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Bachelor's Thesis in Artificial Intelligence

The influence of Virtual Reality on taste perception

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Abstract

Eating disorders or specific food phobias are not uncommon nowadays. Measurements regarding these problems are generally difficult, due to the fact that mental disorders are intangible by nature. Virtual Reality (VR) can be a tool for measuring these disorders, through the simulation of eating environments. In this study we use VR to investigate whether or not incongruent vision could potentially be the key for solving for the aforementioned problems. Specifically, we investigate whether test subjects can be deceived into thinking they are eating something else by creating a situation where there exists incongruence between the food eaten and perceived. This was investigated by 20 participants eating pieces of fruit in the VR environment, while seeing either the same or an entirely different type of fruit. After eating each piece of fruit, they were asked what fruit they tasted and what their ratings are for the sweetness, sourness, citrusness and bitterness of the fruit.

The results provide an indication that it is possible to deceive the taste perception of people, but no statistical proof for this is found.

In order to acquire more confident results in future experiments, it is of importance that the VR environment is sufficiently realistic, and that secondary factors such as ripeness and smell should be eliminated.

Contents

List of Figures

List of Tables

Abbreviations

VR	Virtual Reality
AR	Augmented Reality
MR	Mixed Reality

Chapter 1

Introduction

Eating plays an important role in our daily lives. Not only because of nutrition-related purposes, but also for pleasure. This pleasure is mostly dependent on the degree to which we like the food. Besides this, ‘wanting’ a certain food plays an important part as well. This psychological process of ‘wanting’ is associated with predictive cues of rewards, and the rewards itself [3].
Highly palatable foods, such as foods containing sugar, are associated with reward-related food intake. For this reward, certain peripheral hormones such as ghrelin, insulin and leptin play important roles [11]. The perception of taste, however, does not only depend on rewards and liking, but also on a range of different other factors.

1.1 Factors influencing taste

Several aspects play a role in how ‘taste’ is experienced, such as genetic, metabolic and physiological variables. Besides this, sex and age play a role as well [5].

Smell, temperature and texture are key modalities in taste perception. Taste as a whole tries to identify nutrients (sweetness associated with sugars, saltiness with NaCl and bitterness with poisons). However, smell appears to identify foods more in their totality (e.g. peanut butter, yoghurt, bacon). Because of this identification, there are many more olfactory qualities than taste qualities and their influence is hard to measure [2].

Thermal sensations not only have the function to protect the mouth from thermal damage, but have an effect on the eating experience as well. Coffee for example can have a higher concentration of volatile substances for a higher temperature, which adjusts the taste perception [4].

Preferences or aversions with respect to texture are mostly non-uniform, which means they are probably acquired through learning. Nonetheless, touching the food plays an important role in the localization of the food [2].

Out of all the modalities above, maybe the most important modality influencing taste is vision. A wine tasting experiment, for example, showed that visual information can discount information from the olfactory system. In the experiment, tasters incorrectly labelled artificially colored white wine as red wine. However, the dye used by the researchers had no odor itself [10]. This shows how important vision can be in taste perception.

In another experiment, a digital display was used to adjust the color of orange juice. Researchers found that different colors of the same juice elicited different responses of sweetness, sourness, freshness and bitterness [14].

Moreover, the location where the food is served contributes significantly to our overall acceptability of the food. In Edwards et al., upscale restaurants received higher scores than institutional settings for the same Chicken à la King and Rice dish. [6].

1.2 Techniques influencing taste

Not only sensory factors can affect taste perception, also certain techniques are used to alter the vision of a subject. Examples of this are: Augmented Reality (AR), Virtual Reality (VR) and Mixed Reality (MR).

Augmented Reality (AR) is a technique where virtual objects appear in the real world as an overlay, which makes it look like these objects and the real world are in the same space [1]. For Virtual Reality (VR), the real world is not visible anymore. The viewer completely sees the overlay: a three-dimensional landscape generated by the computer. As in AR, this environment is modifiable through physical gestures or verbal communication [13].
Between AR and VR lies Mixed Reality (MR). MR merges the real and virtual world and can be seen as an enhanced form of AR. In MR, the viewer can interact with both the physical and virtual objects in the environment, and manipulate them [8].

Research on the topic of food and these techniques has for example been done by Gorini et al. The emotional reactions to real food, VR food and food in photographs were tested for bulimia, anorexia and healthy subjects. Results showed that VR is more effective than photographs in eliciting emotional responses that are similar to real life situations [7]. Moreover, in a research from Perpiñá et al, it was found that patients treated in a VR condition instead of the Standard Body Image Treatment (SBIT) condition, showed greater significant improvement in certain Body Image measures [12].

These results support the observation that experimenting with sensory factors and VR provides us with a wide range of custom possibilities, which can help patients cope with disorders such as anorexia or bulimia. Besides this, it can be a way to motivate children to eat more vegetables, or let people overcome their bad eating habits.

Besides research on the appearance and location of food in combination with VR techniques, little research effort has been devoted to the combination of seeing a completely opposite food item in VR. Therefore, in this thesis, congruent and incongruent vision will be analyzed in combination with VR. Different taste perceptions (sweetness, sourness, citrusness and bitterness) will be measured to investigate the influence of incongruent vision.

The main research question will be the following: Is it possible to deceive the gustatory perception by presenting incongruent food vision?
This question will be supported by the following sub-questions: (a) how does the perception of realism of the VR environment influence the taste perception; (b) how does previous experience in VR influence the taste perception.

The main hypothesis is that incongruent visual trials cause incorrect classification of the fruit.
The two sub-hypothesis are: (a) experiencing the VR environment as more realistic results in being more susceptible to the deception of the experiment. This is because a more realistic environment is more convincing, which results in more deception.
(b) more experience in VR results in being more susceptible to the deception of the experiment. This is because these people are less distracted by the technology around them and thus more focused on the experiment itself.
For these hypotheses, being more susceptible to the deception of the experiment means having more differences between the average rating of the congruent and incongruent trials.

For the experiment, mango and peach will be chosen as food items (see section 2.3).
In total, a group of 20 healthy subjects containing both male and female participants, will be exposed to 4 trials in the VR: 2 congruent and 2 incongruent ones.
In the congruent trials, the subject will see the same piece of fruit as the piece of fruit he/she is eating. For the incongruent trials there's a mismatch between what they see and what they eat. This means that the ingested fruits will be switched in those trials.

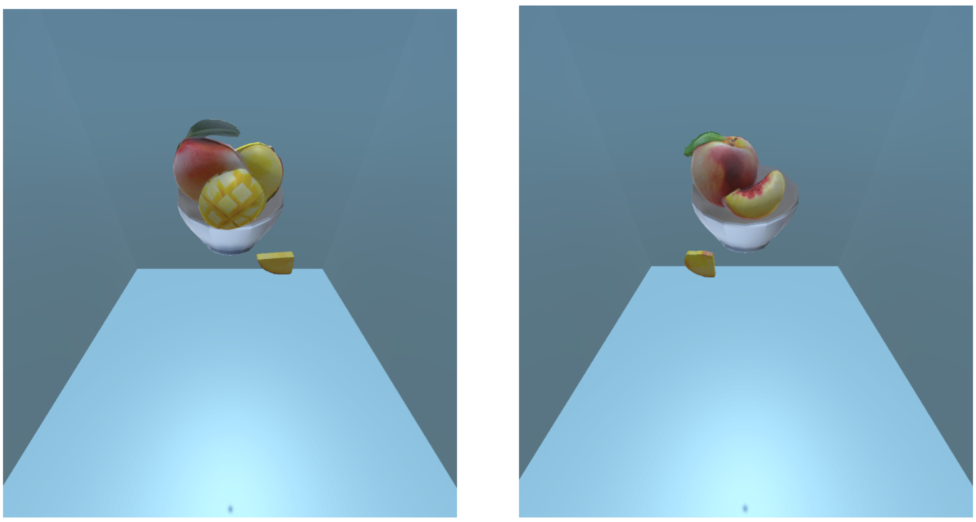
Chapter 2

Methods

The methods used in this experiment are: a VR environment created with the software Unity and a Leap Motion for hand-tracking (see section 2.2 for an explanation of this device). For measuring the influence on taste perception, pre- and post-VR questionnaires and a VR taste rating was used.
For showing the VR environment, the Trust GXT720 VR Glasses was used.
16 female and 4 male subjects attended the experiment, with ages ranging from 19-24.

2.1 Goal of the experiment

The goal of the experiment is to investigate whether people can be deceived into thinking they are eating the fruit they see, instead of the fruit they are actually eating.
Which fruit the subject is tasting will be represented by either a bowl of mangos or a bowl of peaches in the back of the scene. The hands of the subject in the real world are then detected and displayed in the VR environment. With these VR hands, the subject can grab a piece of fruit from the corresponding bowl in the back of the scene. The hand detection is explained in the following section.



(a) Mango bowl (b) Peach bowl

Figure 2.1: Fruit bowls in the scene

2.2 VR hand detection

The choice for the hand detection method was of major importance for the experiment. Without this aspect, the realism of the environment would be degraded immensely. Therefore, several options were considered:

1. **Augmented Reality (AR)/Mixed Reality (MR)**
   With Vuforia, an AR/MR environment could be created so that the subject could see his own hands in the environment through a camera. However, the main use of AR/MR is that they have create overlay over the real world environment. For this experiment, accidentally losing track of the overlay on the fruit item would vanish the main aspect of the experiment: not seeing the fruit. Therefore, this was not a risk that could be taken.
   Lastly, the combination of Vuforia and our existing VR environment was not compatible, and the use of Unity Remote 5 (see section 2.8) made it impossible to use the phone camera as an AR/MR source. Therefore, we eliminated this option.

2. **OpenPose**
   OpenPose is a relatively new method to track complete hand- or body movements. Because of this, documentation was sparse. Moreover, the lack of compatibility with the graphics and file sizes caused the program to run too slow to be useful for the experiment. Therefore, this option was eliminated as well.

3. **Leap Motion**
   Leap motion uses two infrared camera's to track the hands. The device could easily be attached to the VR headset, and after installing the required packages, the hands could be detected in the scene directly without any controllers (see figure 2.2). Therefore, we selected this approach for the final experiment.

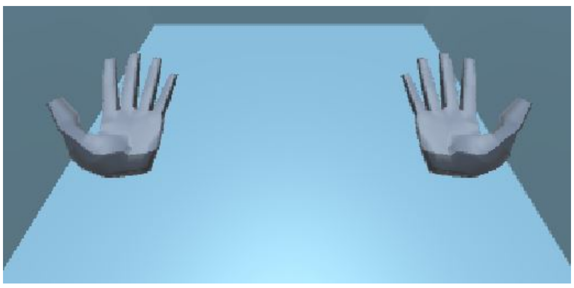


Figure 2.2: Leap Motion hands in the scene

2.3 Choice of food

Several tests were executed before the final combination of fruit was determined. The tested fruits were: apple, pear, peach, mango and melon (Galia). Peach and mango were chosen as a final combination, because of their similarities in taste and structure. To maximize this structure similarity, the pieces were served without their peels and cut into equal cube sizes.

The specific fruits bought were: 'AH Doosjevol perzik partjes' and 'AH Doosjevol mango stukjes'.

2.4 Control condition

As a control condition, blind tasting, tasting without VR and using the congruent trials were considered.

Blind tasting was not chosen as a control condition, because not seeing anything while tasting food can cause wrong identification on its own. The popular Australian cooking competition 'MasterChef' showed for example that contestants couldn't identify cubes of fruit while not seeing anything [9].

