Psychological Aspects of German Signal Words in Evacuation Warnings

Laura Künzer, Gesine Hofinger, and Tina Zink

Friedrich-Schiller-Universität Jena, Department of Intercultural Business Communication, Germany
University of Regensburg, Department of Psychology, Germany
{laura.kuenzer, gesine.hofinger}@uni-jena.de
{zink_tina@yahoo.de}

Abstract. Signal words in evacuation warnings have an alerting and informing function related to the degree of danger. The psycho-acoustic urgency of the signal word used should match the contextual urgency (urgency mapping). In two experiments, characteristics of five German signal words were tested in the context of underground transportation systems. Participants rated the dimensions semantic field, urgency and explicitness for the German signal words. The German signal words were presented individually (exp.1) or embedded in different loud speaker announcements with varying voice styles (exp.2). As expected the ranking order for urgency was the same as for explicitness. Data showed that "Gefahr" is perceived as most urgent and most explicit. "Hinweis" is least urgent and least explicit. For the other three signal words used ("Vorsicht","Warnung", "Achtung") no clear order was found. "Achtung" is familiar in German announcements and warnings which influenced the ratings. Conclusions for the design of evacuation announcements are drawn.

Keywords: spoken warning, signal word, urgency, explicitness, semantic field, evacuation

## 1　Introduction and motivation of the study

Warnings play an important role in evacuation. In general, warnings carry four functions: They provide safety information, they are created to influence human behavior in a certain way, and they aim at avoiding or reducing injury and loss of life, and are also reminders for widely known dangers (Wogalter, 2006; Wogalter & Laughery, 2006). The recipients must be able to act according to the warning which implies understanding of its meaning, reflect the importance of the warnings to the recipient (personalizing), knowing what to do (leave the site) and doing it which is usually named compliance behavior (Fitzpatrick & Mileti, 1994). However, the meaning of a warning is often not clear or cannot be understood properly. Habituation, due to frequent use of a warning without actual danger, can influence the effectiveness of a warning, too (e.g. cry-wolf syndrome; Breznitz, 1984; Tubbs & Meacham, 2007). The

issue of poorly designed warnings has been addressed for the last two decades. For instance, Sime (1995) reports one example: During an unannounced evacuation exercise in an subway station in Great Britain, the warning given was very imprecise and did not contain specific instructions. Hence, passengers started to gather information instead of leaving the station immediately. If warnings lack information or contain unclear meaning, people will spend valuable time on information retrieval instead of leaving the site (Tubbs & Meacham, 2007). Thus, the time until an evacuation can start could be reduced significantly by warnings that include precise instructions.

It is essential for safe egress to provide adequate information about the danger at hand. Hence, warnings have - apart from an alerting function - an informing function regarding the source and consequences of danger as well as the necessary action (Wogalter & Laughery, 2006). The informing aspect is mainly related to information that is processed consciously whereas the figurative aspect ("iconic aspect") is perceived more or less subconsciously and gives implicit information about underlying meanings of a warning. In general, recipients react automatically to iconic aspects of a warning (Edworthy & Adams, 1996).

An important iconic part of visual and verbal evacuation warnings are signal words such as "ATTENTION", "WARNING", "NOTICE" (Edworthy & Adams, 1996; Edworthy, Hellier, Walters, Clift-Matthews & Crowther, 2003; Hellier, Aldrich, Wright, Daunt & Edworthy, 2007). Leonard, Otani and Wogalter (1999) describe signal words as "specific words intended to alert people to the presence of a hazard and the level of danger involved"(S.176), and Rogers, Lamson and Rousseau (2000) define signal words as "word denoting level of hazard" (S.107). Consequently, not every signal word used in natural language is appropriate for every safety message. The response to a signal word will partly depend on the connotations or semantic field of the signal word. For English signal words, the semantic field has been researched for at least two decades (e.g., Edworthy et al., 2003 Hellier et al., 2007; Wogalter & Laughery, 2006). Relevant dimensions are perceived hazard, arousal strength, intended carefulness, and perceived urgency. For example, "NOTE", "NOTICE", "ATTENTION" seem to convey less danger and urgency than "DANGER" or "WARNING" (Edworthy et al., 2003).

