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## **DESIGN AND ASSESSMENT OF INFORMATIVE AUDITORY WARNING SIGNALS FOR ADAS**

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### **ABSTRACT**

The design of acoustic in-vehicle warning signals for advanced driver assistance systems (ADAS) remains a challenging task: Although methods for manipulating perceived criticality and urgency have been investigated there is still no clear guideline how to best convey information about the type of hazard without sacrificing user acceptance. Although representational sounds (also known as auditory icons) have been shown to increase response speed and accuracy there is a risk that drivers do not accept such generated sounds in a car environment. Abstract sounds (such as earcons) on the other hand are usually better accepted but difficult to learn or to distinguish.

The present study is based on the idea to fuse abstract and representational sounds into one warning signal with the aim to increase comprehensibility while maintaining user acceptance. A range of hybrid sound signals have been created that comprise an abstract component to code the urgency of the warning event (cautionary, imminent) and a natural sound component to indicate the type of hazard (vehicle, bicycle, pedestrian).

26 subjects took part in a study to compare six hybrid signals against their abstract warning component in terms of comprehensibility, perceived urgency and discomfort. In order to provide the appropriate driving context a video clip has been prepared that shows a car (from the driver's perspective) driving up a hill. Just before reaching the top of the hill the acoustic warning signal is activated and the video freezes. Immediately thereafter, the subjects were asked to assess the warning sound and the situation. Based on this method the following results were obtained:

All hybrid sound signals conveyed more information about the type of hazard (compared to their abstract components).

The perceived urgency of the hybrid signals can be manipulated by modifying the abstract sound component. Also the natural component itself can increase perceived urgency.

The hybrid sounds used in this study were not perceived as less comfortable than their abstract components.

Although the size of the effects is dependent on the type of auditory icon and the design of the abstract warning component, the obtained results generally confirm the potential of hybrid warning signals. As a next step the hybrid signals will be evaluated in a driving simulator study in order to validate the effects in terms of brake and glance behaviour.

These results on hybrid warning signals have not been published elsewhere. The activity is part of developing a general HMI concept for the EC funded project SAFESPOT. The visual warning concept has already been presented at the FISITA conference in 2008.