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Citizens' adaptive or avoiding behavioral response to an emergency message on their mobile phone

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ABSTRACT

Since November 2012, Dutch civil defense organizations employ NL-Alert, a cellular broadcast-based warning system to inform the public. Individuals receive a message on their mobile phone about the actual threat, as well as some advice how to deal with the situation at hand. This study reports on the behavioral effects of NL-Alert ($n = 643$). The current risk communication literature suggested underlying mechanisms as perceived threat, efficacy beliefs, social norms, information sufficiency, and perceived message quality. Results indicate that adaptive behavior and behavioral avoidance can be predicted by subsets of these determinants. Affective and social predictors appear to be more important in this context that socio-cognitive predictors. Implications for the use of cellular broadcast systems like NL-Alert as a warning tool in emergency situations are discussed.

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1. Introduction

Since November 2012, Dutch civil defense organizations employ NL-Alert, which is a warning system to inform the public in the direct vicinity of an (imminent) incident or emergency. To reduce casualties and damage the public emergency response is essential. It includes the actions taken a short period prior to, during, and after the emergency (Tierney, Lindell, and Perry 2001). Getting the attention of people who are at risk, to enable them to take appropriate protective or mitigating actions are the primary aims of emergency warnings (Mileti and Sorensen 1990). However, the technological developments and its implementation in the form of tools like NL-Alert has outpaced studies on their effectiveness and their limitations (National Research Council 2011, 2013a; Bean et al. 2015). To date, authorities don't know whether citizens are motivated by the messages, or whether their resilience benefits from it. So, studies addressing the effectiveness of these new tools is needed, and this paper therefore describes the results of the first real life tests of this type of alerting systems as it is deployed in an emergency situation. As such, this study distinguishes itself from previous analyses that studied aspects of effectiviness of wireless warnings in virtual experiments (e.g. Bean et al. 2016; Casteel and Downing 2016).

Other countries have implemented (similar) cellular broadcast systems, including Lithuania, Israel, Japan, and Chili (Gutteling et al. 2014). In 2011 the US FEMA started authorizing emergency management officials to send out Wireless Emergency Alerts (WEA) to cell phones and other devices (Bean et al. 2015) to notify receivers of imminent hazards. The current paper describes a study into the effectiveness of the Dutch NL-Alert system as a first attempt to fill the gaps that were identified by Bean et al. (2015).

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Emergencies in the Netherlands, which is a relatively small but heavily populated and industrialized country in Western Europe, can be of various nature: natural or man-made. The warning period sometimes is short or may take place when the emergency has already unfolded. In the latter case, it mainly serves the purpose of reducing the negative impact of the situation. Dutch individuals receive a message on their mobile phone about the actual threat, its location, and advice how to deal with its consequences. The importance of a 'near' real-time, area-specific warning has been recognized widely (Sorensen 2000; Fernandes 2008; Bhattacharya and Ghosh 2011). It is assumed that early and elaborated warning will improve the public's reaction to the threat. The mobile phone technology and its penetration in society offer opportunities for a wide-ranging warning system (Sorensen 2000).

The NL-Alert system uses cellular broadcast technology. The regional civil defense organization[1] selects one or (usually) multiple 'cell(s)' that cover the threatened/incident area. When the alerting message is transmitted, everyone with a mobile phone in the selected cell(s) will receive a short message.[2] Similar developments based on text messaging technology do exist too (Bhattacharya and Ghosh 2011; National Research Council 2013b; Sutton et al. 2014), which are often linked to area-specific hazards (e.g. earth quakes and landslides [Wenzel et al. 2001; Cardellini and Osimani 2008], floods [Hussin, Ismail, and Sofian 2012], or large open-to-the-public organizations like a university [Lee, Chung, and Kim 2013]). However, the cellular broadcast technology has some advantages over the text messaging technology. Cellular broadcast is insensitive to disruption by the massive use of speech, text messaging or wifi, which might occur in case of an emergency when people massively use mobile communication modes (Wood 2005). Furthermore, members of the public do not have to subscribe to the system (like with the text messaging systems), so it is anonimous.

Prior to the official start with NL-Alert, a series of expert workshops were held to discuss the contents of the warning message (Jagtman 2013). It was concluded that ideally a warning message comprises four elements: the threat, its location, the advice and the sender of the message. Based on this result, all NL-Alert messages are modeled like this, and are preceeded with an indication of the sender and time. So, since the start in 2012, the average NL-Alert message takes this form:

> NL-Alert 4-11-2013 15:34 Toxic fumes released with fire in Company X, Municipality Y. Go inside, close windows and doors. Listen to the emergency broadcast

The standard elements are: *sender* (NL-Alert 4-11-2013 15:34), *threat* (Toxic fumes released with fire), *location* (*Company X, Municipality Y*) and *advice* (*Go inside, close windows and doors. Listen to the emergency broadcasting*). Similar necessary ingredients are reported by Bean et al. (2016). The NL-Alert message and its advice can be tailor-made to the specific situation by adjusting the information about the threat, location or advice to any specific situation (Rauhala and Schultz 2009; Horii et al. 2010).