Additionally, tasting the fruit without VR was not chosen as a control condition either. This was because seeing the specific fruit will bias the subject's ability to evaluate the taste of the fruit too much, especially for the question which fruit they are tasting.

The congruent trials were chosen to be the control condition, this way the VR 'feeling' would be the same as for the incongruent trials. Moreover, the subjects would see and eat the same.

2.5 Order of the trials

The order of the trials was chosen in such a way that every subject would first be exposed to the congruent conditions and afterwards to the incongruent conditions. The reason for this was that the subjects would not expect to be deceived when first experiencing congruent conditions.

The 2 trials within the congruent and incongruent conditions were randomized to let the order within the conditions not influence the outcome. This resulted in the 4 possible condition distributions shown in table 2.1.

P = peach
M = mango
Green indicates the congruent trials while red indicates the incongruent trials.

Combination	**See**	**Taste**
1	M	M
	P	P
	P	M
	M	P
2	P	P
	M	M
	P	M
	M	P
3	M	M
	P	P
	M	P
	P	M
4	P	P
	M	M
	M	P
	P	M

Table 2.1: Possible condition distributions

2.6 Practice scene

Before the experiment scene, a practice scene was displayed for practicing the hand movements (see figure 2.3). The virtual Leap hands appeared as soon as the subject's hand were detected by the Leap Motion.

The practice scene consisted of a purple cube and a star. With the Leap hands the subject had to drag the cube to the position of the star 5 times. After each hit, the star appeared on a different position. If the subject succeeded to score 5/5, the experiment scene was loaded automatically.

The goal of the practice scene was to prevent a possible incomprehension from affecting the experiment results, and make the experiment execution easier and quicker for the subject.

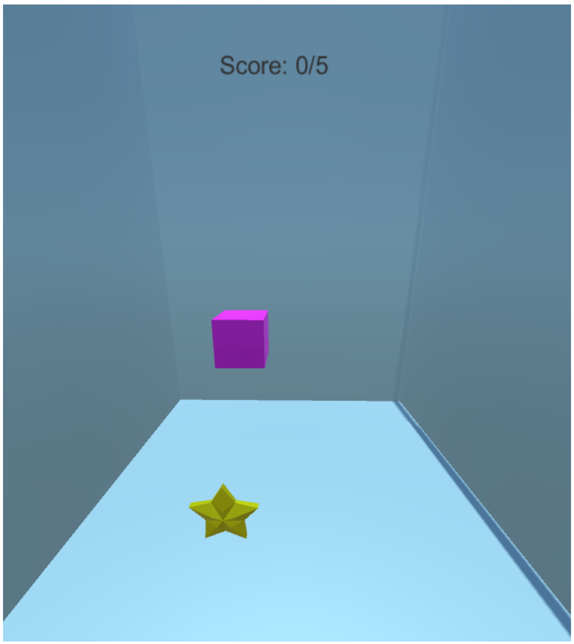


Figure 2.3: Practice scene

2.7 Calibration

In the experiment, correct calibration was the main aspect that made the activity of eating the pieces of fruit in the VR environment realistic. With calibration, the position of the piece of fruit in the VR environment was aligned with the position of the piece of fruit in real life. The calibration steps only had to be executed once for every subject. It worked as follows:

1. While wearing the VR headset (with the leap motion attached), the subject had to place his/her hand on the table.

2. As soon as the leap motion detected the hand on the table, the calibration in Unity was started.

3. Depending on which hand (left/right) was used, a script in Unity obtained the 3D position of that hand in the VR environment.

4. By ending the calibration, the position of the piece of fruit in the VR environment was automatically adjusted to a position close to the hand.

5. The subject was told to remove his hand from the table while still wearing the VR headset.

6. The fruit piece in real life was placed around the position were the hand was placed before. The position of the fruit item in the VR environment and in real life were aligned now.

7. The experiment could start and the subject was told to pick up the food in the VR environment.

2.8 VR environment

An important aspect of the VR environment was that the environment itself should not be too distracting. The main focus should be on the different types of fruit shown. Therefore, a neutral blue color was chosen for the environment.

The VR application was executed via Unity Remote 5, an application which directly streams the Unity scene from a laptop to a mobile device.
Instead of using Unity Remote 5, the VR application could have been build directly to the mobile device as well. However, there were several reasons not to do this. Firstly, the Leap motion could not directly be connected to a mobile device, only to a laptop. Secondly, if the application would only run on the mobile device, following what the participant was doing or helping in case of mistakes/errors was not a possibility. Solving these issues would then require a complete restart of the application.

2.8.1 Assets

The fruit assets could have been bought in the Unity asset store, but these were not suitable for our experiment (not in cube form, not the right fruit or too expensive). Because of this, all fruit assets were created manually with the online tool Smoothie-3D, a tool that helps creating 3D objects out of 2D images.

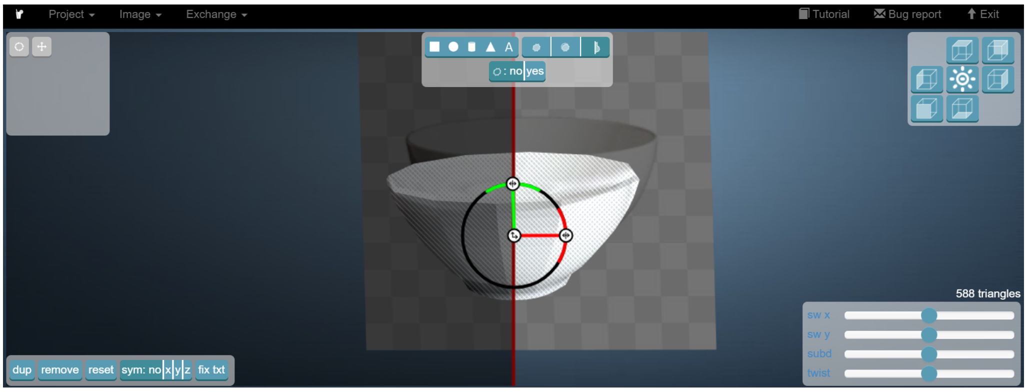
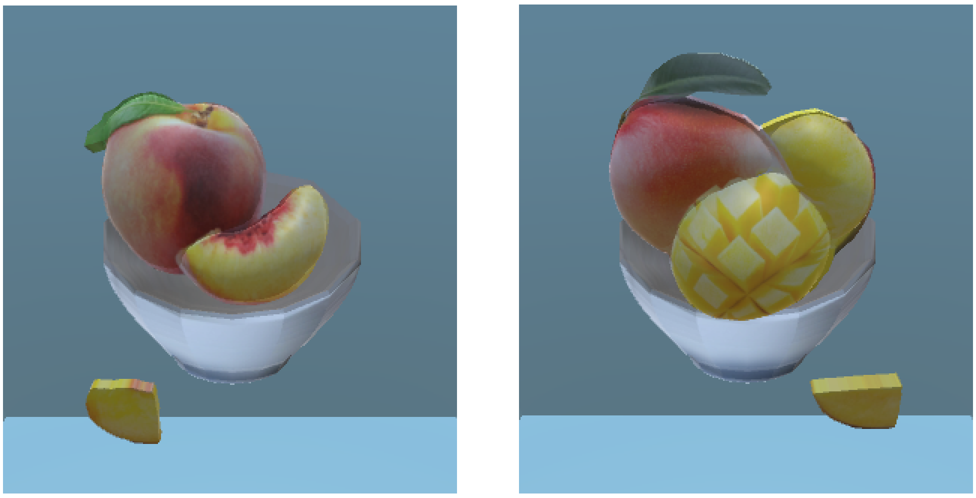


Figure 2.4: Modelling the fruit bowl in Smoothie-3D

As stated in section 2.3, the fruits will be served without their peel. This made it harder to create 3D fruit assets that were easily distinguishable. Therefore, 3D bowls of fruit were created to be put in the back of the experiment scene (see figure 2.5).



(a) Peach piece and bowl (b) Mango piece and bowl

Figure 2.5: 3D fruit assets

2.9 Measurements

2.9.1 Pre- and post-VR questionnaire

Before participating in the experiment, the subjects were first given a short explanation of the experiment (see Appendix, section A) and a pre-VR questionnaire (see Appendix, section B).
After the experiment, the subjects were given a post-VR questionnaire (see Appendix, section B).

For the results, the questionnaire questions are grouped into 3 sub-topics:

Preference of the fruits (pre-VR)

- How much do you like the taste of peach?
- How much do you like the taste of mango?

Level of realism (post-VR)

- How realistic did the VR environment feel to you?
- How realistic did the pieces of fruit in the VR environment feel to you?
- How realistic did the activity of eating the fruit feel to you?

External factors (pre- and post-VR)

- Is this the first time you will have a VR experience? If no, how often did you have a VR experience before?
- How comfortable did you feel during the experiment?

- Did you experience any nausea during the experiment? If so, did this influence your participation in the experiment?
- Age and gender

In the questionnaires, the question 'How realistic did the activity of eating the fruit feel to you?' Was misinterpreted and therefore not included in the analysis. The subjects interpreted this question as: 'Did I really eat pieces of fruit?' instead of 'Did the VR eating activity feel realistic to me?'

2.9.2 Rating

After tasting each piece of fruit, the subject was asked which of the two fruits he/she had tasted. After this, a rating had to be filled in. This rating consisted of the level of sweetness, sourness, citrusness and bitterness. These factors together visualize the taste perception of the subject.

In the first experiment pilots, subjects could adjust the ratings themselves with the virtual Leap hands. However, this approach took too much time and was error-sensitive. Therefore, a different strategy was chosen:
Sliders of the different attributes were shown on the screen. The subject then verbally made his/her choices per attribute clear, and the sliders were adjusted for them. This way, they could directly see what they had chosen. The yellow background color was chosen because it appeared to be more eye-friendly than white.

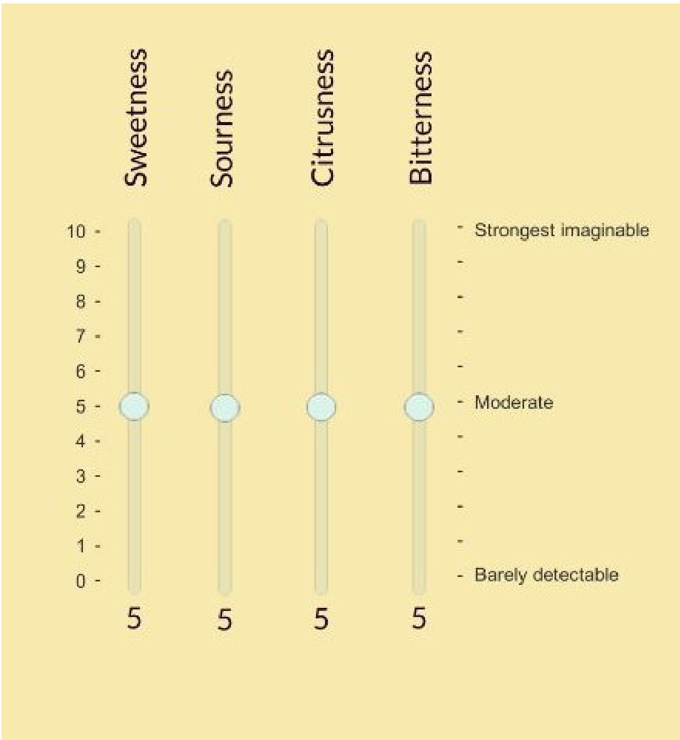


Figure 2.6: Rating

After each rating, the results were automatically stored in an XML file, to simplify processing the data.

2.9.3 Obtaining the results

Several paired t-tests were performed on the data obtained from the ratings in the VR environment and the questionnaires. The purpose of these tests was to visualize the differences on average between the congruent and incongruent trials, in relation to the rated taste perception and the answers from the questionnaires.