Another important iconic aspect of warnings is urgency. The concept of urgency mapping emphasizes that the urgency of a warning must be related systematically to the actual context or the degree of danger (e.g. Edworthy & Adams, 1996; Edworthy, et al., 2003). In that way, recipients can understand intuitively the danger at hand, react faster and compliant with a warning (Laughery et al., 1993). In many cases, warnings are designed by the company's marketing department; sometimes the department only defines few words for spoken warnings. As a result, the perceived urgency of a warning might be inappropriate as the wording of the warning does not match the actual degree of danger (Figure 1a shows inappropriate urgency mapping). Urgency mapping not only stresses the need to design warnings carefully, but also highlights the difficulty of designing to provide appropriate urgency (Figure 1b). Urgency mapping can be applied to different modalities and aspects of warnings. In this paper the focus is on German signal words and spoken evacuation warnings.
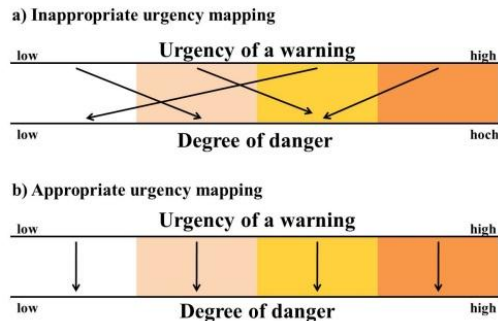
Fig. 1. a) Inappropriate urgency mapping; b) Appropriate urgency mapping (according to Edworthy & Adams, 1996, p. 7; modified by Zink, 2012, S. 27)

Explicitness of the signal word, the semantic field, and the level of perceived urgency are important for spoken warnings. Explicitness should emphasize "the specificity or detail with which potential injury consequences are described. […]. More explicit warnings present information about consequences in greater detail […]." (S. 598; Laughery, Vaubel, Young, Brelsford Jr. & Rowe, 1993). Explicitness is an important factor (in the process) of urgency mapping because the more explicit the warning is the more information about an actual danger, consequences or even behavioral directive are conveyed (Hellier et al., 2007). Therefore, when designing a warning the psycho-acoustic urgency of the signal word used should match the contextual urgency and the content of the warning (congruity).

English signal words have been investigated in numerous studies (e.g. Hellier, Aldrich, Wright, Daunt & Edworthy, 2007) whereas research on German signal words is still missing (Zink, 2012). To our knowledge, no studies on urgency mapping or application of German signal words in spoken evacuation warnings have been conducted. Therefore we conducted two experiments to investigate the design of effective evacuation warnings (loudspeaker announcements) using German signal words. The first part of this study dealt with the mapping of German signal words on the dimensions of semantic field, explicitness and perceived urgency. The second part of the study investigated the influence of signal words in complete spoken evacuation warnings that should initiate evacuation behavior.

Five German signal words were analyzed in two consecutive experiments. As described earlier, signal words in the context of danger can be operationalized according to several dimensions, e.g. hazardousness, intended carefulness. Especially the dimensions urgency, explicitness and semantic field were examined. However, the results also emphasized the impact of context and content, especially in spoken evacuation warnings.

In both experiments the same set of German signal words was selected: ACHTUNG – GEFAHR – HINWEIS – VORSICHT – WARNUNG. Some of these signal words have been suggested by standards (e.g. itl, 2009) to be used as translations for English signal words (GEFAHR = DANGER; VORSICHT = CAUTION; WARNUNG = WARNING). Furthermore, ACHTUNG (literally translated: ATTENTION) was cho-

sen because it is one of the most commonly used signal words in German warnings and it is often suggested as translation for CAUTION or IMPORTANT. The signal words ACHTUNG, GEFAHR, VORSICHT and WARNUNG were expected to represent a moderate to high level of urgency. The German signal word HINWEIS (= NOTICE) was included as a low level counterpart. In both experiments, participants rated several aspects of the signal words on a 6 point rating scale ranging from "extremely strong/urgent/explicit" to "not strong/urgent/explicit at all" (Drake, Conzola & Wogalter, 1998; Hellier et al., 2007; Wogalter & Silver, 1990). In this paper, only selected results will be discussed. For a detailed description of method, material and discussion see Zink (2012).

The results of this study are to be used in a research project on human factors in evacuation from underground transportation systems (OrGaMIR[Plus,] see acknowledgements). Thus, the specific context of loud speaker announcement in subway stations was chosen.