This study is the first to assess the behavioral effects and public perception of NL-Alert in actual warning situations in the first year of its operation (between November 2012 and November 2013).

2. Conceptual approach

The effect of warning systems like NL-Alert on the public at-risk is yet unclear (Sillem 2010; Bean et al. 2015). Neither do we have an existing theoretical model to help understand the motivation inducing or resilience strengthening capacities of warning messages with these new tools. So, this study is also identifying psychological, communicative and behavioral reactions that are assumed to be important for understanding and predicting public behavior after an emergency warning (Malizia et al. 2010).

In this study we are focusing on the predictive value of perceived threat, efficacy beliefs, affective reactions (emotions), information sufficiency, social norms, and perceived message quality on the public's self-protective behavior when people receive an emergency warning. The determinants of adequate resilient behavior perceived threat and efficacy beliefs are derived from conceptual models on risk communication (see e.g. Extended Parallel Process Model or EPPM [Witte 1992; Witte and Allen 2000], and Protection Motivation Theory or PMT [Floyd, Prentice-Dunn, and Rogers 2000; Ruiter, Abraham, and Kok 2001]), or disaster warning studies based on Protective Action Decision model or PADM (Lindell

and Perry 1992, 2012). PMT and EPPM suggest that the receiver of a warning message first assesses the threat level. Sometimes the warning message is accompanied by other indicators of danger (e.g. smoke, fire, smell, the sound of sirenes; other warnings). However, in other circumstances the warning message is the only indicator something is wrong. In both situations the personal relevance of the threat will be assessed ('this is relevant to me', or 'this will not happen to us', 'this message is not meant for me'), creating some level of personal urgency. After this, according to the models, one more assessment will be made, regarding the likelihood of being able to personally cope adequately with the emergency situation (Witte and Allen 2000). The appraisal of successful coping is related to one's self-efficacy belief ('I believe to be able to perform the recommended behavior') and ones belief in the adequacy of the provided advice, which is called respons efficacy ('the recommended behavior is adequate in dealing with the threat'). PMT has been applied to various risk issues, e.g. by Grothmann and Reusswig (2006) with their study on preparatory flood mitigation behavior in Germany, by Martin, Bender, and Raish (2007) focusing on uncontrollable wild fires in the U.S.A., and by Johnston and Warkentin (2010) who applied the model to cyber security issues. And recently, the same is true for EPPM (e.g. Kievik and Gutteling 2011; Kievik, ter Huurne, and Gutteling 2012). PADM finds its roots in PMT but is specifically designed for application with disasters and major incidents (Terpstra and Lindell 2012; De Boer, Botzen, and Terpstra 2014).

When the threat is seen as personally relevant, and the coping appraisal is positive then one will decide to execute the recommended, adaptive behavior (danger control). However, when the threat is seen as relevant but coping is seen as impossible, some psychological reframing of the situation is a likely reaction. This is called fear control, and can be observed in the form of psychological denial, defensive behavioral avoidance or reactance, which are basically maladaptive reactions because no risk mitigation takes place (Witte and Allen 2000). In this study, we operationalize behavioral avoidance as 'doing nothing in terms of risk mitigation but continuing with current activities', when the emergency warning is received. In addition to risk perception and behavioral avoidance this study also assesses fear and other affective reactions (emotions) to the warning message (Slovic et al. 2007).

The NL-Alert warning is intended to contribute to the recipient's resilience by providing an advice that will help mitigate the consequences of the emergency situation, such as to evacuate when needed, or to tune in to a television station or website for further information. It is conceivable that receivers of a warning message will start looking for additional (risk) information even without a specific advice to do so. In recent years studies have shown that in emergency situations the individual is an information seeker, but also an information source for others (Palen et al. 2009; Terpstra et al. 2012). Modern technology enables people to find and send information that they may perceive as relevant to the emergency situation (Gutteling and de Vries 2012). So, in this study the behavioral aspects will focus on compliance with the advice provided, but also on information seeking processes and information sharing as a result of receiving the warning message in the first place. Existing research and conceptual models suggest that perceived information sufficiency, that is to which level one is satisfied with one's information position, predicts additional information seeking (Griffin, Dunwoody, and Neuwirth 1999; Ter Huurne 2008). In this study we will focus on information sufficiency in the context of the emergency warning message. However, it can be seen both as a predictor of behavior, but also as being influenced by the other concepts in this study. So information sufficiency has a dual role here.

