Hausarbeit

Shaping Behavior: The Influence of Virtual Reality on Food Preferences

a randomized controlled trial

Bachelorstudiengang Oecotrophologie

Schwerpunkt Ernährung und Gesundheit

Modul Projektmanagement und Projekt

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Abgabedatum bis 28. Februar 2020

1. Introduction

A short introduction into virtual reality

Imagine there was a machine that could take people to fantastic places. Places, that defied the laws of physics. Magical forests with gently glowing mushrooms, illuminating a beautiful patch of nature. Trips deep down the ocean. Virtual Reality (VR) can let people do that. It is a powerful technology enabling visiting computer-generated environments[1]. So called head-mounted displays (HMD) often combined with controllers enable users to move around in immersive new worlds in real time. When VR is done right, the user will feel present in the environment with their brain experiencing their actions and movements as real (Wiederhold, 2016, p. 3). But not only can a virtual reality create an artificial environment - it is also able to create and modify avatars, digital presentations of the user. This capability made way for a lot of research, investigating e.g. how our self-perception influences our behavior. And it has existed for quite a while: the first HMDs have been around since the 1960s. Being very expensive and high maintenance before, they were long viewed as for researchers and laboratories only. It wasn't until 2016 that the technology cheapened and started to become mainstream, finding its way into living rooms and game stations (Oculus, 2012).
But VR can't only be used for video games or visiting fascinating places. In fact, there are countless applications to the technology: it has a huge potential to improve certain learning (Bailenson et al., 2008); (Bailenson, 2018, pp. 228–246), to overcome fears (Wiederhold, 2016), to increase empathy (Ahn et al., 2013) or to decrease physical pain in medical treatments (Hoffman et al., 2004; Lewis, 2014; Schneider and Hood, 2007; Wiederhold, B. K. et al., 2014; Wiederhold, M. D. et al., 2014). And those are just a few examples. That's why VR's rapidly growing user base (IDC, 2020) makes VR technology all the more interesting. One more very compelling aspect of VR is the so-called Protheus effect, which describes that users tend to identify with their virtual self (their avatar) and change their real world behavior according to that self-perception (Yee and Bailenson, 2007). Jeremy Bailenson, a psychologist who has been working with VR most of his career and part of the team to define the Protheus effect, calls it "the most psychologically powerful medium" (Bailenson, 2018, p. 12).
And while the Protheus effect affords an avatar to identify with, there's also potential for just the virtual experience changing our real life behavior (Ahn et al., 2014; Bailey et al., 2015). One study was even able to show a 1-week effect (Ahn et al., 2015), which in VR research is long term. VR bears a considerable advantage for behavioral change: there is no actual risk. Consider treating spider phobia with VR (which is already done). The subject does not need to interact with a real spider, so it is easier to confront the fear. While the brain treats the confrontation as real, the person knows that it is actually not and thus is better able to face the (virtual) animal (Garcia-Palacios et al., 2002).
Now this eliminated risk or cost does not necessarily need to be anxiety, pain or so on. It could also just make favored decisions easier – like eating fruit instead of candy by giving a virtual incentive.

Applications in the field of nutrition

Eating behavior is hard to change, so using VR seems like an appealing opportunity. The present work aims to test, if that is actually possible and how big the effect could be. Other applications of VR in nutrition include modeling and testing food choice processes (Allman-Farinelli et al., 2019; Marcum et al., 2018), supporting the treatment of eating disorders or restoring a correct body perception (Riva et al., 2018; Roncero and Perpiñá, 2015; Wiederhold et al., 2016), correctly estimating food volume (Zhang et al., 2011 - 2011) and measuring food craving in connection with different environments (Ferrer-Garcia et al., 2015; Ledoux et al., 2013).

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[1] Mainstream media tend to report 360° Videos or other applications such as using smartphone configurations as VR. While they technically might be considered VR, they are far less immersive and are not treated equal to reality by the brain. Therefore, these forms will not be considered VR in the present work.