2 Experiment 1: Influence of semantics on perceived urgency in the context of subway systems

Design and Sample.
Experiment 1 analyzed the five German signal words according to the three dimensions: semantic field (= Bedeutungsfeld), urgency (= Dringlichkeit), and explicitness (= Deutlichkeit). The key hypothesis of this study suggested a clear ranking order of the signal words for all three dimensions (GEFAHR – WARNUNG – VORSICHT – ACHTUNG – HINWEIS), while the ranking order for urgency was expected to be the same as for explicitness. The signal words were presented visually, black letters on white background, on a computer screen to offer the most neutral form of presentation.

51 native German speakers (male = 13) participated in experiment 1. Personal information recorded included e.g. amblyopia, and frequency of use of subway systems. Participants had to be native German speakers.

In experiment 1, questions (Q1 to Q8) had to be answered for all five signal words. In a first step all five signal words were presented in a random order. After each signal word, participants had to indicate to what extent they perceived each word as a warning in general. Afterwards participants were instructed to imagine they were waiting for the subway train on a platform when hearing an announcement which included one of the signal words; the context was emphasized by two pictures of subway stations. Then, the five signal words were presented in random order After each signal word participants answered seven questions concerning the dimensions "semantic field" (Q2), "urgency" (Q3-Q6) and "explicitness" (Q7; Q8).

Results.
The mean ratings of the signal words for the three dimension semantic field, urgency and explicitness are presented in figure 2.
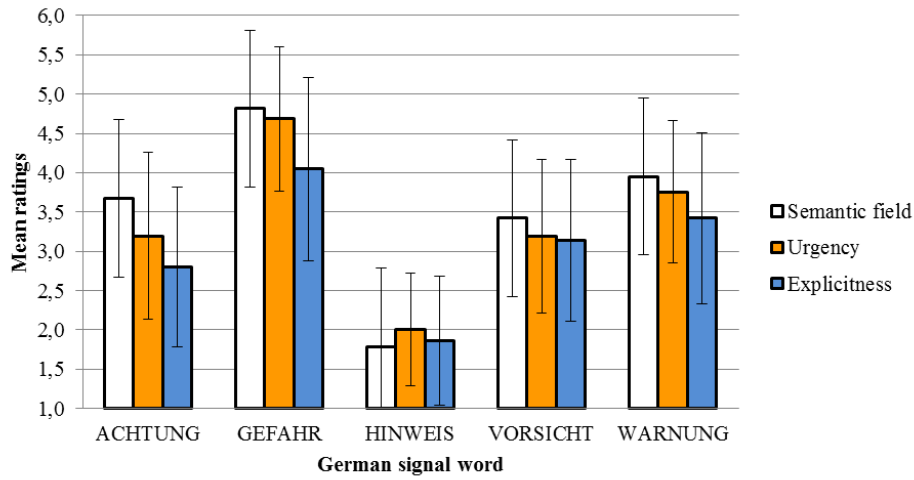
Fig. 2. Mean ratings and standard deviation of signal words for each dimension (semantic field, urgency and explicitness).

As expected, GEFAHR was rated highest for every dimension; HINWEIS was rated lowest for every dimension.

The frequency distributions of the dimension urgency was further analyzed (Fig. 3).
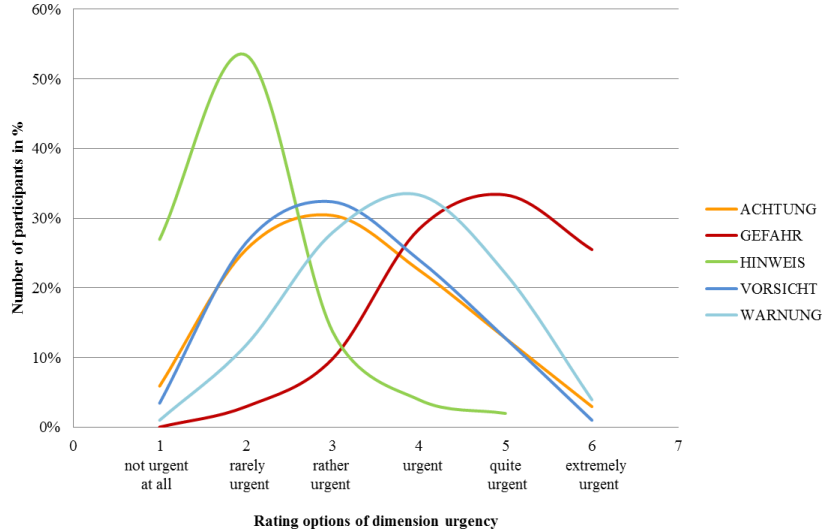
Fig. 3. Frequency distributions of dimension urgency with respect to the six point rating scale.

