Myopic Bike and Say Hi: Games for Empathizing with Myopic Users

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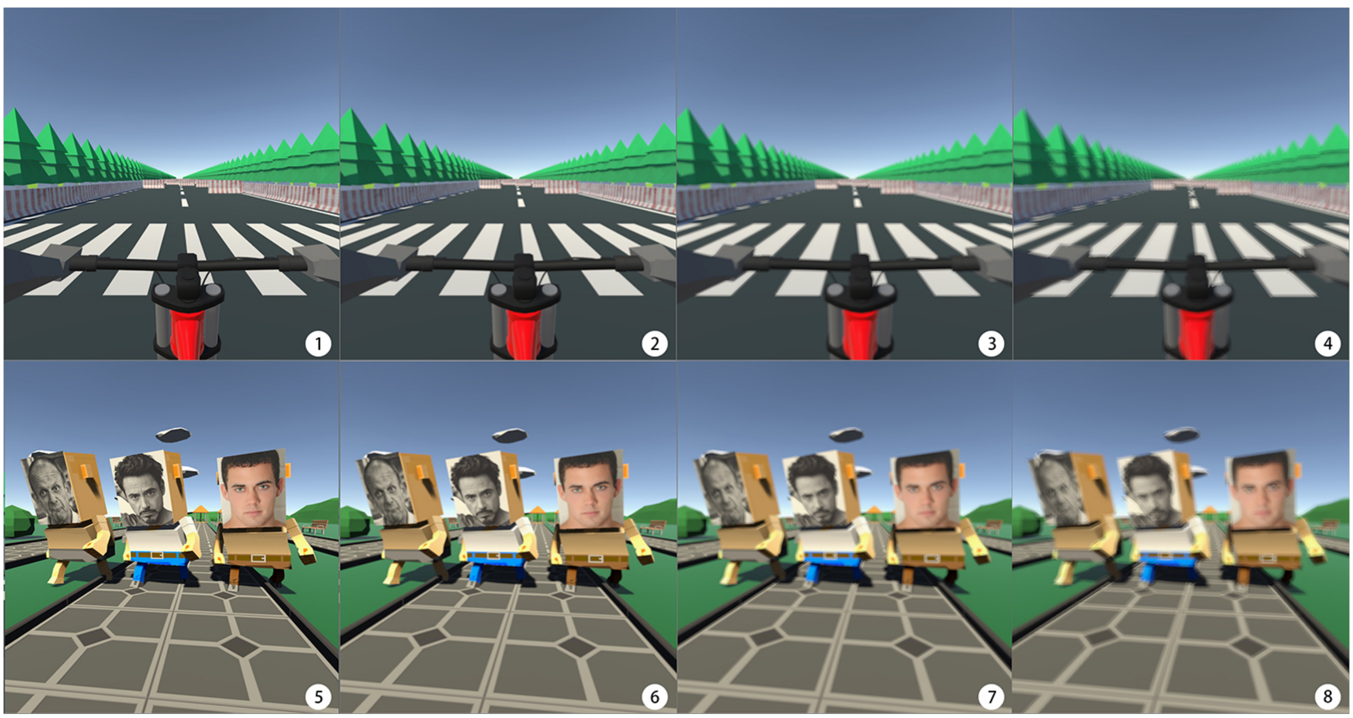

Figure 1: Figures 1.1 to 1.4 and figures 1.5 to 1.8 show two myopic games, *Myopic Bike* and *Say Hi*, in four myopic conditions: NoMyopia, LowMyopia, ModerateMyopia, and HighMyopia.

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ABSTRACT

Myopia is an eye condition that makes it difficult to focus on objects in the distance. It has become one of the most serious eye conditions worldwide and negatively impacts the quality of life. Although myopia is prevalent, many non-myopic people have misconceptions about it and encounter challenges empathizing with myopia situations. In our game, we developed two virtual reality (VR) games, Myopic Bike and Say Hi, to provide a means for the non-myopic population to experience the frustration and difficulties of myopic people, i.e., riding a bicycle and greeting someone on a street. Our games simulate two inconvenient daily life scenarios that myopic people encounter when not wearing glasses. We evaluated four participants' game experiences through questionnaires and semi-structured interviews. We propose that our two VR games can create an engaging and non-judgmental experience for the non-myopic population to better understand and empathize with those who suffer from myopia.

