A Survey on AR/VR Games for Mental and Physical Public Health

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***Abstract*—The use of augmented and virtual reality (AR/VR) has recently been increased in various people's work and life. The combination of technology with digital games have recently received much attention. The 2020 Augmented and Virtual Reality Survey Results report by Perkins Coie, XR Association, and Boost VC, pointed out that immersive techniques are leaving from laboratory research and theoretical applications and growing up as fully mature and income-generating marketplaces. Except for games and entertainment, the most common area reported was healthcare and medical devices from immersive technologies, followed by education. The survey presented in this paper explores the usage, perceived benefits and problems of AR/VR games for mental or physical health. It also highlights future features that users would see as relevant in these applications. Through an online questionnaire, we found examples of used AR/VR games and their usage frequency, the user's perception of their mental or physical health benefits and problems, and the prospects to physical and mental health for AR/VR games. This study is helpful for researchers and developers both in computer science and medical science. It provides people with examples of existing consumer-level products, their advantages and disadvantages, and AR/VR games' requirements relevant to mental and physical health. In future work, the survey sample size would be extended to collect additional user experience data and further explore the challenges and opportunities of such techniques for public health.**

***Index Terms*—Virtual reality, augmented reality, public health, games, survey**

I. Introduction

With the increased development of AR/VR of technologies, as shown in Fig 1, more research focuses on applications of the techniques and their evaluation. There is an increasing amount of consumer-level applications entering the lives of the public. Among them, AR/VR games have received much attention. Such games can provide fun and interest and bring a rich experience including serious objectives [1], such as benefits for users' mental and physical health.

A. Aim and Research Questions

From the perspective of the applied and evaluated techniques, this study explores the usage situation of AR/VR, thereby finding further challenges and opportunities and ideas for future studies. Thus, the main research objectives of this article are to explore the usage of the AR/VR games while bringing entertainment effects, what impact do these games have on the public's physical and mental health; and how the public's future expectations of AR/VR games could affect their physical and mental health. To address the aim, this study conducted an online questionnaire for the public to find potential perceived benefits and problems of VR/AR games for mental and physical health. The usage data regarding how often the AR/VR technology was used in addition to what game applications were tested were gathered from volunteers. The participants were also asked to imagine future features that these applications could incorporate. As such, the main research questions were as follows:

- RQ1: What is the usage experience of VR/AR games of the public?
- RQ2: What are the publics' perceived benefits and problems of VR/AR games for mental and physical health?
- RQ3: What features would the public like to see in future VR/AR games for mental and physical health?

B. Background

The following paragraphs present the definitions and relevant concepts of a game and AR/VR. Game is a rule-based system with variable and quantifiable outcome based on the assigned different values [1]. The game result relies on the players' effort [1] and the degree of understanding of the rules. A game can improve motivation and engagement for special purposes [2], not only for fun and entertainment but also for serious objectives [1].

As shown in Fig 2, mixed reality (MR) covers the whole range from the real world to the virtual environment, AR and augmented virtuality (AV) is the continuum between the natural world and the virtual world, where AR is closer to reality. Like a bridge from real to virtual, AR merges the physical and digital worlds, which is a three-dimensional technique, adds or removes computer-generated digital objects in the real world [3], thereby improving the sensory perception of the real environment by the content layer of information [4].

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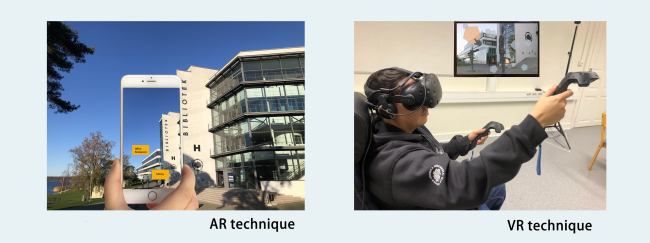

Fig. 1. An example of AR/VR techniques.

AR is not limited to a particular display technique nor the sight sense [4]. AR could operate on three main displays: head-mounted displays (HMD), handheld displays, and spatial displays, such as Microsoft Hololens, Google Glass; smartphone, tablet PC; and spatial augmented reality (SAR) by using video-projectors [5]. AR could also apply to all senses (including smell, touch, and hearing), such as sensory substitution application, which substitutes or augment missing senses for users. For example, AR could help blind and visually impaired users through audio cues and help deaf users through visual cues [6]. The AR technique is based on having support for three aspects: real objects tracking tools, information processing hardware and software, and display devices [3], [6].

