Reactions to Immersive Virtual Reality Experiences Across Generations X, Y, and Z

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Abstract— **Immersive Virtual Reality (IVR) may potentially effect considerable lifestyle changes in societies, comparable to those seen with the spread of smartphones. Questions arise as to the significance of IVR, and how people will respond to this type of innovation. The article presents the results of a qualitative study which assesses the reactions of adults from Generations X, Y and Z to IVR. 18 people aged 20-55 took part in the study; seven IVR applications were used. The study assessed participants' reactions, level of presence, affective response and susceptibility to cybersickness. The development potential of IVR was also considered. It was assumed that older generations would be less present in the IVR and their subjective assessment of satisfaction would be lower. The results of the study confirmed the hypothesis that, as people age, their level of presence in IVR decreases, but surprisingly, it emerged that satisfaction with being in IVR increases along with the age of the participants.**

Keywords - Immersive Virtual Reality; Generations; Presence; Immersion; Emotions; Adults; Qualitative Methods.

I. INTRODUCTION

The definition of presence in virtual space was formulated as early as 2005 by Slater and Sanches-Vives, as the degree to which people actually respond to stimuli in Virtual Reality (VR), at the level of basic psychological reactions as well as in terms of complex emotions and behaviors. The simplest way to describe it is that a person has the impression of being in a virtual space rather than in the place where they are physically present [1].

Currently, the development of VR technology is at an interesting stage where, on the one hand, simulations have reached a relatively high level of advancement and can provide a suggestive experience to the senses of sight and hearing, while, on the other hand, there are few people (at least in Poland) who have had actual contact with the technology. The new devices, introduced in 2016 (Oculus Vive in March of 2016, followed by others) opened a new level of VR-experience quality. High resolution vision, a wide scope of view, instant and smooth reaction to body movements and interactive controllers enabled simulation that had not been technically possible before. Therefore, to distinguish the experience offered by the generation of devices available since 2016, we shall refer to it as Immersive Virtual Reality (IVR).

In the near future, IVR is expected to become commonplace, as devices gradually become more comfortable, lighter, cheaper and simpler to use. It is likely that IVR technology will increasingly be used by people of all ages and will gradually become a more ordinary element of our lives. This impending technological change leads to questions about its use and its likely impact on people's way of life. Who will use it? Is the user group limited to younger people who feel at ease with adopting new technological solutions? Will older people take full advantage of the opportunities offered by IVR? Finally, how will the perceptions of this technology differ among people of different ages?

With these questions in mind, we decided to conduct the qualitative study which is presented in this article. The study evaluates the impressions of adult respondents after their first contact with IVR technology. In order to capture age-related differences, three age-differentiated groups of people were invited to participate in the study. In Section 2, groups representing generations labelled by sociologists as Generations X, Y and Z are described. Section 3 shows age-related differences in the reception of the IVR. Section 4 describes the dimensions on which experience of presence in the IVR is evaluated in the literature. The study objective, research questions and methodological details of the study are laid out in Sections 5, 6 and 7. The results are described in section 8, followed by discussion in Section 9 and conclusions in Section 10.

II. GENERATIONS X, Y, Z AND TECHNOLOGY

People of different ages may have diverse approaches to digital innovation, as Information Technology (IT) plays different roles across generations. The dynamic development of the industrial economy, particularly visible since the second half of the 20th century, has introduced a large number of changes to the world in which subsequent generations grew up. In order to better capture and describe these differences, sociologists have distinguished the following generations [2][3]:

- Generation X was born in the period between 1965-1980. Their younger years were spent in the 'analogue' world, without computers and the Internet. Computers appeared only later in their adult lives when they were either already working (in the case of people born around 1965) or in their late teens (the younger part of

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this generation). This generation became familiar with smartphones as grown-ups.

- Generation Y (Millennials) are those born between 1981 and 1996. Their childhoods coincide with the explosion of the Internet and personal computing. To them, computer literacy and Internet are natural, but in their childhoods, small, portable devices with high-speed Internet access (smartphones, tablets) were not yet widely available, so their childhoods resembled those of previous generations. Generation Y started to use portable devices as teenagers, so they gradually entered the digital world during adolescence.
- Generation Z are those born between 1997 and 2012. To this generation, the digital world and the Internet have always been available. They do not remember a world without mobile devices and broadband Internet access; the "pixel world" functions as a natural complement to the "real world".