CCS CONCEPTS

• **Human-centered computing** → *Accessibility*; **Virtual reality**; • **Software and its engineering** → **Interactive games**.

KEYWORDS

myopic games, serious games, virtual reality, accessibility, empathy in HCI, game design

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1 INTRODUCTION

Myopia (i.e., Nearsightedness) is a common vision condition with which people can see nearby objects clearly but the further-away ones are blurring [28]. Myopia happens when the shape of an eye causes light rays to bend (refract) incorrectly, focusing images in front of the retina instead of on the retina [28]. In general, low myopia is less than 3.0 diopters (<-3.0 D), moderate myopia is less than 6.0 diopters (-3.0 D to -6.0 D), and high myopia is usually greater than 6.0 diopters (>-6.0 D).

Myopia is one of the most common eye problems worldwide. Approximately 600 million residents in China are suffering from myopia [52] and 4% of the population in the United States are suffering from high myopia [40]. For non-myopic people, it is often difficult to empathize with different levels of myopia, and as such, it can be challenging to feel the distress and discomfort experienced by those who have it [3]. The lack of empathy toward the myopia population could result in inadequately considerations when designing products for myopic populations and cause accessibility problems.

Recently, immersive virtual reality (VR) games show great potentials as a medium to foster empathy in a non-judgemental and engaging way [38]. We believe that VR can offer players an embodied first-person perspective of viewing different severities of myopic symptoms when seeing things in the virtual environment. Unlike traditional displays on mobile phones or monitors, VR gives the user a depth experience, bringing the most visual-based and non-tactile feedback in such non-existent scenarios [25], which is beneficial for scenario simulation and immersive experience.

The use of extended reality to study or address health issues is not new. For example, Xu et al. [50] designed a variety of VR exergames in seated or standing postures using head-mounted displays (HMDs). Xu and colleagues [51] designed a high-intensity interval training (HIIT) boxing VR game that allowed players to achieve high heart rates and exertion, rapid fat burning, and reduced exercise time with high intensity.

In this research, we explored the design of two VR games that aimed to foster non-myopic people's empathy toward people with myopia. We first collected opinions from eight myopic and two non-myopic people through a survey. We investigated and studied the potential risks encountered by myopic people when not wearing glasses. Next, we developed two VR myopic games, *Myopic Bike* and *Say Hi* (see Figure 1), based on findings from the initial survey. We then recruited four participants with three levels of myopia to evaluate the games. We collected their feedback through semi-structured interviews and questionnaires. Findings suggested that these two VR games represented a good balance between an engaging game experience and empathy feelings toward people with myopia. Overall, we believe that our research suggests that games could be a promising approach to foster empathy toward myopic people and inspire players to consider accessible designs for people with myopia.

2 RELATED WORK

2.1 Empathy Transmission

One common definition of empathy is "the ability to perceive, understand, and respond to the experiences and behaviors of others" [45]. According to Davis [7], empathy is manifested in three aspects: (1) physical sensations, (2) emotional sensations, and (3) cognitive awareness. As VR can provide users with an embodied and immersive experiences [5], it is a suitable and powerful media to foster empathy toward those with physical and visual disorders or disease [11].

Researchers have been using video games and VR environments to foster empathy toward specific populations [14, 20, 21, 43]. Their findings suggest that VR games can elicit a strong sense of embodied empathy because of VR's immersive nature [10, 30, 31, 38]. Furthermore, the immersive features of VR games can also provide benefits to individuals' perceptions and behaviors [4, 16, 26, 42]. Bailenson et al. [16] found that two experiential aspects of VR, immersion and embodiment, play an essential role in fostering empathy. Similarly, Tong and colleagues [19, 46] designed a VR game named AS IF, and promoted empathy for chronic pain patients through an embodied VR avatar and game tasks. They also identified the critical role of embodiment in eliciting people's empathetic attitudes. Although previous studies have explored empathy toward multiple vulnerable populations, our study targets a unique group, people with different degrees of myopia.