The individual may perceive expectations in the social environment that may influence the informational needs, and the information seeking process (Atkin 1972; Radecki and Jaccard 1995), and as assumed also the compliance with the emergency advice. The expectation that others may know about a situation, may stimulate the individual to seek additional information as well, due to the felt need to be able to compare one's capacities and knowledge with that of others, or to share the information with the other. In this way one expects to gain social support and appreciation (Eagly and Chaiken 1993). This process has been observed in the full range of social situations people engage in: work, family, friends, and other social contexts (Neuwirth and Frederick 2004), and has been reported in the risk communication context too (Ter Huurne 2008). In the present study perceived expectations from the individual's social environment will be assessed (social norms).

One may assume that perceived quality of the warning message is an important indicator of its effectiveness as has been reported by many (risk) communication studies (e.g. Renn and Levine 1991). Assessments of source and message credibility, as well as perceived goodness of fit with the assumed adequate risk-mitigating action might be relevant in the context of an emergency warning. Studies in the risk domain show that credibility of sources and message content are of the utmost importance for creating an atmosphere in which people are likely to comply with a provided advice (Renn and Levine 1991; Earle 2010). More in particular, in emergency situations one can assume that people need information that they trust and can adhere to, without doubts (Gutteling and de Vries 2017). As previous studies indicated, the Dutch public had a favorable first impression of the NL-Alert system (Holzmann et al. 2011; Bouwmeester et al. 2013). However, no data are available about the public's appreciation of the message qualities after an emergency warning. So in the present study, the perceived completeness, relevance and correctness of the warning message will be assessed (Sillem 2010).

To date, only few studies evaluated mobile device-delivered warning messages (mostly Twitter messages) (Sutton et al. 2014; Terpstra et al. 2012). Bean et al. (2015) reported a study about people's interpretation of Wireless Emergency Alerts (WEAs) and Twitter-length messages ('tweets') in a virtual situation (no actual emergency). With four (N = 31) focus groups and 31 think-out-loud interviews, participants' understanding of, belief in and personalization of WEAs and tweets were assessed. While participants offered a wide variety of interpretations, WEAs and tweets were often deemed confusing, difficult to believe and impersonal. Participants also consistently found WEAs and tweets to be fear inducing and uninformative. Casteel and Downing (2016) focused on the question whether 90 characters (which is the max length of a WEA) has impact on the effectiveness of the risk communication. Prototype WEA tornado warning messages were designed in four different formats ranging from tekst only or text combined with graphics like we know from weather apps (e.g. radar images). This was also a virtual emergency and participants were told they were driving through an unknown region of the US. The researchers asked participants to assess the perceived risk, perceived severity, and likelihood to contact a loved one for each message. No differences on these parameters were found for the different conditions and the reaction time was similar the four conditions too.

However, the effect on the public's self-reported coping behavior of the mobile-delivered warning in a real emergency situation is still unknown. The present study is the first to collect data on actual warning effectiveness in the Netherlands regarding the cellular broadcast system.

3. Method

In emergency situations researchers are limited by practical and ethical considerations. Researchers are never on location when an emergency occurs, and in the unlikely situation they are in the right place at the right time, they will not be equipped to collect valid and reliable data. So this study is based on survey data collected as soon as possible after the delivery of the NL-Alert warning (usually within 2 days).

3.1. Data collection procedure

In the period under study, NL-Alert was applied 20 times (see Table 1 for details), of which three situations have been selected for further analysis. The choice of cases were based on three criteria, (1) the type of emergency (the aim was to study different types of emergencies, but in practice this appeared difficult to attain, as we were unable to predict the emergency type a priori, and most incidents were actually major fires – see Table 1), (2) the size of the affected population (to be able to find sufficient respondents), and (3) geographical spread across the country. The actual decision to start collecting data was taken in close collaboration with the Dutch National Crisis Center, who were in close contact to the regional authorities.

Data were collected by a professional survey agency. The data collection activities were positioned within a few days of actual deployment of NL-Alert after emergencies in the Dutch cities Meppel (January 2013), Oisterwijk (June 2013), and Leeuwarden (October 2013). In two of three cases the emergencies

Table 1. NL-Alert deployment in its first operational year (November 2012–November 2013). Underlined deployments were used as cases in this study.

