Fighting Substance Dependency Combining AAT Therapy and Virtual Reality with Game Design Elements

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Abstract: Smoking poses a significant health risk and is still the main cause of premature mortality today. The Approach Avoidance Task (AAT) developed by Rinck and Becker aims to develop a substance dependence therapy that can reach the digital society. In this paper, a demonstrator that transfers the AAT procedure into virtual reality (VR) is presented. This demonstrator was used to carry out an evaluation with twenty participants who were asked to use the program and evaluate it by means of questionnaires and interviews. In addition, the reaction times (RTs) of the test persons were recorded and evaluated. The results show that the transfer of the AAT procedure to VR is possible and promising. Above all, the use of three-dimensional scenarios and objects, with which one interacts during the training, were well received and increased the immersion as well as the felt embodiment. The use of game design elements has also proved helpful and has had a positive influence on user motivation.

1 INTRODUCTION

1.1 Motivation

Tobacco products are among the most consumed addictive substances along with alcohol (Batra et al., 2015). In Germany, approx. 29 % of adults and 9.6 % of adolescents between twelve and seventeen years are smokers, which is one of the many reasons why smoking is still one of the leading causes of premature mortality today (Donath, 2017).

Nevertheless, little attention is paid to this addiction disorder. Hardly any therapy or prevention possibilities are offered or (further) developed. Anyone who wants to start a therapy must expect long waiting times and stigmatization.

The aim of this and our further studies is to develop new and innovative methods of intervention using digital media, which can be used for the treatment of substance dependency and thereby improve the success of therapy. The use of digital medicine (Elenko et al., 2015), in the form of virtual reality (VR) and mobile applications, is not only intended to reduce the inhibition threshold for starting a therapy, but also to improve its availability to the general public and its effectiveness.

The Approach Avoidance Task (AAT) was chosen as the basis therapy procedure for this cause, as past and recent research has already provided promising results, which show that AAT is an effective additional method for the treatment of addiction diseases like smoking or eating disorders (for an overview see (Kakoschke et al., 2017)).

Whereas conventional methods of smoking cessation address reflective processes by, for example, informing patients about the negative consequences of their behavior, AAT uses the cognitive bias modification (CBM) method to cover implicit processes in addition to conventional therapy. Cognitive biases are responsible for the selective processing of stimuli in the environment, and thus influences the emotions and motivation of the viewer (MacLeod and Mathews, 2012). In this context, smokers show a specific approximation behavior for images containing smoking-related stimuli, and, at the same time a comparatively reduced approximation to alternative images. This behavior is measurable and can be observed in the approach and avoidance biases. Due to this fact, the AAT approach is well suited for additional smoking cessation therapies using smoking-related stimuli, as described in (Machulska et al., 2016).

The rest of this paper is structured as follows: First, the theoretical background is explained. This includes the AAT procedure, VR and game design elements. Subsequently, the state of the art and the

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background knowledge will be summarized. Then, the concept as well as the game elements used in this application will be presented. The following section describes the implementation itself and the evaluation. Finally, the results are summarized, conclusions will be drawn and an outlook is given.

1.2 Theoretical Background

1.2.1 The Approach Avoidance Task (AAT)

The AAT is a psychological procedure based on the hierarchical model of Approach Avoidance Motivation. This assumes that each individual follows positive stimuli and moves towards them (*"approach"*) to capture and hold them. In contrast, negative stimuli, such as pain, are avoided, resulting in a movement away from them (*"avoidance"*) to correct or escape them. These movements are not only physical, but also psychological, making this model a fundamental component for understanding and generating motivation or self-regulation (Elliot, 2006). Past studies have shown that people evaluate almost all stimuli as positive or negative (Bargh, 1997), and according to their evaluation react with approach or avoidance to them (Lewin, 2013). Moreover, it was repeatedly noted that this is accompanied by a pushing or pulling movement of the arms (Chen and Bargh, 2016; Marsh et al., 2005).

