Virtual Food Court: A VR environment to Assess People's Food Choices

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ABSTRACT
Immersive virtual reality environments can provide users with realistic experiences of worlds that do not exist or would be hard to reach. The ability to manipulate these environments and influence experiences can be used to understand decision making under different conditions. In this study we explore how VR can be used to understand more about people's food choices. We explore how policy-based interventions such as the "sugar tax" and "nutrition labelling" to promote healthier food choices could be tested. Only limited experimental studies have been conducted about such choices due to the difficulty of trying such interventions in large retail settings. The objectives of the study were to assess how accurately the Virtual Food Court (VFC), represents a real food court. The study (27 participants) had two study conditions; a control with regular food-court prices, and an experimental condition with taxes on food and beverages. Results revealed that participants were able to imagine doing their real-life food purchases in the VFC indicating that it is a good research tool for assessing people's food choices.

Author Keywords
Virtual Reality, Food choices, eHealth

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Virtual reality environments allow users to have what would otherwise not be possible (Pimentel, 2000). Researchers can use these virtual reality environments to explore human behaviours in different experimental conditions, particularly important when this is not possible in the real world.

Given the human and financial cost of obesity governments and research organisation are exploring different interventions that could influence people's food choices. However, it is impossible to evaluate interventions in the real world such as taxes on sugar and saturated fat in the real world before making policy.

Since 2003-04, the proportion of food and non-alcoholic beverage expenditure on meals prepared away from home increased from 27.5% to 30.8% in 2009-10 in Australia (Fisheries and Forestry, 2013). Following this trend, more and more people dine out in less expensive food outlets, typically found in food courts. These food outlets are characterised by availability of food and beverages that are poorer in nutrients, and higher in sugar, saturated fat, and sodium (Dunford et al., 2010). On this basis, a food court environment is ideal for assessing the effects of different policy-based interventions.

In this work, we utilize VR to develop a VFC that represents typical food courts in Australia. The software is flexible in a way that researchers can easily make changes to food prices, nutrition labels, advertisement, and layout of the restaurant menus with limited computer software knowledge required. We also use this software to conduct a randomized controlled trial where we assess how a 20% tax increase on sugar sweetened beverages and a tax on food high in saturated fats affect people's food and beverage choices.

BACKGROUND
The World Health Organization (WHO) has recommended the use of policies to affect food prices and encourage healthy eating (Samuelson, 2004; World Health, 2009). Health-related food taxes are suggested as a mechanism to improve diets. A number of economic modelling studies suggest food taxes will positively influence food and beverage intakes. However, they are based on assumptions and subject to limited data. Furthermore, these studies are targeting specific foods rather than overlooking trends in all food categories (Thow et al., 2010). This indicates that experimental studies are needed to complement current findings, however, running such studies on a population level is complex and difficult.

Virtual Reality Approach
Virtual reality has been used in the treatment of eating disorders (Ferrer et al, 2013), it has not been used to study the impact of real world preventative interventions. One of the few studies trying to overcome the problem of limited experimental studies undertaken on large scale in retail settings, was pioneering Virtual Reality supermarket was developed to study consumer food purchasing behaviour (Waterlander et al., 2011). Results from a pilot study using the virtual supermarket concluded that it was well rated by its users, and they had no problem understanding the application. Moreover, it was reported that the purchases users made in the virtual supermarket were similar to their real life purchases .

Whilst it is nearly impossible to implement policy-based interventions in real world retail settings on a large scale,

the virtual supermarket research tool suggests virtual reality can help us implement such interventions in a near real-life like experience, and run studies to get valuable data about people's food choices.

SYSTEM DESIGN

VR has been used to run experiments when it is infeasible to do so in the real world or when it is too expensive or time consuming. We explore how VR can be used to assess the effect of a range of interventions to promote healthier food choices in a food court. We can model a VFC that easily can be manipulated to accommodate several experimental conditions.

Modelling the Food Court

The VFC is a three-dimensional immersive virtual environment implemented in Unity 4, a cross-platform game engine used to develop powerful 3D games. The environment is a composition of freely available three-dimensional objects modified to achieve a realistic looking food court including food stalls with cashiers, tables and chairs, and other components typically found in real food courts (Figure 1).

Figure 1. Screenshot of the Virtual Food Court.

Aside from the objects in the food court, there are other effects added to increase the realism. Directional and natural lighting is added to increase the perception of depth in the three-dimensional environment, as well as it creates shadows on objects. Furthermore, the entire food court is surrounded by a skybox, which is a way to make the environment look and feel as apart of the real world, by mapping sky textures to the faces of a cube surrounding the food court. The skybox includes textures of clouds, a blue sky, and a halo near the sun. Moreover, through the windows on one side of the food court, big trees and grass can be seen, increasing the feeling that you are inside a building, with nature outside your window.