In Milgram's continuum of real-to-virtual environments statement, as shown in Fig 2 [7], VR is the other end of the coordinate axis relative to the real world. VR was first introduced in the 1960s, which was described as a window, in which users could perceive and interact with a virtual world from the window as if looking, feeling, and sounding real world [8]. The definition of VR is varying, such as an immersion display technique with 3D models, which allow users to real-time interact with the models [9]; an advanced digital human-machine interface in virtual worlds [10]; a 3D immersive environment created by a computer [11], or to simulate physical presence and sense in a virtual environment to reproduce users' sensory experiences [12]. Overall, three main aspects are key here: immersion, interaction, and perception.

Based on the level of immersion, VR could be classified as non-immersive, semi-immersive, and immersive [13]. Different displays can be used to achieve different levels of immersion. The most immersive, such as VR glasses, HMDs, and CAVE, provide a completely immersive simulation experience for the VR applications. Equipment such as desktop, laptop, TV, or large screen supply the cheapest and simplest VR to recreate the real world. A semi-immersive VR is between the two above, which produce a 3D scene viewed on display using a perspective projection coupled to the head position of users, such as Fish Tank VR [13].

Moreover, the perception of VR also rely on audiovisual stimuli as a type of interaction, but some studies reported applications of multisensory VR systems, such as haptics (simple vibration, thermal, tactile, or kinesthetic), smell, and taste [14]. Furthermore, except for those mentioned above, which are relevant to output, the VR interaction also includes input devices. These range from keyboard, mouse, trackball, and joystick for lower immersive VR, to tracking devices for higher immersive VR, such as bend-sensing gloves (tracking hand movements/postures/gestures), pinch gloves (tracking the fingers movements), and users' physical movements trackers [13].

C. Related Work

Perkins Coie LLP, XR Association, and Boost VC conducted the fourth annual Augmented and Virtual Reality Survey Results report in early 2020 by 191 professionals [15]. Their report reviewed the development of the AR/VR industry in the past year and looked forward to its future. They pointed out that their interviewees represent strong optimism for the continued growth of immersive games and broader applications in other areas, such as healthcare, education, telecommunication, manufacturing, retail, and disaster preparedness. Among them, specifically, healthcare obtained more attention. They expected the healthcare industry in AR/VR would reach about 11 billion dollars by 2025. They also said more and more immersive technology applications were being recognised, such as simulated surgical training, remote diagnosis, pain management, palliative hospice care, and molecular level 3D visualisation of diseases. In other various industries, respondents also expected immersive techniques to improve operations and outcomes and enhance efficiencies. For example, such training for global staff could allow less cost for travel and lodging, as well as medical education and training with more opportunities for practice repetitions. The report claimed that immersive techniques appear to become a more significant part of people's daily lives worldwide. In addition, over 75% of the respondents expect that the total revenue of the AR market will eventually surpass that of VR due to the ubiquity of mobile devices that make it easier to use AR applications. On the other hand, the most need for improvement, which will impact users adoption of such techniques, is the continued upgrades of the device. Among them, 42% of the interviewees believed devices should be smaller and sleek, followed by 39% of participants' more comfortable [15].

There has also been a previous online survey in 2020 focusing on the possibilities and challenges with AR/VR/MR and gamification usage in healthcare [16]. Unlike the target participants and research aim of this study, in the previous work, we paid more attention to the staff, researchers, and students in the healthcare-relevant organizations, to discover the state-of-art of AR/VR/MR game applications/software in their working/studying. Based on 30 participants' answering, we explored the actual used digital games and AR/VR/MR applications applied in healthcare. This previous work collected the applications' general information (including name or feature, application purpose, target user, and use occasion), usage situation (covering use time and use frequency), user experience (advantages and disadvantages), obstacles to mass

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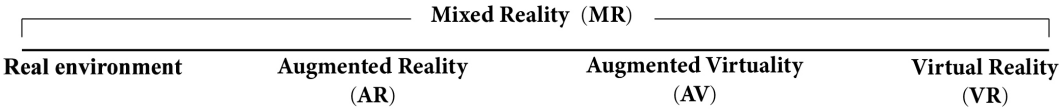

Fig. 2. The relationship of a real environment to virtual reality (VR) [7].

adoption for such techniques, and its future requirements and concerns.

In their answers, 15 software/applications were found. Five were AR/VR/MR games, the other five only involved AR/VR/MR techniques without any game element, and the remaining five were games without AR/VR/MR techniques. From the application purpose view, AR/VR/MR techniques were mainly applied to medical education and training (such as simulation CPR, model operation, 3D body map, virtual surgery, and X-ray imaging training) and mental health (such as stress management, anxiety relief, and for autism treatment). For the usage frequency view, only two participants mentioned it. One of them used a VR game (Deep) five hours per week. Moreover, interviewees claimed the advantages of the game in healthcare were in line with cognition and acceptance of children and stronger motivation than non-game activities. The reported problems were that of the high cost of software and hardware, the potential for being addictive, and not appropriately applied. Furthermore, the benefits of AR/VR/MR techniques in healthcare were the ability to change the setting for the patients/students (simulation CPR), intuitiveness, straightforward and easier to perceive (3D body map), more precise and valuable for the operation and better result (model operation), safe and allowed repetition (virtual surgery, X-ray imaging training), and better game experience (Deep). On the other hands, the disadvantages of AR/VR/MR were high cost and low quality in presentation. In addition, the interviewees mentioned five additional organisation requirements for AR/VR/MR games, such as rehabilitation, psychological and mental treatment, psychological diagnosis or psychotherapy, baby' taking care skills training, and games for elderly health. There were two more requirements mentioned for the AR/VR/MR techniques, being teaching and muscle relaxation.