Each of these generations experienced their initial contact with digital technology at a different stage of their lives, so it is likely that they will have differing opinions about being in a virtual world (Table 1.). One might suspect that the opinions on IVR expressed by Generation Z, born in a world dominated by digital technology and broadband Internet, would be different from those who had to learn to use digital devices when they were adults (Generation X and, to a lesser extent, Generation Y). Evaluation of how age affects users' behaviours and responses to IVR experience can be valuable from various perspectives. Estimation of this technology's potential within specific age groups may help to evaluate how IVR could influence the lifestyle of future societies. Software developers may also benefit from age-related insights, in order to prepare applications more adequately suited to the needs of specific age groups.

In order to verify whether there are any differences between the generations in their assessments of IVR experiences, three age groups were distinguished in the recruitment for the interview. These represent the first years of the X, Y and Z generations, as defined by sociologists and mentioned above. It should be noted that the generational changes described by sociologists from Western Europe and the USA arrived in Poland with a few years' delay.

III. AGE-RELATED DIFFERENCES IN THE RECEPTION OF IMMERSIVE VIRTUAL REALITY

Due to intensified development and increasing availability of IVR technology, the number of research projects using this tool has grown rapidly. It should be noted that the general term 'Virtual Reality' (VR) may be applied to various experiences which differ from one another significantly. Sometimes, it defines an experience with a personal computer, some researchers designate experiences with basic Virtual Technology devices (before 2016) as VR, while others relate VR to the current IVR technology.

TABLE 1. PRESENCE OF A GIVEN TECHNOLOGY (TV, PERSONAL COMPUTER, INTERNET, SMARTPHONE) DURING CHILDHOODS OF SUBSEQUENT GENERATIONS.

Generation vs technology during childhood	Gen X 1965-80	Gen Y 1981-96	Gen Z 1997-12
TV (analogue) 1950-60 - USA, 1960-70 - Poland	yes	yes	yes
Personal Computer 1995 - Windows 95	-	yes	yes
Internet 1995 - civilian use	-	yes	yes
Smartphone 2007 - iPhone 2G	-	-	yes

In this article, we focus on the research projects done in 2016 or later, as the previous studies would have been carried out with earlier generations of VR technology, significantly inferior to the type available today. The vast majority of IVR research is conducted with young respondents. The first results currently available on the potential of IVR technology for older people [4] indicate that IVR may be accepted by this group of users. The usefulness of IVR is also studied on sample groups representing older generations in the context of training courses, for instance, which are aimed at improving the cognitive functions of older people [5] or the development of new tools to assess memory functions in older people [6]. Individual reports [7][8] indicate that performance levels in IVR may be lower among older people than among young people. However, there is no definitive research aimed at exploring how age impacts one's IVR reception. It is also interesting how the age of the users may affect one's approach to using IVR (e.g., the level of task completion), and how the same experience is evaluated, whether in terms of presence, subjectively perceived pleasure or effectiveness. It is also worth noting that all of the studies mentioned above focus on one experience (usually through a widely available application). In order to more effectively capture the potential differences in the reception of IVR, we believe it is necessary to use a wider range of experiences, preferably including experiences created specifically for the study [9].

IV. DIMENSIONS FOR IVR EXPERIENCE EVALUATION

Being in a virtual space is a relatively new possibility. Scholarly sources do not yet have a well-established, universally accepted theory that describes the parameters of virtual reality experiences and their psychological dimensions. Among existing research there is work by

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Slater [10], who suggests that the experience of immersion in a virtual environment should be described in two dimensions: Place Illusion (PI) and Plausibility Illusion (Psi). Slater assumes that PI pertains to the illusion of IVR being the same as actual reality, in terms of physical parameters. Therefore, the level of presence in the PI dimension depends on the physical features of the simulation (image quality, resolution, field of vision, natural simulation of head movements and other factors).

