs mixed designs and is related to what is called "group mean centering in multi-level studies" (Blalock, 1984; Enders & Tofighi, 2007). Disentangling the two arguments is only possible in a research design in which multiple behaviors and risks are evaluated on multiple determinants per person, and are subsequently analyzed in a multi-level manner (Trafimow & Finlay, 1996). Given that we employ a mixed design, our hypotheses can be disentangled into both the within-person (H1a - H6a) and the between-person (H1b - H6b) arguments (visually represented in Figure 2). We expect that the effects primarily will run within-persons, instead of between-persons, also given that most arguments in the literature seem to be based on this idea and given that this is consistent with the relatively small impact that individual characteristics seem to have on prevention measures in the literature. However, for clarity and completeness, we also formulate the between-persons hypotheses.

The probability that an individual performs a specific prevention behavior is larger for a prevention behavior that prevents or reduces a risk that this individual…

… perceives him or herself as more vulnerable to (compared to other risks) (H1a)
… perceives as more severe (than other risks) (H2a)

The probability that an individual performs a specific prevention behavior is larger for a prevention behavior that this individual…

… perceives as more effective (than other behaviors) (H3a)
… perceives as less costly (than other behaviors) (H4a)
… perceives as less effortful (than other behaviors) (H5a)
…is aware of (than one that one is not aware of) (H6a)

Individuals will perform more prevention behaviors if individuals score higher than other individuals on…

… perceived vulnerability (H1b)
… perceived severity of the risks (H2b)
… perceived effectiveness of the prevention behaviors (H3b)
… perceived costs of the prevention behaviors (H4b)
… perceived effort of the prevention behaviors (H5b)
… awareness of the prevention behaviors (H6b)

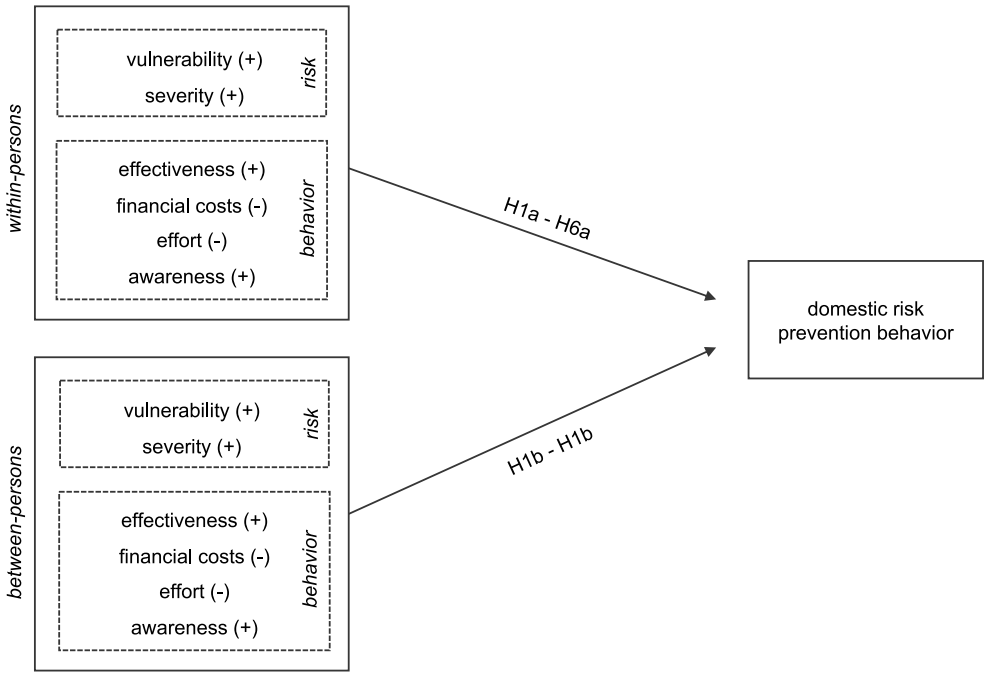


Figure 2:
Hypothesized model of the prevention behavior determinants, disentangled into between-person and within-person variables, that influence domestic prevention behaviors (H1a-H6b). Between-person effects represent the mean of the determinants across persons. Within-person effects represent the deviation from the mean of the determinants per person. (+) represents a positive relationship. (–) represent a negative relationship.

3.2.4 Socio-economic variables

Studies that test the PMT or HBM variables, often also incorporate socio-economic variables such as gender, age, education, or home ownership (Bubeck et al., 2017; Chatterjee & Mozumder, 2014; Grothmann & Reusswig, 2006; Lindell & Whitney, 2000; Lindell & Perry, 2000; Pakenham et al., 2007; Siegel et al., 2003; Zaalberg et al., 2009). Although results differ, in general, correlations of the socio-economic variables with prevention behavior are small (Lindell & Perry, 2000; Zaalberg et al., 2009) and tend to be weaker than the effects of the PMT/ HBM variables (Bubeck et al., 2012; Bubeck et al., 2017; Grothmann & Reusswig, 2006). In this study we incorporate the following socio-economic variables as control variables: age, gender, education, family situation, home ownership, year of construction, and type of home.

3.3 Method

3.3.1 Participants and procedure

The data was collected through a survey sent to a consumer panel managed by a research company in the Netherlands. The survey was sent on April 29th in 2016. The criteria for participation were: participants had to be customers of a specific insurance company in the Netherlands and had to own a contents or a home insurance. As an incentive, participants received points that they could exchange for gifts. In total 263 participants completed the survey. The majority of the participants (77.9%) completed the survey within 5 to 15 minutes, with a median of 613 seconds.[4] In the invitation it was made clear that the research was conducted by the specific insurance company and that the survey was about prevention behavior. It was stated that the survey questions could be best answered by the person in the household who is most involved with burglary, fire, and water damage prevention. It was stressed that there were no right or wrong answers and that the responses were confidential and would only be used for research purposes.

3.3.2. Measures

3.3.2.1 Background questions

The background questions included gender, age, education, household composition, home ownership, type of home, construction date of the home, indication fire-place (beyond the scope of this chapter) and who has the primary responsibility for domestic prevention behaviors within the household.

3.3.2.2 Prevention behavior self-reports

Prevention behavior was measured with nine prevention behavior self-reports. We coded all behavioral self-reports into 0 ("no") or 1 ("yes"). Appendix C shows all items of the prevention behavior self-reports and the cutoff values that were used. The answer possibilities "I do not know' and "not applicable" were treated as missing values. The nine prevention behaviors were selected based on a spread in the risks involved, curtailment and investment behaviors[5], and expected prevalence (see Table 2). The expected prevalence was based on an earlier study (Jansen, Willemsen, & Snijders, 2016).

4 The mean duration was 829.5 seconds (SD = 1303.8). However, the mean duration time is not a good representation here, since if participants did not close their browser, time kept on running.

5 The terms "curtailment behaviors" and "investment behaviors" are adopted from the energy conservation domain. Curtailment behaviors are behaviors someone has to perform regularly in order to conserve energy. Investment behaviors are behaviors that, in general, require a one-time action such as an investment or the purchase of an energy-efficient appliance (Karlin et al., 2012).

Table 2: Measured prevention behaviors and their risk categories, the type of behaviors and their prevalence (%) .

Risk	Type	Prevention behavior	Prevalence[1] (%)
Burglary	Curtailment	Lock doors when leaving	90.1%
	Investment	Anti-burglary strips	(not available)
		Alarm system	12.6%
Fire	Curtailment	Clean kitchen hood	48.0%
		Check smoke alarm	17.0%
	Investment	Smoke alarm	78.0%
		Fire blanket	36.1%
Water damage	Curtailment	Clean roof top gutter	53.0%
	Investment	Dripping tray for washing machine	21.5%

Note.[1] The prevalence of prevention behaviors was based on an earlier study (Jansen, Willemsen, & Snijders, 2016). The prevalence of anti-burglary strips was not included in that study.

3.3.2.3 Prevention behavior determinants

Participants were asked to rate the perceived vulnerability and perceived severity for the risks that can be prevented or mitigated by these nine prevention behaviors. These risks were: burglary, grease fire, a fire of reasonable size, leaking washing machine, and a leaking gutter, all measured with 7-point Likert scales. We measured vulnerability with the following item "How high do you perceive the probability of the following risks for your home to be?" (1 = very low; 7 = very high). Severity was measured through "How severe do you perceive the consequences of the following risks for your home to be"? (1 = not severe at all; 7 = very severe). Participants were asked to evaluate the other determinants (effort, effectiveness, financial costs, and awareness) for every prevention behavior. Effort was measured with "How much effort is it for you to [lock the doors every time when you leave your home]?" (1 = very little effort; 7 = a lot of effort). Effectiveness was measured with "How effective do you find the following measures for your home, to prevent or mitigate the consequences of [burglary; fire; water damage]?" (1 = not effective at all; 7 = very effective). For the item regarding the perceived costs, respondents could fill out an amount in euro. We log-transformed this variable, as is common for variables where differences for smaller values are more pronounced than differences for larger values. The awareness of the prevention behaviors was measured with "Were you, before filling in this questionnaire, aware of the following prevention behaviors in order to prevent or mitigate [burglary; fire; water damage]?" (No = 0; Yes = 1).

3.3.3 Data analysis

We analyzed our data using multilevel logistic regression analyses (Stata 14, 2015), since the data is hierarchically structured so that prevention behaviors are nested within individuals. Our multi-level research design, where every person evaluates multiple prevention behaviors, allows to study the effects of the prevention behavior determinants on two levels: within-persons (i.e. "the individual level" or "Level 1") and between-persons (i.e. "the cluster level" or "Level 2") (Enders & Tofighi, 2007). The between-person variables are defined as the mean of a variable for a person (for instance, the mean effectiveness that a person perceives for the nine behaviors). The within-person variables are defined as the deviations from the person mean. This procedure is referred to as group-mean centering (GMC) or centering within cluster (CWC).

3.3.4 Data preparation

We removed participants who did not vary their answers across the prevention determinants (n = 10). This reduced the dataset to n = 253, with in total 253 * 9 = 2,277 cases. The costs for behaviors that involve no financial costs (clean kitchen hood, check smoke alarm and lock doors) were set to zero. For cleaning the roof top gutter, people were asked to fill out a zero for financial costs if they cleaned the gutter themselves, and to fill out a certain amount if they paid someone to do this. Some people (max 5.2%) filled out a zero for the other prevention behaviors (alarm system, anti-burglar strips, smoke alarm, fire blanket, dripping tray. We treated these zeros as missing values, since these measures obviously should have some (perceived) costs associated with them. With respect to the missing values of the prevention behavior determinants, costs had 14.8% missing values, whereas the other determinants had missing value percentages below 2%. Part of the missing values can be explained by the fact that some items were conditional. For example, a participant did not have to answer items about a dripping tray for the washing machine in case he or she did not own a washing machine. After taking all missing values into account, this results in 1,810 complete cases. With respect to the perceived vulnerability and severity of the risk of fire, we asked separately how high/severe participants perceived the probability and consequences of a general fire (linked to: smoke alarm) and of a grease fire (linked to: fire blanket). As the correlation between these variables was high (vulnerability r = .84; severity r = .90) we included only the variables concerning the general fire in the regression models. Correlations between the independent variables were low (< .28), making multicollinearity unlikely.

3.5 Results

3.5.1 Descriptive statistics

Descriptive statistics of our sample can be found in Table 3.

Table 3: Descriptive statistics of sample (n = 253).

Variable	Category	%
Gender	Male	66.4%
Age	18-29	7.1%
	30-39	14.2%
	40-49	19.8%
	50-59	19%
	60-69	17%
	>70	22.9%
Education	Primary education	.8%
	Preparatory vocational education	28.1%
	Secondary vocational education or secondary education	36.8%
	BSc. or MSc. level education	34.4%
Household composition	Married/ living together, with Children at home	24.5%
	Married/ living together, without children at home	41.9%
	Single with children at home	4.4%
	Single without children at home	29.3%
Ownership home	Yes	64.4%
Type of home	Detached home	17.4%
	Bungalow	1.6%
	Semi-detached home	16.6%
	Terrace home	36.8%
	Apartment/ studio	19.4%
	Room	.4%
	High-rise building	3.6%
	Other	4.4%
Year of construction[1]	< 2003	77.8%
	2003 or later	14.2%
	Do not know	7.9%
Primary responsibility for prevention in home	Me	79.1%
	Partner	17.8%
	Someone else	3.2%

Note.[1] Houses built in 2003 or later were obligated by law to have smoke alarms at the time of their construction.

Table 4 shows the descriptive statistics of the prevention behavior self-reports and the prevention behavior determinants. The most prevalent behavior is 'locking doors when leaving the house' (91.3%), which is also the behavior that most people are aware off (96.8%), is perceived as the most effective (M = 5.78), and perceived as the least effortful (M = 1.87). People feel most vulnerable to burglary (M = 3.22 - 3.27) while a fire is perceived as the most severe risk (M = 5.03 - 5.16).

Table 4: Prevention behavior self-reports and awareness of prevention behaviors in %, and mean (*M*)[1] and standard error (*S.E.*) scores on prevention behavior determinants.

Prevention behavior	Prevalence	Awareness	Vulnerability	Severity	Effectiveness	Cost in €	Effort
	(1 = yes)	(1 = yes)	M (S.E.)	M (S.E.)	M (S.E.)	M (S.E.)	M (S.E.)
1. Alarm system	17.8%	87.0%	3.27 (.10)	4.75 (.11)	4.43 (.12)	617.3 (48.6)	4.03 (.13)
2. Anti-burglary strips	28.8%	69.2%	3.22 (.10)	4.76 (.11)	4.6 (.11)	90.1 (12.3)	3.27 (.12)
3. Lock doors when leaving the house	91.3%	96.8%	3.23 (.09)	4.73 (.10)	5.78 (.10)	0	1.87 (.09)
4. Smoke alarm(s) on every floor	56.3%	87.8%	3.0 (.08)	5.03 (.1)	5.58 (.10)	85.4 (34.0)	2.69 (.12)
5. Check smoke alarm(s)	26.5%	85.0%	3.02 (.08)	5.03 (.10)	5.46 (.09)	0	2.74 (.10)
6. Clean kitchen hood	43.1%	71.2%	3.02 (.08)	5.03 (.10)	5.22 (.09)	0	2.68 (.11)
7. Fire blanket	35.4%	79.8%	3.00 (.08)	5.03 (.10)	5.14 (.10)	30.3 (1.7)	2.22 (.10)
8. Clean roof top gutter	55.5%	74.7%	2.91 (.10)	3.62 (.12)	5.36 (.10)	34.0 (7.0)[2]	2.84 (.13)
9. Dripping tray	27.6%	68.0%	2.94 (.10)	3.81 (.11)	4.60 (.12)	31.0 (2.1)	2.82 (.13)

Note.[1] Mean scores are presented for all cases that were included in the regression analysis. Missing cases are excluded.
Note.[2] When removing the cases who filled out zero (62.2% people clean roof top gutters themselves) costs are *M* = 89.9, *S.E.* = 16.4.

3.5.2 Statistical analyses

Running an empty multilevel logistic regression model showed that the variance in the probability of performing prevention behaviors at the individual level was very small (ρ = .004). Stated otherwise, most of the variance in prevention behaviors resides at the level of the prevention behaviors' characteristics (within-persons) and our data do not support the notion that prevention behavior strongly depends on personal characteristics (between-persons) (Killip, Mahfoud, & Pearce, 2004). Note that we can only make this assessment as a direct consequence of the research design in which we let every person evaluate multiple prevention behaviors.

To test the hypothesized relationships of Figure 2 (H1a - H6a; H1b - H6b), we estimated a multilevel logistic regression model (model 1, Table 5) with the within-person determinants and between-person determinants as predictors, controlling for all socio-economic variables. Of the control variables, only age had a significant negative effect on prevention behavior. On closer inspection, this effect was caused largely by a difference between the 18-29 age group and all others (b = 0.783, *p* = .001). The results of the control variables can be found in Appendix D. Results (see model 1, Table 5) showed that all within-person variables were significant, confirming H1a and H3a - H6a and

rejecting H2a as the effect was significant in the opposite direction. Thus, an individual who perceives a specific behavior as more effective, less costly, and less effortful compared to other behaviors, and feels more vulnerable to the corresponding risk compared to other risks, is more likely to perform that specific behavior (compared to other behaviors). The only exception is the effect of severity. As the severity for a risk for a given individual increases, the probability of performing the corresponding behavior decreases. Of the between-person variables only 'effectiveness' and 'awareness' were significant, in line with H3b and H6b. This suggests that individuals who find prevention behaviors in general more effective and are more aware of prevention behaviors in general, will perform more prevention behaviors compared to persons who score lower on these determinants. Comparing the predicted probabilities between the lowest and highest value of the predictors while keeping the other variables at their mean showed that all the within-person variables had larger effect sizes than the between-person variables (Table 6). When only looking at the within-person variables, effectiveness had the largest effect size (0.775) followed by effort (-0.722). Together, these results imply that all prevention behavior determinants also have significant effects in the domain of domestic risk prevention, and that effects run primarily within-persons. Whether people perform prevention behaviors depends more on the relative evaluation of the prevention behavior determinants within a person, than on general differences in average estimates between persons.

Table 5: Model fit statistics (χ^2, *p*, ρ), unstandardized coefficients estimates (B), standard errors (S.E.), significance level (p) for model 1 (multi-level logistic regression analysis with within- and between-person effects), controlled for socio-economic variables.

	Model 1			
	Within-persons		Between-persons	
	B	S.E.	B	S.E.
Costs	-0.130***	0.030	-0.149	0.086
Effort	-0.385***	0.054	-0.031	0.064
Effectiveness	0.587***	0.062	0.160*	0.066
Awareness	1.255**	0.210	1.394***	0.352
Vulnerability	0.145*	0.077	0.054	0.060
Severity	-0.189***	0.062	- 0.021	0.050
χ^2		474.25		
p		.000		
Pseudo R^2		.206		

Note. * = $p < .05$; ** = $p < .01$; *** = $p < .001$
Note. Between-persons coefficient is based on the mean of the predictor across all persons. Within-person coefficient is based on the deviation of the mean of the predictor across behaviors for one individual.
Note. Control variables were: age, gender, education, family situation, house ownership, year of house construction, type of home.

Table 6: Effect sizes (margin difference between maximum and minimum value) for variables of model 1 (with between-person and within-person effects) controlled for socio-economic variables.

	Model 1	
	Within-persons effect size	Between-persons effect size
Costs	-.343	-.127
Effort	-.742	-.045
Effectiveness	.805	.221
Awareness	.489	.293
Vulnerability	.309	.063
Severity	-.367	-.030

Our design allows us to illustrate that we would have received different, or at least incomplete, results if we had performed multi-level logistic analysis with "fixed effects" or if we had performed a linear regression analysis with aggregated scores as is more common in other PMT/HBM studies (Dang, Li, Nuberg, & Bruwer, 2014; Jayanti & Burns, 1998; Lindell & Prater, 2002; Martin et al., 2007; Zaalberg et al., 2009). First, we estimated a multilevel logistic regression model (model 2, Table 7) with the prevention behavior determinants as predictors, controlling for all socio-economic variables. In this analysis all within and between effects are aggregated ("fixed effects"). The results of model 2 show that all prevention behavior determinants had a significant effect on performing prevention behavior in the expected directions, except for severity, which had a negative direction. Second, we estimated a between-persons regression model with the sum of prevention behaviors as the target variable and the mean scores of the prevention determinants as the independent variables (model 3, Table 7). In this case, the results showed that both 'effectiveness' and 'awareness' are significant determinants for prevention behavior, which is comparable with the between-person results of the multi-level logistic regression analysis (model 1, Table 5).

Analyzing the results by separating within-person and between-person effects (as in model 1) compared to analyzing the effects all together (as in model 2) or performing solely between-person analyses based on aggregated scores (as in model 3), allows to better understand the source of the effects. For example, in model 2, effort had a significant negative effect on prevention behavior, implying that the higher the perceived effort, the less likely the prevention behavior is performed. When separating the effects, the variable effort appeared to only have a significant negative effect within-persons, but not between-persons. Implying that the effect of effort only runs within-persons: the higher the perceived effort of a behavior compared to other behaviors by an individual, the less likely the prevention behavior is performed by that individual. When performing between-person analyses on mean scores, we could have had incorrectly concluded that 'effort', 'financial costs', 'vulnerability', and 'severity' had no effects in the area of domestic prevention behavior. While, when separating the effects, these

determinants all appeared to have significant effects, with the nuance that these effects run within-persons.

Table 7: Model fit statistics, unstandardized coefficients estimates (B), standard errors (S.E.), significance level (p) for model 2 (logistic multi-level regression analysis with fixed effects) and model 3 (linear regression between-person analysis with aggregated scores), controlled for socio-economic variables.

	Model 2		Model 3	
	B	S.E	B	S.E
Costs	-0.186***	0.028	0.002	0.106
Effort	-0.234***	0.044	-0.085	0.101
Effectiveness	0.400***	0.049	0.342**	0.105
Awareness	1.367***	0.192	1.572**	0.521
Vulnerability	0.102*	0.048	0.013	0.095
Severity	-0.110**	0.039	-0.040	0.080
χ^2 resp. F (23, 209)	247.49		3.97	
p	.000		.000	
ρ resp. R^2	.030		.304	

Note. * = $p < .05$; ** = $p < .01$; *** = $p < .001$
Note. Control variables were: age, gender, education, family situation, house ownership, year of house construction, type of home.

We ran several slightly different variants of the analyses to test the robustness of our results under different implementations of the model. Our results are robust to deviations in terms of the kinds of individuals or behaviors included: effects within-persons and between behaviors are generally larger than between-person effects. Also, statistical significances and effect sizes remain similar across analyses, although the within-effect of vulnerability is not that robust when excluding cases or persons (see Appendix E).

3.5 Discussion

In line with the previous literature we found that all PMT/HBM determinants were relevant predictors for domestic risk prevention behavior (Floyd et al., 2000; Janz & Becker, 1984). The determinant 'awareness' that was added in this study, also appeared to significantly correlate with domestic risk prevention behavior. The determinants related to the evaluation of the prevention behaviors (effectiveness, costs, effort, awareness) correlated stronger with prevention behavior than the determinants related to the evaluation of the risk (vulnerability, severity), which is also in line with previous findings (Floyd et al., 2000; Milne et al., 2000). Our findings are also consistent with earlier studies in the domain of flood mitigation behavior that the effects of socio-economic variables are weaker than the effects of the PMT/HBM variables (Bubeck et al., 2012; Bubeck et al., 2017; Grothmann & Reusswig, 2006).

Our study shows that disentangling within-person and between-person effects makes it possible to better interpret the results and draw conclusions that have not been adequately addressed in previous literature. Disentangling the within-person and between-person effects (known as "group mean centering in multi-level studies"; Blalock, 1984; Enders & Tofighi, 2007) is only possible in a research design in which multiple behaviors and risks are evaluated on multiple determinants per person. Most variance in the performance of prevention behaviors could be explained by differences in the characteristics of the prevention behaviors rather than by differences in the characteristics of persons. In line with this result is that within-person variables had a larger and more often significant effect on prevention behavior compared to the between-person variables. Even if we assume that (a larger) part of the variance in the within-person measurements is due to noise because the between-person measures averaged out the noise to some extent (cf. Falk et al., 2018, p. 1665), the size of the effects of the within person measurements is so much larger (than the effect of the between-person measures) that it is unlikely to be explained away by just measurement error. The within-person variables 'vulnerability', 'effectiveness', 'costs', 'effort' and 'awareness' all showed effects in the hypothesized directions. For instance, this means that there is a higher likelihood that a person performs a specific prevention behavior, when he perceives that behavior as more effective than another behavior. Concerning the between-person effects, only 'effectiveness' and 'awareness' had a positive and significant effect on prevention behavior. Persons who find prevention behaviors in general more effective and are more aware of prevention behaviors, have a higher likelihood of performing prevention behaviors compared to persons who score lower on these determinants. However, even for 'effectiveness' and 'awareness', both of which showed significant effects within-persons and between-persons, the within-person effects were larger than the between-person effects. Together, these results indicate that the likelihood of performing prevention behaviors depends more on the relative evaluation of the prevention behavior determinants within a person, than on the relative evaluation of the prevention behavior determinants between-persons.

An important issue is that our study is cross-sectional, so that the data only shows correlation and not causality. This problem is common in PMT/HBM studies and especially holds for the risk perception variables, since someone's perception of a risk might change due to the prevention measure taken (Bubeck et al., 2012; Milne et al., 2000; Siegrist, 2013; Weinstein et al., 1998). The fact that severity in our study showed a negative relationship with prevention behavior might be the consequence of this issue. A person might already undertake prevention behaviors to mitigate the risk (e.g. own a smoke alarm, a fire blanket or a dripping tray) and therefore perceives the risk as less severe compared to other risks (Bubeck et al., 2012; Milne et al., 2000; Weinstein et al., 1998). Although this might be an explanation for the negative within-person effect

found for severity, this (negative) relationship is not found for vulnerability (for which a similar argument could be made).

A second limitation of this study is that we selected nine prevention behaviors out of all possible prevention behaviors concerning fire, burglary, or water damage with a range of differences in prevalence. Although we see no obvious reason why the effects could not be generalized to other prevention behaviors related to these risks, the coefficients might differ when changing the set of prevention behaviors. Also, for some prevention behaviors other effects may play a role. For instance, because some measures are obligated by law in newly built houses (e.g. certified locks on doors) variables that were not significant in this study (e.g. year of house construction) might play a substantial role depending on local rules and regulations.

The findings of this study have important implications for those who want to persuade individuals to perform prevention behaviors, though the argument is a complicated one and can only partially be addressed here. When choosing what to try and influence, one has to take into account what is easiest to influence (which we did not consider), and what kinds of effects this then has on behavior. In principle, and regardless of our findings, it would be more efficient to influence someone's general inclination to perform prevention behaviors, as this would make all prevention behaviors more attractive. However, our results show that this general inclination between individuals cannot easily be explained away by individual differences. For instance, our findings suggest that convincing someone that performing prevention behaviors takes much less effort than they think – assuming that this would be possible to achieve – does probably *not* lead to more prevention behaviors. Instead, it seems to be the relative comparison of prevention behaviors that works better, so that, in the case of domestic prevention behaviors, it would actually be better to highlight that a single prevention behavior takes less effort than people thought. Their general inclination to carry out prevention behaviors would not change, but their likelihood to carry out that particular prevention behavior would increase. Matters become even more complicated when we consider how such arguments pan out when the between-person effect is small (instead of zero). In this case, even a small increase in the general inclination might be worthwhile as this small increase has an effect across a multitude of behaviors. This highlights a line of research that is currently largely absent: what are the net benefits of trying to influence either someone's general inclination versus trying to influence the perception of a single prevention behavior.

A second line of research that would be fruitful is to think through more carefully and elaborately which kinds of scenarios are consistent with the findings as we present

them here. For instance, our findings are consistent with a scenario where individuals have a fixed 'budget' for prevention behaviors that is relatively independent of what they think of prevention in general. Instead, they have a preference order over the different prevention behaviors and choose the ones that they prefer most. In such a scenario, influencing the rank order of prevention behaviors has large effects, whereas influencing the general inclination to prevent has not. We are not claiming that this scenario is necessarily the most likely one but theorizing about the underlying reasoning and behavior more thoroughly and testing these theories with also other than cross-sectional surveys, seems a necessary step.

It is nevertheless possible to come up with relatively straightforward practical implications based on our findings. First, if one wants to increase domestic prevention behavior, we find (for obvious reasons) that awareness is key: you have to make sure people know that the specific behavior exist. Second, influence the perceived effectiveness and/or perceived effort of a specific behavior (compared to other behaviors), given that these are the strongest effects that we find. Based on our results we advise against trying to increase people's general perception to risks, that is, increase people's perceived vulnerability and severity level for fire, water damage, and burglary all together. Additionally, selecting a specific target group to promote prevention behaviors, for instance people that feel particularly vulnerable to all risks or think all prevention behaviors require little effort, also seems not very fruitful since the between-person effects were small and sometimes non-existent.

4

Playing with fire. Understanding how experiencing a fire in an immersive virtual environment affects prevention behavior

This chapter is published as a journal paper:
Jansen, P.C.P., Snijders, C.P., & Willemsen, M.C. (2020).
Playing with fire. Understanding how experiencing a fire in an immersive virtual environment affects prevention behavior. *PlosOne, 15(5).*
https://doi.org/10.1371/journal.pone.0229197

4.1 Introduction

For the year 2014, the US fire Administration reported 379,500 residential building fires of which 12,075 cases resulted in an injury and 2,765 cases were fatal (U.S. Fire Administration, 2016). The most common cause of these residential building fires were cooking fires. For the Netherlands similar findings apply: a grease fire was the most important cause of fatal fire incidents (Institute for Safety, 2015b). The use of prevention measures can help to reduce this number: while a smoke alarm helps to signal a grease fire on time, a fire blanket or a fire extinguisher enables people to extinguish a grease fire before it expands. Insurance companies and society at large would benefit if more people would own and apply preventive measures.

While mass communication is a typical way to influence people's behavior, mass communication about risks tends to only affect the judgement of risks on a societal level and not on a personal level (Tyler & Cook, 1984). In contrast, research concerning natural hazard experiences has shown that personal risk experience can stimulate self-protective and coping behavior (Siegel et al., 2003; Siegrist & Gutscher, 2008; Zaalberg et al., 2009). Personal experience can influence preventive behaviors, and can even have a larger effect on preventive behaviors than general communication messages because of an increase in susceptibility and worry (Weinstein, 1989). A precondition is that the experience is more severe than expected, and that the specific preventive measures are perceived to be effective (Weinstein, 1989).

In the current study we use an Immersive Virtual Environment (IVE) to have participants experience the large impact of a virtual grease fire and to experience how a simple preventive measure such as a fire blanket can reduce the impact of the fire. Our study has three characteristics that, taken together, are an addition to the current IVE literature. First, while there are studies in other domains that study the effects of experiencing a hazard in an IVE (e.g. flood risk, aircraft evacuation, terror attack), our study is the first to study the effects of experiencing a virtual fire. Second, we consider the effects of an IVE on a full set of "psychological determinants" (knowledge, vulnerability, severity, self-efficacy, and locus of control) and analyze them all together. Whenever we refer to psychological determinants in the remainder of this paper, we refer to this set of concepts that are considered drivers for prevention behavior. Third, and most importantly, we measure actual prevention behavior, and test to what extent psychological determinants have an effect on actual behavior. This paper is structured as follows: we first present a brief overview of the use of IVEs to simulate risks. We then present our theoretical framework and hypotheses. Then, we test these hypotheses in a single estimation with a Structural Equation Model. Finally, we discuss the results and their implications.

4.1.1 Risk simulation in an Immersive Virtual Environment

Simulated experiences can be an effective way to influence people, as people often react to virtual experiences as if they were real (Fogg, 2003). They also allow people to (better) observe the link between cause and effect, which in turn can positively influence peoples' attitudes and behaviors (Fogg, 2003). Next to the persuasive benefits that might arise after the message has been delivered, using virtual reality tools can increase the attractiveness of getting the message across, as people may generally be not interested or motivated enough to search for information themselves.

Studies on the effects of simulated risk experiences in immersive virtual environments (IVE), also known as virtual reality (VR), are relatively recent, although the argument as to why they might work has been around considerably longer. In this paper we also consider virtual 3D environments (the precursors of IVE) as a type of IVE. With IVE "users are perceptually surrounded by and immersed in an artificially-created environment" (Persky & Blascovich, 2008, p. 57). Often, the user's position and orientation is tracked through a tracking system and the user experiences the virtual environment and his orientation (i.e. if the user's head turns right, visual information of the right side of the IVE is perceived) through a head mounted display. Physical movement in the IVE can be performed by making use of advanced tracking systems on the user's body (e.g. special gloves), possibly combined with a motion platform, but also more traditional analog devices (e.g. a joystick) can be used. Currently well-known consumer tools that offer IVE through a head-mounted display are the Oculus Rift, Samsung Gear, and the HTC Vive.

A distinctive characteristic of IVE is its influence on a human's sense of *presence*: "the subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer & Singer, 1998, p. 255). This increased sense of presence in IVE can lead to an increase or decrease in emotions, for example an increase of fear when confronted with a virtual spider (Peperkorn, Diemer, & Mühlberger, 2015) or the increase of aggressive feelings in the case of playing a violent videogame (Persky & Blascovich, 2008). This sense of presence makes, amongst other factors, an IVE also a suitable research tool to study human behavior in a simulated environment, for example to study human behavior while in interaction with fire (Andrée, Nilsson, & Eriksson, 2016). Another potential IVE application within the domain of fire, because of the ability to influence emotions and behavior, is to use IVE to influence people's fire prevention behavior.

Several studies have shown that interactive (immersive) virtual environments in which risks are simulated can influence knowledge, emotions, attitudes, and intentions. For

example, Zaalberg and Midden (2013) have shown that an interactive 3D environment showing a flood simulation can result in increased motivation to search for information, increased motivation to evacuate, and a (small) increase in the willingness to buy flood insurance (compared to non-interactive 2D environments). Furthermore, Chittaro and Zangrando (2010) have shown the impact of emotional intensity on awareness of personal fire safety in a fire evacuation game in an IVE. Their results have shown that the highly emotional game (with more visual and audio feedback) produced more anxiety and positively affected participants' attitudes towards the dangers of smoke compared to a more mellow game. Another study of Chittaro and Sioni (2015) in which a terror attack was simulated showed that the interactive 3D environment had more impact on risk perceptions than the non-interactive 3D simulation. In the domain of airplane safety, Chittaro (2012, 2014, 2016) has shown that a 3D serious game increased the knowledge about safety procedures and feelings of self-efficacy, and made participants feel more "in control" when confronted with emergency landings. This result is suggested to have positive behavioral implications since both self-efficacy as well as safety locus of control have proven to be important predictors for the performance of safety behaviors. Also, an IVE can result in more knowledge retention: an IVE in which people experienced a plane crash resulted in more knowledge concerning safety procedures, compared to a safety instruction card, one week after the intervention (Chittaro & Buttussi, 2015).

While it is promising that previous studies have shown positive effects on knowledge, locus of control, and other psychological determinants, such studies more or less implicitly assume that these effects are indicative of a subsequent improvement in behavior. There are hardly any studies in the safety domain that follow through on the effect of IVE on psychological determinants. In fact, as far as we know, the effects of risk simulation in an IVE on behavior are hardly measured at all, with or without the measurement of psychological determinants. This is the main contribution of our study, applied to the domain of fire prevention.

We now discuss a conceptual model that considers how IVE (when compared to non-IVE delivery of information) affects individuals' psychological determinants with respect to (fire) prevention, and through these, may lead to preventive behavior.

4.2 Theory and hypotheses

From literature we have identified five psychological determinants that have an important role in influencing individuals' prevention behavior and that are likely to be influenced by experiencing a fire in an IVE: knowledge, severity, vulnerability, self-efficacy, and locus of control. Three of these psychological determinants are grounded in two popular theories that offer a framework for the explanation of prevention

behavior: Protection Motivation Theory (PMT) and the Health Belief Model (HMB). The HBM, originally developed by Rosenstock (1966) and later discussed and revised by many scholars (Burns, 1992; Janz & Becker, 1984; Rosenstock, Strecher, & Becker, 1988), was developed to explain health prevention behavior. PMT was originally developed to explain the effects of fear arousing communications, referred to as "fear appeals" (Rogers, 1975), and later extended to a more general theory on behavioral change (Maddux & Rogers, 1983). Both theories use similar psychological determinants to explain behavior and are commonly used to explain preventive behaviors in the areas of health- and environmental risk. The basic idea behind both theories is that prevention behavior is driven by the evaluation of the risk (perceived vulnerability and severity), and by an evaluation of the coping response (barriers and benefits of the behavior, self-efficacy). The underlying arguments are equally appropriate for the area of fire prevention behavior, since this contains both a risk element as advised coping responses to deal with the risk. Besides these variables from PMT and HBM, knowledge about the topic and locus of control are also considered variables that may be influenced by IVE and may themselves influence subsequent prevention behavior (Ahn, Bailenson, & Park, 2014; Chittaro, 2014; Chittaro & Buttussi, 2015). Knowledge about the risk and possible risk-mitigating prevention behaviors, enables people to make the right preventive decisions (Proulx, 2001). While locus of control refers to the extent someone believes a negative event is something within their control, which is related to more safe behaviors (Hoyt, 1974; Jones & Wuebker, 1993; Montag & Comrey, 1987; Wuebker, 1986).

The link between these theories and risk simulation in an IVE can easily be established. Research on the effects of IVE's often focuses on exactly the psychological determinants that are considered in PMT and HBM: after the exposure to the IVE someone may feel more vulnerable or at risk of some event *(vulnerability)*, or may assess the consequences of potential events differently than they did before *(severity)* (Chittaro, 2012, 2014; Chittaro & Buttussi, 2015; Chittaro & Sioni, 2015; Zaalberg et al., 2009), or may have more confidence in their ability to perform a specific behavior or in their coping ability *(self-efficacy)* (Chittaro, 2012; Chittaro, Corbett, McLean, & Zangrando, 2018; Chittaro & Sioni, 2015; Manzoni et al., 2009; Tarnanas & Manos, 2004). While almost all IVE research focuses on such potential "mental effects", in many cases the ultimate goal is to affect individuals' behavior. However, many researchers have left the relation between psychological determinants and actual behavior untested and sometimes unmentioned, probably in part because it is often difficult, or even impossible, to test the effects of IVE exposure on behavior.

While some studies have demonstrated the relationship between psychological determinants and behaviors (Armitage, 2003; Huang & Ford, 2012; Schwarzer,

Luszczynska, Ziegelmann, Scholz, & Lippke, 2008), this relationship is not always straightforward (Ahn et al., 2014) and might depend on the context such as the domain, the behavior under study etc. We argue it is appropriate or at least worthwhile to study psychological determinants and the target behavior(s) simultaneously whenever possible, to test whether a change in determinants really results in a change in behavior.

Based on the arguments as suggested in the literature, and specific to our case of fire prevention, we created a conceptual model that outlines the effects we expect to find (see Figure 1). Although these psychological determinants have been used before and are similar across IVE studies, it still depends on the type of risk under study which determinants are relevant, and in what direction they should be influenced. For example, it is hardly necessary to increase the perceived severity of an emergency landing as people already consider this to be very severe; people should be convinced about their survival possibilities through influencing their knowledge and adoption of the advised safety procedures (Chittaro, 2012). On the other hand, in the case of a fire, people are more likely to underestimate the severity, so in this context the aim is to positively influence the perceived severity of a fire (Proulx, 2001).

It is important to note another characteristic of our study: we consider all effects of IVE as compared to a control group. Since the traditional way to persuade people to invest in fire prevention measures is by giving them information in text, it is relevant to compare the IVE experience with an information sheet as a control condition (referred to as: INFO condition). We expect that compared to this INFO condition, the IVE has a stronger effect on the psychological determinants, which in turn results in an increased likelihood of performing prevention behaviors in the IVE condition (compared to the INFO condition), as laid out in the hypothesized model in Figure 1. We now discuss the argumentation behind the hypothesized model in more detail for the separate psychological determinants and their effect on prevention behavior.

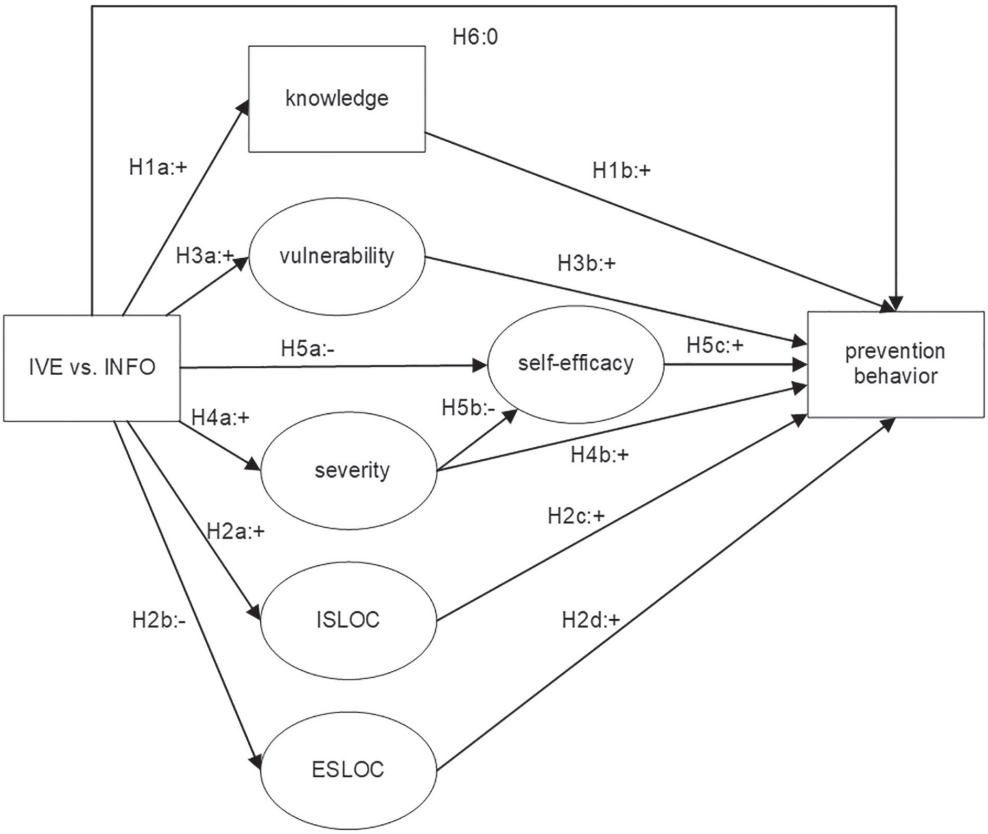


Figure 1:
Hypothesized model of the effects of IVE exposure relative to the INFO condition. Squares represent observed constructs and oval shapes represent latent constructs.

