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A VR cycling study on visual attention allocation and subjective risk perception at intersections

Rul von Stülpnagel

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Background
Cyclists need to scan their surroundings for potential hazards. There are recent findings showing that the spatial configuration of the local environment affects both the experience of subjective safety as well as the allocation of visual attention towards specific locations. A particularly relevant scenario in this regard might be intersections, which have been found to impose an increased risk for cyclists. However, there appears to be little research on how the position of an intersection branch relative to a cyclist's travel direction affects the attribution of risk and attention towards this direction. Virtual reality (VR) provides new possibilities to investigate such potentially dangerous situations with a high degree of experimental control in a safe way.

Aim
We aimed at creating a VR setup that allows us to study subjective risk perception of cyclists crossing an intersection. We speculated that visually more accessible intersection branches (e.g. those located more in front of the cyclist) are perceived as less dangerous. We wanted to test whether the head orientation as measured through the orientation of a head-mounted display can provide insights into the visual focus of participants.

Method
In a first study, we created a virtual model of a real-world intersection, featuring simulated passengers, cars, and motorcycles. Three street directions were accessible for cars and cyclists; one direction was a path shared by cyclists and pedestrians. Twenty participants wore a head-mounted headset (HMD) to enable an immersive and natural viewing experience. Participants were seated on a chair, but accelerated, decelerated, and steered a simulated bike with the Oculus' motion controllers. In twelve subsequent trials, they travelled from all four possible approach directions to each of the three other directions. After each trial, they rated the hazard level of each of the directions (except the one they started at) on 7-point scales. In addition to these ratings, we extracted the viewing direction in relation to the current travelling trajectory from the Oculus' orientation.

Results
In Study 1, we found that the attribution of risk to an intersection branch was less affected by its position relative to the travelling direction, but more on the specificities of a branch and the required turning maneuver. We found that sharp turns and an offset of the travelling direction were rated as more dangerous. We also found that the HMD's orientation is not sufficient to gather reliable information about a person's gaze focus.
The collected data and experiences led to the development of a second virtual environment, which allows an automatic creation of a series of intersections featuring a randomized iteration concerning the number and orientation of intersection branches. We have conducted a first pretest with this environment.

Conclusions
This research showed the potential of VR as a tool for analyzing cycling safety. In particular, it is possible to expose cyclists to potentially dangerous situations and observe their behavior and experiences in a safe way. Current technology allows the creation of immersive environments with reasonable costs and efforts. However, there are also several challenges. Although the basic functions of a cycling VR are comparatively easy to implement, even small issues can break the participants' immersion or affect their behavior. For example, most HMDs are still limited in their horizontal field of view, which may lead to differences in how shoulder glances are performed and used as compared to real-world cycling.