Using VR to induce smoke cravings in low literate or intellectually disabled individuals who have a smoking addiction

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ABSTRACT

This research is conducted to aid the development of treatments of smoking addiction using virtual reality (VR), focusing on individuals with low literacy or an intellectual disability. The main research question is: "How can VR technology be applied for treating smoking addiction for individuals with an intellectual disability?" Firstly, a small literature research was conducted to investigate what primary smoking cues trigger cravings. Secondly, an interview was held with an addiction nurse and observations were taken while joining the addiction nurse during the treatment of patients, to get insight in the current treatments for smoking addiction and the target group of patients. Lastly, a qualitative user study was conducted: a VR environment with smoking cues was tested with smokers that have an intellectual disability. This resulted in insight on smoking cues and how they can be implemented in VR. The conclusion that was drawn is that smoking cues of all different natures can induce cravings in addicts, although different patients respond differently to certain smoking cues. Therefore, more varied and personalized practice situations would lead to the strongest effect. More research is needed to determine more precisely how much cravings participants actually experience.

Keywords

Quit smoking, addiction, Virtual reality, intellectual disability, tobacco dependency, smoking cues, virtual reality exposure therapy

1. INTRODUCTION

There exists a general consensus that we should be working towards a future where no one smokes [9], because this will bring many benefits, of which the health benefits, such as the reduced risks of diseases, is the main one. Smoking addiction is recognized as a complex, chronic disease and therefore, certain treatments are in existence to treat it. However, these treatments have limited effects for vulnerable groups such as patients with low literacy or intellectual disabilities [C. ten Bolscher[1], private communications]. VR offers the opportunity to treat smoking addiction in a new way, because it allows for a more interactive confrontation with triggers in a safe and controlled environment. Here, the patient can practice techniques to reduce cravings, such as self-control techniques (for example, breathing exercises to calm down in stressful situations or finding distractions). The current treatments are mainly based on cognitive behavioral therapy (CBT), which is a more verbal approach. The fact that this VR treatment is more practice-oriented is expected to make this approach more successful for individuals with low literacy or an intellectual disability. This is the case because there is currently a mismatch between the way the treatment is offered and the skills of the patients.

This research concerns finding ways to trigger cravings to smoke in virtual reality. This research can aid the development of treatments of smoking addiction using VR. What distinguishes this research from previously conducted research on smoking is the focus on a vulnerable group, namely individuals with low literacy or intellectual disabilities and what virtual reality exposure therapy (VRET) can mean for them.

1.1 Research questions

This research answers the following research questions:

MRQ: How can VR technology be applied for treating smoking addiction for individuals with an intellectual disability?

SRQ1: What triggers in daily life are the cause of cravings to smoke, for people who are addicted to smoking?

SRQ2: How can smoking cues invoke cravings to smoke in VR?

This paper first addresses the necessary background information in Section 2. Section 3 then gives an overview of related work. Then, the methodology of this research is explained in Section 4. Subsequently, Section 5 will discuss the observations taken at the MST Hospital and the literature, which was used to make the VR environment. The user study in which this VR environment is used is then discussed in Section 6. In Section 7, the results are discussed. Section 8 explains what future work still needs to be done. Lastly, Section 9 are the acknowledgements.

2. BACKGROUND

This section discusses definitions and background information that is needed to understand the context of this research.

2.1 Intellectual disability

About 2 to 3% of the human population is considered to have an intellectual disability [1]. These individuals usually have an IQ-score that is lower than 70 and they can have difficulty generalizing and recognizing patterns and connections [10]. This often leads to difficulties in daily life, including having

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[1] Nurse specialized in smoking addiction at the Stoppen met roken Poli of the MST Hospital in Enschede.

problems with reading. When designing technology for this target group, it is important to use limited vocabulary, repetition and use game elements [11].

2.2 Smoking triggers and smoking cues

Smoking triggers is an umbrella term that relates to all things that make an individual want to smoke, such as situations, smells and habits. Smoking cues are only visual elements that induce cravings, divided in three categories: "(a) objects associated with smoking, (b) holding or handling cigarettes, and (c) actual smoking behaviors" [7]. Different smoking cues from all three categories are combined in the virtual environment that is used in the user study, to test their effectiveness.