Modifications

Food stalls in the VFC have a template look consisting of restaurant logo, advertisement, personnel, and food and drink menus. These components can easily be modified by editing text files and replacing images. There is a total of 14 food stalls in the VFC, allowing up to 14 unique vendors to be customized. However, if less food stalls are desired, we can simply duplicate other food stalls or just leave them empty. If further changes to the environment beyond editing the food stalls are necessary, one can extend the current VFC version by making changes to the project in Unity.

In the following sections we will explain how researchers can make changes to the text and images files found in the VFC software folder to customise the food and drink menus, banners, and advertisement of food stalls.

Food and Drink Menus

The food and drink menus in the VFC consist of an image of the food products superposed by prices and nutritional facts. These food facts are read from a JSON file and can easily be modified in order to change prices and nutrition labels which can be useful when assessing different study conditions, such as food taxes or nutrition labelling strategies. The following example is a food menu of a Thai restaurants, where each menu item is listed using the following key/value-pairs in JSON:

objectID: The ID of the image object containing the image of the food or beverage product.
name: The name of the food or beverage product.
price: The price of the food or beverage product.
energy: The total amount of energy in the food or beverage product.

Changes made to the menus can be saved as different JSON files. In this way, study conditions can be changed at ease by loading different files. This feature is particularly useful when conduction a randomized controlled trial, with two or more study arms.

Banners and Advertisement

The images for the banners can be changed to make each food stall look unique. It will typically consist of the restaurant logo, advertisement and good deals, such as affordable lunch meals. This enables researchers to study the effect of different advertisement and branding strategies. Moreover, it allows us to assess the effects of more untraditional ways of advertising. For instance, in addition to advertising for the cheapest deals available, one can also advertise for food products of higher quality and price, to attract a new costumer base.

Hardware and Game Environment

Hardware Requirements

The VFC uses the Oculus Rift HMD with 360 degrees head tracking, which means that every subtle movement of your head is tracked in real time, giving an intuitive and realistic experience. Furthermore, the HMD has one AMOLED screen for each eye, giving you a stereoscopic three-dimensional experience with a 100 degrees field of view both horizontally and vertically.

For navigation, any compatible plug and play gamepad with joysticks can be used. The gamepad is mainly intended to use for walking movements, whilst the head tracking takes care of movements such as looking to the sides, up or down, or completely turning around. However, if desired, one can also use the gamepad as a replacement for the head tracking, but this is not recommended as it decreases the immersion into VR.

Realism in the Game World

In the VFC, physical laws apply as they do in the real world. This includes gravity, collision with objects and people, and the feeling of distance between objects. This means that users do not need any instructions for how to interpret the VFC, and all the actions performed by a user

inside the virtual environment will feel natural. Moreover, it improves the realism of the virtual environment, as there are no ways to avoid the physical laws in the environment. For instance, in order to move your virtual character from one side of the food court to the other, you have to give the orders to walk, and wait for the time it takes for the character to move to the other side.

METHODOLOGY

Evaluation Goals

The main objective in this study was to study the following hypothesis

H1: The Virtual Food Court is a realistic representation of a real food court.

This hypothesis is the foundation of this paper. In order for the VFC to be an acceptable platform for assessing people's food choices, we need to prove that it is a realistic approximation to real food courts, and that the behaviours of a user in the VFC is similar to those in the real world.

Populating the Virtual Food Court

The VFC was populated with 3 food stalls: a burger vendor, pizza vendor, and a salad vendor with food menus inspired by those found in typical food courts in Australia.

The food stalls we added to the food court were selected to satisfy people with diverse food preferences. This included vendors that provided food options for vegans, vegetarians, and people with different food allergies, so that most of the participants should be able to have sufficient food choices.

The drink menus in the food court consisted of many different beverages, with 55% being SSB. The beverages in the VFC were categorised as following: **1) SSB**: Drinks that are sweetened with sugar. E.g.soft drink, fruit juice, energy drink, and flavoured milk. **2)Water/Die**t: Drinks that are sugar-free. E.g. water

Participants

The study was approved by the Human Research Ethics Committee at the University of Sydney (protocol 2015/227) and all participants gave informed consent. Participants were randomly assigned to one of the two study conditions.

Procedure

Participants were introduced to the Virtual Reality (VR) concepts and taught how to navigate in the game using the head-mounted display and a gamepad.

Food and Beverage Selection

Participants navigated around and selected the food they desired. The person in charge of conducting the study acted as the cashier of each food stall. When the participants had made their final food and beverage choice, they could ask the cashier and the researcher noted the food and beverage choice, cost, and total amount of calories in the food products.