The T-tests were executed by the statistical program R.

To prevent false-positive results, the p-values of all tests were corrected according to the Bonferroni correction. This means that the p-values were divided by the number of statistical tests executed (4), resulting in a significance threshold of $p < .0125$ instead of $p < .05$. Because of this, the probability of finding results that are significant by chance is minimized.

Perception of realism
In order to investigate the influence of the perception of realism of the VR environment on the taste perception, the average rating of realism was calculated for each subject. This average was calculated from the scores of the two remaining realism-related questions in the questionnaire.
From these average ratings, the group of subjects was split into two groups: people rating the average realism < 3 and >= 3. In total, 13 subjects rated the average realism < 3 and 7 rated it >= 3.

Influence of previous experience
In order to investigate the influence of previous experience on the taste perception, previous experience in VR was measured for each subject from the questions of the questionnaires. This experience was measured with the questions: 'Is this the first time you will have a VR experience? If no, how often did you have a VR experience before?'. Out of these scores, the group of subjects was split into two groups: people having experience < 3 times and >= 3 times. In total, 15 people had previous experience < 3 times before and 5 had previous experience >= 3 times before.

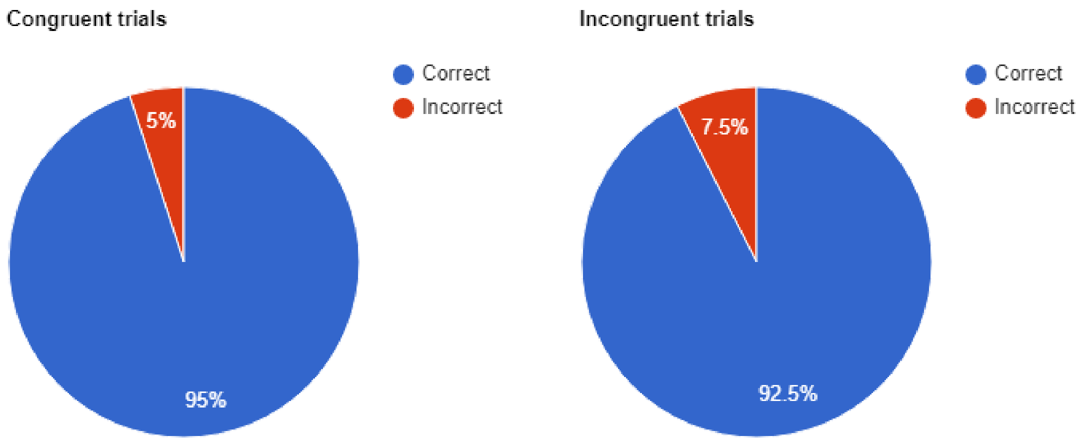
For both the experience and realism ratings, the two groups were not of equal size. However, for realism, the current division was also the optimal one. Besides this, the value boundaries were chosen because they are the middle values of the possible answers on the questionnaire.

Chapter 3

Results

This section will describe the results that were obtained from the VR ratings and the pre- and post-VR questionnaires. For the tabular representations, the 'Mean' implies the differences between the two means.

3.1 Deception



(a) Congruent trials

(b) Incongruent trials

Figure 3.1: Division of the correct/incorrect fruit type guesses

3.1.1 Congruent trials

For the 40 congruent trials (2 per subject), incorrect guesses occurred in 5% of the cases. This was obtained from 2/20 individual subjects. In total, mango was incorrectly classified as peach once and peach was incorrectly classified as mango once. This only occurred for the first piece of fruit in these trials.

3.1.2 Incongruent trials

For the 40 incongruent trials (2 per subject), incorrect guesses occurred in 10% of the cases. This was obtained from 2/20 individual subjects. In total, mango was incorrectly classified as peach 2 times and peach was incorrectly classified as mango once.

3.2 Fruit

To know whether the subjects noted a difference in taste between mango and peach, a t-test was executed for the congruent trials of these fruits.

	Mango and peach			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.78	2.68	19	.015
Sourness	-2.30	-4.72	19	.0001
Citrusness	-0.50	-0.94	19	.36
Bitterness	-0.28	-0.73	19	.48

Table 3.1: T-test mango vs. peach: congruent

As can be seen from table 3.1, all taste values were rated with some differences. The biggest difference in taste lies within the sourness of the fruits (M = -2.30), this result was significant ($p < .0125$). The other results were not significant ($p > .0125$).

3.3 Taste perception

	Mango			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.15	0.78	19	.45
Sourness	-0.48	-1.64	19	.12
Citrusness	0.60	2.06	19	.054
Bitterness	-0.45	-1.23	19	.23

Table 3.2: T-test mango: congruent vs. incongruent

	Peach			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.18	0.84	19	.41
Sourness	0.40	1.47	19	.16
Citrusness	0.10	0.34	19	.74
Bitterness	-0.23	-0.86	19	.40

Table 3.3: T-test peach: congruent vs. incongruent

As can be seen from tables 3.2 and 3.3, all taste values were rated with some differences. The biggest difference in taste lies within the sourness of both mango and peach (M = -0.48 respectively M = 0.40). These results were not significant ($p < .0125$).

For the following plots, the taste values are noted as follows:
Sw = Sweetness
So = Sourness
Ci = Citrusness
Bi = Bitterness

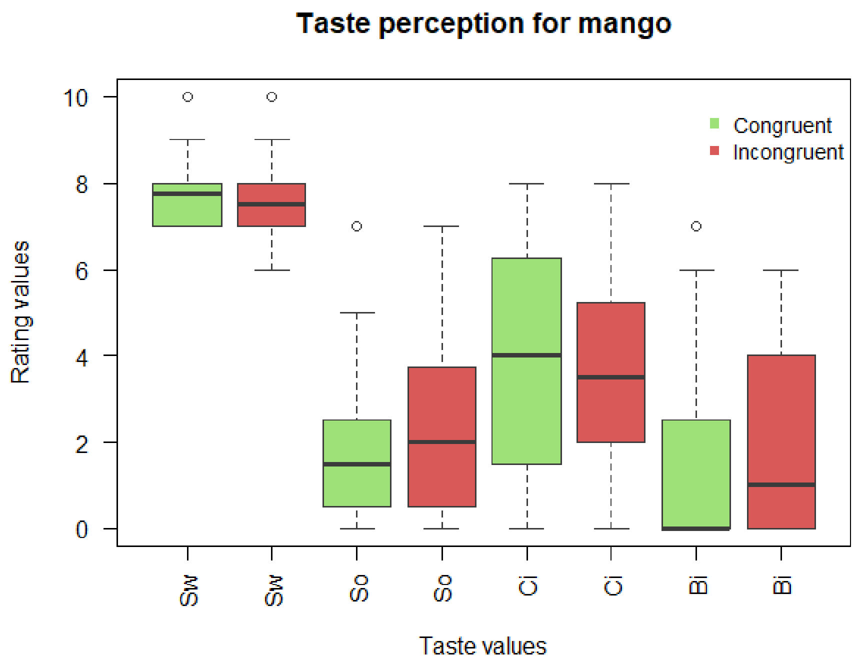


Figure 3.2: Taste perception for mango

As can be seen from figure 3.2, for all tastes there were differences between the congruent and incongruent trials.
For sweetness, the ratings for the congruent and incongruent trials were quite similar. The inter-quartile range is relatively small for both the congruent and incongruent trials compared to the other tastes (less varied ratings). However, the median of the congruent trials is higher compared to the incongruent trials. This means that on average, the sweetness of mango was rated slightly higher in the congruent trials compared to the incongruent trials. Two outliers were detected.

For sourness, the inter-quartile range of the incongruent trials varied more (was wider) compared to the congruent trials. Besides this, the median of the incongruent trials is higher compared to the congruent trials. This means that on average, the sourness of mango was rated higher in the incongruent trials compared to the congruent trials. One outlier was detected.

For citrusness, the inter-quartile range of the congruent trials varied more compared to the incongruent trials. Besides this, the median of the congruent trials is higher compared to the incongruent trials. This means that on average, the sourness of mango was rated higher in the incongruent trials compared to the congruent trials. No outliers were detected.

For bitterness, the inter-quartile range of the incongruent trials varied more compared to the congruent trials. Besides this, the median of the incongruent trials is higher compared to the congruent trials. This means that on average, the bitterness of mango was rated higher in the incongruent trials compared to the congruent trials. One outlier was detected.

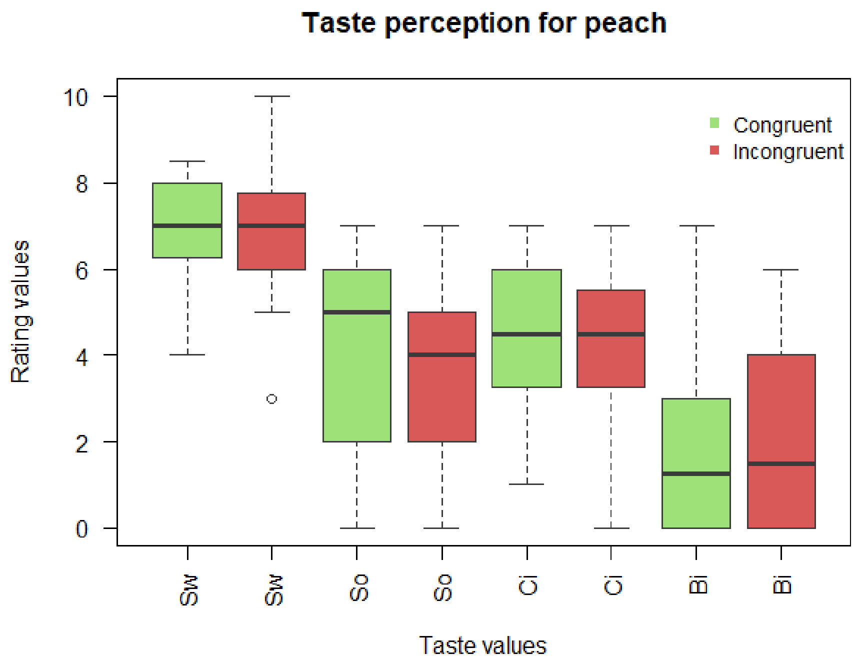


Figure 3.3: Taste perception for peach

As can be seen from figure 3.3, even though some medians are the same, for all tastes there were some differences between the congruent and incongruent trials.
For sweetness, the medians of the congruent and incongruent trials are the same. This means that on average, the sweetness of peach was rated the same. The inter-quartile range is relatively small for both the congruent and incongruent trials, meaning the ratings didn't vary a lot within the congruent and incongruent trials. One outlier was detected.

For sourness, the inter-quartile range of the congruent trials varied more (was wider) compared to the incongruent trials. Besides this, the median of the congruent trials is higher compared to the incongruent trials. This means that on average, the sourness of peach was rated higher in the congruent trials compared to the incongruent trials. No outliers were detected.

For citrusness, the inter-quartile range of the congruent trials varied a bit more (was a bit wider) compared to the incongruent trials. However, the medians of the congruent and incongruent trials are the same. This means that on average, the sourness of peach was rated the same in the incongruent trials compared to the congruent trials. No outliers were detected.

For bitterness, the inter-quartile range of the incongruent trials varied more (was wider) compared to the congruent trials. Besides this, the median of the incongruent trials is a bit higher compared to the congruent trials. This means that on average, the bitterness of peach was rated slightly higher in the incongruent trials compared to the congruent trials. No outliers were detected.