2.3 Measuring cravings

The primary withdrawal symptoms of quitting smoking have been known since 1986 [6], some of which are easily measurable. Measuring cardiac rhythm with a heartbeat monitor and the amount of sweating with sensors that measure skin conductance has been done before. However, this is not as straightforward for measuring cravings. No precise definition of cravings exists in literature, even though it is the most widely reported symptom of abstinence of substance use [3]. Most research experiments use some kind of measure for the strongness of cravings, but there is no unified way to do so. Most methods include verbally asking questions about the amount of cravings the participant experiences, or having them rate their cravings on different scales, since the amount of craving can't directly be observed. Currently, the method that is most widely used is the Visual Analogue Scale (VAS). This is a method were participants rate their craving on a scale from 0 to 100. In this research, the amount of cravings were not measured on a scale.

2.4 Measuring nicotine independence

A widely used test to determine the level of nicotine dependency is the Fagerstöm test [8]. This test consists of five questions and results in a score on a scale from 1 to 10. A score of 0 to 2 means the participant is not dependent on nicotine. When someone scores a 5 or higher, it is recommended that the participant seeks treatment for their nicotine addiction. A score of 7 or higher is considered a strong nicotine dependence.

3. RELATED WORK

Research has been done on the success of cue exposure therapy (CET). CET has already been proven successful in treating disorders such as PTSD, generalized anxiety disorders, social phobias and agoraphobia and fear of flying [5]. The first time CET was tested with VR was in 2001, by Kuntze et al, focusing on heroin dependent males [2]. Kuntze's research inspired the methodology for academic studies related to measuring craving that came afterwards. Cravings were measured by having participants rate cravings on a scale. Furthermore, EEG, skin conductance and cardiac rhythm were measured.

The first VRET research that focused on smoking addiction was held in 2003 by Lee at al [4]. Twenty-two participants were either exposed to smoking cues in VR for four intervals of 5 minutes, or regular photographs of smoking cues. Because looking at photos is only visual, the exposure in VR was only visual as well, meaning the environment was not interactive. The strength of the urges to smoke were collected by asking participants about their cravings using VAS. This research confirmed that the self-reported cravings induced by VR were much stronger than those induced by looking at photographs.

Similar, but broader research than this research has been conducted before, namely the research about the general benefits of using VR in treatments for individuals with intellectual disabilities, by van Aggelen [11]. This research describes the total process of designing VR environments for this target group of individuals with intellectual disabilities. This research also confirms the fact that craving of substances can be induced in VR, but this research mainly focused on drug and alcohol addiction.

4. METHODOLOGY

SRQ1 is answered by using three different methods. Firstly, a small literature research was conducted to investigate what individuals, who are addicted to smoking, describe as their own triggers, and what research has concluded are the primary smoking cues. Secondly, an interview was held with an addiction nurse who works in the MST Hospital in Enschede. Lastly, observations were taken while joining the addiction nurse in the MST during the treatment of patients, to get a better insight in the current treatments for smoking addiction and the target group of patients.

SRQ2 will be answered by means of an user evaluated study. For this user study, a VR environment from the research of van Aggelen [11] is adapted to use for qualitative user testing with smokers with an intellectual disability. Qualitative research allows the results of the testing to be evaluated in greater detail, compared to a statistical analysis of quantitative research. In addition, qualitative research is a better fit for evaluating human experiences and observations. The amount of craving the participant experiences was rated by the participants themselves. The strength of their cravings was not measured. The user study is conducted with participants that are currently in treatment for alcohol addiction, but who are also addicted to smoking. The testing was conducted at the Addiction Facility Tactus in Rekken on the 14th of June 2019. The exact procedure of this user study can be found in Section 7.

4.1 Ethics

The ethics of this research are a concern because of two reasons. Firstly, this research borderlines on being medical research. The case study can possibly induce cravings to smoke, but the research does not measure these cravings, or any other physiological effects. Furthermore, we do not do any medical intervention. We do not ask participants to perform medical actions. Therefore, it is not considered medical research. Secondly, the research is conducted with people from a vulnerable group. However, the participants are informed of what this research includes in the information letter and the informed consent form, that is tailored to their level of comprehension, by using simple words and short sentences. These forms were also read aloud to the participants. The participants were all consenting adults. It was made sure that the participants did not have a curator or a mentor that needed to be consulted.

This research has been approved by both the Ethical Committee of the University of Twente and by the "Wetenschapscommissie Tactus" (The ethical committee of the Addiction Facility Tactus)

5. OBSERVATIONS AND LITERATURE

This section concerns the findings from the observations at the MST Hospital as well as the literature. These findings led to insights on how to build the VR environment and what should be included in it.

