The first survey investigated the contributing factors that affect acceptability of VR HMD use on aeroplanes. It focused on collecting respondents' attitudes towards VR use for varied activities, journey lengths and travel classes (economy or business). The survey also captured respondents' attitudes towards using a VR device on their future flights. 60 respondents completed the survey (27 female, 31 male, one non-binary, one did not declare their gender). The respondents ranged in age from 18 years to over 60, with 53.3% travelling on aeroplanes between two to five times a year, and 70% reporting previous experience with VR headsets. Online VR communities were targeted for recruitment in order to gain responses from people who had previous real-life experience with VR and can base their answers on that knowledge.

2.1   Results

Survey analysis revealed a strong overall interest in using VR - when asked to rank their interest in using a VR HMD on future flights, the majority of respondents were somewhat interested (50%) or very interested (15%) in the idea.

As part of the survey, respondents were asked to rank their interest in using VR for entertainment, communication and work, with entertainment ranking significantly higher the others. Key reasons for this were found through qualitative analysis. Respondents thought that the set-up of the system would be time-consuming and did not replace traditional devices for work or communication, with one participant noting that they are unaware of the benefits that VR could provide outside of entertainment. In addition, the interaction required when using VR for communication was seen as potentially "disturbing" to other passengers, and not offering much over current communication technology. Participants also saw escapism as another potential purpose for VR, especially for a fearful flyer, confirming VR's potential to provide an escape from the confined surroundings of an aeroplane seat.

Respondents were also asked to rank their interest in using VR in business versus economy class. The purpose of this was to understand if there were preconceptions about the image of a VR user. 56.7% of respondents felt they would be more likely to use the headset in business class, but their reasoning was based on the space constrains in economy seating. Not having enough room to manoeuvre or risking accidentally injuring someone were the main concerns. Another significant barrier was the self-image of the wearer and perceived judgement from others, especially in smaller economy seats. Interestingly, participants felt they would be judged more by using a VR headset in a tighter space as the same fears did not occur for business class seating. Respondents were also concerned about other passengers staring at them or being annoyed, especially if they were not using a headset themselves. Judgement from neighbouring passengers seemed to be less of an issue if they were familiar, such as family members travelling in a group.

Journey length was another key influence on VR acceptance. Respondents expressed a strong preference for using VR on longer journeys (more than six hours), whilst domestic flights (up to one hour) were of least interest. The responses revealed that short flights were seen as tolerable and quick, therefore not worth the set-up effort, whilst longer journeys were associated with needing a

Virtual Reality in transit: how acceptable is VR use on public transport?

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ABSTRACT

When travelling on public transport, passengers use devices such as mobile phones or laptops to pass the time. VR (Virtual Reality) head-mounted displays could provide advantages over these devices by delivering personal and private experiences that help the wearer escape their confined space. This paper presents the key factors that influence VR acceptance on different modes of public transport (from buses to aeroplanes), uncovered through two surveys (N_1=60, N_2=108). An initial analysis of responses revealed unique passenger needs and challenges currently preventing wider VR adoption, creating parameters for future research.

Keywords: Social acceptability, virtual reality, head-mounted displays, passengers, public transport, public context.

Index Terms: • **Human-centered computing → Virtual reality** • Human-centered computing → User studies

1   INTRODUCTION

The latest VR head-mounted displays (HMDs) are portable mobile devices, opening new opportunities for their application in transit. VR HMDs could be a solution to making better use of travel time, due to their ability to render private virtual content all around the user, going far beyond the capabilities of traditional physical displays. However, VR use in transit also creates barriers to the outside world. By blocking out reality, HMDs disconnect users from their surroundings, which could influence HMD acceptance when travelling. Several authors have looked at VR use in public contexts [1][2], including transport [3][4], but have not explored how the mode of transport and journey length affect the acceptability of VR. Gaining understanding in what role these factors play in accepting VR is important as it would help tailor the experiences for in-transit use.

To gain a fundamental understanding of how travelling context affects VR adoption in transit, and what key factors contribute to VR use whilst travelling, two surveys were designed and distributed (N_1=60, N_2=108), targeting different forms of public transport. The first focused on VR use in-flight due to it being a more secure travel context (all passengers are screened prior to entry) and there is no turnover of passengers during the trip. The second looked at public transport used on the ground (taxis, buses, trains, subways). These types of trips are typically shorter, with fellow passengers free to (dis)embark as they see fit. Both surveys were analysed using non-parametric statistical tests for ordinal data and a qualitative coding process [5] for open-ended questions.

