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Google Cardboard in Social Science Research – Exploring low-cost virtual reality and its potential

118 – Multimedia retrieval, visualisation and data literacy

Abstract

Currently we experience an ongoing hype and increased public awareness around the potential use of Virtual Reality (VR) Technology in both private and work related application scenarios. While the concept of VR has already been described in the 1960's (Ivan E. Sutherland, 1965) exemplary implementations have long suffered from the need for expensive technical equipment and the availability of physical environments for it to be installed, thus inhibiting any form of greater market penetration. With recent developments, however, producers have eventually managed to exit expensive lab settings and created the necessary foundation for solutions to enter the consumer market. Available products include both high quality head mounted displays (HMD), such as Oculus' Rift and HTC's Vive , which allow for almost full virtual immersion serving several human senses (e.g. vision, hearing, touch, etc.), and low-cost solutions based on Google's Cardboard technology , which uses a cheap cardboard holder (or plastic casing) to turn people's smartphones into capable 'VR gadgets'. Even though both the high quality HMDs as well as the "Cardboards" are now at a price point, which is low enough to support market penetration, it is particular Google's low-cost product that helps grow the potential user base – in particular with those consumers who do not belong to the category of early adopters. Here, Cardboard may even become a mass market product, attracting millions of smartphone owners. Although these developments seem promising and may be perceived as an indicator for a widespread propagation of required hardware, convincing application scenarios which would foster the technology's sustainability are still missing. Starting to close this gap, we have therefore explored Cardboard usage in the following areas of social science research:

- VR for Edutainment: How is it accepted?
- VR for Training: Is it `real' enough?
- VR for Promotion: Does it inform?
- VR for Fun: How does it feel?

Keywords:

Low-cost Virtual Reality, Technology Acceptance, User Experience, Social Science Research

VR for Edutainment – learn while you play (and explore acceptance)

In our first round of exploration we investigated the potential use of Google Cardboard to support playful learning experiences. Doing so the following question served as a guideline: *What is the acceptance of smartphone based virtual reality technology used in basic learning situations?* Davis' *Technology Acceptance Model (TAM)* (Davis 1989) with its core constructs *Perceived Ease of Use (PEOU)* and *Perceived Usefulness (PU)* as determinants for *Intention to Use (IU)* acted as the theoretical framework for this study. In addition, we introduced constructs aiming to measure *Personal Innovativeness (PI)* as well as *Perceived Enjoyment (PE).* A total of 100 volunteers (f=34/m=66) aged between 15 and 66 (*mean=24.12, SD=8.49*) agreed to participate. They first had to play *InMind VR*[1], a game which allows an operator to explore a human's brain in search of neurons that cause mental disorder, and then complete our questionnaire investigating their general attitude and perception towards using low-cost VR technology in these types of learning contexts.

Results show that, even though most participants describe the game itself as not very instructive, 60% of them state that they would see benefits in the general use of low-cost VR technology for educational purposes. Although it seemed that the excitement of using the technology, i.e. its `wow' factor, outweighed the actual benefit in terms of learning. With respect to construct correlations, we did find a moderate link between *PEOU* and the participant's anticipated use of Google Cardboard (*r=0.44, p<0.01*). Links to the other variable constructs (i.e. *Perceived Usefulness*, *Perceived Enjoyment*, and *Personal Innovativeness*), however, were rather weak (*i.e. r<0.40*), which hints to a certain *iffiness* currently attached to the use of VR. In other words, participants seem interested and felt excited about the technology, but do not yet see a viable use case for its application. Finally, an analysis with respect to game performance showed that people aged 30 and older scored significantly lower than younger participants (*U=90.5, Z=-3.849, p<0.05*), which may further hint to the need for certain virtual navigation skills – a characteristic which seems more prevalent with the younger population. In summary, this initial study showed that Google's Cardboard VR manages to excite. Yet, it lacks perceived usefulness for which a clear acceptance with respect to basic learning contexts is not yet apparent. Future studies will explore whether more targeted learning environments (e.g. tutorials on fluid dynamics, business process management, machine learning, etc.) are more capable of convincing learners of their usefulness.