PI concerns the interpretation of events that take place in virtual reality. The level of presence in this dimension depends on the extent to which virtual events are perceived by the participant as actually occurring, whereby the participant will react to them as he/she would in the real world. Importantly, these two dimensions are independent of each other, i.e., it is possible to experience a presence at the PI level (where technical excellence in the simulation is high) while the Psi level is low (where events are interpreted as unrealistic and therefore do not engage the participant). The opposite situation may occur when, despite the low technical quality of the simulation, events are perceived as real (for example, this could be the experience of high involvement in a game running on a simple personal computer from the 1980s).

In 2018, a review of literature on immersion technology was published by Suh and Prophet [11]. Based on an analysis of 54 articles on the topic, the authors compiled a list of the most common dimensions used to describe the IVR experience. The analysis showed that the concepts used are similar in meaning to the definition of presence by Slater [10] in terms of PI and Psi. Alternative notions describing presence in IVR include Immersion (with its two dimensions: Physical Immersion and Mental Immersion) and Presence (with its three dimensions: Physical Presence, Spatial Presence and Social Presence). An important complement of Suh's and Prophet's work on the approach proposed by Slater, is a subjective evaluation of the IVR experience, measured by the intensity of one's affective reactions, such as Pleasure, Arousal, Dominance, and Positive/Negative Emotions.

Cybersickness is an important aspect of being in virtual reality. It describes a deterioration of well-being, resulting from a virtual world experience. Shafer et al. conducted a study proving that cybersickness occurs among players using IVR technology and is particularly common in games with higher levels of sensory conflict, like first person games [12]. This aspect of IVR experience would also be covered in the study.

V. The Study Objective

The study presented in this article was designed to evaluate the reactions of adults to their first experiences with IVR technology. In particular, the goal of the research was to compare the reactions of people of different generations (X, Y and Z). Our aim was to find out if the age at which at which a person first became familiar with digital technology has an impact on one's sense of presence during IVR experience and its evaluation.

Based on a literature review of virtual reality, we decided to describe this experience on the basis of two dimensions defining the sense of presence in virtual space, according to Slater's methodology [10], namely physical presence (PI) and reality of events (Psi). We assumed that a high sense of presence is manifested by the fact that the participant behaves in the virtual world as he/she would in reality: moves around freely, grips and manipulates objects, or reacts to stimuli in the same way as he or she would react in reality.

Based on the work of Suh and Prophet [11], the experience was also evaluated in terms of the respondent's affective reaction (Positive/Negative Emotions, Pleasure, Arousal, Dominance). We assumed that affective reaction is an indicator of subjective evaluation of the experience. A high level of positive emotions and feelings of pleasure following the experience indicate positive evaluation and satisfaction from experience, while negative emotions and unpleasant impressions indicate a negative evaluation.

Our study was also intended to find out if the respondents were affected by cybersickness during their IVR experiences. This issue was raised by the researchers and was the subject of a follow-up telephone conversation one day after.

VI. Research Questions

Following a review of the literature on the subject, we formulated the following questions concerning the relationship between age and reactions to an IVR experience:

Would the youngest respondents exhibit the highest levels of presence? How might the level of presence change as the age of the respondents increases?

Presence is understood here in two dimensions - as the physical presence (the freedom of movement, the speed of learning object manipulation) and as the sensed reality of the events in the virtual world (behaves similarly as one would in the real world).

VII. Method

The qualitative interview was conducted in June and July of 2019, in Warsaw. Each interview with a respondent took about 1.5 hours to complete and consisted of the following three stages:

1. Introduction. An initial conversation concerning the purpose and procedure of the research, the participants' interests and their previous experience with IVR. At this stage, the IVR equipment was also presented to the participant with information about how to operate it.
2. IVR experience. At this stage, seven different applications were used, one after another, in random order. The total time spent in the IVR was about 40 minutes.
3. Interview. At the beginning, questions were asked about the respondent's general impressions, the perceived attractiveness of the experience and about the elements that drew his or her attention. The respondent's impressions of the IVR experience were discussed in detail, with the respondent comparing the experience to reality, the factors

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that make the experience "real" and the factors negatively impacting the feeling of presence. Questions were also asked regarding any difficulties or barriers the respondent felt, and about his or her interest in repeating the experience. The interview also discussed the future applications of the technology, the potential for its development and the expected benefits and risks associated with the dissemination of IVR.