Location/City	Population (approx. 1/1/2013)	Date	Event/Emergency	Event starting time	Deployment NL-Alert	% cells reached[a]	Safety Region
Tolbert	4500	14.12.2012	Fire shop	06:32	07:35	100 [b]	Groningen
Meppel	28,400	20.1.2013	Fire warehouse	n/a	14:50[c]	90	Drenthe
Cothen	2700	30.1.2013	Fire warehouses	n/a	20:47	100[d]	Utrecht
Hoogeveen	55,000	2.4.2013	Fire shops	n/a	09:00	85	Drenthe
Haarlem	1,55,000	3.4.2013	Fire abandoned warehouse	21:10	21:56	86	Kennemerland
Alkmaar	1,07,600	5.5.2013	Fire junkyard	n/a	10:40	85	Noord-Holland noord
Rijsenhout	4000	15.5.2013	Fire church	10:50	11:47[e]	82	Kennemerland
Dinteloord	5600	26.5.2013	Fire cafe	04:50	05:52[f]	82	Midden&West-Brabant
Garsthuizen	250	27.5.2013	Fire community center	n/a	17:36	100	Groningen
Oosterhout	54,000	4.6.2013	Fire chemical plant	21:15	23:54[g]	79	Midden&West-Brabant
Heerenveen	50,200	9.6.2013	Fire warehouse	08:00	09:01	100	Fryslân
Oisterwijk	25,000	20.6.2013	Fire chemical plant	n/a	06:08	81	Midden&West-Brabant
Zevenaar	32,200	6.9.2013	Fire chemical plant	06:15	07:26[h]	52	Gelderland Midden
Ameland	3600	13.9.2013	Fire campground	12:00	13:25[i]	100	Fryslân
Rotterdam	6,29,000	29.9.2013	Fire incineration installation	16:00	17:19	90	Rotterdam-Rijnm.
Assen	67,000	4.10.2013	Fire office building	n/a	18:56	91	Drenthe
Dieren	15,500	5.10.2013	Fire bicycle plant	03:00	04:52[j]	100	Gelderland Midden
Leeuwarden	1,07,900	19.10.2013	Fire inner city shops/ apts	17:30	20:05	100	Fryslân
Noord-Nederland	1,717,200	28.10.2013	Severe storm	00:01	13:38	76	Groningen, Drenthe, Fryslân
Wijk bij Duurstede	17,900	3.11.2013	Tornado	n/a	n/a	n/a	Utrecht

[a]% cell reached is proxy for the transmission area.
[b]In Tolbert only one provider was used (T-Mobile). Other providers (KPN, Vodafone) were not present in the affected area.
[c]An 'all clear' message was transmitted in Meppel at 18:28. This was not standard protocol.
[d]Area selection failure resulting in only one 'cell' being used (provider KPN).
[e]At 13:00 the alarm sirene was used too in the affected area.
[f]In Dinteloord in total 4 NL-Alert were prepared, among which an "all clear" message. Only one message was actually used, at 5:52.
[g]Decision to send NL-Alert was taken at 23:05. Several technical issues delayed the actual transmission to the indicated time.
[h]In Zevenaar 4 NL-Alerts were transmitted. Message 1 reached 52% of the 'cells', message 2 reached 85% of the 'cells'.
[i]In Ameland an 'all clear' message was transmitted at 14:40.
[j]In Dieren 2 NL-Alert messages were transmitted, at 4:52 and 05:11, respectively.

were large industrial fires with release of potentially hazardous smoke and soot particles to nearby residential areas. The third situation was a large fire in an historic city center. Randomly selected mobile and landline phone numbers of people living in the 'cells' that were used to broadcast the warning message were dialed by trained agency interviewers, asking whether they had received the NL-Alert warning message. When they did, some additional questions were asked (e.g. their self-reported behavior) and people were invited to complete an additional online questionnaire (measuring determinants). The data collection aimed at a minimum of 150 cases per situation. In all three cases the actual respons was higher (Appendix 1 provides more details).

3.2. Participants

Within 48 h the survey agency first randomly called potential participants in the affected areas using the Computer Assisted Telephone Interview (CATI) technology to assess their first respons to the warning message. After that participants were asked to also participate in an online survey which was mailed to the participants during the telephone conversation (Computer Assisted Web Interviewing; CAWI). In this analysis we focus on the participants that completed both CATI and CAWI (see Appendix 2 for more details). The three samples consist of 643 persons (n = 175 Meppel, n = 181 Oisterwijk, n = 287 Leeuwarden, respectively). The three samples are compatible with regard to their distribution of socio-demographics (Appendix 2). Due to the small samples and the specific locations we do not assume representativeness for the Dutch population, and the samples were not tested for that.

3.3. Concepts (measurement)

The questionnaires contained items measuring behavior, perceived threat, efficacy beliefs, affective reaction, social norms, information need, perceived message quality, as well as socio-demographics. Items were measured with five-point Likert scales, unless otherwise indicated. Table 2 provides information on the assessed internal consistency of each concept.

Behavior. Questions are formulated as: 'Did you immediately comply with the advice given in the warning message?' Other items dealt with 'finding other information first', 'carefully monitor your environment', 'talk to others about the best action', 'inform others'. Behavioral avoidance was measured with one item: 'Did you pay little attention to the warning message and continued with what you were doing'. Answers were recorded (CATI) yes/no question (1 = yes, 2 = no, which was recoded in the analysis in 1 = no, 2 = yes).