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bigger variety of activities to keep yourself occupied and entertained.

3 SECOND SURVEY: VR ON PUBLIC TRANSPORT

The second study focused on VR for five modes of ground transport: buses, coaches (long-distance bus travel), local trains/subways, long-distance trains and taxis. 108 respondents completed the survey (37 females, 56 males, 15 did not declare their gender). The respondents' ages ranged from 18 years old to 74 years old, with 86.3% reporting previous experience with VR headsets. Recruitment for the second survey also targeted dedicated VR groups to gain answers from respondents with VR experience.

3.1 Results

The results of the second survey showed clear differences in respondents' interest in VR based on the mode of transport. Long-distance trains and coaches were the most accepted modes of transport for VR use, whilst local buses and taxis ranked lowest. Respondents associated buses, local trains/subways and taxis with short journeys that require attention and control of one's surroundings. The key concerns were missing the required stop, personal safety and losing one's belongings. Because of this, respondents thought that wearing a headset would make them look reckless or "stupid." Coach and train journeys were more favourable for VR use because they were seen as requiring less concentration in addition to VR HMDs being more socially acceptable. Taxis were least favourable not just because of the short journeys, but also because it might be considered "rude" to ignore the driver. The open-ended questions also revealed that motion sickness and safety were other important barriers to VR acceptance. Motion sickness was mentioned as mostly being felt in buses and taxis, whilst worries about safety were linked to shorter journeys. Conversely, several respondents also brought up the issues that might put them off from using VR on longer journeys, including eye strain, cybersickness as well as battery life and discomfort caused by the bulkiness of the device.

Other passengers were another important influence on VR acceptance in ground transport. When asked if they would be more likely to use VR when travelling alone, with friends and family, or work colleagues, 65.63% of respondents said they were more likely to use a headset when travelling alone; family and friends were the second option (26.04%); travelling with work colleagues (4.17%) or feeling neutral (4.17%) were the least common answers.

To understand how unfamiliar passengers affect one's comfort of using VR, respondents were also asked how comfortable they would feel using a headset in two commuting scenarios - a busy and a quiet subway carriage (Figure 1). Only 10.98% of respondents thought they would feel 'very comfortable' or 'comfortable' using VR in the busy scenario compared to 26.15% in the empty subway carriage scenario. The analysis of respondents' comments showed that, although there was less chance for embarrassment or accidental interaction in the quieter carriage, the detachment from surroundings was still seen as an issue because new passengers could board at any moment. Being the only VR user was seen as an embarrassment in both scenarios, feeling they may attract unwanted attention for wearing a headset.

Figure 1: Two image scenarios showed to the respondents.

4 DISCUSSION AND CONCLUSIONS

The two surveys presented in this paper provide new insights on what factors contribute to VR acceptance for different modes of public transport. The in-flight survey responses revealed that there is bias towards VR use for entertainment, which hints that VR use for communication and work require more research and development. These attitudes towards VR use could change if VR benefits for communication and work could be demonstrated to potential users. Concerns about accidental interaction with others and loss of awareness were also prominent in both surveys. A significant challenge is finding new ways of delivering experiences that are engaging yet require less movement of the headset wearer. As for the loss of awareness, respondents' answers suggested that VR could provide cues from reality as well as incorporate location-based information in the headset, specifically for in-transit use.

The tendency to prefer longer journeys for VR also showed the need for quicker set-up time for VR devices, which might improve as technology improves and becomes more mobile. However, it is also important to further investigate what VR could offer its users for shorter journey lengths and how that would compare to other mobile mixed reality devices in terms of acceptance.

Finally, the analysis showed that respondents were particularly conscious of their self-image as a VR user and perception from other passengers. Respondents were worried about being "judged" by other passengers for blocking out reality, or being the only one with a headset. Further research is needed to better understand what affects self-image and perception of a wearable technology user, including a better understanding of how other passengers feel towards VR users.

This summary paper presented the results of two surveys focused on assessing the VR acceptance on public transport. Analysis showed travellers would prefer VR on longer journeys and there was a strong bias towards VR use for entertainment versus other activities, such as work and communication. However, we also found that concerns of accidentally interacting with other passengers, loss of awareness and self-image were barriers preventing wider VR adoption.

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