4.2.1 Knowledge

Knowledge is considered to be a likely determinant for performing the advised behaviors in a risky situation, especially if one has little time to decide what to do or when in panic (Proulx, 2001). People tend to have limited, or even incorrect, knowledge about fire situations, which makes them insufficiently prepared for a fire (Proulx, 2001). It is evident that to able to select the optimal risk-mitigating actions, one must have knowledge of the risk and be aware of possible actions and their implications (e.g. water cannot be used to extinguish a grease fire but a fire blanket can) (Martin et al., 2007). Thus, in order to stimulate people to make the right preventive choices, increasing people's knowledge level of fires and fire prevention might be important. An effective way to sustainably increase knowledge is by an emotional experience (Bradley, Greenwald, Petry, & Lang, 1992; Cahill, & McGaugh, 1995; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002). Particularly negative experiences enhance the memory of that experience and

its details (Kensinger, 2009). The literature strongly suggests that serious games can be an effective way for learning (Eck, 2006; Shaffer, Squire, Halverson, & Gee, 2005; Van Eck, 2008) because games are a good way to attach emotions to problem solving and with that, enhance learning (Gee, 2008). Several empirical studies have indeed shown positive effects of serious games on knowledge. Kato, Cole, Bradlyn, and Pollock (2008) have shown a positive effect of a 3-month serious game on knowledge about cancer treatment, compared to a control group who received a commercial game video game (i.e. Indiana Jones). One-time interventions have also proven to work: Wong et al. (2007) have shown that a serious game is better in transferring factual knowledge compared to traditional textbooks, both directly after the intervention as one week later. A study of Chittaro and Buttussi (2015) has also shown positive effects of a serious aircraft evacuation game in an IVE on knowledge retention. One week after the intervention the players of the game had a significantly higher score on the knowledge items than the group who had read a safety card, even though immediately after the intervention there was no difference between the groups. Furthermore, Chittaro (2018) showed that an interactive mobile VR application teaching how to don a life preserver had positive effects on donning a life preserver in real life, comparing a traditional safety card.

Consequently, we expect that a serious game in an IVE, one that triggers emotions and increased attention by a virtual fire, can positively influence people's knowledge level about fire prevention. We also expect that an increase in knowledge positively influences prevention behavior.

H1a: The knowledge level of participants in the IVE condition is higher than the knowledge level of participants in the INFO condition.

H1b: Knowledge positively influences prevention behavior.

4.2.2 Safety Locus of Control (SLOC)

Locus of control is an important psychological determinant that can influence our attitudes and behaviors and for that reason it is often studied in situations where the goal is to change people's behavior (Rotter, 1954). Locus of control is our perception of where control lies, and most researchers distinguish between an internal and an external orientation (Hunter, 2002; Montag & Comrey, 1987; Suárez-Álvarez, Pedrosa, García-Cueto, & Muñiz, 2016). Someone with an internal orientation is more likely to consider outcomes as a consequence of their own behavior, as opposed to someone with an external orientation, who often sees outcomes as something beyond their own control. In the literature there is no consensus about the dimensionality of the locus of control construct (Parkes, 1985; Suárez-Álvarez et al., 2016). Although the original scale

of Rotter (1966) presents a one-dimensional construct (where internal and external are two ends of a continuum), later studies reveal two (with internal and external being two separate constructs) or even multiple dimensions. Most studies that we came across find empirically that locus of control is a two-dimensional construct, rather than the more intuitive one-dimensional construct (Hunter, 2002; Montag & Comrey, 1987; Suárez-Álvarez et al., 2016). The underlying argument is that people for example can attribute their health both to internal beliefs (for example related to their own smoking behavior) as well as to external beliefs (for example to chance events). An internal locus of control is associated with safer attitudes and behaviors: the more someone feels that he or she is responsible for how matters are progressing, the more likely that someone will take action. Inversely, an external locus of control is associated with a lack of caution and prevention. Studies have indeed shown that, for instance, people with an internal locus of control compared to people with an external locus of control are more likely to wear seat belts (Hoyt, 1974) and have less accidents at work (Jones & Wuebker, 1993; Wuebker, 1986). Furthermore, studies showed that internal control is negatively related to fatal car accidents while external locus of control is positively related to fatal car accidents (Montag & Comrey, 1987). Huang and Ford (2012) have shown in addition that locus of control is not a fixed human characteristic but can be influenced by training, as they have demonstrated with respect to safe driving behaviors. Murray, Fox, and Pettifer (2007) have shown that a higher sense of realism in a virtual environment can likewise lead to an increased perception of locus of control. Also Ahn, Bailenson, and Park (2014) managed to influence environmental locus of control with an IVE in which deforestation was at stake. Furthermore, in the domain of air safety Chittaro (2014) showed that a videogame that focused on the brace position during a plane crash resulted in a significant increase in internal orientation and a significant decrease in external orientation, which together indicated that participants felt more in control over the outcomes of an emergency landing than before playing the game.

As far as we know, locus of control has not yet been analyzed in the fire safety domain, but it makes sense that it is relevant in that domain as well. We follow the line of reasoning that safety locus of control (SLOC) is a two-dimensional construct, existing of an internal orientation (ISLOC) and an external orientation (ESLOC). We expect ISLOC and ESLOC to be affected more for IVE than for the INFO condition and expect changes in ISLOC and ESLOC to positively influence behavior.

H2a: Perceived ISLOC is higher for participants in the IVE condition than for participants in the INFO condition.

H2b: Perceived ESLOC is lower for participants in the IVE condition than for participants in the INFO condition.

H2c: Perceived ISLOC positively influences prevention behavior.

H2d: Perceived ESLOC positively influences prevention behavior.

4.2.3 Vulnerability

An important determinant to take preventive measures according to the HBM and PMT, is the likelihood that an event will occur, referred to as the perceived vulnerability (or: susceptibility) (Rogers, 1975; Rosenstock, 1966). A common barrier to take preventive measures is that people tend to think that bad things will not happen to them, a phenomenon known as 'unrealistic optimism' (Weinstein, 1989). A way to increase people's perceived vulnerability is through personal experience (Weinstein, 1989). A study of Zaalberg et al. (2009) has shown that people who have experienced a flood before, perceive themselves as more vulnerable to a future flood. This higher perceived vulnerability, together with a higher perceived effectiveness for adaptive actions, made that flood-victims had more intentions to take adaptive actions (e.g. tie up or remove curtains to prevent them from getting wet) than non-victims. However, no effect was found with respect to preventive measures (e.g. sandbags in front of the house). This might be explained by the fact that victims perceived the adaptive actions to be more effective than non-victims, while the effectiveness for preventive actions was found more effective by non-victims. That is, increased vulnerability leads to more preventive or adaptive measures, provided that the measures are considered effective enough.

Since we want to prevent people to become victims in the first place, we could increase the perceived vulnerability through the *simulation* of a risk. This has also been done by Schwebel et al. (2017) who studied the effects of the virtual simulation of crossing a street while texting, and Chittaro who measured the effects of the simulation of an aircraft emergency and a terror attack (Chittaro, 2012, 2014, 2016; Chittaro & Sioni, 2015). While the IVE's concerning street crossing and a terror attack showed significant positive effects on perceived vulnerability (Chittaro & Sioni, 2015; Schwebel et al., 2017), the IVE's that simulated an aircraft emergency (Chittaro, 2012, 2014, 2016) showed no significant effects. While the perceived probability of an aircraft evacuation might not increase through a virtual experience given that most people fly on airplanes relatively rarely, affecting people's perceived vulnerability to a fire is more likely, as most people cook several times a week, or use lighters, candles etc. much more regularly. We expect that the virtual experience of a fire increases people's perceived vulnerability to a fire, which in turn will result in more preventive behaviors.

H3a: The perceived vulnerability of participants in the IVE condition is higher than in the INFO condition.

H3b: Perceived vulnerability positively influences prevention behavior.

4.2.4 Severity

Another important determinant for taking preventive measures according to the HBM and PMT, is the perceived severity of the event and its consequences (Rogers, 1975; Rosenstock, 1966). The direction of this relationship depends on the expected severity beforehand, since some experiences appear to be milder than expected (Weinstein, 1989). With respect to flood experiences, research has shown that the experience of a flood did increase the perceived severity of a future flood, compared to people who did not have this experience (Zaalberg et al., 2009). Chittaro (2014, 2016) managed to increase perceived severity in an aircraft evacuation game using rich and vivid feedback to induce fear, although the effect was small. In the domain of fire safety, increasing perceived severity is even more relevant (an airplane crash is already considered quite severe) since with fires in buildings people seem to downplay the severity and as a consequence do not respond quickly enough, which decreases their chances of survival (Proulx, 2001). Chittaro and Zangrando (2010) argue that people's fire evacuation behavior can be influenced by increasing anxiety and risk perception. Their study showed that a game about the dangerous effects of smoke had more impact on anxiety and attitude when emotional intensity was high (as it might be in an IVE). We therefore expect that a fire in an IVE can similarly increase perceived severity, which itself is considered a relevant psychological determinant for prevention behavior.

H4a: The perceived severity of a fire by participants in the IVE condition is higher than in the INFO condition.

H4b: Perceived severity positively influences prevention behavior.

4.2.5 Self-efficacy

Another important determinant to take preventive measures that is related to the person (instead of related to the risk) according to the extended versions of the PMT and the HBM is self-efficacy, a construct that is related to locus of control (Maddux & Rogers, 1983; Rosenstock et al., 1988). "Perceived self-efficacy is the belief in one's competence to tackle difficult or novel tasks and to cope with adversity in specific demanding situations" (Luszczynska & Schwarzer, 2005, p. 81). In this sense, self-efficacy is different from locus of control: it does not consider the extent to which a person feels that the situation depends on his or her own behavior, but instead how well a person perceives he or she would perform in the part that does depend on his or her behavior. According to Bandura (1994) optimistic efficacy beliefs lead to better

performance outcomes, those beliefs can be acquired by gaining experience, and this experience can be gained through an IVE (Fogg, 2003). For example, in the healthcare domain, serious games for children, compared to a control group, have shown positive effects on self-efficacy in taking care of a chronical condition (Lieberman, 1997, 1998). Also in the safety domain similar effects are found: a serious aircraft evacuation game has shown positive effects on self-efficacy in safely evacuating an aircraft (Chittaro, 2012, 2016) and a mobile VR application concerning life preserver donning increased people's self-efficacy (Chittaro et al., 2018). Sometimes, instead of pursuing an increase in people's self-efficacy level, it is desirable to decrease self-efficacy. For instance, in driving studies people tend to overestimate their driving ability (Svenson, 1981) and in this case a higher perceived self-efficacy is related to more unsafe driving behaviors and accidents (Morisset, Terrade, & Somat, 2010; Sümer, Özkan, & Lajunen, 2006; Taubman-Ben-Ari, Mikulincer, & Iram, 2004). This is comparable to the fire prevention domain where people generally tend to overestimate their ability to evacuate, because people downplay the severity of a fire (Proulx, 2001, 2003). In general, people start moving too late and too slowly in the case of a fire, and often even move through smoke while this should be avoided as this slows down their speed and is dangerous for their health. The suggested negative relationship between perceived severity and self-efficacy has been empirically shown in the health domain (Amir, Roziner, Knoll, & Neufeld, 1999; Somers et al., 2010). Since we expect that people underestimate the consequences of a grease fire, and overestimate their own ability to act properly, we expect that the IVE can decrease perceived self-efficacy with respect to a grease fire, both directly as well as through an increase in perceived severity and that a lower self-efficacy will motivate people to take more fire prevention measures.

H5a: The perceived self-efficacy of participants in the IVE condition is lower than in the INFO condition.

H5b: Perceived severity negatively influences self-efficacy.

H5c: Perceived self-efficacy negatively influences prevention behavior.

4.2.6 Benefits and barriers of behavior

Other determinants that drive prevention behavior according to the HBM and PMT are the benefits of the behavior (more specifically: its effectivity) and the barriers of the behavior (e.g. financial costs, effort). Because in our experiment a fire blanket is promoted as an effective measure to extinguish a grease fire in both conditions, we do not expect 'effectivity' to be influenced more in the IVE condition and therefore do not include effectivity in our study. Because the IVE and INFO condition did not stress the

costs and effort involved concerning a fire blanket, we also do not expect costs and effort to play an important role in our study, and therefore do not include these determinants in our study.

4.2.7 Prevention behavior

The ultimate goal of the simulation of a fire in an IVE is to increase people's fire prevention behavior. Most studies have only considered the effect of IVE on psychological determinants and sometimes on intentions but did not measure subsequent behavior. This implies we do not have much empirical support for an effect of IVE on prevention behavior. However, if our earlier hypotheses about the effects of IVE on psychological determinants are valid and changes in psychological determinants lead to changes in behavior, then the logical consequence is that IVE influences behavior.

H6: Because of the changes in psychological determinants caused by the IVE condition, we expect that participants in the IVE condition display more prevention behaviors than participants in the INFO condition.

4.2.8 Retention of the psychological determinants

Most IVE-related effect studies only consider effects immediately following the intervention. However, in some cases longer term effects on knowledge have been studied and have led to positive results for IVE. In Chittaro and Buttussi (2015) we find that while there no was no immediate effect of a serious aircraft evacuation game on knowledge, the players of the game had a significantly higher score on knowledge than the control group one week later. Furthermore, Wong et al. (2007) have shown that a serious game was better in transferring factual knowledge than a traditional textbook, and this effect was still demonstrable one week later. The sometimes implicit and largely intuitive argument for this effect is that because people have an increased sense of presence in an IVE (compared to people who read an information sheet), their experiences make a more lasting impression, which improves retention. Along these lines, we expect a higher retention rate (or slower decrease of retention) of the effects of the IVE on the psychological determinants.

4.3 Method

4.3.1 Design

We used a 2 factor (IVE versus INFO) between-subjects design, with 3 time points at which we asked the participant to fill out a questionnaire. The first questionnaire was right before the intervention, the second questionnaire right after the intervention and the third questionnaire four weeks after the intervention. Our main intervention has two levels: the IVE fire game (IVE) and a fire prevention information sheet (INFO) as a control.

4.3.2 Participants

Participants were recruited from the Dutch commercial "CG Selections" consumer panel, a panel consisting of 80,000 consumers. We determined that we would need 2 x 119 participants to have 90% power of showing an expected difference in prevention behavior of about twenty percentage points (assuming 20% for the INFO group vs 40% for the IVE group; using an alpha-level of 5%).The prevention behavior that we targeted was whether a participant would invest part of his or her show-up fee in a fire blanket and whether a participant would take home flyers related to fire safety. We recruited participants based on the following criteria: between 18 and 70 years old, not living in a student home or living with their parents (due to prevention responsibility), who did not own a fire blanket and who did not suffer from motion sickness (to prevent them from getting nauseous during the IVE). CG Selections approached potential participants based on the age and location information in their database with the opportunity to participate in a study about "property damage" for an incentive of €25. We did not mention the topic "fire prevention" to prevent any bias (e.g. attract people that have a special interest in fire; people becoming extra aware of their own fire prevention). To determine whether people fitted the required criteria to engage in the study they first had to fill out a survey with questions concerning their living situation, motion sickness, and whether they owned a fire blanket. Because we did not want to prime people with the fire blanket, we confronted people with a list of possible home appliances and asked which products they owned.

After enrolling, participants were randomly assigned to the IVE group or the INFO group. Each day was either an IVE day or an INFO day, and participants were assigned to a condition based on availability. In total 297 participants started the experiment, of which 49 were omitted from the analysis because in the first questionnaire (right before the intervention) they reported to own a fire blanket, three were excluded because they failed to fill out the second questionnaire and three others were excluded because they did not complete the IVE due to nausea. In total 242 participants remained in the dataset for analysis.

4.3.3 Procedures

The experiment was approved by the ethical committee of the Department Human Technology Interaction of the Technical University of Eindhoven. The experiment ran in the lab for nine days. In total nine persons assisted the first author in running the experiment. When entering the lab, first the participant was asked to read and sign a written informed consent. Second, we asked participants to fill out the first online questionnaire. Then, dependent on the assigned condition, the participant was asked to play the IVE game or read the INFO sheet. Participants in INFO condition received fire prevention information on a single page A4 (Appendix F) with basically the same content as the experiences in the IVE contained (Appendix G). The intervention lasted about 8 minutes for the IVE group and 2 minutes for the INFO group. To evaluate the IVE game, participants were asked afterwards whether they became nauseous or dizzy, how realistic they considered the fire experience, and how severe they considered this virtual experience. Then, participants in both groups were asked to fill out a second online questionnaire. Then, we offered the participant a choice of receiving their promised €25 or receiving €12.50 and a certified fire blanket with a value of €20. The money would be transferred after they filled out the third questionnaire (four weeks later), the fire blanket could be taken home immediately. In addition, to measure the interest for fire prevention information, there were two types of fire prevention related flyers on the table, which participants could take home. To avoid social desirability bias the availability of these flyers was not specifically mentioned by the experimenter. Four weeks after the participant was exposed to the intervention, the participant received the third online questionnaire.

4.3.4 The IVE condition and participant's actions

In the IVE condition, participants were told that they were going to do a fire drill in a virtual environment. The participant received a game controller, a headphone, and a head-mounted-display. It was explicitly stated that if the participant became nauseous or otherwise uncomfortable, he or she could stop at any time. First, the simulation showed a practice scene so that the participant could get acquainted with the virtual environment. During the practice scene it was explained to the participant how to move in the environment (walk through the house, go up- or downstairs) and how to select an action (use water or fire blanket, open doors, pick-up toddler). The participant can move (walk, turn) in the IVE by using the joystick of the controller and choose different actions by focusing on the objects with his eyes. If the participant focusses on an object (e.g. the fire blanket), a blue lightbulb appears that is counting down from 5 seconds to 1 second, after which the action is performed (e.g. use fire blanket to extinguish fire). When the participant indicated to be ready for it, the actual game was started. See Figure 2 for screenshots of the IVE fire game.

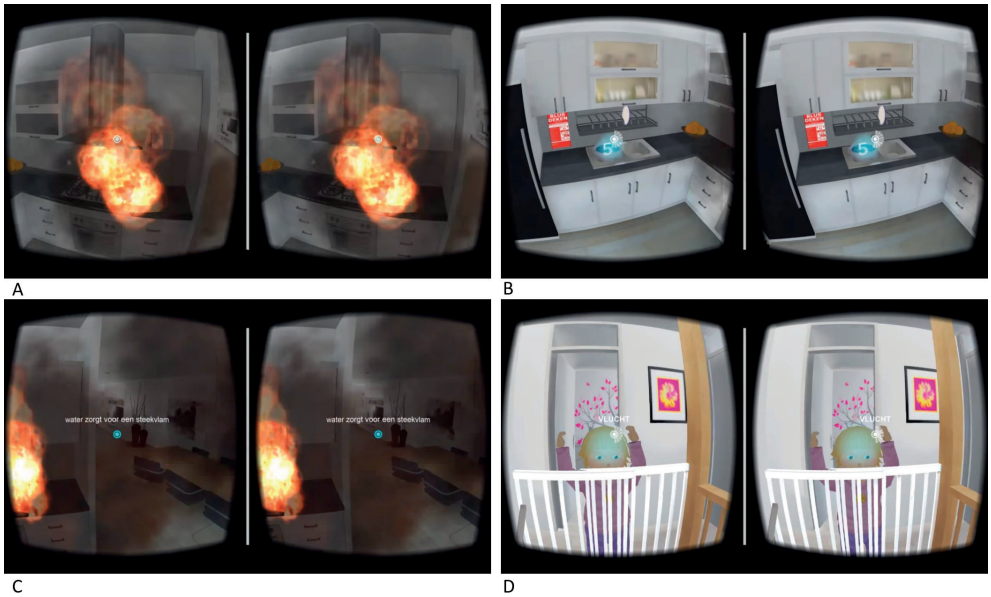


Figure 2:
Screenshots of the IVE fire game. (A) View of the grease fire. (B) View of the bucket of water and the fire blanket that can be selected to extinguish the fire. (C) View of the flash fire. (D) View of the toddler that is waiting to be rescued.

At the start of the game the participant (in the IVE) is situated on the couch in the living room, watching television. Suddenly the smoke detector goes off, and smoke is entering the living room. The participant can 1.) go towards the source of the fire (the kitchen) and extinguish the fire with the fire blanket. The fire will be extinguished and the game ends. Or 2.) go towards the source of the fire (the kitchen) and extinguish the fire with water. In this case a flash fire occurs, and the participant has to escape the house to survive (using the fire blanket at this point will not help any more). A final option was 3.) to escape from the home immediately through the front door. The participant could however also not perform action 1, 2 or 3, but stay in the house. Thirty seconds after the smoke detector goes off, the fire gets bigger as the flames now hit the kitchen hood and cabinets. At this point, if the participant is still in the house, he will hear a toddler crying upstairs, and he could choose to go upstairs and rescue the child. After the participant had either extinguished the fire, escaped the home or 105 seconds had passed, the game ended. Dependent on the decision the participant made, textual feedback and information about fire prevention was presented. For instance, if the participant had not been able to extinguish the fire and was still in the house, a text would explain that in case of a fire in all likelihood three minutes is the maximum one has to escape, and that proper use of the fire blanket can prevent a lot of harm. See Appendix G for the possible scenarios and the feedback given after each scenario.

After playing the game for the first time, participants were asked to play the game once again. If they had extinguished the fire with the fire blanket the first time, they were now suggested to play the game without using the fire blanket (in which case the optimal strategy would be to try to escape). If they did not extinguish the fire with the fire blanket the first time, they were asked to try to extinguish the fire with the fire blanket. This way, all participants experienced both escaping and extinguishing a fire.

4.3.5 Hardware

We used the Oculus Rift DK2 Head-Mounted Display (HMD) with a resolution of 960 x 1080 per eye and a 100 degrees diagonal field of view. Audio was played through Sennheiser HD 265 linear headphones. For the study, the software was implemented on one desktop machine and one laptop. Given our setup, the specifications of the hardware needed to be substantial, given current day hardware. The desktop machine was a Mac Pro 3.7GHz, with 16GB of RAM, a 256GB Flash Drive and 2x AMD Fire Pro D300 graphics card with 2GB each. The laptop was a MacBook Pro 2.4Ghz, with 8 Gb of RAM, 1 TB HDD, and a GeForce video card with 512MB.

4.3.6 Measurements

For this study we used measurements at three time points. The first measurement was a questionnaire right before the intervention that included background questions and current prevention behaviors that are beyond the score of this paper. Background questions included family composition, type of home, ownership of home, year of construction, frequency of cooking, frequency of playing computer games and experience with home fire(s). The second measurement took place right after the intervention and was set up for the measurement of the psychological determinants and the target prevention behaviors. The hypothesized model (Figure 1) is based on differences between the IVE and the INFO group at the time of the second measurement. The third measurement, four weeks after the intervention, was set up to be able to analyze the development of the psychological determinants over time. In this measurement, the determinants *knowledge*, *vulnerability* and *severity* were included, and we also included the same prevention behaviors as in the first measurement. We excluded self-efficacy, ISLOC and ESLOC from the third measurement because of lengthiness, which could negatively affect responses to the (at-home) questionnaire and reliability of the answers. The prevention behaviors that were measured in the first and third measurement are not analyzed in this paper.

Knowledge

Knowledge concerning fire prevention was measured with nine self-constructed items that were related to the information provided in the IVE fire game and the INFO sheet. Example items are: "What happens when you throw water on a grease fire?" and "On average, how many minutes does a person have to safely leave the home in case of a fire?" See Appendix H for an overview of all items. Correct answers were coded 1 and incorrect answers were coded 0. The overall knowledge score was the percentage of correctly answered items.

Internal and external safety locus of control

We designed the locus of control scale specific for fire prevention, since a domain-specific locus of control scale is a better predictor for domain specific behavior than the general locus of control scale (Wallston, Wallston, Kaplan, & Maides, 1976). In line with Chittaro (2014) locus of control was measured with 12 items, which were adopted from Hunter (2002), and were adapted to fit the topic of fire. There were 6 items internally oriented (ISLOC) and 6 items externally oriented (ESLOC). What complicates matters somewhat is that locus of control can refer to two separate matters in the event of a fire: whether someone feels that he or she can influence the probability of a fire, and whether one can influence the consequences of a fire. We formulated items for both matters. An example of an internally oriented item that was focused on preventing a fire was: "If you are careful, you can prevent fire in your home." An example of an externally oriented item that was focused on reducing the consequences of a fire was: "If there is a fire in your home, there is usually nothing you can do." Ratings were given on a five-point Likert scale (1= fully disagree; 5= fully agree).

Vulnerability

Vulnerability was measured with 3 items. In line with Chittaro (2012, 2014) we adopted the items from de Hoog, Stroebe, and de Wit (2008), and transferred the items to the subject of a grease fire. Ratings were given on a five-point Likert scale (1=very low; 5=very high). An example item was: "How high do you perceive the risk of a grease fire in your home to be?"

Severity

Severity was measured with 3 items. In line with (Chittaro, 2012, 2014) we again adopted the items from de Hoog et al. (2008) and transferred the items to the subject of a grease fire. Ratings were given on a 5-point Likert scale (e.g. 1 = not severe at all; 5

= very severe). An example item was: “How severe do you perceive the consequences of a grease fire to be?” We changed one item of original scale, namely concerning the seriousness of the grease fire, since in Dutch this would also be translated as “severe”. We changed the item to “panic” since this also reflects the severity of the grease fire.

Self-efficacy

Self-efficacy was measured with 10 items. The items were adopted from the General Self-Efficacy Scale (GSE) (Schwarzer, & Jerusalem, 1995) and from the scale that Chittaro (2012) used to measure self-efficacy with respect to aircraft evacuation (which was also based on the GSE). All 10 items were transferred to the domain of fire prevention behavior, following Bandura (2006) who argues self-efficacy should be tailored to the specific domain of functioning to have the best explanatory and predictive value. Ratings were given on a five-point Likert scale (1 = fully disagree; 5 = fully agree). An example items was: “I am confident that I can extinguish a grease fire”.

Specific prevention behavior

In both conditions of the experiment a fire blanket is the advised behavior to extinguish a grease fire. The primary measurement for the effect of IVE on prevention behavior will be the participants’ purchase of a fire blanket, and the secondary measurement is the participants’ interest in fire prevention information (which is a more ‘soft’ measurement of behavior). We measured the purchase of a fire blanket by offering the participant a choice between the promised incentive of €25, or €12.50 and a fire blanket for participation. Concerning fire prevention information, there were two types of prevention related flyers on the table that participants could take home. We registered (unobtrusively) whether a participant chose the fire blanket (0 = no fire blanket; 1 = fire blanket) and whether the participant took one (or more) flyers (= no flyers; 1 = flyers).

Additional measurements

For the experiment we only recruited people that reported not to own a fire blanket. To verify, we asked again if people had a fire blanket in the first questionnaire. If so, they were excluded from the analysis. Furthermore, we included several variables that we used for evaluation purposes and robustness checks: we verbally asked the IVE group right after the IVE to what extent they became nauseous or dizzy, how realistic they considered the fire experience, and how severe they considered the virtual experience.

4.4 Results

First, we briefly describe our preparation of the data and then show some descriptive statistics. To answer our research question with respect to the impact of IVE on the psychological determinants and the actual prevention behavior, we use Structural Equation Modelling (SEM). Finally, we analyze the development of the psychological determinants between the second and the third measurement.

4.4.1 Data preparation

There were no missing values in the first and the second questionnaire, except as a consequence of conditional items. However, 10.6% of the participants (26 out of 242) did not fill out the third (at home) questionnaire. We checked the data for multivariate outliers with the BACON algorithm using Stata 14 (Weber, 2010) and did not find any. We checked the data for normality with a skewness and kurtosis test (D'agostino, Belanger, & D'Agostino Jr, 1990) and the Shapiro-Wilk test (Shapiro & Martin, 1965) and found that not all variables were normally distributed so we used a robust estimator for non-normally distributed data. For SEM it is important that items or latent constructs do not correlate too much with each other (Kline, 2016) and there were no bivariate correlations larger than .85. Detecting multicollinearity among multiple variables was done by considering the variance inflation factors (VIF) after a logistic regression with the choice of a fire blanket as the target variable and all scale constructs included. This assumption was not violated: all variables have a VIF <10 and together have a mean VIF of 1.20 (Kline, 2016).

4.4.2 Descriptive statistics

Of the remaining 242 participants in our analysis, 124 were assigned to the IVE condition, and 118 to the INFO condition. Of these 242, 146 females (60.3%) and 96 males (39.7%). Mean age equaled 42.5 (SD = 10.11). A chi-square test and a two-sample Wilcoxon rank-sum test (age was non-normally distributed) showed that there was no significant difference between the IVE and INFO condition in terms of gender and age respectively (χ^2 (1, N = 242) = .703, p = .402; z = .164, p = .870).

After the IVE game, 21.8% indicated that they had felt nauseous or dizzy during the experience, 32.3% indicated that they felt a little nauseous or dizzy, and 46.0% did not feel nauseous or dizzy. Participants rated the realism and severity of the IVE experience on a five point Likert scale (where a five stands for very realistic / severe). The mean scores were 3.82 (SD = .97) for realism and 3.43 (SD = 1.11) for severity. In the IVE condition, 48.4% of the participants chose the fire blanket and €12.50 and in the INFO

condition this was 39.8% (χ^2 (1, N = 242) = 1.795, p = .180). In the IVE condition, 23.1% of the participants took the flyers home and in the INFO condition this was 12.8% (χ^2 (1, N = 242) = 4.179, p = .041). So there is some evidence for a relation between the IVE manipulation and prevention behavior, but the effect is smaller than we assumed (a twenty percent point difference) when calculating our sample size. The specific actions that people took in the IVE fire game can be found in Appendix I.

4.4.3 Statistical analyses

We tested the model in Figure 1 through SEM with a robust estimator for non-normally distributed data. We used SEM because we wanted to determine the relations between the observed and latent constructs in a single estimation. An alternative possibility to test the hypothesized model is to analyze the model with SEM in three steps, namely first test the total effect, then the effects of IVE on the psychological determinants followed by the effects of the determinants on prevention behavior, in line with a standard mediation analysis. Or, we could separately show the effect of VR on the psychological determinants, and only then the (separate) effects of the psychological determinants on behavior. We found that these separate analyses show substantially the same results: all hypotheses of interest remain statistically significant and of similar size. For parsimonious reasons, we present the SEM model that tests all the relationships in a single estimation.

Some further beneficial features of SEM are that it is possible to use both observed and unobserved (i.e. latent) variables, and that the measurement error of observed and unobserved variables is taken into account simultaneously. Different compared to most experimental IVE studies is that with SEM the model as a whole is being tested instead of a set of individual hypotheses, including the role the psychological determinants might play in the effect of IVE on prevention behavior. The SEM model was analyzed in Mplus version 8 (Muthén, & Muthén, 2016). The estimation procedure that we used was the default weighted least squares with means and variance adjusted (WLSMV, which implies using probit as the underlying analytical model) since this is considered the best estimator for categorical data (Bandalos, 2014; Kline, 2016). Whether the model fits the data can be determined through the model fit statistics and the individual parameter estimates. As advised in Hair, Black, Babin, and Anderson (2010) we report the following model fit statistics: model chi-square, root mean square error of approximation (RMSEA) and its 90% confidence interval (Browne & Cudeck, 1993), the comparative fit index (CFI) (Hu & Bentler, 1999) and the Tucker Lewis Index (TLI) (Tucker & Lewis, 1973). The higher the model chi-square the worse the fit, and the associated level of significance must be non-significant (Hair et al., 2010). For the RMSEA Hu and Bentler (1999) advise a value smaller than .06 for a good fit, with the

upper bound of its 90% CI falling below 0.10 (Knijnenburg & Willemsen, 2015). For the CFI and the TLI, Hu and Bentler (1999) advise a value larger than .95.

4.4.4 Confirmatory factor analysis

The latent constructs were analyzed by CFA in a single estimation, so that correlations between (items of) latent constructs could be taken into account (Brown, 2006; Knijnenburg & Willemsen, 2015). When all items of the latent factors (vulnerability, severity, self-efficacy, ISLOC and ESOC) were used, model fit statistics were poor: χ^2 (340) = 1080.666, p = <.001, CFI = .875, TLI = .861, RMSEA = .095, 90% CI [.089 - .101]. In order to establish construct validity we inspected the significance levels of the items, the direction of the estimates, the item estimates and R-squares (Brown, 2006). Convergent validity and a more precise measurement is established by removing items based on the AVE, which ideally has to be larger than .5 (Hair et al., 2010). Indeed, inspecting the CFA we find that many items have low R-squares and that the AVE of the constructs was low (below .5 for some). We increased the AVE for self-efficacy from .560 to .682 by removing five items, for ISLOC we increased the AVE from .364 to .413 by removing three items, and for ESLOC we increased the AVE from .343 to .549 by removing four items. Since ESLOC only had two items left, and a minimum of three indicators per latent variable is needed for model identification (Brown, 2006) the correlation between ISLOC and ESLOC was very high (-.792, suggestion discriminant validity is compromised as the correlation is higher than the square root of the AVE of ISLOC itself), and the items seem to fit well on one scale, we decided to use a one factor SLOC instead. When performing CFA with all latent constructs and the latent factor SLOC, the same results apply concerning item deletion, as with CFA with all latent constructs and the latent factors ISLOC and ESLOC. Internally orientated items (I) contribute positively to SLOC, while externally orientated items (E) contribute negatively to SLOC. Although in literature two factors are more common, LOC was originally developed as a one-dimensional construct and is still used as such by various studies (Ahn et al., 2014; Rotter, 1966; Ryon & Gleason, 2014). Table 1 shows the final AVE and Cronbach's alpha values of the latent factors, and the factor loadings per item. The model fit then improved to χ^2 (98) = 478.448, p = <.001, CFI = .914, TLI = .895, RMSEA = .127, 90% CI [.115 - .138]. The factor loadings and the Cronbach's alpha values of the original scales can be found in Appendix J, Table 1. In addition, we performed CFA on the individual factors and similar results apply compared to testing the measurement models all together, and the same items should be removed to improve AVE. See Tables 1-5 in Appendix J for the model fit statistics and Tables 6 and 7 in Appendix J for the R-squared estimates and AVE's.

Table 1: AVE, Cronbach's alpha and standardized factor loadings (stdYX) for the latent factors, after removing poorly fitting items. Items without a factor loading where excluded from analysis.

Latent factor[a]	Item[b]	Factor loading[c] (stdYX)
Vulnerability α = .745 AVE = .584	How high do you think the risk of a grease fire in your home is?	.570
	How high do you perceive the chance that a grease fire will pass over to the exhaust hood and the kitchen cabinets?	.660
	How high do you perceive the chance that you should escape your home because of a grease fire?	1.002
Severity α = .752 AVE = .705	How dangerous do you think a grease fire is?	.829
	How severe do you perceive the consequences of a grease fire?	.851
	How much panic do you think there will be in case of a grease fire?	.840
Self-efficacy α = .834 AVE = .682	I am confident that I can extinguish a grease fire.	.834
	I am confident I will remain calm in case of a grease fire.	.848
	I am confident I will remain calm in case of a grease fire, even if it will pass over to the exhaust hood and the kitchen cabinets.	
	When a grease fire exists I am afraid I will panic. [d]	.782
	I know what to do in case of a grease fire.	.772
	I am capable of acting correctly in case of a grease fire.	.889
	I am convinced of my capability to put my family/ myself into safety in case of a fire.	
	I am convinced of my capability to quickly leave my home in case of a fire.	
	I am convinced of my capability to quickly leave my home in case of a fire, even if escape routes are blocked.	
	I am convinced of my capability to quickly leave my home in case of a fire, even if there is a lot of smoke.	
Safety Locus of Control (SLOC) α = .710 AVE = .528	If you are careful, you can prevent a fire in your home yourself. (I)[c]	
	If a fire breaks out in your home, there is usually nothing that you can do. (E)[e]	
	A home fire is usually caused by a short-circuit/ overheating of electrical appliances. (E)	
	Whether people can escape in time in case of a fire, is a matter of luck or bad luck, not of preparation. (E)	
	People can ensure that a small fire does not expand. (I)	.653
	Most home fires are caused by chance events that cannot be influenced. (E)	
	Preparing yourself for a fire, enlarges your survival possibilities in case of a fire. (I)	.661
	Whether you succeed in extinguishing a grease fire, is a matter of luck or bad luck, not a matter of preparation. (E)	-.777
	People should be rewarded by their insurance company if they take preventive measures to prevent or control a fire. (I)	
	By taking preventive measures you can make sure that you can extinguish a fire on time. (I)	.733
	Home fires are usually caused by the people themselves. (I)	
	It has no use to prepare yourself for a fire in your home. (E)	-.796

[a] Latent factor originates from the second measurement.
[b] Items are translated from Dutch.
[c] Factor loadings are only present for items that were not removed from the scales.
[d] This item was reversed coded.
[e] The (I) refers to an internally orientated item. The (E) refers to an externally oriented item.

4.4.5 Structural Equation Models

We now test the model as depicted in Figure 1. Table 2 shows the results of fitting six different models, each slight variations of the base model from Figure 1. The models differ in terms of the changes that were made to improve model fit, but do not change in terms of the significance and size of the effects for our underlying hypotheses. That is, the general conclusions with respect to our hypotheses do not depend on, which model is used, underscoring the robustness of our findings.

Model fit statistics of the initial model (Figure 1, not in Table 2) were poor: χ^2 (155) = 807.382, p = <.001, CFI = .840, TLI = .804, RMSEA = .132, 90% CI [.123 - .141]. Since IVE did not significantly affect SLOC and SLOC did not relate to prevention behavior, we removed SLOC from further analyses. We then tested the model as proposed in Figure 1 again without SLOC *(model 1).* Model fit statistics improved but were still not adequate, as can be seen in Table 2. We further improved the model fit, as suggested by the mod-indices, by adding correlations between latent variables that we did not hypothesize a-priori *(model 2) (severity ↔ vulnerability; self-efficacy ↔ vulnerability).* There relations are not illogical since for example vulnerability and severity together are assumed to represent a larger construct referred to as "risk perception" (Bubeck et al., 2012) or "threat appraisal" in Protection Motivation Theory (Maddux & Rogers, 1983; Rogers, 1975). Also, we added correlations between items (*model 3) (self-efficacy ↔ sev15; self 6 ↔ self5; self6 ↔ self1*), as these relations were suggested by a mod-indices analysis. We only incorporated this step to show how model fit could be improved, but will not elaborate on this step, as adding correlations at the item level is not very common. A logical next step, after model 2, is to inspect the significant relations and remove the non-significant ones (*model 4*). Some relations that were hypothesized a priori appeared to be non-significant and were removed, of which many represented the effect of psychological determinants on behavior (*vulnerability → fire blanket; severity → fire blanket; self-efficacy → fire blanket; knowledge → flyers; severity → flyers; self-efficacy → flyers; IVE → flyers*). Model fit indeed improved compared to model 2. For a visual representation of model 4 see Figure 3. Next, we removed the non-significant relations from model 3 and found that the model fit further increases but the relations themselves do not change *(model 5)*. We then elaborated on model 4 and removed all constructs that have no direct or indirect effect on the target variables (fire blanket or flyers) (*Model 6)*. Although this procedure results in a better model fit, the relationships between the observed and latent constructs remain the same, which underscores the robustness of our findings. Model fit statistics are then very good. For a visual representation of model 6, see Figure 4.

4.4.6 Robustness checks

We tested the hypothesized relationships also on variations of the original sample to check the robustness of the outcomes. We tested all the relationships on the sample minus the participants who stated they became nauseous during the IVE experience (n = 215), on the sample with only the IVE participants who stated to find the experience (very) realistic (n = 199), and on the sample with only the IVE participants who stated to find the experience (very) severe (n = 187). With the exception of some small deviations in model fit statistics and standardized regression weights, results showed that all estimated relationships remained stable across the different samples.

