# Enhancing Pedestrian Safety with Directional On-Smartphone Warnings


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## Abstract
“Smartphone Zombies” (or *smombies*, Langenscheidt‘s youth word of the year 2015) are suffering from bad situation awareness, therefore representing a safety risk for themselves and other road users. We propose to use visual, directional warnings directly on users’ Smartphones and implemented a prototype to assess its potential. A pilot study (N=5) executed in the field using a “Wizard-of-Oz” approach revealed, that trust in the system is one of the main challenges to cope with. This position paper serves as the foundation to discuss involved issues as well as how other related aspects (feedback design, etc.) influence effectivity and usability of such a system.



## Author Keywords
Pedestrian safety; Smartphone interaction; Warning system; Trust in technology; VRU distraction

## CCS Concepts
**•Human-centered computing → Empirical studies in HCI; Empirical studies in ubiquitous and mobile computing;**

**Setup for the Pilot Study**

**System:** 1 User + 1 Wizard-of-Oz device, 2 native Android applications, connected via WiFi Hotspot; Directional warnings displayed on user's device-borders

**Study:** Field study, Within-subjects Design, Randomized conditions, $N = 5$

**Conditions:** With red *negative* warnings (RW); no warnings, task only (B)

**Goal:** Gain insights in important design aspects of a on-person pedestrian safety system

## Increased Danger for Vulnerable Road Users

The prevention of injuries resulting from road accidents is a major target for governments, researchers, and vehicle manufacturers. According to recent crash statistics, vulnerable road users (VRUs, such as pedestrians or cyclists) are involved in approximately 30% among all accident types, and their share increases while the total numbers of accidents decreased in recent years (minus 70% in Germany between 1991 and 2014 [6]). Accidents at urban junctions account for 36% of injuries and 18% of fatalities, where the main reasons are misinterpretation of the driving situation, inattention and obstructions [11]. Reasons for inattention include smartphone usage [2], which is a significant safety problem as roughly 17% of pedestrians use their Smartphones in crowded traffic situations [9]. This number might further increase with the usage of location based applications or augmented reality games (such as Pokemon GO, [1]).

*Smartphones as Safety Devices*

Pedestrian safety research with mobile phones or smart devices as source of distraction traditionally focuses on common tasks, such as telephony or writing messages. Nasar et al. prove that cognitive distraction from mobile phone use (telephony and listening to music) reduces situation awareness and increases risky behavior [7]. Similar studies were conducted by several other authors ([8, 5, 3] to list a few). Wang et al. even implement a prototypical safety warning application called WalkSafe that utilizes the phone's rear camera to detect oncoming vehicles [10] back in 2012. This again highlights the potential of Smartphones with their highly capable sensors and computation power.

## Methodology

We want to investigate whether a visual system, which distributes directional warnings on pedestrians' Smartphones, is accepted and trusted by users in order to effectively improve safety. Therefore, we conducted a field experiment with traditional red warnings (in case of danger) or green signals (for clear passage) as another feedback modality. Directional alerts are directly displayed as additional layer over a visual distraction task.

Within this position paper we present the results of a pilot study (N=5) as a basis for discussion of the underlying experimental setting within the research community. While we do not specifically address automation of cars, we believe that accompanying technological advances in sensing and communication (Car2X, X2X) provide an important opportunity for VRU safety – not only as passive (victims) but also as active actors (by actively avoiding hazardous situations).

*System Overview*

Our system is implemented using a Wizard-of-Oz approach and consists of two separate mobile applications: (1) the user-application, and (2) the controller application. The latter features 4 "alert borders" (danger in front, back, left, and right considering the walking direction) and the secondary task in the screen center (Figure 1). Warnings are issued only visually in the direction of danger (alternatively in the direction of free passage in the second condition). Additionally, a fullscreen "STOP" overlay exists to warn the user about highly safety critical situations, which require him or her to immediately stop walking. With the controller application, the experimenter can start/stop recording data, select the type of warnings and, most importantly, issue them. Buttons for each device border are aligned in the same way as warnings appear on the user's screen, with the critical "STOP"-Button in the center. As secondary task, the user was supposed to hit a big button on the bottom of the screen, whenever one of the randomly appearing digits on the screen was the digit '6'. Beside secondary task per-