3.4 Taste perception and level of realism

The realism of the VR environment was rated with a 2.35 on average, with a minimum of 1, a maximum of 4 and a standard deviation of 0.81.
The realism of the pieces of fruit was rated with a 2.6 on average, with a minimum of 1, a maximum of 5 and a standard deviation of 0.99.
As mentioned in section 2.9.3, to investigate the influence of the experienced realism on taste perception, the group of subjects was split into two groups: people rating the average realism < 3 (13 people) and >= 3 (7 people).

3.4.1 Realism < 3

	Mango			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.15	0.72	12	.49
Sourness	-0.69	-1.74	12	.11
Citrusness	0.19	0.54	12	.60
Bitterness	-0.31	-0.65	12	.53

Table 3.4: T-test mango: congruent vs. incongruent, given realism < 3

	Peach			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.12	0.39	12	.70
Sourness	0.19	0.59	12	.57
Citrusness	-0.15	-0.37	12	.72
Bitterness	0.00	0.00	12	1

Table 3.5: T-test peach: congruent vs. incongruent, given realism < 3

As can be seen from the tables 3.4 and 3.5, not all taste values were rated with differences. For bitterness in the peach condition, there was no difference noted between the congruent and incongruent trials. The biggest difference in taste lies within the sourness of both mango and peach (M = -0.69 respectively M = 0.19). These results were not significant ($p > .0125$).

3.4.2 Realism >= 3

	Mango			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.14	0.35	6	.74
Sourness	-0.07	-0.21	6	.85
Citrusness	1.36	3.49	6	.013
Bitterness	-0.71	-1.18	6	.28

Table 3.6: T-test mango: congruent vs. incongruent, given realism >= 3

	Peach			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.29	1.08	6	.32
Sourness	0.79	1.62	6	.16
Citrusness	0.57	1.92	6	.10
Bitterness	-0.64	-1.44	6	.20

Table 3.7: T-test peach: congruent vs. incongruent, given realism >= 3

As can be seen from the tables 3.6 and 3.7, all taste values were rated with differences. The biggest difference in taste lies within the citrusness of mango and the sourness of peach (M = 1.36 respectively M = 0.79). These results were not significant ($p > .0125$).

3.4.3 Rated realism: comparison

For convenience, the group that rated the realism < 3 is referred to as the 'left group' and the group that rated the realism >= 3 is referred to as the 'right group'.

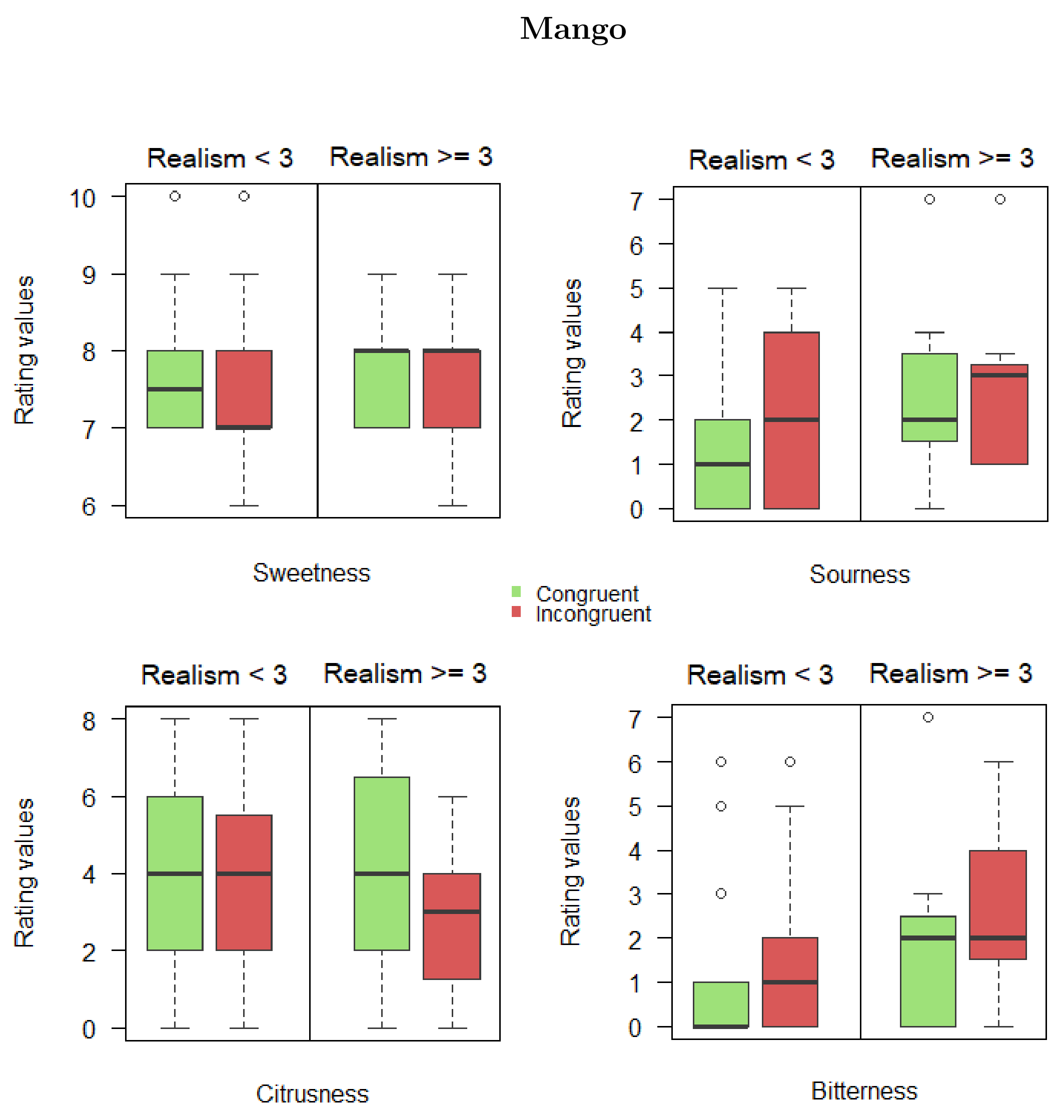


Figure 3.4: Mango: taste ratings in relation to different ratings of realism

As can be seen from figure 3.4, for sweetness, there was a bigger difference between the medians of the congruent and incongruent trials for the left group compared to the right group. Moreover, the left group contained more outliers compared to the right group. Except for the small differences, the distribution of the box plots was similar.

For sourness, the absolute difference between the medians of the congruent and incongruent trials was the same for the left group and the right group (both difference of 1.0). However, the medians were more centered to the lower rating values for the left group compared to the right group. Besides this, the right group contained more outliers compared to the left group.

For citrusness, the difference between the medians of the congruent and incongruent trials was bigger for the right group compared to the left group.

For bitterness, the difference between the medians of the congruent and incongruent trials was bigger for the left group compared to the right group. Besides this, the left group contained more outliers compared to the right group.

Peach

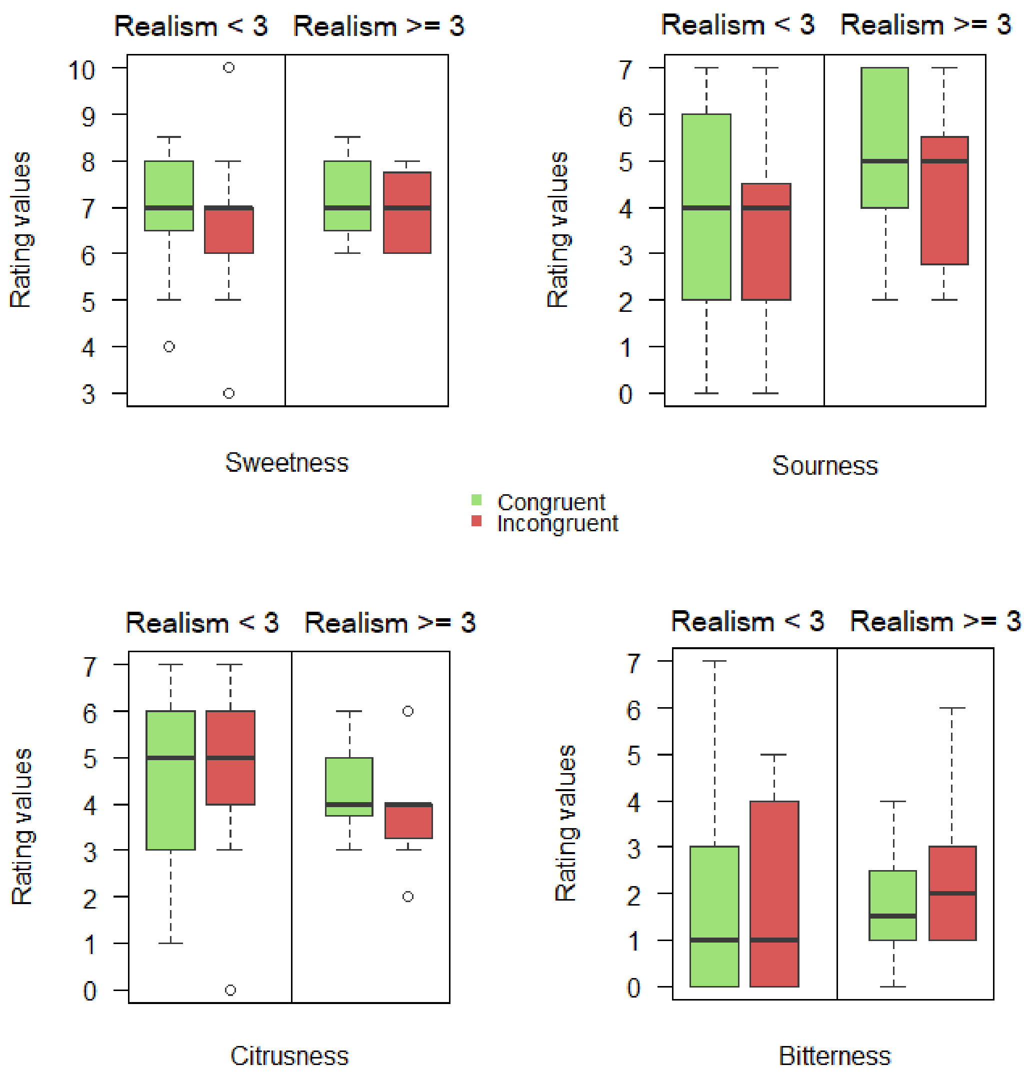


Figure 3.5: Peach: taste ratings in relation to different ratings of realism

As can be seen from figure 3.5, for sweetness, the difference between the medians of the congruent and incongruent trials was the same for both groups. However, the rating distributions were not exactly the same and the left group contained more outliers compared to the right group.

For sourness, the absolute difference between the medians of the congruent and incongruent trials was the same for both groups (both no difference). However, the medians were more centered to the lower rating values for the left group compared to the right group.

For citrusness, the difference between the medians of the congruent and incongruent trials was bigger for the right group compared to the left group. Besides this, the average rating distribution varied more (wider range), for the left group compared to the right group.

For bitterness, the difference between the medians of the congruent and incongruent trials was bigger for the right group compared to the left group. Besides this, the average rating distribution varied more (wider range) for the left group compared to the right group.