Perceived Threat was measured with 4 items (CAWI; five-point Likert items with extremes 'totally disagree' – 'totally agree') to assess participants risk perception regarding a fire releasing toxic fumes to their environment. An example question is: 'I thought that the consequences of a major fire in a commercial building with the release of toxic fumes are very serious for me'.

Table 2. Internal consistency of the measured concepts in the three samples (Cronbach's alpha).

	# of items	Meppel	Oisterwijk	Leeuwarden
N =		175	181	287
Self-reported behavior				
Adaptive	5	0.45	0.51	0.58
Avoidance	1	na	na	na
Social norms	3	0.86	0.81	0.77
Efficacy beliefs	6	0.89	0.91	0.92
Perceived threat	4	0.65	0.67	0.56
Information sufficiency	3	0.95	0.95	0.95
Affective reaction	5	0.60	0.63	0.62
Perceived message quality	12	0.95	0.96	0.94

Efficacy beliefs were measured with 6 items (CAWI; five-point Likert with extremes 'totally disagree'–'totally agree') reflecting both self-efficacy and respons efficacy. Example question reflecting on self-efficacy is: 'I felt capable of complying with the advice in the warning message'. Example question reflecting on response efficacy is: 'The advice in the warning message helped me to deal with this situation adequately'. Both perceived threat and efficacy belief items were based on the Risk Behavior Diagnosis Scale (Witte et al. 1996).

Affective reaction was measured with 5 items (CAWI; five-point scales with extremes 'not at all' – 'very much'). The question was, after reading the warning message: Please indicate how you were feeling after reading the warning message? Items were relaxed, anxious, concerned, reassured, and angry. Similar questions were used by Kievik and Gutteling (2011) and Kievik, ter Huurne, and Gutteling (2012).

Social norms reflect the personal assessment of expectations from the social world. The scale consisted of 3 items (five-point Likert with extremes 'totally disagree'–'totally agree'). An example question is: 'Other people expected me to know a lot about the situation'. Items were based on Ter Huurne (2008).

Information sufficiency reflects on people's level of satisfaction with their own knowledge of the specific situation. It is measured with 3 items (five-point Likert with extremes 'very dissatisfied' – 'very satisfied'). An example question is: 'Please indicate your satisfaction with your knowledge about the consequences of a major fire with the release of toxic fumes'. Items were based on Ter Huurne (2008).

Perceived message quality. In the questionnaire all four message elements (source, threat, location and advice) were judged by the participants on comprehensibility, completeness, reliability (on five-point scales with extremes 'not at all' – 'very'). An example question is: 'Part of the warning message is highlighted (e.g. the sender is underlined), please indicate whether you found this part reliable'. In total 12 items were used to assess the quality of four message elements on three aspects.

4. Results

Table 3 presents the descriptive statistics of all variables/concepts measured in the study. After the NL-Alert deployment in Meppel and Oisterwijk the mean self-reported adaptive behavior is 1.7 (almost yes). In Leeuwarden the mean is somewhat lower (1.6). The mean scores for behavioral avoidance in Meppel and Oisterwijk are about 1.1 (which indicates 'no'), but is higher in Leeuwarden (1.5).

Perceived threat assesses the likelihood of a negative outcome, the severity of that outcome, and the assessment of severity of the outcomes for the participant. After the actual deployments of NL-Alert the average perceived threat ranges from 2.4 in Meppel to 2.9 in Leeuwarden (which on the scale indicates between 'low' and 'not low/not high'). The scores for Efficacy beliefs are similar in all three samples (M = 3.9, which indicates a relatively high assessment of efficacy). The average score for social norm

Table 3. Descriptive statistics (mean, s.d.) for the measured concepts in all three samples.

	Meppel	Oisterwijk	Leeuwarden
N =	175	181	287
Self-reported behavior[a]			
Adaptive	1.71 (0.26)	1.69 (0.29)	1.55 (0.29)
Avoidance	1.17 (0.38)	1.12 (0.33)	1.46 (0.50)
Social norms[b]	2.37 (1.10)	2.30 (1.03)	2.13 (0.99)
Efficacy beliefs[b]	3.93 (0.93)	3.90 (1.06)	3.97 (1.04)
Perceived threat[c]	2.41 (0.82)	2.59 (0.86)	2.90 (0.82)
Information sufficiency[d]	3.59 (1.11)	3.63 (1.11)	2.98 (0.82)
Affective reaction[e]	1.72 (0.62)	1.69 (0.57)	2.32 (0.69)
Perceived warning quality[c]	4.31 (0.77)	4.37 (0.75)	4.32 (0.81)

[a]Cati: 1 = no, 2 = yes.
[b]Cawi: 1 = agree, 5 = disagree.
[c]Cawi: 1 = low, 5 = high.
[d]Cawi: 1 = dissatisfied, 5 = satisfied.
[e]Cawi: 1 = not, 5 = very.