In addition, the day after the study, the investigator called the participants to ask if they had noticed any changes in their mood and if they had any other observations about the experience that they would like to convey.

The qualitative interview format was selected as the most adequate method for exploring the subject of this study, as the topic had not yet been well researched. The use of qualitative interviews allows one to generate new hypotheses and define interesting avenues for future research. The data collected during the study were subjected to qualitative analysis for commonly-recurring themes, using the method of thematic analysis [13]. The study was carried out in compliance with rules governing the implementation of qualitative research; a moderator and an observer taking notes took part in the implementation of each study.

A. Respondents

The study involved 18 people (9 females and 9 males), all residents of Warsaw, Poland. The respondents were recruited in three age groups (50% F and 50% M):

- 6 people aged 20-25 (from Generation Z)
- 6 people aged 35-40 (from Generation Y)
- 6 people aged 50-55 (from Generation X)

The aim of the recruitment process was to invite individuals typical of their respective populations in terms of education (mostly secondary education), income and occupation (the dominant group were employed in the commercial and services sectors).

B. Equipment

To conduct the research, we used a computer set equipped with an Nvidia GTX 1070TI graphics card to ensure the smooth operation of the applications. The IVR set used in the study was an HTC Vive Pro with HTC Vive controllers, selected due to its image quality, wide field of view, easy-to-use goggles, built-in headphones and pupil spacing adjustment mechanism.

C. Stimuli

The study used seven applications that present different IVR environments. We selected the applications that demonstrate IVR's practical capabilities in a variety of uses. Games were deliberately not used, as these are generally marketed to younger target users and tend to be focused more on entertainment or competing for scores than on simulating reality. The applications were chosen to allow for diverse modes of transport and user interaction within the virtual environment. Only stable, high quality and smooth-running applications were selected for the study. The applications were presented to respondents in randomised order.

Two applications were created specifically with the Vizard environment [14] (Contemporary Loft Apartment and Walk the Plank), while the remaining applications were selected from publicly available software on the Steam platform. The 360° film was taken from YouTube. The experiences presented in the study were as follow:

1. *360° Video.* This 5-minute, stereoscopic 360° film shows short shots of places of natural interest. The film consists of several shots, including a flight next to a helicopter over a beach in a big city in the USA, a view of a sandy beach, swimming underwater with a turtle and diver, swimming on a boat in Thailand, and a rocky seaside beach with a pier. The film was played through the DeoVR Player application. While watching, the respondents were sitting in a chair, so the stimulus was an example of passive transport/passive locomotion. The aim of this simulation was to present the real world using IVR technology.
2. *Dreams of Dali.* This abstract world, inspired by the works of Salvador Dali, shows the nearly unlimited possibilities for creating spaces in Virtual Reality, which can be governed by entirely different laws than those in the real world. The application uses transport based on predefined points with a visual choice of a "gaze pointer". It was also possible to move, by walking in the physical world.
3. *Contemporary Loft Apartment.* The application simulates an environment familiar to the participants of the study (living in an apartment building), where free movement and interaction with objects is possible (e.g., lifting equipment). The participant could move physically by walking or moving his character, using the arrows on a controller. The environment was created in WorldViz [15].
4. *Walk the Plank.* This is a simulation of a suspended board which the user is supposed to walk on. The environment was created in Vizard software [14]. The reason for using this application was to test the respondents' reactions to the simulation of being at a high altitude.
5. *Droid Repair Bay.* This consisted of a robot repair station on board a spacecraft, set in a world inspired by the Star Wars series.

This application allowed for advanced interaction with the environment (control of devices, robots, manipulation of controllers).

6. *The VR Museum of Fine Art.* This is a virtual museum with outstanding works of art (sculptures and paintings) in their actual sizes. The user moves around the virtual museum on foot or by teleporting him/herself to a designated location. The application is distinguished by a very accurate representation of both the museum building and the collected works.
7. *Google Earth - Virtual Tour Landmarks.* This allows for a bird's eye view sightseeing tour of unique tourist attractions worldwide (including Rio de Janeiro, the Vatican, the Grand Canyon and Barcelona). The user can see the places from high above and hear sounds that are typical of a given location. He/she is only an observer and has no influence on the course of the tour.