3.4.4 Mango and peach: comparison

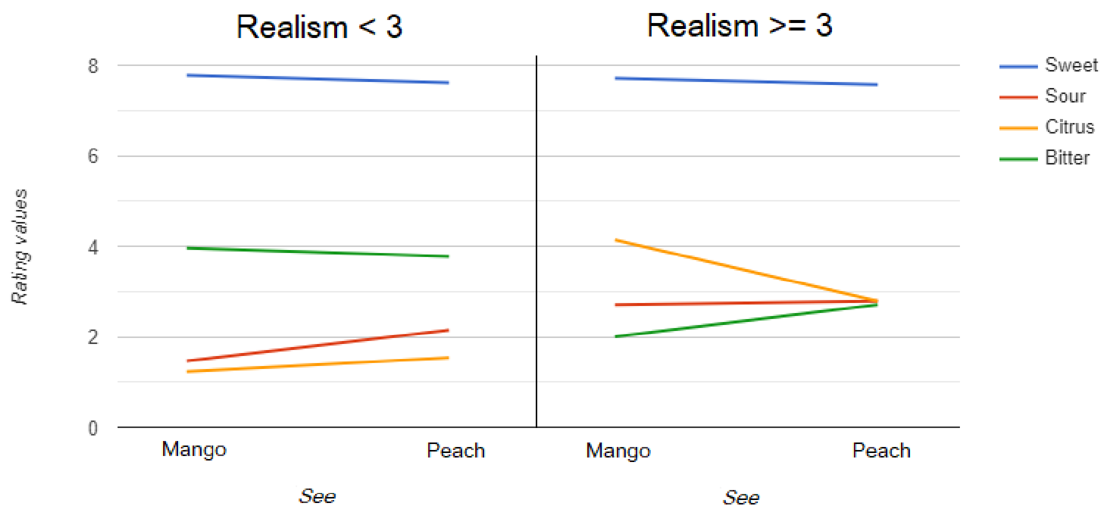


Figure 3.6: Mango

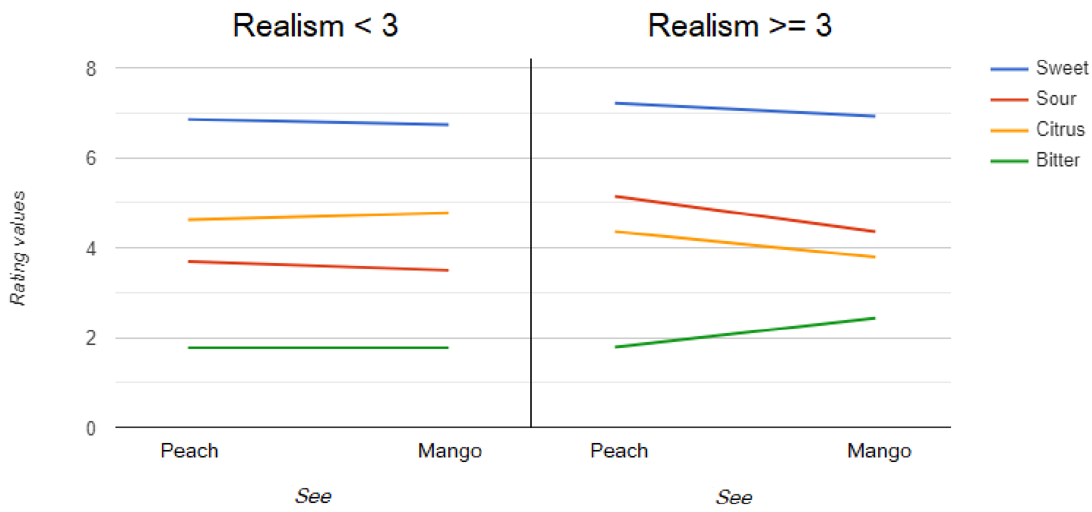


Figure 3.7: Peach

Figures 3.6 and 3.7 describe the differences in taste rating values (from the VR) for the congruent and incongruent trials. The left point of the colored lines are the average taste ratings for the congruent trials, the right lines for the incongruent trials (e.g. see mango - taste peach). The left group (rated realism < 3) is displayed against the right group (rated realism $>= 3$).

As can be seen from the figures, for sweetness, there was not a lot of difference between the rating values of both groups for mango and peach.

For sourness, the average ratings as a whole were higher for the right group compared to the left group for peach and mango.

For citrusness, for mango, the average ratings as a whole were higher for the right group compared to the left group. For peach, this was vice versa. Besides this, there was more difference in rating between the congruent and incongruent condition (the line is more steep) for the right group compared to the left group. This was for both mango and peach.

For bitterness, for mango, the average ratings as a whole were lower for the right group compared to the left group. For peach, this was vice versa. Besides this, there was more difference in rating between the congruent and incongruent condition (the line is more steep) for the right group compared to the left group. This was for both mango and peach.

Overall, the lines were steeper for the right group. This means that for the group that experienced the environment as more realistic, there was more difference in their ratings in the incongruent trials compared to the congruent trials.

3.5 Taste perception and experience

As mentioned in section 2.9.3, to investigate the influence of previous experience on the taste perception, the group of subjects was split into two groups: people having experience < 3 times (15 people) and >= 3 times (5 people).
The average number of times the subjects had a VR experience before was 1.65, with a minimum of 0, a maximum of 5 and a standard deviation of 1.63.

3.5.1 Experience < 3

	Mango			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.23	1	14	.33
Sourness	-0.23	-1.10	14	.29
Citrusness	0.57	1.51	14	.15
Bitterness	-0.27	-0.74	14	.47

Table 3.8: T-test mango: congruent vs. incongruent, given experience < 3

	Peach			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.13	0.54	14	.60
Sourness	0.60	2.10	14	.054
Citrusness	0.00	0.00	14	1
Bitterness	-0.30	-0.89	14	.39

Table 3.9: T-test peach: congruent vs. incongruent, given experience < 3

As can be seen from the tables 3.8 and 3.9, not all taste values were rated with differences. For citrusness in the peach condition, there was no difference noted between the congruent and incongruent trials. The biggest difference in taste lies within the citrusness of the mango condition and the sourness of the peach condition (M = 0.57 respectively M = 0.60). These results were not significant ($p > .0125$).

3.5.2 Experience >= 3

	Mango			
	Mean	**t-value**	**df**	**p-value**
Sweetness	-0.10	-0.30	4	.78
Sourness	-1.20	-1.24	4	.28
Citrusness	0.70	1.87	4	.13
Bitterness	-1.00	-0.95	4	.39

Table 3.10: T-test mango: congruent vs. incongruent, given experience >= 3

	Peach			
	Mean	**t-value**	**df**	**p-value**
Sweetness	0.30	0.69	4	.53
Sourness	-0.20	-0.30	4	.78
Citrusness	0.40	0.78	4	.48
Bitterness	0.00	0.00	4	1

Table 3.11: T-test peach: congruent vs. incongruent, given experience >= 3

As can be seen from the tables 3.10 and 3.11, not all taste values were rated with differences. For bitterness in the peach condition, there was no difference noted between the congruent and incongruent trials. The biggest difference in taste lies within the sourness of the mango condition and the citrusness of the peach condition ($M = -1.20$ respectively $M = 0.40$). These results were not significant ($p > .0125$).

3.5.3 Previous experience: comparison

For convenience, the group that had previous experience < 3 is referred to as the 'left group' and the group that had previous experience >= 3 is referred to as the 'right group'.

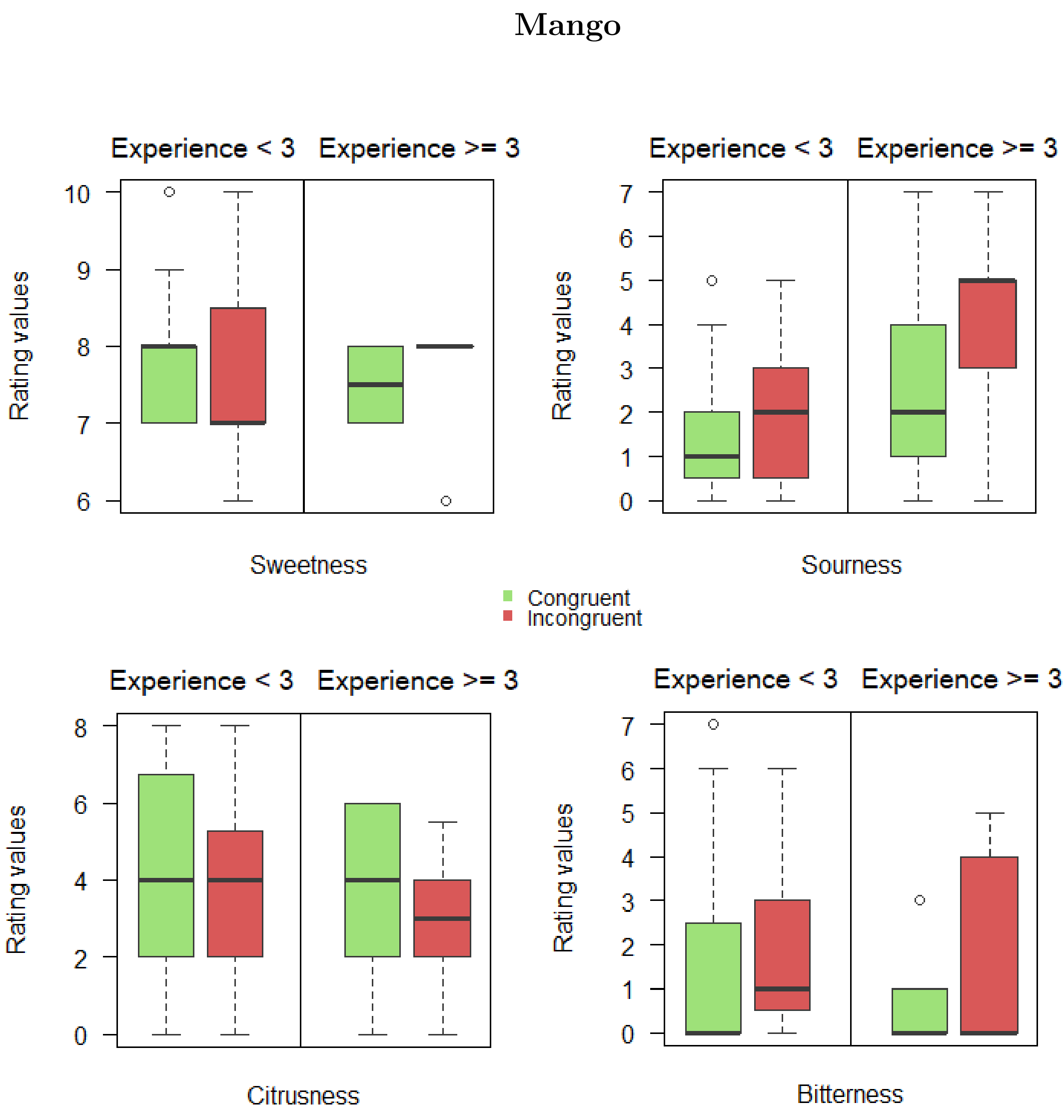


Figure 3.8: Mango: taste ratings in relation to different previous experience

As can be seen from figure 3.8, for sweetness, there was a bigger difference between the medians of the congruent and incongruent trials for the left group compared to the right group. Besides this, the inter-quartile range varied more (was wider) for the left group compared to the right group.

For sourness, there was a bigger difference between the medians of the congruent and incongruent trials for the right group compared to the left group. Besides this, the average rating distribution varied more (was wider) for the right group compared to the left group.

For citrusness, there was a bigger difference between the medians of the congruent and incongruent trials for the right group compared to the left group. Moreover, for the left group, the inter-quartile range for the incongruent trials varied more (was wider) compared to the left group.

For bitterness, there was a bigger difference between the medians of the congruent and incongruent trials for the left group compared to the right group. Moreover, for the right group, the inter-quartile range for the incongruent trials varied more (was wider) compared to the left group. For the congruent trials of the right group, this difference was vice versa.