Further studies were able to examine the effect VR and games had on weight loss as well as weight loss maintenance (Sullivan et al., 2013). Using the Protheus effect, researchers were able to show that people increase their physical activity according to their avatar (Coons et al., 2011; Li et al., 2014).

2. Method

The present study aims to test the following hypotheses:

H_0 = Eating behavior cannot be influenced by a VR game
H_1 = Eating behavior can be influenced by a VR game.

A literature research was conducted in order to construct the experiment alongside already published ones. Searching Elsevier, Google Scholar and the digital library of the University of Applied Sciences FH Münster delivered no result in a RCT using a VR game to examine its influence on eating behavior.

2.1. Design

The present study is a randomized controlled trial (RCT) with the subjects being blind to the condition. A virtual treasure hunt that required healing oneself with either food or potions was conducted to see if actual eating behavior could be influenced. For this, healthier food had a more positive effect on the game than the unhealthy option. All subjects underwent the same procedure with those being in the intervention group playing the game with food to refill their stamina and those in the control group playing with potions to do that (see Figure 1). Subjects were led to believe the test served market research which in turn was conducted to ultimately find more developers and investors to then produce an actual, purchasable game.

Figure 1: food (intervention) vs. potions (control) to refill stamina

2.2. Procedure

The testing process was aimed to take about 30 minutes of which a maximum of 20 would be spent in VR, since spending a long time in VR can be straining on the user (Bailenson, 2018, p. 67). It included 5 phases which will later be further explained in their respective paragraphs:

1. Getting accustomed to the controls using the game "Mirrors"
2. Measurement point one/alleged enhancement of control settings (t_1)
3. Treasure hunt (actual intervention vs. control)
4. Measurement point two/alleged testing of now enhanced controls (t_2)
5. Filling out a questionnaire to reinforce appearance as market research and to gather data on simulator sickness and immersion

2.3. Measures

To see if the VR game could influence eating behavior, food choices before and after playing the game were measured; more specifically, the number of grapes, tomatoes, chewing candy and chocolate eggs eaten in the measurement point (MP) environment. For the evaluation of the results they were later grouped into the amount of “healthy option” and “unhealthy option” eaten[2]. Other calculated measures are the percentage of “healthy option” and the one of “unhealthy option” before and after playing the treasure hunt game as well as the percentage gain of the healthy option from t_1 to t_2.

2.4. Materials

Technical devices

The experiment was conducted using the HTC Vive HMD and controllers. Two lighthouses or base stations (devices that track the user’s position in the room) were used to cover a field of 2.1 x 1.9 meters (6.2 x 6.9 feet) in which the VR could be used. In addition to that a device called LeapMotion was used to optically track the user’s hands via infrared sensors and use them as controls in the virtual environment (VE). That way, interactions would feel more realistic. LeapMotion was only used during the measurement points and the “Mirrors” game used to accustom to the controls.

In order to create good VR that makes the user feel present in the VE, three key elements need to work flawlessly: tracking, rendering and display. The used equipment ensured that quality. All used applications ran at 90 fps, meaning the image the user saw was updated 90 times per second, thus reducing simulator sickness and enhancing the feeling of a real experience (Bailenson, 2018, pp. 21–23).

2.5. Virtual environments

Mirrors

Being a short demo game for the LeapMotion device, “Mirrors” was perfectly suited to get the participants accustomed to the controls used in the MP environment. That way, the measurements were less distorted by the participants first having to get used to the controls. In the game, users could touch 4 different mirrors, thereby changing the way their avatar and especially their arms and hands looked and would be affected when moved (see Figure 2).

