A Virtual Reality Tool Applied to Improve the Effects on Chronic Diseases - Case: Emotional Effects on T2DM

Leticia Neira-Tovar[1(✉)] and Ivan Castilla Rodriguez[2]

[1] Universidad Autónoma de Nuevo León, San Nicolas de Los Garza, N.L., México
leticia.neira@gmail.com
[2] Universidad of La Laguna, Tenerife, Canary Islands, Spain
icasrod@ull.edu.es

Abstract. A large part of the world population suffers from type 2 diabetes mellitus (T2DM). Since most life-threatening consequences of the disease do not appear during its first stages, there is an inherent difficulty to establish prevention strategies at young age. Technology is a tool of high potential for this purpose. Virtual Reality (VR) tools are already used in many areas, such as education, entertainment, advertising, and health; and might prevent the impact of some of the physical and emotional effects of T2DM. There are products that become global phenomena with the simple use of this kind of sophisticated technology, impressing people, and making these products more interesting. The purpose of this paper is to present work in progress towards the development of a VR videogame that aims to motivate exercise and combat depression, thus preventing some of the T2DM consequences. The videogame uses a model based on a user experience, gamification and immersive virtual reality element.

Keywords: Virtual reality · Diabetes effects · Depression · Serious game · Gamification · User experience · Immersive technology

1 Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disease that causes blood glucose levels to rise higher than normal. Long-term consequences include minor and major cardiovascular problems, (stroke, heart disease, poor blood flow), diabetic retinopathy and kidney failure. There is also evidence on the relationship between diabetes and depression [1]. According to the World Health Organization, 422 million people above 18 suffered from diabetes in 2014, and the trend is increasing [2]. 1.5 million people died in 2012 due to diabetes.

Apart from the impact on health, T2DM places a considerable economic burden on society, not only because of the expenditure in treatments and health care services, but also due to productivity losses at work. Although the causes of these losses are not completely determined yet, they are usually related to poor disease control, adverse health outcomes and quality of life impairment [3].

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Healthy diet, regular physical activity, and avoiding tobacco have proved to be effective to avoid or delay the worst consequences of T2DM. However, people suffering from the disease is reluctant to actively change their lifestyle due to the "silent" appearance of the disease, which seems harmless at the first stages.

There are a number of successful examples on the use of virtual reality (VR) technology, to prevent and empower people on the consequences of this terrible disease [4]. These examples include prototypes to teach healthy food habits [5], to perform physical activity [6], and some special cases using "exergames" [7], mainly in diabetic patients of a single community.

Interventions such as those mentioned above, must be designed rigorously, relying on strong medical and psychological foundations, and following a comprehensive and well-structured model. A related clinical trial on T2DM (DEPLAN) identified the key elements to design this kind of models [8]. The results of that study shown that three main factors must be selected to reflect the interaction experience when using some kind of "mini-game". These factors are lifestyle, physical activity and nutritional intervention.

We proposed a model to develop a serious game, accessible to people between 21 and 45 years who have access to a computer and internet connection at their work place, and designed in a fun way. This game will help the users reducing their depression level, thus improving their subjective well-being and also acting as prophylaxis against other emotional effects. The game will focus on two out of the three key factors stated in the DELPLAN trial: lifestyle and physical activity. The nutritional intervention will be considered at an informative level. The game will also use a VR prototype to generate a report collecting the results of selected employees with T2DM. This report will provide organizations with meaningful information about the effectiveness of the intervention.

In this work on process, we propose to select adults with work and productive activity, with the purpose of benefiting employees staff of an academic institution. Therefore, they will develop a lifestyle that allows them not to decrease their productivity because of the effects of T2DM, especially as referred to the depression effect.

2 Method

The proposed game is based on a model that integrates psychological and physical therapies with computer science and video games. Hence, a virtual world is created that encourages the development of skills and strategies to deal with emotional effects such as depression. The model relies on five key elements that integrate the involved areas, and work together to produce the goal of the game (Fig. 1).

The main component of the game is the person, who selects a character that interacts in a virtual world with physical treatments in order to manage emotional techniques trough the gameplay.