Table 2: Model fit statistics, standardized regression weights [stdYX] and standard errors [S.E.] for model 1-6.

Model fit statistics							
Goodness of fit	Target values	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
χ^2		590.867	408.292	150.458	390.103	148.994	15.753
df		78	76	73	81	78	12
p	>.05	<.001	<.001	<.001	<.001	<.001	.203
RMSEA	<.06	.165	.134	.066	.126	.061	.036
90% *CI*	<.10	.153-.177	.122-.147	.051-.081	.113-.138	.046-.076	.000-.079
CFI	>.95	.854	.905	.978	.912	.980	.994
TLI	>.95	.803	.869	.968	.886	.973	.990
Relationships							
Independent variabele	Dependent variabele	*StdYX [S.E.]*	*StdYX [S.E.]*	*StdYX [S.E.]*	*StdYX [S.E.]*	*StdYX [S.E.]*	*StdYX [S.E.]*
IVE	knowledge	-.333***[.060]	-.333 ***[.060]	-.333***[.060]	-.333***[.060]	-0.333***[.060]	-.333***[.060]
IVE	vulnerability	.229**[.069]	.231**[.067]	.231 **[.068]	.240***[.067]	.240***[.067]	.239**[.069]
IVE	severity	.169*[.069]	.169*[.069]	.158*[.071]	.169*[.069]	.158*[.071]	
IVE	self-efficacy	-.231***[.064]	-.230***[.064]	-.276***[.066]	-.230***[.064]	-.276***[.066]	
severity	self-efficacy	-.387***[.054]	-.388***[.054]	-.189 **[.068]	-.388***[.054]	-.189**[.068]	
knowledge	fire-blanket	.225**[.086]	.225**[.086]	.225**[.086]	.225**[.086]	.225**[.086]	.225**[.086]
vulnerability	fire-blanket	.124[.123]	.091[.102]	.078[.103]			
severity	fire-blanket	.136[.118]	.102[.101]	.096[.095]			
self-efficacy	fire-blanket	.049[.118]	.074[.107]	.033[.102]			
knowledge	flyers	.079[.659]	.225[.086]	.010[.084]			
vulnerability	flyers	.321*[.138]	.246*[.110]	.245*[.111]	.251*[.103]	.252*[.103]	0.264**[.102]
severity	flyers	-.024[.121]	-.057[.099]	-.052[.094]			
self-efficacy	flyers	-.143[.144]	-.032[.128]	-.030[.128]			
IVE	fire-blanket	.154[.092]	.167[.088]	.160[.088]	.183* [.084]	.183*[.084]	.183*[.084]
IVE	flyers	.228[.220]	.143[.100]	.142[.101]			
Independent variable	Independent variable						
fire blanket	flyers	.488 ***[.107]	.490 **[.106]	.490**[.101]	.505***[.108]	.505***[.108]	.507***[.108]
severity	vulnerability		.292***[.059]	.287***[.060]	.289***[.059]	.285***[.061]	
self-efficacy	vulnerability		-.324***[.058]	-.395***.[055]	-.325***[.058]	-.395***[.055]	

Model 1: as proposed in Figure 1 but without SLOC
Model 2: as model 1 and with correlations between the latent variables
Model 3: as model 2 and with three correlations on an item level
Model 4: as model 2 but without the non-significant relationships
Model 5: as model 3 but without the non-significant relationships
Model 6: as model 4 but without all relationships that did not have an (in)direct effect on the target variables
* = p<.05; ** = p<.01; ***= p<.001.

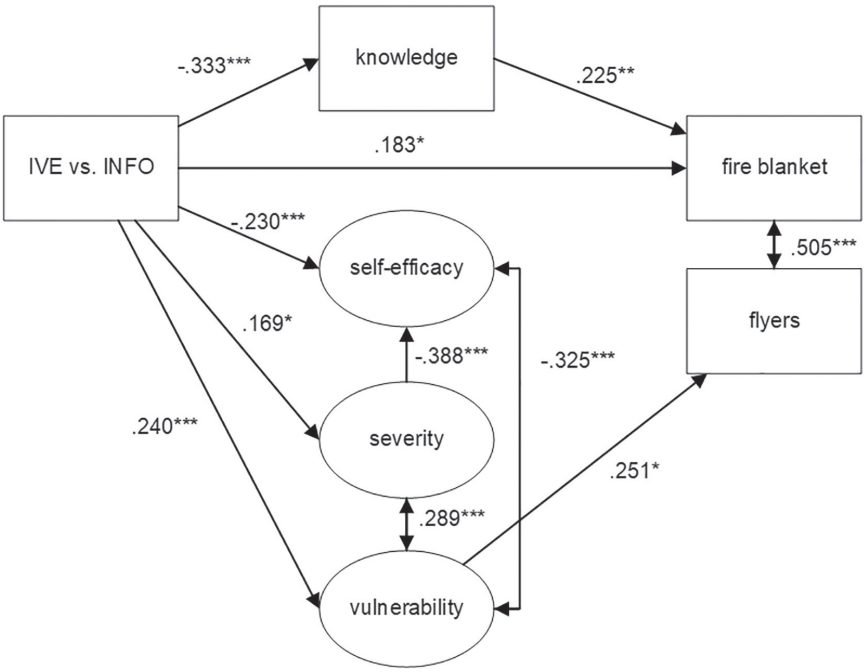


Figure 3:
Structural Equation Model of model 4 with standardized regression weights [StdYX]. Squares represent observed constructs and oval shapes represent latent constructs. Significance levels: *=*p* <.05; **=*p*<.01; ***= *p*<.001.

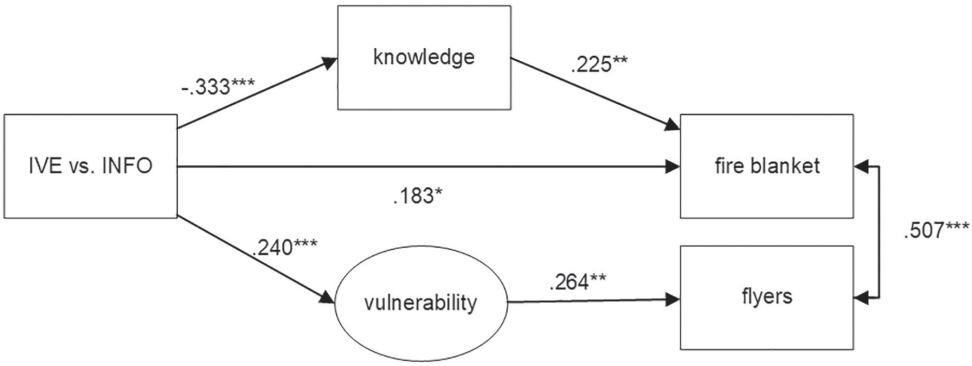


Figure 4:
Structural Equation Model of model 6 with standardized regression weights [StdYX]. Squares represent observed constructs and oval shapes represent latent constructs. Significance levels: *=*p*<.05; **= *p*<.01; ***= *p*<.001.

4.4.7 Hypotheses

Tests of the hypothesized relationships can be found in Table 2 and we will address them here in more detail based on Model 4 (Figure 3). Contrary to what was hypothesized (H1a), the IVE fire game results in a lower knowledge level than the INFO condition (-.333, $p < .001$). Thus, participants who were provided the text sheet knew more about fire prevention than participants who experienced the virtual fire and were provided with this same information in the IVE. As expected, an increase in knowledge implies a higher probability to choose the fire blanket (H1b) (.225, $p = .009$). H2a-H2d concerned ISLOC and ESLOC. Based on our results we integrated ISLOC and ESLOC into a single concept: SLOC, and as a consequence we could only test H2a and H2c. Further analyses showed that participants who experienced the virtual fire did not have a higher internal safety locus of control compared to participants who were provided with the text sheet. Also, a higher level of internal safety locus of control did not correlate with prevention behavior. Therefore, H2a and H2c are rejected. H3a is supported: the vulnerability of participants in the IVE condition is higher than the vulnerability of participants in the INFO condition (.240, $p < .001$). H3b can be partly confirmed, as an increase in vulnerability only influenced taking home flyers (.251, $p = .015$), but did not affected participants' choice for the fire blanket. H4a is supported: the severity of a fire by participants in the IVE condition is higher than the severity by participants in the INFO condition (.169, $p = .014$). However, an increase in severity did not influence prevention behavior (H4b). As hypothesized in H5a, the self-efficacy of participants in the IVE condition is lower than the self-efficacy of participants in the INFO condition (-.230, $p < .001$). Also, a higher severity negatively influenced self-efficacy (H5b) (-.388, $p < .001$). However, a lower self-efficacy did not affect prevention behavior (H5c). Strictly speaking, H6 is rejected, but some careful consideration is necessary here. To test H6 we now distinguish the total, direct, and indirect effects based on model 6 from Table 2 (Figure 4), using a percentile bootstrap estimation approach with 1000 samples (Shrout & Bolger, 2002). All coefficients are presented as standardized regression weights (*stdXY*). The total effect of IVE on fire blanket consists of a significant direct effect of IVE on the fire blanket (b = .197, SE = .081, 95% CI [.065, .726], p =.016) and a significant indirect effect via knowledge (b = -.080, SE = .030, 95% CI [-.279, -.044], p = .007). The total effect, however, is non-significant (b = .116, SE = .078, 95% CI [-.082, .550], p =.136). Hence, the non-significant total effect of IVE on fire blanket appears to be a combination of two significant opposite effects (positive and negative). Additionally, the effect of IVE on flyers is the consequence of (only) an indirect effect via vulnerability. There is a positive and significant effect of IVE on vulnerability (see Model 6, Table 2) and a positive and significant effect of vulnerability on flyers (see Model 6, Table 2), but the total effect is only significant at the p=.052 level (b = .063, SE = .032, 95% CI [-.002, 254], p = .052). Moreover, H6 implies that any effect of IVE on prevention behavior will

be mediated by the psychological determinants. This part of the hypothesis is clearly rejected for the fire blanket, as there remains a direct effect of IVE on choosing the fire blanket.

4.4.8 Retention after four weeks

We now consider the development of the scores on the psychological determinants, to test whether the IVE has a positive effect on retention. Results are analyzed with a multilevel regression analysis with robust errors, correcting for the non-normality of the residuals. On average, the knowledge level had decreased after 4 weeks, as there was a significant difference on knowledge between the first measurement (M = .86, SD = .13) and the second measurement (M = .78, SD = .13; b= - .038, $p < .001$). This decrease in knowledge is much stronger for the INFO group (from M = .91, SD = .09 to M = .79, SD = .13) than for the IVE group (from M = .82, SD = .14 to M = .78, SD = .13), as reflected in a statistically significant interaction (b= -.096, $p < .001$). For a graphical illustration of these differences, see Figure 5.

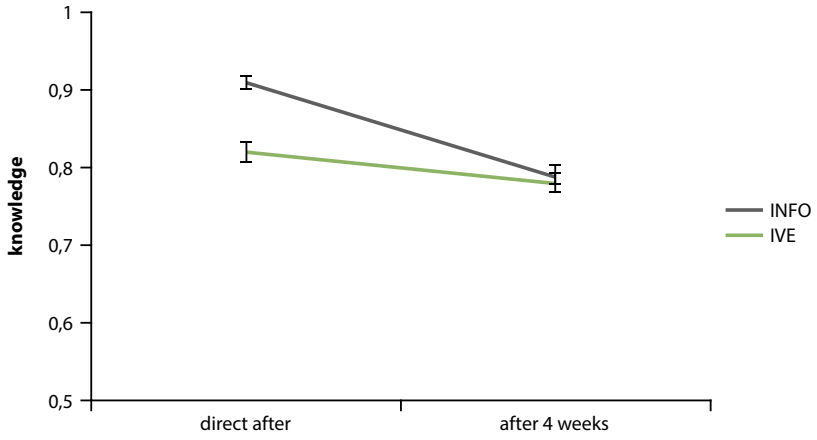


Figure 5:
Knowledge level of the IVE and the INFO condition in the first and second measurement. The error bars represent the standard error (SE).

On average, the vulnerability level was lower after 4 weeks, as there was a significant difference with respect to vulnerability between the first measurement (M = 2.64, SD = .83) and the second measurement (M = 2.54, SD = .82; b = .327, p=.002). There was no significant interaction effect between IVE and vulnerability (b= .1636, p=.085) (see Figure 6).

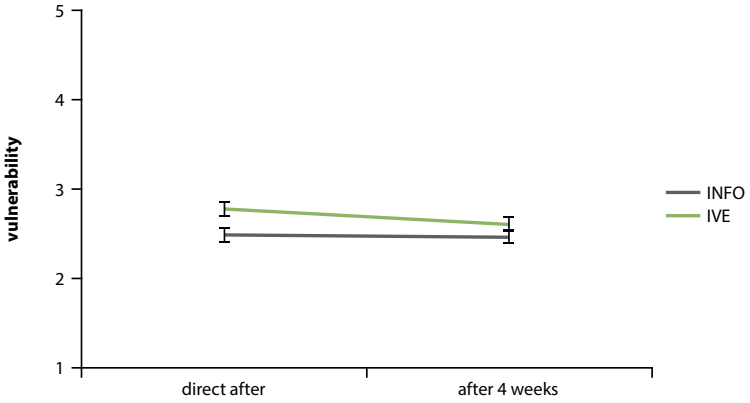


Figure 6:
Vulnerability level of the IVE and INFO condition in the first and second measurement. The error bars represent the standard error (SE).

On average, the severity level was slightly lower after four weeks, but there was no significant difference on severity between the first measurement (M = 3.73, SD = .62) and the second measurement (M= 3.63, SD= .61; b= -.062, *p*=.218). There was no significant interaction effect between IVE and severity (b= -.063, *p*=.379) (see Figure 7).

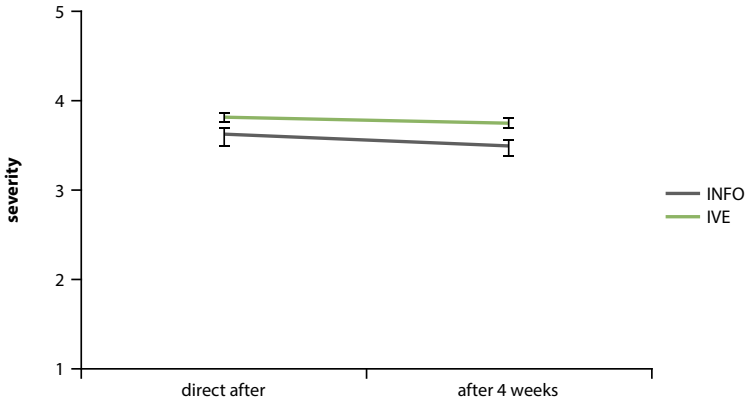


Figure 7:
Severity level of the IVE and INFO condition in the first and the second measurement. The error bars represent the standard error (SE).

Whereas previous results in the literature have suggested increased retention in IVE, our results support this only to a limited extent. First, vulnerability decreases somewhat over the span of four weeks, but we do not find substantial differences between the IVE and the INFO condition. Severity does not significantly decrease over time. There is a difference over time in terms of knowledge retention. After four weeks, the higher knowledge that the participants had in the INFO condition has decreased to the level of the IVE condition,

which itself hardly decreased over the four weeks. In this sense, there is some evidence for an IVE leading to better retention than INFO in terms of knowledge. However, in our case the IVE condition had a lower knowledge level to begin with.

4.5 Discussion

We considered the effects of an IVE on relevant and frequently used determinants for prevention behavior - knowledge, vulnerability, severity, self-efficacy, and locus of control - , and the extent to which these effects in turn affect subsequent prevention behavior. The main reason for our approach was that most IVE studies only consider the effect of the IVE on these psychological determinants (Chittaro, 2012, 2014, 2016; Chittaro & Buttussi, 2015; Chittaro & Zangrando, 2010; Tarnanas & Manos, 2004; Zaalberg & Midden, 2010), but not its effects on actual prevention behavior, nor the mediating effects of the psychological determinants.

The IVE had effects on almost all of the psychological determinants. As expected, the vulnerability and severity levels were higher in the IVE condition compared to the INFO condition: people in the IVE group felt more vulnerable to fire and thought a grease fire was more severe. After four weeks these feelings were approximately equally present in both groups. Also, as expected and desired, the level of self-efficacy was lower in the IVE condition compared to the INFO condition. That is, people felt less confident that they would act properly in case of a grease fire. This is partly a direct effect, and partly an indirect effect through the increase of the perceived severity of a grease fire. An unexpected result was that people in the INFO condition scored higher on knowledge. This could possibly be explained by the fact that the information in the IVE was presented as text in the head-mounted display, which may not have been so easy to read and perhaps also not compatible enough with the rest of the virtual experience. Also, in the INFO condition people were really focused on the information, as their only task was to read the presented information, while in the IVE condition people were more focused on the fire and on how to act and interact. One could imagine that the effect of the IVE could be improved by changing the way in which information is put forward. For instance, improved software might make it easier to produce a static text that is easier to read than the one in our IVE was, or by getting the information across through sound. Also, instead of showing the information afterwards, it might work more effectively to integrate all knowledge components in the IVE game (as in: Chittaro & Buttussi, 2015; Chittaro et al., 2018). Even though this was done for some knowledge components (e.g. the text ”water causes a flash fire” was shown after the participant used water to extinguish the grease fire), other knowledge components were only presented at the end. Although the INFO group scored higher on knowledge directly after the intervention, their knowledge level significantly decreased after 4 weeks and decreased more rapidly than in the IVE group. This suggests that knowledge presented

in a traditional text format is not retained over a longer time span as well as information in an IVE, as in line with results of Chittaro and Buttussi (2015). Safety locus of control (SLOC) was not influenced by the IVE at all, even though effects of interventions (e.g. IVE, training) on locus of control have been found in other domains (Chittaro, 2014; Huang & Ford, 2012). A possible reason for this might be that locus of control is hard to influence in the fire prevention domain, possibly because the score of SLOC was already quite high (the mean score of the SLOC items equaled 4.3 were all items were measured on a five point scale).

The IVE did affect the measured prevention behaviors, however it affected different behaviors in different ways. When only comparing the subsequent behavior and the original conditions, IVE did not have the desired positive effect on investing in a fire blanket, compared to a control condition in which the same information was delivered on paper. However, closer inspection of this result shows that this effect was a combination of a direct positive effect of IVE and an indirect negative effect via a decrease in knowledge. One could potentially argue that the negative effect of IVE on knowledge could have had consequences for the other psychological determinants, however we did not came across these relationships in literature, nor did the mod indices in our SEM models suggest this. IVE had a (small) effect on vulnerability and vulnerability had a (small) effect on taking home flyers. Taken together this lead to a (smaller) total effect of IVE on taking home flyers that was no longer significant in our sample. It is somewhat unexpected and noteworthy that the IVE affects these prevention behaviors in different ways. This highlights the importance of a better understanding of the causal mechanisms that might lead individuals to change their behavior. In this case we found that a higher knowledge level results in investing in a fire blanket, but not to more information seeking through taking home flyers. More knowledge about the risk, the available actions and its consequences results in the fire blanket as the perceived optimal choice. The explanation for no increase in flyers might be that because one already has an increased knowledge level, there is no interest in further information. On the other hand, we found that a higher vulnerability did lead to more information seeking. Perhaps the higher vulnerability is a sign that participants realized that they knew less about the risks that they thought they did, and therefore wanted to get more information, which is understandable, although we arrive at this only in hindsight. It remains to be seen whether this connection between vulnerability and information seeking holds across a broader set of domains. Nevertheless, it seems sensible for future research to categorize the prevention behaviors in terms of the kind of psychological determinant it is affected by, instead of assuming that all prevention behaviors are equally affected by the psychological determinants.

The IVE affected knowledge, vulnerability, severity, and self-efficacy but the latter

two did not relate significantly to prevention behavior, despite the fact that previous literature has indicated these to be potentially important determinants of behavior. The effects on the prevention behaviors are only affected by two of the psychological determinants: knowledge and vulnerability, and both are determinants for different prevention behaviors. Moreover, the effect of IVE on investing in a fire blanket is not fully mediated by the decrease in knowledge, but is for the most part a direct effect that cannot be explained away by any of the psychological determinants that we considered. This raises the question which other factors there might be that could explain the direct relationship between IVE and prevention behavior that we did not take into account. One possibility would be to consider the other factors of the HBM and the PMT that we did not include here, namely whether the perceived benefits and barriers related to the prevention behavior in question might nevertheless have played a role (Rogers, 1975; Rosenstock, 1966). One of these variables is for example the perceived effectiveness of the prevention behavior, an important determinant, together with vulnerability, for taking adaptive actions to minimize the consequences of a flood (Zaalberg et al., 2009). Another question that arises because of the results of this study is how to interpret the effect of IVE on psychological determinants in other studies. Does an increase in for instance vulnerability or severity through IVE necessarily imply an actual behavioral change? Especially in fields in which the specific psychological determinants under study have not been validated with real behavioral outcomes (e.g. aircraft evacuation, flood experience, fire) our analyses suggest that one must be careful with the interpretation and generalization of such results.

Limitations

As the focus of this study was on fire and fire prevention, it remains to be seen whether results are generalizable to other areas of risk. For example, SLOC was not influenced by the IVE in our study, and did not affect the measured prevention behaviors, while studies in other domains did show these results.

Furthermore, we only measured two kinds of behavior: investing in a fire blanket and taking home flyers. As we have seen, direct and indirect effects may differ depending on the measured behavior and we do not know whether and how results would differ had we included additional prevention behaviors. For example, maybe an increase in the perceived severity would have influenced the probability of purchasing a fire extinguisher or would have led to paying more attention to the fire escape plan in the building. In addition, one could argue about the appropriateness of the INFO condition as the control condition, as it differs on multiple aspects from the IVE condition (e.g. occupation time, no graphics, no gaming element). An alternative would have been to complement the current setup with a more comparable condition such as the 2D version

of the same fire game, although this would probably lead to smaller sized effects. Our power analysis showed that we needed about 240 participants, so adding an additional condition would already dramatically increase the number of participants. Moreover, if the effect size would indeed be smaller given that the two conditions are more similar, this would imply a still larger necessary sample size.

We could also have measured the psychological determinants before the experimental manipulations, so that they could be used as control variables in our analyses, which might have increased precision and could have provided a baseline measurement against which to compare post-intervention measurements. The trade-off, however, is that we would be priming the participants in the direction of effects on these determinants by the intervention (possibly making it 'easier' to find differences). We therefore chose not to measure the determinants beforehand.

A further useful addition could have been to include the perceived effectiveness of the fire blanket as a measurement, since this is perceived to be an important determinant for performing prevention behaviors (Weinstein, 1989). However, we did not included this question since we did not want to prime participants too much in the direction of buying the fire blanket.

Conclusion

Although the IVE influenced most of the psychological determinants, not all of these psychological determinants subsequently influenced the target prevention behaviors. The effect of the IVE on investing in the fire blanket was partly mediated by knowledge (and partly a direct effect), and the effect on taking home the prevention flyers was fully mediated by an increase in vulnerability. Given that we have included all psychological determinants that we found in the literature, it is surprising that the larger part of the effect of IVE does not seem to be correlated with these determinants. This suggests three issues that are noteworthy for IVE research in general. First, merely that only establishing effects of IVE on psychological determinants such as vulnerability and locus of control (as is usually the case in IVE studies) does not necessarily imply effects on prevention behaviors as not all psychological determinants lead to subsequent prevention behavior. Second, different prevention behaviors can be influenced by different psychological determinants: there is a real need to consider in more detail which determinants trigger which kinds of prevention behaviors. Finally, our study shows that not all effects of IVE on prevention behavior can be "explained away" by the psychological determinants that find their origins in the HBM and PMT and are typically measured in IVE research. Taken together, these two findings should be cause for some concern with regard to the often used setup in IVE research, where only the effect of IVE on psychological determinants is measured.

5

Do smoke alarms save lives? Using behavioral psychology to increase smoke alarm ownership

5.1 Introduction

In the Netherlands and worldwide, attempts are made to convince people to invest in fire prevention. One of the most important fire prevention measures for households is a functioning smoke alarm. Analysis of domestic fire incidents in the USA between 2012 and 2016 identified that the death rate in homes without a functioning smoke alarm was more than twice as high than in houses with functioning smoke alarms (12.3 vs 5.7 deaths per 1000 fires) (Ahrens, 2019). Although smoke alarm ownership has increased in the last decades, still about 25% to 30% of the households in the Netherlands do not own a smoke alarm (Institute for Safety, 2015). In the U.S. percentages are higher with 96 - 97% of households reporting to own a smoke alarm, although households that experienced a home fire only 76% reported to have a smoke alarm (Ahrens, 2019). Moreover, about a quarter to one-third of the smoke alarms do not appear to function properly (Institute for Safety, 2015a; Parmer, Corso, & Ballesteros, 2006), mostly due to non-functioning or missing batteries (Ahrens, 2019).

Despite the fact that functioning smoke alarms should be a priority for every household, there is little understanding about why people do not prioritize this behavior and about how we can motivate people to buy, install, and maintain smoke alarms (Clark & Smith, 2018). Although worldwide quite some fire prevention interventions have been implemented, the majority has not been scientifically evaluated nor published and as a consequence quite some effects are unknown (Eysink Smeets, Heijman, Postma, 2015). The interventions that are published, are rarely based on a comprehensive problem analysis that includes behavior change theories (Eysink Smeets, Heijman, & Postma, 2016; Gielen & Sleet, 2003; Thompson, Waterman, & Sleet, 2004), although there are some studies that apply the key determinants from prevention behavior theories such as the Health Belief Model (HBM: Rosenstock (1966) or Protection Motivation Theory (PMT: Rogers, 1975) as a basis for the development of fire prevention interventions (e.g. Miller, Bergen, Ballesteros, Bhattacharya, Gielen & Sheppard, 2014; Shani, Ayalon, Hammad, & Sikron, 2003). Although these theories offer a good starting point, knowing what the key determinants from these theories are, is not necessarily enough to increase fire prevention behavior. The beliefs that a fire in a home is likely and has severe consequences, that smoke alarms are effective and that one is capable of installing and maintaining a smoke alarm, offer an intuitively logical basis to explain a lack of functioning smoke alarms. However, as has been shown by Miller et al. (2014), addressing the factors of the Health belief Model in an intervention does not automatically increase the number of functioning smoke alarms.

We want to address three issues that relate to this matter. First, these theories are formulated on a rather abstract level and for any kind of practical application the determinants need to be defined more precisely in order to be relevant for the specific

behavior of study. Second, not all prevention behaviors will be driven by the same determinants to the same extent. As shown by Kronenfeld, Glik and Jackson (1991), different fire prevention behaviors, such as fire escape planning, having a smoke detector or having a fire extinguisher, can be driven by different determinants. Similarly, determinants might differ for the different behaviors necessary for functioning smoke alarms: the reasons for not purchasing a smoke alarm, might differ from not installing one (smoke alarms can often be found unwrapped in a closet) and might differ from not regularly testing or not changing the batteries. Third, also determinants other than prescribed by the prevailing prevention behavior theories (PMT: Rogers, 1975, HBM: Rosenstock, 1966) might be important to consider. This is also in line with the study of Miller et al. (2014) who showed that hands-on practice with testing the smoke alarm, changing the battery and using the hush button was the key to increase the number of functioning smoke alarms, while the intervention that addressed the HBM factors did not. This indicates that probably a lack of knowledge concerning how to keep smoke alarms operational was an important inhibitory factor, instead of a low risk perception or people not recognizing the benefits of a smoke alarm. Other promising determinants to consider that have - to our knowledge - not yet been addressed in relation to smoke alarms, are descriptive and injunctive social norms (Cialdini et al., 2006; Melnyk, Van Herpen, Jak, & Van Trijp, 2019), which have been proven to be important factors in the field of risk prevention behavior (Bubeck, Botzen, Laudan, Aerts, & Thieken, 2017; McEachan, Conner, Taylor, & Lawton, 2011).

We argue that in order to increase fire prevention behavior, it is necessary to determine the specific target behavior, determine all potentially relevant determinants for this behavior, analyze which specific determinants influence this specific behavior, and address the relevant determinants in an intervention. This is our aim for this chapter.

5.1.1 Smoke alarm ownership

Ending up with a functioning smoke alarm involves a number of steps, or behaviors: acquisition of one or more smoke alarm(s), correct installation (appropriate number and placement) of smoke alarm(s), periodic testing of the alarm(s), maintenance (removing dust), and replacement of batteries and malfunction alarm units (McKnight, Struttman &, Mays, 1995; Thompson et al., 2004). Since the determinants might differ for these different behaviors, we decided to focus our study on one specific behavior. To determine the target behavior for this study we performed a survey under a sample of Dutch individuals (n = 525). See Table 1 for the possible target groups and target behaviors and Appendix K for all items and results. Although the intention to change is the lowest for the group that lacks a smoke alarm, we decided to focus the rest of our study on this group because this was by far the largest group. It also poses the greatest challenge to get this group to acquire a smoke alarm.

Table 1: Potential target groups, and accompanying target behaviors, for interventions directed at increasing the number of functioning smoke alarms. Percentages are weighted to the Dutch population based on: gender, age, education and region (n = 525).

Target behavior	Target group	%	Intention (score 4-7)
Buy smoke alarm	No smoke alarm present	16.6%	32.8%
Install smoke alarm	No smoke alarm installed, but smoke alarm in packaging	6.6%	74.1%
Change batteries, repair, dust off, or buy new smoke alarm	Smoke alarm(s) installed, but (some) non-functioning	5.8%[1] -7.8%[2]	67.8%
Test smoke alarm	Smoke alarm(s) installed, but functioning unknown	1.9%[1] – 5.2%[2]	
Not applicable	Smoke alarm(s) installed, and all functioning	87.1%[2] – 92.2%[1]	

Note.[1] Base: all people with multiple smoke alarms (unweighted n=100; weighted n=104).
Note.[2] Base: all people with one smoke alarm (unweighted n=302; weighted n=294).

5.1.2 Outline of the study

The central question of our study is which determinants drive smoke alarm ownership and intention to purchase one, and whether we can increase smoke alarm ownership by addressing these determinants in a communication-based intervention. To answer these questions, we followed a long and extensive path, in which we performed multiple sequential studies. We first made an exhaustive inventory of all possible motivations and barriers (referred to as "determinants" in this study) for smoke alarm ownership, by conducting interviews together with the Fire Department (n = 15), and by consulting prominent prevention behavior theories (PMT, HBM), but also looking at other relevant literature such as the persuasion and risk literature (e.g. environmental risk, cybercrime). In this way we developed a model of possible determinants that was as complete as possible and analyzed the relationships between these determinants and smoke alarm ownership and intention in a survey (n = 622). Based on these results we developed two messages to stimulate smoke alarm ownership: one focused on the determinants we found to be strong predictors in the survey and one focused on the typically used determinants but that were not significant in our survey. We subsequently tested the effects of these messages (versus a control group) in a between-subject field experiment on smoke alarm ownership and intention (n = 310). Taken together, our results give a promising direction for interventions to increase smoke alarm ownership, and above all, show that conducting a comprehensive problem analysis for a specific target behavior is a necessary step to induce behavioral change.

5.2 Theory and hypotheses

5.2.1 Qualitative pilot study

To gain a better understanding of why people do not have (functioning) smoke alarms, we conducted 15 interviews. Participants were selected based on whether they lived in Tilburg, had no (functioning) smoke alarm installed or did not know if their smoke alarm functioned.[6] Participants were visited at their own home, by the author of this thesis together with an employee of the Fire Safety Department. We briefly mention the key conclusions of the interviews for smoke alarm ownership and leave the other behaviors out of scope here.

Most people stated that they did not own smoke alarms because they simply did not think about a fire or smoke alarms. Another often mentioned reason was that people thought a fire will not happen to them because they are very careful or because there are no risks in the home (e.g. no smoking, no gas stove). Some people mentioned that they did not know which smoke alarm to buy, where to install and how to install one, and/or thought that installation was a hassle. Some other mentioned reasons include that smoke alarms are not necessary as people will notice a fire in their homes themselves, that people are afraid the smoke alarm will go off accidently because of cooking or showering and that the costs of a smoke alarm were too high (especially to prevent something that probably will not happen). Less frequently mentioned reasons were (all n = 1): afraid the sound of the smoke alarm will be annoying for my cat, a smoke alarm is ugly, fatalism "if it is my time I will go anyway", and superstition "buying a smoke alarm will jinx the risk of a home fire". These results gave relevant input for developing the model of possible determinants. For instance, we decided to include knowledge, frequency of thought, wishful thinking and unrealistic optimism (see section 5.2.2), and to exclude superstition and fatalism. Also, the results helped to operationalize these and other determinants (e.g. annoyance) in a specific manner.

5.2.2 Determinants for smoke alarm ownership

In this section we discuss possible determinants for smoke alarm ownership. The determinants originate from two prominent risk prevention behavior theories (PMT, HBM) but also from other theories and various other sources. The determinants are divided into four categories: risk, prevention behavior, social environment and personal characteristics.

6 Interviews were in time performed before the choice for the target behavior "smoke alarm ownership" was made. Therefore, interviews included also people that had non-functioning smoke alarms, people that did not know if their smoke alarm functioned and people that had a smoke alarm still in the packaging.

5.2.2.1 Risk

Vulnerability and severity

According to both PMT and HBM, two important determinants to take preventive measures are the perceived likelihood that an event will occur, referred to as the *perceived vulnerability*, and the perceived consequences of this event, referred to as the *perceived severity* (Rogers, 1975; Rosenstock, 1966). These determinants are extensively tested, especially in the health and environmental risk domain, and have proven positive effects on intentions and behaviors, although effects are often small (Bubeck, Botzen, & Aerts, 2012; Floyd, Prentice-Dunn, & Rogers, 2000; Janz & Becker, 1984; Milne, Sheeran, & Orbell, 2000; Sheeran, Harris, & Epton, 2014). Vulnerability might be a relevant determinant in relation to smoke alarm ownership since home fires are typically perceived as a low probability event, especially compared to other risks (American Red Cross, 2018; Hodsoll & Nayak, 1999). Severity might be a relevant determinant given that a typical problem with fire hazards is that people tend to downplay the severity of a fire, especially the serious implications of smoke cues and smoke inhalation (Chittaro & Zangrando, 2010; Proulx, 2001, 2003). A study of (Kronenfeld, Glik, & Jackson, 1991) showed that both vulnerability and severity were significant predictors of smoke alarm ownership for households with young children. Vulnerability and especially severity are determinants that are often addressed in the current fire prevention communication efforts.

Wishful thinking and denial

When people are not motivated to perform a prevention behavior, a variety of coping mechanisms - such as wishful thinking, denial and, fatalism - can be used to deal with the negative emotional consequences of the threat (Grothmann & Reusswig, 2006; Rippetoe & Rogers, 1987). Although mentioned by PMT these variables are typically not included in studies that test the relationships of PMT variables with prevention behavior. Studies that did include these variables showed these variables were important explanatory variables for not performing prevention behaviors (Abraham, Sheeran, Abrams, & Spears, 1994; Grothmann & Reusswig, 2006; Rippetoe & Rogers, 1987; Allen, Phillips, Pekmezi, Crowther, & Prentice-Dunn, 2009). Two relevant coping mechanisms concerning domestic fires might be wishful thinking and denial. Wishful thinking is defined as a strategy that brings up unrealistic solutions for the problem (Rippetoe & Rogers, 1987), while denial is defined as an attempt to actively evade the threat to avoid psychological discomfort (Mclennan, Every, Bearman, & Wright, 2017). A sometimes mentioned argument for not having a smoke alarm, in the line of wishful thinking, is that people think they will notice it if there is a fire in their home. While,

according to fire experts, people do not smell a fire or smoke during their sleep. Hence, fire prevention campaigns in Belgium and the Netherlands, often focus on the fact that people do not smell anything during their sleep, and consequently will wake up too late.

Frequency of thought

Clark and Smith (2018) showed that an important reason for not having (functioning) smoke alarms was that people not explicitly or consciously think about a fire in their home or fire prevention measures. As quoted by a participant in this study "It is just not in my everyday thoughts, I don't think about fires". Also, a study about fire escape plans showed that simply not thinking about it, was an important reason for not practicing the fire escape plan (Thompson et al., 2004). Although this reasoning sounds logical and recognizable, this is not a typical studied factor in general prevention behavior literature. However, the frequency with which thoughts about a hazard come to mind, is a concept that is mentioned and has been measured before in relation to earthquakes, often framed as "hazard intrusiveness" (which also contains talking and receiving information about a hazard) (Lindell, Arlikatti, & Prater, 2009; Lindell & Prater, 2000; Pennebaker & Harber, 1993; Russell, Goltz, Bourque, 1995; Tierney, Lindell, & Perry, 2001). The general conclusion is that the frequency of thoughts about a hazard has a positive relationship with prevention behavior (Lindell et al., 2009; Russell, Goltz, Bourque, 1995), and might even have more impact than the risk perception variables, as shown by Lindell and Prater (2000).

Worries

A concept that is related to the frequency of thought, but with emphasis on the role of affect instead of cognition, is worrying about the hazard (Dooley, Catalano, Mishra, & Serxner, 1992; Lindell & Prater, 2000). A study of Baron, Hershey, and Kunreuther (2000) that investigated people's perception of various risks (e.g. floods, earthquakes, fire at home, car accidents) showed that a higher level of worry was positively related to prioritizing taking preventive action. Also Dooley et al. (1992) showed that worrying about earthquakes had a positive relationship with preparedness behavior. Also the willingness to pay for insurance, which can be also perceived as a form of prevention, is positively influenced by feelings of worry, even more so than perceived probabilities of risks (Schade, Kunreuther, & Koellinger, 2011). These findings are consistent with other studies that take into account the role of affect in decision making under risk (Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, Finucane, Petere, & MacGregor, 2004). Following this line of thought, worrying about a home fire might be related to smoke alarm ownership.

Unrealistic optimism

A factor that prohibits people to undertake prevention measures is the thought that "an event won't happen to them" (Weinstein, 1980, 1989). The ruling thought is not that negative events won't happen, but that they will not happen to them (McKenna, 1993). This idea, referred to as *unrealistic optimism* or *optimism bias*, can in part be explained by people's perceived personal control over a situation (DeJoy, 1989; Weinstein, 1980), and it also has positive implications for people since it reduces stress and anxiety (Sharot, 2011). Then again, a domestic fire might be the kind of event that people are unrealistically optimistic about, which might prohibit people from installing a smoke alarm. Unrealistic optimism can also be the consequence of not taking preventive measures, namely to resolve the conflict of "cognitive dissonance" (Festinger, 1957).

5.2.2.2 Prevention behavior characteristics

Benefits

The motivation to take preventive action also depends on the perception of the extent to which the recommended behavior is likely to reduce the perceived probability or severity of the risk or, in other words, to what extent the behavior is seen as effective. In PMT this is referred to as the *response efficacy*, and in HBM this is referred to as the *perceived benefits* of the behavior (Rogers, 1975, 1983; Rosenstock, 1966). Primarily studies in the health- and environmental risk domain have shown that the 'perceived benefits' can be an important predictor for intentions and behaviors, typically showing larger effect sizes than perceived vulnerability and severity (Bubeck et al., 2012; Floyd et al., 2000; Janz & Becker, 1984; Milne et al., 2000; Sheeran et al., 2014; Valkengoed & Steg, 2019). Whether this is also a relevant determinant for smoke alarm ownership is still an open question. In fact, a qualitative study found that also people without smoke alarms agree about the importance of smoke alarms, and also endorse the fact that smoke alarms facilitate evacuation and save lives (Clark & Smith, 2018). Although this might imply that stressing the benefits of a smoke alarm might not be the most effective strategy, "smoke alarms save lives" is a commonly used campaign slogan (Roberts et al., 2004).

Barriers of the behavior

Response costs in PMT (which is the same as *perceived barriers* in HBM) negatively influence the motivation to take preventive action. One could think of financial costs, time, effort, discomfort, painfulness, or general unpleasantness (Floyd et al., 2000; Rosenstock, 1966). Meta-analyses have shown that 'perceived barriers' is an important

predictor for intentions and behaviors and, in general with larger effect sizes than perceived vulnerability and severity (Bubeck et al., 2012; Floyd et al., 2000; Janz & Becker, 1984; Milne et al., 2000; Sheeran et al., 2014). It depends on the type of behavior though, which specific barriers are most relevant. In the case of smoke alarm ownership, the *perceived effort* concerning installation seems important, also given that ceilings can be difficult to reach, especially for people with limited physical abilities (Clark & Smith, 2018; Roberts et al., 2004). Another important barrier seems to be the *perceived annoyance*, since (in people's perception) smoke alarms have the tendency to beep at inconvenient times (miraculously, batteries always tend to go low in the middle of the night), for ambiguous reasons (this is often because of excessive dust) or give false alarms (e.g. after cooking or showering). This results in people dismantling their smoke alarm (or removing the batteries) or people refraining from installation to begin with (Clark & Smith, 2018; Roberts et al., 2004). Another barrier for installing a smoke alarm can be the *perceived aesthetics*, as some participants in the study of Clark and Smith (2018) expressed their concerns about a smoke alarm disrupting the aesthetics of their homes. Finally, as smoke alarms involve a financial investment the *perceived financial costs* might also act as a barrier, although as far as we could see this has not been mentioned in the literature about smoke alarms before.