Based on this knowledge, the AAT procedure was developed by Rinck and Becker (2007) . For this method, participants were shown individual pictures on a computer screen, to which they should react utilizing a joystick. Depending on its movement, the size of the currently displayed image changed: by pulling the joystick, it became larger, while pushing made it smaller (see Fig. 1). Instructed not to pay attention to the content of the images, but only to a certain distinguishing feature, like the image format (portrait or landscape) or its clearly visible tilting, the test persons should thus subconsciously learn to push away stimuli related to their addiction, as these are always shown in the format that should be avoided. In addition, the reaction times (RTs) were measured and evaluated to determine the approach/avoidance bias of the participants. The calculation for each stimuli type is as follows:

$$Bias = MedianRT[PUSH] - MedianRT[PULL] \quad (1)$$

A positive value implies an approach bias and suggests an affirmative attitude towards the stimulus, which is reflected in an approaching behavior. A negative value represents an avoidance bias, resulting in an unfavorable attitude and averting behavior.

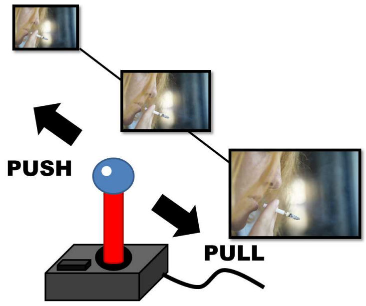

Figure 1: Idea of the Approach Avoidance Task.

Smokers should therefore get a higher approach bias in smoke-related stimuli than non-smokers, as this would imply an approaching behavior towards them.

The results of various studies (Kakoschke et al., 2017) have shown that the AAT method could be used for therapeutic purposes. Studies to this topic are still undergoing, and this motivated us to transfer the AAT procedure to VR in order to treat addiction disorders more efficiently.

1.2.2 Virtual Reality and Game Design Elements

VR is a computer-generated three-dimensional alternative reality in which a person can interact and move (Sherman and Craig, 2003; Simpson et al., 2000). This virtual environment (VE), into which the user can immerse, can be used in a wide range of applications, such as the simulation of an alternative reality (duPont, 1995) or for the representation of complex data (Pickover and Tewksbury, 1994; Simpson et al., 2000). But it is also possible to use VR in quite different environments, e.g. in medical or military context. Applications are also seen in education, architecture (virtual house inspections), psychology (treatment of phobias and dependence illnesses), entertainment (video games) and many other domains (Giraldi et al., 2003).

Since users can immerse into the virtual world on a visual, auditive, and motoric level, the feeling of immersion is significantly higher compared to conventional systems. This type of human-computer interaction is called "presence" and can increase the effectiveness of interactions in VE (Schultze, 2010). If implemented correctly, the VE can generate a high cognitive absorption in the users, which means that they lose the sense of time, can focus better, and feel that the content is entertaining and arouses the curiosity for more. Temporarily, the user tends to get the feeling that he has full control over the system and is not depending on it (Agarwal and Karahanna, 2000). This effect can be enhanced by the use of game design elements. The aim is to motivate users to act in a more targeted manner and thus increase their general motivation to interact with the system (Sailer et al., 2017). In addition, AAT can contribute a lot to early intervention when used in a timely manner, especially to ensure that the users stay motivated for a sufficient period of time to carry out the therapy and do not drop out prematurely (Boendermaker et al., 2015).

2 RELATED WORK

Lee et al. (2004) linked a VE to cue exposure therapy (CET), which aim is to reprogram the behavior of patients by learning to deal differently with situations that trigger addiction. They are regularly exposed to stimuli that cause craving until their respective tolerance level towards them has increased to such an extent that they can think about their actions in risk situations instead of involuntarily giving in to their urge (Murphy, 2014). In the experiment of Lee and his colleagues, a VE was created which was composed of addictive environments and components. In their case, it was a bar containing various objects such as ashtrays, cigarette packs, or lighters, a smoking avatar, and the audio track of a noisy restaurant. For all objects, three-dimensional models were used, since Lee et al. had already found out in a previous study that these trigger a much higher addiction pressure than two-dimensional images (Lee et al., 2003). The study participants, sixteen late adolescent men who consumed at least ten cigarettes a day, were repeatedly exposed to addictive stimuli in six sessions. The results showed that in the course of the test series the number of cigarettes consumed as well as the addiction pressure has gradually decreased, which is why it can be assumed that the use of a VE within treatment programs can be extremely helpful.