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VIII. RESULTS

A. Opinions on IVR prior to the study

IVR is widely known in industry circles, but it does not yet evoke many specific associations outside of the IT environment. The respondents in this study had not had experience with IVR prior to the study. The experience was difficult for them to imagine in advance, and they did not know how to describe it; they had made assumptions based on previous experiences with 3D cinemas, sci-fi movies or friends' opinions about IVR games played on consoles in shopping centres. Some respondents associated IVR primarily with entertainment and computer games. Others expected the study to be a virtual simulation of the world and were curious to see how realistic it would feel.

B. First Reactions

Only one person rated the impressions from IVR's experience as average (a 25-year-old female). The remaining respondents, regardless of their age, said that their expectations had been significantly surpassed. Interestingly, the most enthusiastic reactions were recorded among the respondents from the oldest age group. While there appeared to be a high level of satisfaction from the experience based on the descriptions of impressions given by people from the younger group (20-25 year olds), the middle group (35-40 year olds) and the older group (50-55 year olds) in particular, expressed even more enthusiastic opinions. The oldest age group reacted very emotionally to the experience and specifically stated that it was something they had not expected, at all. The respondents felt their IVR experience was too short, and a few people even said that they did not want to return to reality: *"I didn't want to go back; I'm excited, I'm fascinated, It really exceeded my expectations"*.

All respondents claimed that the time in IVR passed very quickly: "*I'd never say it took such a long time. I thought it was only 10-15 minutes, really. It finished too soon"* (M, 50). Everyone declared that they would like to repeat the experience, and several people said they wished to buy IVR devices for home use.

C. The sense of presence

Almost all respondents in the study used similar words to describe their IVR experience: "*You put on the goggles and simply move to another world".* While younger people (aged 20-25) highlighted new functionality offered by this technology, the older age groups saw the study as a surprising and very emotional experience. One person described it thus: "*I didn't think the human mind could play such jokes on you, not at all. It seems to me that normally I stand with my feet firmly on the ground, and that I am in control of everything. And here, it turns out I am not. I close my eyes, or rather (...) I put on the goggles and I think I'm doing something different than I am doing in reality. So this study lets you go on a collision course with yourself, with what you expect and how you perceive reality."* (F, 51)

The sense of physical presence in IVR (PI) was experienced by all respondents. The graphic quality and the possibilities of interaction with the virtual environment were highly rated, as the controllers allowed those taking part in the study to move around freely and grip objects precisely. Everyone claimed that the mapping of head movements, the wide field of vision, the simulation of hand movements and capabilities for object manipulation were so convincing that they produced a sense of physical presence.

The applications themselves, however, aroused different levels of sense of presence. Sometimes it was just a sense of physical presence (PI dimension - 360° Video, Google Earth), whereas in some applications the respondents *also* felt an illusion of the reality of events (Psi - Dreams of Dali, the VR Museum of Fine Art, Walk the Plank, Droid Repair Bay).

The sense of presence depended on the interests of the respondents. Those keen on art got deeply immersed in the world of Salvador Dali:

"It was incredibly real.... I think somebody must've worked hard on making sure that the person who wears the goggles really feels as if they were in another world. Because I felt like I'd been teleported to another world. Everything was there actually, I had a feeling that wind was blowing in my face. I don't know why, but it was probably because of the realness of the experience of that other reality" (F, 51, commenting on her experience with Dreams of Dali).

In turn, those who liked entertainment and games were interested in the simulation of a service station on a spacecraft inspired by Star Wars: "*You get the feeling that you are genuinely involved in it (...) you're there and it feels fantastic*" (F, 40).

Despite positive subjective assessments from all of the respondents, our observation of their behavior led us to conclude that the older people explored the environment less intensely, and ventured to try out the interaction possibilities less frequently. As well, the older the respondents were, the more often they needed guidance from the researcher; they needed more time to get used to virtual reality and that process appeared more complicated.