Awareness

Although awareness of the behavior is not operationalized as a determinant for prevention behavior in PMT or HBM, it seems logical that someone first must be aware of the prevention behavior in order to consider the behavior. Awareness of the risk and/or the prevention behavior are commonly studied factors in the domain of cyber security prevention (Hanus & Wu, 2016; Talib et al., 2010), earthquake prevention (Vincente, Ferreira, Maio, & Koch, 2014; Yang, Gao, Liu, He, & Fan, 2010), and health risk prevention, for instance in the case of Ebola prevention (Tenkorang, 2018). Although we expect that most people are aware of what a smoke alarm is and does, we did include this factor in our study to be complete.

Knowledge

Specialized knowledge and skill can be important resources someone must have in order to be able to implement (specific) prevention measures (Lindell and Perry, 2003). In general, a lack of knowledge about "when to", "where to" or "how to" can be a barrier to behavioral change (Snyder, 2007). This is in line with the study of Clark and Smith (2018), who showed that a lack of knowledge about how and where to install smoke alarms for some people is a reason for not having smoke alarms installed. Although specific knowledge might be an important factor, it is often not so explicitly addressed

and measured in prevention behavior literature as often it is implicitly part of self-efficacy. However, in our study we wanted to capture and measure determinants as precise as possible, since we belief this gives the clearest direction for an intervention.

Self-efficacy

Another important determinant to take preventive measures, according to the extended versions of the PMT and the HBM, is self-efficacy (Maddux & Rogers, 1983; Rosenstock et al., 1988). "Perceived self-efficacy is the belief in one's competence to tackle difficult or novel tasks and to cope with adversity in specific demanding situations" (Luszczynska, Gutiérrez-Doña, & Schwarzer, 2005, p.80). The more someone is confident about his own capabilities to perform the target behavior, the more likely it is that someone will successfully carry out the behavior (Bandura, 1994). Self-efficacy is proven to be a very important determinant for successful performance of preventive health behaviors (Floyd et al., 2000; Milne et al., 2000). Self-efficacy might also be a relevant determinant for smoke alarm ownership since a qualitative study showed that reasons for not having a smoke alarm are that people perceive they lack the skills and are uncertain over where to place them (Clark & Smith, 2018). Something to take into account is an issue mentioned by Weinstein (1993), that the distinction between self-efficacy and barriers of the behavior is not always that clear. In PMT studies self-efficacy is often operationalized as the barriers of a behavior, namely as the problems people expect to encounter (e.g. something is difficult for me to do) instead of people's perceived ability to, for instance, stop smoking.

5.2.3.3 Social environment

Social norms

There is lots of empirical evidence that social norms are an important determinant in shaping intentions and behavior (e.g. Cialdini et al., 2006; Cialdini, Reno, & Kallgren, 1990; Goldstein, Cialdini, & Griskevicius, 2008; Reno, Cialdini, & Kallgren, 1993; Melnyk et al., 2019), also in the field of risk prevention behavior (Bubeck, Botzen, Laudan, Aerts, & Thieken, 2017; McEachan, Conner, Taylor, & Lawton, 2011). A distinction is often made between injunctive social norms (the perception of approval of the behavior by others) and descriptive social norms (the perception of how many others perform the behavior). In mass communication social norms are often used to influence behavior, which is especially relevant if there is a misconception of the true social norm, as in the case of college students that overestimated drinking behavior of their peers (Abroms & Maibach, 2008). Research showed that the higher the social norm, the higher the intention to act, and that the presentation of objective norms (i.e. percentages) works

better than subjective norms (i.e. "the majority") (Baaren, Leeuwen, Siebelt, & Lange, 2012). To the best of our knowledge, the concept of social norms in relation to smoke alarms has not been studied before. Nevertheless, it might be a promising determinant to consider. Especially if people underestimate the level of smoke alarm ownership of (important) others.

5.2.3.4 Personal characteristics

Responsibility

Prevention responsibility refers to the degree to which a person feels personally responsible for taking preventive measures to protect oneself or their possessions from the negative consequences of a hazard (Kellens, Terpstra, Schelfaut, & De Maeyer, 2013). Studies related to earthquake preparedness behavior found that the more someone feels personally responsible for taking preventive action – instead of putting the responsibility on others such as the government – the more likely it is that someone will take some kind of action (Becker, Paton, Johnston, & Ronan, 2013; Lara et al., 2010; Lindell & Whitney, 2000), although one study concerning Dutch flood management did not find this relationship (Terpstra & Gutteling, 2008). In the case of smoke alarms it might be that people believe others are responsible for installing a smoke alarm in their home, such as the fire safety department (Clark & Smith, 2018), the home owner, or the housing cooperation.

Experience

Weinstein (1989) studied the effects of personal risk experience on prevention behavior in a variety of domains (road safety, natural hazards, crime), and showed that personal experience can positively influence prevention behavior, because of an increase in vulnerability, severity and worries. However, this only holds when the nature of the harm is severe, and the advised prevention behaviors are perceived to be effective (Weinstein, 1989). When the experience was mild, this can make people optimistic about future events (referred to as "normalization bias") which does not motivate prevention behavior (Becker et al., 2013; Mileti & Brien, 1992). In addition, Weinstein (1989) argues that risk experience can also influence people that did not directly suffered from the risk, because of an increased level of communication and attention. The direct or indirect experience of a domestic fire might also be a determinant for smoke alarm ownership.

Socio-economic variables

Characteristics that in previous studies were associated to smoke alarm ownership are: education, income, home ownership, year of construction, type of home, smoking, households with children, and marital status (Harvey, Sacks, Ryan, & Bender, 2014; Jones et al., 2001; Roberts, 1996; Shults et al., 1998; McKnight, Struttman, & Mays, 1995). In the Netherlands the following variables are found to be associated to smoke alarm ownership: size of the household, education, employment, income, value of the home and year of construction of the home (Van Teerns in Kobes & Groenewegen-ter Morsche, 2015).

5.2.3.5 Intention

If all determinants mentioned in the previous paragraphs are influenced in the right direction, this should result in the motivation, or intention, to purchase a smoke alarm. However, intentions do not always result in actions, also known as the 'intention-behavior' gap (Sheeran & Webb, 2016). Sheeran and Webb (2016) discuss several explanatory factors why not all intentions make it to behaviors, such as over-optimistic planning or goals being too difficult. It might also be that intentions can lead to an internal conflict: between what people want to do (nothing, or something else more exiting or necessary) and what they planned to do (install smoke alarm) (Milkman, Rogers, & Bazerman, 2008). Buying and installing a smoke alarm could be a chore someone in principle intents to do but does not act upon. If this is the case, persuasion techniques that close this intention-behavior gap might be effective such as formulating "implementation intentions" (Gollwitzer & Sheeran, 2006).

5.2.3.6 Conclusion

A multitude of potential determinants related to the risk of a domestic fire, to the characteristics of a smoke alarm, to the individual or the household, or to someone's perception of the social environment might be relevant (de)motivators for smoke alarm ownership or the intention to purchase one. Next, we test the relationships of these determinants with smoke alarm ownership and intention in a survey (see section 5.3 and 5.4), to ultimately test a message addressing the most significant determinants in a field experiment (see section 5.5 and 5.6).

5.3 Method study 1

We conducted a survey to determine which determinants and to what extent they influence smoke alarm ownership and intention.

5.3.1 Participants and procedure

Participants were selected from a commercial consumer panel: 217 participants that reported to have a smoke alarm installed and 404 participants that reported not to own a smoke alarm. Participants were excluded if they owned a smoke alarm in the packaging that was not installed, as the target behavior of our study was to *buy a smoke alarm*. Participants that lived in a home built in 2003 or later were excluded, since all houses built after that date must be provided with smoke alarm(s) as required by Dutch law. Participants that already participated in our first survey about smoke alarms (see paragraph 5.1.1) were not allowed to participate. In the invitation it was made clear that the research was conducted by Eindhoven University of Technology and that the survey was about fire prevention behavior. It was stressed that there were no right or wrong answers and that the responses were confidential and would only be used for research purposes. The survey was programmed in such a way that participants were required to provide an answer in order to proceed, except for items with an open text field, those were optional.

5.3.2 Measures

All measures were based on the literature and transferred to the topic of fire and/or smoke alarms. The results of the qualitative pilot study as described in paragraph 5.2.1 also gave input to formulate some of the items. For all items we used 7-point Likert scales.

Vulnerability and severity

Similar to de Hoog, Stroebe, and de Wit (2008) and Zaalberg, Midden, Meijnders, and McCalley (2009) we measured perceived vulnerability of a domestic fire with one item: "How high do you perceive the probability of a fire in your house to be?" (1 = very low; 7 = very high). Perceived severity of a domestic fire was measured with one item: "How severe do you perceive the consequences of a fire in your house to be?" (1 = not severe at all; 7 = very severe).

Wishful thinking and denial

Wishful thinking and denial were inspired by measures from other studies (Abraham, Sheeran, Abrams, & Spears, 1994; Allen, Phillips, Pekmezi, Crowther, & Prentice-Dunn, 2009; Lehman & Taylor, 1987; Rippetoe & Rogers, 1987). Wishful thinking was measured with two items: "If there is a fire in my sleep, I will probably wake up on time because of the smoke or the heat". "If a fire breaks out in my home, I will notice that automatically, I do not need a smoke alarm for that" (1 = do not agree at all; 7 = fully agree). Denial was measured with one item: "I prefer to avoid thinking about a fire in my home." (1 = do not agree at all; 7 = fully agree).

Frequency of thought

Frequency of thought was measured with three items. "How often do you think about the possibility of fire in your home?" "How often do you think about what to do in the case of a fire in your home?" "How often do you think about fire prevention measures for your home?" (1 = never; 7 = always). These items were inspired by items that measured hazard intrusiveness (Lindell, Arlikatti, & Prater, 2009; Lindell & Prater, 2000)[7].

Worries

To what extent people are worried was measured with one item "To what extent are you worried about a fire in your home?" (as in Zaalberg et al., 2009) (1 = no worries at all; 7 = extremely worried).

Unrealistic optimism

Unrealistic optimism was measured with two items: "A fire in my home will not happen to me, because there are few places where a fire could occur." "A fire in my home will not happen to me, because I am very careful" (1 = do not agree at all; 7 = fully agree). Instead of using only "a fire in my home will not happen to me" as in Becker et al. (2013), we specified the items more precisely as suggested by McKenna (1993).

Benefits of the behavior

Benefits of the behavior was measured by two items: "In the event of a fire, a smoke detector ensures that I can bring myself, and any family members, into safety on time." "In the event of a fire, a smoke alarm ensures that I can act on time, so that

7 Hazard intrusiveness exist out of items that measure thinking about a hazard, talking about the hazard and receiving information about the hazard (Lindell et al., 2009; Lindell & Prater, 2000).

there will be less damage to my home." (1 = do not agree at all; 7 = fully agree). This is a typical way of measuring this determinant (see, e.g. Maddux & Rogers, 1983).

Barriers of the behavior

The perceived effort was measured by two items: "How much effort do you think it is to buy a smoke alarm for your home?" "How much effort do you think it is to attach a smoke alarm to the ceiling of your home?" (1= no effort at all; 7 = a lot of effort). For both items, participants that perceived this as being medium to high effort (score: 4 - 7) were asked to explain their answer. Reasons were predefined and there was an open answer option. Multiple answers were possible. Perceived annoyance was measured with three items: "A smoke alarm regularly gives a false alarm (for example due to cooking, smoking or steam)." "A smoke alarm often makes annoying noise for inexplicable reasons." "A smoke detector often beeps at inconvenient times when the battery is empty (like at night)." (1 = do not agree at all; 7 = fully agree). We measured the perceived aesthetics by asking: "What do you think about a smoke alarm in your home?" (1 = not ugly at all; 7 = very ugly). Perceived financial costs were measured with two items: "How high do you perceive the costs of one smoke alarm? Please do not search for the price on the internet. It is about your first estimate. Please give an estimation in rounded euros." Answers could be filled in in an open text field. Followed by: "What do you think of these costs?" (1 = very cheap; 7 = very expensive).

Awareness

Awareness was measured for three fire prevention measures, in order to control for reliability of the answers. "Before completing this questionnaire, were you aware of the following measures to prevent fire in your home or to mitigate its damage: [smoke alarm] [fire blanket] [fire knock out]. Answer possibilities were: 1 = never heard of; 2 = I heard of it, but do not know how it works; 3 = I know what it is and how it works. Images of the measures were presented. Only the awareness of the smoke alarm was used for the analyses.

Knowledge

Knowledge was measured with two items. "Do you know how to install a smoke alarm in your home"? "Do you know where to install a smoke alarm in your home?" (1 = yes; 2 = somewhat; 3 = no).

Self-efficacy

Self-efficacy was measured as suggested by Bandura (2006) "How certain are you that you are able to successfully carry out the following actions?" [buy a smoke alarm for your home] [attach a smoke alarm to the ceiling] (1 = not sure at all; 7 = very sure).

Responsibility

Responsibility was measured on two levels: on the level of smoke alarm and on a general prevention behavior level. Responsibility concerning smoke alarms is measured with one item: "Who do you think is responsible for installing a smoke alarm in your home?" Answer possibilities were: me; my partner; my father/ mother/ child; home owner; housing corporation; my roommates; different. Responsibility concerning prevention behavior in general is measured with one item: "Who in your household is most concerned with prevention measures against burglary, fire and water damage?" Answer possibilities were: me; my partner; someone else; nobody. With both items multiple answers were possible.

Experience

Experience was measured on the individual and on a community level as suggested by Weinstein (1989). "Have you ever experienced a fire in your home or do you know people who have experienced this?" Answer possibilities were: I have experienced this; my neighbors experienced this; my friends or family experienced this; my acquaintances experienced this; I do not know anyone who experienced this. Multiple answers were possible.

Socio-economic variables

The following variables were measured: gender, age, education, household composition, pets, home and/or content insurance, ownership home, year of construction of the home, type of home, value of the home, and smoking.

Social norms

The injunctive norm was measured by one item. "To what extent do most people who are important to you think you should have a smoke alarm? I think they find it ..." (1 = not important at all; 7 = very important). The descriptive norm was measured with two items. "How many households in the Netherlands do you think have smoke detectors?" "How many of the people who matter to you have smoke detectors, do you think?"

Estimates could be given in an open text field [...%]. Although phrasings differ from study to study, this is a typical way of measuring social norms (see, e.g. Paek, Hilyard, Freimuth, & Barge, 2010). We used percentages instead of a Likert scale (as in Glynn, Huge, & Lunney, 2009), since using the social norm in an intervention is especially relevant if there is an underestimation of the true percentage of smoke alarms.

Intention

Intention to buy a smoke alarm was measured with two items which were adopted from the three item scale of Orbell, Hodgkins, & Sheeran (1997): "I plan to buy a smoke alarm in the next four weeks" (1 = do not agree at all; 7 = fully agree). "How likely is it that you will buy a smoke alarm in the next four weeks?" (1 = very unlikely; 7 = very likely). Participants with a medium to high intention (score: 4-7) were asked to explain why they did not bought a smoke alarm before (referring to the "intention-behavior gap"). Reasons were predefined and there was an open answer option. Multiple answers were possible.

5.3.3 Data description

There were 622 participants in the dataset: 404 participants stated not to own a smoke alarm and 217 stated to own one or more smoke alarms installed in their house. When dividing the completion time in four quarters, the middle 50% had a completion time between 351-578 seconds.[8] We manually inspected every participant with a completion time less than 289 seconds (10%) and deleted one participant with a suspicious answer pattern (gave answer option 7 to 20 consecutive items and stated a smoke alarm costs 1222 euro's). We performed regression analyses on the data, to test the relationships between the prevention behavior determinants and smoke alarm ownership and intention. The variable 'costs of a smoke alarm' had 1.6% missing values, the descriptive norm for the general Dutch population had 0.8% missing values and the descriptive norm for important others had 1% missing values. This resulted in n = 607 for our logistic regression analysis (with smoke alarm ownership as the target variable) and n = 379 for the linear regression analysis (with intention as the target variable). 72.5% filled in the survey on desktop or tablet and 27.5% on a mobile phone. The research company provided information on how many surveys the participants had filled out in the last two months. Most people had taken between 11 - 20 surveys (39.9%), followed by 0 - 10 (29.3%), 21 - 30 (19.8%), and more than 30 surveys (10.6%).

8 We did not present the mean duration time since the time kept on running if participants did not close their browser, which makes the mean duration time unreliable.

5.4 Results study 1

5.4.1 Factor analysis

Since we have collected a broad spectrum of determinants and adapted these to the topic of fire prevention, we performed factor analysis on all items to identify the most appropriate number of dimensions and composition of the determinants. As many items ask for concepts that are quite closely related, we performed factor analysis on all items, except for the socio-economic variables, with principal-components factoring and promax rotation in STATA 15. The data showed that 6 factors could be extracted (see Table 2). The rest were individual items. The factors 'benefits', 'descriptive norm' and 'annoyance' were expected beforehand. The factor 'knowhow' consisted out of two items that were supposed to measure 'knowledge', two items that were supposed to measure 'self-efficacy' and one item that was supposed to measure 'effort'. This is in line with the argument that self-efficacy often relates to the knowledge, skill and energy needed to successfully perform the task and therefore these concepts are often correlated (Lindell & Perry, 2004; Lindell et al., 2009; Weinstein, 1993). The factor 'wishful thinking' consisted out of two items that were supposed to measure 'unrealistic optimism' and two items that were supposed to measure 'wishful thinking'. The factor 'frequency of thought' appeared to consist out of three items that measured how often people think about it, and one item that supposed to measure 'worry'. The remaining items were individual factors: awareness, vulnerability, severity, denial, costs in euro's, subjective costs, aesthetics, injunctive norm, and effort of buying. Table 3 shows all determinants as formulated in the theoretical framework and the determinants after factor analysis.

Table 2: Results of the principal-components factor analysis with promax rotation.

Factor	Item	Factor loading	Alpha
Knowhow	Do you know how to install a smoke alarm?	.808	.754
	Do you know where to install a smoke alarm?	.746	
	How much effort do you think it is to install a smoke alarm at the ceiling of your home?	-.732	
	How certain are you that you can successfully carry out the following actions? Buy a smoke alarm for your home.	.536	
	How certain are you that you can successfully carry out the following actions? Install a smoke alarm at the ceiling of your home.	.839	
Benefits	In the event of a fire, a smoke detector ensures that I can bring myself, and any family members, into safety on time.	-.925	.873
	In the event of a fire, a smoke alarm ensures that I can act on time, so that there will be less damage to my home .	-.931	
Wishful thinking	A fire in my home does not happen to me because I am very careful.	.867	.811
	A fire in my home does not happen to me because there are few places where a fire could occur.	.863	
	If there is a fire during my sleep, I will probably wake up on time (for example due to smoke or heat).	.708	
	If a fire breaks out in my home, I will notice that automatically, I don't need a smoke alarm for that.	.564	
Frequency of thought	Do you ever think about… the possibility of a fire in your home?	.866	.856
	Do you ever think about… what you would do if a fire breaks out in your home?	.874	
	Do you ever think about… fire prevention measures for your home?	.787	
	To what extent do you worry about a fire in your home?	.670	
Descriptive norm	What percentage of households in the Netherlands do you think has smoke alarms?	.800	.701
	What percentage of the people that are important to you do you think has smoke alarms?	.801	
Annoyance	A smoke alarm regularly gives false alarm (for example due to cooking, smoking or steam).	.750	.728
	A smoke alarm often makes annoying noise because of inexplicable reasons.	.735	
	If the battery is low, a smoke alarm often beeps at inconvenient times (such as at night).	.785	

Table 3: Determinants before and after factor analysis.

Category	Determinant before factor analysis	Determinant after factor analysis
Risk	Vulnerability	Vulnerability
	Severity	Severity
	Wishful thinking	Wishful thinking
	Denial	Denial
	Frequency of thought	Frequency of thought
	Worries	Frequency of thought
	Unrealistic optimism	Wishful thinking
Prevention behavior	Benefits	Benefits
	Effort	Knowhow
		Effort of buying
	Aesthetics	Aesthetics
	Annoyance	Annoyance
	Financial costs	Costs in euro's
		Subjective costs
	Awareness	Awareness
	Knowledge	Knowhow
	Self-efficacy	Knowhow
Social environment	Descriptive norm	Descriptive norm
	Injunctive norm	Injunctive norm
Personal characteristics	Responsibility	Responsibility
	Experience	Experience

5.4.2 Logistic regression analyses with smoke alarm ownership

We performed a logistic regression with smoke alarm ownership as the target variable and the prevention behavior determinants and personal characteristics. First, we checked for multicollinearity by considering the variance inflation factors (VIF). This assumption was not violated: all variables have a VIF much smaller than 10 and together have a mean VIF of 1.33 (Kline, 2016). We also inspected the correlation matrix, which showed no correlations higher than .45, and checked the data for multivariate outliers with the BACON algorithm and did not find any (Weber, 2010). We performed three logistic regression analyses: one with the prevention behavior determinants, one with the personal characteristics and one with both the prevention behavior determinants and the personal characteristics (see Table 3). We performed an analysis separately for the personal characteristics since these are the more "fixed" variables, and are not, or at least not easy, influenceable with an intervention. The first analysis with the prevention behavior determinants showed that frequency of thought, knowhow, effort of buying, annoyance, descriptive norm, and injunctive norm had significant effects in the expected directions. The second analysis with the personal characteristics showed that male, having a home and/or content insurance, fire experience, and living in an apartment had significant effects. The third analysis, with prevention behavior determinants and the personal characteristics combined, showed that the effects of the prevention behavior determinants remained stable, and of the personal characteristics now only two variables

were significant: having a home/content insurance and responsibility of housing cooperation. Model 1 with solely the prevention behavior determinants had a better model fit than model 2 with solely the personal characteristics (Pseudo R^2 .324 versus .069). A Wald test, to evaluate the difference between nested models, showed that model 3 had a significantly better model fit than model 1(χ^2 (18) = 30.51, p = < .001).

Table 3: Results of logistic regression analysis with smoke alarm ownership as the dependent variable. Coefficients estimates (b), standard errors (S.E.) and significance levels (p) for all variables, and model fit statistics (χ2, *p*, ρ).

	Model 1		Model 2		Model 3	
	b	S.E.	b	S.E.	b	S.E.
Vulnerability	.073	.102			.036	.108
Severity	-.105	.078			-.116	.086
Wishful thinking	-.152	.103			-.176	.110
Denial	.076	.076			.096	.082
Frequency of thought	.523***	.134			.555***	.146
Benefits	-.059	.110			-.069	.119
Knowhow	.879***	.194			.907***	.216
Effort of buying	-.195*	.089			-.223*	.097
Aesthetics	-.112	.070			-.136	.078
Annoyance	-.303**	.092			-.327**	.101
Costs in €	.000	.003			-.001	.003
Subjective costs	-.018	.104			-.052	.113
Awareness	.862	.441			1.134*	.475
Descriptive norm	.031***	.005			.032***	.006
Injunctive norm	.225**	.084			.205*	.091
Responsible for smoke alarm						
Me			-.116	.241	-1.129	.314
My partner/ roommate/ family member			.099	.231	.125	.230
Home owner			.422	.312	.451	.411
Housing cooperation			.479	.318	1.042*	.433
(In) direct fire experience			.702***	.183	.422	.243
Male			.478*	.194	.355	. 262
Age			-.006	.006	-.011	.008
Education			.045	.062	.011	.082
Living together with partner			.256	.211	-.205	.282
Child(ren) at home			.301	.209	.485	.279
Pet(s)			.235	.188	.103	.242
Smoking			-.134	.217	.178	.278
Ownership home			-.336	.239	-.226	.306
Insurance			1.030*	.590	1.184*	.590
House type (base = terraced house)						
Detached home			.001	.287	.460	.367
Semi-detached			-.062	.275	-.098	.354
Apartmen/ studio			-.512*	.246	-.591	.321
Different			-.880	. 485	.179	.633
χ^2	254.33		54.92		287.62	
p	<.001		<.001		<.001	
Pseudo R^2	.324		.069		.368	
N	607		619		605	

Note. * = p<.05; ** = p<.01; ***= p<.001
Note. Model 1: model with prevention behavior determinants.
Model 2: model with personal characteristics.
Model 3: model with prevention behavior determinants and personal characteristics.

To get a better idea of the effect sizes of the prevention behavior determinants we calculated the predicted probabilities for different values of each separate predictor variable, with other predictor variables fixed at their mean. Our results (based on model 3, Table 3) showed that frequency of thought has the largest effect size: the predicted probability of smoke alarm ownership for value 1 was .081 compared to .712 for value 7 (a percentage point difference of .631) (see Table 4).

Table 4: Effect size for all significant prevention behavior determinants.

	Effect size
Frequency of thought	.631
Knowhow	.434
Annoyance	-.353
Awareness	.230
Effort buy	-.215
Descriptive norm	.556
Injunctive norm	.208

Note. We define effect size as difference in predicted probability (maximum value minus minimum value), evaluated with other predictors at their mean.

5.4.3 Robustness

To test the stability of the results, we performed the analysis of model 3 (Table 3) on two subsets of the data. First, we performed the analysis on only the people that stated to be the one in the household that is most concerned with prevention measures in the home (71.3%). Results showed that the same variables were significant as in model 3 Table 3, although wishful thinking now also has a significant effect (b = -.314, p = .021). Second, we performed the analysis on only the people who took more than five minutes to complete the questionnaire (87.8%). Results show that the same variables are significant as in model 3, Table 3. To further test the robustness of the results, we tested if there were any interaction effects of the significant determinants (based on model 3, Table 3) with the personal characteristics. Although we did not had hypotheses a priori about the interaction effects, most results were not surprising. The effort of buying a smoke alarm had a negative effect on smoke alarm ownership for women (-.389, p = .002). Men differed significantly from women regarding this determinant (.448, p = .010) essentially eliminating the net effect of the effort of buying a smoke alarm for men. The injunctive norm had a positive effect on smoke alarm ownership for women (.230, p = .016). Men differed significantly from women regarding this determinant (.607, p = .001), indicating that the injunctive norm was even more important for men. There was an interaction effect age * annoyance (b = .018, p = .003) indicating that annoyance is a stronger barrier for smoke alarm ownership for younger people (baseline: b = -1.205, p = .000). There was no effect of frequency of thought on smoke alarm ownership for people in a rental home (b = - .106, p = .615), while there was

a positive effect of this determinant for people that own a home (b = .970, p = .000). There is no effect of knowhow for people that do not have a home or content insurance (b = -.641, p= .467), while there was a positive effect of this determinant for people that have insurance (b = 1.821, p = .042). Considering that most people in the sample have an insurance (93.7%), this effect holds for most people. For the other personal characteristics (education, living together with partner, fire experience, responsibility smoke alarm, smoking, type of home) no interaction effects were found. Results showed that the other main effects remained stable when including all interaction effects.

5.4.4 Descriptive norm

As mentioned in paragraph 5.2.3.3, social norms are especially effective to use in communication efforts if there is a misconception of the social norm (Abroms & Maibach, 2008). Therefore, it is relevant to know what the perceived norm is, compared to the objective norm. An independent-samples t-test for equal variances was conducted to compare the descriptive norm, both for important others as for the general Dutch population, for people who own (a) smoke alarm and people who do not. Participants that own a smoke alarm think that 59.4% (SD = 27.7) of their important others also have (a) smoke alarm(s) compared to 30.5% (SD = 27.5) in the group that does not own a smoke alarm; t (613) = -12.407, p <.001. Participants that own a smoke alarm think that 55.2% (SD=19.7) of the Dutch population has (a) smoke alarm(s) compared to 43.9% (SD = 18.5) in the group that does not have a smoke alarm; t (614) = -7.0737, p <.001. Since in the Netherlands 76% of the households has (a) smoke alarm(s) (see Appendix K), we can conclude there is a misconception of the social norm, especially among people that do not own a smoke alarm. Furthermore, an interesting detail is that people with a smoke alarm think that a higher percentage of their important others have a smoke alarm than the Dutch population (t (214) -2.8344, p = .005), while people without a smoke alarm think a higher percentage of the Dutch population has a smoke alarm than their important others (t (398) 10.9213, p <.001).

5.4.5 Regression analyses with intention

We performed regression analyses with smoke alarm intention as the target variable and the prevention behavior determinants as predictors, to understand what drives the intention to purchase a smoke alarm among people that do not have a smoke alarm (yet). The residuals of the model do not have a normal distribution, as tested by a skewness and kurtosis test (D'agostino et al., 1990), which is why we estimated the p-values using robust standard errors. The assumption of homoscedasticity of the residuals of the model was not violated (although it was marginal with p = .058). We performed all analyses with the personal characteristics as control variables, of which

the results can be found in Appendix L.

The scores of 'intention' were quite skewed: 66.5% had no or a low intention to buy a smoke alarm in the next four weeks (score: 1 - 3.5), of which 31.9% had no intention at all (score 1 of 7). We speculated that there might be some differences between people that do not have an intention at all (score: 1) and people that might have some intent (score: > 1), which would imply that these people should be motivated differently. For this reason, we transformed intention also into a binary variable in which score 1 was coded into 0 (= no intention) and scores 1.5-7 were coded into 1 (=some intention). We performed linear regression analyses with the original variable 'intention'(score 1-7) on the total group (Table 5, model 1) and on the group that at least had some intent (score 1.5-7) (Table 5, model 2), and a logistic regression analyses on the binary intention variable (Table 5, model 3). In model 1, frequency of thought, awareness, and the injunctive norm had significant effects on intention. In model 2, where people without any intention were excluded, significant variables were vulnerability, frequency of thought, awareness, and knowhow. This shows that although vulnerability and knowhow are not relevant for people without any intention, these are relevant factors for people with some sort of intent. If people already have some intent, the injunctive norm is not relevant anymore. In model 3, frequency of thought, physical appearance, and descriptive norm were significant. This shows that physical appearance and the descriptive norm might be relevant to move people from 'not interested at all' to 'somewhat interested', while these factors do seem not relevant for people that already have some intent (see model 2).

Although there are some similarities between the models (frequency of thought, awareness) there are also some remarkable differences, based on the extent of intention of an individual. Compared to the analysis to predict smoke alarm ownership (model 3, Table 3) we see, overall, that the same determinants are significant and non-significant when predicting the intention to buy a smoke alarm (although this depends a bit on the way intention is used in the analysis). The sole exceptions are annoyance and the effort of buying, those were important predictors for smoke alarm ownership but not for intention. We noticed that awareness had a negative coefficient when relating it to intention (instead of a positive one which was the case with smoke alarm ownership, see Table 3). Thus, if someone was not or less aware of the existence of a smoke alarm prior to the survey -but became aware of it because of the survey-, someone had a higher intention to buy a smoke alarm. Concerning the socio-economic variables, the significance of variables differs a bit depending on the way intention is analyzed, but significant positive effects have been found for men, responsibility smoke alarm, smoking and living in a detached home (see Appendix L). A significant but negative effect is found for (in)direct fire experience; people who experienced a fire before or

know people who did, have less intention to purchase a smoke alarm. This variable had a positive coefficient when correlating this with smoke alarm ownership (see table 3).

Table 5: Results of (logistic) regression analyses with intention as the target variable. Unstandardized coefficients estimates (b), standard errors (S.E.) and significance levels (p) for all variables, and model fit statistics (χ2, *p*, ρ).

	Model 1		Model 2		Model 3	
	b	S.E.	b	S.E.	b	S.E.
Vulnerability	.142	1.95	.174*	2.18	.193	(1.45)
Severity	-.058	-1.09	-.036	-.60	-.123	(-1.30)
Denial	.052	1.02	.017	.30	.102	(1.09)
Wishful thinking	-.026	-.37	.003	.03	-.082	(-0.64)
Frequency of thought	.434***	5.20	.254**	2.75	.704***	4.46
Awareness	-.475*	-2.32	-.452*	-2.12)	-.271	-.72
Knowhow	.210	1.61	.364**	2.70	-.138	-.59
Benefits	.098	1.32	.047	.59	.219	1.63
Annoyance	-.053	-.84	-.007	-.09	-.100	-.86
Effort buy	-.047	-0.88	-.108	-1.72	-.032	-.33
Price in €	.002	1.15	.001	.47	.004	1.33
Price perception	-.000	-.00	.056	.77	-.109	-.91
Physical appearance	-.078	-1.62	-.037	-.68	-.200*	-2.30
Descriptive norm	.003	.64	-.004	-.99	.019*	2.55
Injunctive norm	.149**	2.61	.105	1.65	.144	1.46
F resp. χ^2	(33, 361) 4.59		(33, 230) 2.93		116.64	
p	.000		.000		.000	
N	395		264		395	
Adjusted R^2 resp. Pseudo R^2	.231		.195		.232	

Note. * = p<.05; ** = p<.01; ***= p<.001
Note. Model 1: regression model with intention (score 1 - 7) as the target variable.
Model 2: regression model with intention as the target variable, of only the people that have some intent (score: 1.5 - 7).
Model 3: logistic regression model with binary variant of intention (score 0 - 1) as the target variable.

5.4.6 Intention

People who stated to have a medium to high intention (score 4 - 7; 33.5%) to buy a smoke alarm were asked to explain their answer. 39.3% stated that they keep on forgetting it, 39.1% stated that they did not found the time yet, 20.2% stated that they do not know which smoke alarm to buy, 16.7% stated that they did not have this intention before this survey, 4.8% stated that they do not know where to buy smoke alarms, 6.6% gave a different reason.

5.4.7 Effort

People who perceived buying a smoke alarm as medium to high effort (score 4 – 7; 38%) were asked to explain their answer. 43.2 % stated that they do not know which smoke alarm to buy, 27.5% stated it is a job they rather not do, 23.3% stated that they specifically have to go to a store for this, 22.5% stated that they do not know where to buy a smoke alarm, 7.2% stated that they are physically not mobile and 15.7% gave a different reason. People that perceived it to be medium to high effort to install a smoke alarm in their home (score 4 - 7; 58.5%) were asked to explain their answer. 41.6 % stated that they do not know how to install a smoke alarm, 28.9% stated that they do not know where to install the smoke alarm, 28.7% stated that it is a job they rather not do, 26.7% stated that the ceiling is difficult to reach, 18.5% stated that they are physically not mobile, and 10.7% mentioned a different reason.

5.4.8 Conclusion

To identify the correct number and composition of the determinants, we performed factor analysis on all items. Although factor analysis is not common in papers that study the determinants for prevention behavior, we see here that this as an essential step since some determinants were strongly correlated with each other, and consequently we merged them together. Results of the regression analyses showed that the most important determinants for smoke alarm ownership were (in order of importance): frequency of thought, descriptive norm, knowhow, annoyance, injunctive norm, awareness, and the effort of buying a smoke alarm. In other words: the likelihood of owning a smoke alarm increases if people frequently think and worry about a fire in their home, the more they think other people have smoke alarms, the more they know how and where to install a smoke alarm and think installation is a relatively easy chore which they are capable of doing, do not perceive a smoke alarm as annoying, if they think other people think they should have a smoke alarm, if they are more aware of what a smoke alarm is and does, and if they perceive buying a smoke alarm is easy.

Surprising is the fact that determinants not mentioned in prominent prevention behavior theories (PMT, HBM) such as frequency of thought, awareness, and social norms had significant effects, while others, that do have a prominent place in these theories such as vulnerability, severity, and the benefits of a smoke alarm did not have significant effects (except for vulnerability in model 2, Table 5). We feel the most obvious conclusion based on these results is that people without a smoke alarm have a similar risk perception as people with a smoke alarm (low vulnerability M = 2.6; high severity M = 5.3), and both groups understand the benefits of a smoke alarm (M = 5.3). These are simply not the reasons for not having a smoke alarm.

Social norms, both descriptive and injunctive, had significant relationships with smoke alarm ownership. Surprising is that all persons heavily underestimated the descriptive norm concerning smoke alarm ownership in the Netherlands, which is 76%. Persons without a smoke alarm underestimated this norm even more than persons with a smoke alarm (43.9% versus 55.2%).

Two significant barriers for smoke alarm ownership were a lack of knowhow and the perceived annoyance of a smoke alarm. Especially knowhow appeared to be an important factor. This variable consisted out of the knowledge about how and where to install a smoke alarm, effort of installation and self-efficacy. Effort and self-efficacy are also variables that are addressed in PMT and HBM, and the fact that knowledge, effort and self-efficacy can be strongly correlated is mentioned before by other scholars (Lindell & Perry, 2004; Lindell et al., 2009; Weinstein, 1993).

The intention of people that do not own a smoke alarm to purchase one was low: only 32.8% had a medium or high intention to buy a smoke alarm (see Table 1). Especially when comparing this to other behaviors: the intention of people to install a smoke alarm that was still in the packaging and the intention to ensure its functioning in the case of non-functioning smoke alarms was much higher (74.1% resp. 67.8%). Because the intention to purchase a smoke alarm is low, it is not key to close the intention-behavior gap, but it is necessary to motivate people to buy a smoke alarm in the first place.

For the intention to purchase a smoke alarm the significant determinants were comparable, although not completely the same, and depended on how 'intention' was used in the analysis. Overall significant determinants were: frequency of thought, vulnerability, knowhow, awareness, descriptive norm, injunctive norm, and physical appearance. Furthermore, results showed that people in a different intention category (no intention at all versus some intention) were driven by different determinants, indicating that it might be a good idea to differentiate people according to their intention phase and adjust the intervention accordingly.

5.4.9 Intervention

The results of this study provide relevant insights concerning which determinants to address in an intervention in order to stimulate smoke alarm ownership. We designed two communication-based interventions to increase smoke alarm ownership: one promising and one less promising. The promising message was based on the significant determinants (based on model 3, table 3): knowhow, annoyance and descriptive norm. These determinants had the largest effect sizes (after frequency of thought) and had the potential of being "influenceable" with a communication-based intervention. Also,

knowhow and descriptive norm had significant correlations with intention. Increasing the perceived descriptive norm could move people from 'no intention' to 'some intention', while increasing knowhow could move people from 'some intention' to 'high intention'. Although frequency of thought was the most important determinant in our study, we did not address this determinant in the intervention, since it is quite difficult to influence this determinant without influencing the other determinants (i.e. if you make people think about fire and fire prevention, you might also increase vulnerability or severity, or decrease denial or wishful thinking). Furthermore, it can be argued if the frequency of thought can be influenced at all, since it might also concern a personality trait. The less promising message was based on determinants that are often used in fire prevention communication efforts but appeared non-significant in our study (based on model 3, Table 3 and model 2, Table 5): vulnerability, severity, and the benefits of a smoke alarm. We tested the effects of the interventions on smoke alarm ownership and intention in a field experiment, see chapter 5.5.

5.5 Method study 2

The goal of this study was to design a message to motivate smoke alarm interest, intention, and ownership, based on the results of study 1. We conducted a field experiment in which we developed two messages: one focused on the significant determinants and one focused on the non-significant determinants. We tested the effects of the messages versus a control group in a between-subject experiment.

5.5.1 Participants and procedure

Participants were recruited from the customer panel of an insurance company (Interpolis) that is hosted by a research company (MWM2). Participants entered this panel (n = 5458) on their own initiative and do not receive incentives for participation in studies. Participants were selected for our study if they stated to not own a smoke alarm. This information was collected by a survey in November 2019, together with other variables for research purposes out of the scope of this study. 2950 participants replied to this survey, of which 389 (13.2%) stated to not own a smoke alarm. Participants who did not replied to the earlier survey received a screener question (n = 2508). Participants were randomly assigned to one of the three conditions. In total 310 participants participated in our study.[9] In the invitation, participants were asked to evaluate an e-mail of the insurance company, and it was stressed that there were no right or wrong answers. When entering the survey, participants were asked to fill in their gender and birthdate. Then, we asked

9 We pre-registered this study on OSF https://osf.io/pvmbu as we intended to do sequential analyses with two samples. Because we did not know what the effect size was likely to be, we could not calculate the necessary sample size. Therefore, we first conducted the study on the 'full' consumer panel. Based on the results of sample one (Table 6), we could calculate the necessary sample size and accompanying costs for sample two. Because the costs exceeded the 5000 euro's (the stopping rule) we decided not to continue the study.

them to attentively read an e-mail, and mentioned that we would afterwards ask some questions about it. Four filler items (showed on one page) were used to evaluate the message. Participants had the possibility to view the e-mail again when confronted with these items. Two items (showed on one page) were used to measure possible interest in smoke alarm communication. After the last item, the participant had to press "continue" and a smoke alarm offer was presented (see Figure 1). Only when the participant pressed "continue" his data from the previous two items was saved. Because of this feature we may assume the participant viewed the offer when there is data available of the last item. Data was collected from December 24, 2019 until January 7, 2020.