In the pilot study of Girard et al. (2009) , the participants should find, grasp and destroy up to 60 cigarettes, which were hidden in a medieval VE. Over a period of four weeks, one session was held every week, each lasting 30 minutes. The control group had similar conditions, however, no cigarettes were to be destroyed here, but balls were to be collected and taken along. The results showed a statistically significant reduction in nicotine use and the abort rate of the accompanying treatment program as well as an increase in the abstinence rate compared to the control group. In addition, 23 % of the participants stated that they repeatedly remembered destroying the cigarettes within the VE, which only 3 % of the participants in the control environment did. This could indicate that an increased belief in self-efficacy can be achieved if an individual watches himself destroying cigarettes and also invests time and effort in finding others to destroy them as well. The perceived embodiment within the VE additionally contributed to the effectiveness.

A first attempt to transfer CBM to VR for the treatment of eating disorders was made in 2016 by Schroeder et al. (2016) . Here, 23 participants were asked to interact in a VR scenario with 3D objects representing either a food item or a ball by making a rejecting or gripping hand movement. The RT is measured at three different points in time: At the beginning of the hand movement, at object contact, and as soon as the object has been collected. During the study, the participants sat on a chair and wore an Oculus Rift DK2 as a Head-Mounted-Display (HMD). In addition, the Leap Motion infrared sensor (Leap Motion, 2018) was used to track the hand movements and transfer them to the VE. The visible virtual hand should help the users think that it was their own hand (*body-ownership*) (Slater et al., 2009). As soon as the starting conditions (placing the dominant hand at a predefined starting position, HMD oriented centrally and no head movements for 1.000 ms) were met, a 3D object appeared in front of the players, to which they should either react with a defensive hand movement, or grab and collect it. During the game, a progress bar filled up, and the last six collected objects were displayed at the top of the screen. The study results showed that food objects, especially with increasing body mass index (BMI) of the test persons, were collected significantly faster than ball objects. In summary, VR in conjunction with CBM, possibly also together with other technologies, such as eye-tracking, can be a helpful tool for the detection and treatment of addiction disorders.

3 CONCEPT AND GAME DESIGN

3.1 Requirement Analysis

Figure 2: Three-dimensional mock-up of the virtual house.

As a pilot study (Eiler, 2018), a basic VR demonstrator had to be implemented that should compare the original desktop AAT (DAAT) procedure with a slightly extended version that contains more game design elements. The Unreal Engine and a HTC VIVE HMD with a resolution of 2160 x 1200 pixels and a refresh rate of 90 Hz will be used. The training concept, e.g. the tilting of the images as a distinguishing feature, is based on the AAT studies of Machulska et al. (2016) . To make the two scenarios comparable, the VE should consist of two rooms, one for each procedure. Free movement within an area of 2 m x 2 m will be permitted. A mock-up for the three-dimensional layout and design of the rooms, created with *eTeks Sweet Home 3D*, Version 5.6, is shown in Fig. 2. Within these rooms, in the sense of the AAT procedure, various stimuli ought to be shown one after another and have to be interacted with. They display either addiction-related or neutral stimuli. As implemented in the studies of Machulska et al. (2016) , the addiction-related 2D images in the first room have to be tilted to the right and should be pushed, while the neutral ones have to be tilted to the left and require to be pulled. In the second room, where 3D objects instead of 2D images should be used, the distinguishing feature will be the border color of the stimuli: Red-bordered objects ought to be thrown away into a trash can and blue-bordered ones pulled and collected inside a cardboard box. Correctly treated stimuli will disappear immediately. Following the original procedure the next stimulus appears after the thumb stick on a controller is pressed. Within the VE short instructions on the wall will show how the task should be fulfilled in case the participants need to reassure themselves within the training scenario.