Furthermore, there was a previous survey of AR/VR/MR technologies targeting another field, such as using the VR technique in higher education. From Cicek et al. work, we could see most of the interviewees (46/55, 84%) had experience with VR applications, 25 of them had such applications at home [17]. To compare a 2D display with HMD, they created several questions about the sense of the passage of time, immersion in the virtual world, and the opinions on the VR techniques. From their result, 77% thought VR systems could provide more information, 96% believed the visual stimuli of the VR applications was fascinating, and 60% claimed using the VR system would bring them to feel present in a virtual environment [17].

D. Structure

The rest of this paper organised as follow. Section II explains the research method, covering the research ethics, questionnaire design, procedure, participants, and analysis methods. Next, Section III presents the result based on 74 individual questionnaire answers, including the AR/VR games usage situation, benefits and problems of such games for mental and physical health, and the future features expectation of AR/VR games for mental and physical health. Section IV compares the outcomes with relevant previous work and explores the possible reasons behind the results. Finally, Section **??** gives a summary of the research and highlight its contribution and future work.

II. Method

This section presents the research method, including relevant aspects regarding research ethics, questionnaire design, structure and logic description, pilot study, procedure, participants and analysis methods.

A. Research Ethics and Questionnaire Design

Based on the General Data Protection Regulation [18] and Singer and Vinson's guidelines for practical ethics [19], we generated a research ethics explanation for the study, which was included as part of the informed consent form shown before the beginning of the online questionnaire. It also highlighted that no sensitive data was collected, there was no link to any person, as well as all data were confidential.

As shown in Fig 3, the questionnaire has three sections with 60 questions. Except for the Q1 and Q2, which are the consent form question and age group evaluation, the other 58 questions could be organised into two parts: (1) the usage of VR games and (2) the usage of AR games. To answer RQ1, each part included questions about VR/AR usage (Q3/Q32), use frequency (Q4/Q33), and application name (Q5/Q34). To answer RQ2, the questions (Q6/Q35) explored benefits for mental health and (Q7/Q36) benefits for physical health. To further address RQ2, the questions also mentioned VR/AR games advantages (Q8/Q37), and problems (Q9/Q38). Moreover, questions (Q31/Q60) were created for exploring RQ3 and imagined future features of VR/AR games for mental or physical health. Apart from Q31 and Q60, the other questions in each part were repeated three times (Q10-Q16, Q17-23, Q24-Q30, Q39-Q45, Q46-Q52, Q53-Q59) to deal with the participants who reported more than one VR/AR game user experience. If they did not have any more experience, they could directly skip the repeated questions. The mandatory questions were marked with a star.

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The questionnaire were designed with single choice questions, 7-Likert scales, and open questions. For the first two, we quantified the options for descriptive statistics and statistical analysis. For the latter, we extracted and analyzed the high-frequency key words in the answers. Before the formal document survey, the researcher conducted a pilot study to test the usability of the questionnaire and its provided link.

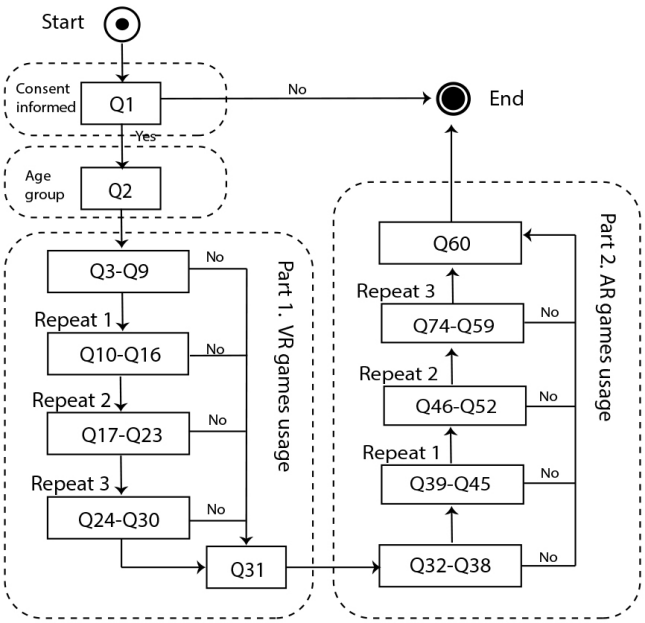

Fig. 3. The questionnaire structure and logic.