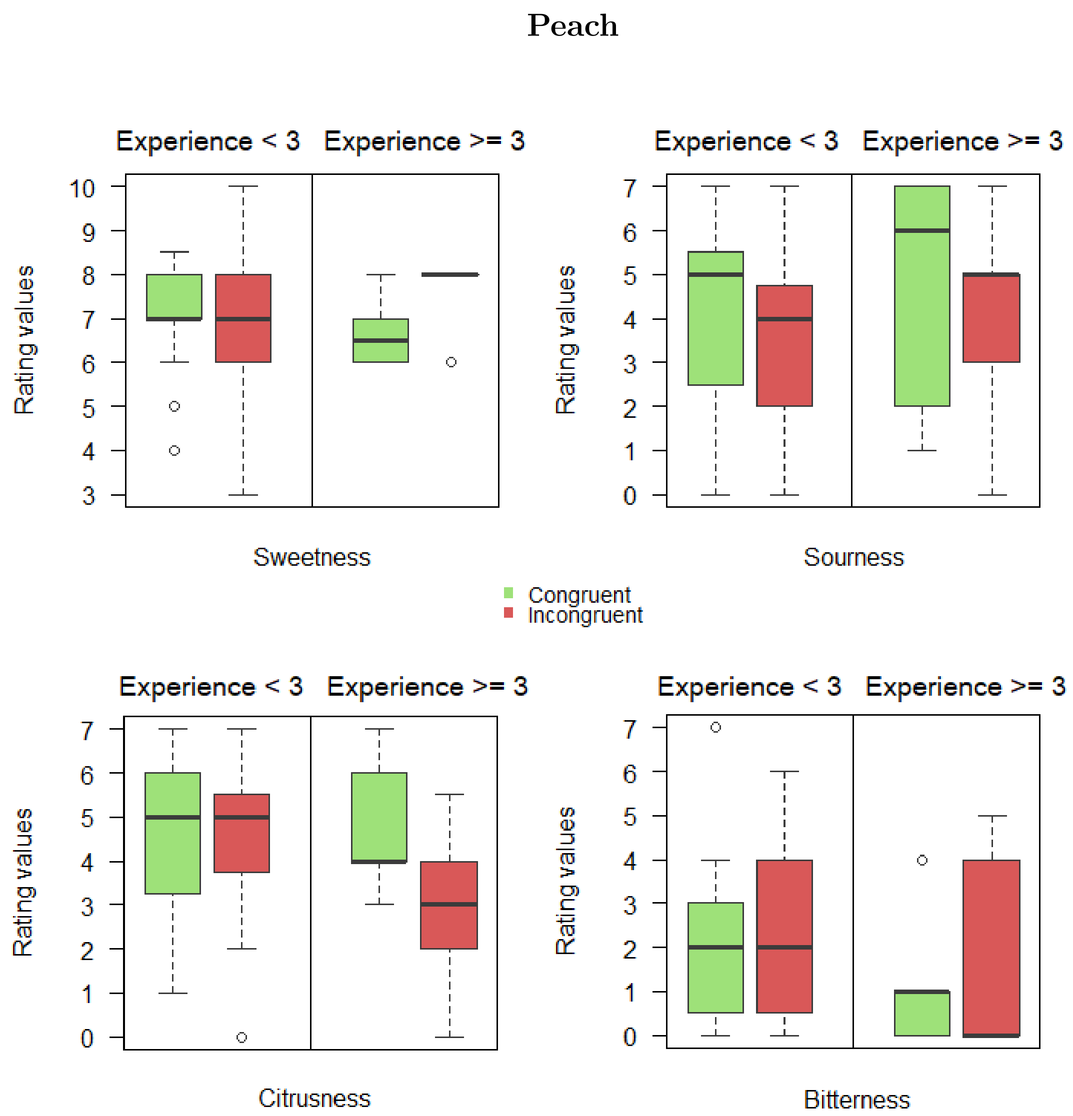


Figure 3.9: Peach: taste ratings in relation to different previous experience

As can be seen from figure 3.9, there was a bigger difference between the medians of the congruent and incongruent trials for the right group compared to the left group. However, the inter-quartile range varied more (was wider) for the left group compared to the right group.

For sourness, the absoute difference between the medians of the congruent and incongruent trials was the same for both groups (both difference of 1.0). However, the medians were more centered to the lower rating values for the left group compared to the right group. Moreover, for the right group, the inter-quartile range for the congruent trials varied more (was wider) compared to the left group. For the incongruent trials of the right group, this difference was vice versa.

For citrusness, there was a bigger difference between the medians of the congruent and incongruent trials for the right group compared to the left group.

For bitterness, there was a bigger difference between the medians of the congruent and incongruent trials for the right group compared to the left group. Moreover, for the right group, the inter-quartile range for the incongruent trials varied more (was wider) compared to the left group. For the congruent trials of the right group, this difference was vice versa.

3.5.4 Mango and peach: comparison

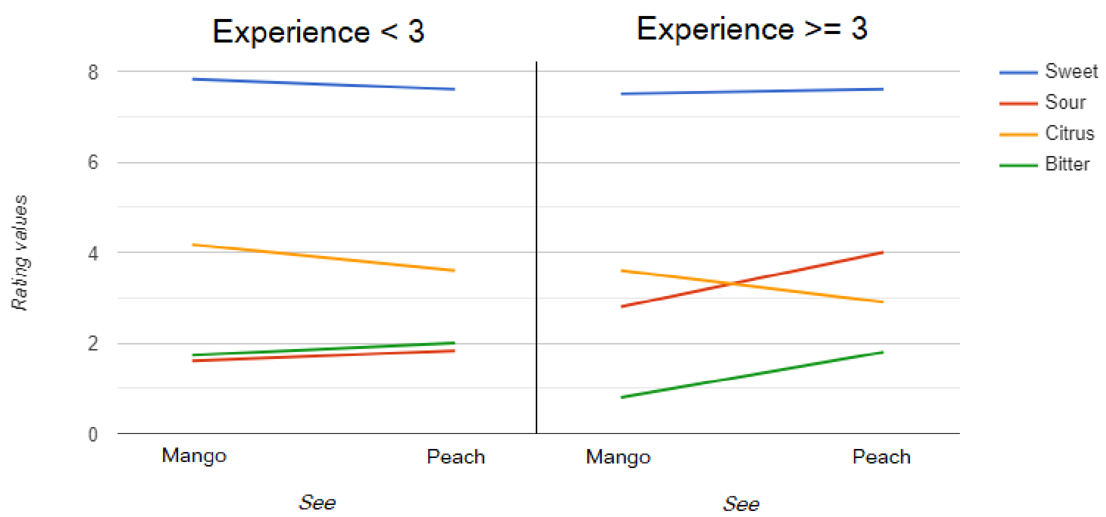


Figure 3.10: Mango

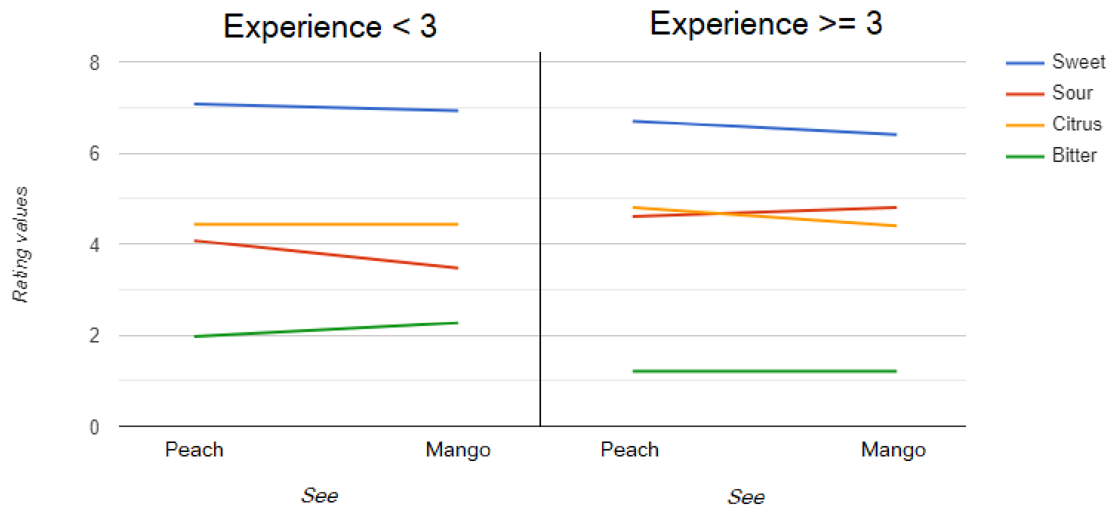


Figure 3.11: Peach

Figures 3.10 and 3.11 describe the differences in taste rating values (from the VR) for the congruent and incongruent trials. The left point of the colored lines are the average taste ratings for the congruent trials, the right lines for the incongruent trials (e.g. see mango - taste peach). The left group (previous experience < 3 times) is displayed against the right group (previous experience $>= 3$ times).

As can be seen from the figures, for sweetness, there was not a lot of difference between the rating values of both groups for mango and peach.

For sourness, the average ratings as a whole were higher for the right group compared to the left group for peach and mango. For mango the line for the right group was more steep compared to the left group. This means that there was more difference in their average ratings in the incongruent trials compared to the congruent trials.

For citrusness, for mango and peach, the average ratings as a whole were lower or almost equal for the right group compared to the left group.
For bitterness, for mango and peach, the average ratings as a whole were lower for the right group compared to the left group. Besides this, for mango, there was more difference in rating between the congruent and incongruent condition (the line is more steep) for the right group compared to the left group. For peach, this was vice versa.

Overall, for mango, the lines were steeper for the right group compared to the left group. This means that for the group that experienced the environment as more realistic, there was more difference in their ratings in the incongruent trials compared to the congruent trials. For peach, the steepness of the lines did not differ that much. This means that there was not a lot of difference in their ratings in the incongruent trials compared to the congruent trials.

3.6 Other factors influencing taste perception

3.6.1 Preference of the fruits

On average, the preference of mango was rated with a 4.65, with a minimum of 4, a maximum of 5 and a standard deviation of 0.49.

On average, the preference of peach was rated with a 4.1, with a minimum of 3, a maximum of 5 and a standard deviation of 0.72.

None of the subjects disliked mango or peach. Because of this, no data was available to split the subjects into two groups (preference vs. non-preference). Therefore, no analysis has been executed about the influence of the (non-)preference of the fruits on taste perception.

3.6.2 Taste perception and comfortability

In general, subjects felt comfortable during the experiment.
The average comfortability over the 20 subjects was rated as a 4.6, with a minimum of 3, a maximum of 5 and a standard deviation of 0.60. Because there were no subjects that rated comfortability < 3, no analysis could be executed about the influence on taste perception due to feeling less comfortable during the experiment.

3.6.3 Taste perception and nausea

None of the subjects experienced nausea during the experiment. Therefore, this influence was excluded from the analysis.

3.6.4 Age and gender

16 female and 4 male subjects attended the experiment. Ages ranged from 19-24, with an average age of 21.9 and a standard deviation of 1.37.
The number of male subjects in comparison to female subjects was not enough to analyze gender differences. Therefore, no differences between gender in relation to taste perception were analyzed.

Chapter 4

Discussion

4.1 Research Question

Is it possible to deceive the gustatory perception by presenting incongruent food vision?

We hypothesized that incongruent visual trials causes incorrect classification of the fruit. This was true in 7.5% of the cases. However, for the congruent trials, incorrect classification of the fruit also occurred in 5% of the cases. Because for the congruent trials, this incorrect classification only occurred for the first piece of fruit the participants tasted, the effect can be explained by not being familiar with the tastes of peach and mango in general.