While the participants complete the AAT training, their reaction times have to be recorded twice: The time that has passed between the appearance of the stimulus and the first contact by the user, and the time that has passed until the correct action has been taken. Time measurements have to be taken as accurate as possible, ideally in the millisecond range, to calculate the approach/avoidance bias. This is due to the fact that we want to measure and alter automatic processes, which happen very fast. Reactions lasting longer than 300 ms are accessible to rational consciousness and therefore are no longer involuntary (see P300 wave). In addition, the differences resulting from AAT training are often only a few milliseconds, and such accuracy is needed to validate these differences.

A configuration file should allow the test leader to specify the test subject ID, the degree of tilting, the number of stimuli shown, how many of these stimuli should show an addiction-independent distinguishing feature and if a 3D model of the HTC Vive controller or a robotic hand should be used to represent the interactions of the users.

Our aim was to find out if a transfer of the AAT procedure to VR is possible and if so, which room works better and what has to be changed in the design for the further course of the study. The measured RTs and the biases derived from the measurement results were compared to the results of the studies by Machulska et al. (2015) . Due to the fact that the psychologists involved wanted as few distracting elements as possible in order to make the results comparable, game design elements were kept to a minimum in this pilot study. The evaluation carried out should provide initial results in terms of design, user-friendliness and immersion in order to develop an improved demonstrator which will be used for the elaborated studies in the future.

The two rooms, the VE, and the training execution are described in more detail below.

3.2 The Desktop Room

Figure 3: Interaction within the desktop room.

The first room, called ”desktop room” (DR), should differ as little as possible from the DAAT and contains hardly any game design elements. For this reason, 2D images floating in the middle of the room are used here (see Fig. 3). These images, kindly provided by Rinck and his colleagues (2007) , are either tilted to the left or right because the distinguishing feature ought to be clearly recognizable, but should not distract too much from the image content, as the avoidance of addiction-specific stimuli is to be automated. Since the zooming factor is extremely decisive in the AAT procedure, the images pushed away are artificially reduced in size, whereas the enlarging perspective effect is sufficient when pulled. Correct actions are rewarded with a positive sound effect, and pressing the thumb stick will display the next image. In the event of an error, a negative-sounding tone rings out and the ceiling light turns red until the correct movement is done. In addition, the interactions are visually represented with two different 3D models (see Fig. 4), which can be set via the configuration file. The first model represents the HTC Vive Controllers, which the test subjects will hold in their hands during the experiment and which can also be seen on the instructions. The second model is a robotic hand with gripping animations.

Figure 4: The two models that can be used for the interaction.

3.3 The VR Enrichment Room

In the second room, the ”VR enrichment room” (VRER), more game design elements are used, like 3D modeled surroundings as well as a particle effect accompanying the appearance of the stimuli (Fig. 5). The most important elements for the training are a table and two containers: a cardboard box and a trash can. The box stands between the users and the table on which the objects will appear. Since the users stand directly in front of the box and the trash can is located behind the table, arm movements necessary for the AAT training can thus be transferred into three-dimensional space. Instead of 2D images, 3D objects are used to further increase immersion since the studies by Lee et al. (2003) and Gorini et al. (2010) could prove that they produce a higher craving than 2D images. The objects are to be sorted according to their border color: In case of having a blue border, they should be placed in the box, if they have a red border, they have to be thrown into the trash can. Visual and acoustic feedback is the same as in the DR. The appearance of the objects is accompanied by a purple cloud of smoke, so that they, unlike the images in the first room, do not appear ”out of nowhere”. The added elements should have the benefit that the training is more entertaining, which would increase motivation and therefore the success rate of the therapy.

