

## **Cybersickness in Augmented Reality: Gradual changes with the course of prolonged exposure**

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Growing interest in virtual reality (VR) and augmented reality (AR) emphasizes the need for guidelines for proper and healthy usage of such new technical instruments. Compared to the intensive evidence regarding cybersickness in VR, however, symptomatic experiences in AR are not yet thoroughly tackled (Vovk et al., 2018). Therefore, this study aims to investigate cybersickness and discomfort during the use of AR equipment while manipulating content intensity and exposure duration. Participants viewed racing simulation game videos through AR glasses. Content intensity was defined by racing speed: slow (110km/h on average) and fast (290km/h). Participants watched three 10-minute videos of one speed type on the first day and another speed type a week after. This resulted in a 30-minute AR equipment exposure per day. Cybersickness was reported subjectively with the Simulator Sickness Questionnaire (SSQ; Kennedy et al., 1993). SSQ was given before the initial exposure, after every 10-minute stimuli, after the whole 30-minute exposure, and finally, after taking off the AR glasses. While watching the video, participants performed a detection task in which they reported transitions of the video scene from color to grayscale. The SSQ results showed that as exposure duration got prolonged, the total score of SSQ showed a steady increase—scores significantly differed from the pre-test SSQ after 20 cumulative minutes of exposure. Only after taking off the glasses did the subscale scores return to the initial state. Among the three subscales of SSQ, oculomotor (O) scores were greater than nausea (N) and disorientation (D), indicating that the participants' discomfort was related most to the oculomotor domain. The behavioral results revealed that as the exposure duration increased, participants' color change detection reaction times also increased. The effect of speed was not significant on both SSQ scores and reaction times. Our study shows that prolonged usage of AR equipment can lead to an increase in cybersickness and discomfort, particularly concerning oculomotor-related issues. This shows distinguishable profiles compared to previous VR studies employing similar visual stimuli (Hughes

et al., 2020), since the symptoms from VR exposure are reported to be related most with D, and least with O (Stanney & Kennedy, 1997). These findings highlight the need for future research specifically targeting AR. We are currently investigating the related psychophysiological responses to further support these subjective reports.