

An Exploration of Users' Thoughts on Rear-Seat Productivity in Virtual Reality

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ABSTRACT

With current technology, mobile working has become a real trend. With wireless head-mounted displays we could soon even be using immersive working environments while commuting. However, it is unclear what such a virtual workplace will look like. In anticipation of autonomous cars, we investigate the use of VR in the rear seat of current cars. Given the limited space, how will interfaces make us productive, but also keep us aware of the essentials of our surroundings? In interviews with 11 commuters, they generally could imagine using VR in cars for working, but were concerned with their physical integrity while in VR. Two types of preferred working environments stuck out in the physical dimension and three information levels for rear-seat VR productivity emerged from our interviews: productivity, notification, and environment. We believe that the interview results and proposed information levels can inspire the UI structure of future ubiquitous productivity applications.

CCS CONCEPTS

• **Human-centered computing** → **User studies; Virtual reality.**

KEYWORDS

Virtual Reality; HMD; Rear-Seat Productivity; Commute.

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1 INTRODUCTION & BACKGROUND

With cheap and fast transportation, in big cities such as London, nearly half of the work force commutes to work [3]. Commuting time is often considered working time, and in some cases even compensated as such. Hence, commuters seek to be productive during travel. Prior work found that this also influences their choice of transportation. A train with sufficient room and a network might be preferred over a car that needs to be driven [7]. In contrast, if the car was autonomous or a chauffeur-driven "taxi", in which commuters could work in the back seat, their preference may change.

As a proxy for (or intermediate step towards) autonomous cars, we investigate rear-seat passenger productivity. Some of the prior work suggests that automated driving would not significantly increase passengers' willingness to do certain tasks just because they ride in an automated car [5]. However, Lee et al. [6] found that there is a discrepancy between opinions based on hypothetical scenarios and ones that were formed after actively experiencing autonomous cars. Unlike automated vehicles, being productive in the rear seat of a current car is feasible today.

Currently, productive activities are mostly carried out on mobile phones and laptops. However, recent progress in wireless head-mounted displays (HMDs) provide an opportunity for travelers to be productive in Virtual Reality (VR). They completely immerse users in a VR and (at least conceptually) free them from screen space limitations. However, previous work highlighted three challenges for VR in cars: Passengers experience it as a confined space and are concerned about social acceptability and motion sickness [8]. In our study, we focus on the confined space and on the problem that users cannot see the physical reality and its borders, which creates uncertainties regarding physical integrity. This WiP paper hence explores (i) passengers' willingness to use HMDs for productivity tasks, (ii) which [physical] environments they perceive to increase their productivity, and (iii) what expectations they have regarding incident awareness while in VR.

2 STUDY PROCEDURE

In a field study we conducted semi-structured interviews with 11 participants (1 female) between 26 and 42 years ($M=31.5$, $SD=4.9$). They were recruited from the personal network of the experimenters based on the regularity (more than once a week), length

(over 30 min) and type of their commute (5 chauffeur-driven, 6 train).

After verbally negotiating consent and some demographics questions, participants were shown a short (2:20) video clip about rear-seat VR featured by interactive experience in virtual environments synchronized with dynamic vehicle movements on real roads¹. Then we followed the structure of our interview template. The interview ended with an open question on their thoughts and feedback regarding HMD usage during commuting.

3 RESULTS & DISCUSSION

Quantitative results are shown as Likert plots in Figure 1 and qualitative results were analyzed through thematic analysis [2]. Due to the space limitations only selected results are presented. However, the concrete questions and fundamental raw data are available online². No differences were found between chauffeur-driven and train commuters.

As a preliminary study for a full project, the interviews with 11 participants were mainly aimed for gathering user's thoughts and exploring concept insights for rear-seat VR productivity applications. We discussed what the participants said and derived the idea of spaces for information levels in rear-seat VR productivity applications based on the connections we drew between their thoughts.

3.1 General Attitudes Towards VR Commute

The majority of interviewees confirmed they usually use smartphones, laptops and prints for productivity tasks. Several participants mentioned that they perceived the small screen of the smartphone as a limitation. Using the laptop allows a larger screen but leads to ergonomic issues.