As a thank you for participating in this study, you will receive a €7,50 discount on a smoke alarm with a 10-year battery. This smoke alarm is recommended by the Consumers' Association (test 2019) and by Interpolis.

Click here to view the smoke alarm and to possibly order.

The discount is valid until January 7 2020 and only available via de link above. If you want to think about it for a while, save this link so you can order the smoke alarm later.

Figure 1:
Text as presented at the end of the survey (original text was in Dutch).

5.5.2 Experimental conditions

The data collection was based on a between-subjects design with three treatment conditions. One message was based on three significant determinants: knowhow, annoyance, and descriptive norm (condition A, 213 words). The other message was based on three insignificant determinants in our study: vulnerability, severity, and benefits (condition B, 199 words). A control message (C) was added to establish a baseline effect, with no form of smoke alarm communication but only the smoke alarm discount (condition C, 188 words). We expected message A to have more effect on interest in smoke alarm communication, smoke alarm ownership and intention than message B and C, and message B to have more effects on these variables than message C.

All messages had the same structure: a headline, three numbered paragraphs with a title, a picture related to the issue, and a final sentence with an action perspective at the bottom. We tried to make sure that the messages do not trigger other determinants than the ones intended. That is for example why we used a neutral image of a smoke alarm in message B, instead of a burning house, which might also evoke frequency of thought. See Figure 2 - 4 for the treatment conditions as presented to the participants, translated to English. See Appendix M for the original Dutch text.

76% of the Dutch population has a smoke alarm

Do you already have one?

Install your smoke alarm with these 3 simple steps

1. Choose the right room

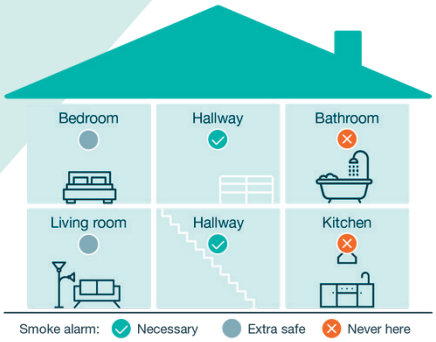
The basics: place at least 1 smoke alarm on every floor of your house. Place the smoke alarms in the hallways. This is usually the escape route if a fire breaks out.

For extra safety: place smoke alarms in all areas where you live and sleep, such as the bedrooms and living room.

Do not place smoke alarms in the kitchen, bathroom or garage. This prevents an unnecessarily activation of the smoke alarm caused by, for example, showering or cooking.

2. Choose the right spot

Place the smoke alarm on the ceiling, at least 50 cm from the walls. Smoke always rises, so this is where the smoke alarm detects the smoke the fastest.



3. Install the smoke alarm, a piece of cake!

You can easily install a smoke alarm with the supplied screws and mounting plate. If you don't want to drill, you can install the smoke alarm easily with magnetic stickers. You have to stick 1 magnet on the ceiling and 1 on the smoke alarm. You can buy the magnetic stickers for smoke alarms at a hardware store or online.

Do not wait any longer and buy a smoke alarm today. With these 3 simple steps, you have installed your smoke alarm within a few minutes!

Interpolis. Glashelder

Figure 2:
Message A: meant to address knowhow, descriptive norm, and annoyance.

Smoke alarms save lives!

A nice and safe idea

Three reasons why a smoke alarm is important in every home

1. A fire can happen to you too!

The fire brigade receives thousands of reports of house fires every year. That's about 13 house fires a day. Most of the house fires are caused by fireplaces or wood stoves, cooking or electrical appliances.

2. Smoke kills

A house fire is very dangerous. Not only because of the extreme heat, but especially because of the toxic smoke that is released. This smoke is suffocating. Even a brief inhale of smoke can be fatal. Smoke often spreads quickly, for example to the hallway. Within 3 minutes, a house fire can become so large that the amount of smoke in the room(s) becomes life-threatening.

3. A smoke alarm warns fast, both at night and during the day

A smoke alarm immediately warns in case of fire, so that you and your family members can safely leave the house as soon as possible. When a fire is still small, you may be able to prevent further damage with a suitable extinguishing agent.

Do not wait any longer and buy a smoke alarm today. That's how you ensure your own safety in case of fire.

Interpolis. Glashelder

Figure 3:
Message B: meant to address vulnerability, severity, and benefits.

3 useful facts about Interpolis insurance

An easy fix

Read here what you may not have known

1. Which Contents Insurance suits you best?

With the Contents Insurance you insure the individual items in your house. For example your furniture, smartphone and clothing. From now on, you can choose between an Extended Contents Insurance or an All-Risk Contents Insurance. Do you opt for a cheaper premium? Or do you also want to be insured in case of damage if you knock over something or drop it yourself?

2. Check and take out your insurances with your smartphone

Do you have the Rabo Banking App? If so, you can take out, change and view insurance policies with the app. Where and whenever it suits you. That's the convenience of banking and insurance together in one app. How convenient, if you are at Schiphol and have to take out a Travel Insurance.

3. Interpolis Vehicle Help

With Vehicle Assistance everyone who drives your car is assured of breakdown assistance. Also with a flat tire, empty battery or in case of misfueling. You can choose from Vehicle Assistance Netherlands and / or abroad. With Vehicle Assistance Netherlands, we also help you in your hometown. Very useful because 40% of the breakdowns occur in people's hometowns.

Check which insurances policies suit you and your situation at www.interpolis.nl

Interpolis. Glashelder

Figure 4:
Message C is the control message.

5.5.3 Measures

Manipulation checks

We did not implement a manipulation check to figure out whether the intended determinants were really affected by the corresponding messages, as measurements of the determinants might have influenced our dependent measures. Furthermore, this would extend the time between the treatment and the target measurements which might have blurred the effect of the messages.

Evaluation of the message

To make sure the participant would read the message, but also as a distractor for the actual behavioral measurements, four filler items were used to evaluate the e-mail "The message [is useful; is credible; is clear; makes me think]". Answers could be given on a 5-point Likert scale (1 = totally disagree; 5 = totally agree).

Interest in smoke alarm communication

Interest in smoke alarm communication was measured by two separate items. The first item was inspired by the measurement of 'information seeking' by Neuwirth, Dunwoody, & Griffin (2000)[10], and adjusted to our context. We introduced that the insurance company has a newsletter, about topics such as living and safety. Followed by: "We would like to know in which topics you are interested, so we can address them in our newsletter". Participants had to rate their interest on a 5-point Likert scale (1 = not interested at all; 5 = very interested) for seven topics [burglar alarms; smoke alarms; carbon monoxide detectors; smart thermostats; smart doorbells; solar panels; heat pumps]. All items - except for the item about smoke alarms - were fillers, since we did not want to prime participants to much in the direction of 'smoke alarms'. The second item was "Do you want to subscribe for the newsletter? You will receive the newsletter once a month, and you can always unsubscribe." Answer possibilities were just yes or no. This item was added as a behavioral measurement for interest in the topic.

Intention and smoke alarm ownership

Intention to purchase a smoke alarm was measured by capturing the click on a link to visit a web shop in which one could purchase a smoke alarm with a discount of €7.50 (original price: €24.95, shipping costs included), as presented in Figure 1. This discount

10 Neuwirth et al. (2000) measured information seeking with "How interested would you be in obtaining more information about this topic?" Ratings could be given on a 9-point scale (from "not at all interested" to "very interested").

was given as an extra trigger to purchase the smoke alarm. Also, the same smoke alarm was available at a very popular website (Bol.com) for €21.94, and we wanted to avoid that people would order the smoke alarm on another website. Actual smoke alarm purchase was measured by the orders placed in the web shop via the provided link.

Socio-demographic variables

The following demographic variables were provided by the panel: gender, age, education, home ownership, and family composition. To check whether the participant was the same person as registered by the consumer panel, we asked for gender and age in the survey.

5.6 Results study 2

5.6.1 Data description

There were 100 participants in condition A, 103 in condition B, and 107 in condition C. Some items had missing values: the item 'birth date' (optional field) had 17 missing values, the item that measured interest in smoke alarms had 3 missing values, the item about the subscription for the newsletter had 4 missing values. A chi-square test and a Kruskal-Wallis rank test (age was non-normally distributed) showed there were no significant differences between the participants in the conditions in terms of their gender (χ^2 (2, N =310) = .0244, p = .870) and age (H(2)= 5.132, p = .077). The Kruskal-Wallis rank test showed there was a significant difference between conditions concerning the evaluation of the messages on the filler items (α = .846) (H(2)=15.175, p <.001) (see Table 6 for the mean scores). The messages directed at smoke alarms were evaluated both equally, and both more positively than the control message that was about insurance. The distribution of the socio-demographic variables per condition can be found in Appendix N.

Table 6: Descriptive statistics of measurements per condition. Statistics are presented in means (M), standard deviations (SD), percentages (%) and number of participants (N).

Condition	Evaluation message			Interest in smoke alarm information			Subscribe newsletter		CTR		Smoke alarm orders	
	M	SD	N	M	SD	N	%	N	%	N	%	N
A	4.0	.63	100	2.4	.91	100	72.7	99	47.5	99	9.1	99
B	4.0	.72	103	2.6	.89	103	81.2	101	41.6	101	4.0	101
C	3.7	.62	107	2.3	.91	107	72.6	106	37.7	106	.9	106

Note. Condition A addresses knowhow, descriptive norm, and annoyance. Condition B addresses vulnerability, severity, and benefits. Condition C is the control message.

5.6.2 Data analyses

For all mean scores and percentages of the measurements per conditions see Table 6. We tested whether people who read the more promising message (A) had more interest in smoke alarm information than the control group (C), and whether people who read the less promising but "typical" message B had more interest in smoke alarm information than the control group (C). Also, we tested if message A produced a higher interest score than message B. There was only a statistical difference between message B and C (U(2) = 4296.5, Z = 3.051, p =.002, M=2.6 vs M=2.3), as tested with a Mann Whitney test, indicating that participants who read the message that addressed vulnerability, severity and benefits (B) had more interest in smoke alarm information than participants that read the control message (C). A possible explanation for the fact that participants who read message A did not have more interest in information, might be that they were already provided with 'enough' smoke alarm information, since they actually received information about how and where to place a smoke alarm. Instead, participants that read message B were possibly triggered but not yet saturated. We tested if people who read the more promising message (A) and the less promising but "typical" message (B) had a higher likelihood to subscribe for the newsletter, click through the website (CTR), and order a smoke alarm than people who read the control message (C). Also, we tested if message A produced higher scores on these variables than message B (Table 7). We find a significant difference between message A (9.1%) and C (0.9%) for the smoke alarm orders (B = -2.35, p = .027), indicating that the message that addressed descriptive norm, knowhow, and annoyance was the only message that significantly increased smoke alarm ownership compared to the control group. When adding the variables gender and age to the analyses, similar results were found. Although few statistically significant differences were found, the qualitative results of the CTR and smoke alarm orders are in line with what was expected: higher scores in condition A than in C, higher scores in condition B than in C, and higher scores in A than in B.

Table 7: Results of logistics regression analyses with as dependent variables: subscribing for the newsletter, Click Through Rate (CTR) and smoke alarm orders. Unstandardized coefficients estimates (B), standard errors (S.E.) and significance levels (p) are presented for condition A and B (both versus C), and condition A versus B.

Baseline = condition C	Subscribe newsletter (1 = yes)			CTR (1 = yes)			Smoke alarm orders (1 = yes)		
	B	S.E.	p	B	S.E.	p	B	S.E.	p
Condition A	.004	.314	.989	.400	.284	.159	2.35	1.06	.028
Condition B	.486	.335	.147	.161	.284	.572	1.47	1.13	.193

Note. Scores for condition A versus C:
Newsletter: B = .481, S.E. = .340, p = .157; CTR: B = -.239, S.E. = .285, p = .402; Smoke alarm orders: B = -.886, S.E. = .618, p = .152.

5.6.3 Conclusion

To test whether we could increase smoke alarm interest, ownership, and intention by addressing the significant determinants resulting from our regression analyses, we ran a simple field experiment. The results showed that a message directed at the significant determinants – descriptive norm, knowhow and annoyance – showed more positive results on smoke alarm intention and ownership than a message based on the non-significant (but typically used) determinants – vulnerability, severity, and benefits - although differences between the two messages were not significant. However, the message directed at the significant determinants was the only message that resulted in significantly more smoke alarm ownership (9.1%) compared to a control condition (.9%), while the message based on the typically used determinants did not significantly differ from the control condition (4%). Although we did not include a group that did not receive a discount and, hence, cannot compare groups, solely offering a discount (as in message C) seems not very effective, since this only resulted in .9% of the people ordering a smoke alarm. This is in line with the results of the regression analyses that showed that price, both in euro's as subjective, was not a significant determinant for smoke alarm ownership or intention.

5.6 Discussion

Even though smoke alarms can save lives in the case of a home fire, still many households do not have (functioning) smoke alarms. Considering that ending up with functioning smoke alarms involves several sequential steps, that each can be driven by different determinants, we decided to focus our study on one specific behavior. Smoke alarm ownership was chosen as the target behavior of our study, since our survey showed that the biggest problem in the Netherlands was a lack of smoke alarms, and not the installation of smoke alarms that are still in the packaging or non-functioning smoke alarms (based on self-reports). The central question of this chapter was which determinants drive smoke alarm ownership and the intention to purchase one, and if we could increase smoke alarm ownership by addressing these determinants in a communication-based intervention.

First, we made an inventory of all possible determinants for smoke alarm ownership, by doing interviews with people without smoke alarms, consulting prominent prevention behavior theories (Protection Motivation Theory: Rogers, 1975, Health Belief Model: Rosenstock, 1966), but also looking at persuasion (e.g. Cialdini et al., 2006), and environmental risk literature (e.g. Lindell, Arlikatti, & Prater, 2009; Lindell & Prater, 2000). We measured the determinants in a specific manner to pinpoint the underlying motives and barriers and analyzed the relationships of these determinants with smoke

alarm ownership and intention. Results showed that determinants not mentioned in prevention behavior theories (PMT, HBM) such as frequency of thought, awareness, knowhow and social norms had significant effects, while others, that have a prominent place in these theories such as vulnerability, severity and the benefits of a smoke alarm (mostly) did not have significant effects. This remarkable finding, that especially determinants other than the ones mentioned in prevailing prevention behavior theories, makes one wonder to what extent these general theories are actually relevant for truly understanding the (non) performance of specific prevention behaviors? Also, considering that the determinants mentioned in these theories often lack specification when it comes down to specific behaviors. For instance, these theories describe that self-efficacy is important for the performance of prevention behavior, but what does this actually imply for smoke alarm ownership? Does this mean that people lack self-efficacy because they perceive difficulties concerning buying a smoke alarm or that they perceive difficulties of installing one, and if so, what are those difficulties? Because in our study we formulated a "full" set of determinants and measured them in a specific manner, we could come up with concrete guidelines to design a communication-based intervention.

To increase smoke alarm ownership, we developed two messages: one focused on the determinants we found to be strong predictors in the survey (descriptive norm, knowhow and annoyance) and one focused on typically used determinants of which most were not significant in our analyses (vulnerability, severity, benefits). We tested the effects of these messages (versus a control group) in a between-subject field experiment on smoke alarm interest, ownership and intention. The message directed at the significant determinants showed more positive results on smoke alarm ownership and intention than the message based on the non-significant (but typically used) determinants, although differences between the two messages were not significant. However, the message directed at the significant determinants was the only message that resulted in significantly more smoke alarm ownership (9.1%) compared to a control condition (0.9%). This clearly shows that telling people how vulnerable they are to fire, how severe a fire is, and that "smoke alarms save lives" is not enough to let them change their behavior (in line with the study of Miller et al., 2014). Our design revealed different reasons for not having smoke alarms, such as 'not being in mind', 'others don't have them either' or 'a lack of specific knowledge about how and where to place them'. These factors would not have been clarified without a comprehensive problem analysis specifically performed for smoke alarm ownership. Only, when addressing the 'true' underlying motives and barriers motivation for change can be set into motion.

A limitation of our study is that data underlying the regression analyses is cross-sectional, while the inferences we want to make are causal. This problem is common in PMT/HBM

studies since someone's perception of the risk or the behavior might change after the behavior is performed (Bubeck et al., 2012; Milne et al., 2000; Weinstein, Rothman, & Nicolich, 1998). For instance, severity had a negative coefficient (instead of the hypothesized positive relationship) which might indicate that after the installation of a smoke alarm people perceived a home fire as less severe than before. Or the significant positive relationship between knowhow and smoke alarm ownership might indicate that more knowhow results in a higher motivation to own a smoke alarm, but it might also indicate that more knowhow is the result of smoke alarm purchase and installation. To a certain extent, we tested the causality of these relationships in a field experiment by manipulating some of the determinants, which showed that addressing the descriptive norm and knowhow did result in more smoke alarm ownership, indicating the predicted causality. A second limitation of this study is that the sample size of study 2 was too small to find significant differences between conditions A and B. For the differences in smoke alarm ownership (9.1% versus 4.0%) to be significant we would have needed n = 549 participants per condition as calculated with a post-hoc power analysis, which was beyond budget. Although the effects are small, if one puts the results in perspective with the type of intervention – a simple message in text – the generated CTR's and purchases are promising. Something that could have improved the study, is if we had performed a manipulation check to test if the interventions provided the desired changes in the targeted determinants (and not influenced others), and if we had added a combination of message A and B in our field experiment.

Taken together, our study shows that using behavioral psychology and conducting a comprehensive problem analysis for a specific prevention behavior can help us to better understand people's underlying motivations and barriers, which gives a promising and concrete direction for designing behavior change interventions. Turning back to the title of this chapter, smoke alarms indeed can save lives. However, this commonly used slogan is believed by all people, also by people that do not have them (yet). Therefore, people should be persuaded with slogans other than this one.

6

General discussion

Motivating people to take prevention measures is and has always been a challenging task. Most people do not daily contemplate about the risks they run in their lives, let alone about domestic risks such as fire, burglary, or water damage. And this is understandable: risks are uncertain events, which implies that they might not happen at all. Prevention measures to prevent or mitigate the consequences of these risks cost immediate money, time, or effort, while the benefits of these prevention measures will likely only unfold somewhere in the distant future, if they do materialize at all. However, when the risks do actually occur, the consequences can be devastating, and people wished they had taken the appropriate prevention measures. This thesis aimed to contribute to the challenge of increasing prevention behavior, by gaining more understanding of people's domestic prevention behavior and the psychological determinants driving this behavior.

Remember Alice, that we introduced in the first chapter? Although she has taken a few of the basic prevention measures such as locking doors when she leaves home, some important prevention measures were lacking. We wondered how we could motivate her to take more preventive action and brought up the following questions. If we want to promote six behaviors to Alice - buy a smoke alarm, install the alarm, monthly test the alarm, close windows when leaving home, and buy and install anti-burglar strips - how should we approach this? Can we use the same approach for buying a smoke alarm as for closing windows, or should we use a different motivational approach for each separate behavior? Or is there a way to motivate her to perform all six behaviors, for instance by changing her attitude about risks and prevention in general? Or could we better start with promoting one specific behavior and if so, which one?

These, and other prevention related questions were addressed in this thesis, and this final chapter will provide more concrete guidelines, based on the studies presented in this thesis, of how we can promote prevention behaviors to Alice, and people in general. Moreover, this thesis contributes to the larger process of prevention behavior change, which is notoriously long and complex, by offering guiding principles both for academics and practitioners to more thoroughly understand and better influence prevention behavior. We contributed to the literature and the understanding of the behavior change process by studying prevention behavior from two perspectives: that of the individual and that of the behavior (chapters 2 and 3). Also, we studied the psychological determinants for fire prevention behavior in detail, together with the causal mechanisms behind behavior change (chapter 4 and 5). In this final chapter we will not merely summarize the individual chapters but rather offer a more integrative view of our findings, connecting the different insights from the chapters. Accordingly, we give implications for future research and behavior change attempts.

6.1 All different domestic prevention behaviors stem from one underlying disposition.

In chapter 2 we found that a multitude of domestic prevention behaviors form a one-dimensional scale, when ordering the behaviors according to their prevalence and ordering the individuals according to their prevention performance. This indicates that people behave consistently across different types of risks and behaviors, suggesting the existence of an underlying general disposition towards domestic risk prevention. This idea can be best explained as a 'prevention pyramid' in which the behaviors at the bottom are performed by most people and the behaviors at the top by just a few. A transitive ordering applies to this pyramid, implying that people who perform the rare behaviors located at the top (e.g. own a burglary alarm or practice a fire escape plan), most likely also perform behaviors located at the middle (e.g. have a fire blanket and clean the rooftop gutter) and are even more likely to perform behaviors positioned at the bottom (e.g. always close windows and lock doors when they leave their home). This insight offers several useful implications. For instance, it would be fruitful to advice prevention behaviors dependent on someone's position in the 'prevention pyramid', or stated otherwise, based on their general disposition towards domestic risk prevention. This is in line with studies in the energy domain that showed how tailoring advice based on someone's general disposition resulted in advice that was perceived as more adequate than non-personalized approaches (Starke et al., 2020; Starke, Willemsen, & Snijders, 2017).

Let's see what this means for Alice and Jim. Alice is positioned rather low in the prevention pyramid, since she only performs a few basic prevention behaviors, such as locking doors when she leaves her home and checking for burning candles when she goes to bed. To stimulate Alice to engage in more prevention behaviors, it would be wise to advise prevention behaviors to her that match her prevention disposition, such as closing the windows every time she leaves her house or buy a smoke alarm. This is more likely to be effective than advising her behaviors from the top of the pyramid, for instance buying a heat detector or a drip tray for the washing machine, or to test a smoke alarm on a monthly basis. Jim, on the other hand, is located higher up in the pyramid so we can advise him prevention behaviors that are less frequently performed such as installing a carbon monoxide detector or practicing a fire escape plan. Behaviors at the bottom of the pyramid, such as owning a smoke alarm and having exterior lightning, will probably be less useful recommendations because there is a high probability that he already performs those.

When one wants to give tailored advice, information about an individual's current prevention behavior is needed. However, not all information about someone's prevention

behavior is necessary. The fact that different types of prevention behaviors form a single scale implies that, if we for instance know which fire prevention behaviors someone performs, a prediction can be made about someone's burglary prevention behavior and, accordingly tailored burglary prevention advice can be given (see chapter 2). When no information about someone's prevention behavior is available, an alternative strategy can be to try to determine the position of specific target groups in the prevention pyramid and give advice to individuals belonging to that group in accordance with the average position of that target group. Another strategy, much simpler but still more effective than randomly advise behaviors, would be to suggest behaviors positioned at the middle of the prevention pyramid as most individuals are positioned there. An example of a TV commercial that does not live up to this pyramid strategy is one of a Dutch burglary prevention campaign with the slogan "Don't make it easy on them". This commercial promotes the behavior of locking doors when leaving the house by showing how attractive an unlocked house is to burglars (for an evaluation of this campaign see Van den Berg, Borkus, Loef, Perkin, & Warmoeskerk, 2015). However, since this behavior is performed by almost all people, most Dutch households will not be attracted to this message. A more recent commercial of this campaign promotes, next to locking doors, also switching on lights and closing windows (for an evaluation see Cammaert & van Amerongen, 2020). This is probably a better strategy, since this advice includes two behaviors positioned in the middle of the prevention pyramid and will therefore serve a much larger audience while at the same time not being too 'difficult' to implement (see chapter 2).

The idea of multiple domestic risks forming a one-dimensional scale allows us to speculate whether other risks could also be plotted on this one-dimensional scale, implying that people's general disposition would not be limited to "domestic risk prevention" but might be expanded to "risk prevention in general". This idea is not as strange as it might seem at first sight, since our study in chapter 2 showed that behaviors related to safe driving (e.g. winter tires, skid course) and theft from a car (e.g. leave valuables out of sight) could also be plotted on the same one-dimensional scale. In a similar vein, this scale can possibly be expanded with other safe traffic behaviors, such as not using a smartphone during driving or cycling, or even with health-related behaviors, such as exercising or healthy eating habits. A similar idea has been mentioned in the domain of road safety, where studies have shown that people who did not wear seatbelts in the 80/ 90's also engaged in other risky behaviors, even unrelated to road safety, such as not having health insurance or drinking large amounts of alcohol (Mäkinen et al., 1991; Reinfurt, Williams, Wells, & Rodgman, 1996). If this assumption holds, this would imply that we can for instance predict safe driving behaviors from someone's fire prevention behavior, and vice versa.

6.2 Influencing behaviors or influencing persons

The existence of a general disposition towards domestic risk prevention highlights two different perspectives on how to approach behavior change attempts: 1) change someone's perception of a specific risk and target behavior versus 2) change someone's disposition towards risks and prevention behaviors in general. We do not claim that one is to be preferred over another, but rather that a trade-off between the two routes, that both involve different costs and benefits, is something that has not received much attention in the academic literature but is relevant to consider.

The first, and most often chosen strategy, is to try to change someone's perceptions about a specific risk and accompanying prevention behavior, thereby increasing the likelihood of an individual to engage in that specific behavior (Cismaru & Lavack, 2007; Collins, 2006; Curran & Bauer, 2011). An example of this route would be a campaign to promote carbon monoxide alarms, by increasing people's perceived vulnerability and severity of this invisible gas, also referred to as the 'silent killer'. In the campaign the benefits of a carbon monoxide alarm are stressed, and people's self-efficacy is increased by giving clear instructions how to install the alarm. If an individual is confronted with this campaign, this will - hopefully - increase the likelihood of this individual to buy and install a carbon monoxide alarm. However, it is unlikely that this campaign will have an effect on other domestic prevention behaviors such as installing a smoke alarm or informing neighbors when going on holiday. This can be viewed as a "within-person" effect: for a given person the perception of a risk has changed (compared to other risks that remained equal) and the perception of a behavior has changed (compared to other behaviors that remained equal). In chapter 3 we found that all prevention behavior determinants had significant within-person effects, that is, the likelihood of engaging in a specific prevention behavior is higher when an individual perceived oneself as more vulnerable to this risk and perceived this risk as more severe compared to other risks. Furthermore, the likelihood of engaging in a specific prevention behavior is higher when an individual is more aware of this behavior, perceives this behavior as more effective, less costly, and less effortful compared to other behaviors. This implies that a desired change in these determinants as perceived by an individual, will result in a higher motivation for an individual to engage in a specific behavior.

The second strategy is to change someone's general disposition towards (domestic) risks and prevention, so that someone will be generally inclined to take more prevention measures overall. Theoretically, this is the holy grail of persuasion: a small change could result in multiple new and wanted behaviors. An example of a strategy aiming at changing people's general disposition towards prevention behavior would be that of a housing cooperation that wants to increase the liveability and (domestic) safety

in a particular neighborhood. As part of their strategy, interested renters must write a motivation letter with arguments of why they are a good fit to the neighborhood and what they contribute to the liveability and safety level (a behavior change technique referred to as "self-persuasion", see for instance Müller et al., 2009). Also, posters and flyers are spread in this neighborhood with slogans like "Safety is our responsibility." and "We take care of our neighbors and ourselves." Ideally, someone touched by these interventions will be more motivated to engage in all kinds of domestic prevention behaviors, such as installing a carbon monoxide alarm, install smoke alarms, informing neighbors when going on holiday, regularly clean the rooftop gutter, use exterior lightening when it is dark and actively use the neighborhood prevention WhatsApp. This is referred to as a "between-person effect": the general disposition of the individual who experienced these interventions has changed compared to other individuals whose general disposition remained the same. Consequently, the motivation of this individual to engage in multiple prevention behaviors across risks increases.

Although changing someone's general disposition seems very effective, the challenge is obviously how to do it since it does not seem so easy to influence someone's general disposition. In the first place because differences in general dispositions (that is, the number of prevention behaviors people perform) could not be easily explained by individual characteristics. It turned out that these between-person differences could only be explained by two of the six prevention behavior determinants, that is 'awareness' and 'effectiveness' (see chapter 3). Indicating that people who are more aware of prevention behaviors in general and find all behaviors more effective compared to others, perform more prevention behaviors. Moreover, effect sizes of these between-person determinants were smaller than of the within-person determinants. Socio-economic variables such as gender, household situation, education, home ownership or characteristics of the house could also not adequately explain differences between individuals (chapter 3, 5). A determinant, or derivative thereof, that could possibly be relevant in explaining differences in the performance of prevention behavior, is the extent people think and worry about risks, which appeared the most important determinant for smoke alarm ownership (chapter 5). This determinant is often studied in relation to earthquakes, since people are more mentally occupied with this risk after they experience an earthquake (e.g. Lindell & Prater, 2000). However, this might also be considered a personality trait, where people that think and worry more about risks in general, engage in more prevention behaviors compared to people who do not. Furthermore, it is relevant to study if there are other factors, such as personality traits, personal values, or lifestyle changes that can explain individual differences in prevention performance. Personality traits such as consciousness, agreeableness, extraversion, and locus of control have for instance been found to be predictors of risky behaviors and hence, accidents, and might also explain domestic risk prevention behavior (Clarke &

Robertson, 2005; Hoyt, 1974; Montag & Comrey, 1987). However, suppose that one does uncover these explanatory factors, these characteristics are all related to individual characteristics, and therefore probably more 'fixed' and difficult to change.

Although this thesis offers a more solid foundation for the first strategy, it would be worthwhile to explore the second considering the potential impact it can have on multiple behaviors across various risks. This highlights a line of research that is currently largely absent: the possibilities of influencing someone's general disposition towards (domestic) risk prevention and the net benefits of doing so, compared to influencing the characteristics of a single behavior.

6.3 Specific behaviors need specific determinants

Although the determinants as used in theoretical models such as Protection Motivation Theory (PMT) or the Health Belief Model (HBM) offer a good starting point for understanding and changing prevention behavior, solely applying the determinants from these theories is not enough to increase prevention behavior. A common practice in communication-based interventions that aim at stimulating prevention behavior is that one or more of these PMT/HBM determinants are addressed (e.g. Cismaru & Lavack, 2007). For instance, smoke alarm efforts often focus on the vulnerability to fire ("It can also happen to you"), the severity of a fire ("Smoke kills"), and stress the benefits of a smoke alarm ("Smoke alarms save lives"). In general, this is not a bad idea since these determinants are all relevant for performing prevention behavior, as shown in chapter 3 and by several meta-analyses (Bamberg, Masson, Brewitt, & Nemetschek, 2017; Floyd, Prentice-Dunn, & Rogers, 2000; Milne, Sheeran, & Orbell, 2000; Sheeran et al., 2014). There is a lot to be gained, however, from a more thorough problem analysis, that gives more insight into the motives and barriers of why people do or do not engage in a specific behavior, before developing a behavior-change intervention.

There is a range of prevention behaviors, and although the determinants of PMT/HBM in general all matter, individual behaviors can be driven by different determinants[11] (Kronenfeld et al., 1991; Weigman, Taal, van den Bogaard, & Gutteling, 1992). The reason that Alice does not own a fire extinguisher (for instance because of a lack of self-efficacy) can differ from the reason why she does not have certified locks on her doors and windows (for instance a lack of perceived vulnerability and high financial costs). Increasing the perceived vulnerability of a fire or providing a discount will not increase the likelihood of Alice buying a fire extinguisher, while increasing her self-efficacy

11 This was shown by an additional analysis performed on the data of chapter 3. Results showed that not all determinants were significant for all individual prevention behaviors, and that different behaviors were driven by different determinants. For instance, the determinant 'trouble' had a negative significant relationship with locking doors but did not have a significant relationship with purchasing a fire blanket.

concerning the use of a fire extinguisher will. The argument that prevention behaviors, even related to the same risk, can be driven by different determinants, is one of the main messages of chapter 4. Our study about the effects of experiencing a virtual fire showed that the purchase of a fire blanket was driven by an increase in knowledge and by an unexplained direct effect, while taking home flyers about fire prevention was driven by an increase in vulnerability. Interestingly, the other determinants (self-efficacy, severity) did not relate to any of the prevention behaviors. Also, behaviors that at first sight might seem as one behavior, such as owning and properly using smoke alarms, involve several sequential steps (purchase, installation, dusting, testing, battery change) that can each be driven by different determinants. For this reason, it is crucial to first define the specific target behavior one wants to promote. One might argue that, instead of first studying

the specific determinants that drive a specific prevention behavior, one can also simply address *all* determinants as mentioned by PMT/HBM in an intervention. However, also *other* determinants than the ones prescribed in these theories can be relevant. Moreover, these theories describe the determinants on a rather general level, while in order to stimulate behavior it is necessary to address the *specific* motivations or barriers that are relevant.

That other determinants than the typical ones might be relevant, is endorsed by the studies in chapter 5. We found that the typical determinants (i.e. perceived vulnerability, severity, effectiveness, and financial costs) did not relate to smoke alarm ownership and, hence, addressing these determinants in an intervention did not result in additional smoke alarm purchases. In a similar vein, another often used determinant in smoke alarm communication efforts known as 'wishful thinking' did not seem to be relevant for smoke alarm ownership. Wishful thinking, in the case of fire prevention, occurs when people wrongly assume that they or their pets will wake (them) up on time in the case of a fire because of the smell of smoke. This assumption, which is false, is invalidated in these campaigns by slogans as "Your nose is also sleeping". Although wishful thinking is mentioned in PMT as a coping mechanism, it is not a commonly studied determinant. By explicitly measuring wishful thinking, it became clear this myth was not an important barrier for smoke alarm ownership in this particular case. On the other hand, less typical determinants, that is, ones not so commonly used in communication efforts and sometimes not even mentioned in HBM/PMT, were significantly related to smoke alarm ownership. An important determinant was the extent to which people think and worry about fire, a determinant originating from the field of environmental risk. Also, social norms - descriptive and injunctive - were important predictors for smoke alarm ownership. Other important determinants were 'knowhow' (a combination of knowledge, effort of installation, and self-efficacy related to installation), the perceived annoyance of false alarms, and the effort of buying a smoke

alarm. Consequently, addressing the descriptive norm, knowhow, and annoyance in a communication-based intervention increased smoke alarm ownership compared to a control condition, while addressing the 'typical' determinants did not. This shows that conducting a comprehensive problem analysis based on an inventory of a richer set of possible determinants that go beyond the common theories, can reveal other relevant determinants that otherwise would have been missed.

An additional important notion is that the determinants in PMT/HBM are defined on a rather general level, which allows for interpretation and ambiguity when applying these determinants in an intervention. For instance, an important determinant in both theories is self-efficacy: someone must have the confidence in oneself to perform the target behavior. However, these general theories do not offer any guidelines as to which barriers might be the cause of this lack of confidence. In our smoke alarm case, interviews, and survey research (chapter 5) made clear that people lacked self-efficacy because they did not know how and where to install smoke alarms. Because of this insight, an intervention could be designed that included specific knowledge about how and where to install smoke alarms, resulting in a significant increase in smoke alarm ownership. Although specific knowledge might be an important factor, it is often not explicitly addressed and measured in the prevention behavior literature and instead often seen as an implicit part of self-efficacy. When measurements are formulated as specific as possible, this allows one to pinpoint exact motives and barriers, and consequently, develop more effective opportunities for behavior change. In fact, if underlying details concerning the determinants are lacking, it is unclear what exactly to address or how to address this.

Ideally, for every new prevention behavior one wants to promote, a new inventory of all possible determinants and analysis of the relationships should be made. A complete list of possible prevention determinants can offer guidance for this problem analysis process, of which the inventory of smoke alarm determinants (chapter 5) and flood mitigation determinants (see S1 of Poussin, Botzen, & Aerts, 2014) can offer a good starting point. It must be noted that this approach of making an inventory of a 'full' set of determinants is not new, it is a common approach in other fields, such as in the field of behavior change and quantitative sociology (e.g. Lau, Au, & Ho, 2003; Suntornsut et al., 2016). However, in risk prevention behavior research and practice, studying and applying the 'standard' prevention behavior determinants is still a common routine. Since, evidently, a comprehensive problem analysis phase is time-consuming, it is worth to consider whether generalizations can be made about which determinants are relevant dependent on the type of behavior. One can imagine that behaviors that include a technical component such as installation, need more focus on effort and self-efficacy. Or behaviors that have to be performed regularly, need more focus on stressing

the benefits of the behavior and reducing effort. If such generalizations could be made, this can help to add more nuances to the existing theories, facilitating the development process of behavior change interventions.

6.4 Conclusion

Although prevailing prevention behavior theories include relevant guidelines for understanding and promoting domestic risk prevention behavior, the scientific and practical challenge is to take it a step further. This thesis aimed to contribute to this challenge by generating more understanding of the individuals on the one hand versus specific behaviors on the other hand, and by gaining more insight into psychological determinants that drive change. As summarizing all conclusions of the studies performed that contributed to this thesis would be too extensive, we conclude by providing the most important implications for academics and practitioners:

I. For more effective behavior change attempts, one needs to match the prevention advice with someone's general disposition towards domestic risks and prevention. As obvious as this may sound, it is still a common approach to promote general prevention behaviors to society as a whole or to target groups based on their risk profile (for instance promote smoke alarms to low-income groups). While this advice is certainly important given the relevance of prevention behaviors for society as a whole or a specific group, tailoring the message to someone's general disposition might result in prevention advice that one is generally inclined to accept.

II. When one wants to study or promote prevention behavior one can at least consider two possible routes: 1.) change someone's perception of a specific risk and behavior to stimulate a specific behavior versus 2.) change someone's disposition towards risks and prevention in general to stimulate multiple prevention behaviors across risks. This thesis provided a more solid foundation for the first route, whereby changing perceived characteristics of a specific risk and behavior results in a higher likelihood of performing this behavior. However, the second route offers the potential to increase multiple prevention behaviors across risks if it would be possible to change someone's general disposition. Although the first route may be easier, the second route may be more beneficial overall. Therefore, a trade-off between the two routes, that compares the possibilities and net benefits of both, is one that should get more attention in future work.

III. Although the determinants as used in Protection Motivation Theory and the Health Belief Model offer a good starting point for understanding domestic prevention

behavior, solely applying these determinants in an intervention is not sufficient to increase prevention behavior. Yet, this is the standard practice. These theoretical frameworks are too generic to directly change specific behaviors, and determinants other than the ones included in these theories can be relevant. A lot can be gained when performing a more thorough problem analysis before developing a behavior change intervention. That is, make an inventory of all possible determinants for a specific behavior, formulate them in a detailed manner and analyze the relationships. This provides a better understanding of the true underlying motives and barriers and offers guidance for more effective behavior change interventions.

References

Abraham, C.S., Sheeran, P., Abrams, D. & Spears, R. (1994). Exploring teenagers' adaptive and maladaptive thinking in relation to the threat of hiv infection. *Psychology & Health*, *9*(4), 253–272. https://doi.org/10.1080/08870449408407485

Abroms, L. C., & Maibach, E. W. (2008). The effectiveness of mass communication to change public behavior. *Annual Review of Public Health*, *29*(1), 219–234. https://doi.org/10.1146/annurev.publhealth.29.020907.090824

Ahn, S. J., Bailenson, J. N., & Park, D. (2014). Short- and long-term effects of embodied experiences in immersive virtual environments on environmental locus of control and behavior. *Computers in Human Behavior*, *39*, 235–245. https://doi.org/10.1016/j.chb.2014.07.025

Ahrens, M. (2019). *Smoke Alarms in U.S . Home Fires*. National Fire Protection Association (NFPA).

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*, *50*, 179–211.

Allen, R. S., Phillips, L. L., Pekmezi, D., Crowther, M. R., & Prentice-Dunn, S. (2009). Living well with living wills: Application of protection motivation theory to living wills among older caucasian and African American adults. *Clinical Gerontologist*, *32*(1), 44–59. https://doi.org/10.1080/07317110802474643

American Red Cross. (2018). New Red Cross survey shows many Americans overconfident and underprepared for home fires. Retrieved from https://www.redcross.org/about-us/news-and-events/press-release/New-Red-Cross-Survey-Shows-Many-Americans-Overconfident-and-Underprepared-for-Home-Fires.html

Amir, M., Roziner, I., Knoll, A., & Neufeld, M. Y. (1999). Self-efficacy and social support as mediators in the relation between disease severity and quality of life in patients with epilepsy. *Epilepsia*, *40*(2), 216–224. https://doi.org/10.1111/j.1528-1157.1999.tb02078.x

Andrée, K., Nilsson, D., & Eriksson, J. (2016). Evacuation experiments in a virtual reality high-rise building: Exit choice and waiting time for evacuation elevators. *Fire and*

Materials, *40*(4), 554–567. https://doi.org/10.1002/fam.2310

Armitage, C. J. (2003). The relationship between multidimensional health locus of control and perceived behavioural control: How are distal perceptions of control related to proximal perceptions of control? *Psychology & Health*, *18*(6), 723–738. https://doi.org/10.1080/0887044031000141216

Baaren, R. Van, Leeuwen, M. Van, Siebelt, J., & Lange, M. De. (2012). *Communicatie van nalevingsniveau als gedragsbeïnvloeding*. Den Haag: Boom Lemma uitgevers.