3.4 The Virtual World

The two rooms are connected by an elevator, which has an operating panel and a level indicator. After the successful completion of the first room, which is indicated by a green light, the elevator opens its door so that the user can enter and proceed to the second floor. The ride is accompanied by a sound file that reproduces the sounds of a moving elevator. After the user has reached the upper level, a bell sounds, and at the same time, the door opens again so that the user can step outside. The main purpose of the elevator is to ensure that the start and end points are always identical when changing rooms. If the rooms were connected by a door, the user would have to turn 180 degrees to enter the next room without leaving the boundaries of the tracking area, which would feel unnatural and therefore disrupts the immersion.

Outside the house a virtual environment was created, which is visible through the windows. It consists of an extensive grassy landscape with trees, flowers and bushes. This should help ensure that the VE has no visible end and appears more natural. In addition, the oppressive feeling within the small rooms should be reduced so that the users feel more comfortable during the training.

3.5 Conducting the Training

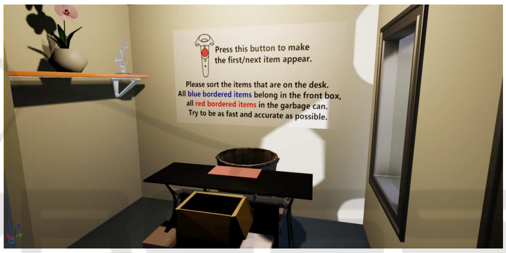

Figure 5: The VR enrichment room.

In summary, the training is conducted as follows: The user starts in the DR, where the thumb stick of the controller needs to be pressed to start the training and the first run. Each run includes one stimulus. The recording of the RT also starts at this point. After pressing the button, the first image appears, to which the user must react according to its tilting. When the image is grasped, by pressing the trigger, the first RT is saved. If the user’s subsequent action was correct, the image disappears, a positive-sounding tone is played, the second RT is saved and the run is considered finished. However, if the action is faulty, the ceiling light in the room turns red and a negative-sounding tone rings out to signal the error. The image is also moved back to its original location and the current run continues until the correct action has been executed. Once the image has been moved correctly, the ceiling light returns to its natural color. In this case the run is finished and the next one can be started by pressing the thumb stick. Errors are also recorded, since incorrect runs must not be taken into account when calculating the bias. Once the amount of images specified in the configuration file have been handled correctly by the user, the light turns green for one second and the elevator opens. If this happens, the DR is considered finished. Via the lift the user now enters the VRER, which is similar in functionality, with the exception that 3D objects are used here whose border color specifies into which container they must be sorted. The ID of the user and the recorded data are exported to an external .csv file.

4 IMPLEMENTATION

The Unreal Engine (UE) (Epic Games, 2017), in the version 4.18, was used for the implementation of this Windows x64 application. Mainly Blueprints were used, a kind of visualized programming language of the UE. However, some functions, e.g. for reading and writing external files, have been programmed in C++.

A ”canvas” is placed in the middle of the DR (see Fig. 3), whose blueprint controls the entire functionality of this room. It contains an array in which all pictures that can appear are stored. File names and substring queries are used to determine whether the stimulus is negative or positive. To determine whether the executed movement was an pulling or pushing action, the difference between the image distance before and after the participant grasps and releases it is calculated. A buffer area of 6 cm in both directions was implemented in order to ensure that the program does not evaluate the slightest movement as pushing or pulling away.

The VRER works very similarly, although 3D objects are used here. These are taken from the Google Poly database (Google LLC, 2018). The border color that decides into which container the item is to be sorted, was implemented using Tom Looman’s ”Multi Color Outline Post Process” extension (Tom Looman, 2015), which requires a post-process volume and the use of a custom stencil. In order to be able to determine whether the objects have been sorted correctly, they were provided with tags, which are queried in the event of a collision with one of the trigger boxes inside the containers. An ongoing sorting process can be seen in Fig. 6. The smoke effect was taken from the ”Infinity Blade Effects” asset collection made by Epic Games and adapted for the use inside the demonstrator.

Figure 6: Sorting within the VR enrichment room.