Compared to prior work by [5], our participants seemed willing to complete productivity tasks in the car. They regularly make phone calls, read or edit texts, check or organize their schedules, and occasionally watch videos. These results highlight the need to investigate which tasks can be transferred from the mobile phone to a VR headset in order to increase performance. Although our participants also chose *watching videos* ($n=8$) as their preferred task for VR, this did not match the productivity tasks they currently perform during their commute, namely writing and reading texts. This suggests a gap between what VR is currently offering and the needs of rear-seat commuters. For future work we propose to review how the unlimited virtual 3D space can be leveraged to facilitate reading and typing during the commute. For example, similar to the *reader view* on the Iphone [1], could there be a *VR view* for visualizing, analyzing and reading [bigger amounts of] data/text?

Although more than half of the participants had never experienced VR before, they overall agreed that they could imagine using VR for productivity in the rear seat. They justified their judgement by arguments such as "...immersive world is helpful for concentration", "visual cues could ease motion-sickness", and "better ergonomics compared to current laptop usage in cars". However,

they also pointed out the downsides of rear-seat VR for productivity, such as "invading other passengers' space" and "lack of social interaction with other travelers".

Most interestingly, compared to the daily mobile work with small screens, many participants prioritized the potential of videos for rear-seat productivity in VR, e.g., for video conferences or meetings. This also documents their high expectation for the quality of visual representations in VR.

3.2 Notification and Working Environment Preference

When exposed to VR during a real trip, participants mostly wanted to be aware of physical borders (see in Figure 1), either actively (being close to hitting the car interior) or passively (invading another passenger's space). Other concerns are either social (e.g., no conversation with other passengers), technical (e.g., missing an incoming phone call), or concerning potentially dangerous traffic situations. However, participants showed a lower interest in staying informed about stable traffic situations while immersed in VR productivity tasks. In general, traffic aspects were found relatively unimportant to the user compared to physical, social, and technical aspects. A potential explanation could be that all traffic-related tasks were assigned to a human driver or an equally trustworthy automated system in our scenario. The least wanted events were uncritical notifications such as text messages or emails, probably because these would harm concentration. Independently of the automotive context, we found a variety of preferences regarding the most productive working environment. For example, some interviewees are most productive when confined to a single office without distractions from colleagues or the environment, while others prefer an open-plan workplace or a library shared with other workers who are also focused and thereby motivate them.

3.3 Information Levels for Rear-Seat VR Productivity Applications

In our interviews, we investigated what incidents users wanted to get notified about, as well as their visions of productive working environments in VR during transit. In the results, three information levels for rear-seat VR productivity emerged. Figure 2 illustrates these three information levels we call productivity, notification, and environment.

Productivity level. The innermost level targets VR productivity itself. Using VR at rear seats would offer the user an opportunity to "dive into the own world of concentration", which means less distraction and more focus on work compared to nowadays laptop or smartphone usage in cars. We propose to position corresponding UI parts in this central area, while feedback could also be shown slightly beyond its limits. Restricting UIs to this inner layer avoids users breaching physical integrity by accidentally hitting the car interior or invading other passengers' space. The productivity level also occupies the majority of their cognitive resources.

Notification Level. The middle layer includes all information within the physical restrictions of the rear seat. Participants pointed