The gameplay uses a simulated world to create a sense of immersion. The appearance and the elements included in this virtual world are based on psychological tests to avoid depression.

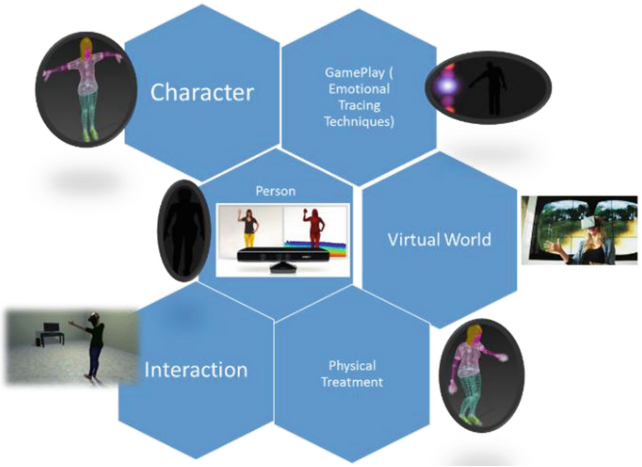


Fig. 1. Model based on interactions, to be used on a dodge mini game

We use a Cohen test to measure the stress level of the users [9]. The test is intended to be applied before and after the gameplay.

A usability test was applied to validate the user acceptance and visual immersion on the gameplay.

The results of these activities will be used to improve the following steps.

3 Virtual Tool Proposal

3.1 Equipment Requirements

Table 1 summarizes the equipment requirements. The gameplay area requires 2 × 2. The user must be provided with an Augmented reality glasses (oculus rift) or a Kinect 2.0 device. The software consists on a combined unreal engine and Unity 3D application.

The virtual reality project simulates a like-forest real space (Fig. 2). The interactions with the virtual world are based on a number of mini-game that were selected to challenge movement and distress.

Currently, two mini-games have been developed. The first mini-game poses the player a scenario where he/she is challenged to move sideways and backwards by dodging objects that appear from multiple directions. Figure 3 illustrates a typical screen of the game. The exercise can vary in difficulty, from very easy to heavier exercises.

The second mini-game puts the player to face several “enemies”. The player’s hands become weapons that can be used to fight the enemies. The main purpose of this mini-game is relax.

There is a third mini-game, currently under development, aimed to make movements in a certain way by coordinating body and vision. Figure 4 shows a typical

Table 1. Software and hardware required

Image HW	Software	Type
oculus	Unity3D	Videogames engine
KINECT	Unreal Engine	Videogames engine

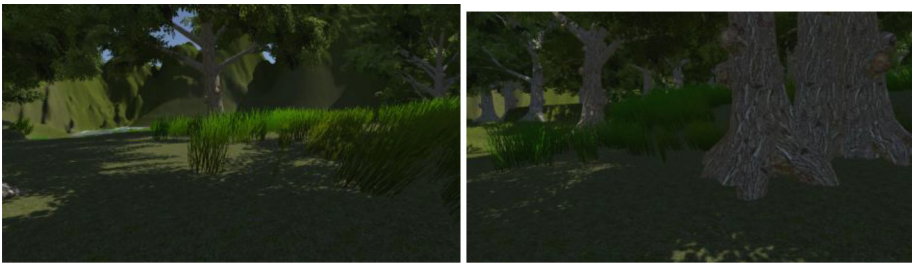


Fig. 2. Simulated forest

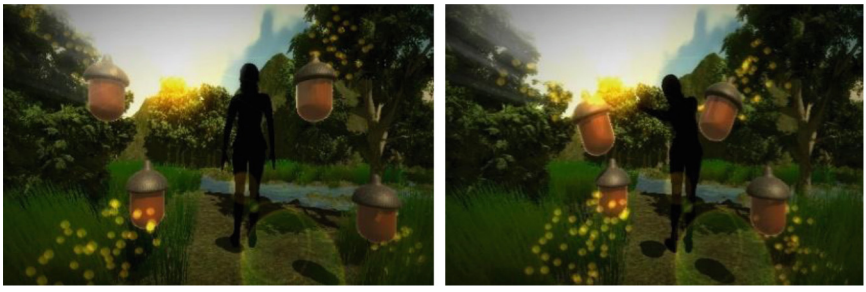


Fig. 3. Simulated forest space and dodge mini game.

scenario for this game. This mini-game is intended to promote, in the T2DM patient, specific movements that have shown effectiveness to prevent motor disability, such as having hands and knees up.