A challenge was the accuracy of the time recording. This must be very precise, since even a few milliseconds make a difference in the evaluation of the recorded RTs in order to determine the cognitive bias. Initially, it was attempted to achieve this over the system time, but the result was not satisfactory because the function call, implemented in C++, was made via a custom blueprint node. Due to our inexperience in VR programming at this time, after some research we found out that blueprints have a frame dependency. This means that function calls are always executed with the next frame, never between two frames, which in turn means that the accuracy depends on the performance of the used computer. Due to these circumstances, a time recording accurate to the millisecond is not feasible using blueprints. Next, the time measurement was implemented using a time line, which, while it is running, continuously updates a variable in which the time that has passed so far is stored. For time measurement, this variable can simply be read and the return value saved in further variables. This resulted in an accuracy of 12 ms to 16 ms on the working machine, which is critical in terms of precision, especially since less powerful computers are therefore unsuitable.

5 METHOD

5.1 Participants and Design

Twenty participants (ten females and ten males; mean age: 29.74 years, range: 18-60; five smokers) took part in the evaluation. For 75 % of the test persons, the experiment was their first point of contact with VR.

The experimental design required the participants to be shown twenty stimuli in each room, the first ten of which show a tilting or border color independent of the image content, which means that addiction-related stimuli may be pulled and neutral ones pushed. In the last ten stimuli, each smoking-related stimulus had to be pushed away and vice versa. All participants started in the DR and completed both rooms. They conducted one test run to learn the controls and to determine how understandable the demonstrator is only with the contained instructions.

After signing a declaration of consent, the test persons were introduced to the framework plot and functionality of the program, while it was already known that the demonstrator was aimed at the therapy of nicotine addiction. After the participants put on the HTC Vive HMD the application was started. During the test run, the controller model was used in the DR to visually represent the interaction, while the hand model was used in the legitimate run whose RTs were used for bias calculations.

Afterwards, all subjects were asked to complete a non-standardized questionnaire containing fifteen questions to determine how they perceived the program with regard to various components like comprehensibility of the task, control, user-friendliness, enjoyment or the perception of certain game design elements. By means of a short interview, some of the answers had to be explained in more detail.

6 RESULTS

6.1 Observations

As anticipated, observations during the experiment have shown that while using the DR especially those participants who have not had any previous experience with VR have found it difficult to perform the correct arm movements. Only after a verbal instruction on how the movement should be carried out, these test persons were able to continue the AAT training correctly. Further problems that could be observed in the DR include participants having difficulty gripping the pictures. Often, despite the feedback given by the vibration of the controller, they were uncertain whether they were close enough to the image to be able to grasp it. For the majority of the test subjects, it was difficult to determine which arm movement is required by the tilting of the images, which is why they often positioned themselves in such a way that they always had the instructions in view. In addition, it was tedious for most participants to press the thumb stick after each stimulus to make the next one appear. Each subject forgot this at least once during the training.

The observations in the VRER differ greatly from those in the DR. Surprisingly, even the inexperienced participants had significantly fewer problems in carrying out the required task, and instead began to experiment with the objects during the test run. By using the three-dimensional scenario and virtual hands, the subjects had virtually no problems gripping and sorting the objects. In addition, significantly fewer mistakes were made. Furthermore, the test persons felt more comfortable and less oppressed in this room, which led to a stronger immersion. Moreover, they had significantly more enjoyment performing the task, which contributes positively to their motivation. However, pressing the thumb stick to make the next object appear was also perceived as disrupting in this room. It should be noted that the participants forgot to trigger it much less frequently, which may be caused by the fact that they could already internalize this behavior through training in the DR.

6.2 Questionnaires

The evaluation of the questionnaires showed that both immersion and embodiment were rated very well (on average 7.5 and 7.4 points on a scale between 1 and 10). User-friendliness was generally perceived as very good and beginner-friendly. The execution of the task did not cause any further problems, except for the difficulties in the DR mentioned above. The movements felt natural, especially the VRER received very good ratings. However, six people (30 %) stated that they found the movements in the DR unnatural and unusual. Two of them explained that this was due to the fact that grasping ”floating images” felt peculiar.