B. Procedure and Participants

The questionnaire was created in Microsoft Forms and spread by social media (LinkedIn, Facebook, Twitter, and WeChat). By mid-April (2021-04-15), there were 76 answers. Two declined to join this survey resulting in 74 effective obtained replies. The following analysis is based on the 74 answers. The age group of the participants was mainly concentrated within the range 25-30 years old (52), followed by the age group 18-24 (17). Four participants came from the age group 35-44, and only one from the 45-55 age group.

III. Results

To answer the three RQs, this section organises and analyses the results in four subsections: the AR/VR games usage situation (III-A), perceived benefits (III-B) and problems (III-C) for mental and physical health, and the future imagined features of AR/VR games for mental and physical health (III-D).

TABLE I
THE AR/VR GAME USAGE SITUATION OUT OF POSSIBLE FOUR OPTIONS.

	Q3/Q32	Q10/Q39	Q17/Q46	Q24/Q53
VR	38	6	4	2
AR	21	2	1	1

TABLE II
THE USAGE FREQUENCY OF THE MENTIONED AR/VR GAMES.

(a week)	VR				AR			
	Q4	*Q11*	*Q18*	*Q25*	*Q33*	*Q40*	*Q47*	*Q54*
Less than once	35	4	4	1	16	1	0	0
2-3 times	3	1	0	1	2	0	0	0
Over 3 times	0	1	0	0	2	1	1	1

A. Usage Situation

Table I shows the number of "Yes" answers from Q3/Q32 (Do you have experience with VR/AR game applications?) and their three repeated questions (Q10/Q39, Q17/Q46, Q24/Q53). It can be seen that from the possible four times data could be collected, the VR technique (50 person-times in total answered yes) had been more used than the AR technique (25 person-times in total answered yes) out of the 74 volunteers of the questionnaire.

1) Application Purpose: From the positive answers, there were 23 applications mentioned. Among them, 17 were VR games, and the others were games with AR techniques. Based on the game genres, the 24 games could be grouped into eight types. As shown in Table III, the VR shooter game and AR adventure game were the most used game genres. VR shooter games (6) was also the genre with the most number of games mentioned in this survey, followed by VR adventure games (4) and simulation games (4). Only one game was mentioned in the AR adventure game category. However, this game was mentioned by ten of the participants. This outcome is quite natural since the game *Pokémon Go* previously has been reported as one of the most popular games with health benefits [20], [21]. *Pokémon Go* has also previously been evaluated in terms of physical and psychological benefits for dog owners [22].

2) Use Frequency: Although more than half of interviewees have VR/AR game experience, the use frequency of most games was lower than once per week. As shown in Table II, only six people mentioned they play the VR/AR games more than three times per week and the other six people 2-3 times per week.

B. Perceived Benefits of AR/VR Games to Health

Even little play still provides the user experience on health benefits. Fig 4 shows the statistics of the mentioned games' benefits on mental and physical health. Horizontal comparison, most of them believed the AR games benefit their mental (18/25, 72%) or physical (19/25, 76%) health. However, the percentages for VR games were lower. Twenty-nine person-times thought that the VR games had benefits for their mental health (29/50, 58%), and twenty-four person-times reported supported benefits for physical health (24/50, 48%). Vertical comparison, more than twice as person-times who disagree, there was 90 person-times thought that AR/VR games were good for physical and mental health. Among them, there were four more person-times (47 vs 43) who believed AR/VR games were beneficial to their mental health than their physical health.

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TABLE III
OVERALL AMOUNT STATISTICS OF THE MENTIONED VR/AR GENRES AND GAMES.

	VR			AR		
	Genres	***Games***	***Name/Feature***	***Genres***	***Games***	***Name/Feature***
Action game	1	1	*Sword battle*	1	1	*Alipay's Ant Manor* AR hand exercises [1]
Shooter game	11	6	*Beat saber* [3], Shooting zombie [2], Shooting game [1], First-person shooter game [3], *Fruit Ninja* [1], *Gunfight* [1]	1	1	Dead lands [1]
Rhythm game	1	1	Dance game	0	0	null
Adventure game	4	4	*Moss* [1], Discovery game [1], Sword and magic [1], *Mage guard: the last grimoire* [1]	10	1	*Pokémon Go* [10]
Role-playing game	1	1	*Perfect World* [1]	0	0	null
Simulation game	5	4	Car racing game [2], Fire fighting simulation [1], *Roller Coaster* [1], Flight training [1]	0	0	null
Strategy game	0	0	null	2	1	*Onmyoji* [1]
Casual game	0	0	null	2	2	Take picture with dinosaur [1], Collecting "Fu" card [1]

Note: In the "Name/Feature" columns, the italic names are real games, whereas the other ones are only a type of game feature. The number in "[ ]" means the total number of participants mentioning such games.