The differences between people of different generations were particularly pronounced when using the Droid Repair Bay simulation. The youngest people in the study immediately looked around the room, actively explored it and quickly learned how to operate the devices. The oldest group (50-55 year olds) looked around to a lesser extent and were less at ease in their attempts to interact with the environment. It seemed that an attempt to interact with an object that could not be manipulated was perceived as an error and should therefore be avoided. Older respondents needed more frequent guidance from the investigator and advice on which actions were 'the right ones'. However, they also positively evaluated the application and said that they had felt present in the virtual world.

Based on the interviews with the respondents, we can conclude that the positive evaluations of the realism in the simulations were partly due to a large gap between low and incorrect expectations and the surprisingly high quality of the actual IVR experience. The experience was highly evaluated, though it was not ideal. Respondents mentioned a

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number of factors that reduced their sense of presence in the virtual worlds.

The lack of other people in IVR was brought up several times in the interviews. In particular, the youngest group (20-25 year olds) wished to see more interactive elements (including other people) in the assessed applications. In the opinion of the younger respondents, the presence of people – even those generated by the application – would have increased the perceived realism of the experience: "*Well, I guess other people were missing. And that's what real life is all about. I'm getting a ticket, I'm walking with it and into the coffee shop. The waiter's offering me something. It doesn't need to be a long experience, but it will produce the illusory impression that I'm really there"* (F, 25).

A full immersion in the virtual world was also hampered by stimuli from the outside world (the voice of the researcher, the weight of the goggles, the cable connecting the goggles with the computer) and imperfections of the applications. Sometimes pixels were visible in the image and the use of the controller was inconsistent across the applications. There were also some software errors and gaps, e.g., those enabling the user to pass through objects or walls. Such stimuli worked as "anchors", keeping part of the respondent's consciousness in the real world.

D. Affective Response

The descriptions of the respondents' reactions show a clear difference between traditional flat screen media and IVR. Virtual reality is not only perceived, but above all it is experienced. When describing their experiences, all of the respondents spontaneously talked about feelings and emotions. The content of the experience was of secondary significance. They used such words as: *pleasure, fear, anxiety, bliss, joy, horror, excitement, relaxation*.

In the youngest group (aged 20-25), the evaluation of the experience was positive or very positive, yet at the same time the respondents were not very surprised by what they saw – probably due to the fact that representatives of Generation Z have spent their lives in a world full of digital devices, and IVR is a natural expansion of an experience they already know. They were less emotional than the older group, and used words such as: "*cool; wow; I liked it; great"*. People aged 35-40 (Generation Y) did not expect such a level of realism. To them, the IVR experience was both positive and emotional. Representatives of Generation Y use technology to a lesser extent than younger people, so the gaps between their expectations and actual impressions following the experience were greater than those seen among respondents from Generation Z. They used terms like: *I am excited, stunned; I'm literally trembling inside; I haven't experienced anything like that in my whole life.*

The experience was the most surprising to the oldest people involved in the study (50-55 year olds, Generation X). This group rated the experience very highly – we could even say they were enthusiastic, and their emotions seemed the strongest of all the respondents: "*I don't know if I want to go back to the real world (...) yes... I think I'm still in a state of great shock. | Clearly, I was overwhelmed in the way I hadn't expected"* (M, 55); "*That reality shocked me (...) the label 'reality' is truly justified. Through this study you've encouraged me to buy this device, seriously.* (M, 51); "*I'm fascinated at the moment. I was surprised at the realness of it"* (M, 50); "*I didn't want to go back because everything was so beautiful out there"* (F, 50).

One respondent (F, 50) described her experience as follows: "*I was very emotional about it. Even now I have tears in my eyes, because when I saw the sea, I was immediately emotional... I would like to go back to my holiday time. It was so...gosh, it was so emotional to me...incredibly emotional, that's for sure. It's the first time I've ever had one of those goggles on me. Honestly, it felt good for me there. It was cool".*

E. Cybersickness

The literature indicates cybersickness as a significant factor reducing satisfaction from IVR experiences [12]. For this reason, special attention was paid to this phenomenon in the course of the study. In addition to raising the question of cybersickness during the interview, the respondents were telephoned and asked follow-up questions concerning their mood during the day after the research.