¹AUDI CES 2019, accessed: July 2020

²Interview Questionnaire & Raw Data, accessed: July 2020

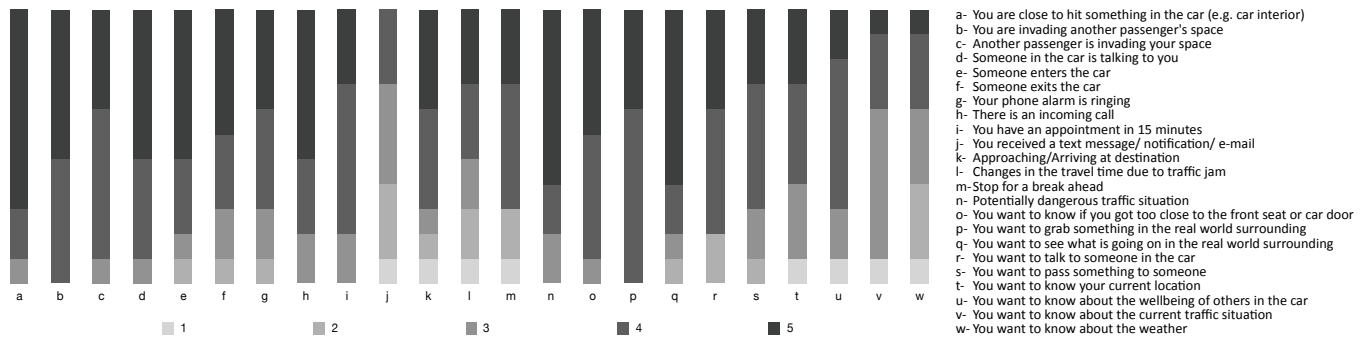


Figure 1: Results from 5 point Likert scale (1=not at all) questionnaire asking rear-seat commuters to rate which types (a-w) of incidents they want to be aware of.

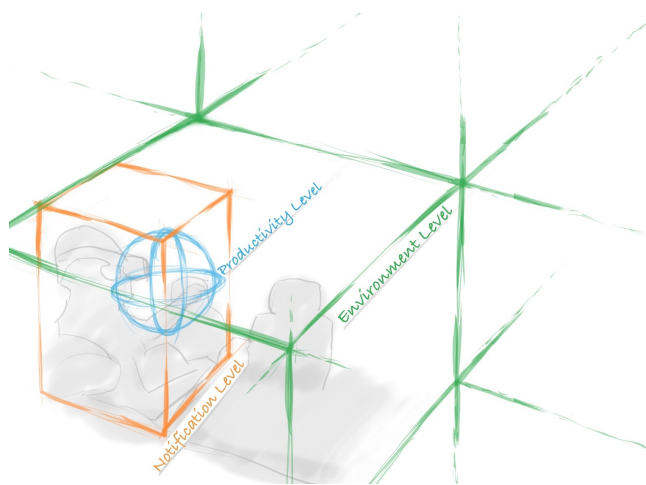


Figure 2: Information Levels for Rear-Seat VR Productivity Applications: environment level (in green), notification level (in orange) , and productivity level (in blue).

out possible downsides of rear-seat VR productivity, such as "invading other passengers' space" and "lack of social interaction with other travelers". Based on the interview results, we propose to provide virtual representations of the physical borders to avoid users hitting the car interior or invading each others' space. Also, interaction with other travellers such as a conversation or someone getting on or off is closely related to the physical position. Therefore we propose to communicate social aspects together with the physical bounds at this level. Finally, the middle layer also provides opportunities for unobtrusively communicating other, more peripheral information, such as text or email messages, location and traffic situation, stops ahead, or estimated travel time.

Environment level. As an inherently borderless environment, VR enables different virtual environment types ranging from a limited space matched with the car interior to the unlimited space (which is hard to find on modern roads). We propose the environment level for tailoring an appropriate virtual environment according to the productivity purpose as well as the working environment preference ranging from "easy to be productive in my own zone"

to "feel motivated by other colleagues in a shared workspace". For example, in a follow-up study, we will compare a confined office to a wide forest regarding their impact on productivity and user experience. Finally, as the most peripheral layer, the environment level could contain visual cues synchronized to vehicle movements in order to reduce the risk of motion sickness [4]. However, as this WiP focused on the confined space and the problems concerning physical integrity, we chose not to elaborate more on the motion sickness concept here.

4 SUMMARY

In semi-structured interviews with 11 "rear-seat" commuters, we elicited a collection of user expectations for VR productivity applications and a spatial framework of three different information levels in such a scenario. At the time of writing, we prepare an initial implementation of a study environment according to our framework in order to evaluate its productivity. Through this WiP publication, we would like to start a discourse with other researchers and practitioners working on virtual workplace and notification design for rear-seat VR productivity applications.

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