5.1 Observations at the MST Hospital

On the third of May 2019, observations were taken in the MST Hospital, in addition to questions that were asked to an nurse that is specialized in quitting smoking. The people who seek treatment at the MST can be roughly divided into two categories. First, there are people who decided they wanted help to quit smoking and sought help on their own initiative. A significant part of this group has low literacy or an intellect that is lower than average. The second group is people that need to quit smoking for a more urgent reason, for example, medical treatments, operations, or because of a pregnancy.

Patients in this treatment have regular appointments with one of the addiction nurses, that are on individual basis. These appointments usually take 30 to 40 minutes, and generally have the same structure: discussing how the last week has been, what process has been made and then discussing the plan for the upcoming week(s). The treatment at the MST includes at least 10 appointments, but it could take many more if necessary. The treatment can take anywhere from 4 till 12 months.

Before the intake appointment, the potential patient is given an intake form, containing 47 questions about themselves, their medical history, their symptoms, their addition, their smoking behavior and their motivations for quitting. The purpose of the intake appointment is for the nurse and the patient to meet and to establish some short-term and some long-term goals. The answers to the intake form are discussed and the addiction nurse can also ask the patient to fill in the Fagerström test [8]. The patient will also receive a workbook in this first session. This book contains 10 chapters with both text to read and exercises to make. Every appointment discusses aspects of one of the chapters. As mentioned before, this is a very verbal oriented part of the treatment.

The treatment continues with preparing the participant to quit smoking, before actually quitting. In this process, the addiction nurse will create a smoking schedule with smoking moments. The patient is only aloud to smoke a cigarette at these smoking moments. At the smoking moments, they should start to smoke a cigarette, even if they don't finish it. The purpose of this schedule is that patient cannot smoke out of habit anymore, because they are instructed on when to smoke and when not to smoke. It eliminates the internal dialogue on whether or not to go smoke. Furthermore, they can practice resisting to smoke when they have the craving to do so, but knowing that they only need to hold out until their next smoking moment. This all aids the change of behavior that is needed. During every following appointment, the addiction nurse makes a new schedule with fewer smoking moments in per day. Eventually, it is decided when the patient actually makes an attempt at quitting smoking altogether.

Furthermore, the addiction nurse can also prescribe medical aids such as nicotine patches and nicotine tablets. Using these aids increase the change of successfully quitting smoking with more than 20% [C. ten Bolscher[2], private communications]. Nicotine patches exists with different quantities of nicotine and will start working about 2 hours after applying it. It works up until 24 hours. Nicotine tablets can take about 20 minutes until the tablets have a physical effect.

Lastly, other things the addiction nurse can provide is papers with motivational quotes, explaining which apps can provide support for quitting smoking and teaching the patients breathing techniques that can reduce stress, which patients often report is a big problem when trying to resist smoking. Different breathing exercises can also be aided with different apps.

[2] Nurse specialized in smoking addiction at the Stoppen met roken Poli of the MST Hospital in Enschede.

5.2 Literature

Different patients confirmed different smoking cues as described in literature. As mentioned before, smoking cues are divided into tree categories: (a) objects associated with smoking, (b) holding or handling cigarettes, and (c) actual smoking behaviors [7]. The first category includes seeing objects like cigarettes, packets of cigarettes, lighters and ashtrays. One patient told the nurse that she purposefully hid all her ashtrays in closets and cabinets, as to not remind herself of smoking. What she found especially difficult was seeing ashtrays on tables outside, specifically in her garden, as it urged her to smoke. Smoking cues of category b were not discussed during sessions with patients, as this was not relevant. Cues that belong to the third category are rooted in habits and behavior. This also relates to different situations patients usually smoke in. Cues that were discovered here are smoke-rooms, terraces, smoking after having a meal, seeing others smoke and having others ask patients to join them to smoke. The last two seemed important to most patients in the MST. This was very apparent in a couple that wanted to quit smoking together. They were doing great when they were supporting one another, but once either of them smoked again, the other immediately joined. An overview of these findings are presented in Table 1. This table of smoking cues answers SRQ1: *What triggers are the cause of cravings to smoke in people who are addicted to smoking?*

Objects	Holding and handling cigarettes	Behaviors and situations
- Cigarettes - Smoke - Ashtrays - Lighters - Boxes of cigarettes	- Being able to pick up all objects in column (a). - Being able to pick up cigarettes that have a smoking animation	- Seeing others smoke - Characters asking the player to smoke - Characters having dinner - A smoke-room - A terrace - A wall of cigarette boxes

Table 1: Overview of smoking cues

6. USER STUDY

6.1 Equipment and software

Unity 3D was used to make the virtual environment. Unity is "The world's leading real-time creation platform" and it is the most widely used VR development platform [12]. One can make 3D environments with the use of SteamVR [13].