Baker, F. B. (2001). *The basics of item response theory*. *ERIC Clearinghouse on Assesment and Evaluation* (Second edi). https://doi.org/10.1111/j.1365-2702.2011.03893.x

Bamberg, S., Masson, T., Brewitt, K., & Nemetschek, N. (2017). Threat, coping and flood prevention – A meta-analysis. *Journal of Environmental Psychology*, *54*, 116–126. https://doi.org/10.1016/j.jenvp.2017.08.001

Bandalos, D. L. (2014). Relative Performance of Categorical Diagonally Weighted Least Squares and Robust Maximum Likelihood Estimation. *Structural Equation Modeling*, *21*(1), 102–116. https://doi.org/10.1080/10705511.2014.859510

Bandura, A. (1986). *Social foundations of thought action: a social-cognitive theory.* Englewood Cliffs, N.J.: Prentice-Hall.

Bandura, Albert. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, Albert. (1994). Self-Efficacy. *Encyclopedia of Human Behavior*, *4*, 71–81. https://doi.org/10.1002/9780470479216.corpsy0836

Bandura, Albert. (2006). Guide for constructing self-efficacy scales. *Self-Efficacy Beliefs of Adolescents*, 307–337. https://doi.org/10.1017/CBO9781107415324.004

Baron, J., Hershey, J. C., & Kunreuther, H. (2000). Determinants of priority for risk reduction: The role of worry. *Risk Analysis*, *20*(4), 413–427. https://doi.org/10.1111/0272-4332.204041

Becker, J. S., Paton, D., Johnston, D. M., & Ronan, K. R. (2013). Salient beliefs about earthquake hazards and household preparedness. *Risk Analysis*, *33*(9), 1710–1727. https://doi.org/10.1111/risa.12014

Bengel, J., Belz-Merk, M., & Farin, E. (1996). The role of risk perception and efficacy cognitions in the prediction of HIV-related preventive behavior and condom use. *Psychology and Health*, *11*(4), 505–525. https://doi.org/10.1080/08870449608401986

Bhat, G., Beck, L., Bergen, G., & Kresnow, M. J. (2015). Predictors of rear seat belt use among U.S. adults, 2012. *Journal of Safety Research*, *53*, 103–106. https://doi.org/10.1016/j.jsr.2015.03.011

Blair, E. H., Seo, D. C., Torabi, M. R., & Kaldahl, M. A. (2004). Safety beliefs and safe behavior among midwestern college students. *Journal of Safety Research*, *35*(2), 131–140. https://doi.org/10.1016/j.jsr.2003.11.003

Blalock, H. M. (1984). Contextual-effects models : theoretical and methodological issues. *Annual Review of Sociology*, *10*(May), 353–372.

Bond, T. G., & Fox, C. M. (2012). *Applying the Rasch model: Fundamental Measurement in the Human Sciences* (Second Edition). Lawrence Erlbaum Associates. https://doi.org/10.4324/9781410614575

Bradley, M. M., Greenwald, M. K., Petry, M. C., & Lang, P. J. (1992). Remembering pictures : pleasure and arousal in memory, *18*(2), 379–390.

Brown, T. A. (2006). *Methodology in the social sciences. Confirmatory factor analysis for applied research*. (D. A. Kenny, Ed.). New York: The Guilford Press.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In J. S. Bollen, K.A, Long (Ed.), *Testing structural equation models* (pp. 136–162). Thousand Oaks, CA: Sage.

Bubeck, P., Botzen, W. J., Laudan, J., Aerts, C. J. H., & Thieken, A. H. (2017). Insights into flood-coping appraisals of Protection Motivation Theory: empirical evidence from Germany and France. *Risk Analysis*. https://doi.org/10.1111/risa.12938

Bubeck, P., Botzen, W. J. W., & Aerts, J. C. J. H. (2012). A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Analysis*, *32*(9), 1481–1495. https://doi.org/10.1111/j.1539-6924.2011.01783.x

Burns, A. C. (1992). The expanded health belief model as a basis for enlightened preventive health care practice and research. *Journal of Health Care Marketing*, *12*(3), 32–45.

Byrka, K. (2009). *Attitude-behavior consistency. Campbell's paradigm in environmental and health domains (Dissertation)*. Eindhoven University of Technology.

Byrka, K., & Kaiser, F. G. (2012). Health performance of individuals within the Campbell paradigm. *International Journal of Psychology : Journal International de Psychologie*, (August 2013), 37–41. https://doi.org/10.1080/00207594.2012.702215

Cahill, L. & McGaugh, J. L. (1995). A novel demonstration of enhanced memory associated with emotional arousal. *Consciousness and Cognition*, *4*, 410–421.

Cammaert, M., & van Amerongen, B. (2020). *Campagne effectonderzoek woninginbraak winter*. DVJ Inisights.

Campbell, D. T. (1963). Social attitudes and other aquired behavioral dispoitions. In S. Koch (Ed.), *Psychology: A study of a science. Study II. Empirical substructure and relations with other sciences.* (pp. 94–172). McGraw-Hill.

CBS. (2016). *Veiligheidsmonitor 2016*. Den Haag.

CBS. (2020). *Integrale veiligheidsmonitor 2019*. Den Haag.

Chatterjee, C., & Mozumder, P. (2014). Understanding Household Preferences for Hurricane Risk Mitigation Information: Evidence from Survey Responses. *Risk Analysis*, *34*(6), 984–996. https://doi.org/10.1111/risa.12196

Chittaro, L. (2012). Passengers' safety in aircraft evacuations: employing serious games to educate and persuade. In E. Bang, M., Ragnemalm (Ed.), *Persuasive 2012* (Vol. 7284, pp. 215–226). Sweden: Springer.

Chittaro, L. (2014). Changing user's safety locus of lontrol through persuasive play : an application to aviation safety. In A. Spagnolli et al. (Ed.), *PERSUASIVE 2014* (pp. 31–42). Switzerland: Springer.

Chittaro, L. (2016). Designing serious games for safety education: learn to brace versus traditional pictorials for aircraft passengers. *IEEE Transactions on Visualization and Computer Graphics*, *22*(5), 1527–1539. https://doi.org/10.1109/TVCG.2015.2443787

Chittaro, L., & Buttussi, F. (2015). Assessing knowledge retention of an immersive serious game vs. a traditional education method in aviation safety. *IEEE*

Transactions on Visualization and Computer Graphics, *21*(4), 529–538.

Chittaro, L., Corbett, C. L., McLean, G. A., & Zangrando, N. (2018). Safety knowledge transfer through mobile virtual reality: A study of aviation life preserver donning. *Safety Science*, *102*, 159–168. https://doi.org/10.1016/j.ssci.2017.10.012

Chittaro, L., & Sioni, R. (2015). Serious games for emergency preparedness: evaluation of an interactive vs. a non-interactive simulation of a terror attack. *Computers in Human Behavior*, *50*, 508–519. https://doi.org/10.1016/j.chb.2015.03.074

Chittaro, L., & Zangrando, N. (2010). The persuasive power of Virtual Reality: effects of simulated human distress on attitudes towards fire safety. In H. Ploug, T., Hasle, P., Oinas-Kukkonen (Ed.), *Persuasive 2010* (pp. 58–69). Denmark: Springer.

Cialdini, R. B., Demaine, L. J., Sagarin, B. J., Barrett, D. W., Rhoads, K., & Winter, P. L. (2006). Managing social norms for persuasive impact. *Social Influence*, *1*(1), 3–15. https://doi.org/10.1080/15534510500181459

Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology*, *58*(6), 1015–1026. https://doi.org/10.1037//0022-3514.58.6.1015

Cismaru, M., & Lavack, A. M. (2007). Interaction effects and combinatorial rules governing Protection Motivation Theory variables: A new model. *Marketing Theory*, *7*(3), 249–270. https://doi.org/10.1177/1470593107080344

Clark, A., & Smith, J. (2018). Owning and testing smoke alarms: findings from a qualitative study. *Journal of Risk Research*, *21*(6), 748–762. https://doi.org/10.1080/13669877.2016.1240707

Clarke, S., & Robertson, I. T. (2005). Clarke Meta-analyse big five en crash rate. *Journal of Occupational and Organizational Psychology*, *78*, 355–376.

Collins, L. M. (2006). Analysis of longitudinal data: The integration of theoretical model, temporal design, and statistical model. *Annual Review of Psychology*, *57*, 505–528. https://doi.org/10.1146/annurev.psych.57.102904.190146

Crowe, J. W. (1995). Safety Values and Safe Practices Among College Students. *Journal of Safety Research*, *26*(3), 187–195.

Curfman, G. D. (1993). Is exercose beneficial - or hazardous - to your heart? *The New England Journal of Medicine*, *329*(23), 1730–1731.

Curran, P. J., & Bauer, D. J. (2011). The disaggregation of within-person and between-person effects in longitudinal models of change. *Annual Review of Psychology*, *62*, 583–619. https://doi.org/10.1146/annurev.psych.093008.100356

D'agostino, R. B., Belanger, A., & D'Agostino Jr, R. B. (1990). A Suggestion for Using Powerful and Informative Tests of Normality. *The American Statistician*, *44*(4), 316–321.

Dang, H. L., Li, E., Nuberg, I., & Bruwer, J. (2014). Understanding farmers' adaptation intention to climate change: A structural equation modelling study in the Mekong Delta, Vietnam. *Environmental Science and Policy*, *41*, 11–22. https://doi.org/10.1016/j.envsci.2014.04.002

Davis, J., Conlon, E., Ownsworth, T., & Morrissey, S. (2016). Measuring situational avoidance in older drivers: An application of Rasch analysis. *Accident Analysis and Prevention*, *87*, 68–77. https://doi.org/10.1016/j.aap.2015.11.018

de Hoog, N., Stroebe, W., & de Wit, J. B. F. (2008). The processing of fear-arousing communications: How biased processing leads to persuasion. *Social Influence*, *3*(2), 84–113. https://doi.org/10.1080/15534510802185836

DeJoy, D. M. (1989). The optimism bias and traffic accident risk perception. *Accident Analysis and Prevention*, *21*(4), 333–340. https://doi.org/10.1016/0001-4575(89)90024-9

Diguiseppi, C., Roberts, I., Wade, A., Sculpher, M., Edwards, P., Godward, C., … Slater, S. (2002). Incidence of fires and related injuries after giving out fee smoke alarms : cluster randomised controlled trial. *BMJ*, *325*, 2–5.

Dooley, D., Catalano, R., Mishra, S., & Serxner, S. (1992). Earthquake preparedness: predictors in a community survey. *Journal of Applied Social Psychology*, *22*(6), 451–470. https://doi.org/10.1111/j.1559-1816.1992.tb00984.x

Eck, R. Van. (2006). Digital game-based learning: It's not just the digital natives who are restless. *Educause Review*, *41*(2), 1–16. https://doi.org/10.1145/950566.950596

Ejeta, L. T., Ardalan, A., Paton, D., & Yaseri, M. (2016). Predictors of community

preparedness for flood in Dire-Dawa town, Eastern Ethiopia: Applying adapted version of Health Belief Model. *International Journal of Disaster Risk Reduction*, *19*, 341–354. https://doi.org/10.1016/j.ijdrr.2016.09.005

Enders, C. K., & Tofighi, D. (2007). Centering predictor variables in cross-sectional multilevel models: a new look at an old issue. *Psychological Methods*, *12*(2), 121–138. https://doi.org/10.1037/1082-989X.12.2.121

Eysink Smeets, M., Heijman, M., Postma & R. (2015). *Gedragsverandering voor brandveilig leven. Inzichten en aanbevelingen.* Arnhem.

Eysink Smeets, M., Heijman, M., Postma, R. (2016). *Behaviour change for community fire safety. Insights and recommendations.* Arnhem.

Festinger, L. (1957). *A theory of cognitive dissonance*. California, U.S.: Stanford University Press.

Floyd, D., Prentice-Dunn, S., & Rogers, R. (2000). A meta-analysis of research on Protection Motivation Theory. *Journal of Applied Social Psychology*, *30*(2), 407–429. https://doi.org/10.1111/j.1559-1816.2000.tb02323.x

Fogg, B. J. (2003). *Persuasive technology: Using computers to change what we think and do*. San Fransisco: Morgan Kauffman.

Gee, J. P. (2008). Learning and games. In K. Salen (Ed.), *The Ecology of Games: Connecting Youth, Games, and Learning* (pp. 21–40). Cambridge, MA: The MIT Press. https://doi.org/10.1162/dmal.9780262693646.021

Gielen, A. C., & Sleet, D. (2003). Application of behavior-change theories and methods to injury prevention. *Epidemiologic Reviews*, *25*, 65–76. https://doi.org/10.1093/epirev/mxg004

Ginnelly, L., Sculpher, M., Bojke, C., Roberts, I., Wade, A., & Diguseppi, C. (2005). Determining the cost effectiveness of a smoke alarm give-away program using data from a randomized controlled trial. *European Journal of Public Health*, *15*(5), 448–453. https://doi.org/10.1093/eurpub/cki146

Glynn, C. J., Huge, M. E., & Lunney, C. A. (2009). The influence of perceived social norms on college students' intention to vote. *Political Communication*, *26*(1), 48–64. https://doi.org/10.1080/10584600802622860

Goldstein, N. J., Cialdini, R. B., & Griskevicius, V. (2008). A Room with a Viewpoint: Using Social Norms to Motivate Environmental Conservation in Hotels. *Journal of Consumer Research*, *35*(3), 472–482. https://doi.org/10.1086/586910

Gollwitzer, P. M., & Sheeran, P. (2006). Implementation intentions and goal achievement: a meta-analysis of effects and processes. *Advances in Experimental Social Psychology*, *38*, 69–119. https://doi.org/10.1016/S0065-2601(06)38002-1

Green, K., & Frantom, C. (2002). Survey development and validation with the Rasch model. *International Conference on Questionnaire Development*. Retrieved from http://medcontent.metapress.com/index/A65RM03P4874243N.pdf

Grothmann, T., & Reusswig, F. (2006). People at risk of flooding: Why some residents take precautionary action while others do not. *Natural Hazards*, *38*(1–2), 101–120. https://doi.org/10.1007/s11069-005-8604-6

Hagger, M.S., Cameron, L.D., Hamilton, K., Hankonenm N., Lintunen, T. (2020). *The handbook of behavior change*. Cambridge, UK: Cambridge University Press.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate Data Analysis* (7th ed.). Upper Saddle River: NJ: Pearson Prentice Hall. https://doi.org/10.1016/j.ijpharm.2011.02.019

Hanus, B., & Wu, Y. (2016). Impact of users' security awareness on desktop security behavior: a Protection Motivation Theory perspective. *Information Systems Management*, *33*(1), 2–16. https://doi.org/10.1080/10580530.2015.1117842

Harvey, P.A., Sacks, J. J., Ryan, G. W., & Bender, P. F. (1998). Residential smoke alarms and fire escape plans. *Public Health Reports*, *113*(5), 459–464. Retrieved from http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1308417&tool=pmcentrez&rendertype=abstract

Harvey, P.A., Aitken, M., Ryan, G. W., Demeter, L. A., Givens, J., Sundararaman, R., & Goulette, S. (2004). Strategies to increase smoke alarm use in high-risk households. *Journal of Community Health*, *29*(5), 375–385. https://doi.org/10.1023/B:JOHE.0000038653.59255.57

Heckhausen, H., & Gollwitzer, P. M. (1987). Thought contents and cognitive functioning in motivational versus volitional states of mind. *Motivation and Emotion*, *11*(2), 101–120. https://doi.org/10.1007/BF00992338

Hodsoll, K., & Nayak, U. S. L. (1999). The perception of fire risk by older people and its impact on relevant fire safety education. *International Journal for Consumer and Product Safety*, *6*(3), 159–168. https://doi.org/10.1076/icsp.6.3.159.7539

Hoyt, M. F. (1974). Internal-external control and beliefs about automobile travel. *Journal of Research in Personality*, *7*, 288–293.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Huang, J. L., & Ford, J. K. (2012). Driving locus of control and driving behaviors: Inducing change through driver training. *Transportation Research Part F: Traffic Psychology and Behaviour*, *15*(3), 358–368. https://doi.org/10.1016/j.trf.2011.09.002

Hunter, D. R. (2002). Development of an aviation safety locus of control scale. *Aviation, Space, and Environmental Medicine*, *00*(0), 1–5.

Institute for Safety. (2015a). *Gebrand op inzicht. Een onderzoek naar de effectiviteit van rookmelders.* Arnhem.

Institute for Safety. (2015b). *Jaaroverzicht fatale woningbranden 2014*. Retrieved from http://www.ifv.nl/advieseninnovatie/Documents/20151030-BA-Jaaroverzicht-fatale-woningbranden-2014.pdf

Institute for Safety. (2018). *10 Jaar Fatale Woningbranden Onderzocht*. Arnhem.

Jackson, M., Wilson, J., Akoto, J., Dixon, S., Jacobs, D. E., & Ballesteros, M. F. (2010). Evaluation of fire-safety programs that use 10-year smoke alarms. *Journal of Community Health*, *35*(5), 543–548. https://doi.org/10.1007/s10900-010-9240-y

Jansen, P. C. P., Willemsen, M. C., & Snijders, C. C. P. (2016). *Prevention performance through behavioral self-reports: an application of the one-dimensional Rasch model.* Unpublished manuscript.

Janssen, K., Van Den Berg, M., & Tieben, B. (2009). *Brandveiligheid: wie doet wat, hoe en waarom?* Amsterdam.

Janz, N. K., & Becker, M. H. (1984). The Health Belief Model: A decade later. *Health*

Education Quarterly, *11*(1), 1–47. https://doi.org/10.1177/109019818401100101

Jayanti, R. K., & Burns, A. C. (1998). The antecedents of preventive health care behavior: an empirical study. *Journal of the Academy of Marketing Science*, *26*(1), 6–15. https://doi.org/10.1177/0092070398261002

Jensen, A. R. (1998). *The g Factor: The science of mental ability arthur*. Westport, CT: Greenwood Publishing. https://doi.org/10.1042/bj1470373

Jones, A. R., Thompson, C. J., & Davis, M. K. (2001). Smoke alarm ownership and installation: A comparison of a rural and a suburban community in Georgia. *Journal of Community Health*, *26*(5), 307–329. https://doi.org/10.1023/A:1010478116532

Jones, J. W., & Wuebker, L. J. (1993). Safety locus of control and employees' accidents. *Journal of Business and Psychology*, *7*(4), 449–457.

Kahneman, D. (2011). *Thinking, Fast and Slow.* New York: Farras, Straus & Giroux.

Kaiser, F. G., Byrka, K., & Hartig, T. (2010). Reviving Campbell's Paradigm for Attitude Research. *Personality and Social Psychology Review*, *14*(4), 351–367. https://doi.org/10.1177/1088868310366452

Kaiser, F.G., Hartig, T., Brugger, A., & Duvier, C. (2011). Environmental protection and nature as distinct attitudinal objects: an application of the Campbell paradigm. *Environment and Behavior*, *45*(3), 369–398. https://doi.org/10.1177/0013916511422444

Kaiser, F.G., & Keller, C. (2001). Disclosing situational constraints to ecological behavior : a confirmatory application of the mixed Rasch model. *European Journal of Psychological Assessment*, *17*(3), 212–221.

Kaiser, F.G. (1998). A general measure of ecological behavior. *Journal of Applied Social Psychology*, *28*(5), 395–422. https://doi.org/10.1111/j.1559-1816.1998.tb01712.x

Kaiser, F.G., Byrka, K., & Hartig, T. (2010). Reviving Campbell's paradigm for attitude Research. *Personality and Social Psychology Review*, *14*(4), 351–367. https://doi.org/10.1177/1088868310366452

Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., & Stokols, D. (2012). Dimensions of conservation: exploring differences among energy

behaviors. *Environment and Behavior*, *46*(4), 423–452. https://doi.org/10.1177/0013916512467532

Kato, P. M., Cole, S. W., Bradlyn, A. S., & Pollock, B. H. (2008). A video game improves behavioral outcomes in adolescents and young adults with cancer: a randomized trial. *Pediatrics*, *122*(2), 305–317. https://doi.org/10.1542/peds.2007-3134

Kay, L., Bundy, A., Clemson, L., & Jolly, N. (2008). Validity and reliability of the on-road driving assessment with senior drivers. *Accident Analysis and Prevention*, *40*(2), 751–759. https://doi.org/10.1016/j.aap.2007.09.012

Kellens, W., Terpstra, T., Schelfaut, K., & De Maeyer, P. (2013). Perception and communication of flood risks: a systematic review of empirical research. *Risk Analysis*, *33*(1), 24–49. https://doi.org/10.1111/j.1539-6924.2012.01844.x

Kendrick, D., Young, B., Mason-Jones, A. J., Ilyas, N., Achana, F. A., Cooper, N. J., … Coupland, C. (2013). Home safety education and provision of safety equipment for injury prevention. *Evidence-Based Child Health: A Cochrane Review Journal*, *8*(3), 761–939. https://doi.org/10.1002/ebch.1911

Kensinger, E. A. (2009). Remembering the details: effects of emotion. *Emotion Review*, *1*(2), 99–113. https://doi.org/10.1177/1754073908100432

Kensinger, E. A., Brierley, B., Medford, N., Growdon, J. H., & Corkin, S. (2002). Effects of normal aging and Alzheimer's disease on emotional memory. *Emotion*, *2*(2), 118–134. https://doi.org/10.1037//1528-3542.2.2.118

Killip, S., Mahfoud, Z., & Pearce, K. (2004). What is an intracluster correlation coefficient ? Crucial concepts for primary care researchers. *Annals Of Family Medicine*, 204–208.

Kline, R. B. (2016). *Principles and practice of structural equation modeling.* (4th ed.). New York: The Guilford Press.

Knijnenburg, B. P., & Willemsen, M. C. (2015). Evaluating Recommender Systems with User Experiments. In B. Ricci, F, Rokach, L., Shapira (Ed.), *Recommender Systems Handbook* (pp. 309–352). New York: Springer Science+Business Media. https://doi.org/10.1007/978-0-387-85820-3

Kronenfeld, J., Glik, D., & Jackson, K. (1991). Home Fire Safety and Related Behaviors

Among Parents of Preschoolers. *Children's Environments Quarterly*, *8*(3/4), 41–40. Retrieved from http://www.jstor.org/stable/41514789

Lara, A., Saurí, D., Ribas, A., & Pavón, D. (2010). Social perceptions of floods and flood management in a Mediterranean area (Costa Brava, Spain). *Natural Hazards and Earth System Science*, *10*(10), 2081–2091. https://doi.org/10.5194/nhess-10-2081-2010

Lau, V. C. S., Au, W. T., & Ho, J. M. C. (2003). A qualitative and quantitative review of antecedents of counterproductive behavior in organizations. *Journal of Business and Psychology*, *18*(1), 73–99. https://doi.org/10.1023/A:1025035004930

Lehman, D.R. & Taylor, S. E. (1987). Date with an earthquake: coping with a probable, inpredictable disaster. *Personality and Social Psychology Bulletin*, *13*(4), 546–555.

Lieberman, D. A. (1997). Interactive video games for health promotion: Effects on knowledge, self-efficacy, social support and health. In R. L. Street, W. R. Gold, & T. R. Manning (Eds.), *Health promotion and interactive technology: theoretical applications and future directions.* Mahwah, NJ: Lawrence Erlbaum Associates.

Lieberman, D. A. (1998). Health education video games for children and adolescents: theory, design, and research findings. In *Annual meeting of the International Communication Association*. Jersusalem. Retrieved from http://www.eric.ed.gov/ERICWebPortal/detail?accno=ED422312

Linacre, J. M. (2012). Winsteps® Tutorial 4. Beaverton, Oregon.

Linacre, J. M. (2015a). Winsteps® Rasch measurement computer program. Beaverton, Oregon.

Linacre, J. M. (2015b). Winsteps® Rasch measurement computer program User's Guide. Beaverton, Oregon.

Lindell, M.K. & Perry, R. W. (2004). Communicating Environmental Risk in Multiethnic Communities. In W. . Gudykunst & S. Ting-Toomey (Eds.), *Communicating Effectively in Multicultural Contexts*. California, U.S.: Sage Publications, Inc.

Lindell, M.K., Arlikatti, S., & Prater, C. S. (2009). Why people do what they do to protect against earthquake risk: Perceptions of hazard adjustment attributes. *Risk Analysis*, *29*(8), 1072–1088. https://doi.org/10.1111/j.1539-6924.2009.01243.x

Lindell, M.K., & Prater, C. S. (2000). Household adoption of seismic hazard adjustments: A comparison of residents in two states. *International Journal of Mass Emergencies and Disasters*.

Lindell, M.K., & Prater, C. S. (2002). Risk area resident' perceptions and adoption of seismic hazard adjustments. *Journal of Applied Social Psychology*, *32*(11), 2377–2392.

Lindell, M.K., & Whitney, D. J. (2000). Correlates of household seismic hazard adjustment adoption. *Risk Analysis*, *20*(1), 13–25. https://doi.org/10.1111/0272-4332.00002

Lindell, Michael K., & Prater, C. S. (2000). Household adoption of seismic hazard adjustments: A comparison of residents in two states. *International Journal of Mass Emergencies and Disasters*.

Lindell, Michael K, & Perry, R. W. (2000). Household adjustement to earthquake hazard. A review of research. *Environment and Behavior*, *32*(4), 461–501.

Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin*, *127*(2), 267–286. https://doi.org/10.1037/0033-2909.127.2.267

Lund, J., & Hovden, J. (2003). The influence of safety at work on safety at home and during leisure time. *Safety Science*, *41*(9), 739–757. https://doi.org/10.1016/S0925-7535(02)00021-8

Luszczynska, A., Gutiérrez-Doña, B., & Schwarzer, R. (2005). General self-efficacy in various domains of human functioning: Evidence from five countries. *International Journal of Psychology*, *40*(2), 80–89. https://doi.org/10.1080/00207590444000041

Luszczynska, A., & Schwarzer, R. (2005). Multidimensional health locus of control: comments on the construct and its measurement. *Journal of Health Psychology*, *10*(5), 633–642. https://doi.org/10.1177/1359105305055307

Maddux, J. E., & Rogers, R. W. (1983). Protection motivation and self-efficacy: A revised theory of fear appeals and attitude change. *Journal of Experimental Social Psychology*, *19*(5), 469–479. https://doi.org/10.1016/0022-1031(83)90023-9

Mäkinen, T., Wittink, R. D., & Hagenzieker, M. P. (1991). *Het gebruik van autogordels en factoren die daarbij een rol spelen : een internationale vergelijking*. Leidschendam.

Mantler, T. (2013). A systematic review of smoking Youths' perceptions of addiction and health risks associated with smoking: Utilizing the framework of the health belief model. *Addiction Research and Theory*, *21*(4), 306–317. https://doi.org/10.3109/16066359.2012.727505

Manzoni, G. M., Pagnini, F., Gorini, A., Preziosa, A., Castelnuovo, G., Molinari, E., & Riva, G. (2009). Can relaxation training reduce emotional eating in women with obesity? An exploratory study with 3 months of follow-up. *Journal of the American Dietetic Association*, *109*(8), 1427–1432. https://doi.org/10.1016/j.jada.2009.05.004

Martin, I. M., Bender, H., & Raish, C. (2007). What motivates individuals to protect themselves from risks: The case of wildland fires. *Risk Analysis*, *27*(4), 887–900. https://doi.org/10.1111/j.1539-6924.2007.00930.x

McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the theory of planned behaviour: A meta-analysis. *Health Psychology Review*, *5*(2), 97–144. https://doi.org/10.1080/17437199.2010.521684

McKenna, F. P. (1993). It won't happen to me: Unrealistic optimism or illusion of control? *British Journal of Psychology*, *84*(1993), 39–50. https://doi.org/10.1111/j.2044-8295.1993.tb02461.x

McKnight, R. H., Struttman, T. W., & Mays, J. R. (1995). Finding homes without smoke detectors: one step in planning burn prevention programs. *Journal of Burn Care & Rehabilitation*, *16*(5).

Mclennan, J., Every, D., Bearman, C., & Wright, L. (2017). Reduction On the concept of denial of natural hazard risk and its use in relation to householder wild fire safety in Australia. *International Journal of Disaster Risk Reduction*, *21*, 176–186. https://doi.org/10.1016/j.ijdrr.2016.12.006

Melnyk, V., Van Herpen, E., Jak, S., & Van Trijp, H. C. M. (2019). The mechanisms of social norms' influence on consumer decision making. A meta-analysis. *Journal of Psychology*, *227*(1), 4–17. https://doi.org/10.1027/2151-2604/a000352

Mileti, D. S., & Brien, P. W. O. (1992). Warnings during disaster : normalizing

communicated risk. *Social Problems*, *39*(1), 40–57.

Miller, T. R., Bergen, G., Ballesteros, M.F. Bhattacharya, S., Gielen, A. C., & Sheppard, M. S. (2014). Increasing smoke alarm operability through theory-based health education: a randomised trial. *Journal of Epidemiol Community Health*, *68*(12), 1168–1174. https://doi.org/10.1136/jech-2014-204182.Increasing

Milne, S., Sheeran, P., & Orbell, S. (2000). Prediction and intervention in health-related behavior: A meta-analytic review of Protection Motivation Theory. *Journal of Applied Social Psychology*, *30*(1), 106–143. https://doi.org/10.1111/j.1559-1816.2000.tb02308.x

Mittleman, A. M., Maclure, M., Tofler, G. H., Sherwood, J. B., Goldberg, R. J., & Muller, J. E. (1993). Triggering of acute myocardinal infarction by heavy physical exertion. *New England Journal of Medicine*, *328*(23), 1167–1172.

Molenaar, P. C. M. (2004). A manifesto on psychology as ideographic science: bringing the person back into scientific psychology, this time forever. *Measurement*, *2*(4), 201–218. https://doi.org/10.1207/s15366359mea0204

Montag, I., & Comrey, A. L. (1987). Internality and externality as correlates of involvement in fatal driving accidents. *The Journal of Applied Psychology*, *72*(3), 339–343. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3624153

Morisset, N., Terrade, F., & Somat, A. (2010). Perceived self-efficacy and risky driving behaviors: The mediating role of subjective risk judgment. *Swiss Journal of Psychology*, *69*(4), 233–238. https://doi.org/10.1024/1421-0185/a000027

Mroczek, D. K., Spiro, A., & Almeida, D. M. (2003). Between-and within-person variation in affect and personality over days and years: How basic and applied approaches can inform one another. *Ageing International*, *28*(3), 260–278. https://doi.org/10.1007/s12126-002-1007-z

Mulilis, J., & Lippa, R. (1990). Behavioral change in earthquake preparedness due to negative threat appeals: A test of Protection Motivation Theory. *Journal of Applied Social Psychology*, *20*(8), 619–638. https://doi.org/10.1111/j.1559-1816.1990.tb00429.x

Müller, B. C. N., van Baaren, R. B., Ritter, S. M., Woud, M. L., Bergmann, H., Harakeh, Z., … Dijksterhuis, A. (2009). Tell me why... The influence of self-involvement on

short term smoking behaviour. *Addictive Behaviors*, *34*(5), 427–431. https://doi.org/10.1016/j.addbeh.2008.12.016

Murray, C. D., Fox, J., & Pettifer, S. (2007). Absorption, dissociation, locus of control and presence in virtual reality. *Computers in Human Behavior*, *23*(3), 1347–1354. https://doi.org/10.1016/j.chb.2004.12.010

Muthén, L., & Muthén, B. (2016). Mplus Version 8. Los Angeles: Muthén, & Muthén.

Neill, P. O. (2004). *Developing a risk communication model to encourage community safety from natural hazards*. *Com Safety Program*.

Neuwirth, K., Dunwoody, S., & Griffin, R. J. (2000). Protection motivation and risk communication. *Risk Analysis*, *20*(5), 721–734. https://doi.org/10.1111/0272-4332.205065

Newnam, S., Mamo, W. G., & Tulu, G. S. (2014). Exploring differences in driving behaviour across age and years of education of taxi drivers in Addis Ababa, Ethiopia. *Safety Science*, *68*, 1–5. https://doi.org/10.1016/j.ssci.2014.02.012

Nielsen, M. B., Hystad, S. W., & Eid, J. (2016). The brief Norwegian safety climate inventory (brief NORSCI) - Psychometric properties and relationships with shift work, sleep, and health. *Safety Science*, *83*, 23–30. https://doi.org/10.1016/j.ssci.2015.11.004

Orbell, S., Hodgkins, S., & Sheeran, P. (1997). Implementation intentions and the theory of planned behavior. *Personality and Social Psychology Bulletin*, *23*(9), 945–954.

Paek, H., Hilyard, K., Freimuth, V., & Barge, J. K. (2010). Theory-based approaches to understanding public emergency preparedness: implications for effective health and risk communication, *14*(4), 428–444. https://doi.org/10.1080/10810731003753083

Pakenham, K. I., Pruss, M., & Clutton, S. (2000). The utility of socio-demographics, knowledge and health belief model variables in predicting reattendance for mammography screening: A brief report. *Psychology & Health*, *15*, 585–591. https://doi.org/10.1080/08870440008405472

Parkes, K. R. (1985). Dimesionality of Rotter's locus of control scale: an application of the "very simple structure" technique. *Personality and Individual Differences*, *6*(1),

115–119. https://doi.org/10.1016/0191-8869(85)90036-4

Parmer, J. E., Corso, P. S., & Ballesteros, M. F. (2006). A cost analysis of a smoke alarm installation and fire safety education program. *Journal of Safety Research*, *37*(4), 367–373. https://doi.org/10.1016/j.jsr.2006.05.006

Pennebaker, J. W., & Harber, K. D. (1993). A social stage model of collective coping: the Loma Prieta earthquake and the Persian Gulf war. *Journal of Social Issues*, *49*(4), 125–145. https://doi.org/10.1111/j.1540-4560.1993.tb01184.x

Peperkorn, H. M., Diemer, J., & Mühlberger, A. (2015). Temporal dynamics in the relation between presence and fear in virtual reality. *Computers in Human Behavior*, *48*, 542–547. https://doi.org/10.1016/j.chb.2015.02.028

Persky, S., & Blascovich, J. (2008). Immersive virtual video game play and presence: Influences on aggressive feelings and behavior. *Presence: Teleoperators and Virtual Environments*, *17*(1), 57–72. https://doi.org/10.1162/pres.17.1.57

Poussin, J. K., Botzen, W. J. W., & Aerts, J. C. J. H. (2014). Factors of influence on flood damage mitigation behaviour by households. *Environmental Science and Policy*, *40*, 69–77. https://doi.org/10.1016/j.envsci.2014.01.013

Prochaska, J. O., & Di Clemente, C. C. (1982). Transtheoretical therapy: Toward a more integrative model of change. *Psychotherapy*, *19*(3), 276–288. https://doi.org/10.1037/h0088437

Proulx, G. (2001). Occupant behaviour and evacuation. *Proceedings of the 9th International Fire Protection Symposium*, 219–232.

Proulx, G. (2003). Playing with fire: why people linger in burning buildings. *ASHRAE Journal*, *45*(7), 33–35.

Rasch, G. R. (1960). *Probabilistic models for some intelligence and attainment tests.* Copenhagen: Danish Institute for Educational Research.

Reinfurt, D., Williams, A., Wells, J. A., & Rodgman, E. (1996). Characteristics of drivers not using seat belts in a high belt use state. *Journal of Safety Research*, *27*(4), 209–215. https://doi.org/10.1016/S0022-4375(96)00026-6

Reno, R. R., Cialdini, R. B., & Kallgren, C. A. (1993). The transsituational influence of

social norms. *Journal of Personality and Social Psychology*, *64*(1), 104–112. https://doi.org/10.1037//0022-3514.64.1.104

Rippetoe, P.A. & Rogers, R. W. (1987). Effects of components of Protection-Motivation Theory on adaptive and maladaptive coping with a health threat. *Journal of Personality and Social Psychology*, *52*(3), 596–604.

Roberts, H., Curtis, K., Liabo, K., Rowland, D., DiGuiseppi, C., & Roberts, I. (2004). Putting public health evidence into practice: Increasing the prevalence of working smoke alarms in disadvantaged inner city housing. *Journal of Epidemiology and Community Health*, *58*(4), 280–285. https://doi.org/10.1136/jech.2003.007948

Roberts, I. (1996). Smoke alarm use: prevalence and household predictors. *Injury Prevention*, *2*(4), 263–265. https://doi.org/10.1136/ip.2.4.263

Robertson, A. S., Rivara, F. P., Ebel, B. E., Lymp, J. F., & Christakis, D. A. (2005). Validation of parent self reported home safety practices. *Injury Prevention*, *11*(4), 209–212. https://doi.org/10.1136/ip.2005.009019

Rogers, R. W. (1975). A Protection Motivation Theory of fear appeals and attitude change. *The Journal of Psychology*, *91*(1), 93–114. https://doi.org/10.1080/00223980.1975.9915803

Rogers, R. W. (1983). Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. In *Social Psychophysiology: A Source Book* (pp. 469–573). https://doi.org/10.1093/deafed/ent031

Rosenstock, I. M. (1966). Why people use health services. *The Milbank Quarterly*, *44*(3), 94–124. https://doi.org/10.1111/j.1468-0009.2005.00425.x

Rosenstock, I. M., Strecher, V. J., & Becker, M. H. (1988). Social learning theory and the health belief model. *Health Education Quarterly*, *15*(2), 175–183. https://doi.org/10.1177/109019818801500203

Rosenstock, I. M., Strecher, V. J., & Becker, M. H. (1994). The health belief model and HIV risk behavior change. *Preventing AIDS Theories and Methods of Behavioral Interventions*, 5–24.

Rotter, J. B. (1954). *Social learning and clinical psychology*. Englewood Cliffs, N.J.: Prentice-Hall.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs: General and Applied*, *80*(1), 1–28.

Russell, L. A., Goltz, J. D., & Bourque, L. B. (1995). Preparedness and hazard mitigation actions before and after two earthquakes. *Environment & Behavior*, *27*(6), 744–770.

Ryon, H. S., & Gleason, M. E. J. (2014). The role of locus of control in daily life. *Personality and Social Psychology Bulletin*, *40*(1), 121–131. https://doi.org/10.1177/0146167213507087

Schade, C., Kunreuther, H., & Koellinger, P. (2011). Protecting against low-probability disasters: The role of worry. *Journal of Behavioral Decision Making*, *25*, 534–543. https://doi.org/10.1002/bdm

Scheuthle, H., Carabias-Hütter, V., & Kaiser, F. G. (2005). The motivational and instantaneous behavior effects of contexts: Steps toward a theory of goal-directed behavior. *Journal of Applied Social Psychology*, *35*(10), 2076–2093. https://doi.org/10.1111/j.1559-1816.2005.tb02210.x

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. *Psychological Science*, *18*(5), 429–434. https://doi.org/10.1111/j.1467-9280.2007.01917.x

Schwarzer, R., & Jerusalem, M. (1995). Generalized self-efficacy scale. In M. Weinman, J., Wright, S., Johnston (Ed.), *Measures in health psychology: A user's portfolio. Causal and control beliefs.* (pp. 35–37). Windsor, UK: Nfer-Nelson.

Schwarzer, R., Luszczynska, A., Ziegelmann, J. P., Scholz, U., & Lippke, S. (2008). Social-cognitive predictors of physical exercise adherence: three longitudinal studies in rehabilitation. *Health Psychology*, *27*(1), S54–S63. https://doi.org/10.1037/0278-6133.27.1(Suppl.).S54

Schwarzer, R. (2008). Modeling health behavior change: How to predict and modify the adoption and maintenance of health behaviors. *Applied Psychology*, *57*(1), 1–29. https://doi.org/10.1111/j.1464-0597.2007.00325.x

Schwebel, D. C., McClure, L. A., & Porter, B. E. (2017). Experiential exposure to texting and walking in virtual reality: A randomized trial to reduce distracted pedestrian behavior. *Accident Analysis and Prevention*, *102*, 116–122. https://doi.org/10.1016/j.aap.2017.02.026

Shaffer, D. W., Squire, K. R., Halverson, R., & Gee, J. P. (2005). Video games and the future of learning. *Phi Delta Kappan*, *87*(2), 104–111. https://doi.org/10.1002/piq.20020

Shani, E., Ayalon, A., Hammad, I. A., & Sikron, F. (2003). What picture is worth a thousand words? A comparative evaluation of a burn prevention programme by type of medium in Israel. *Health Promotion International*, *18*(4), 361–371. https://doi.org/10.1093/heapro/dag416

Shapiro, S. S., & Martin, B. W. (1965). An analysis of variance test for normality. *Biometrika*, *52*(3/4), 591–611.

