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Measuring Physiological Responses to VR-Based Urban Environments

Julian Keil [a,*], Marco Weißmann [a], Annika Korte [a], Dennis Edler [a], Frank Dickmann [a]

[a] *Ruhr University Bochum, Geography Department, Bochum, Germany, julian.keil@rub.de, marco.weissmann@rub.de, annika.korte@rub.de, dennis.edler@rub.de, frank.dickmann@rub.de*

* Corresponding author

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Abstract:

In order to ensure social acceptance and to reduce the risk of lengthy legal procedures, modern urban planning uses approaches that include different stakeholders in the planning process. However, to effectively communicate different planning scenarios to stakeholders such as residents, investors, or political decision makers, suitable cartographic visualization methods are required (Postert et al., 2022). The cartographic methods available for visualizing spatial scenarios are continuously expanded based on technological advances (Edler et al., 2018). Examples are the introduction of interactive multimedia cartography and 3D spatial representations. As a next step from screen based 3D representations, the recent availability of cheap and effective Virtual Reality (VR) hardware enables unprecedented levels of immersion in spatial perception of urban planning scenarios (Jamei et al., 2017). In VR, spatial planning scenarios can be represented in a scale of 1:1 (Hruby et al., 2020) and perceived from a multitude of egocentric perspectives (Edler et al., 2019). Thus, by using VR technology, stakeholders can experience urban planning scenarios in ways that closely resemble the natural perceptions of real-world environments (Keil et al., 2021).

The feedback of stakeholders in planning processes is usually given explicitly, for example in the form of questionnaires or structured and unstructured interviews (e.g., Ballantyne et al., 2013; Ghorbanzadeh et al., 2019; Tress & Tress, 2003). However, spatial environments and environmental parameters as pollution or noise can also evoke implicit positive and negative responses of which people are not consciously aware (Hébert et al., 2005; Schnell et al., 2012). These responses can include stress or affects as fear, anger, happiness and disgust.

To assess these usually hidden responses to urban planning scenarios, we develop an experimental approach based on measuring physiological responses to visual and auditory stimuli. For this purpose, we created a VR-capable virtual urban model based on a virtual 3D environment described in Weißmann et al. (2022). The model includes three different scenarios with traffic variations in terms of traffic density and noise, as well as varying observer locations within the model. During the experiment, participants are equipped with an HTC Vive Pro Virtual Reality Headset and a non-invasive wristband (Empatica E4) for measuring electrodermal activity (EDA), which has been demonstrated to reflect both stress and fear (Faghih et al., 2015; Reinhardt et al., 2012).

First results demonstrate that peaks in the EDA data can reliably be related to both visual and auditory key stimuli in the environment as noise and closely passing vehicles that were created to evoke stress or fear. The delay between the stimuli and the EDA peaks was low enough to allow stimulus and response matching. To expand the addressed types of implicit affects (e.g. happiness, anger or disgust), planned future studies will address additional physiological responses as heart rate, skin temperature and pupil dilation. In conclusion, with our experiment design, we provide a simple approach for urban planners to assess implicit responses to urban planning scenarios. By using advanced VR-based visualization techniques and physiological measurements, previously unnoticed sources for potential social conflicts in urban development can be uncovered and integrated into the planning process.

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