COGNITIEF

Persuasive systems for safety

Many accidents and injuries at workplaces are caused by violations against safety regulations, like the use of personal protective equipment. Instead of trying to enforce safe behavior by controls and sanctions we tried to assist users by showing them computer-generated reminders at the most relevant moments. To gain insight in the psychological processes, we tested the impact of different looking reminders against each other. Surprisingly, a laboratory study shows that a reminder per se has lesser impact on the behavior than its optical appeal. These results strongly advocate to not only consider the information of computer output concerning safety or warning signs, but also their shape and psychological impact.

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What is persuasive technology?

Have you ever been in an online store and bought more articles than originally intended because the webpage literally 'guided' you to the products you like and to the checkout? Have you ever received emails that advertised exactly the kinds of products you are interested in? Have you spend more time than intended on websites which employed animated characters? If so, you probably encountered persuasive technology.
This term, first used by Fogg (2003), includes computer interfaces that are purposely designed to change the behavior or the attitudes of users. It does so by using the same strategies as in human communication, such as using positive emotional feedback like a smile or praise to encourage behavior. or stressing the scarcity of products to make it appear as more valuable.

In the scientific community, there are numerous approaches in the field of persuasive technologies to investigate the applications for e-commerce, environmental protection or private healthcare. In contrast, there are only few efforts on how persuasive technology can be applied in the working environment. This is surprising, because many modern workplaces offer plenty of man-machine interfaces. Therefore, they offer lots of opportunities to implement persuasive elements to adjust misbehavior, for example concerning safety and health aspects.
Presently, adequate information, rules and regulations are mainly used to ensure safe and healthy behavior in operational practice, including the use of personal protective equipment (PPE). The effectiveness of these measures varies a lot, depending on the field of application. In sum however, concerning safe and healthy behavior in everyday

working life there is a substantial deficit. Especially intentional violations pose a high risk, because they commonly form a habit and will most likely be repeated in similar situations. As a result, the individual risks add up over time and may cause an accident sooner or later. The consequences of such events can range from minor damages to huge catastrophes. The probability for such violations is very high when safety behavior is perceived as hindering the working goals. To counteract this risk, a solution might be to remind the user of the relevant safety behavior and encourage it, preferably at the very moment the behavior is indicated.
We think that modern man-machine systems have the potential to provide such assistance. Within the scientific community, this kind of autonomous systems adapting to the situations are called Ambient Intelligence. This technology paradigm is based on the idea of 'ubiquitous computing' by Marc Weiser (1991) and is characterized by Aarts (2001) by the central features context awareness, personalization, adaptive behavior and anticipation. In the working environment, these are called adaptive work assisting systems (AWAS; Windel & Hartwig, 2012). In this particular case, AWAS may help to reduce violations by (1) being aware of the behavior of the user, (2) evaluating it autonomously regarding violations and (3) presenting evaluative feedback that changes user behavior.

While there is extensive knowledge within social psychology about feedback and behavior change, it is still unclear whether the outward appearance of automatic generated feedback is relevant for persuasion. Two approaches are particularly relevant for the described scenario: (a) forms that are already associated with action stimuli from everyday life such as traffic lights, and (b) anthropomorphic interfaces such as animated virtual agents. Reeves and Nash (1996) were able to show that users involuntarily attribute human characteristics to computer interfaces with human-like appearances. Therefore, computers can provide similar social cues as human do. The question, if this implies similar effects and action mechanisms as in social persuasion, is subject of an ongoing debate (for examples see (Roubroeks, Ham & Midden, 2011; Schulman & Bickmore, 2009).

Using computer feedback to facilitate safety behavior (a laboratory study)

The German Federal Institute for Occupational Safety and Health (BAuA) conducted a laboratory experiment to investigate the potential of different persuasive feedback forms to facilitate the use of personal protective equipment (PPE). The study is part of its current research focal point Ambient Intelligence (AmI), evaluating chances and risks of new adaptive technologies in the working environment. Testing the effects of persuasive feedback for safety and health behavior requires a setting that meets certain requirements. Participants should be able to accomplish the task without special knowledge, the need for PPE should be easily comprehensible without exposing participants to real hazards and the setting should be static, so the feedback on a monitor can always be seen by the participants. Taking these aspects into account, a simulation of a simple electrical engineering task was chosen as working task, while usage of isolating gloves was selected as corresponding safety behavior.

All participants were given detailed standardized instructions on their task to manually build ten electronic circuits correctly and as quickly as possible according to a step by step guide on the monitor. They were also informed that during certain working steps there is a risk of an electric shock (which was in fact not the case). The subjects were instructed to wear insulated gloves as PPE in these operations. Usage of these gloves was the primary dependent variable of the experiment. The thick and stiff work gloves impaired and slowed down the filigree task of building the circuits significantly, creating a conflict between the two given objectives.