The VR headset that the virtual environment is developed for is the HTC Vive [14]. This headset is developed by HTC and Valve Corporation. It provides an immersive experience due to the headset tracking and the possibility to actually walk

around in the virtual space. In addition, it is also possible to teleport through the virtual environment. There are two additional controllers with which the participant is able to interact with the world and its objects, such as picking up a cigarette.

Blender was used to create some of the 3D objects in the environment, along with their corresponding texture mapping. “Blender is a free and open source 3D creation suite that supports modeling, rigging, animation, simulation, rendering, compositing and motion tracking and even video editing and game creation” [15].

6.2 Implemented smoking cues

The list of smoking cues in Table 1, that were retrieved in Section 6, is implemented in the VR environment. The environment consist of a restaurant-type building with a garden. Using Blender and Unity, objects were made that are related to smoking. This includes ashtrays, lighters, cigarettes and packets of cigarettes. Some of the cigarettes also have smoking animations. The boxes of cigarettes were made with a big assortment of different brands and packaging, as can be seen in Figure 1.

Figure 1: Big assortment of different boxes of cigarettes

In the garden there are some tables and chairs that look like a terrace. On these tables are flowers in vases, ashtrays and some boxes of cigarettes and a cigarette in an ashtray that is still smoking. Furthermore, there are some benches. On one of these benches, a character is sitting and holding a smoking cigarette. Next to him on the bench lays a box of cigarettes. When the player gets near this character, the character asks the player if they want to join him, and he then offers the player a cigarette. In addition, on the other side of the garden, a woman is sitting in a lawn chair with a small table next to her, on which an ashtray and some cigarettes are placed. When the player gets near, audio is played of a woman’s voice, asking the player if they want to join her while smoking and she offers a lighter to borrow.

Figure 2: Characters that ask the player to join them while smoking

In the middle of the garden are some more people who are just walking and talking to each other. Lastly, there is a smoke-room in the garden. This is modeled to resemble a real smoke-room as much as possible, including metal ashtrays with cigarette ends that are attached to the walls of the smoke-room, as seen in Figure 3.

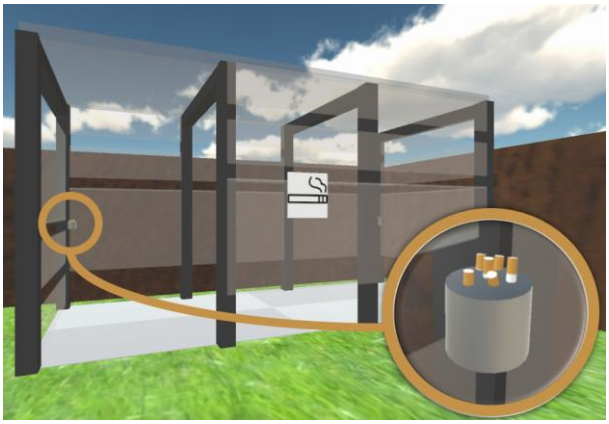

Figure 3: The smoke-room implemented in the VR environment

The building in the VR resembles a restaurant. All alcohol related drinks and objects are purposefully removed, in order to more clearly differentiate between craving for alcohol and craving for smoking. This is done because there are a substantial amount of individuals addicted to both alcohol and smoking and we do not intend on inducing alcohol related cravings. Inside, there are booths in which characters are sitting, talking and eating. On the tables are cans of soda, cups of coffee, plates with pancakes and plates with croissants. Some of these characters have a box of cigarettes with them on the table. There are also some snack machines in this building. Furthermore, there is a bar with barstools, on which a couple of characters are talking to each other. On the bar is also a cash register in front of a barman. Behind the bar is wall of boxes of cigarettes, displayed in a way they would be in a store. There is also a coffee machine and a lot of cutlery. On the bar also lay some smoking related objects and a phone. The restaurant is decorated to look as realistic as possible and also contains a dartboard with some arrows.