VR for Training – train your speech (and explore realism)

In our second round of exploration we investigated the applicability of smartphone based virtual reality technology for the study of social phenomena triggered by public speaking. While the use of more complex virtual reality technologies for this purpose has been subject to several previous studies (e.g. Felnhofer et al. 2014; Slater et al. 1999; Vîslă et al. 2013; Powers / Emmelkamp, 2008), our goal was to empirically investigate the suitability of a low-cost smartphone-based solution. Therefore, we conducted a controlled experiment in which 16 volunteering participants were exposed to two different public speaking situations – one in front of a real and the other one in front of a virtual audience. All participants were exposed to both scenarios yet, to control for order effects, their sequence was randomized. In addition, we controlled for gender equality and topic assignment. That is, we had two different topics which were randomly given to either the VR or the real setting, and vice versa. Although the two topics were different in content they were still comparable in terms of complexity. For each of them participants were given a sheet containing relevant background information, eight minutes to prepare and two minutes to talk. A heart rate monitor was used to measure excitement in both contexts. For the VR situation, we additional asked the participants to complete the *Igroup Presence*

[1] https://play.google.com/store/apps/details?id=com.nivalvr.inmind&hl=en [Accessed Online: 17.01.2017]

Questionnaire (IPQ) which aims at measuring perceived telepresence in virtual environments (Schubert et al. 2001).

Results show that the participants' heart rate was significantly lower in virtual compared to real settings (*mean=99bpm vs. mean=122bpm, p<0.01*), although their perceived tele-presence in the virtual world was rated consistently positive, i.e. on average participants assigned to perceived tele-presences a value of +0.59 on a scale ranging from -3 (not strong at all) to +3 (very strong). To this end, some participants reported that from time to time they even held eye contact with the avatars present in the virtual room. Their lower pulse frequency, however, showed that they were less anxious than when talking to a real audience. An explanation for the difference in heart rate may be found in the perceived realism. Here the quality difference between Cardboard and other, more expensive HMDs, seemed to play an important role. That is, while participants gave high credits to the level of immersion, the perceived realism was rated consistently negative (*mean= -1.34*). In other words, even though the use of Google's Cardboard technology was sufficient to make people feel immersed, i.e. present in the virtual world, this world seemed to lack realism and detail so that speaking in this setting felt significantly different from speaking in public. Future studies will examine whether better, more detailed virtual environments, as they are supported by more advanced HMDs, lead to a more realistic experience and consequently may be used as viable training and study settings.

VR for Promotion – promote your flat (and explore perception)

Our third round of exploration investigated perception and presence in a smartphone based virtual environment. Perception is a cognitive process which links sensory input with higher level cognitive processes such as attention and learning and therefore also influences a person's actions. In this round of exploration, we thus focused on potential differences between perception in real world and virtual settings. As an application scenario, we used an apartment viewing. One group of participants was invited to physically visit the flat (N=15 participants). A second group (N=24 participants) was asked to virtually visit the flat using a smartphone based VR application. Finally, a third group of people (N=106 participants) was asked to look at photos online, such as it is common with private property websites. Five questions were used to measure how much participants remembered from their viewing. Each right answer would give them one point, i.e. they could score up to 5 points. The *Everyday Memory Questionnaire (EMQ)* (Cornish 2000) was used to control for the variation in participants' short term memory. That is, we aimed at having a harmonic sample size in which people would have similar memory capabilities.