The distribution of HINWEIS showed the most prominent peak at "not urgent at all" and was the only signal word that was never rated "extremely urgent". The distribution of GEFAHR showed a left-skewed distribution, GEFAHR was rated more often

"extremely urgent" and "quite urgent" than all other signal words, and GEFAHR was never rated as "not urgent at all".

Three signal words (ACHTUNG, VORSICHT, WARNUNG) revealed mediate levels of urgency. To further analyze these words, a one-way ANOVA was conducted which showed a significant main effect for the factor signal word ($F_{(1,4)}= 90.21$, $p<.001$). Additionally, paired comparisons with repeated measures ANOVAs were conducted for all dimensions. Simple correlations between all three dimensions showed positive correlations for all paired comparisons. The dimensions urgency and explicitness revealed a strong positive correlation ($r = .73$, $p<.001$)
Table 1 shows the ranking order for all three dimensions.

Dimension	Rank 1	Rank 2	Rank 3	Rank 4
Urgency	GEFAHR	WARNUNG	ACHTUNG VORSICHT	HINWEIS
Explicitness	GEFAHR	WARNUNG	VORSICHT ACHTUNG	HINWEIS
Semantic field	GEFAHR	WARNUNG ACHTUNG	VORSICHT	HINWEIS

Table 1. Ranking order of signal words separated by the three dimensions urgency, explicitness and semantic field.

A clear ranking order of the five signal words, the ranking order for urgency being expected the same as for explicitness. Table 1 shows that the expected ranking order was found for the extreme levels (GEFAHR and HINWEIS). For the mediate level no clear ranking order for the signal words WARNUNG, VORSICHT, ACHTUNG within all three dimensions was found, but ranking orders for explicitness and urgency were the same. The mapping of five German signal words seems to be ambiguous. More signal words should be taken into consideration in order to get clearer ranking orders. Furthermore, we suggest that further research is necessary, mere translation of signal word as often suggested in norms seem not appropriate, especially with respect to international use of signal words, e.g. English into German.

3   Experiment 2: Effects of German signal words in spoken evacuation announcements in the context of subway systems

Design and Sample.
The design of experiment 2 used the four fundamental elements of warnings. The focus was on the dimension urgency of German signal words. We expected that perceived urgency of a spoken evacuation warning might not only be influenced by the signal word itself. Hence, we seek to further examine the effect of the semantics of

the four warning elements on perceived urgency (see Table 2). Different levels of urgency were implemented using voice style, information about the source of danger and consequences of the situation.

In experiment 2, the signal words were integrated in spoken warnings consisting of the four fundamental elements (Sanders & McCormick, 1993; Wogalter, Conzola & Smith-Jackson, 2002):

Element 1	Element 2	Element 3	Element 4
Signal word	Information about situation/ existing hazard	Explanation of consequences of situation/hazard	Behavioral directives for avoiding the hazard

Table 2. Overview of the four fundamental elements of warnings

All of the four elements were applied in the spoken evacuation warnings ("complete warnings") and the sequential arrangement (1-4) of the four elements was retained through the whole experiment. The signal words were the same as in experiment 1. The information about the situation/existing hazard conveyed information about two emotionally neutral situations ("current information"; "technical malfunction") and two situations which were expected to be considered as dangerous ("fire development[1]" and "dispersion of gas"). The explanation of consequences of the situation/hazard named one neutral consequence ("Train operations will be stopped!") and one consequence that was supposed to convey risk for the physical well-being of the recipient ("Your health may be at risk!"). At the end of the evacuation warning there was only one behavioral directive offered ("Leave the subway station!") as in a subway system this would be the appropriate action following an evacuation warning. The announcements resulting from the combination of these factors are presented in table 3.

The spoken evacuation warnings were recorded by a professional female announcer in an urgent and non-urgent voice. Before recording, specific instructions were given to the announcer for each voice style. One instruction was designed to focus on a neutral situation and aimed at recording a voice with a neutral pitch. The other instruction aimed at producing an urgent voice style by asking the speaker to imagine a situation where a beloved person was in danger.