6.3 Procedure

The VR environment is used for user testing. First, the participants are given an explanation of the study. They are given the information letter and the informed consent form. Both of them are also read aloud to the participants, as they might have difficulty reading. Both documents have been written in a way that is appropriate for this target group. Any questions that the participants might have are answered. Then, the audio recording was started and the facilitator asked the participants some general questions and the questions of the Fagerstöm test. After this, the facilitator explained how the controls on the remote work. Then, the participant was placed in a virtual practice area. Here, the participant can safely practice the controls and get used to the VR experience, without being subjected to the smoking cues yet. The participant was allowed to practice until they were confident enough to move on, which took about 5 to 10 minutes, depending on the participants technological skills. Subsequently, the participant was placed in the VR environment with the restaurant and the garden. The participants did not get any specific instructions, but they

were encouraged to walk around and explore as many things as they wanted to. They could quit whenever they wanted to, which usually took about 10 to 20 minutes. The user study is concluded by a semi-structured interview about the participants experience and a discussion about the things they saw and experienced in the VR environment. In this interview the following things were discussed: their immediate reaction to the experience, the opinions about the different objects, and whether they are realistic enough and whether they induce cravings, what situations trigger strong cravings for the participant in real life, how can VR help smoking addiction and how the environment could be improved.

6.4 Pilot testing

Before the user study was conducted with intellectually disabled people at Tactus Rekken, a test run of the user study was done with someone that does not actually smoke.

This pilot testing shred light on a few issues. First of all, there was quite some inconsistency with the objects that are and are not grabbable. The participant wanted to grab quite some objects that were static. In addition, some objects got highlighted when the player is close enough to grab it, while others did not. These things were changed before the user study. Furthermore, the audio of characters offering cigarettes kept repeating very fast, when standing in certain areas in the VR environment. This was resolved as well. The audio does repeat, but with a break of silence in between. Then, the player can hear the audio again if they did not hear it the first time, but it does not get repeated at an annoyingly fast rate. Furthermore, the pilot tester explained that it was weird that there was a table with food on it, without there being people at that table. This food was removed afterwards. The tester also mentioned that it would have been nice to be able to actual use the lighter, or at least that the lighter can make a small flame. This was not implemented before the user study. Even though this participant did not smoke, they did advise to also place objects that are more related to people that roll their own cigarettes. Before the user study, some more packets of rolling paper were put into the environment, however, there are no packets or bags with shag placed into the VR.

6.5 Results of the user study

The user study was conducted with five participants who were, at the time of the study, in treatment for alcohol addiction in the addiction treatment facility Tactus Rekken, but were also addicted to smoking. It was made sure that the participants did not have a curator or a mentor. The ages of the participants range from 25 to 58 years old.

6.5.1 Participant 1 (F)

This participant (58 years old) had no experience with VR and who was currently not trying to quit smoking. Her nicotine dependence, according to the Fagerstöm test, was 7 out of 10. She was very surprised by the technology and found it to be a very realistic experience. When a character asked her to join her with smoking, she refused and asked politely if the woman could go to the smoke-room to smoke. Afterwards, she explained that deep in her heart, she wanted to join her, and that refusing cigarettes is actually really difficult, especially in this situation, because it feels so real. She admitted that this did induce cravings to smoke. She continued to explain that others asking her to smoke is one of the strongest triggers, because in real life, she would join them, even she does not feel like smoking herself. However, saying “no” to a virtual character is still somewhat easier that saying no someone in real life. Nevertheless, she does see the potential utility in being able to practice this in VR. The participant introduced the idea of the VR environment to be supporting as well: she said that she would like to have characters that help her stop smoking, or characters that are also trying to quit smoking. Her instinct was to get rid of all the cigarettes and cigarette packets, to reduce cravings as much as possible. She wanted to throw them in a trashcan, and thought it would have been good if this can be implemented. She also pretended to be able to step on and crush the boxes of cigarettes. The participant explained that seeing ashtrays or lighters did not induce cravings. The lighters can be made slightly more realistic if they have certain brands on them. She always carefully picked lighters with certain brands that matched the brands of her cigarettes, but now, she has been using Bic lighters for a long time. Some tables that are very low were an issue for the participant, as this participant did not want to bend over too far, because it was hurting her back. At home, she usually smokes in her own garden, she explained. Therefore, if her own garden was made in VR, she would be very temped to smoke. After the user study, the participant told us that she immediately wanted to go smoke, although she wasn’t completely sure if that was caused by the user study or by the fact that it had been a while since she smoked her previous cigarette.