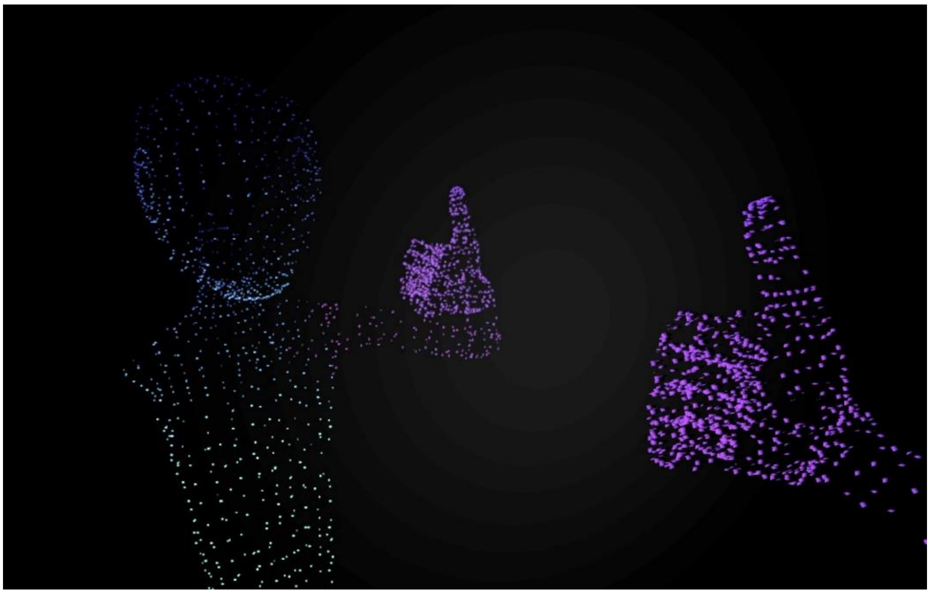

Figure 2: real movements of the user are mirrored on a virtual mirror

[2] While the classification of foods into “healthy” and “unhealthy” is generally outdated, it is used in this context to simplify the communication about the food choices.

Both of the following environments were built using unity. A large number of assets (prebuilt 3D objects) and scripts (programmed instructions for said objects) were used to form the virtual environments and to enable controls and VR use in general. The most important assets included "SteamVR" and LeapMotion's "unity core assets", "interaction engine" and "hands module"[3].

Measurement point environment

In order to measure actual eating behavior, the MP environment was built very similar to the original room the participants were in. For the participants to fulfill multiple tasks, real and virtual world held a table with certain objects to lift or eat (see Figure 3). All tasks were to be executed simultaneously in VR as well as in the real world. Thus, participants had to actually eat the food of their choice.
First, participants had to lift a paper plate and one to three Styrofoam balls. This was done to conceal the actual purpose of the environment. For the next step, participants had to walk a line on the ground in order to stand centered right in front of the food choices. Before, pretests had revealed that people would tend to just eat the first thing they could reach if they were to eat right after lifting a ball. Walking the line got rid of that effect. In order to avoid any further sequence effects, the order of the food was randomized as shown in Figure 4. To better enable picking up the food, the virtual bowls were filled higher than the real ones. Thus, the virtual hands had more entities to grab, making a simultaneous grab more likely.

Figure 3: table in the measurement point environment holding multiple tasks

Figure 4: food order constellations A and B

Treasure hunt courtyard

For the treasure hunt, a small courtyard environment was used. Subjects had to find five hidden, small chests and bring them to a cart close to the starting point. All chests were placed in a way that enabled the user to see them while moving around in the environment. While searching for the chests, their virtual stamina would decrease as illustrated by a visual indicator above the left wrist displaying "Stamina:" and the current value (see Figure 5). If the stamina dropped to zero, the game would be over. To restore stamina, participants could use certain objects at multiple restoring stations by touching them with their right hand. For the intervention group, these objects were the same food offered to them in the MP environment. Grapes and tomatoes would restore five points of stamina each while chewing candy and chocolate eggs would only restore one point of stamina. For the control group, these objects would be purple and orange potions with the orange ones restoring five points of stamina and the purple ones restoring one point of stamina. Being less common in video game potions, these colors were chosen in the intention as

Figure 5: stamina ("Ausdauer" in German) being displayed above the left wrist

[3] available at https://developer.leapmotion.com/unity#5436356, last visited 14.01.2020

not to prime the subjects. There was no further difference between the games for intervention and control group.
Added to that, an eating sound effect was played whenever a player used an object to restore their stamina. This was done to increase the immersion and thus the potential effect on real-life eating behavior.
The game would be won when all five treasure chests were delivered to the cart. In order to motivate and enhance the fun, the participants' time was taken and told to them in the end. It ranged from approximately four to eight minutes.