It was surprising that the participants did not mention any negative feelings (such as dizziness, imbalance, discomfort or nausea) during the interviews, nor were they mentioned during the telephone conversations. Shifts in mood (if any) were caused by the intensity of the experience, though respondents did not describe them as a change for the worse.

This result may differ from observations described elsewhere in the literature, as most of the reports describing the phenomenon of cybersickness are based on IVR games, whereas in our study, games were deliberately excluded. Games are highly stimulating applications and often involve controlling one's own body movements in IVR with the buttons on a controller, which causes unpleasant feelings among a majority of adult users.

IX. Discussion

The study has shown differences in the perception of IVR by people at different ages. A look at IVR experiences through the lens of generational differences is an important complement to existing knowledge on human interactions with IVR. At the same time, the study has shown that there are a number of related topics that may be subject to research and analysis.

The first of them is user experience in IVR. So far, there have only been a few papers on this subject. The quality of user experience affects the user's satisfaction and performance in the virtual world. Another prospective research idea concerns social interactions within IVR. Most of the current research relates to the experience of one person who is in IVR on his/her own. It would be interesting to see how several people interact within one IVR simulation. What would be the similarities and differences compared to their social interactions in the real world? Yet another interesting perspective on IVR is to measure the acceptable cost of real versus virtual experiences, of similar content. The first publications concerning Willingness to

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Pay (WTP) in IVR are already available, but the area is still new.

Furthermore, the definition of the dimensions through which IVR experiences are described may need to be updated. The quality of IVR simulations changes quickly, such that the theories proposed a few years ago may no longer apply to all aspects of the experiences being made available by today's technologies. Another interesting area is the analysis of factors influencing the level of presence (immersion) in virtual reality. Information about what affects amplification and what weakens presence in IVR can shed new light on our understanding of the phenomenon. Taking into account the results of this study, it can be expected that once the technical imperfections of the equipment are eliminated and the simulation is complemented with social aspects, the sense of presence in IVR would increase even further.

X. CONCLUSIONS

The results of the study suggest that the level of presence in IVR decreases with age. We observed that the older respondents moved around less freely in the virtual world and had more difficulty using interactive objects. In the case of the Generation X, there was a greater difference between their behaviors in reality and in the virtual world than in the case of the younger respondents. It is surprising, however, that the subjective evaluation of IVR did not decrease with the age of the participants. In fact, the oldest group evaluated the IVR experience at the highest level.

With regard to generational differences, one explanation of this outcome may be the fact that people from Generation X grew up in a world with far less ubiquitous digital technology. They have had to adapt to the use of digital devices and as adults may need additional technological education. Today, these people are primarily task-based IT users who use it more to perform specific tasks, rather than using it for fun and leisure. That is why they less frequently play computer games and may be less interested in the functionality of new devices. In addition, their previous experiences with technology may have left them convinced that new devices are usually difficult to operate and designed for the younger generations. It is likely that to Generation X, it was unexpected and very attractive that IVR turned out to be surprisingly easy to operate. In IVR, there is no need to learn an intermediate interface, such as an operating system, a keyboard or a mouse). In order to look around, one only needs to move one's head; in order to go forward, one needs to take a few steps; in order to grip an object, it is enough to clench one's hand on the controller. From this point of view, IVR responds well to the needs identified by Kowalski et al. (2019), in a study on the use of smart speaker assistants (Google Home) by older people. One of the needs identified is that the new technology should offer "*accessible design with low barrier of entry, unlike regular computers"* [5].

In the case of Generation Z, the reason for their relatively low evaluations of IVR experience (still high, but not enthusiastic) may be the fact that new technologies have always been present in their lives. Rather unsurprisingly, Generation Z perceived IVR as a very attractive technology. However, from their point of view, the rise of IVR is a fully expected stage of digital technology development. The evaluations of the middle-aged group are situated between the extremes described above, determined by the youngest (Generation Z) and the oldest (Generation X). What follows from the above is a practical recommendation for software developers who should account for the fact that the older the group of potential users, the easier an IVR application should be.