For mango and peach, taste perception differed for the incongruent trials compared to the congruent trials. However, these differences were not significant. Other factors influencing the taste can be reasons for this:

- **Ripeness**
  Within pieces of the same piece of fruit, as well as between different pieces of the same type of fruit, the level of ripeness could have varied.

- **Temperature**
  Even though with cooling bags the temperature was kept as equal as possible, a rising temperature during the day could have influenced the results.

- **Smell**
  The nose of the subjects was not covered by the VR glasses, therefore the smell of the fruit being eaten could have influenced the results.

- **Texture**
  Even though the fruits were chosen in a way that their texture was as equal as possible, still some minor differences could be distinguished which could have influenced the results.

The percentages of the deception were small and the results of the taste perception for mango and peach were non-significant. Because of this, the results were not enough to confirm the hypothesis that incorrect visual trials cause incorrect classification of the fruit.

4.1.1 How does the perception of realism of the VR environment influence the taste perception?

Our hypothesis was that the group of subjects that experienced the VR environment as more realistic, will be more susceptible to the deception of the experiment and thus have more differences between the average rating of the congruent and incongruent trials.

According to the corrected p-value, no significant result was found for the rated realism < 3 or rated realism $>= 3$. Reasons for this could be the relatively small number of participants in each group: 13 subjects rated the average realism < 3 and 7 subjects rated the average realism $>= 3$.
The reason these groups weren't of bigger size is because a total of 20 participants seemed enough to gain significant p-values in this experiment. However, it appeared that more participants were needed for this.

Another reason for the non-significant results could be the calibration. As explained in section 2.7, the alignment of the fruit in the real world and VR environment was executed based on the hand position of the subject in the real- and VR world. However, this food position could change a bit when the subject moved their head a lot during the experiment. This was due to the gyroscope not functioning optimal sometimes.
Besides this, the pieces of fruit in the VR environment were sometimes hard to recognize and pick up. This was due to the Leap Motion sometimes losing track of the hands and the pieces of fruit being quite small (they had to be proportional to the real pieces of fruit).

Not only these factors, but also the resolution could have influenced the perception of realism.
As explained in section 2.8, Unity Remote 5 was used to directly stream the Unity scene from a laptop to a mobile device. Because of this streaming, the resolution of the scene was decreased. This issue was solved as much as possible by automatically downsizing the resolution for the eating part (optimized the hand movements) and normalizing the resolution for the rating part (optimized the readability of the text). However, an optimal solution might still not have been reached.

Because the p-values were not significant and there were a lot of other influencing factors, we could not confirm our hypothesis.

4.1.2 How does previous experience in VR influence the taste perception?

Our hypothesis was that the group of subjects that had more experience in VR would be more susceptible to the deception of the experiment and thus have more differences between the average rating of the congruent and incongruent trials.

According to the corrected p-value, no significant result was found for the previous experience < 3 or $>= 3$ times. Reasons for this could also be the relatively small number of participants in each group: 15 subjects had previous experience $<$ 3 times before and 5 subjects had experience $>= 3$ times before.

Besides this, independent of their previous experience, some people had ideas beforehand about what the experiment would look like. For example if they heard the experiment explanation, they sometimes already guessed that not all trials would be congruent. This could have influenced their beliefs.

Because the p-values were not significant and there were a lot of other influencing factors, we could not confirm our hypothesis.

Chapter 5

Conclusion

In this experiment, we managed to deceive the gustatory perception of some test subjects by presenting incongruent food vision. However, results were not strong enough to confirm our hypotheses. This is believed to be mainly due to the environment lacking sufficient realism. Besides this main factor, secondary factors could have influenced the results, among which ripeness and small experiment test group size.

Because our p-values were not significant, we could not confirm that the perception of realism of the VR environment had a direct influence on the taste perception. Testing for the effect of the subjects' VR experience on the degree to which they could be deceived, our p-values were not significant either. Therefore, it could not be confirmed that previous experience in VR had a direct effect on taste perception either.

For the incongruent trials, the food item shown in the VR had a different color compared to the item that was eaten. This color difference can be linked to the research of Wei et al. [14]. They found that different colors of the same juice elicited different responses for sweetness, sourness, freshness and bitterness. In our research, different responses to incongruent trials (different colors) were also found. Despite the non-significance, our results can support the notion that color possibly has an influence on the taste perception.

Besides this, little research effort has been devoted to the specific combination of VR and incongruent food items. Therefore, the results cannot directly be compared to other research results. However, the small deception percentages and differences in taste ratings for different groups still support the observation that experimenting with sensory factors and VR provides us with a wide range of custom possibilities, which can help patients cope with disorders such as anorexia or bulimia.

With this experiment, we did not manage to deceive a large number of people. However, deceiving even a small number of people means that the results are promising for further research. With a more realistic environment and minimization of the other influencing factors (such as ripeness and smell), more people within this experiment size could possibly be deceived. When combined with an even bigger number of participants, the expectation of the number of people that could be deceived would be higher.

Further recommendations for future research would be to mash the fruits. The slight differences in the textures of the fruits could have influenced the results more than was thought beforehand. By mashing the fruits, the textures will be a 100% equal. Besides this, it will solve the problem of having different levels of ripeness (within the same piece of fruit and between pieces of the same type of fruit).
Lastly, combinations with smell could be investigated. For example, experiments were the ingested type of fruit is the same but the smell is incongruent, or vice versa.

All in all, several interesting findings have been observed in this study. The use of VR in the deception of gustatory experiences has shown promise for the future, to a reasonable extent. Concluding, we recommend follow-on research for which the valuable lessons learned from our study should act as a source of inspiration.

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Appendix A

Introduction

A.1 Experiment explanation

Welcome to my experiment on the influence of VR on eating experience. In this experiment, you will be tasting two types of fruit in the VR: mango and peach. Your task in this experiment is to distinguish which of these two fruits you are eating in each trial, and rate the taste values of these fruits.

If you have any allergies for mango or peach, you can unfortunately not participate in this experiment.

A.1.1 The experiment

First, you will see a practice scene to practice the movement of the VR hands. The VR hands will appear in the scene as soon as the sensor detects your own hands. The goal of the practice scene is to grab the cube and move it to the position of the star by using the VR hands. After scoring 5/5, you will automatically be redirected to the experiment scene.

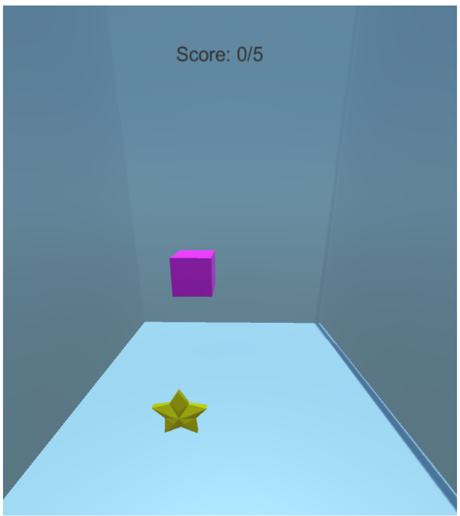
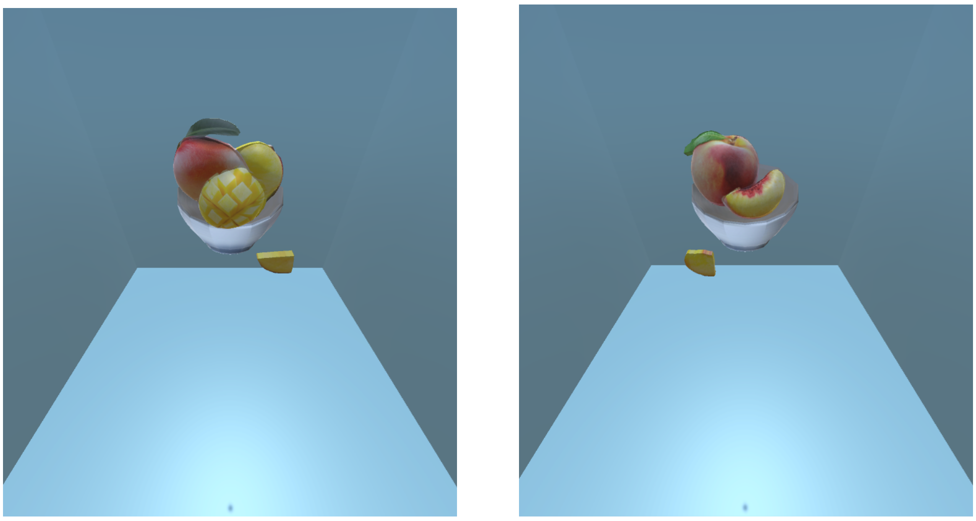


Figure A.1: Practice scene

In the experiment scene, you will taste pieces of fruit by grabbing them with the VR hands. In the back of the scene you see either a bowl of mangos or a bowl of peaches. This bowl indicates the fruit you are tasting at that moment. In total, you will taste and rate 4 pieces of fruit.



(a) Mango bowl (b) Peach bowl

Figure A.2: Fruit bowls

After tasting each piece of fruit, I will ask you to give ratings of different taste values of the fruit. The values that I will ask you are: sweetness, sourness, citrusness and bitterness. If you don't know what any of these terms means, you can ask me.

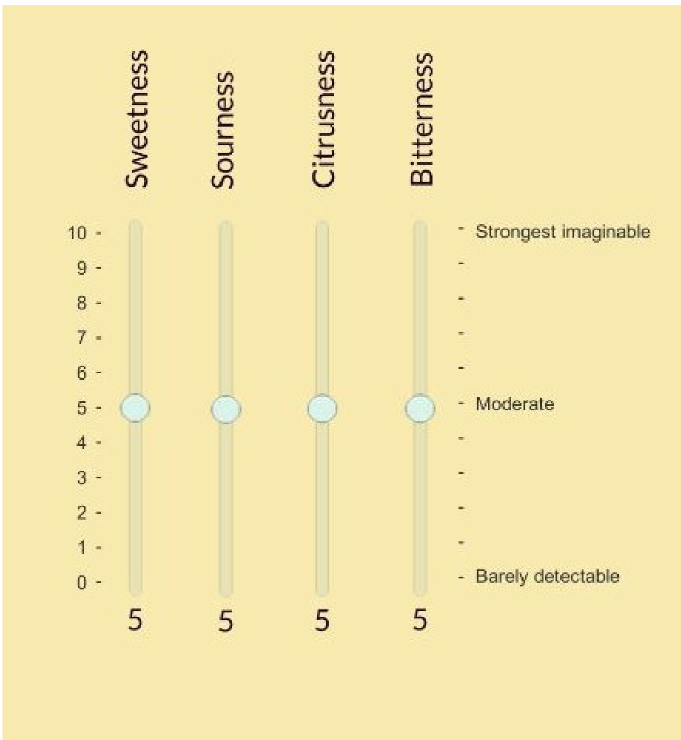


Figure A.3: Rating part after each tasting

Thank you for wanting to participate in this experiment!

No other data than your responses to the ratings will be collected. Please read and sign the informed consent, read the general information provided by the Donders institute, and fill in the pre-VR questionnaire before we start.

Appendix B

Pre- and post-VR Questionnaire

Pre-VR Experiment Questionnaire

Britt van Gemert

May 2018

Number of the subject:

Age:

Gender:

Questions

Please circle the answer that is applicable to you.

1. How much do you like the taste of the following fruits?

   (a) Peach

1	2	3	4	5
Not at all		*Neutral*		*Very much*

   (b) Mango

1	2	3	4	5
Not at all		*Neutral*		*Very much*

2. (a) Is this the first time you will have a VR experience?