Table 3 shows all warning variables and related values of variables used in experiment 2. Due to the large number of variables only 28 combinations (14 urgent and 14 non-urgent combinations) were selected to permit comparative testing of the spoken evacuation warnings.

41 participants (male=10) unknown to the first experiment participated took part in experiment 2. Personal information was recorded including e.g. hearing problems and frequency of use of subway systems; all participants were native German speakers.

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[1] The word we used, "Brand", is not a signal word itself in contrast to „Feuer"(= fire) in English.

	Variable	Values of variable	Code
0	Voice style	non-urgent	nd
		urgent	dr
1	Signal word	ACHTUNG	A
		GEFAHR	G
		HINWEIS	H
		VORSICHT	V
		WARNUNG	N
2	Information about situation/ existing hazard	Current information (Aktuelle Informationen)	1
		Technical malfunction (Technische Störung)	2
		Fire development (Brandentwicklung)	3
		Dispersion of gas (Gasausbreitung)	4
3	Explanation of consequences of situation/hazard	Train operations will be stopped! (Der Bahnbetrieb wird eingestellt!)	BB
		Your health may be at risk! (Ihre Gesundheit könnte beeinträchtigt werden!)	GS
4	Behavioral directives for avoiding situation/ hazard	Leave the subway station! (Verlassen Sie den U-Bahnhof!)	No code

Table 3. Overview of variables and values of variables of experiment 2. Codes were used to specify different versions of spoken evacuation warnings, e.g. drH3GS[2].

Participants were instructed to imagine they were waiting for the subway train on a platform when hearing an announcement. The context was illustrated by two pictures of subway stations. All 28 spoken evacuation warnings were presented to the participants via headphones. Participants had to answer four questions regarding the dimension urgency (Q3-Q6 of experiment 1) after each warning. The questions were slightly customized in experiment 2. At the end, participants were asked to answer five reflective questions concerning experiment 2.

Results.
Some important results are (for a detailed description see Zink, 2012):

- As intended (expected), participants perceive an urgent voice style as more urgent than the indifferent / neutral voice style.
- As expected, GEFAHR received the highest urgency ratings; HINWEIS the lowest ratings. Surprisingly, ACHTUNG achieved second highest urgency ratings, followed by WARNING and VORSICHT. Similar to experiment 1, no clear ranking

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[2] Combination "drH3GS" = (urgent voice style) HINWEIS! Fire development: Your health may be at risk! Leave the subway station!

order was found in experiment 2. Mean ratings of variable signal words on dimension urgency are presented in figure 4.
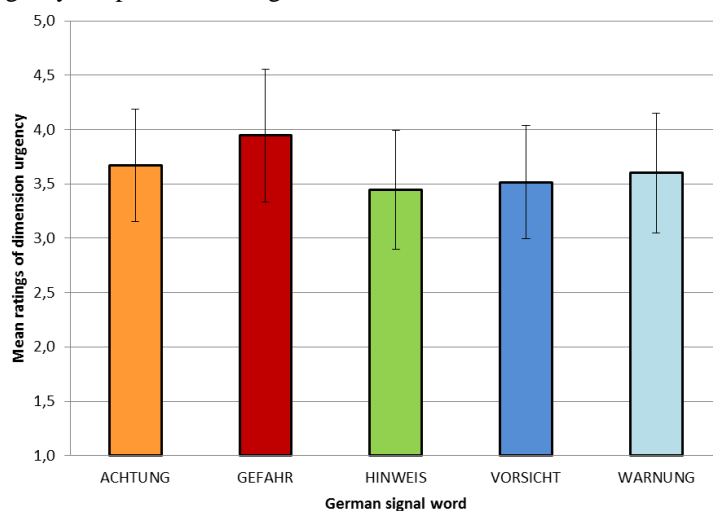
Fig. 4. Mean ratings and standard deviation of five German signal words arranged by the dimension urgency (obtained from data of all spoken evacuation warnings).