6.5.2 Participant 2 (M)

The second participant (25 years old), was currently not trying to quit smoking and had used VR once before with a PlayStation, but that was long ago. His nicotine dependence is rated as a 6 out of 10, according to the Fagerstöm test. He was faster at learning the controls, but it also did not keep his interest for very long. The smoke-room did a lot to him. He explained that a smoke-room induced stronger cravings if you are not allowed to smoke anywhere else. The logo on the front is what makes it recognizable and realistic. The iron ashtrays with cigarette ends is a big point of recognition. In contrary to the first participant, this participant admitted that he gets cravings to smoke by seeing the ashtrays in VR, but mostly by those in the smoke-room (see Figure 3). This participant confirmed that he got cravings by seeing the characters smoke as well. However, he did not trigger the audio during the user study. Afterwards, he explained that he would never accept cigarettes from strangers anyway, but that it would have been more effective if the characters in the VR were people that he really knew. Then, as the previous participant mentioned as well, he would join them, even if he did not crave a cigarette himself. The participant offered the idea of having a separate VR environment where one can buy cigarettes, because everyone who smokes has to get their cigarettes from somewhere, so every smoker has to deal with that situation. That situation would be especially difficult if the cigarettes are visible. In order to reduce the cravings in VR, the VR environment should include nicotine patches or other nicotine replacements. Having games in the VR environment that could function as distractions could work, although some patients might find it childish, according to participant 2. During the discussion after the participant experienced the VR, we took another look at the cigarettes and the lighters on the computer screen. His face instantly changed as a wave of craving hit him, which he instantly admitted. Overall, he found the environment very realistic, although the thought the cigarette end could be a bit bigger in comparison to the size of the cigarette, to make the cigarettes slightly more similar to real ones. This participant believes that the VR environment could really help people, if the before mentioned objects are also included.

6.5.3 Participant 3 (F)

The third participant (46 years of age), was currently not trying to quit smoking, but was cutting back her amount of cigarettes a day. She had never used VR before. She scored a 6 out of 10 on the Fagerstöm test. She was very opinionated about the fact that the VR environment needed more people. This was because she found it weird that there were smoking related items laying around without corresponding owners nearby. She would also find the restaurant much more attractive if there were more people inside. The main effect of the VR was that this participant experienced a lot of craving for alcohol. So much that she became very hot and started blushing. After the user study, she talked about this with treatment facilitators of Tactus and she explained that she felt like this confrontation with her own craving had really helped her to realize how serious her addiction is. She said that an environment like a lunchroom with a terrace would induce craving to smoke, without inducing craving to drink, because a lunchroom is clearly a place where you do not consume alcoholic drinks. Even though the building in the user study was described as a restaurant, the fact that it contained a bar made her crave alcoholic drinks. Furthermore, she had some comments about the realism of the VR objects. She would have liked the cans of soda to have actual soda brands on them. In addition, she thought the top of the lighter needed to look more like metal, instead of just like grey plastic. In addition, she found it unrealistic that so many ashtrays were empty. According to her, there should be more ash and cigarette ends. However, she explained that she really liked the cigarettes with the smoking animation, because that made it look very realistic. Situations in which she would imagen she would get more cravings to smoke would be a disco, during lunch breaks, during a bad and stressful day and right after dinner and at home. She described the image of her relaxing on the couch at home, in front of the tv, with something to drink and some snacks and agreed that it would be good if a situation like that would be implemented in VR as well. The strongest trigger for smoking in the VR environment was the people asking her to smoke. According to the participant, this is the case because it is hard to refuse such an offer in the real world as well. However, she did have some conflicting thoughts about this. First, she said that she would never join someone that she does not know to smoke together. Nevertheless, she also said that she did want to join the character that asked her in VR, even though she does not know her. She said that she felt like the character wanted to make contact with her, and asking someone to smoke is an easy way to do that and make some small talk. Just like the other participants, she said that she would join them, without craving a cigarette. Lastly, she wanted some elements that would help her stop smoking. For example, advertisements in which smoking is depicted very negatively, so that the player is reminded of all the effects smoking has on one's body and the amount of money that it costs. It would be good if there are people in the VR environment that ask you to do something other than smoking or that say that you should not smoke in their area.