Yes	No

(b) If no, how often did you have a VR experience before? _____________

3. Are you susceptible to nausea
(for example in vehicles/boats)?

Yes	No

Post-VR Experiment Questionnaire

Britt van Gemert

May 2018

Questions

Please circle the answer that is applicable to you.

1. How realistic did the VR environment feel to you?

1	2	3	4	5
Not at all		*Neutral*		*Very much*

2. How realistic did the pieces of fruit in the VR environment feel to you?

1	2	3	4	5
Not at all		*Neutral*		*Very much*

3. How realistic did the activity of eating the fruit feel to you?

1	2	3	4	5
Not at all		*Neutral*		*Very much*

4. How comfortable did you feel during the experiment?

1	2	3	4	5
Not at all		*Neutral*		*Very much*

5. (a) Did you experience any nausea during the experiment?

Yes	No

   (b) If so, did this influence your participation in the experiment?

Yes	No

6. General comments I have about the experiment:

Appendix C

Informed Consent

Donders Centre for Cognition
STUDY-SPECIFIC INFORMED CONSENT FORM

For participation in:* ☐ Behavioural ☐ EEG ☐ Sled ☐ Robot ☐ EEG-FES
***tick the applicable box(es)**

To be filled out by the PARTICIPANT prior to the start of the experiment:
I confirm that:
- I was satisfactorily informed about the study both verbally and in writing, by means of the general information brochure and additional study specific information brochure(s) (version 2.1, December 2018).
- I have had the opportunity to put forward questions regarding the study and that these questions have been answered satisfactorily.
- I have carefully considered my participation in the experiment.
- I participate voluntarily.

I agree that:
- My research data will be acquired and stored for scientific purposes as mentioned in the general information brochure until 10 years after the research has been finalized.
- Personal data is acquired for administrative and scientific purposes.
- The connection between my personal and research data is stored until maximally one month after finalization of this study.
- Demographic data or data concerning my health, background or preferences is collected for scientific purposes.
- My not directly identifiable experimental data will be made public for verification, re-use and/or replication.
- Regulatory authorities can access my data for verification purposes.
- I will be informed by a designated expert, my general practitioner or a general practitioner of the Academic General Practitioner Center Heyendaal about any information which is of clinical relevance to me.

I understand that:
- I have the right to withdraw from the experiment at any time without having to give a reason.
- I have the right to request disposal of my experimental data up to 1 month after participation.
- My privacy is protected according to applicable European law (European General Data Protection Regulation (GDPR).
- My consent will be sought every time I participate in a new experiment.

I agree that I can be approached for a future study for comparable scientific research and to this end my contact details are stored until maximally one month after finalization of this study YES/NO
(make a choice)

I give my consent to take part in this experiment:

Name:……………………………………………….. Date of birth:………………………………....... (dd/mm/yy)

Signature:.. Date and place:…………………………………………....

To be filled out by the RESEARCHER prior to the start of the experiment:
The undersigned declares that the person named above has been informed both in writing and in person about the experiment. He /she guarantees subjects' privacy protection according to Dutch law.

Name:………………………………………………. PI group:……………………………………………………

DCC PPF number:………………………………………………………………………………………….

Signature:..…………Date and place:……………………………………………

DONDERS INSTITUTE

Donders Centre for Cognition

SCREENING FORM BEHAVIOURAL*
Version 2.1

To be filled out by the PARTICIPANT prior to the start of the experiment

Please answer the following question first	**Yes**	**No**
- Are you younger than 18 years?		

***If you answered Yes to the above question, you are not be able to participate in the experiment*.**

Signature:	Date:

To be filled out completely by the RESEARCHER after the experiment

Adverse event **YES/NO****

If YES: dd/mm/yyyy time

- Date and time of occurrence: …………….. ……
- Description:
- Severity: mild/moderate/serious**
- Relation to measurement procedure: none/unlikely/possible/likely/definite**
- Action taken:
- Abated / follow up:
    - o **Follow Standard Operating Procedure Adverse Event**

Incidental Finding **YES/NO****

If YES: `

dd/mm/yyyy

Date: ………………

- o **Follow Standard Operating Procedure Incidental Finding**

**make a choice

** This form is only to be used for research with people of 18 years or older, who are of sound mind and judgment. The person involved has to give his or her consent personally.*

Appendix D

General Information

GENERAL INFORMATION
Version 2.1

Donders Centre for Cognition

This folder contains important information if you consider participating in one of the studies at the Donders Centre for Cognition of the Donders Institute. Please read the following information carefully.
The Donders Institute is a university research centre investigating the brain, cognition and behaviour. The Donders Centre for Cognition (DCC) is part of the Donders Institute and has at its disposal various techniques in order to measure behaviour and brain activity. For our research we need volunteers to participate in various experiments, e.g. language, perception, action or memory tasks. All our research and research methods have negligible to minimal risks.

Ethics check

Each study you may participate in has been reviewed and approved by an independent ethics committee (the 'Ethics Committee of Faculty of Social Sciences , Radboud University Nijmegen', https://www.radboudnet.nl/socialsciences/research/ethics-committee-social-science/ or the medical ethics committee, www.cmoregio-a-n.nl).

Clinical data

Researchers at the DCC do not examine the data from a clinical perspective. Participation in any of the experiments can therefore not be considered as a clinical or screening test.
In exceptional circumstances the data collected may give indications concerning your health conditions. Prior to participation in these kinds of experiments you are required to provide name and address of your general practitioner. Additionally, in these types of experiments, we will archive your name, your personal identification number (of our subject database), and/or your (email) address. In case of a possible finding which is of clinical relevance you will be informed by a designated specialist of the DCC, or your general practitioner. In case you do not have a general practitioner (in the Netherlands), you will be informed by the Academic General Practitioner Center Heyendaal, for which you will then have to register as a patient once. Your insurance policy will cover these costs; In case you are uninsured the Academic GP Center is required to charge you a minimal amount for consultation. If you do not wish to be informed about findings concerning your health, you cannot participate in experiments at the DCC.

Information about the experiment and giving consent

You will receive a study specific information brochure from the researcher sufficiently in advance (this means minimally 24 hours in advance) of participation in the experiment. This will allow you time to reflect on your participation. Prior to participation, you are asked to sign a study specific informed consent form in which you confirm that you have been informed satisfactorily and are willing and able to participate voluntarily. The researcher will also sign the form, confirming that you have been informed about the experiment satisfactorily. The researcher will also ensure your privacy and that the necessary privacy conditions will be met. You have the right to withdraw from the experiment at any time without giving a reason. You can request disposal of your experimental data up to 1 month after participation in the study. After that your data will be pseudonymized, this means not directly identifiable, and stored in a repository. An example of the study specific “informed consent” is attached to the applicable study specific information brochure.

Insurance

On legal grounds a liability insurance and in some cases an additional subject insurance has been concluded for subjects participating in studies at the DCC as part of the Donders Institute. The subject insurance covers damage due to participation in the study, becoming apparent during participation in the study or within four years after termination of participation in the study.

Use and preservation of your data

For our research it is necessary to collect, use and preserve personal information. This concerns personal data like name, address, date of birth, email address or personal identification number of the participant database. Use and preservation of your personal data is necessary for administrative and scientific goals. These goals are: the documentation of consent for participation in research, payment for participation, granting request to destroy data, to approach in the case of incidental findings, and to approach for future research (in case consent has been given for this). In some cases it is necessary to collect demographical data or data concerning your health, background, or preferences for scientific purposes. If you do not agree with this, you cannot participate in this research.

Confidentiality of your data

The information you provide for the purpose of the study will be handled carefully and will only be accessible to employees who are authorized to do so. Your data will be treated confidentially. All your research data will be coded in order to protect your privacy. Your name and other information, which might lead to your identity, will be kept separate from the experimental data. Only with a so called key file your experimental data can be linked to your identity. To protect your privacy this key file will also be stored apart from the research data. Only members of the research team who are directly involved and for whom it is necessary can access your personal data and the key file. Other parties involved in the research receive only access to the coded research data and won’t be able to identify you directly on the basis of this data. Reports or publications on the study will also only report your coded not directly identifiable research data.
In some studies additional audio, photo and/or video recordings will be obtained during the experiment. These are solely collected for scientific purposes. The experimenter will always inform you about this prior to participation, additionally asking for your approval. In all cases your privacy will be protected according to European law (European General Data Protection Regulation, GDPR)

Preservation time

Your data will be archived during for an established period of time, which is until 10 years after the research has been finalized. The connection between your personal data and your research data will be stored until maximally one month after finalization of the research.

Sharing your experimental data

Given the importance of verification, re-use and/or replication of research results, experimental data are shared or made public more often. Prior to this sharing the data will completely be pseudonymized (this means not traceable to your identity). In case of concerns regarding sharing your experimental data, you have the right to request disposal of your experimental data up to 1 month after participation.
Some experimental data cannot be pseudonymized completely due to its nature, e.g. video-, photo or audio recordings. You have the right to disapprove sharing these data

with other researchers beyond the scope of the study. This can be done via the study specific consent form.

Right to inspection

Few other people or agencies have the right to inspect your data, both personal and research data. This is necessary in order to check if the research was properly and reliably conducted. The persons or agencies who can obtain access to your data for the purpose of verification are: a controller who works for the responsible institute, and national or international regulatory bodies such as the Ministry of Health. They will protect and keep your personal information secret. You are requested to approve this right to inspection. In case you do not agree, you cannot participate in the study.

Future studies

After participation in an experiment at the DCC, it may be the case that we would like to approach you again for a future study. You can indicate on the consent form whether you agree with this. In case you consent to be approached we will store name, address, email address and your identification number from the participant database, if applicable. Also in these future experiments, participation is always voluntary and consent will be sought every time you participate in a new experiment.

Preparation of the experiment

Generally, no extra preparation is required before participation. It is important that you are fit, alert and that you did not drink alcohol or used drugs the night before.
Before the start of the actual experiment the researcher will explain the aims of the research and the applied measurement techniques to you. You will receive instructions about what you are asked to do during the experiment, such as watching a monitor, listen to sounds (possibly over a headset), perform a reaction task, make different movements or just lie still and relax. After everything has been fully explained, you will be asked to sign the consent form. Subsequent procedures depend on the research method that is being used. You can read more about this in the information brochures on EEG, moving chair, robot or EEG-FES.

Payment

Participation in experiments is reimbursed. The DCC gives this reimbursement by means of participant hours or 'VVV giftcards (https://www.vvvcadeaubonnen.nl/). In this latter case we need your name and address for administrative reasons.

Additional information, independent contact person and contact

If you are unable to make it to the appointment (on time), please inform the responsible researcher as soon as possible. You may also contact this researcher for additional information or if you would like to withdraw from participating.

After participation

We appreciate hearing about your experiences as a participant. You can give your feedback – with or without personal information - via this webform. In case of questions or complaints about an experiment, contact the responsible experimenter first. You can also contact an independent contact person who is not involved in the study (independent contact person: Miriam Kos, of the Donders Centre for Cognition (dcclabcoordinator@socsci.ru.nl; tel 0243612650)) or fill out our webform. If applicable the independent contact person will contact you by phone.

More information concerning your rights for processing data

For more information with respect to compliance with your rights regarding the processing your personal data, you may contact the responsible entity for processing your data. The

Radboud University is responsible for compliance with the rights of processing personal data for this research. You may contact the office of the data Protection Officer of the Radboud University via privacy@ru.nl. More information about your rights regarding processing of personal data can be found at https://www.ru.nl/privacy/english/ and on the website of the Dutch Data Protection Authority: https://autoriteitpersoonsgegevens.nl/en.