2.2 Accessibility Designs for Visual Impairments

Prior research on the accessibility design for those with visual impairments in VR has focused on blindness [13, 27, 32, 33], guidance systems [24, 35, 36, 47–49, 54, 55], and non-visual interfaces [1, 39]. Researchers also explored haptic interaction techniques for people with visual impairments [18, 41, 53]. Krosl et al. [22] simulated the perspective of a person suffering from cataracts in AR to foster understanding and insights on how patients experience cataracts

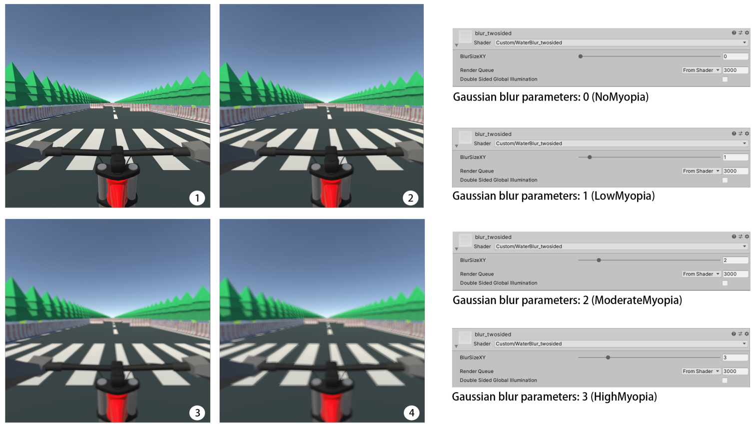

Figure 2: Four conditions in Myopic Bike. We engaged three groups of users with different degrees of myopia (low, moderate and high myopia), two from each group, in a pre-experience data collection survey to frame the development of the games and, based on their feedback, we adjusted the Gaussian blur parameters to match the real-world myopic situation as much as possible, which are 0, 1, 2 and 3 for Figures 2.1 - 2.4, respectively.

in their daily lives. Prior work contributed on techniques that are useful for blind people or low vision groups; our games focus on foster empathy toward people with severe myopia from groups without myopia or with low or moderate myopic conditions. We believe that only by truly experiencing simulated difficulties of varying degrees of myopia we can truly achieve empathy and thus have a deeper awareness of their challenges and ultimately provide improved accessibility designs for myopic people.

3 MYOPIC GAMES

3.1 Background

Benford et al. introduced the concept of "uncomfortable interaction" [2, 3], which explores the benefits and unexplored potential interests of uncomfortable user experience in games. Our work falls under the category of uncomfortable interactions from the perspective of the player's experienced to deliver an entertaining but also enlightening and socially bonding experience [3], specifically in the myopia context.

We first collected myopic people's distress and challenges in their daily lives and non-myopic people's perceptions of the distress of myopic people around them from an online survey. We received a total of 10 responses (6 males and 4 females with an average age of 27 years), 8 from myopic people (7 with moderate myopia in both eyes and 1 with low myopia in both eyes) and 2 responses from non-myopic people.

Nine participants had prior experience with VR devices. Eight myopic people reported that if they forgot to wear glasses in their daily lives, they would be afraid of riding bicycles because they could not see their obstacles. Six thought they would be afraid of greeting people on the street because they could not recognize their acquaintances. The other two non-myopic respondents also mentioned that they thought myopic people would be afraid to use transportation and greet people because of embarrassment if they did not recognize them. Based on these initial findings, we decided to design the following two myopia games based on the above-mentioned two scenarios, i.e., *Myopic Bike* and *Say Hi*.

3.2 Innovations

Our games have three innovations. First, our targeted audience who will play our games are non-myopic or a low to moderate myopic population. Second, we provided four myopia VR game levels for players to choose from to experience different degrees of myopia experiences. Third, our two VR games represented close real-life inconveniences of myopic people, allowing players to resonate with them and possibly facilitate empathy. The details of innovations are described in the following subsections.

3.3 Myopic Bike

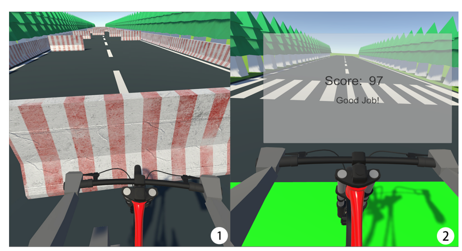

Figure 3: Roadblocks (1) and the Scoreboard (2).