Sharot, T. (2011). The optimism bias. *Current Biology*, *21*(23), R941–R945. https://doi.org/10.1016/j.cub.2011.10.030

Shea, T., De Cieri, H., Donohue, R., Cooper, B., & Sheehan, C. (2016). Leading indicators of occupational health and safety: An employee and workplace level validation study. *Safety Science*, *85*, 293–304. https://doi.org/10.1016/j.ssci.2016.01.015

Sheeran, P., Harris, P. R., & Epton, T. (2014). Does heightening risk appraisals change people's intentions and behavior? A meta-analysis of experimental studies. *Psychological Bulletin*, *140*(2), 511–543. https://doi.org/10.1037/a0033065

Sheeran, P., & Webb, T. L. (2016). The intention–behavior gap. *Social and Personality Psychology Compass*, *10*(9), 503–518. https://doi.org/10.1111/spc3.12265

Shrout, P. E., & Bolger, N. (2002). Mediation in experimental and nonexperimental studies: New procedures and recommendations. *Psychological Methods*, *7*(4), 422–445. https://doi.org/10.1037//1082-989X.7.4.422

Shults, R. A., Sacks, J. J., Briske, L. A., Dickey, P. H., Kinde, M. R., Mallonee, S., & Reddish Douglas, M. (1998). Evaluation of three smoke detector promotion programs. *American Journal of Preventive Medicine*, *15*(3), 165–171. https://doi.org/10.1016/S0749-3797(98)00071-3

Siegel, J. M., Shoaf, K. I., Afifi, A. A., & Bourque, L. B. (2003). Surviving two disasters: Does reaction to the first predict response to the second? *Environment and Behavior*, *35*(5), 637–654. https://doi.org/10.1177/0013916503254754

Siegrist, M. (2013). The Necessity for Longitudinal Studies in Risk Perception Research. *Risk Analysis*, *33*(1), 50–51. https://doi.org/10.1111/j.1539-6924.2012.01941.x

Siegrist, M., & Gutscher, H. (2008). Natural hazards and motivation for mitigation behavior: People cannot predict the affect evoked by a severe flood. *Risk Analysis*, *28*(3), 771–778. https://doi.org/10.1111/j.1539-6924.2008.01049.x

Slovic, P., Finucane, M., Petere, E., & MacGregor, D. G. (2004). Risk as analysis and risk as feelings: some thoughts about affect, reason, risk, and rationality. *Risk Analysis*, *24*(2), 311–322. Retrieved from http://eds.b.ebscohost.com.ezproxy.derby.ac.uk/eds/pdfviewer/pdfviewer?vid=16&sid=459647e3-043f-47f5-9955-177e7ad6d6f9%40sessionmgr120

Snyder, L. B. (2007). Health communication campaigns and their impact on behavior. *Journal of Nutrition Education and Behavior*, *39*(2), S32–S40.

Somers, T. J., Shelby, R. A., Keefe, F. J., Godiwala, N., Lumley, M. A., Mosley-Williams, A., … Caldwell, D. (2010). Disease severity and domain-specific arthritis self-efficacy: Relationships to pain and functioning in patients with rheumatoid arthritis. *Arthritis Care and Research*, *62*(6), 848–856. https://doi.org/10.1002/acr.20127

Starke, A. D., Willemsen, M. C., & Snijders, C. C. P. (2020). Beyond "one-size-fits-all" platforms: Applying Campbell's paradigm to test personalized energy advice in the Netherlands. *Energy Research and Social Science*, *59*(March 2018), 101311. https://doi.org/10.1016/j.erss.2019.101311

Starke, A., Willemsen, M., & Snijders, C. (2017). Effective user interface designs to increase energy-efficient behavior in a Rasch-based energy recommender system. *RecSys 2017 - Proceedings of the 11th ACM Conference on Recommender Systems*, 65–73. https://doi.org/10.1145/3109859.3109902

Suárez-Álvarez, J., Pedrosa, I., García-Cueto, E., & Muñiz, J. (2016). Locus of Control revisited: Development of a new bi-dimensional measure. *Anales de Psicología*, *32*(2), 578. https://doi.org/10.6018/analesps.32.2.200781

Sümer, N., Özkan, T., & Lajunen, T. (2006). Asymmetric relationship between driving and safety skills. *Accident Analysis and Prevention*, *38*(4), 703–711. https://doi.org/10.1016/j.aap.2005.12.016

Suntornsut, P., Wongsuwan, N., Malasit, M., Kitphati, R., Michie, S., Peacock, S. J., & Limmathurotsakul, D. (2016). Barriers and recommended interventions to prevent Melioidosis in Northeast Thailand: A focus group study using the behaviour change wheel. *PLOS Neglected Tropical Diseases*, *10*(7), 1–16.

https://doi.org/10.1371/journal.pntd.0004823

Sütterlin, B., Brunner, T. A., & Siegrist, M. (2013). Impact of social value orientation on energy conservation in different behavioral domains. *Journal of Applied Social Psychology*, *43*(8), 1725–1735. https://doi.org/10.1111/jasp.12128

Svenson, O. (1981). Are we all less risky and more skillful than our fellow drivers? *Acta Psychologica*, *47*(2), 143–148. https://doi.org/10.1016/0001-6918(81)90005-6

Swiss Re Institute. (2018). *World insurance in 2017: solid, but mature life markets weigh on growth*. *Sigma*. Zurich.

Talib, S., Clarke, N. L., & Furnell, S. M. (2010). An analysis of information security awareness within home and work environments. *ARES 2010 - 5th International Conference on Availability, Reliability, and Security*, 196–203. https://doi.org/10.1109/ARES.2010.27

Tarnanas, I. A., & Manos, G. (2004). A clinical protocol for the development of a virtual reality behavioral training in disaster exposure and relief. *Annual Review of Cybertherapy and Telemedicine*, *2*, 71–84. https://doi.org/10.3233/978-1-60750-561-7-44

Taubman-Ben-Ari, O., Mikulincer, M., & Iram, A. (2004). A multi-factorial framework for understanding reckless driving-appraisal indicators and perceived environmental determinants. *Transportation Research Part F: Traffic Psychology and Behaviour*, *7*(6), 333–349. https://doi.org/10.1016/j.trf.2004.10.001

Tenkorang, E. Y. (2018). Effect of knowledge and perceptions of risks on Ebola-preventive behaviours in Ghana. *International Health*, *10*(3), 202–210. https://doi.org/10.1093/inthealth/ihy009

Terpstra, T., & Gutteling, J. M. (2008). Households' perceived responsibilities in flood risk management in the Netherlands. *International Journal of Water Resources Development*, *24*(4), 555–565. https://doi.org/10.1080/07900620801923385

Thaler, R., & Sunstein, C. R. (2008). *Nudge. Improving decisions about health, wealth and happiness.* Yale University Press.

Thompson, N. J., Waterman, M. B., & Sleet, D. A. (2004). Using behavioral science to improve fire escape behaviors in response to a smoke Alarm. *Journal of*

Burn Care and Rehabilitation, *25*(2), 179–188. https://doi.org/10.1097/01.BCR.0000111767.05553.91

Tierney, K. J., Lindell, M. K., & Perry, R. W. (2001). *Facing the unexpected: Disaster preparedness and response in the United States.* Washington D.C.: Joseph Henry Press.

Trafimow, D., & Finlay, K. A. (1996). The importance of subjective norms for a minority of people: between-subjects and within-subjects analyses. *Society for Personality and Social Psychology*, *22*(8), 820–828.

Tucker, L. R., & Lewis, C. (1973). A reliability coefficient for maximum likelihood factor analysis. *Psychometrika*, *38*(1), 1–10. https://doi.org/10.1007/BF02291170

Tyler, T. R., & Cook, F. L. (1984). The mass media and judgments of risk: Distinguishing impact on personal and societal level judgments. *Journal of Personality and Social Psychology*, *47*(4), 693–708. https://doi.org/10.1037/0022-3514.47.4.693

U.S. Fire Administration. (2016). *Residential building fire trends (2005-2014)*. Emmitsburg, Maryland. Retrieved from https://www.usfa.fema.gov/downloads/pdf/statistics/res_bldg_fire_estimates.pdf

Valkengoed, A. M., & Steg, L. (2019). Meta-analyses of factors motivating climate change adaptation behaviour. *Nature Climate Change*, *9*(2), 158–163. https://doi.org/10.1038/s41558-018-0371-y

Van den Berg, P., Borkus, B., Loef, J., Perkin, S., & Warmoeskerk, M. (2015). Jaarevaluatie campagnes Rijksoverheid 2014, 157.

Van den Handel, C., Nauta, O., van Soomeren, P., & Nelissen, T. (2009). Hoe doen ze het toch? Modus operandi woninginbraak, 102.

Van Eck, R. (2008). *Review of the ecology of games: Connecting youth, games, and learning*. *Educause Quarterly*. https://doi.org/10.1162/dmal.9780262693646.vii

Verbond van Verzekeraars. (2014a). *Risicomonitor woninginbraken 2014*. Den Haag.

Verbond van Verzekeraars. (2014b). *Verzekerd van Cijfers 2014*. Den Haag. Retrieved from http://www.verbondvanverzekeraars.nl/UserFiles/File/cijfers/VvC2010.pdf

Verbond van Verzekeraars. (2015). *Risicomonitor Woningbranden 2014*. Retrieved from https://www.verzekeraars.nl/verzekeringsbranche/dossiers/veiligheid/Documents/Risicomonitor Woningbranden/brandmonitor2014.pdf

Vincente, R., Ferreira, T.M., Maio, R., & Koch, H. (2014). Awareness, perception and communication of earthquake risk in Portugal. *Procedia Economics and Finance*, *18*, 271–278.

Vollaard, B. (2014). *Beinvloeding van inbraakpreventiegedrag. Een handreiking voor beleidsmakers.*

Wallston, B. S., Wallston, K. A., Kaplan, G. D., & Maides, S. A. (1976). Development and validation of the health locus of control (HLC) scale. *Journal of Consulting and Clinical Psychology*, *44*(4), 580–585. https://doi.org/10.1037/0022-006X.44.4.580

Weber, S. (2010). Bacon: An effective way to detect outliers in multivariate data using Stata (and Mata). *Stata Journal*, *10*(3), 331–338. https://doi.org/The Stata Journal

Weigman, O., Taal, E., J., van den B., & Gutteling, J. M. (1992). Protection Motivation Theory variables as predictors of behavioural intentions in three domains of risk management. In S. M. J.A.M. Winnubst (Ed.), *Lifestyles, stress and health: New developments in health psychology* (pp. 55–70). Leiden: DSWO Press.

Weinstein, N. D. (1980). Unrealistic optimism about future life events, *39*(5), 806–820.

Weinstein, N. D. (1989). Effects of personal experience on self-protective behavior. *Psychological Bulletin*, *105*(1), 31–50. https://doi.org/10.1037/0033-2909.105.1.31

Weinstein, N. D. (1993). Testing four competing theories of health-protective behavior. *Health Psychology*, *12*(4), 324–333. https://doi.org/10.1037/0278-6133.12.4.324

Weinstein, N. D., Rothman, A. J., & Nicolich, M. (1998). Use of correlational data to examine the effects of risk perceptions on precautionary behavior. *Psychology and Health*, *13*(3), 479–501. https://doi.org/10.1080/08870449808407305

Wiegman, O, Taal, E., van den Bogaard J., & Gutteling, J. M. (1992). Protection Motivation Theory variables as predictors of behavioural intentions in three domains of risk management. In S. M. J.A.M. Winnubst (Ed.), *Lifestyles, stress and health: New developments in health psychology* (pp. 55–70). Leiden: DSWO Press.

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: a presence questionnaire. *Presence: Teleoper. Virtual Environ.*, *7*(3), 225–240. https://doi.org/10.1162/105474698565686

Wong, W. L., Shen, C., Nocera, L., Carriazo, E., Tang, F., Bugga, S., … Ritterfeld, U. (2007). Serious video game effectiveness. *Proceedings of the International Conference on Advances in Computer Entertainment Technology*, 49–55. https://doi.org/10.1145/1255047.1255057

Wuebker, L. J. (1986). Safety locus of conrol as a predictor of industrial accidents and injuries. *Journal of Business and Psychology*, *1*(1), 19–30.

Yang, S., Gao, H., Liu, L., He, L., & Fan, C. (2010). Analysis on public earthquake risk perception: Based on questionnaire. *3rd International Conference on Cartography and GIS*, (129), 1–10.

Yarbrough, S. S., & Braden, C. J. (2001). Utility of Health Belief Model as a guide for explaining or predicting breast cancer screening behaviors. *Journal of Advanced Nursing*, *33*(5), 677–688.

Zaalberg, R., & Midden, C. (2010). Enhancing human responses to climate change risks. In H. Ploug, T., Hasle, P., Oinas-Kukkonen (Ed.), *PERSUASIVE 2010* (pp. 205–210). Denmark: Springer. https://doi.org/Doi: 10.1007/978-3-642-13226-1_21.

Zaalberg, R., & Midden, C. J. H. (2013). Living behind dikes: Mimicking flooding experiences. *Risk Analysis*, *33*(5), 866–876. https://doi.org/10.1111/j.1539-6924.2012.01868.x

Zaalberg, R., Midden, C., Meijnders, A., & McCalley, T. (2009). Prevention, adaptation, and threat denial: Flooding experiences in the Netherlands. *Risk Analysis*, *29*(12), 1759–1778. https://doi.org/10.1111/j.1539-6924.2009.01316.x

Appendix A

Table A1: Item difficulties (δ), mean squares (MNSQ) and standardized mean squares (ZSTD) for infit and outfit.

	Item	δ *(SE)*	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
44	Track & Trace system	2.95 (.08)	0.97	-0.4	0.86	-1.5
12	Practice fire escape plan	2.91 (.11)	0.95	-0.6	0.82	-1.6
4	Heat detector	2.87 (.07)	0.97	-0.4	0.89	-1.3
28	Alarm system	1.97 (.05)	0.98	-0.6	0.87	-2.6
45	Steering lock	1.97 (.05)	1.04	1.1	1.17	3.2
10	Fire escape ladder	1.94 (.06)	1.02	0.6	1.06	1.1
5	Carbon monoxide detector	1.82 (.05)	1.00	0.1	1.02	0.3
22	Lightning conductor	1.70 (.05)	1.04	1.4	1.17	3.6
9	Access fire escape ladder	1.64 (.09)	0.96	-0.7	0.88	-1.5
46	Skid course	1.56 (.05)	1.03	1.1	1.05	1.2
18	Check cupboard	1.49 (.05)	0.96	-1.6	0.95	-1.3
3	Check smoke alarm	1.38 (.05)	0.97	-1.3	0.93	-2.0
1	Police Certificate Safe Living	1.33 (.05)	0.96	-1.4	0.95	-1.4
38	Drip tray for washing machine	1.26 (.04)	1.05	2.3	1.12	3.6
23	Unplug appliances when lightning strikes	1.21 (.04)	1.01	0.3	1.04	1.2
39	Dip tray connected to drain	0.88 (.08)	1.03	1.0	1.05	1.1
11	Fire escape plan	0.55 (.04)	0.96	-2.8	0.97	-1.3
8	Fire extinguisher	0.53 (.04)	1.0	0.1	1.0	0.0
42	Parking sensors	0.50 (.04)	1.0	0.4	1.0	0.2
6	Fire blanket	0.48 (.04)	1.03	2.3	1.04	2.2
25	Certified locks on windows	0.36 (.04)	0.92	-6.3	0.89	-6.1
30	Alarm system on when sleeping	-0.02 (.10)	1.02	0.7	1.03	.7
24	Certified locks on doors	-0.08 (.04)	0.94	-5.5	0.93	-4.8
7	Clean kitchen hood	-0.22 (.04)	0.99	-1.2	0.99	-0.8
43	Winter tires	-0.24 (.04)	1.04	3.4	1.05	3.4
21	Surge protector	-0.30 (.04)	0.98	-2.1	0.97	-2.3
34	Close windows when sleeping	-0.32 (.03)	1.05	4.9	1.06	4.4
27	Outdoor lightning on	-0.34 (.04)	1.04	4.0	1.07	4.7
40	Gutter pipe leaf wire balloon	-0.48 (.04)	0.99	-0.7	0.99	-0.3
29	Alarm system on when leaving the house	-0.67 (.11)	0.99	-0.2	0.99	-0.2
16	Sweep chimney	-0.80 (.09)	1.07	1.8	1.09	1.8
41	Clean the roof gutter	-0.95 (.04)	0.96	-2.5	0.94	-2.5
19	*Stuff stored in cupboard*	-0.96 (.04)	1.08	4.9	1.08	3.7
47	Store luggage in trunk when parking car	-1.01 (.04)	1.02	1.4	1.06	2.6

Table A1: Coninued.

	Item	δ *(SE)*	Infit MNSQ	Infit ZSTD	Outfit MNSQ	Outfit ZSTD
17	Check central heating	-1.09 (.04)	1.05	2.6	1.06	2.6
13	Spark screen in front of fireplace	-1.24 (.15)	1.0	0.0	0..99	0.0
26	Outdoor lightning	-1.32 (.04)	0.95	-2.4	0.93	-2.7
2	Smoke alarm	-1.58 (.04)	0.99	-0.3	-0.99	-0.1
35	Inform neighbours when going on holiday	-1.59 (.04)	0.96	-1.6	0.95	-1.7
37	Water lock on washing machine	-1.79 (.05)	0.98	-0.7	0.94	-1.3
20	Clean dust filter of washing machine	-1.81 (.05)	1.07	2.1	1.16	3.2
36	Water lock on dish washer	-1.86 (.06)	0.96	-0.9	0.93	-1.4
33	Close windows when leaving the home	-1.88 (.05)	0.95	-1.7	0.89	-2.9
32	Lock front door when going to sleep	-2.03 (.05)	0.98	-0.6	0.99	-0.1
48	*Leave valuables in the car*	-2.46 (.06)	1.03	0.8	1.13	2.1
31	Lock front door when leaving the home	-2.57 (.06)	0.95	-1.1	0.87	-2.3
15	Burning clean and dry wood when using fireplace	-3.72 (.24)	0.98	0.0	0.78	0.7

Note. Items in italics were negatively formulated items and were recoded.

Appendix B

Table B1: Differential Item Functioning for New Homes versus Old Homes.

	Item	DIF
1	Police Certificate Safe Living	2.11*
2	Smoke alarm	1.36*
24	Certified locks on doors	1.98*
25	Certified locks on windows	2.06*
39	Drip tray for washing machine connected to drain	-1.05*

Note. A positive number indicates this item is easier for new homes.
*= $p < .001$.

Table B2: Differential Item Functioning for Owned versus Rental homes.

	Item	DIF
18	Check cupboard	-1.10*
22	Lightning conductor	1.50*
30	Alarm system on when sleeping	1.09*

Note. A positive number indicates this item is easier for owned homes.
*= $p < .001$.

Table B3: Differential Item Functioning for Terrace Homes versus Detached Homes.

	Item	DIF
28	Alarm system	-1.46*
38	Drip tray for washing machine	1.20*
41	Clean the roof gutter	-1.24*

Note. A positive number indicates this item is easier for terrace homes.
*= $p < .001$.

Table B4: Differential Item Functioning for Apartments versus Detached Homes.

	Item	DIF
1	Police Certificate Safe Living	1.29*
10	Fire escape ladder	1.40*
22	Lightning conductor	3.22*
28	Alarm system	-1.61*
29	Alarm system on when leaving the house	-1.28*
30	Alarm system on when sleeping	-1.70*
32	Lock front door when going to sleep	-1.16*
35	Inform neighbours when going on holiday	-1.16*
41	Clean the roof gutter	-1.36*

Note. A positive number indicates this item is easier for apartments.
*= $p < .001$.

Table B5: Differential Item Functioning for Apartments versus Semi-detached Homes.

	Item	DIF
1	Police Certificate Safe Living	1.28*
10	Fire escape ladder	1.45*
22	Lightning conductor	3.37*
27	Outdoor lightning on	1.15*
30	Alarm system on when sleeping	-1.21*
32	Lock front door when going to sleep	-1.29*
35	Inform neighbours when going on holiday	-1.39*

Note. A positive number indicates this item is easier for apartments.
*= $p < .001$.

Table B6: Differential Item Functioning for Apartments versus Terrace Homes.

	Item	DIF
10	Fire escape ladder	1.41*
22	Lightning conductor	2.89*
27	Outdoor lightning on	1.19*
30	Alarm system on when sleeping	-1.39*
32	Lock front door when going to sleep	-1.11*
35	Inform neighbours when going on holiday	-1.03*

Note. A positive number indicates this item is easier for new homes.
*= $p < .001$.

A

Appendix C

1. **Variable: alarm system**
   Do you have an alarm system in your home?
   - Yes (= 1)
   - No (= 0)

2. **Variable: anti-burglar strip**
   Is there an anti-burglar strip or a front door safety device installed on your front door?
   - Yes, an anti-burglary strip (= 1)
   - Yes, a front door safety device (= 1)
   - Yes, an anti-burglar strip and a front door safety device (= 1)
   - No (= 0)
   - I do not know (= missing)

3. **Variable: lock doors when leaving**
   Do you lock the front door when you leave the house?
   - Yes, (almost) always (= 1)
   - Sometimes (= 0)
   - No, (almost) never (= 0)

4. **Variable: smoke alarm**
   Is/ are there (a) working smoke alarm(s) installed in your home?
   - Yes, on every floor (= 1)
   - Yes, but not on every floor (= 0)
   - No (= 0)

5. **Variable: check smoke alarm**
   Do you sometimes check the operation of the smoke alarm(s)?
   This is done by pressing the test button and holding it for a moment.
   - Yes, weekly (= 1)
   - Yes, monthly (= 1)
   - Yes, every half a year (= 0)
   - Yes, yearly (= 0)
   - Yes, less than once a year (= 0)
   - No (= 0)

6. **Variable: clean kitchen hood**
   Do you sometimes clean the kitchen hood?
   - Yes, weekly (= 1)
   - Yes, monthly (= 1)
   - Yes, every half a year (= 0)
   - Yes, yearly (= 0)
   - Yes, less than once a year (= 0)
   - No (= 0)
   - Not applicable (no kitchen hood) (= missing)

7. **Variable: fire blanket**
   Is there a fire blanket in your kitchen?
   - Yes (= 1)
   - No (= 0)

8. **Variable: clean roof top gutter**
   Do you let gutters be cleaned or do you do this yourselves sometimes?
   - Yes, at least every half a year (= 1)
   - Yes, every year (= 1)
   - Yes, every 2 to 3 years (= 0)
   - Yes, every 4 to 5 years (= 0)
   - Yes, less than once a year (= 0)
   - No (= 0)
   - Not applicable (no private gutter) (= missing)

9. **Variable: dripping tray for washing machine**
   Do you have a tripping tray under your washing machine?
   - Yes, a stand-alone dripping tray (= 1)
   - Yes, an integrated dripping-tray (= 1)
   - No (= 0)
   - I do not know (= missing)
   - Not applicable (no washing machine) (= missing)

Appendix D

Table D1: Unstandardized coefficients estimates (B), standard errors (S.E.) and significance levels (p) for the socio-economic variables of model 1 (with within- and between-person variables).

		Model 1	
		B	S.E.
	Male	.183	.134
	Age	-.088***	.025
Education (base = primary education)	Preparatory vocational education	.656	.766
	Secondary vocational education or secondary education	.610	.759
	BSc. or MSc. level education	.743	.769
Household (base = living together with child(ren) living at home)	Living together, no child(ren) living at home	.134	.161
	Single with child(ren) living at home	-.085	.340
	Single, no child(ren) living at home	-.148	.173
	Home owner	.102	.148
House type (base = detached house)	Bungalow	-.609	.503
	Semi-detached house	-.120	.191
	Terraced house	-.376	.176
	Apartment/ studio	-.337	.203
	Room	-1.686	1.240
	High-rise building	-.186	.515
	Other	-.492	.320
Year of construction (base = <2012)	2013 or later	.077	.165

Note. * = p<.05; ** = p<.01; *** = p<.001.

A

Appendix E

First, we repeated the analyses on only those cases where participants mention that they are aware of the particular behavior (1,491 cases). When we repeat the analysis where we distinguished between- and within-person effects (model 1, Table 4), results are consistent, except that the within-person effect of vulnerability becomes non-significant (b = .127; p =. .121). Second, we repeat the analyses for only the persons that stated to have the primary responsibility for prevention behaviors in the home. If we repeat the analysis where we distinguished between-person and within-person effects (model 1, Table 4), similar results are found, except that the between-effect of costs becomes statistically significant (b = -.247; p = .011) and the within-effect of vulnerability becomes non-significant (b = .145; p = .095).

Another way of testing the robustness of our findings is to test whether the results vary for different types of behaviors. We distinguished curtailment (e.g. cleaning the roof top gutter) and investment behaviors (e.g. smoke alarm), and prevention (e.g. anti-burglar strips) and mitigation behaviors (e.g. fire blanket) (Zaalberg et al., 2009). We tested the robustness of our results (of model 1, Table 4) by analyzing the effects for these different categories of prevention behaviors, by (separately) including these as interaction variables in our model. The results showed that the main effects are stable independent of the interaction variables, and that the interaction variables themselves do not have significant effects on prevention behavior. There was one exception: the within-person effect of costs for mitigation behaviors was positive while the within-person effect of costs for prevention behaviors was negative.

Appendix F

Text for INFO group (translated from Dutch).

Master the fire!

With prevention, you simply reduce the chance of damage and limit your damage. Do you have a smoke detector or fire blanket in your house? Then you are well on your way. Below we explain what to do when a pan catches fire when you are cooking.

What to do when a pan catches fire?

A grease fire is caused by overheated fat or fat or oil that runs over the edge of the pan and comes into contact with the stove's fire. A grease fire can, if you do nothing, lead to a house fire within minutes.

A good way to extinguish a grease fire is with a fire blanket. So hang up a fire blanket in the kitchen. Follow the following steps in case of a grease fire:

- Use the fire blanket to extinguish the grease fire by placing the fire blanket over the flame
- Switch off the cooking stove and the exhaust hood.
- Leave the fire blanket on the pan for at least 20 minutes.
- The flame can quickly skip the exhaust hood and the kitchen cabinets. Therefore, clean your exhaust hood monthly.
- Do not walk with the burning pan.
- Never extinguish a grease fire with water, resulting in a burst of flame.
- Caution: Do not use a fire blanket for a deep fryer, as the fire blanket can then be soaked with oil and may catch fire itself.

What if the flame is too big to extinguish?

If the flame is bigger than a football, the flame is too big to extinguish with a fire blanket and you have to flee. Working smoke detectors and a good flight plan ensure you can leave your home quickly and safely. In case of fire, the stairs, the hallway and the overflow are sometimes difficult to find or difficult to reach. This is not only due to the fire, but especially by the smoke that is released by the fire.

Therefore, create with your housemates a flight plan. These are agreements on what to do in case of fire. This allows you to leave the house quickly and safely in case of emergency. In case of fire, you have in average 3 minutes to leave the house safely.

Appendix G

Text in IVE (translated from Dutch).

Scenario 1: fire blanket

Perfect! You have extinguished the fire on time with a fire blanket which prevented a lot of damage.

- For a grease fire, use a fire blanket to extinguish the flame.
- Switch off the cooking stove and the exhaust hood.
- Leave the fire blanket on the pan for at least 20 minutes.
- The flame can quickly skip the exhaust hood and the kitchen cabinets. Therefore, clean your exhaust hood monthly.
- Do not walk with the burning pan.
- Caution: Do not use a fire blanket for a deep fryer, as the fire blanket can then be soaked with oil and may catch fire itself.

Scenario 2: Bucket of water, escape with child, on time

Fine! You and your family left the house on time. However, the fire caused a lot of damage to your house and belongings.

Make a flight plan together with your housemates. These are agreements about what to do in the case of a fire, so that you can leave your house quickly and safely. In case of a fire, you have an average of 3 minutes to leave your house safely.

By throwing water on a grease fire, a burst of flame is created. The water evaporates and takes oil droplets which then catch fire. A fire blanket is a good way to extinguish a grease fire. Try to extinguish the grease fire within 30 seconds.

Give it a try again!

Scenario 3: Bucket of water, escape without child, on time

Fine! You have left the house on time. However, there is still a family member left behind.

You can prevent this by making a flight plan. These are agreements you make with your housemates about what to do in the event of a fire, so that you can leave your home quickly and safely. In case of a fire, you have an average of 3 minutes to leave your home safely.

By throwing water on a grease fire, a burst of flame is created. The water evaporates and takes oil droplets which then catch fire. A fire blanket is a good way to extinguish a grease fire. Try to extinguish the grease fire within 30 seconds.

Give it a try again!

Scenario 4: Bucket of water, escape, too late

Unfortunately! You did not leave the house on time.

In case of a fire, you have an average of 3 minutes to safely leave your home. Make a flight plan together with your housemates. These are agreements about what to do in case of a fire, so that you can leave your home quickly and safely.

By throwing water on a grease fire, a burst of flame is created. The water evaporates and takes oil droplets which then catch fire. A fire blanket is a good way to extinguish a grease fire. Try to extinguish the grease fire within 30 seconds.

Give it a try again!

Scenario 5: escape with child on time

Very well! You and your family left the house on time. However, the fire caused a lot of damage to your house and belongings.

Make a flight plan together with your housemates. These are agreements about what to do in the event of a fire, so that you can leave your home quickly and safely. In the event of a fire, you have an average of 3 minutes to safely leave your home.

A fire blanket is a good way to extinguish a flame in the pan. Try to extinguish the grease fire within 30 seconds.

Give it a try again!

Scenario 6: escape without child, on time

Fine! You have left the house on time. However, there is still a family member left behind.

You can prevent this by making a flight plan. These are agreements you make with your housemates about what to do in case of a fire, so that you can leave your home quickly and safely. In case of a fire, you have an average of 3 minutes to safely leave your home.

A fire blanket is a good way to extinguish a grease fire. Try to extinguish the grease fire

within 30 seconds.

Give it a try again!

Scenario 7: escape too late

Unfortunately! You did not leave the house on time.

In case of a fire, you have an average of 3 minutes to safely leave your home. Make a flight plan together with your housemates. These are agreements about what to do in case of a fire, so that you can leave your home quickly and safely.

A fire blanket is a good way to extinguish a flame in the pan. Try to extinguish the grease fire within 30 seconds.

Give it a try again!

Appendix H

Knowledge scale (translated from Dutch).

1. **What happens when you use water to extinguish a grease fire? [open answer]**
   Correct answer: a burst of flame arises

2. **What happens when you use a fire blanket to extinguish the grease fire? [open answer]**
   Correct answer: the fire extinguishes

3. **Is a fire blanket suitable to extinguish a deep fryer fire?**
   - Yes
   - No
   - I do not know

   Correct answer: no

   Indicate if it is a good idea, in case of a grease fire, to:
   [yes; no; I do not know]

4. Turn off the cooking stove

5. Turn off the exhaust hood

6. Take the burning pan outside

7. **If you have extinguished the flame, check immediately if the flame is out**
   Correct answers: [4] yes; [5] yes; [6] no; [7] no

8. **How often does the exhaust hood have to be cleaned to prevent fire?**
   - Once a week
   - Once a month
   - Once every three months
   - Once a half year
   - Once a year

Correct answer: once a month

9. **On average, how many minutes does someone have to safely leave their home in case of fire? Give an answer between 0-30 minutes [open answer]**
   Correct answer: 3 minutes

Appendix I

Table I1: Actions people took in the IVE fire game, during the first and second game play.

Scenario	Action	First game	Second game
1	Fire blanket	56.1%	43.1%
2	Bucket of water, escape with child, on time	8.1%	13.8%
3	Bucket of water, escape without child, on time	.8%	1.6%
4	Bucket of water, escape, too late	3.3%	5.7%
5	Escape with child, on time	20.3%	28.5%
6	Escape without child, on time	7.3%	.8%
7	Escape, too late	4.1%	4.9%
	Did not play		1.6%

Note. N=123

Appendix J

Table J1: Factor loadings and Cronbach's Alpha (α) when performing CFA with all factors together of the original scales (one time with ISLOC and ESLOC, and one time with SLOC).

Original scale (with ISLOC and ESLOC)	Items	Factor loading (stdYX)	Original scale (with SLOC)	Items	Factor loading (stdYX)
ISLOC	ISLOC1	.534	SLOC	ISLOC1	.498
	ISLOC5	.723		ESLOC2	-.326
	ISLOC7	.687		ESLOC3	.024
	ISLOC9	.516		ESLOC4	-.528
	ISLOC10	.784		ISLOC5	.689
	ISLOC11	.151		ESLOC6	-.336
	α	*.583*		ISLOC7	.642
				ESLOC8	-.779
ESLOC	ESLOC2	.354		ISLOC9	.493
	ESLOC3	-.007		ISLOC10	.742
	ESLOC4	.570		ISLOC11	.142
	ESLOC6	.367		ESLOC12	-.778
	ESLOC8	.831			
	ESLOC12	.828			
	α	*.587*		α	*.658*
Vulnerability	VUL10	.618	Vulnerability	VUL10	.620
	VUL11	.653		VUL11	.651
	VUL12	.971		VUL12	.972
	α	*.745*		α	*.745*
Severity	SEV13	.827	Severity	SEV13	.827
	SEV14	.826		SEV14	.825
	SEV15	.885		SEV15	.886
	α	*.752*		α	*.752*
Self-efficacy	SELF1	.798	Self-efficacy	SELF1	.798
	SELF2	.827		SELF2	.827
	SELF3	.668		SELF3	.668
	SELF4	.778		SELF4	.778
	SELF5	.729		SELF5	.729
	SELF6	.832		SELF6	.832
	SELF7	.760		SELF7	.760
	SELF8	.691		SELF8	.691
	SELF9	.682		SELF9	.682
	SELF10	.694		SELF10	.694
	α	*.863*		α	*.863*

Table J2: Model fit scores of original scales, when performing CFA on individual scales.

Goodness of fit	Target values	ESLOC	ISLOC	SLOC	Vulnerability*	Severity*	Self-efficacy
χ^2		19.025	58.007	237.912	.000	.000	672.567
df		9	9	54	0	0	35
p	>.05	.025	<.001	<.001	<.001	<.001	<.001
RMSEA	<.06	.068	.150	.119	.000	.000	.274
90% *CI*	<.10	.023-.111	.115-.188	.103-.134	.00-.00	.00-.00	.256-.293
CFI	>.95	.982	.918	.894	1.00	1.00	.846
TLI	>.95	.969	.863	.870	1.00	1.00	.801

*Note. model is "just identified" (*df*= 0).

Table J3: Model fit scores of modified scales, when performing CFA on individual scales.

Goodness of fit	Target values	ESLOC	ISLOC	SLOC	Vulnerability*	Severity*	Self-efficacy
χ^2		.000	.000	24.813	.000	.000	192.345
df		0	0	5	0	0	5
p	>.05	<.001	<.001	<.001	<.001	<.001	<.001
RMSEA	<.06	.000	.000	.128	.000	.000	.393
90% *CI*	<.10	.00-.00	.00-.00	.081--.180	.00-.00	.00-.00	.347-.442
CFI	>.95	1.000	1.000	.984	1.00	1.00	.935
TLI	>.95	1.000	1.000	.969	1.00	1.00	.869

*Note. model is "just identified" (*df*= 0).

Table J4: Model fit scores of original scales, when performing CFA on all scales together.

Goodness of fit	Target values	With SLOC	With ISLOC and ESLOC
χ^2		1087.979	1080.666
df		344	340
p	>.05	<.001	<.001
RMSEA	<.06	.095	.095
90% *CI*	<.10	.088-.101	.089-.101
CFI	>.95	.874	.875
TLI	>.95	.862	.861

A

Table J5: Model fit scores of modified scales, when performing CFA on all scales together.

Goodness of fit	Target values	With SLOC	With ISLOC and ESLOC
χ^2		478.448	521.170
df		98	109
p	>.05	<.001	<.001
RMSEA	<.06	.127	.125
90% *CI*	<.10	.115-.138	.114 -.136
CFI	>.95	.914	.906
TLI	>.95	.895	.882

Table J6: R-squared estimates (R^2) and Average Variance Extracted (AVE) when performing CFA with all factors together and with the individual scales separately (with SLOC instead of ISLOC and ESLOC).

		CFA with all factors		CFA with individual scales	
		Original scale R^2	Modified scale R^2	Original scale R^2	Modified scale R^2
SLOC	ISLOC1	.285		.191	
	ESLOC2	.126		.112	
	ESLOC3	0		0	
	ESLOC4	.304		.262	
	ISLOC5	.523	.427	.408	.351
	ESLOC6	.135		.125	
	ISLOC7	.472	.437	.417	.448
	ESLOC8	.69	.604	.576	.549
	ISLOC9	.266		.250	
	ISLOC10	.615	.538	.611	.593
	ISLOC11	.023		.030	
	ESLOC12	.686	.634	.654	.673
	AVE	*.304*	*.528*	*.303*	*.523*
Vulnerability	VUL10	.385	.325	.369	.369
	VUL11	.423	.435	.583	.583
	VUL12	.945	*undefined*	.754	.754
	AVE	*.584*		*.569*	*.569*
Severity	SEV13	.683	.687	.799	.799
	SEV14	.681	.723	.954	.954
	SEV15	.786	.705	.293	.293
	AVE	*.717*	*.705*	*.682*	*.682*
Self-efficacy	SELF1	.637	.696	.627	.695
	SELF2	.683	.718	.666	.702
	SELF3	.446		.469	
	SELF4	.605	.612	.581	.583
	SELF5	.531	.596	.532	.609
	SELF6	.692	.789	.704	.820
	SELF7	.578		.576	
	SELF8	.477		.481	
	SELF9	.466		.485	
	SELF10	.482		.488	
	AVE	*.560*	*.682*	*.561*	*.682*

A

Table J7: R-squared estimates (R^2) and Average Variance Extracted (AVE) when performing CFA with all factors together and with the individual scales separately (with ISLOC and ESLOC instead of SLOC).

		CFA with all factors		CFA with individual scales	
		Original scale R^2	Modified scale R^2	Original scale R^2	Modified scale R^2
SLOC	ISLOC1	.285		.263	
	ISLOC5	.523	.500	.444	.238
	ISLOC7	.472		.324	
	ISLOC9	.266	.325	.365	.329
	ISLOC10	.615	.734	.789	*undefined*
	ISLOC11	.023		.034	
	AVE	*.364*	*.413*	*.369*	
ESLOC	ESLOC2	.126		.180	
	ESLOC3	0		.027	
	ESLOC4	.423	.339	.384	.381
	ESLOC6	.135		.196	
	ESLOC8	.690	.685	.667	.677
	ESLOC12	.686	.624	.588	.595
	AVE	*.343*	*.549*	*.340*	*.551*

A

Appendix K

Table K1: Result of smoke alarm survey (n = 525). Both unweighted and weighted percentages are presented. Percentages are weighted to the Dutch population based on: gender, age, education and region.

		Unweighted %	Weighted %
Do you have one or more smoke alarms installed in your home?	Yes	76.6%	76.0%
	No, but have some alarm(s) in packaging	6.1%	6.6%
	No	16.6%	16.5%
	I don't know	.8	.9%
Number of smoke alarms	1	24.9%	26.2%
	2	36.1%	36.9%
	3	24.1%	23.5%
	>3	14.9%	13.5%
In case of 1 smoke alarm: Does your smoke alarm function?	Yes	89.0%	87.1%
	No	5.0%	7.8%
	I don't know	6.0%	5.2%
In case of multiple smoke alarms: Do your smoke alarms function?	Yes, they all function	92.4%	92.2%
	No, they do not function all	6.0%	5.8%
	No, none of them functions	0%	0%
	I do not know	1.7%	1.9%
When did you test your smoke alarms for the last time?	Last week	8.2 %	9.7 %
	Last month	33.3 %	31.3 %
	Last 6 months	29.4 %	28.6 %
	Last year	10.7 %	9.9 %
	More than a year ago	8.0 %	8.6 %
	I never tested them	10.5 %	11.8 %
When did you changed the batteries for the last time?	Last week	4.0 %	4.57 %
	Last month	16.9 %	18.7 %
	Last six months	32.8 %	30.7 %
	Last year	13.2 %	11.7 %
	Longer than a year ago	13.9 %	14.6 %
	Not applicable	19.2 %	19.7 %
Who installed your smoke alarm(s)?	me	39.8 %	38.9 %
	my partner	19.4 %	20.4 %

Table K1: Continued.