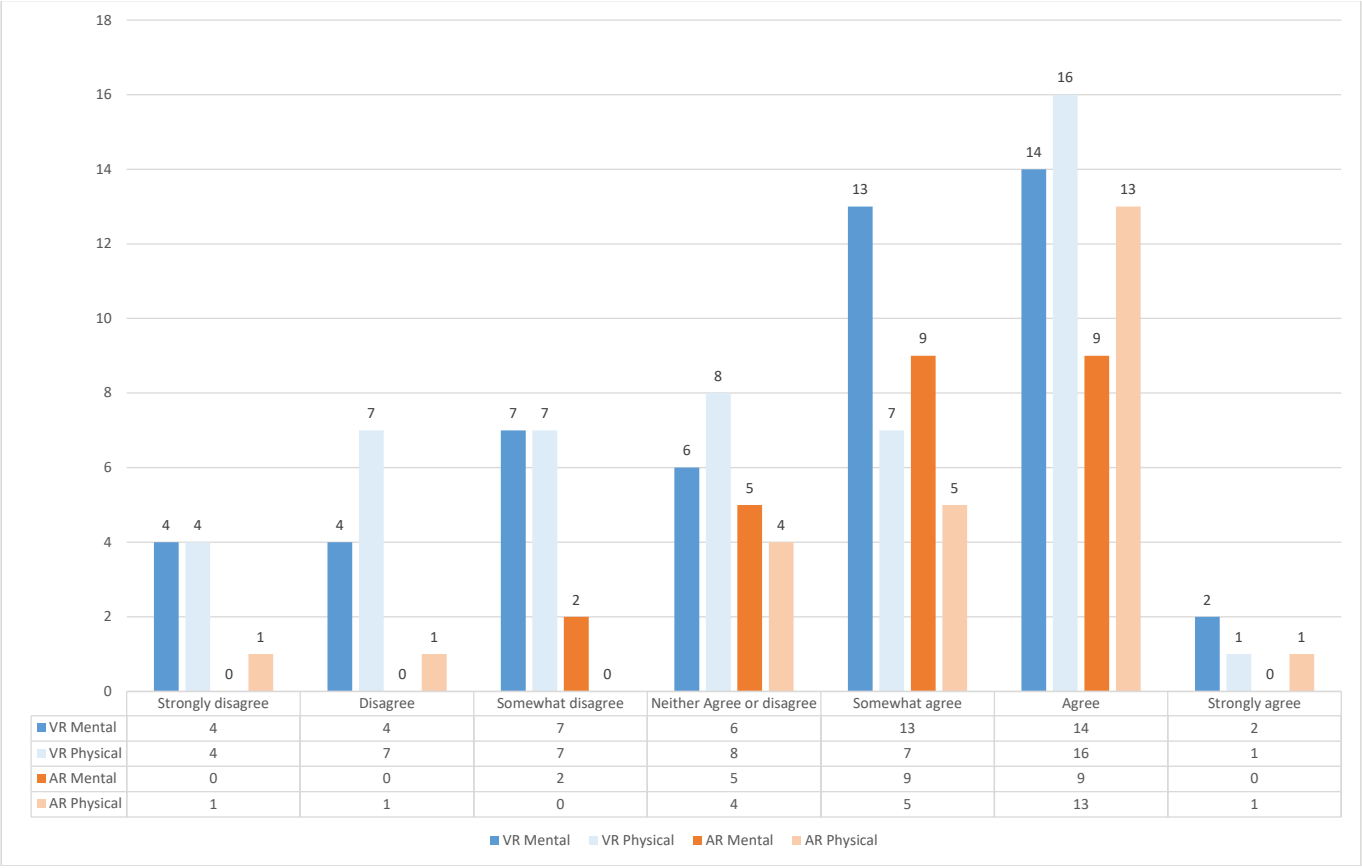

Fig. 4. Distribution of the 7-point Likert scale results of whether AR/VR games benefits the mental or physical health (Strongly disagree-Strongly agree).

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Before the formal data analysis of whether the mentioned games benefit mental and physical health, we explored the reliability and validity of the scales, by a Cronbach's Alpha (CA) test and Exploratory Factor Analysis (EFA) through SPSS [23]. The answers were transformed to numbers in the statistical analysis (strongly disagree 1, disagree 2, somewhat disagree 3, neither agree or disagree 4, somewhat agree 5, agree 6, strongly agree 7).