3.3.1 Game Concepts and Mechanics. *Myopic Bike* offers four levels of myopia for players to choose from (NoMyopia, LowMyopia, ModerateMyopia and HighMyopia) (see Fig. 2). In this game, users play as a person with varying degrees of myopia (including those without myopia) while riding a bike. Players need to reach the end of the line through a straight route with roadblocks (see Fig. 3.1). There are three levels of difficulty for each of the four myopia

	Myopic Bike				Say Hi			
	NoMyopia	LowMyopia	ModerateMyopia	HighMyopia	NoMyopia	LowMyopia	ModerateMyopia	HighMyopia
Competence	2.65 (.44)	2.65 (.79)	2.50 (.48)	2.70 (.42)	2.25 (.87)	1.95 (.10)	1.85 (.77)	1.60 (.40)
Sensory and Imaginative Immersion	2.58 (.22)	2.83 (.19)	2.67 (.30)	2.75 (.22)	3.04 (.55)	2.71 (.25)	2.28 (.35)	2.79 (.50)
Flow	2.25 (.19)	2.40 (.49)	2.30 (.26)	2.25 (.30)	2.10 (.62)	2.05 (.57)	2.25 (.70)	2.05 (.64)
Tension	1.05 (.66)	.80 (.43)	1.00 (.52)	1.10 (.42)	.90 (.50)	.85 (.55)	1.15 (.25)	.85 (.44)
Challenge	2.05 (.79)	1.75 (.94)	2.75 (.44)	2.60 (1.21)	1.80 (1.06)	2.45 (.44)	2.80 (.37)	2.65 (1.25)
Negative affect	.90 (.74)	.90 (.70)	1.20 (.82)	1.40 (.91)	1.50 (.50)	1.10 (.35)	1.05 (.44)	1.55 (.98)
Positive affect	2.60 (.28)	2.95 (.72)	2.30 (.26)	2.20 (.59)	2.65 (.41)	2.15 (.44)	1.95 (.19)	2.00 (.40)

Table 1: Players' Component scores for the seven Core GEQ Modules, in terms of Mean (SD).

conditions, i.e., the amount of roadblocks increased along the route (i.e., 40, 60, 80). Thus, players need to be skilled at handling the bike and avoid hitting the roadblocks to not losing points. We also provide sound effects when hitting roadblocks and a scoreboard (see Fig. 3.2) to show players their performance when they pass the finish line.

3.4 Say Hi

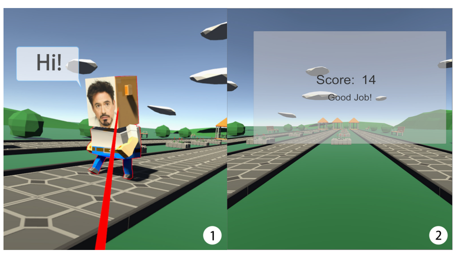

Figure 4: The player is saying 'Hi' on the road (1) the Scoreboard (2).

3.4.1 Overall Concept and Playful Mechanics. In *Say Hi*, players take on the role of a pedestrian standing still and greeting "acquaintances" who are among other pedestrians. We set four international famous people as "acquaintances" for players to choose. Before starting the game, we show their pictures to the participants to ensure they know these faces. Batches of pedestrians will walk facing the player at the same speed, and disappear after 15 seconds. In each batch, the game will show either one or no person from the four faces. Players need to identify or choose the one they know from all pedestrians before they disappear (see Fig. 4.1). Furthermore, the chosen pedestrian will provide positive or negative audio feedback after the player made a choice. In the meantime, players' performances will be shown on a scoreboard (see Fig. 4.2) when they complete the game.

We predefined the total number of batches in each round and the number of batches without any acquaintance (i.e., 20 and 4 in our game). Moreover, for each batch, pedestrians' clothes and faces are randomly allocated. There are three difficulty levels in *Say Hi*, and the higher level means the number of pedestrians will increase (i.e., 1 per level in our game) in one batch.

3.5 Development and Apparatus

We used Unity[1] 2019.4.0 f1 game engine to develop the two myopic games and Oculus Rift S[2] for the VR HMD. All development and user evaluation are conducted in a university's research lab.

3.6 Target Audience

The most significant difference between our VR games and previous studies is that our games do not reinforce the accessibility design for people with myopic; rather, our games were created for people with different degrees of myopia (including non-myopic people) to take the perspective of myopic people and experience their real-life scenarios. We aim to enable people with different levels of myopia (including non-myopic people) to empathize with myopic people about the inconveniences in their daily lives.