Figure 1. Two different negative (left) and positive (right) Avatar feedbacks

To exacerbate this conflict, a financial bonus for fast task completion was promised, which was hard to achieve when using the gloves properly. In addition, all subjects received a faked computer generated message during the task, stating that they performed about 2 Minutes slower than the average so far (regardless of their actual speed) and that their current working speed would therefore not be sufficient to receive the bonus.

In the control group, the subjects worked on these tasks without additional information on their PPE use. In the three other experimental groups, different forms of feedback on their use of gloves appeared on one half of the instruction monitor at each corresponding step. All feedback was accompanied by a very short ringing sound, to make sure that they were recognized. In the experimental group 'text' a short, purely informative held writing appeared, either 'gloves used' as positive feedback, or 'please wear gloves' as negative feedback. In the experimental group 'traffic light' the same text was presented, accompanied by a picture of a traffic light, displaying either green (positive) or red (negative) light. Finally, in the experimental group 'virtual agent' an anthropomorphic virtual agent was shown, which presented either one of two positive predefined expressions (joy) or one of two negative (anger or sadness, all four different expressions are shown in figure 1). Additionally, working speed and quality of work were recorded. 75 subjects aged from 19 to 35 years in the final sample were randomly assigned to one of four experimental conditions. The experiment lasted between 120 and 150 minutes, for which the participants were paid 25 euro.

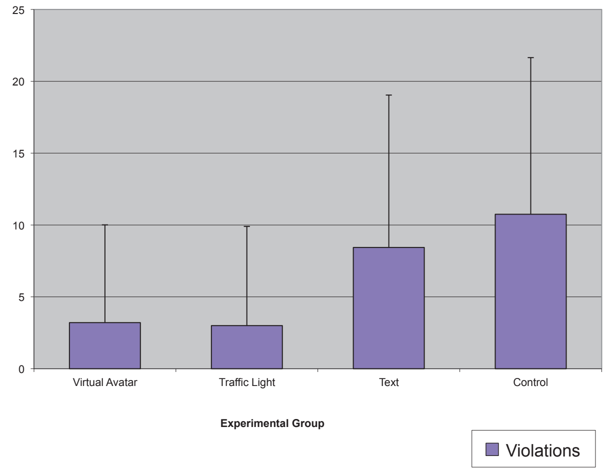

Figure 3. Average violations and standard deviations for the experimental groups

Results of the study

The safety behavior was operationalized by counting the number of operations where the participant was not wearing gloves although supposed to (called 'violation'). After the faked speed message, the average number of per-