Using stamina instead of health (which is the usual case in video games) was a conscious decision to reduce experienced harm. With VR experiences being so close to real ones, using forms of brutality has been shown to be perceived as actual, real brutality and is able to trigger actual, real anxiety (Rundle, 2015; Slater et al., 2006; Vincent, 2016). Furthermore, the speed of stamina decay was designed to be motivating but not stressful as stress can influence eating behavior (Rutters et al., 2009; Wallis and Hetherington, 2004).

2.6. Food

In the MP environment, subjects were able to choose between four kinds of food, more precisely seedless grapes, tomatoes, cola-flavored chewing candy (MAOAM® Pinballs) and chocolate eggs with milk-hazelnut filling (Kinder Schoko-Bons). All of these were chosen to have a similar form for it not to influence the choice of food. They were further selected for the experiment so that there was a range of kinds of sweetness to choose from. In VR, chocolate eggs and chewing candy each had one 3D model due to their industrial-produced nature. Grapes and tomatoes had five different 3D models each to comply with natural variance. The 3D models of the food were constructed using measurements of the actual products used in the experiment. The virtual chewing candy was displayed in a lighter color to still be distinguishable from the chocolate eggs (see Figure 4).
To avoid color-priming, the bowls in which the food was placed as well as the paper plate and Styrofoam balls were colored either white or transparent.
Before using it, all food was ensured to be clean and unspoiled.

2.7. Questionnaire

The questionnaire was built using five items of the Slater-Usoh-Steed Questionnaire (SUS) to examine immersion and the Short Symptoms Checklist (SSC) to check on experienced simulator sickness. Additional questions on the game's quality, recommendatory character, and potential price were added to further conceal the actual purpose of the experiment.

2.8. Participants

The study was promoted using posters and sending a call for participants to students of the faculty electrical engineering/computer science. Other participant's faculties included chemical engineering, mechanical engineering, economics, engineering physics/laser engineering and energy, building services, environmental engineering. Participants were recruited by phone interview or email exchange. They were asked for their age, if they were left- or right-handed, for their course of study and for food they avoid in general. The purpose of the study was explained to them as market research, the purpose of the food as way to improve the fine tuning of the controls. In order to have a coherent group of subjects, participation criteria included being aged 18 - 30, being right-handed, being male and not avoiding tomatoes, grapes, chewing candy or chocolate.

Male gender was chosen because food preferences differ between genders (Max Rubner-Institut, 2008; Setzwein, 2004; Zittlau, 2002) and the total cohort size was too small to include more than one sex. There were 15 participants in total, eight in the intervention group, seven in the control group.

Both groups were roughly the same age, represented roughly the same faculties of students and also showed similar appointment times in mean and standard deviation (see Table 1).

Table 1: general data on intervention and control group

		intervention group (n = 8)	control group (n = 7)
age (years)	mean (SD)	24 (2)	22 (3)
appointment time	mean (SD)	12:13 (3:03)	11:35 (2:52)
members of the faculty…			
chemical engineering		1	1
electrical engineering and computer science		3	3
energy, building services, environmental engineering		1	2
mechanical engineering		2	1
engineering physics and laser engineering		1	0

3. Results

Participants showed very low levels of simulator sickness (mean 0.93, SD 1.3) and moderate levels of immersion (mean 25.9, SD 5.4). The decay speed of stamina was just right for most of the participants (mean -0.1, SD 0.8), indicating the time constraint not being experienced as stressful. There were no significant differences in these criteria among intervention and control group.

As participants were free to eat how much they wanted, the amount of food eaten differed between them. Thus, percentages of healthy and unhealthy option were analyzed rather than total amounts.

In order to evaluate if there was an actual change in food preference, a t-test was used to analyze for a difference in the mean percentage gain of the healthy option. No significant difference was found, thus rejecting H_1 = Eating behavior can be influenced by a VR game.