Due to that the CA results were over 0.6 (AR: 0.710, VR: 0.606), we could say our scales have internal reliability. Moreover, based on the result of the Kaiser-Meyer-Olkin measure (KMO) and Bartlett's test, in which the KMO of Sampling Adequacy was greater than or equal to .50 (AR: 0.50, VR: 0.50), and the significance value less than 0.05 (AR: 0.002, VR: 0.004), thereby we could say our data was suitable for the EFA [24]–[26]. From the results of the EFA; the Total Variance Explained results shown the cumulative variance contribution rate of the four questions (VR-M/AR-M: questions of whether VR/AR games benefit mental health, VR-P/AR-P: questions of whether VR/AR games benefit physical health) divided into two dimensions (AR-M/AR-P and VR-M/VR-P) was 78.18. Due to the value being over 60, which means the classification is suitable [26]. In addition, the results of the Rotated Component Matrix shows that each question only has one contribution value to these two dimensions, which proves that they contributed to the scale separately and cannot be deleted.

We first conducted the normal distribution test to select the statistical method for the difference relationship analysis. The data of the VR-M, VR-P, AR-M, AR-P answers and the total combined attitude of VR-C (for mental and physical together) was in line with the normal distribution, but the total attitude of AR-C (for mental and physical together) was not. Thus, to compare data groups with equal sample size and normal distribution (such as VR-M/VR-P, and AR-M/AR-P), we used the paired T-test (parametric test). However, for the analysis of the data group that had different sample size or not in the normal distribution (such as VR-M/AR-M, VR-P/AR-P, and VR-C/AR-C), we used the Wilcoxon test (non-parametric test).

For the two rounds of paired T-tests, the Sig. values were over 0.05 (VR-M/VR-P: 1, AR-M/AR-P: 1). Thus, the difference in the answer of VR-M and VR-P, as well as AR-M and AR-P, were not statistically significant. Thereby, we could say, facing the technology, AR or VR, the interviewees have similar attitude towards them whether benefits their physical and mental health. Moreover, for the three rounds of Wilcoxon test, the Sig. values were less than 0.05 (VR-M/AR-M: 0.017, VR-P/AR-P: 0.027, VR-C/AR-C: 0.018). Thus, the difference in the answers of VR-M/AR-M, VR-P/AR-P, and VR-C/AR-C was statistically significant. Based on the result, we could say, facing different health needs, physical or mental or both, the participants' attitudes towards different technologies were perceived different.

From the result of advantages in VR games, the participants mentioned some high-frequency keywords, such as immersive, fun (happy), relax (release), and real (realistic, realism). From the above keywords, the interviewees began to describe the user experience of VR games as a more stimulating environment, more interesting, reducing pressure, and pushing the attention only to the game. They also said VR games gave them a new and improved game experience to enjoy and discover a new place they never been to before. VR games could reduce the limitations of entertainment and the real danger of experience in a danger-like situation. Moreover, some participants believed that VR games could provide an online social community, making them feel less lonely. Furthermore, "exercise" and related words were said several times. Someone specifically claimed that VR games could motivate more exercise. Another pointed out that the VR game help to strengthen his/her body. Furthermore, the VR game can benefit reaction practice. Last but not least, a participant mentioned that the VR game could provide great visual effects.

For AR games, the most perceived advantages were around motivating the players to go outdoors, which is beneficial to their bodies and to see the outdoor environment, thereby enhancing mental and physical health. Moreover, some interviewees said, AR games do not need additional equipment and that it is easy to use. Furthermore, AR games were reported more novel and immersive compared to traditional games. Other participants pointed out that they could bring a good visual experience, interest, and happiness to the users.

C. Perceived Problems of AR/VR Games to Health

On the other hand, the disadvantages of VR games were mainly focused on the physical discomfort and risks with equipment. Many participants pointed out the dizziness and motion sickness problem caused by 3D vertigo. Another remark concerned negative impacts on the eyes. Some interviewees believed VR games were not good for the eyes. Except for the tired and uncomfortable eyes, they claimed that playing VR games for a long time could easier cause eyestrain and deepen myopia. Someone also mentioned being dazzled when he/she used the VR game. Moreover, the physical discomfort and risk also included neck pain and risk of falling. Furthermore, some interviewees said that when playing VR games, the player or the surrounding environment were at risk of injury or damage.

Another main problem came from the device. A participant mentioned the high cost of software and equipment. Some others pointed to that devices are too heavy, and this being the main problem affecting the user experience. Furthermore, due to the device, playing VR games was not easy at home. It needs enough space to layout equipment and play, which limited the playing environment. The cable impacted movement and easiness to twist and wind when playing the VR games as well. Moreover, some answers showed a negative impression on imaging. Someone claimed the VR device was not mature enough, and the imaging had bad details.

In addition to the above main issues, the respondents' negative impression of VR games lied in their impact on the real world. Some interviewees said that after a long time of playing, the VR game impacted the feeling of the true world,

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more than this, the influence also on the distinction between the real world and the virtual world. Besides, VR games were also reported to have similar problems as other games, such as addiction, wasting time, and reducing communication with friends face to face.