Table 4. Means, s.d. and correlation coefficients for adaptive behavior and behavioral avoidance with their hypothesized determinants (actual deployment of NL-Alert, $n = 643$).

	M	sd	8	7	6	5	4	3	2
1. Adaptive behavior	1.69	0.28	0.07	0.10	0.20**	0.23**	0.01	0.33**	0.39**
2. Avoidance	1.28	0.45	0.06	0.09	0.27**	0.16**	−0.03	0.39**	
3. Affect (Emotion)	1.97	0.71	−0.07	−0.02	0.29**	0.11**	−0.18**		
4. Perceived message quality	4.34	0.78	0.39**	0.33**	−0.02	−0.03			
5. Social norm	2.25	1.04	0.11**	0.16**	0.25**				
6. Perceived threat	2.68	0.86	0.04	0.28**					
7. Efficacy beliefs	3.94	1.02	0.39**						
8. Information sufficiency	3.66	1.09							

**$p < .01$.

Table 5. Regression of concepts on self-reported adaptive behavior, self-reported behavioral avoidance and information sufficiency in the total sample, as well as the regression of information sufficiency on adaptive and avoidance behavior ($N = 643$). Reported are standardized beta's.

	Adaptive behavior	Behavioral avoidance	Information sufficiency
Affective reaction (Emotion)	0.31***	0.30***	ns
Perceived warning quality	0.05*	ns	0.29***
Social norms	0.15**	0.08*	0.08*
Perceived threat	ns	0.16**	ns
Efficacy beliefs	ns	ns	0.29***
Information sufficiency	ns	ns	

*$p < .05$; **$p < .01$; ***$p < .001$; ns = non-significant.

in Meppel and Oisterwijk is very similar ($M = 2.3$, 'somewhat disagree'). In Leeuwarden, the average is somewhat lower ($M = 2.1$). With respect to information sufficiency in Meppel and Oisterwijk the average score is 3.6 (between 'not disagree/not agree' and 'somewhat agree'). In Leeuwarden information sufficiency is considerably lower ($M = 3.0$, 'not disagree/not agree'). The perceived warning message quality was assessed with 12 items (9 in Leeuwarden, see Appendix 1). In all three samples, the average scores are relatively high ($M = 4.3$).

Regression analysis was used to find the predictive value of the concepts we assessed in the study on the dependent variables (adaptive behavior, avoidance, and information sufficoency (see Table 5 for details), after inspecting the correlation coefficients (see Table 4). It was assessed to which extend socio-cognitive variables (perceived threat, efficacy beliefs), emotions, social norm and perceived message quality, as well as information sufficiency, predict the self-reported adaptive behavior after the reception of a warning message. In Table 5 the same set of variables is used to predict behavioral avoidance. We also assessed the predictive value of the used concepts on information sufficiency.

The self-reported adaptive behavior could be predicted with the set of variables moderately well ($R^2 = .16$, $F_{(6,637)} = 10.64$, $p < .001$). Of the assumed predictors of adaptive behavior three were found to be significant (Emotion; $p < .001$; Social norms, $p < .01$; Perceived message quality $p < .05$).

Behavioral avoidance was also predicted by this set of variables to a similar extend as self-reported behavior ($R^2 = .16$, $F_{(6,602)} = 19.55$, $p < .001$). Of the used variables, perceived threat ($p < .001$), emotion ($p < .001$) and social norm ($p < .05$) predicted behavioral avoidance significantly.

Information sufficiency after the deployment of NL-Alert was predicted by the used variables too, even a bit better than adaptive behavior or avoidance ($R^2 = .23$, $F_{(5,646)} = 38.99$, $p < .001$). Three of the assumed predictors of information sufficiency were found to be significant (Efficacy beliefs and Perceived message quality at $p < .001$; and social norm at $p < .05$).

5. Conclusion and discussion

This paper set out to measure the behavioral effects of receiving an NL-Alert warning message on a mobile phone in the Netherlands. NL-Alert is a rather new tool in the context of emergency warnings

enabling the authorities to inform the public about (immiment) threats and to provide the public with tailor-made, instant advice on how to deal adequately with a threat. As was suggested earlier by Bean et al. (2015) the insight what effects these messages might have on the public at-risk is lagging behind the technological developments. After the introduction of the NL-Alert system in November 2012, it has been applied in several emergency situations. This study is the first to assess the effectiveness of the new tool. It does so by analyzing the predictive value of perceived threat, efficacy beliefs, social norms, information sufficiency, and perceived message quality on adaptive behavior, behavioral avoidance, and information sufficiency, in three separate emergencies.