		Unweighted %	Weighted %
	father/ mother/ child/ roommate	7 %	9.7 %
	home owner	3.7 %	4.1 %
	housing corporation	18.7 %	18.8 %
	past residents	2.7 %	2.9 %
	during construction	11.2 %	10.8 %
	other	6.5 %	6.3 %
I am planning to buy a smoke alarms in the next 4 weeks.	Low intention (1-3)	69.2 %	67.2 %
	Medium (4)	17.6 %	17.7 %
	High intention (5-7)	12.3 %	15.1 %
How likely is it that you will buy a smoke alarm in the next 4 weeks?	Not likely (1-3)	74.7 %	74.9 %
	Medium likely (4)	9.9 %	9.7%
	(Very) likely (5-7)	15.4 %	15.5 %
I am planning to install my smoke alarm in the next 4 weeks.	Low intention (1-3)	28.1 %	25.9 %
	Medium intention (4)	12.5 %	8.4 %
	High intention (5-7)	59.4 %	65.7 %
How likely is it that you will install your smoke alarm in the next 4 weeks?	Not likely (1-3)	28.1 %	25.9 %
	Medium likely (4)	3.1 %	1.8 %
	(Very) likely (5-7)	68.8 %	72.3 %
I am planning to make sure that my smoke alarms function in the next 4 weeks.	Low intention (1-3)	34.8 %	32.3 %
	Medium intention (4)	13.0 %	12.0 %
	High intention (5-7)	52.2 %	55.8 %
How likely is it that you will make sure that your smoke alarms function in the next 4 weeks?	Not likely (1-3)	47.8 %	46.3 %
	Medium likely (4)	13.0 %	10.3 %
	(Very) likely (5-7)	52.2 %	52.7 %

A

Appendix L

Table L1: Results of the socio-economic variables for the (logistic) regression analyses with the prevention behavior determinants and the socio-economic variables as predictors and intention as the target variable. Unstandardized coefficients estimates (b), standard errors (S.E.) and significance levels (p) for all variables, and model fit statistics (χ^2, *p*, ρ).

	Model 1		Model 2		Model 3	
	b	S.E.	b	S.E.	b	S.E.
Responsible for fire alarm						
me	.520*	2.35	.313	1.42	.725	1.78
my partner/ roommate/ family member	.394*	2.01	.315	1.58	.416	1.16
home owner	.202	.71	-.063	-.23	.554	1.04
housing cooperation	.194	.65	.101	.101	.577	1.05
(in) direct fire experience	-.270	-1.68	.060	.35	-.808**	-2.80
male	.160	.006	-.324	-1.90	.983**	3.21
age	.006	1.06	.007	1.28	.009	.86
education	-.030	-.59	-.019	-.36	-.044	-.48
living together with partner	.070	.39	-.098	-.52	.194	.62
child(ren) at home	-.155	-.86	-.024	-.13	-.260	-.84
pet(s)	.029	.18	.258	1.54	-.485	-1.73
insurance	.342	1.17	.589*	2.02	-.166	-.31
smoking	.336*	1.89	.131	.072	.503	1.56
ownership home	-.082	-.40	-.135	-.64	.372	1.02
house type (base = terraced house)						
detached home	.493	1.92	.872**	3.11	.192	.43
semi-detached	.122	.52	-.012	-.05	.544	1.25
apartment/ studio	.199	1.02	.279	1.36	.424	1.19
different	-.695	-.17	-.182	-.50	.060	.11
F resp. χ^2	(33, 361) 4.59		(33, 230) 2.93		116.64	
p	.000		.000		.000	
N	395		264		395	
Adjusted R^2 resp. Pseudo R^2	.231		.195		.232	

Note. The results of the prevention behavior determinants can be found in Table 5 in Chapter 5.

Appendix M

Dutch text (original) of the messages

76% van de Nederlanders heeft een rookmelder

Heb jij er ook al één?

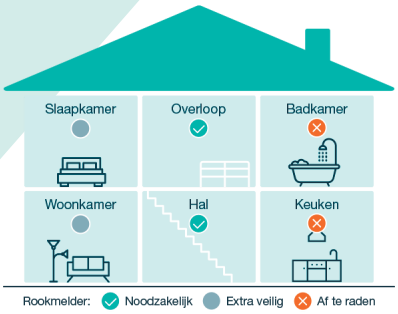
Hang je rookmelder op in 3 simpele stappen

1. Kies de juiste ruimte

De basis: hang minimaal 1 rookmelder op iedere verdieping van je huis. Hang de rookmelders in de hal en op de overloop. Dit is meestal de vluchtroute als er brand uitbreekt.

Voor extra veiligheid: hang rookmelders in alle ruimtes waar je leeft en slaapt, zoals de slaapkamers en de woonkamer.

Plaats geen rookmelders in de keuken, badkamer of garage. Zo voorkom je dat de rookmelder onnodig geactiveerd wordt door bijvoorbeeld douchen of koken.



2. Kies de juiste plek

Hang de rookmelder tegen het plafond, minimaal 50 cm van de muren. Rook gaat altijd omhoog, dus dit is de plek waar de rookmelder de rook het snelst detecteert.

3. Je rookmelder ophangen, zo gepiept!

Een rookmelder bevestig je makkelijk met de bijgeleverde schroeven en montageplaat. Geen zin om te boren? Met magneetplakkers bevestig je de rookmelder snel en simpel zonder te boren. Je plakt 1 magneet tegen het plafond en 1 op de rookmelder. Je koopt magneetplakkers voor rookmelders in een bouwmarkt of online.

Stel het niet uit en bestel vandaag nog een rookmelder. Met deze 3 simpele stappen hangt hij binnen een paar minuten aan jouw plafond!

Interpolis. Glashelder

Figure M1: Message A: addresses knowhow, descriptive norm, and annoyance.

A

Rookmelders redden levens!

Een fijn en veilig idee

Drie redenen waarom een rookmelder belangrijk is in ieder huis

1. Brand kan jou ook overkomen!

De brandweer krijgt jaarlijks duizenden meldingen van brand in woningen. Dat zijn zo'n 13 woningbranden per dag. De meeste branden in huis ontstaan door stoken in een open haard of houtkachel, koken of brand in elektrische apparaten.

2. Rook is dodelijk

Een woningbrand is heel gevaarlijk. Niet alleen vanwege de extreme hitte, maar vooral door de giftige rook die erbij vrijkomt. Deze rook werkt verstikkend. Zelfs het kort inademen van rook kan al dodelijk zijn. Rook verspreidt zich vaak snel verder, bijvoorbeeld naar de gang en overloop. Binnen 3 minuten kan een woningbrand zelfs zo groot worden dat de hoeveelheid rook in de kamer(s) levensbedreigend wordt.

3. Een rookmelder waarschuwt snel, zowel 's nachts als overdag

Een rookmelder waarschuwt meteen in geval van brand, zodat jij en eventuele gezinsleden zo snel mogelijk het huis veilig kunnen verlaten. Als een brand nog klein is kun je met een geschikt blusmiddel soms nog verdere schade voorkomen.

Stel het niet uit en bestel vandaag nog een rookmelder! Zo zorg je voor je eigen veiligheid in geval van brand.

Interpolis. Glashelder

Figure M2: Message B: addresses vulnerability, severity, and benefits.

A

3 handige weetjes over Interpolis verzekeringen

Zo geregeld!

Lees hier wat je mogelijk nog niet wist

1. Welke Inboedelverzekering past het beste bij jou?

Met de Inboedelverzekering verzeker je de losse spullen in het huis. Bijvoorbeeld je meubels, smartphone en kleding. Je kiest vanaf nu tussen een Inboedelverzekering Uitgebreid of een Inboedelverzekering All-Risk. Kies je voor een voordeligere premie? Of wil je ook verzekerd zijn bij schade als je zelf iets omstoot of laat vallen?

2. Bekijk en sluit je verzekering af met smartphone

Heb je de Rabo Bankieren App? Dan kun je verzekeringen afsluiten, wijzigen en inzien via de app. Waar en wanneer het jou uitkomt. Dat is het gemak van bankzaken en verzekeringen onder één dak. Wel zo handig als je bijvoorbeeld op Schiphol staat en nog een Reisverzekering moet afsluiten.

3. Interpolis Voertuighulp

Met Voertuighulp is iedereen die in je auto rijdt verzekerd van hulp bij pech. Ook bij een lekke band, lege accu of verkeerd getankte brandstof. Je hebt de keuze uit Voertuighulp Nederland en/of buitenland. Met Voertuighulp Nederland helpen wij je standaard ook in je woonplaats. Wel zo handig omdat 40% van de pechgevallen plaatsvindt in de eigen woonplaats.

Kijk welke verzekeringen bij jou en je situatie passen op www.interpolis.nl

Interpolis. Glashelder

A

Figure M3: Message C: the control message.

Appendix N

Table N1: Distribution of socio-demographic variables per condition (%).

		Condition			
		A	B	C	Total
male (n=310)		71%	70.9%	70.1%	70.1%
age (n=293)		56.3	61.2	58.5	58.6
family composition (n=192)	living alone	26.7%	29.7%	25%	27.1%
	living together with roommates	1.7%	0	0	.5%
	living alone with children	5%	4.7%	0	3.1%
	living together with partner	21.7%	20.3%	25%	22.4%
	living together with partner and children	45%	43.8%	50%	46.4%
	other	0%	1.6%	0%	.5%
Home ownership (=yes) (n=275)		81.6%	87%	87.5%	85.5%
education (n=275)	primary education	0%	1.1%	0%	.7%
	preparatory vocational education	0%	3.3%	0%	1.8%
	secondary vocational education or secondary education	39.1%	41.3%	34.4%	38.2%
	BSc. level education	47.1%	39.1%	43.8%	43.3%
	MSc. level education	13.8%	15.2%	18.8%	16%

Note. The item 'birth date' was optional and contained missing values. The variables 'family composition, ownership home, education' were provided by the research company and contained missing values. The missing values are not represented in the percentages.

Summary

Prevention measures, such as a smoke detector or certified locks, can be beneficial because they can reduce the likelihood of a risk or reduce its - sometimes very serious - consequences. Motivating people to take these prevention measures is, however, a challenging task. The probability of a fire or burglary is very small, and the benefits of these measures are not always that clear. For instance, residents probably will not notice it if a burglar passes their house because it is well-protected. Moreover, the benefits of prevention might arise in the future or maybe even never at all, while the costs have to be incurred now.

The primary aim of this thesis is to get a better understanding of people's prevention behavior and the psychological determinants driving this behavior, to motivate (more) people to take (more) prevention measures. Prevention behavior in this thesis concerns behaviors to reduce the probability or limit the consequences of fire, burglary, and water damage in the home.

Two prominent theories that explain why people perform, or do not perform, prevention behaviors are the Protection Motivation Theory (PMT; Rogers, 1975) and the Health Belief Model (HBM; Rosenstock, 1966). These theories explain this behavior by various *determinants*. To be motivated to take action in the first place, someone must feel that there is a probability of being exposed to a certain risk (*perceived vulnerability*) that goes with negative consequences that one wants to avoid (*perceived severity*). Given these, someone must perceive the advised prevention behavior as effective in reducing the likelihood or severity of the risk (*response efficacy or perceived benefits*), and the costs and effort involved should not be too high (*response costs or perceived barriers*). Moreover, someone must have the belief that he or she can successfully perform the prevention behavior (*self-efficacy).*

Although these theories offer a useful framework to understand what drives people to take preventive action and offer guidance for behavior change, there are some remaining questions that have remained unanswered in the literature:

I. Are people consistent in their prevention behavior across different risks and different types of behaviors?

II. Why do some people engage in more prevention behaviors than others and why do some prevention behaviors occur more often than others?

III. Does a change in one or more of these prevention behavior determinants necessarily result in a desired behavior change?

IV. Is this the complete set of prevention behavior determinants or are there also other determinants that can elicit prevention behavior?

More insight into these issues leads to an improved understanding of domestic prevention behavior and can consequently result in designing better interventions for behavior change. These issues are addressed in the studies in this thesis.

In **chapter 2** we test whether people are consistent in their behavior across different types of risks and different types of behaviors. We test this by performing Rasch analysis on survey data. One way to understand this procedure is by considering a "pyramid" of prevention behaviors. At the bottom of the pyramid we find the behaviors that are carried out by most people (e.g. locking doors when leaving the house), in the middle section of the pyramid we find the behaviors that are performed by approximately half of the people (e.g. own a fire blanket, clean kitchen hood monthly), and at the top of the pyramid we find the behaviors that are only performed by a few very prevention-minded people (e.g. practice a fire escape plan, own an alarm system). If this "pyramid model" of behaviors holds, then someone who performs the behaviors close to the top, will most likely also perform the behaviors that are in the middle and at the bottom of the pyramid. People's position in this pyramid reflects their general disposition towards prevention behavior. Our results are consistent with such a "pyramid model" of prevention behaviors. This has several implications. First, we can determine someone's position in this prevention pyramid and accordingly give personalized prevention advice. Suggesting an alarm system to someone who does not even lock their doors, would not be a very effective strategy. In all likelihood, easier or cheaper behaviors such as informing neighbors when going on a holiday or installing a smoke alarm will be more attractive for this person. Second, if we have information about someone's behavior in one risk domain, for example we know which burglary prevention behaviors someone takes, we can predict someone's behavior in another risk domain, for example which fire prevention behaviors someone takes.

In **chapter 3** we test if the prevention behavior determinants, as mentioned in the prevention behavior theories, are also relevant drivers specifically for domestic risk prevention behavior (that is, prevention behaviors related to burglary, fire, and water damage). Our results can confirm this. However, the more important question is what does this result actually mean? Does this imply that these determinants explain why some behaviors are more frequently performed than other behaviors? For instance: is locking doors a more frequently performed behavior than switching on exterior lights,

because it is perceived as more effective in reducing the likelihood of a burglary? Or, does this imply that these determinants explain why some persons engage in more prevention behaviors than other persons? For instance: does someone who feels vulnerable to all risks and/ or perceives all prevention behaviors as very effective, engages in more prevention behaviors than someone who does not? Although these two interpretations are not the same, this distinction is not yet addressed in the literature. Our results show that the prevention behavior determinants explain well why some prevention behaviors are more often performed than others. This happens more when 1.) the behavior is more known, 2.) the perceived effectiveness of the behavior is higher, 2.) the perceived costs and/ or effort are lower, and 4) perceived vulnerability and severity of the risk are higher. However, the fact that some people engage in more prevention behaviors than others could not be explained that well by these determinants. So, based on our results it does not seem very fruitful to increase a person's general perception to risks and behaviors in general, for instance increase someone's vulnerability of all risks, since this will not result in someone engaging in more prevention behaviors overall. Although if there would be a way to change people in such a way that they would engage in more prevention behaviors overall, of course that would be considered the "holy grail of persuasion".

In **chapter 4** we study the effects of experiencing a fire in Virtual Reality (VR) on fire prevention behavior. The idea behind this intervention is that people are more inclined to take prevention measures *after* they have experienced a hazardous event, as several studies have shown. A simulation in VR that makes people experience a grease fire might give similar results, but without the negative implications of an actual fire. We test the effects of experiencing a fire in VR versus reading an information sheet about fire prevention on various relevant determinants of prevention behavior. Crucial in our setup, and different from most studies, is that we also study if a change in these determinants indeed results in more prevention behaviors. To measure real behavior, we gave participants the opportunity to purchase a fire blanket and take flyers about fire prevention home. The results show that people who experienced the VR perceive themselves as more vulnerable to fire, perceived a fire as more severe, and felt less confident to handle a fire situation versus people who read the information sheet. The results also show that people who experienced the VR, more often bought a fire blanket, and more often took flyers home compared to people who read the information sheet, although the differences were small. However, the changes in these prevention determinants were not necessarily the cause of a change in behavior. For instance, after people experienced the VR they felt more vulnerable to fire, but this increased feeling of vulnerability was not the cause of the more frequent fire blanket purchases. However, this increased vulnerability did result in more people taking home flyers about fire prevention. Also, both prevention behaviors were driven by different determinants.

This shows that there is a need to consider in much more detail which determinants trigger which prevention behaviors, instead of simply addressing the determinants as mentioned in the prevention behavior theories.

In **chapter 5** we show that when we want to influence behavior, it is a good idea to first make the behavior specific and then investigate why people do not perform that specific behavior. If we look at the purchase and maintenance of smoke alarms, we see that the current campaigns often try to convince people by responding to people's perceived vulnerability ("already xx house fires this year"), the severity of fire ("smoke kills") and the benefits of a smoke alarm ("smoke alarms save lives"). However, one can wonder whether these messages really ensure that more households have functioning smoke alarms. First, "having functioning smoke detectors" consists of several consecutive steps: a smoke detector must be bought, installed, tested regularly and batteries must be changed. However, the reasons why people do not test a smoke alarm may differ from the reasons why people have not installed or bought a smoke alarm yet. Because these reasons can differ per behavior, we choose to focus this research specifically on "the purchase of a smoke alarm". We study which determinants are all important in the decision to purchase a smoke alarm, in which we also go further than the regular prevention theories. Results show that determinants that are less commonly addressed in current communication efforts (such as social norms) are more important than determinants that are often addressed (such as vulnerability and severity). Based on these results we developed two e-mails to promote smoke alarms: one focused on the typically used determinants and one focused on the significant determinants from our study. An experiment shows that the e-mail focused on the significant determinants causes more people to buy a smoke alarm (compared to a control group), while the e-mail that addresses the typically used determinants does not sort this effect. This shows that in the case of smoke alarms, telling people how vulnerable they are to fire, how severe a fire is, and that "smoke alarms save lives" is not an effective way to let people change their behavior. Our study revealed different reasons for not having smoke alarms, such as 'others don't have them either' or 'a lack of specific knowledge about how and where to place them'. These underlying reasons would not have been found without a comprehensive problem analysis that was specifically geared at smoke alarm ownership. Only when addressing the 'true' underlying motives and barriers, we can spark the motivation to change.

When we consider all studies performed in this thesis, we can formulate relevant guiding principles to more carefully understand and, consequently, influence prevention behavior:

Different domestic prevention behaviors stem from one underlying disposition

People behave consistently across different types of risks and behaviors, suggesting the existence of an underlying general disposition towards domestic risk prevention. People with a high general disposition carry out more prevention behaviors and behaviors that are less common. When promoting prevention behavior, it seems more effective to give tailored prevention advice that matches with someone's general disposition towards domestic risk prevention, instead of giving the same prevention advice to everyone. Since our study showed that we can order persons according to their general disposition and order behaviors according to their prevalence, this gives us direct implications for tailoring prevention advice.

Influencing behaviors versus influencing persons

When one wants to study or promote prevention behavior one can consider (at least) two possible routes: 1.) change someone's perception of a specific risk and behavior to stimulate a specific behavior or 2.) change someone's disposition towards risks and prevention in general. Although this thesis provided a more solid foundation for the first route, the second route offers the potential to increase multiple prevention behaviors across risks, *if* it would be possible to change someone's general disposition. We argue that a trade-off between the two routes, that compares the possibilities and net benefits of both, is one that should get more attention in future academic work.

Specific behaviors need specific determinants

Although the determinants as used in PMT and HBM offer a good starting point for understanding domestic prevention behavior, solely addressing these determinants in an intervention is not enough to increase prevention behavior. First, since different prevention behaviors can be driven by different determinants or, at least, to another extent. Second, since these theoretical frameworks are too generic to change specific behaviors. Third, since also other determinants than the ones included in these theories can be relevant. A lot can be gained when performing a thorough problem analysis before developing a behavior change intervention. That is, make an inventory of all possible determinants for a specific behavior, formulate them in a detailed manner and analyze the relationships. This provides a better understanding of the true underlying motives and barriers and offers guidance to develop more effective behavior change interventions.

Summary (Dutch)

Preventiemaatregelen, zoals een rookmelder of gecertificeerde sloten, kunnen gunstig zijn, omdat ze de kans op een risico kunnen verkleinen of de - soms zeer ernstige - gevolgen ervan kunnen verminderen. Mensen motiveren om deze preventiemaatregelen te nemen is echter een uitdagende taak. De kans op een brand of inbraak is namelijk klein en de voordelen van deze maatregelen zijn niet altijd zo duidelijk. Zo merken bewoners het meestal niet als inbrekers hun woning overslaan vanwege de buitenverlichting en het goede hang- en sluitwerk. Bovendien liggen de voordelen van preventie vaak pas in de toekomst, als ze er al zijn, terwijl de investeringen wel nu gemaakt moeten worden.

Het primaire doel van dit proefschrift is om preventiegedrag en de psychologische determinanten die dit gedrag veroorzaken beter te begrijpen, om zo uiteindelijk (meer) mensen te motiveren om (meer) preventiemaatregelen te nemen. In dit proefschrift gaat het over gedragingen gericht op het voorkomen of beperken van brand, inbraak en waterschade in huis.

Twee prominente theorieën die verklaren waarom mensen wel of geen preventieve maatregelen nemen, zijn de Protection Motivation Theory (PMT; Rogers, 1975) en het Health Belief Model (HBM; Rosenstock, 1966). Deze theorieën verklaren dit gedrag aan de hand van verschillende *determinanten*. Om in de eerste plaats gemotiveerd te zijn om actie te ondernemen, moet iemand het gevoel hebben dat er een kans bestaat op een bepaald risico *(gepercipieerde kans)* dat gepaard gaat met negatieve gevolgen die men wil vermijden *(gepercipieerde ernst)*. Daarbij dient iemand een preventiemaatregel als effectief te beschouwen in het verminderen of beperken van het risico *(gepercipieerde effectiviteit)*, en de kosten en inspanningen die ermee gemoeid zijn mogen niet te hoog zijn *(gepercipieerde kosten of nadelen)*. Bovendien moet iemand de overtuiging hebben dat hij of zij het preventiegedrag succesvol kan uitvoeren *(zelf-effectiviteit)*.

Hoewel deze theorieën een nuttig kader bieden voor het begrijpen en beïnvloeden van preventiegedrag, zijn er een aantal vragen die nog niet beantwoord zijn in de literatuur:

I. Zijn mensen consistent in hun preventiegedrag over verschillende risico's en verschillende soorten gedrag heen?

II. Waarom doen sommige mensen meer aan preventie dan anderen en waarom worden sommige preventiemaatregelen vaker uitgevoerd dan andere?

III. Als we één of meer van deze determinanten in de gewenste richting veranderen, leidt dit dan per definitie tot de gewenste gedragsverandering?

IV. Is dit de complete set van determinanten van preventiegedrag of zijn er ook andere determinanten die preventiegedrag kunnen beïnvloeden?

Meer inzicht in deze vraagstukken leidt tot het beter begrijpen van preventiegedrag waardoor betere interventies kunnen worden ontworpen om dit gedrag effectief te veranderen. Deze vraagstukken behandelen we in de studies in dit proefschrift (hoofdstuk 2 – 5).

In **hoofdstuk 2** testen we of mensen consistent zijn in hun gedrag over verschillende soorten risico's en verschillende soorten gedraging heen. We testen dit door een Rasch-analyse uit te voeren op enquêtegegevens. Een manier om deze procedure te begrijpen, is door preventiegedrag als een "piramide" te zien. Onderaan de piramide vinden we de gedragingen die door de meeste mensen worden uitgevoerd (bijv. deuren op slot doen bij het verlaten van het huis), in het middelste gedeelte van de piramide vinden we de gedragingen die worden uitgevoerd door ongeveer de helft van de mensen (bijv. een blusdeken of maandelijks de afzuigkap schoonmaken), en bovenaan de piramide vinden we de gedragingen die alleen worden uitgevoerd door een paar zeer preventie gerichte mensen (bv. een vluchtplan oefenen of een alarmsysteem hebben). Als dit "piramidemodel" van gedrag opgaat, zal iemand die het gedrag aan de top uitvoert, hoogstwaarschijnlijk ook het gedrag uitvoeren dat in het midden en onderaan de piramide staat. Hoe hoog mensen in deze piramide staan weerspiegelt hun algemene houding ten opzichte van preventiegedrag. Onze resultaten laten zien dat een dergelijk "piramidemodel" van preventiegedrag bestaat. Dit heeft verschillende implicaties. Ten eerste kunnen we iemands positie in deze preventiepiramide bepalen en daarmee iemand gepersonaliseerd preventie advies geven. Een alarmsysteem aanbevelen aan iemand die niet eens zijn deuren op slot doet, zou geen erg effectieve strategie zijn. Naar alle waarschijnlijkheid zullen gemakkelijkere of goedkopere gedragingen, zoals het uit het zicht plaatsen van kostbaarheden of het installeren van een rookmelder, aantrekkelijker zijn voor deze persoon. Ten tweede, als we informatie hebben over iemands preventiegedrag in een bepaald risicodomein, bijvoorbeeld als we weten wat iemand doet aan inbraakpreventie, kunnen we iemands preventiegedrag in een ander risicodomein voorspellen, bijvoorbeeld wat iemand doet aan brandpreventie.

In **hoofdstuk 3** testen we of de determinanten van preventiegedrag, zoals genoemd in de preventiegedrag theorieën, ook relevante drijfveren zijn voor preventiegedrag specifiek gericht op inbraak, brand en waterschade. Onze resultaten bevestigen dit. De belangrijkste vraag is echter: wat betekent dit resultaat eigenlijk? Betekent dit dat deze determinanten verklaren waarom sommige gedragingen vaker worden uitgevoerd dan andere? Bijvoorbeeld: wordt het op slot doen van deuren vaker uitgevoerd dan het inschakelen van buitenverlichting, omdat dit als effectiever wordt ervaren om

de kans op inbraak te verkleinen? Of betekent dit dat deze determinanten verklaren waarom sommige personen meer aan preventiegedrag doen dan andere personen? Bijvoorbeeld: doet iemand die de kans op risico's over het algemeen hoog inschat en/of alle preventiegedragingen als zeer effectief beschouwt, meer aan preventie dan iemand die dat niet doet? Hoewel deze twee interpretaties niet hetzelfde zijn en tot verschillende implicaties leiden, komt dit onderscheid in de literatuur nog niet aan de orde. Onze resultaten laten zien dat de determinanten goed verklaren waarom sommige preventiegedragingen vaker worden uitgevoerd dan andere. Dit gebeurt vaker naar mate 1.) dit gedrag bekender is, 2) de gepercipieerde effectiviteit van het gedrag hoger is, 3.) de gepercipieerde kosten en/of moeite die met het gedrag gepaard zijn lager zijn en 4.) de gepercipieerde kans en ernst van het risico hoger is. Met andere woorden: zo goed als alle elementen van de theoretische modellen gaan op. Echter, het feit dat sommige mensen meer aan preventie doen dan anderen, kan veel minder goed worden verklaard door deze determinanten. Op basis van deze resultaten lijkt het dus niet erg kansrijk om iemands algemene perceptie van risico's en preventiegedrag in het algemeen te veranderen, aangezien er geen aanwijzing is dat dit dan leidt tot het nemen van meer preventiemaatregelen. Dat is jammer, want als er een manier zou zijn om mensen zo te veranderen dat ze over het algemeen meer aan preventie gaan doen (in plaats van het promoten van één specifieke gedraging), dan zou dat natuurlijk de "heilige graal van overtuigen" zijn.

In **hoofdstuk 4** onderzoeken we in welke mate het ervaren van brand in Virtual Reality (VR) een effect heeft op brandpreventiegedrag. Het idee achter deze interventie is dat mensen eerder geneigd zijn om preventieve maatregelen te nemen nadat ze een gevaarlijke gebeurtenis hebben meegemaakt, iets wat in de literatuur vaker is opgemerkt. Een simulatie in VR waarbij mensen een vlam in de pan ervaren kan vergelijkbare resultaten opleveren, maar zonder de negatieve gevolgen van een echte brand. We onderzoeken de effecten van het ervaren van brand in VR versus het lezen van een informatieblad over brandpreventie op verschillende relevante determinanten van preventiegedrag. Cruciaal in onze opzet, en anders dan de meeste onderzoeken, is dat we ook onderzoeken of een verandering in deze determinanten daadwerkelijk leidt tot meer preventiegedrag. Om gedrag te meten, gaven we deelnemers de mogelijkheid om een blusdeken aan te schaffen en flyers over brandpreventie mee naar huis te nemen. De resultaten laten zien dat mensen die de VR hebben ervaren de kans op brand hoger inschatten, een brand als ernstiger ervaren en minder zelfvertrouwen hebben om met een brandsituatie om te gaan dan mensen die het informatieblad hebben gelezen. De resultaten laten bovendien zien dat mensen die de VR hebben meegemaakt vaker een blusdeken kochten en vaker flyers mee naar huis namen in vergelijking met mensen die het informatieblad lazen, al waren de verschillen klein. De veranderingen in de preventiedeterminanten waren echter niet altijd de oorzaak

van de gedragsverandering. Zo schatten mensen de kans op brand hoger in na het ervaren van de VR, maar deze hogere ingeschatte kans was niet de oorzaak van het vaker aankopen van een blusdeken. Wel zorgde dit ervoor dat meer mensen folders over brandpreventie mee naar huis namen. Ook werden beide preventiegedragingen gedreven door andere determinanten. Deze resultaten tonen aan dat er veel meer in detail gekeken moet worden welke determinanten tot welk preventiegedrag leiden, in plaats van simpelweg de determinanten te beïnvloeden zoals genoemd in de bekende preventiegedrag theorieën.

In **hoofdstuk 5** laten we zien dat wanneer we gedrag willen beïnvloeden, het een goed idee is om het gedrag eerst specifiek te maken om vervolgens te onderzoeken waarom mensen dat specifieke gedrag niet uitvoeren. Als we kijken naar de aanschaf en het onderhoud van rookmelders zien we dat huidige campagnes mensen vaak proberen te overtuigen door in te spelen op: de kans op brand ("al xx woningbranden dit jaar"), de ernst van brand ("rook is dodelijk") en de voordelen van een rookmelder ("rookmelders redden levens"). De vraag is of deze boodschappen er ook echt voor zorgen dat meer huishoudens werkende rookmelders hebben. Ten eerste bestaat 'het hebben van werkende rookmelders' uit verschillende opeenvolgende stappen: een rookmelder moet worden gekocht, opgehangen, regelmatig worden getest en batterijen moeten tijdig worden verwisseld. De redenen waarom mensen een rookmelder niet testen kunnen echter verschillen van de redenen waarom mensen de rookmelder nog niet hebben opgehangen of geen rookmelder kopen. Omdat deze redenen kunnen verschillen per stap, kiezen we ervoor om dit onderzoek specifiek te richten op 'het kopen van een rookmelder'. We onderzoeken welke determinanten allemaal een rol spelen bij de aankoop van een rookmelder, waarbij we ook verder gaan dan de reguliere preventietheorieën. Resultaten laten zien dat determinanten die minder vaak worden geadresseerd in de huidige communicatie-inspanningen (zoals sociale normen) belangrijker zijn dan determinanten die vaak worden geadresseerd (zoals de kans en ernst van brand). Op basis van deze resultaten ontwikkelden we twee e-mails: één op basis van de typisch gebruikte determinanten en één gericht op de significante determinanten uit ons onderzoek. Een experiment laat zien dat de e-mail gebaseerd op de significante determinanten ervoor zorgt dat meer mensen een rookmelder kopen (vergeleken met een controlegroep), terwijl de e-mail gebaseerd op de typisch gebruikte determinanten hier niet voor zorgt. Hieruit blijkt dat in het geval van rookmelders, mensen vertellen hoe hoog de kans op brand is, of hoe ernstig brand is, of dat 'rookmelders levens redden' geen effectieve manier is om mensen rookmelders te laten kopen. Ons onderzoek laat zien dat mensen andere redenen hebben om geen rookmelders aan te schaffen zoals 'anderen hebben ze ook niet' of 'ik weet niet hoe en waar ze moeten worden geplaatst'. Deze achterliggende redenen zouden niet zijn gevonden zonder een uitgebreide probleemanalyse die specifiek gericht was op de

aanschaf van een rookmelder. Alleen als we de ware en volledige set onderliggende motieven en barrières aanpakken, kunnen we mensen in beweging krijgen om hun gedrag te veranderen.

Wanneer we alle studies van dit proefschrift beschouwen, kunnen we relevante richtlijnen opstellen om preventiegedrag beter te begrijpen en te beïnvloeden. We vatten deze hieronder samen.

Verschillende preventiegedragingen komen voort uit één onderliggende houding

Mensen gedragen zich consistent over verschillende soorten risico's en gedragingen heen, wat duidt op het bestaan van een onderliggende algemene houding ten aanzien van risico's en preventie. Mensen met een zeer positieve preventiehouding doen meer aan preventie en voeren bovendien gedragingen uit die minder vaak voorkomen. Bij het bevorderen van preventiegedrag lijkt het effectiever om advies op maat te geven; advies dat aansluit bij iemands preventiehouding, in plaats van aan iedereen hetzelfde preventieadvies te geven. Aangezien uit ons onderzoek is gebleken dat we personen kunnen ordenen op basis van hun preventiehouding en gedrag kunnen ordenen op basis van hoe vaak dit gedrag voorkomt, geeft dit ons directe implicaties voor het vormgeven van gepersonaliseerd preventieadvies.

Beïnvloeding van gedrag versus beïnvloeding van personen

Wanneer men preventiegedrag wil bestuderen of bevorderen, kan men (minstens) twee mogelijke routes overwegen: 1.) iemands perceptie van een bepaald risico en gedrag veranderen om een specifieke gedraging te stimuleren of 2.) iemands houding ten aanzien van risico's en preventie veranderen met als doel het stimuleren van preventiegedrag in het algemeen. Hoewel dit proefschrift een meer solide basis vormt voor de eerste route, biedt de tweede route het potentieel om meerdere gedragingen over risico's heen te beïnvloeden, *mits* het mogelijk is om iemands algemene houding te beïnvloeden. Het afwegen van deze twee routes, waarbij de mogelijkheden en de netto-opbrengsten van beiden worden vergeleken, is iets wat meer aandacht verdient in toekomstig academisch werk.

Specifiek gedrag heeft specifieke determinanten nodig

Hoewel de determinanten zoals gebruikt in de preventie theorieën (PMT, HBM) een goed uitgangspunt bieden voor het begrijpen van preventiegedrag in huis, is het uitsluitend adresseren van deze determinanten in een interventie niet voldoende om het preventiegedrag te stimuleren. Ten eerste omdat verschillende preventiegedragingen kunnen worden gedreven door verschillende determinanten, of in ieder geval in

een andere mate. Ten tweede omdat deze theoretische kaders te algemeen zijn om specifiek gedrag te veranderen. Ten derde omdat ook andere determinanten, niet genoemd in deze theorieën, relevant kunnen zijn. Er valt veel te winnen door een gedegen probleemanalyse uit te voeren voorafgaand aan het ontwikkelen van een gedragsinterventie. Dat wil zeggen: inventariseer alle mogelijke determinanten voor een specifieke gedraging, formuleer deze op een gedetailleerde manier en analyseer de relaties. Dit geeft een beter begrip van de werkelijke onderliggende motieven en barrières en biedt richtlijnen voor het ontwikkelen van effectievere gedragsinterventies.

Acknowledgments

Eight years ago, it started to itch. I loved my job as a marketing researcher at Interpolis, and at the same time I was looking for more academic depth and development. I was driven by curiosity and the desire to fully dive into a problem to unravel. But before I would make the jump, I first did a 6-month 'study' to figure out whether I really wanted to do a Ph.D., and if so, how and about what. In that time, I interviewed various persons that did a full-time or part-time Ph.D., persons that finished or had quitted their Ph.D. project, and professors of different universities. After six months I had the plan figured out: I wanted to do a part time Ph.D. project about prevention behavior at the University of Technology in Eindhoven, under the supervision of Chris Snijders and Martijn Willemsen. The topic of study became 'risk prevention behavior'. Everyone who knows me (and has seen me leaving my house), knows that this topic is a perfect fit for my personality!

I would like to thank Interpolis, since without their support this Ph.D. project would never have happened. A special thanks go to Frank van Tiggelen and René Voets who made this happen for me. Interpolis gave me space to work on my research one day a week, while the other day was my own investment. The deal was six years. However, performing academic studies, writing them down, and the review process took some more time than expected. I got an additional year to wrap up my thesis, for which I thank Ruben Mercx and Peter Marcelis. I would also like to thank my colleagues at Interpolis, the directors and senior management for their inspiration, their support and sincere interest in my studies and insights.

After diverse conversations at universities, I chose Eindhoven University of Technology because of the nice and extensive conversations I had with Ron Broeders and Chris Snijders. I had learned from all the interviews with (former) Ph.D. students that personal attention and a good connection with your supervisor is the most important aspect for a successful Ph.D. project. I never regretted this decision. I would like to thank Martijn Willemsen and Chris Snijders, my supervisors, for their guidance through this challenging and exciting process. They always made time for me to discuss my endless questions and review my work. I learned a lot about statistics, academic reasoning, and writing. Of course, sometimes our meetings or feedback sessions frustrated me, but looking backward, I am especially grateful for these moments since these really pushed my thinking processes. Chris, you always believed in me and motivated me to pursue, even though I was sometimes discouraged by tough review processes.

At the department of Human Technology Interaction (HTI), I entered a "warm bath". At the secretariat Anita, Ellen, and Renata were there for a chitchat or to give some

supporting words in times of Ph.D. troubles. In the secretary office at the IPO building I was impressed by the beautiful paintings, of which Anita appeared to be the artist. To my great surprise I received one of her paintings as a present after the second year of my Ph.D.: a symbol for my Ph.D. process and warmth of the HTI department. I enjoyed the game and dinner nights (although hot pot is really *too* hot), Chinese tea ceremonies, lunch and cookie breaks, and even an Italian wedding, with amongst others, Shengnan, Caixia, Mieke, Elena, Frank, and Mariska. However, Ph.D.'s come and go. The last two years in the ATLAS building I enjoyed office fun and colleague support of "the roof's on fire club": Samantha, Maaike, Milou, and Sima. I really enjoyed our dinner parties, brainstorm sessions and (online) coffee breaks. With a special thanks to Sima, one of the most helpful persons I know and "my personal" designer, as she designed the cover of this thesis. A thank you to all others that made my time at HTI unforgettable (Marc, Ans, Nicole, Heleen, and many more). Some HTI-specifics I will also not forget: the amazing performances of the HTI band at defense ceremonies, the interesting Brown bag sessions, and legendary Christmas lunches.

I am thankful for all researchers on the way who have taken the time to review or discuss my studies, which improved the quality of my work. In particular, I would like to thank the members of my doctoral examination committee who spent their valuable time reading my extensive epistle on prevention behavior and shared their thoughtful comments.

Also, I would like to thank the Behavior Change Group from who I learned a lot about the psychology of behavior change and who inspired me (together with Johan Ringeling) to write the chapter about smoke alarms.

I am blessed to have great friends and family in my life. A special thanks to Sabine, my best friend from the age of 15, who read my introduction and discussion and provided extensive feedback. You were super attentive during the whole process, always showing your interest, even when you were miles away, and comforted me when things went not as desired. A true friend! Then, there are the girls from the Friday night club (Anja, Susanne, Mariken, Chantal, Femke, Joska) with whom I experienced fun and sometimes crazy Fridays with, and with whom I experience precious friendships. Judith, a friendship that started with a Schrobbelèr at the Interpolis Christmas Party, and that ended up in a true friendship. Melanie and Jan-Willem, who I can always join for dinner or a glass of good wine. My salsa / kizomba friends: it started with our mutual passion for dancing but turned out to be a great group of friends, with also mutual passions for cheese fondue, games, and camping. A thank you to all my other friends (you know who you are!) for being part of my life.

Dan een stukje in het Nederlands, speciaal voor mijn lieve pap en mam: jullie hebben mij altijd gesteund in mijn keuzes, en zo ook in de keuze om te gaan promoveren. Na mijn vrijdag op de TU/e was ik altijd welkom om -spontaan- bij jullie aan te schuiven, voor lekkere frietjes met vis. Bedankt dat jullie er altijd voor mij zijn!

Ook wil ik mijn lieve oma bedanken, met de mooie leeftijd van 97 jaar, voor haar onvoorwaardelijke liefde en steun.

It was a great journey: thank you for being part of it!

About the author

Patty Jansen was born on November 7, 1983, in Eindhoven, The Netherlands. In 2005 she obtained her Bachelor's degree in Tourism Management at the University of Applied Sciences in Breda. In 2008 she obtained her Master's degree in Organization Studies at Tilburg University. She wrote her Master thesis at Interpolis. Her thesis, about donating micro-insurances by paying an additional insurance premium, was published in the Journal of Business Ethics and received the Best paper Award of 2009.

In 2008 she started her career as a marketing analyst at Interpolis. In 2010 she became a marketing researcher, where she conducted consumer research with the aim of improving marketing efforts. In 2013 her work shifted towards behavioral psychological research in the domain of risk and prevention behavior. In that year, she also started to pursue her Ph.D. at Eindhoven University of Technology, at the Human Technology Interaction group. She carried out her Ph.D. project part-time, for two days a week for a period of seven years. For her Ph.D. she studied decision-making processes related to risk and prevention behavior with the aim of behavior change. She presented her work at a variety of (international) conferences and published two academic articles: one in Risk Analysis and one in PLOS ONE. Currently, she works as a senior behavioral scientist at Interpolis.

EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

Department of Industrial Engineering
& Innovation Sciences