The AR games have reported usage problems as well. The same as for VR and other games, addiction was mentioned by some interviewees. Some participants compared the user experience of AR games with VR games. They said AR games were not as fun as VR games and could not make them immersed due to that the design is not so real. Moreover, they also claimed device problems, such as networking problems, the high challenge of their cellphone battery, and the limitation of the screens. Except for the above comments, the risk of traffic accidents was pointed out several times. Some respondents said that when playing AR games, they may ignore their surrounding environment. Furthermore, there was one interviewee who reported the AR technique to be seriously abused.

D. Proposed Future Features of AR/VR Games for Health

Some participants mentioned the sci-fi movie ”Ready Player One”. Adapted from the novel of the same name, it depicted much imagination about VR and reality. The interviewees imagined living realistically in the VR world like the movie's description. It imagined a high mix between the VR world and the real world, blurring the boundaries between realism in a virtual world and the virtual in the real world. The respondents' positive attitudes towards VR technology and demand for the realism of virtual objects are shown here. It is also reflected in keywords that appear in the answers many times, such as ”pleasure”, ”enjoyment”, ”immersive”, ”simulation”, and ”real (realistic)”. The interviewees also described their requirements and expectations of VR techniques and VR games into two main aspects: user experience and content offerings.

The most mentioned comments were about multi-senses, multi-user interaction, unlimited location of use, wireless, naked eyes VR from the user experience point of view. Several participants claimed they want future VR games to perceive senses, including gustatory, tactile, and olfactory, as the new interaction brings a more realistic and immersive experience. In addition, interaction with other players was also pointed out as important. Interviewees wanted to see and collaborate with other users. Furthermore, a VR should be possible to play without specific physical demands on the location. Some answers showed that the participants need to use it in a wide barrier-free venue, playing at home and without going outside. Except for the above, the expectations of VR games were to be more portable, easy to apply and to be cheaper. Users complained that helmet glasses are too heavy and that there is limited activity when having cables to consider. Wireless VR and naked eyes VR were mentioned several times. Moreover, someone also pointed out to have body control and not just the controllers using the hands.

From the content offerings point of view, many interviewees mentioned the VR games' application purposes in healthcare. As an aim for mental and psychological health, they pointed out that VR games could be applied for mental training, mental treatment, and psychological counselling. Especially for diseases and problems such as social barriers, autism, and Alzheimer. In addition, they claimed VR games could help to release pressure and promote or improve sleep. Facing physical health, participants mentioned that VR games could be used as a training and treatment method. Some of them believed it might help disabled people and expected it to recover muscle activation. Furthermore, several participants hoped VR games could support extreme games, sport and exercise, such as skydiving, VR gyms, live football games, and other interactive exercises. Except for directly health-relevant purposes, respondents mentioned aims of VR games' applications to be for education and learning (such as emergency handling for children), training (in schools, construction sites, and office buildings), team building, travel and tours, scene and memory reappearance, virtual meetings, record and observe, and for religious activities.

In addition to the purpose of the application, the answers also described the expectations for the functions and features. Some interviewees imagined VR games with biofeedback, such as perceiving individual moods or emotions and recommended games suitable for the current mood. These were reported to use, for example, advanced chips that could connect to the human brain, monitoring of heart rate detection, pulse detection, and other physical indicators. Moreover, when playing VR games, participants wished to break the sitting or standing playing mode and being able to run and exercise, and provide the leg movement system, in-situ movement. Furthermore, more freedom and interaction and less distance between non-player characters (NPCs) in video games and players were also pointed out for an improved experience. However, negative opinions could also be found in the answers, which involved addiction and harm to the eyes as other types of digital games. In addition, someone said VR is not a very mature technique.

As the expectations of VR games, the participants described their vision of the future for AR games in healthcare and their potential application purposes and features. Except for the requirements of training and treatment for mental and physical health, such as depression, stress relief, sitting a long time, eye protection, and fitness/sport/exercise, they also mentioned that AR games could help education and communication in health and telemedicine (remote surgery). For example, someone said AR games might be used to introduce the human body, how it works, what conditions can cause injuries, and learn things about healthcare. Furthermore, it might also help to study human anatomy. The 3D structure of the human body could be generated by an AR game based on computed tomography (CT) scan or other tools. Moreover, doctors and patients could use AR games to better communicate, such as for therapies, pills, and symptoms. In addition, there were also some mentioned application purposes not directly relevant to healthcare,

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such as online shopping, virtual meetings, navigation and map exploration, movies, record and observe, product design, travelling, learning and improving knowledge and skills, and experiencing different life types.