The data in this study lead to several conclusions. Adaptive behavior and behavioral avoidance as a consequence of receiving an NL-Alert warning can be predicted with the determinants that were identified from the current literature.

The conclusion is that people are more likely to perform adaptive behavior when emotions run higher, when there is some social pressure perceived, and when the warning message quality is seen as higher. This result confirms the importance of affective reactions as a driver for behavior (e.g. Slovic et al. 2007). Even though cognitive factors like assessed message quality are obvious prerequisites for behavior, our results show that emotions and social environment are main predictors for actually performing the required behavior.

Interestingly, people seem to be inclined to avoid the warning when emotions run high too, in combination with a higher level of perceived threat, and the perceived external pressure. The main difference with adaptive behavior is that behavioral avoidance is also predicted by perceived threat. As noted by Witte and Allen (2000) behavioral avoidance occurs when people do perceive threat but do not have the coping mechanisms to deal with it. Even though coping is mostly operationalized by efficacy, the assessment to be able to deal with the situation at hand, emotions presumably affect coping too. When emotions run high citizens may in theory by able to perform the requested behavior but inhibited by for example fear. Our measurement of affective state mainly concerned arousal level; higher scores meant that people felt more worried or concerned. We therefore did not distinguish between specific emotions such as anger or fear. Future research could make a disctinction between these qualitative emotional states as to provide a well-founded explanation for the role of emotions in more or less adaptive behaviors.

The importance of emotions and social context may also be related to the fact that we measured behavior in real emergency situations. Respondents were phoned within 48 h after the incident occurred, granting our results high validity. Generally, future emotions (and related behavior) are hard to imagine when people are in a relatively unemotional state (Loewenstein 2005; Nordgren, Banas, and MacDonald 2011). Measuring behavior in real emergency situations therefore provides increased opportunities to actually assess emotional effects.

Looking in more detail at the reactions of the public to receiving the NL-Alert warning some findings are noteworthy (all measures on five-point scales). The warning resulted in below midpoint levels of emotion ($M = 2.0$), social norm ($M = 2.3$), and perceived threat ($M = 2.7$), but above midpoint levels of perceived information quality ($M = 4.3$), information sufficiency ($M = 3.7$), and efficacy beliefs ($M = 3.9$). So, in absolute terms emotions and perceived threat were not high, which seems reasonable regarding the type of emergency events. The other scores indicate that on average people were very satisfied with the information provided, and perceived their coping possibilities as relatively high. The main explanation for these scores is that the emergencies had relatively little personal impact for most participants. However, even in this relatively low impact situations, we still found three significant predictors of behavior. Presumably, when the personal impact is higher, the effects of emotions and social environment are even larger.

After an emergency warning, self-reported behavior is predicted with a small set of determinants. This behavior is predicted positively by Emotion, Social norms and Perceived warning quality. Apparantly, in this study the socio-cognitive elements of perceived threat and efficacy beliefs are not related directly to self-reported adaptive behavior. The maladaptive avoidance reaction is to a certain extend also predicted by the variables used in this study. After receiving a warning message, a higher risk perception, a

higher level of emotions and more perceived expectations from one's social environment seem to result in a higher avoidance probability. More avoidance with more emotions and perceived risk seems to be in accordance with literature (Floyd, Prentice-Dunn, and Rogers 2000; Witte and Allen 2000). It is an unexpected result that efficacy beliefs do not seem to play a role in predicting adaptive behavior, nor in predicting avoidance. Several explanations come to mind here that are related to the study design. Adaptive and maladaptive behavior and the efficacy beliefs were measured some days after the event. Perhaps the delay explains the results. People undoubtedly had seen developments to a more stable non-emergency situation. It cannot be ruled out that these newer experiences have positively biased their earlier reactions after the reception of the NL-Alert warning message. Another observation is that the explained variance is not very high (16% for both adaptive and avoidance behavior) and the number of significant predictors is relatively low. This may be partly due to measurement issues: Self-reported behavior was measured (by phone) with items that asked for a yes/no answer, reducing variance. In addition to this behavioral avoidance was measured with a single item.

Information sufficiency is a concept that is of importance for adequate coping with emergency informations, or in the preparation for those situations (Griffin, Dunwoody, and Neuwirth 1999; Ter Huurne 2008). Information sufficiency is also predicted with three variables (perceived warning quality, efficacy beliefs and socials norms) and somewhat better than the behavioral variables (23% explained variance). Apparently, people are more satisfied with their own level of information about the emergency when they appreciate the warning quality higher, when they think they are better able to cope with the threat, and when their perceived social expectanties are higher. However, the present results indicate that it plays a rather complex role in dealing with an emergency warning, because no predictive value was assessed for both behavioral measures. It is unclear how to interprete these findings. Are they the result of the study design, or is the role of information sufficiency in the emergency warning process not yet conceptualized completely? Additional studies are needed here.