- **Importance of context**: An interaction of the variable "Information about situation/ existing hazard" and "Explanation of consequences of situation/hazard" was found. Therefore, a new combined variable "context" was composed for further analysis The variable "context", has three values: *neutral context* ("Current information"/ "Technical malfunction" combined with "Train/Rail operations will be stopped"), *dangerous context* ("Fire development"/"Dispersion of gas" combined with "Your health may be at risk!") and *mixed context* ("Current information"/ "Technical malfunction combined with "Your health may be at risk!"; or "Fire development"/"Dispersion of gas" combined with "Train operations will be stopped"). The results showed that the dangerous context conveys a higher degree of urgency than neutral context and thus emphasizes the importance of context in spoken evacuation warnings.

- **Influence of voice style**: Interactions between signal word, context and voice style were found in a repeated measure three-way ANOVA ($F (1.4) = 54.02$; $p < .001$, $\eta_p^2 = .58$): Voice style and context seem to increase a signal word's urgency. But with respect to ACHTUNG, further analysis showed that rankings in urgency for ACHTUNG showed different interaction effects for the variables context and voice style. Hence we concluded the high ratings of ACHTUNG in perceived urgency to be influenced by other variables, e.g. congruity (see Figure 5).

- **Congruity within spoken evacuation warning**: congruity of the four elements of a warning seems to play an important role with respect to perceived urgency of a warning. Congruity represented the "compatibility" of variables within a complete

warning: For instance, ndH1BB[3] and drG3GS[4] were considered to be congruent because the composition of these warnings showed no internal contradiction whereas ndH3GS[5] for example was considered as incongruent. Results revealed more extreme ratings ("extremely urgent" or rather "not urgent at all") for congruent warnings. Consequentially, congruity should be considered as important factor in urgency mapping of spoken warnings. These results are in accordance with the literature suggesting congruity to increases the credibility of a spoken warning (Edworthy, J, Clift-Matthews & Crowther, 1998; Edworthy, Judy et al., 2003).
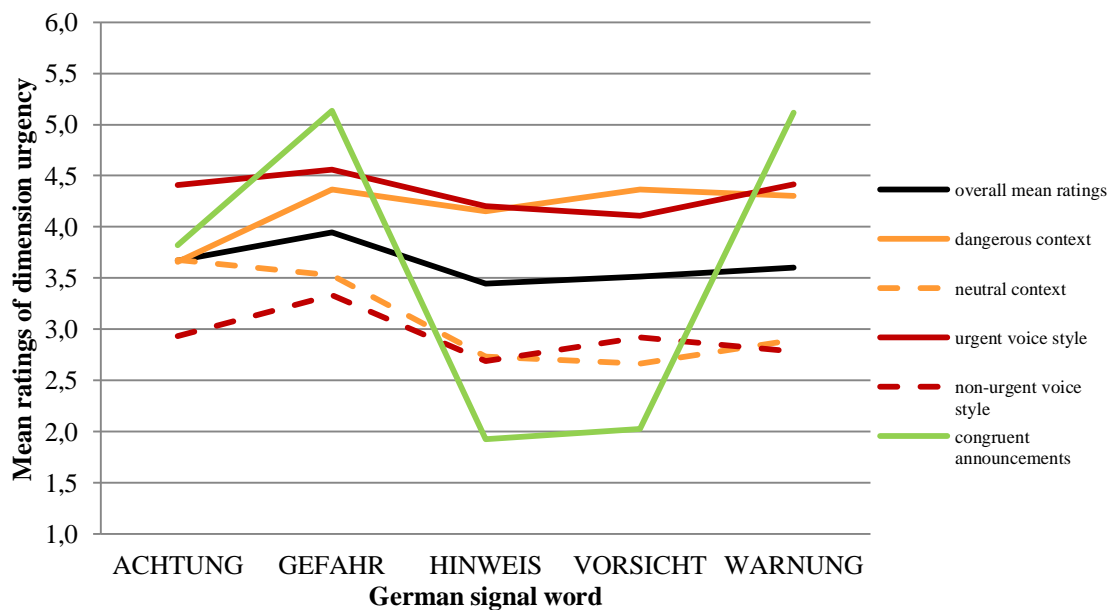
Fig. 5. Overall mean urgency ratings for the German signal words and mean ratings for the variables context, voice style and congruity.

At the end of experiment 2, participants were asked to answer reflective questions:

The participants were asked if they had detected different signal words in the beginning of the warnings and if they were able to recall the signal words used (without having being instructed to remember the signal words at the beginning of the experiment). 41% of participants remembered at least one signal word. ACHTUNG was

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[3] Combination "ndH1BB" = (non-urgent voice style) HINWEIS! Current information: Train operation will be stopped! Leave the subway station!