6.5.4 Participant 4 (M)

The fourth participant (33 years old), had never used VR before and is currently not trying to quit smoking. His result of the Fagerstöm test was 5 out of 10. This participant was very interested in the technology of Virtual Reality and therefore spend a lot time in the environment, trying to uncover everything he could find. When he first encountered cigarettes, his instinct was to pick them up and bring them to his mouth. He later explained that this urge faded after some time in the VR, as his body realized that it is not actually possible to smoke these fake cigarettes. During the exploring of the environment, he also tried to pick up the cigarette ends in the smoke-room, even though that is not possible. He also experienced the same relieve when finding a smoke-room that a previous participant experienced, due to smokers constantly being on the lookout where they are allowed to smoke. According to the participant, the smoking symbol on the front was the main focus point. When he triggered the audio of the woman asking him to smoke, the vocally answered with "No". However, he immediately imagined how this can be used to practice refusing cigarettes. He is convinced that it will get easier to refuse cigarettes in real life if it is repetitively practiced in VR. It would be great if patients can also walk away from certain situations, and find a distraction, such as the bowling practice exercise that was in the practice VR environment. It would be great if the VR environment would be made much more elaborate, in which you can do such things, like bowling or biking. Another idea that he offered was having a shed in which one can do woodworking. He liked that the dartboard was already in the environment, although it gave him a distraction, which decreased his cravings, as well as stress, which increased cravings again. The participant explained that he experienced the most cravings due to the smoking cigarettes. He illustrated this with the fact that he even gets cravings from seeing people smoke in movies. He concluded that VR was more realistic than seeing people smoke in movies though, because this experience is much more immersive. Seeing lighters did not invoke cravings, because the participant does not immediately associate lighters with smoking. The ashtrays did catch his attention however, as it is a clear indication that it is allowed to smoke in that area. Lastly, he explained that he felt like seeing the wall of cigarette boxes does something to an addict's brain as well. He immediately searched for his own brand. His instinct caused him to walk behind the bar, and then he tried to pick up various boxes, which was not possible. The participant came up with the idea of making the buying process even more realistic by displaying how much money the player has. This way, the player, has to debate whether or not the cigarettes are worth the money, just like in real life. The environment does not need to be changed to an entire shop, as long as it is convincing that one can buy cigarettes there. It could also be a gas station.

6.5.5 Participant 5 (M)

This participant (42 years old), was not trying to quit smoking and had never used VR before. According to the Fagerstöm test, this participant was not dependent on nicotine at all, as he got a score of 0. This is mainly due to the participant smoking a maximum of 5 cigarettes a day, and only after dinner. He voiced the opinion that he could easily quit smoking, because he did not classify himself as addicted. This participant only smokes after dinner or after exercising, usually in his garden, or if the weather is very bad, hanging out of his window or underneath the exhaust hood in the kitchen. He thinks it would be interesting to see these things implemented in VR as well. This participant did not have much patience, as mentioned by himself as well, which caused him to be easily frustrated by the controls of the VR and that stress did lead to some craving for a cigarette. In those situations, distraction is essential. He went on explaining that seeing the VR did not trigger cravings. However, he could image how it would feel for people who are very addicted to smoking, especially if he imagined the same environment full

of alcoholic drinks and other drink-related cues, because that would have a big effect on him. Furthermore, he imagined that the outside area of the environment would be much harder than the inside area, because there are not many buildings in which you are allowed to smoke. This participant did not trigger any of the audio, but could imagine that it would be hard to hear that if the participant is very addicted to smoking. Nevertheless, he himself considers refusing a cigarette to be easy. He was confused by the characters that did not trigger audio but still made very big hand gestures and therefore thought that they might have been arguing or fighting. The participant does not like smoke-rooms at all and considers them very gross. The participant is convinced of the great potential use of VR in addiction therapy. He is sure that the environment is realistic enough.

6.5.6 General results

Most participants had similar opinions about most of the triggers. However, there were also quite some differences and some conflicting results. First of all, not everyone triggered the audio, and people that did trigger audio did not necessarily trigger both audio clips. All participants agreed that characters asking you to smoke results in relatively strong cravings to join them. None of the participants were interested in the outdoor terrace tables, which might be caused by the fact that there were no characters sitting at any of those tables. Four out of the five participants had trouble with the fact that they had no clear objective in the VR environment. They kept asking what they had to do. All the participants mentioned that there should be more people in the smoke-room, either to make it more realistic, or more attractive to join. Four out of five participants expressed a strong preference toward one or two brands of cigarettes. However, when presented with the wall of cigarette packets behind the bar, all five participants admitted to quickly searching for certain brands. Two participants were confused in which areas of the environment people were allowed to smoke and where it was not allowed. One of the participants was very confused why there were characters smoking outside the smoking-room, as a smoking-room indicates that one is only allowed to smoke in there.

6.6 Discussion of results

First of all, the results of the user study show much potential for using VR for this specific purpose. They also shed light on the fact that all participants might have slightly different smoking cues that trigger cravings for them, and that the reactions to certain situations can differ greatly per participant. Ideally, this is taken into account during the treatment of the patient. Having completely personalized environments for each patient is unfeasible, but having multiple environments with different practice scenarios and smoking cues could positively impact the effect of the treatment, as the treatment practitioner could pick environments and situations that are important to practice for each patient in treatment. Again, the effects of this should be carefully researched before widely implemented in treatments.