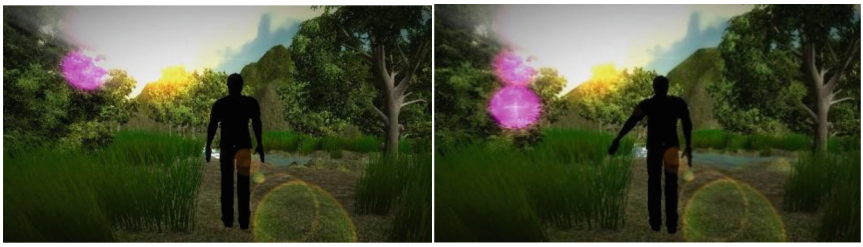


Fig. 4. Simulated forest space and draft mini game.

3.2 Prototype Simulation

After a process of integration of the required equipment, a simulation test was designed and tested with a volunteer employee. Figure 5 shows several scenes comparing the real player and his/her virtual representation.

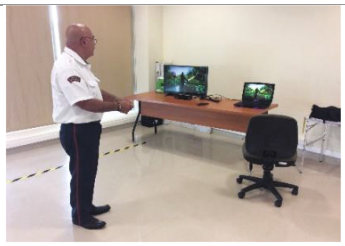
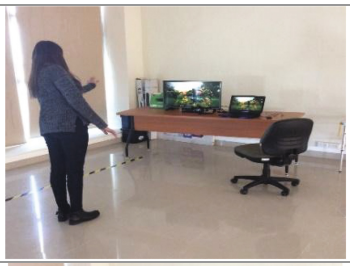
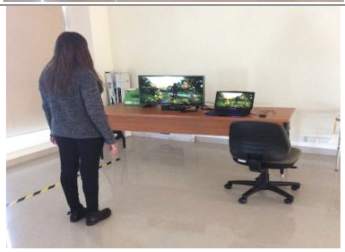
Player in the real environment representation	Player in the virtual environment representation
	
	
	

Fig. 5. Sequence of player movements on the virtual and real environment in virtual combat game.

Fig. 6. Space scenario draft.

Apart from the forest scenario, the prototypes also include a stars and space scenario, as shown in Fig. 6. These scenarios are planned to pose different experiences to the player, thus enhancing the entertainment options of the game.

4 Results

We assessed the stress of the volunteer players by using the Spanish adaption of the Cohen perceived stress scale (PSS) [9]. This instrument consists of 14 items with a response format of a five-point Likert scale (0 = never, 1 = rarely, 2 = occasionally, 3 = frequently, 4 = very often). Preliminary test of Cronbach's alphas ($\alpha = .877$) suggest that the elements have relatively acceptable internal consistency.

0 = Never
1 = Almost Never
2 = Occasionally
3 = Frequent
4 = Very Frequent

This test was applied in two different moments:

1. Approximately a week before the first interaction of the player with the game.
2. In a daily basis, one week after starting the interaction with the game.

The test was applied to 30 participants, during their normal work period.

Table 2. PSS descriptive measures of responses.

	Mode	Mean	Std. deviation	Variance
Pre test	2.57	2.63	0.457	0.209
Post test	1.54	1.00	0.502	0.252

Table 2 shows the differences between the responses of the participants before and after the video game sessions. A t-student test was performed to compare these two sets of quantitatively collected data independently to find statistical significance difference.