3.7 Playtesting

	NoMyopia	LowMyopia	ModerateMyopia	HighMyopia
Myopic Bike	0.25	2	2.75	4
Say Hi	0.25	2	3.25	4

Table 2: Players' empathy in the two games with different myopic conditions via a 5-likert scale, range from 0 to 4.

We recruited four participants from a local university, each from a unique condition of myopia (including the non-myopic condition), i.e., NoMyopia, LowMyopia, ModerateMyopia, and HighMyopia. We collected their feedback from pre-prepared questionnaires, i.e., Game Experience Questionnaire (GEQ)[3] [17] (results can be found in Table 1), a subjective emotion questionnaire (SEQ) using 5-Likert scale (results can be found in Table 2), and conducted semi-structured interviews to analyze the players' preferences and empathy in each case [6]. We only tested the low difficulty mode of both VR games and asked each participant to experience all four myopic conditions and collected the game scores (GS). After each experimental condition, participants were asked to complete the above-mentioned questionnaires. Participants finished two games in around thirty minutes.

All participants had fun playing the two VR myopia games, but all had their own preferences. For instance, P1 (who doesn't have myopia) specifically talked about his VR experience of being a

[1] Unity: https://unity.com/
[2] Oculus Rift S: https://www.oculus.com/rift-s/
[3] Although some studies have disputed the results of GEQ's analysis [23], it does not affect our research on player experience feedback.

myopic person; P1 said, *"I enjoyed playing both VR myopic games, [because] I'm not myopic, so this is the first time I've felt the inconveniences experienced by people with different levels of myopia in their lives. It's almost impossible for me to see anything else in high myopia condition..."*. P3 (how has moderate myopia) talked about his previous misconceptions about high myopia, saying that *"I thought before that high myopia might be nothing [different] [because] I was moderately nearsighted. But after experiencing two games I found I was wrong. These two games have enhanced my empathy [toward people with high myopia]."*

4 LIMITATIONS AND FUTURE WORK

We investigate that our design work has limitations [12]. Our two VR games express myopic people's distress from two specific real-life scenarios. We also think that referring to body interaction theories in HCI research can complement our future work. For example, Merleau-Ponty's "motor intentionality" [44], Mueller et al.'s proposal of the concept of limited body interaction [10] and his group's theoretical basis about using the body as an interface for games [29] could enrich our notion of body control for more immersive myopic simulations [34]. Therefore, future work can investigate how to better utilize the body as a more direct mode of interaction and thus enhance the myopic game experience and achieve better empathy resonance.

We reflected from our study and game design that we can be further refined myopia rendering in VR. Prior research has explored cataract perspectives in VR for doctors and patients [22] and deployed a more realistic scene for cataract view rendering in VR. We only blurred the screen without using any other extra graphic rendering deformations or transformations for players to experience different cases of myopia. Moreover, moderate to high myopia is usually accompanied by other ocular diseases such as astigmatism [15], which is difficult to simulate in VR. Given that our main study was on myopia experience per se, future work should further explore the possibility of simulating the concomitant or superimposed ocular diseases in VR.

Regarding empathy measurement, we used a self-reported questionnaire to collect empathy changes. In future work, we plan to add the detection of facial expressions [8, 9] and EEG signals, such as Neo-Noumena [37], to record participants' affective and biological changes.

Further exploration is required to form a framework for developing myopic VR games. From the perspective of accessible design, only by fully experiencing different levels of myopia can designers effectively design accessible products for people with myopia [39]. Aside from product design, the ability to empathize with people with different degrees of myopia is conducive to the inclusive and understanding development of our society. Therefore, we will include a larger sample size to further evaluate our VR games, extract design inspirations and recommendations for future work. Hopefully, we will also formulate a framework that can guide the design features of VR games that aim at fostering people's empathetic attitudes toward people with different degrees of myopia.

5 CONCLUSION

In this paper, we presented two VR myopic games, *Myopic Bike* and *Say Hi*, to simulate the inconvenient daily life scenarios that myopic people encounter when not wearing glasses. We evaluated these two games with four participants and collected their feedback from questionnaires and semi-structured interviews. Findings suggested that using VR myopic games could represent a suitable balance between fun experiences and meaningful outcomes, which allows people to enjoy the gameplay as well as foster their empathy toward people with myopia. Our research provides an initial impetus to the design of VR games that foster empathy toward myopic people, ultimately promoting successful accessibility products by bringing the designers more understanding through VR games.

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