Second of all, the user study was only conducted with five participants. This was sufficient because of the qualitative nature of this research and these five participants are very representative of the desired target group, which are hard to find. The participant were all addicted to smoking and all have low intellect or a minor intellectual disability. Nevertheless, all participants that partook in this user study have an alcohol addiction as well, for which they were currently in treatment at the addiction facility. In order to generalize these results, it would be recommended to include individuals who are only addicted to smoking in this study as well. It is also important to note that participants might have influenced each other during this study, as they were able to talk to each other in between user study sessions.

In order to develop the desired treatments for quitting smoking, more extensive research is needed, as described in section 8, Future work. This research is only meant as an exploration of the possibilities that VR technology can bring to induce cravings.

Lastly, the organizations that are involved in this research (ZGT Hengelo, MST Enschede, Tactus Rekken and University of Twente) are delighted with the results of this preliminary research and are convinced of the potential new treatments that might be developed after more research is conducted. The results of this research have impact and are real-world.

7. CONCLUSIONS

The first sub-research question is: *What triggers are the cause of cravings to smoke in people who are addicted to smoking?* This question was answered by consulting literature, but was mainly answered with the use of the observations taken in the MST hospital in Enschede. Different patients have different triggers, but the most important ones are included in these three categories: (a) Objects, (b) Holding and handling cigarettes, and (c) Smoking behaviors and situations. The specific smoking cues are presented in Table 1.

The second sub-research question is: *"How can smoking cues invoke cravings to smoke in VR?"* This can be done by implementing the smoking cues from Table 1 in VR and letting participants actively interact with the environment. Inducing cravings in this way was proven successful according to the self-reported craving the participants experienced.

The main research question of this research is: How can VR technology be applied for treating smoking addiction for individuals with an intellectual disability? After looking at the answers of the sub-research questions and the observations of the user study, it can be concluded that VR technology can be applied for treating smoking addiction. Concerning the "how" of this question: it is important to implement the smoking cues, described in the first sub-research question, as realistically as possible. From the user study, it can be concluded that participants experience cravings differently, and due to different smoking cues. The treatment would ideally include multiple environments with different practice scenarios and smoking cues, to positively impact the effect of the treatment, as the treatment practitioner could pick environments and situations that are important to practice for each patient in treatment. These environments should then also include elements that can help patients reduce their cravings.

8. FUTURE WORK

There are a lot of aspects that need more research before certain elements can be applied to be used in new treatments for smoking addiction, because this research was very exploratory. First of all, the physiological effects of VR environments of this nature should be examined. This way, we can form a clearer image of the amount of craving the participants experience and how this effects their body. This can be done with equipment like heart rate monitor or skin conductance measurement equipment. Other interesting and relevant data can be collected by using VR equipment that

supports eye tracking. Seeing what things intuitively and unconsciously attract a participants attention could lead to new insights that cannot arise from simply asking the participant about this.

As mentioned by one of user study participants of this study, we could get more insight on how cravings are induced if more research is done using mixed VR. This could include having participant smell smoke while looking at smoking cigarettes and having participants actually holding cigarettes and lighters while handling them in VR.

The VR environment that was tested showed a lot of potential but could include various more elements that were discussed with the participants. The effects of these elements should be elaborately tested again. The VR environment could also be made to implement more functionality, such as being able to use lighters, being able to light a cigarette with a lighter, being able to buy boxes of cigarettes or being able to throw away smoking related items. Furthermore, characters could be animated to actually smoke their cigarettes, instead of just holding smoking cigarettes in their hands. Lastly, it would be useful to get more insight in how stressful situation can lead to cravings and how these stressful situations can be replicated in VR to achieve the same effect. However, these situations can be very personal.

Generally, more elaborate environments should be tested with the target group, to see what effects they can have and if they can be a part of the treatment that is desired to be developed. Areas mentioned by the participants are gardens of houses, a living room setting with a tv, a kitchen with an exhaust hood, a lunchroom with a terrace, a gas station, or a shop where one can buy cigarettes. Another situation could be a bedroom in which the player wakes up, since most people with a high nicotine dependency smoke more in the first hour of their day, compared to the rest of the day, in addition to smoking within the first 5 minutes of waking up. Other areas could be bus stops, smoke areas at train stations or a car, since these are also places in which people who smoke often smoke.

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