Regarding the 3D models, 65 % of the participants thought that the robotic hand model is more realistic and makes the gripping movement, not only visually, more intuitive. 15 % of them found the hand model to be better in principle, but noted that the controller model is better suited for beginners, since the instructions are easier to understand with it. 10 % considered the controller model better because it reflects reality due to the fact that this controller is held in the real world. However, it was emphasized that the hand model would be preferred instead if a glove or another technique would be used that would transfer own hand movements realistically into the VE. The remaining 25 % of the respondents stated that they found both models to be of equal value.

Only 5 % of the participants expressed a negative opinion about the particle effect used because it felt too intrusive. Another 5 % stated that although the smoking effect was not disturbing, ideally it should only be used for smoking-related stimuli and the positive stimuli should have a different effect. 55 % considered the effect to be appropriate, as the objects do not appear ”out of nowhere”, instead their appearance is ”spectacular and made interesting”. Surprisingly, 35 %, including 60 % of the participating smokers, stated that they did not notice the effect during the experiment.

6.3 Evaluation of RTs and Comparison with the Desktop AAT

Fig. 7 and Fig. 8 summarize the RT distribution of smokers and non-smokers per image category and

Table 1: Evaluation of RTs.

	Desktop Room	VR Enrichment Room	Desktop AAT
median time until first contact	886 ms	851 ms	/
median time until correct reaction	1416 ms	1319 ms	620 ms
mean duration of arm movement	530 ms	469 ms	not necessary
Error rate smokers (%)	10	0	8
Error rate non-smokers (%)	8	6	11
Ø smoking-related bias (smokers)	256	44	25
Ø smoking-related bias (non-smokers)	-312	-11	10
Ø neutral bias (smokers)	123,5	21.5	0
Ø neutral bias (non-smokers)	95	27.5	11

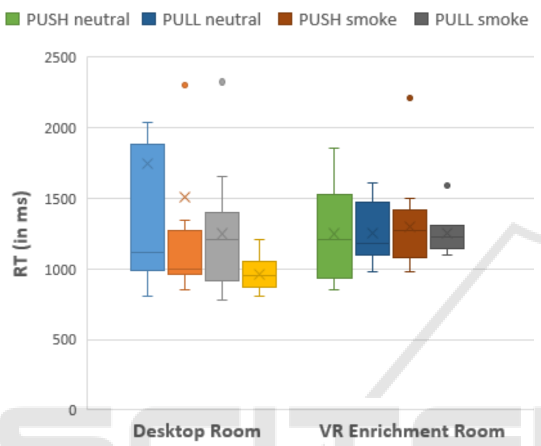

Figure 7: RT distribution of smokers.

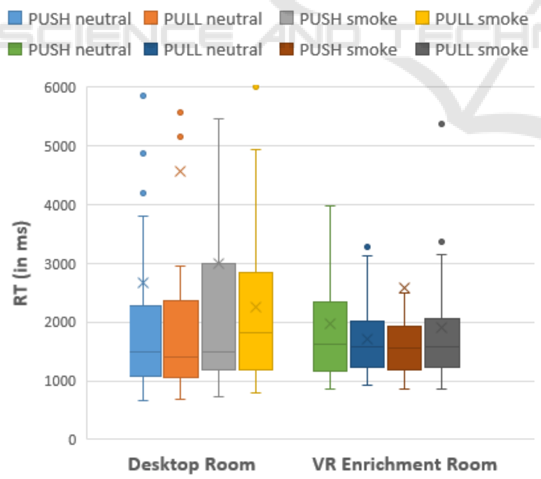

Figure 8: RT distribution of non-smokers.

room. The results show that both groups were faster in the VRER, whereby smokers were significantly quicker to pull smoking-related stimuli in the DR (M = 964.7,SD = 118.9) than in the VRER (M = 1252,SD = 146.7). The lower deviation from the mean value when pulling smoking-related stimuli also supports the statement that smokers have a higher approach bias for these stimuli. In addition, it is noticeable that smokers have generally reacted faster than non-smokers in all categories.