In general, there was a moderately high correlation (Pearson 0.65) between the percentage of kind of food eaten before the exposure and the percentage gain of healthy option afterwards (see Figure 6). The gain was smaller for those subjects who in relation had eaten more healthy options at the start of the experiment and was higher for those who in relation had eaten more unhealthy options.

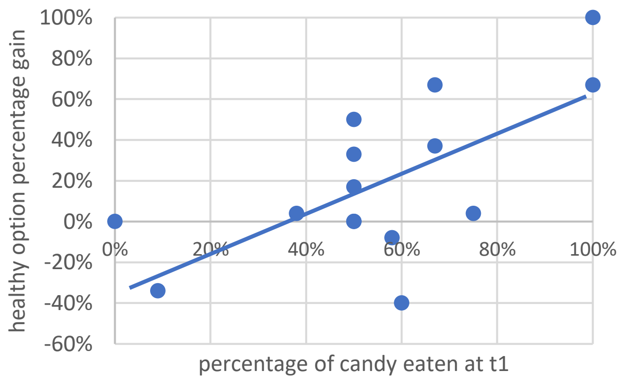

Figure 6: correlation of percentage of candy eaten at t_1 and healthy option percantage gain

In this particular sample, the control group performed better in terms of change of eating behavior, with an 8% higher percentage gain in healthy food options. Considering the above correlation, this result is likely to be explained by the intervention group having relatively eaten more healthy option food at t_1 than the control group (51% on average as opposed by 38% in the control group).

4. Discussion

The most obvious flaw of this study has to be the very small number of participants. Due to that, significant results were highly unlikely. While the groups do not differ in the enquired socio-demographic factors, they do differ in the amounts of sorts of food eaten at the very beginning, thus being less comparable. This is most likely caused by chance. The influence of chance furthermore shows in an unexplainable correlation between immersion and healthy option percentage gain. This would usually be expected to only appear in the intervention group and only if there was an effect of the VR game on food preference. Yet in this sample, there was no correlation for the intervention group (Pearson 0.01) but a strong one for the control group (Pearson 0.78).
But even if the sample would have been greater and starting conditions would have been the same, the results would only be true for male, right-handed university students aged 18 - 30.
Participants also arrived at different times of the day and were not asked for their state of satiety, both being possible confounders.

In general, effect sizes of VR interventions use to be fairly modest (Bailenson, 2018, p. 99). Good immersion is crucial for effect size. The treasure hunt game missed a few opportunities to be more immersive, e.g. using ambient noise or implementing a more lifelike eating gesture to restore stamina. And while this study failed to measure an effect of VR games on food preferences, it would only be able to show a short-term effect even if it did succeed.

In the MP environment, participants who eat a lot or experience a certain software malfunction are confronted with mostly empty virtual bowls and thus forced to choose a different kind of food. In order to minimize this effect, the MP environment was rebooted if possible so that the bowls would be filled again. This was not possible for subjects who did not mind eating another food at all because there would be no plausible reason to reboot it under the given disguise as market research.
A further flaw of the MP environment included the different kinds of food taking different amounts of time to chew. Thus, faster chewable foods might be preferred under the experimental circumstances.

Added to these factors, there are limitations to VR in general: the HMD is awkward to wear, some people might get simulator sickness and while the cost has rapidly sunken in the last few years, good VR still takes expensive hardware.

5. Conclusion

Virtual Reality is a powerful tool that will most likely have a great influence on our daily lives someday. While the effect size is modest at most times, behavior can be influenced by the use of this technology. While this study failed to prove an effect of VR games on food preference, more refined studies with a larger number of participants might be able to show an effect.

6. Acknowledgments

I would very much like to thank Prof. Dr.-Ing. Backhaus and Prof. Dr. troph. Wahrburg for making this experiment possible by lending their time, advice and resources to this project. I would furthermore like to thank Simon Siebers who especially during the development process always lent a helping hand when I felt frustrated and clueless. And thank you to all my friends without whose pretests and support this project would have taken even longer.

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