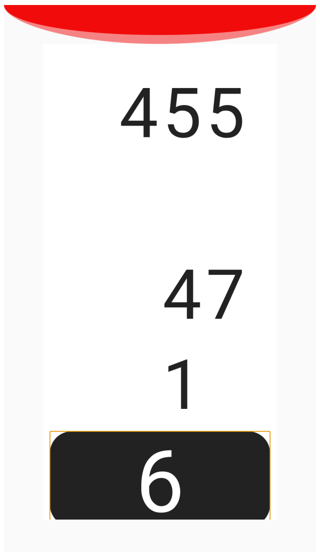


**Figure 1:** User's device screen with front-facing warning and secondary task

formance, we also recorded every participant's field of view using a wide-angle action cam mounted under the shield of a baseball cap.

*Study Procedure*

Our pilot study involved 5 participants using a within-subjects design. Every participant used the system in two ways: once without warnings (baseline, *B*) and once with red warnings (*RW*, i.e. danger/obstacle indicated by red warning bar) in randomized order. Each participant had to complete a pre-test questionnaire first and was then equipped with the user-device as well as the head-mounted camera. Besides an initial explanation of the task, participants with the *RW*-run were shown a short demonstration of the warnings in advance. Further, it was verbally emphasized that it's the participant's own responsibility to not run into danger. He or she should thus find a balance between engagement in the secondary and in the walking task. In the first run, each participant was accompanied by an experimenter right next to him/her, who also gave directional instructions and acts as additional safety measure in case of safety-critical situations. Another experimenter, the *Wizard of Oz*, follows the participant and uses the controller application on his device to issue directional warnings. After the course was complete, a questionnaire based on the Technology Acceptance Model (TAM;: see Davis et al. [4]) had to be completed. This procedure was repeated for the other condition before a short post-test interview was conducted.

## Initial Results

Due to the low number of participants in the pilot study statistical significance tests make no sense, however we still want to list some early results (see Figure 2) and only pick some qualitative observations. Nevertheless, for the observed TAM dimensions we conducted a Cronbach's Alpha reliability analysis with positive outcome for all rated statements ($\alpha > 0.70$).

| **Question / TAM dimension** | **Avg. Baseline** | **Avg. Red-Warnings** |
|---|---|---|
| I felt save using the smartphone while walking | 3.4 (0.8) | 4.0 (1.67) |
| I felt concentrated on walking (wutspaw) | 3.6 (1.62) | 3.8 (1.17) |
| I felt concentrated on the task (wutspaw) | 3.8 (1.47) | 4.0 (1.67) |
| (TAM1) Perceived Usefulness | – | 2.95 (1.80) |
| (TAM2) Attitude | – | 4.27 (1.77) |
| (TAM3) Perceived Ease of Use | – | 5.0 (1.71) |
| (TAM4) Trust | – | 4.4 (1.78) |

**Figure 2:** Questionnaire results after conditions B (baseline, without warnings) and RW (with red warnings). *wutspa* is an abbreviation for "while using the smartphone". Standard Deviation in brackets. All ratings with a Likert-Scale (min: 1, max: 7).

*Qualitative Results (Interviews)*
One participant said that he did not trust the system at all and behaved similar to the condition without warnings while ignoring the given feedback completely. Another user has stated that he fully trusted the system but afterwards realized how badly this could end if the system fails to detect a source of danger. Further, one user mentioned that he anyway scans the environment for dangers and the additional warnings became just an additional source of workload.

## Discussion and Future Work

While we did not yet execute and fully analyze a statistically valid experiment, we gained important insights, especially from qualitative statements by the first few participants. Although our initial study lacked perfect reproducibility and consistency of the scenario, as is typical in field studies, we believe that it reached a high level of realism (compared to e.g. simulator studies) and thus provides meaningful insights. Our first conclusions are: **(A)** A system which is not fully accepted by the user will not achieve safety improvements as it's ignored in the worst case. Further, **(B)** overtrust may be harmful too, in case of system failure. Thus, it's important to not only find a technical solution on how to implement a safety system for pedestrian, but also focus on designing appropriate human-computer interaction.

Besides continuing the current study setup to reach higher statistical validity, we will introduce *positive green signals* instead of red warnings, which highlight directions with clear passage. This will help us gain insights whether positive reinforcement, rather than warnings of danger, reaches different levels of acceptance and trust.

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