The evaluation of the measured RTs compared to the DAAT can be seen in Table 1. The DAAT values refer to the study by Machulska et al. (2015) , in which 92 smokers and 51 non-smokers participated and responded to smoking-related vs. non-smoking-related pictures.

Our measured RTs show that the median time elapsed in the DR before the first contact with the stimulus is 886 ms and 1416 ms until the correct interaction with it, 530 ms were required to execute the arm movement. The overall result of the VRER shows that the subjects needed a median time of 851 ms until the first contact and 1319 ms until the correct arm movement, the execution took 469 ms. As expected, due to Fitt's Law our measured RTs are longer than with the DAAT, where the median RT was 610 ms until the correct reaction.

The calculated bias values are comparable with those of the DAAT, with the exception that smokers show an approach bias for neutral stimuli instead of being neutral towards them. The bias values of the VRER come closer to those of the desktop ATT, as the values of the DR are much larger. Nevertheless, in both rooms smokers had an approach bias towards smoking-related stimuli, which suggests that those were pulled faster than they were pushed away, whereas non-smokers had an avoidance bias towards them. Interestingly, non-smokers had no avoidance bias when using the DAAT, but an approach bias, which at first would not be suspected.

The recorded data also show similarities between the VRER and the DAAT regarding error rate, as smokers made significantly fewer mistakes (0 % vs. 8 %) than non-smokers (6 % vs. 11 %) in these processes. In the DR, on the other hand, more mistakes were made in general, as smokers had an error rate of 10 % and non-smokers of 8 %.

7 CONCLUSION

On the basis of our findings, the transfer of the AAT procedure into virtual reality is promising, and should be pursued further, as almost all required functions are possible in VR, except for the time measurement, which is not sufficiently accurate due to the frame dependency of the blueprints.

An added value can be recognized by using VR and game design elements, since the evaluation showed that the VRER was appraised more favorably in all areas, especially considering enjoyment and therefore motivation. The use of border colors as the distinguishing feature also resulted in a lower error rate. As anticipated, participants found interactions with 3D objects more realistic, intuitive and visually appealing, which contributed to an increased presence. The recorded data also reflect that the VRER works better, as not only the RTs are faster, but the VRER also shows more similarities with the DAAT compared to the DR, especially considering the calculated bias values, which are an essential part of the AAT therapy.

The built-in game design elements were positively received by the participants and therefore receive a legitimization for implementation. Still, it had to be examined whether the smoke effect is a disturbing element, since the test subjects could possibly form an association between the effect and smoking itself, which would lead to biased results. However, the assessments of the subjects lead to the conclusion that the smoke effect could be maintained in the further development of the project and can represent an added value, whereby alternative particle effects should be considered.

With regard to control, most respondents favored the robotic hand model, as it feels more natural and increases the feeling of embodiment. However, the controller model was considered useful to make it easier for beginners, as the controller is mapped in the instructions. It was often criticized that the thumb stick has to be pressed repeatedly to make the next image or object appear. Here it would make more sense for the next stimulus to appear immediately after the previous one has been treated correctly.

For the future development of the project, a new demonstrator, which incorporates the results of this study, fixed the problems regarding the time measurement and corrects design errors, is already in development. Solutions suitable for therapeutic purposes, which allow a visualization of the entire body within the VE without interfering with the training, will be examined. This would make the VR experience even more realistic and pleasant, as it would improve embodiment and therefore presence. In addition, this would allow users to move more securely within the VE. Regarding controls, the usage of the Leap Motion sensor (Leap Motion, 2018) or data gloves will be evaluated, since hand movements can be transferred even more faithfully to the VE. In this way, a positive effect on embodiment can be expected.

In addition, consideration can be given to introducing gamification elements like progress bars, a scoring system, achievements, or other elements, as there is a significant increase in user motivation when the context in which points or other rewards are received is more closely related to the actions performed - even if there are no stories or characters (Dovis et al., 2012). The increased enjoyment while playing should thereby raise the motivation to continue the therapy.

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