4.1 Usability Test

We identified and evaluated the usability problems of the virtual scenario by conducting an eye-tracking study. The study analyzed the player as he/she watches a mini-game consisting on a forest scenario which included several objects that

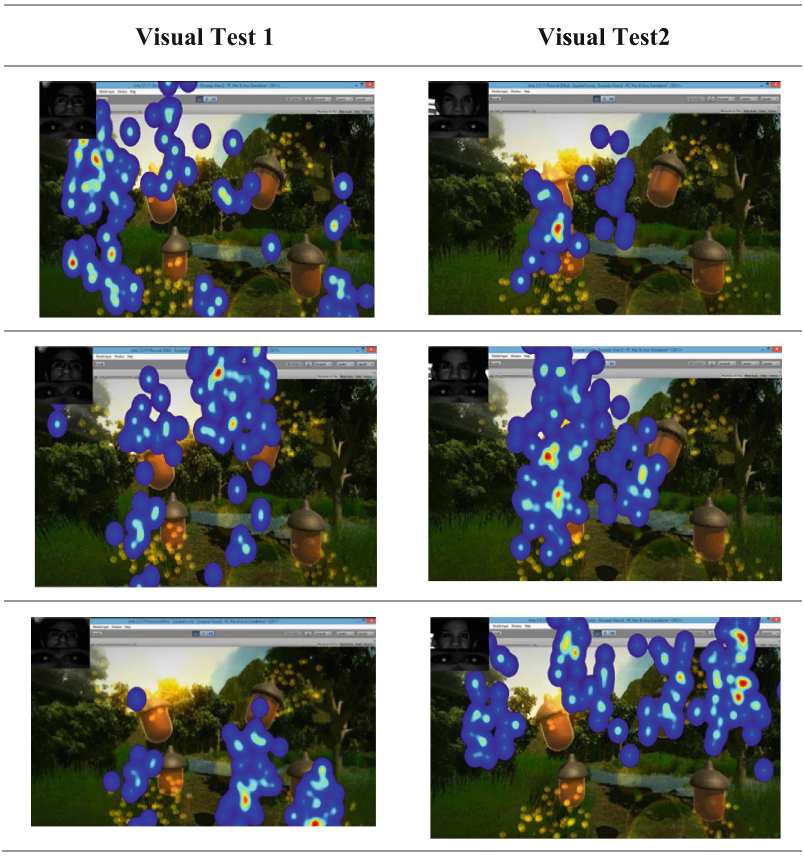


Fig. 7. Visual test 1 and 2 (Color figure online)

represented "enemies" willing to attack the player. The player was supposed to move side by side in a coordinated exercise to avoid the attacks.

Figure 7 shows two example visual tests. Visual Test 1 highlights the objects to dodge, whereas virtual test 2 highlights green areas.

Although the mini-games were originally designed by taking into account the key principles of usability, the results of the tests were not homogeneous among the players, probably due to their different conception of usability.

5 Conclusion and Future Work

This work is a one-year (two-semester) project intended to develop an interactive experience for university employees that helps them to prevent negative T2DM emotional effects. The main achievement of this research is a clearer assessment of the potential acceptability of the proposed game interactions.

Next steps include developing a second game level which will provide data on how to improve the immersion experience and the adherence to the prevention treatment of the users. Together with this new level, a survey will be conducted to assess the emotional progression of the user.

After completely testing the new level, another objective is to assess the effectiveness and usability of the game with employees of a Spanish University, hence trying to detect social or cultural differences that may affect the game performance.

The behavior results observed during play suggest that this research could be extended to share experiences in a remote group and to use a different kind of scenarios for the same group of exercises. Connecting the game with social networks could also act as a motivational impulse for the potential users of the game [10].

We are planning to design and develop more mini-games which should improve the experience of the users. The key idea is to add more types of exercises and expand their entertainment options, not only by implementing different difficulty levels aimed to improve the coordination and posture, but by using new technologies. Although the virtual environment allows immersion, our group is considering the usage of other technologies to implement these new mini-games, either alone or in combination, thus enabling a more optimal experience. For example, one of this new mini-games is planned to use a static bicycle combined with Oculus Rift and Arduino. The combination of these technologies would allow the user to lose stress in a relaxing VR scenario.

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