About AR functions/features and devices, the results are also similar to VR games. Interviewees said light AR glasses might attract players more. They also pointed out that if an AR game was more open and free, with better realism and immersion, the interaction and connection with the real world would be improved. Moreover, a better sensory experience with tactile feedback was also required. On the other hand, participants also held negative opinions on the use of AR games in health. One of them reported that AR could not be used in any healthcare project. Some others mentioned problems of violence and that violent games being too real could potentially increase the player's violent tendency and make it harder to distinguish between the virtual and real world. One interviewee said it is necessary to protect teenagers from such problems. Another person complained that AR games were not vivid enough.

IV. Discussion

It is noticed that all participants were in the age range 18-55, and most of them were under 30 years old. Although the adoption of smartphones, the Internet, and social media has risen amongst seniors over the last 15 years, it is still relatively low compared to young people. A 2017 survey in the United States [27] showed that 40% of senior citizens now own a smartphone. Even this number was more than double the amount in 2013, but still much lower than the smartphone ownership rate of young people. Moreover, the separate Internet and broadband use were different in various demographic groups. The report pointed out it was impacted by educational attainment and family income. Compared with households with an annual income of $75,000, the Internet usage rate of the elderly in households with an annual income of less than $30,000 has dropped by nearly 50% 94% vs 46%. Compared with those with a college degree or below, more college graduates use the Internet (92% vs 49%). Furthermore, the report also claimed 34% of elderly who are over 65 uses social media such as Facebook or Twitter. Even though the number was 6% higher than in 2013, it is significantly smaller than the general population. The majority of the elderly did not use social networking, and the younger elderly more possible use social media than the elderly. The lower use rates of the smartphone, the Internet, and social media of the elderly was both the limitation of the research method (online questionnaire spread by social media) and the challenges of AR/VR techniques. Due to an increase in elderly users of the technology, the positive view for the future could allow a growth in opportunities for this age group as well. Based on these results the authors also think it would be relevant in the future to find novel AR/VR game solutions, for mental and physical health, that look into possible collaborations between young and elderly, such as proposed in [28].

In the data analysis, we found one answer that confusing AR and VR technologies. Someone thought "Pokémon Go" was a VR game. It might be just a mistake, but it also could due to the vague understanding of such techniques. It could reflect that there is still room for AR/VR techniques application and popularisation to a certain extent. Facing AR/VR techniques, the participants have similar opinions for such applications benefits to their health, but with different attitudes for applying AR/VR on different health issues. Although far more VR games were mentioned than AR (17 vs 6), a single AR game had far more users than a single VR game (10 vs 3). This confirmed to a certain extent that the AR technique had greater development potential, mentioned in the related work, due to the popularity of mobile devices that can run AR applications. Some interviewees had a negative attitude towards AR/VR games and its benefits to physical and mental health, but far more people held the opposite opinion. As shown in the results III-B, several advantages could be seen. For example, VR could provide a more interesting and attractive game experience with fewer limitations and dangerous risks. It could also stimulate sports' motivation and being used to enjoy social communication online. In addition, AR games do not require additional equipment apart from a phone and could be encouraged to go outdoors. Those are some of the opportunities for AR/VR game development, especially for mental and physical health. However, the challenges should be paid attention to as well. Specifically, the device/equipment problems in cost and still be perceived as uncomfortable are shown in III-C.

Comparing the result of the related work and this study, we could see the similarities of the future requirements of AR/VR games, like mental, physical and psychological health, education, and learning. It is worth noting that the training, healing, and relaxation for psychological and mental health were the most mentioned in the related work and the survey conducted in this paper. The previous research and this study also have similar results of relatively low use frequency of AR/VR software applications and games. This was similar for healthcare-relevant staff or students in previous work and the public as reported in this survey. This shows that AR/VR techniques still have room for development and popularisation. In a comparison between the studies, there are also similar results in the benefits and problems of AR/VR/MR and games. For example, both mention more cost-effective devices and software, the potential of being addictive, space for hardware equipment to improve, stronger motivation to continue its use, safety, portability, and an improved experience.

V. Conclusion and Future Work

This paper has presented an online questionnaire, based on 74 interviewees, exploring and evaluating the usage situation, the impact of public physical and mental health, and future features in AR/VR games. Most interviewees had experience in AR/VR games, but their practical use frequency was low. Among the 23 AR/VR games mentioned, the number of VR games were higher than AR games. However, the number

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of users of a single game is far greater in AR than in VR. More than 70% of participants believed that AR games are good for the body and mind, but the data for VR games was around 50%. Interviewees mentioned many of the benefits, problems, features, and functions requirements in the future development of AR/VR games. These could provide references to researchers and developers about what is worthy of attention to improve the technology and applications. Future work will also be extending the sample size, especially to an elderly group (over 55 years old), to better know their opinions of AR/VR games for mental and physical health. As such, we can better understand their specific requirements for such techniques, thereby enriching and perfecting the results and making them more universal.

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