There are some limitations and suggestions for future research that are worth mentioning. The first limitation is that even though the incidents were realistic and significant enough to send an alert, they were not major in the sense that they were life threatening. We believe that our results are relevant for these incidents as well, but they may not be completely generalizable to more severe situations. Relatedly, as mentioned above, we did not make a distinction between qualitative emotions like anger of fear. Future research could be geared towards these different emotional states as to provide more insight into the relation between affect and types of behavior such as adaptation and avoidance.

A main advantage of alerting systems in comparison to for example sirens is that specific groups can be reached and behavioral recommendations can be provided suited for the situation at hand. As such these kind of alerting systems are tailor-made. However, as also noted by Bean et al. (2016) *standard* messages such as used by NL-Alert could also be viewed as rather impersonal. Different people may need different information, such as dog owners or parents with children at school. It could be argued that more personalized information attributes to more adaptive behavior. Future research is needed as to identify how such differences can be assessed and how it relates to information need and recommendations for action.

Notes

1. The Netherlands has 25 Safety regions, which are the administrative and operations centers for disaster management.
2. More information on the technical aspects of cell broadcast on Wikipedia. (https://en.wikipedia.org/wiki/Cell_Broadcast).

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Appendix 1

NL-Alert was deployed in emergency situations in the Dutch cities Meppel, Oisterwijk, and Leeuwarden. Data were collected by TNS-NiPO. Respondents were approached via mobile and fixed line telephone numbers.

The first actual measurement was done in Meppel (approx. 38,000 inhabitants, in the northern province of Drenthe). On Sunday 20 January 2013 in the afternoon a major fire in an industrial building was reported. The fire caused a lot of smoke with concern of hazardous particles that was blown in the direction of nearly residential areas. The material damage was severe, no personal harm was done. The NL-Alert was:

NL-Alert 20–01-2013 14.50 Setheweg Meppel. Major fire. Keep clear of the smoke! Close windows and doors. Turn off ventilation. New message follows.

In June 2013 a second actual deployment was monitored. This deployment related to a fire in the industrial estate in Oisterwijk (approx. 20,000 inhabitants in the southern province of Northern Brabant). The fire started after an explosion on Thursday 20 June at 5:30 AM in a factory producing firelighters and charcoal briquettes (with the ominous name 'Fire up').The smoke spread across the nearby cities of Oisterwijk and Tilburg (with 1,91,000 inhabitants). Nobody was injured, but the material damage was substansive. The NL-Alert was:

NL-Alert 20–06-2013 Fire in Oisterwijk, Laarakkerweg. A lot of smoke. As a precaution close doors and windows and turn off ventilation.

The third and last monitored deployment was in October 2013 in Leeuwarden (approx. 1,08,000 inhabitants, capital city of the northern province of Friesland). The historic city center was the scene of a major fire on Saturday 19 October. The fire started around 17:30 in a shop, around midnight the fire still was not under control. Dozens of people living nearby were evacuated from the scene. One person died and five shops and 11 houses were completely destroyed. The NL-Alert was:

NL-Alert: NL-Alert 19–10-2013 20:05 Large fire with smoke. Stay out of the smoke! Close windows and doors. Turn off ventilation. New message follows.

Because this last message had no indication of location, so in the measurement instrument applied in Leeuwarden no questions about location were included.

Appendix 2

In all samples the man/woman ratio is compatible (49–54% women, respectively). The average age of the participants is approx. 48 years (46.8–50.3-y/o, respectively). With respect to their formal educational level the three samples are compatible. Approx 10% of the participants report no formal education, only primary education or introductory vocational training (8–11%, respectively). Almost half the sample reports secondary education (44–52%, respectively). A bachelor or master's degree is reported by over 40% (41–46%, respectively) (see Table 6).

Table 6. Response rates (Numbers and percentages) of the three samples used in the true emergency situations in Meppel, Oisterwijk, and Leeuwarden). Reported are CATI and CAWI response rates (phone and online research, respectively), as well as the receipts of the NL-Alert warning message.

	Meppel (20.1.2013)		Oisterwijk (20.6.2013)		Leeuwarden (19.10.2013)	
	N	%	*N*	%	*N*	%
CATI+CAWI completed (net samples used in the analyses)	175	17	181	15	287	26
CATI, outside target group[a]	618	60	672	55	102	9
CATI completed, CAWI not started	109	11	183	15	409	37
CATI completed, CAWI partly completed	99	10	155	13	280	25
CATI not completed	31	3	23	2	44	4
Total gross sample	1032		1214		1122	
NL-Alert received personally	102	24.6	201	37.1	111	11.0
NL-Alert received via another person	85	20.5	66	12.2	87	8.6

[a]Meaning: did not live or work in the area where the emergency occurred.