Another interesting conclusion is that IVR is distinct from other media we currently use. What is characteristic of IVR is the fact that it is experienced, rather than received or read, as in the case of conventional media. The respondents talked about their impressions of IVR as if they were reports from their real lives. They did not describe their impressions as they would have described a book, a film or a newspaper article. The most important elements were feelings and emotions. The content of the application was of secondary importance.

The results of the study indicate that IVR may already have many practical applications. It can be a substitute for travel, especially for people who find it difficult to travel longer distances in reality. Virtual spaces, such as the VR Museum of Fine Art used in the study, offer experiences very similar to an actual museum visit. For many people, IVR can also constitute an attractive form of entertainment.

Based on the results of the study, we can assume that IVR technology will continue to develop because it is highly attractive and generates positive reactions. Additionally, from a technical point of view, IVR devices are becoming increasingly comfortable: this year (2019) has seen the introduction of the first autonomous goggles; they do not require an external computer or a cable connection (the Oculus Quest). We believe that this process may facilitate further expansion of IVR technology.

REFERENCES

[1] M. V. Sanchez-Vives and M. Slater "From presence to consciousness through virtual reality," *Nature reviews. Neuroscience*, vol. 6, no. 4, pp. 332–339, Apr. 2005.

[2] M. Dimock, "Defining generations: Where Millennials end and Generation Z begins," *Pew Research Center*, vol. 17, 2019 [Online]. Available: http://tony-silva.com/eslefl/miscstudent/downloadpagearticles/defgenerations-pew.pdf

[3] M. McCrindle and E. Wolfinger, "The ABC of XYZ: Understanding the Global Generations." The ABC of XYZ, 2009.

[4] H. Huygelier, B. Schraepen, R. van Ee, V. Vanden Abeele, and C. R. Gillebert, "Acceptance of immersive head-mounted virtual reality in older adults," *Sci. Rep.*, vol. 9, no. 1, p. 4519, Mar. 2019.

[5] J. Kowalski et al., "Older Adults and Voice Interaction: A Pilot Study with Google Home," *arXiv* [cs.HC], 17-Mar-2019 [Online]. Available: http://arxiv.org/abs/1903.07195

[6] É. Ouellet, B. Boller, N. Corriveau-Lecavalier, S. Cloutier, and S. Belleville, "The Virtual Shop: A new immersive virtual reality environment and scenario for the assessment

of everyday memory," *J. Neurosci. Methods*, vol. 303, pp. 126–135, Jun. 2018.

[7] J. Chen and C. Or, "Assessing the use of immersive virtual reality, mouse and touchscreen in pointing and dragging-and-dropping tasks among young, middle-aged and older adults," *Appl. Ergon.*, vol. 65, pp. 437–448, Nov. 2017.

[8] A. Plechatá, V. Sahula, D. Fayette, and I. Fajnerová, "Age-Related Differences With Immersive and Non-immersive Virtual Reality in Memory Assessment," *Front. Psychol*., vol. 10, p. 1330, Jun. 2019.

[9] S. A. McGlynn, R. M. Sundaresan, and W. A. Rogers, "Investigating Age-Related Differences in Spatial Presence in Virtual Reality," *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, vol. 62, no. 1. pp. 1782–1786, 2018 [Online]. Available: http://dx.doi.org/10.1177/1541931218621404

[10] M. Slater, "Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments," *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, vol. 364, no. 1535, pp. 3549–3557, Dec. 2009.

[11] A. Suh and J. Prophet, "The state of immersive technology research: A literature analysis," Comput. Human Behav., vol. 86, pp. 77–90, Sep. 2018.

[12] D. M. Shafer, C. P. Carbonara, and M. F. Korpi, "Factors Affecting Enjoyment of Virtual Reality Games: A Comparison Involving Consumer-Grade Virtual Reality Technology," *Games Health J*, vol. 8, no. 1, pp. 15–23, Feb. 2019.

[13] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative research in psychology*, vol. 3, no. 2, pp. 77–101, Jan. 2006.

[14] "Vizard | Virtual Reality software for researchers." [Online]. Available: https://www.worldviz.com/vizard-virtual-reality-software. [Accessed: 09-Aug-2019]

[15] "WorldViz - Virtual Reality Creation and Collaboration." [Online]. Available: https://www.worldviz.com/. [Accessed: 09-Aug-2019]

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