Results highlight significant differences in perception between the three viewing conditions. Participants who viewed the apartment via Google Cardboard remembered significantly less than those who went there physically (mean=2.29 vs. mean=3.87 points, *p<0.01*), and even the viewing of online photos led to better results than the VR setting (*mean=2.29 vs. mean=3.17 points, p<0.01*). Interestingly, however, visiting the apartment did not lead to many more remembered details than looking at respective online pictures (*mean=3.87 vs. mean=3.17, p=0.03*). One reason for the lower performance exhibited by the VR condition may be found in a lack of familiarity with the employed medium; i.e. whenever participants were lost they had to reorient themselves, which kept them from paying attention to their actual environment. Also, particularly in comparison with the online condition, participants could not easily revisit parts of the apartment by quickly flipping through photos but rather had to virtually walk there. Despite these lower scoring results, we still believe that virtual reality viewings via Google Cardboard are an innovative and viable tool for the real estate market. Consequently, future studies will focus on how to boost the degree of transported information as well as on how to improve the overall user experience, so that eventually companies may be able to bring the perception of a virtual apartment very close to what it feels like when physically going there.

VR for Fun – play the game (and explore experience)

Our final round of exploration aimed at investigating both the acceptance and user experience of a smartphone based virtual reality video game. We again used Davis' TAM as a theoretical framework (Davis 1989). This time we had more than 100 volunteers participating in the study. They were asked to play the VR game *GermBuster* and thereafter complete a questionnaire exploring *Perceived Usefulness* in comparison to traditional, non-VR game settings(3 questions), *Perceived Ease of Use* (4 questions), *Perceived Enjoyment* (4 questions), and its potential effect on the *Intention to Use* (2 questions). In addition we asked 26 questions from the *User Experience Questionnaire (UEQ)* proposed by Langwitz et al. (2006), which aimed at measuring different UX characteristics on a 7 point semantic differential ranging from -3 (very negative) to +3 (very positive). Those characteristics included *Attractiveness*, *Transparency/Usability*, *Efficiency*, *Controllability*, *Stimulation*, *and Originality*.

With respect to acceptance, results show a moderate link between *Perceived Enjoyment* and a participant's *Intention to Use* Google Cardboard VR ($r=0.448$, $p>0.05$). This connection, which illustrates that perceived enjoyment is an important determinant for the use of games, is usually much stronger. However, the Google Cardboard technology lacks the relevant performance to produce a similarly strong effect (particularly when it is evaluated by `gamers' who are typically used to interact with high resolution displays and processing units which are able to produce high frame rates and low latencies). In addition, participants reported occurrences of blurred vision and feelings of slight nausea. The correlation with the other two variable constructs, i.e. *Perceived Ease of Use* and *Perceived Usefulness,* was even smaller (*i.e.* $r<0.35$). So, it seems that currently the smartphone based VR is simply not mature enough to attract the gaming community.

As for user experience, the VR game scored particularly high in terms of *Attractiveness* (*mean=+1.75, SD=1.04*) and *Transparency/Usability* (*mean=+1.82, SD=1.00*). *Controllability* scores were, however, considerably lower (*mean=0.84, SD=0.81*), which may again be caused by technology related performance issues as well as the still relatively novel way of interaction. Nevertheless, the overall satisfaction reported by our participants hints to a potentially bright future for low-cost VR gaming. Recently announced hardware improvements[2] support this assumption, so that our next round of exploration might be able to identify a number of gaming categories in which VR has the potential of becoming the dominant technology platform.

Summary and Future Research Directions

Above we reported on a number of initial studies exploring the use of Google Cardboard VR for social science research. Results have shown that, apart from gaming, Cardboard still lacks viable applications scenarios. While it does receive a basic level of acceptance, particularly in areas where it can easily be employed (e.g. apartment viewings, edutainment, etc.), is it currently more of an (often welcoming) distraction rather than an effective interaction medium. To that end, our studies have shown that low-cost VR is not yet able to offer the realism needed to train public speaking. Neither does it offer the details required to act as a viable information acquisition channel. However, it brings along a certain level of playfulness and excitement which motivates people and lets them explore. Consequently, Cardboard may be seen as a viable technical foundation to build upon and develop more serious applications both for research and industry. Our future work aims to contribute to these developments. In particular, we are interested in deepening our understanding of when and how to use low-cost VR, as well as how low-cost VR compares to better, more powerful HMDs.

[2] http://source.android.com/compatibility/android-cdd.html#7_9_virtual_reality [Accessed Online: 17.01.2017]

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