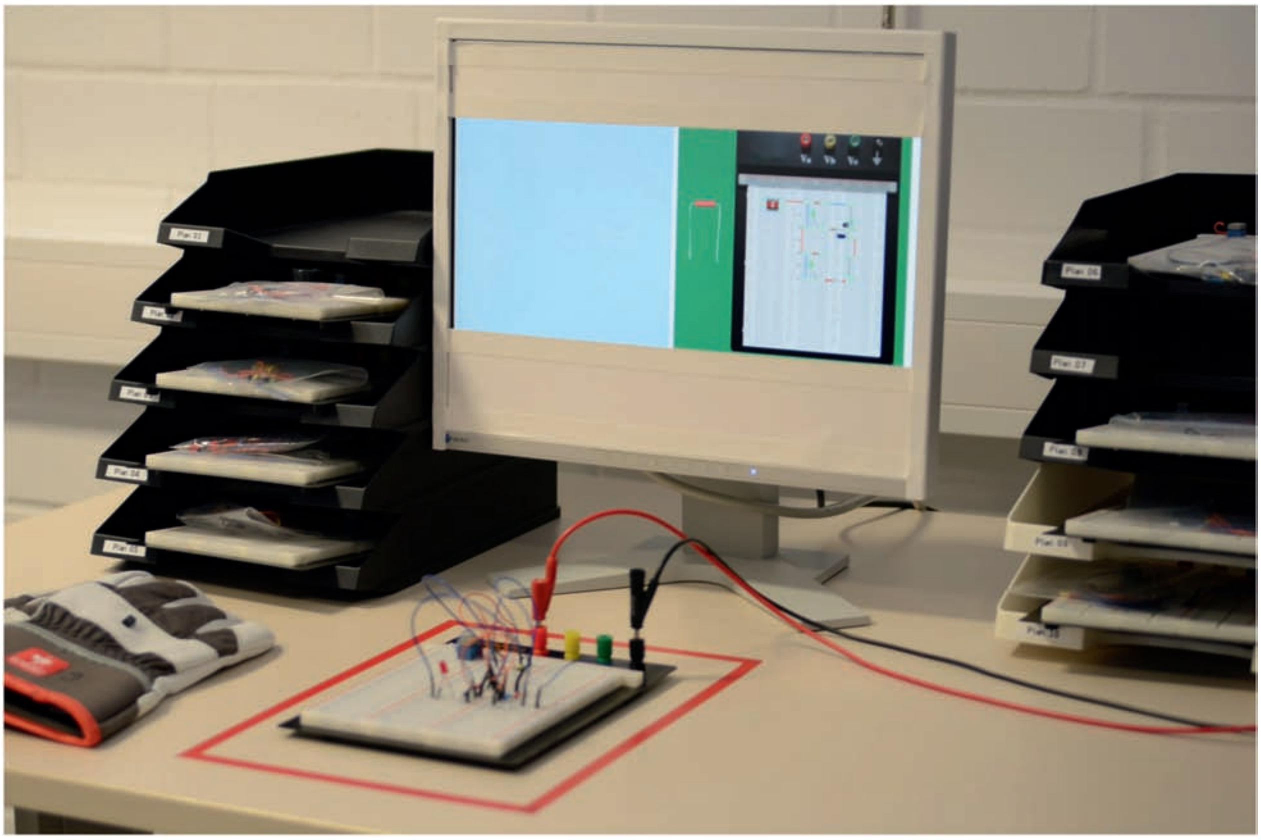

Figure 2. Experimental work station with gloves (left), circuit board (bottom) and instruction monitor (center)

formed violations was 6,43 (*SD* 9,54, Range 0-23) out of 23 possible violations. 41 participants scored zero violations, always wearing the gloves during the corresponding steps. To compare the violations between the different feedback groups, we used an ANOVA (analysis of variance). The average score and standard deviations of violations in the experimental groups are shown in figure 3.

The *Hypothesis 1* states that text-based, purely informative feedback would lead to fewer violations than in the control group without any feedback. After the message, the experimental groups differed significantly from each other regarding glove usage. (ANOVA: $F = 3{,}445$, $p = 0{,}021$). The additionally conducted Welch Test revealed a significant difference as well ($F = 3{,}286$, $p = 0{,}031$).

Hypothesis 2a states that fewer violations occur in the group that saw purely informative feedback compared to the control group. A one tailed t-test results in a $p = 0{,}516$ ($t = -0{,}656$), so the hypothesis is not confirmed.

Hypothesis 2b postulates that fewer violations occur in the persuasive feedback groups compared to the control group. A one tailed t-test reveals a significant difference ($t = 2{,}252$, $p = 0{,}002$) between the averages, confirming the hypothesis.

In *Hypothesis 3*, it was assumed that the persuasive feedback groups have fewer violations compared to the textual feedback group. The respective one tailed t-test shows a significant difference as well ($t = 2{,}252$, $p = 0{,}028$), so hypothesis 3 is confirmed.

Interpretation

To conclude, displaying feedback per se was not sufficient to significantly reduce safety violations. However persuasive designed feedback, either in form of a traffic light or a virtual avatar showing an emotional expression, had not only a statistically significant but also a substantial impact on safety behavior, reducing the violations occurring in the absence of any feedback by roughly 60%.

These results suggest that purely informative feedback on safety behavior is not sufficient to reliably prevent violations, even when it is presented at the most relevant moment. Instead, the appearance of the feedback seems to be a crucial factor when it comes to impact on user behavior. The feedback in this experiment did not only change behavior of the participants, but it successfully persuaded them to actively cut their own profits, which is remarkable. This strongly suggests that persuasive designed feedback does not only work as reminder that triggers a behavior to which people are motivated anyway, but can act as a factor of its own in decision making. Therefore, we would strongly advice researchers interested in behavior change studies to incorporate some kind of conflict to determine the strength of the persuasive elements.

For occupational practice, the results strongly advocate to consider the human psychology when using signs and guidelines to ensure safety behavior. It might not be enough to make sure these signs are readable and understandable. On the contrary, the actual impact on the behavior might depend on its outward appearance. In our view, this leads to both chances and risks of such technologies. Persuasive technology offers new possibilities to facilitate safety even where certain safety behaviors are desirable, but prohibitions or sanctions are inappropriate. At the same time, the results imply that a responsible application of persuasive technology is mandatory. Because of its impact on behavior, this kind of technology works somewhere in between assisting the users and manipulating them. Future research efforts should evaluate this continuum and define the terms of an ethical action guiding versus an unacceptable violation of autonomy.

In our view, future studies should focus on the behavior impact under different circumstances, for instance longer working time, higher cognitive demands of the primary task, or regarding persistence of behavior change. The last aspect is considered of particular importance. In real working environments, a temporary use of interactive assistance systems might be easier to implement, so the most efficient form of feedback might be the one where the changed behavior persists, even after the feedback has vanished. As a result, a planned follow up study will focus on more accurate insights (1) on the psychological mechanisms how different forms of automatic feedback influence user and (2) the stability of behavior changes.

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