[4] Combination „drG3GS"= (urgent voice style) GEFAHR! Fire development: Your health may be at risk! Leave the subway station!

[5] Combination „ndH3GS"= (non-urgent voice style) HINWEIS! Fire development: Your health may be at risk! Leave the subway station!

remembered most often (88%), followed by GEFAHR (59%), HINWEIS (54%), WARNUNG (39%) and VORSICHT (34%). ACHTUNG has been suggested to be one of the most often used German signal words, so the high ratings of ACHTUNG on dimension urgency in spoken evacuation might arouse from the frequent use and awareness of participants for this signal word. Even though ACHTUNG seems to imply a moderate level of urgency (for the participants). It is unclear how the frequent use of ACHTUNG influences the ratings identification.

Another question concerned the credibility of the spoken warnings. Credibility was defined as colloquial expression (Greuel, 2001). Over a quarter of the participants (27%) stated that the urgent voice style was not credible, because the voice style sounded hysterical and exaggerated and they wouldn't expect a voice style like that in a subway announcement. 22% participants stated the non-urgent voice style to be incredible because the spoken warnings sounded too monotone, bored and indifferent. Some participants reported that a non-urgent voice style increased (personal) importance of the spoken warnings whereas other participants reported that the voice style did not draw attention to the contents of the warning. Other participants (22%) stated both voice styles to be credible. 37% of participants stated that a spoken warning had little credibility when voice style and contents of the spoken warning did not fit ("lack of congruity"). So, the influence of congruity was reconfirmed by the participants.

4 Discussion and conclusions

Our research indicates the variables "German signal words", "context" and "voice style" to have differentiated effects on the perceived level of urgency of spoken evacuation warnings. The effects and interactions of these variables seem to have more impact than expected. The results extended our initial expectations, the following aspects were concluded:

- Urgency mapping needs closer consideration and application in standards for evacuation warnings. Our findings suggest varying degrees of urgency depending on variables (German signal word; context; voice style) and warning combinations. By standardizing the use of signal words in warnings and announcements, a determined level of urgency might implicitly be conveyed to the listener and thus increase effectiveness of the presented warning. The signal words GEFAHR or WARNUNG or VORSICHT should not be combined with advisories or passenger information. HINWEIS on the other hand should not be used for spoken evacuation warnings or emergency warnings in general.

- In general, using a signal word in a warning is better than not using a signal word. But our results raise questions concerning the use of ACHTUNG. ACHTUNG, as expected, was mentioned by the participants to be the most frequent used German signal word and was remembered best by participants. Memory effects of urgency are still unknown. However this might offer valuable approaches to warning design in the future. Due to the frequent use of the German signal word ACHTUNG in

other (written and spoken) warnings, ACHTUNG should be used with care in in evacuation warnings.

- Voice style was found to be effective in arousing attention but also showed problems concerning credibility, especially if the voice style was considered to be too monotone or too hysterical for a publicly spoken announcement. Finding the right balance, especially for avoiding emotions of fear and attitudes of complacency, will be a challenge for warning design in specific contexts. In subway systems, the use of an alarm signal to announce a following spoken warning in a normal vocal range (non-urgent voice style in experiment 2) should be used. The latest developments of synthesized speech might make the use of artificial voices more appropriate.
- A spoken evacuation warning should be presented completely, containing all four fundamental elements of a warning, but also has to be kept as short as possible. "Information on the current situation", "Explanation of consequences" and "behavioral directives" will help the receiver of a spoken warning to adopt the personal involvement Therefore, the receiver will start the evacuation without hesitation. However, time to listen, if necessary, the presentation in different languages which prolong presentation times and restricted attention span, might have negative effects on the perception of a spoken warning. Therefore, words like "please", "Dear passengers" were avoided in the experiment and should be avoided in spoken evacuation warnings, too.

Warnings are not supposed to substitute safety precautions, rather proper warnings must be designed in a safety system in addition to other safety precautions. The presented experiments highlight the complexity of and challenge to designing spoken evacuation warnings adequately. Hence, research on German signal words and warnings has to be extended.

The results presented in this paper suggested semantic differences concerning the different elements of warnings and its/their context dependency. A next step in our research will include a comparison of these findings with US data.

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