Evaluation

After the participants left the environment, they answered two short questionnaires about the usability and realism of the VFC.

The first questionnaire filled out by participants uses questions from the virtual supermarket study (Waterlander et al., 2011), to determine the overall quality of the VFC as a research tool that simulates a real food court. Moreover, participants scoring low in the realism questions were excluded from further analysis, as their food and beverage choices were not likely to represent those they would have made in the real world.

The second questionnaire, System Usability Scale (SUS), is a 10 item questionnaire that measures the overall usability of the system (Brooke, 1996). It was chosen to get an overall measure of the usability of the VFC. From the questionnaire we can calculate a SUS score from 0 to 100, where a score over 68 generally means that the usability of the application is above average. As the VFC software is designed to run short experiments on many participants, it is important that the users are able understand the software the first time they use it.

RESULTS

Participant Characteristics

N = 27 participants registered for the experiment, with the vast majority being men (n = 21). Furthermore, all the participants were aged between 18 and 30, and only six participants stated that they had experienced VR before this experiment. One participant was excluded from the food and beverage choice analysis due to a low score in the realism questions, as the participant was not able to imagine doing a real food court purchase in the VFC, with a score of 2 (1 = lowest, 5 = highest).

Perceived Realism and Usability of the VFC

Realism Questionnaire Results

All the participants scored ≥ 4 on the comprehension of the VFC software (in the realism questionnaire). Furthermore, 96% stated that their purchases in the VFC resemble their regular food purchases (score ≥ 4) and 85% were able to imagine doing their real-life food purchases in the VFC (score ≥ 4). Moreover, 96% scored ≥ 4 when asked if they were able to find their way around the VFC and if they easily could find all the products in the VFC. However, only 63% stated that the VFC contained sufficient product variety and that it had a fair representation of the stock of a real food court (score ≥ 4). This was an expected outcome as our pilot study only consisted of 3 food stalls, with limited food choices. Even so, only 7% thought that the stock of the VFC did not contain sufficient product variety (score ≤ 2).

Usability Questionnaire Results

The second part of the post-experiment questionnaire used the SUS to figure out how easy the VFC is to use.

The results showed that a vast majority (93%) found the VFC easy to use (score ≥ 4). Moreover, none of the participants found the system unnecessarily complex and no one thought that they would need a technical person to use the VFC (score ≤ 2). On the question relating to the

confidence in using the system, 85% of the participants scored ≥ 4, whilst nobody thought they needed to learn a lot of things before they could start using the system (score ≥ 4). However, 15% stated that they found the VFC cumbersome to use (score ≥ 4).

The overall SUS score was 84.81, which is considered to be an *excellent* score on the adjective rating scale in Bangor et al. (2009).

Analysis

H1: The Virtual Food Court is a realistic representation of a real food court.

The results gathered from the post-experiment questionnaires show that an overwhelming majority thinks that the VFC is a fair representation of a real food court. The most important result gathered from the questionnaire was that only 1 out of 27 participants was unable to imagine doing their real-life food purchases in the VFC. This indicates that the regular purchasing-patterns of the participants were preserved when buying food and beverages in the VFC.

Discussion

The data gathered from the randomized controlled trial showed promising results in the usability and realism of the VFC. Virtual Reality was a new and unexplored technology to most of our participants with only 22% stating that they had ever tried it before. Despite this, everyone was able to understand how to navigate and make food choices inside the VFC. Although the results are positive, the small sample size (n=27), and narrow age sample (18-30) is comprehensive enough. In our sample joysticks on the gamepad were found somewhat challenging to use.

During the experiment only one participant experienced slight nausea. The VFC used 75 fps (above the minimum recommended of 60 fps). Participants were only in the VFC for a couple of minutes, longer sessions may induce motion sickness.

CONCLUSION

We have presented Virtual Food Court, a virtual replica of a real one that can be experienced using an Oculus Rift Virtual Reality head-mounted display and a gamepad. The main purpose of the study was to assess if such virtual reality environments could be used as a tool for studying the impact of factors like tax and displays on food choices.

Results from the pilot study with n = 27 participants indicated that even though the vast majority (78%) had never tried Virtual Reality before, they all found the VFC intuitive and easy to understand. Moreover, after we introduced taxation on sugar sweetened beverages and food high in saturated fats, we could see a clear downtrend in purchases of these products, indicating that taxation on food and beverages can have a positive effect on people's food choices. However, no statistically significant results can be found with the limited number of participants.

Although the VFC has proven to be a good alternative to real world experiments on food purchasing behaviours, it can never fully replace experiments conducted on real food vendors. However, it can be used to conduct inexpensive experiments to try out different interventions before we implement them on real food vendors.

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