The impact of visual information within the Sensory Interactive Table on food perceptions

Master thesis Interaction Technology

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"Where we eat and how we eat have changed in the evolution of humankind. We have gone from simple tools to facilitate eating all the way to digitizing our food experiences."

Velasco, C., Obrist, M.. *Multisensory experiences: Where the senses meet technology*
Oxford University Press, 2020

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With the help of all these people I was motivated to achieve quality results, thank you all for this.

Abstract

This research focuses on perceptions of food properties that can be altered by receiving visual information in the eating environment. Through a literature review study it was found that colors affect attitudes toward food and hence, eating behavior can be influenced. Therefore, this thesis investigates the influence of colors on perception of food in the domain of Human-Computer Interaction (HCI), where a Sensory Interactive Table (SIT) provides visual cues to the user to alter their perceptions of food flavor.

The literature study revealed that not only the color of the food can affect judgements toward it, but also colors in the eating environment - namely the color of the plateware is suggested to enhance perceptions of taste of food (the sweetness of the food can be enhanced by the contrast between the color of the dish and color of the plate, as well as the spiciness of food that can be enhanced by the color of the plate). However, resources are scarce and a gap in literature about the influence of plateware color on perceptions of food flavor was identified (for example, impact of plate color on perceptions of strawberry flavor, blueberry flavor, etc.).

Therefore, the objective of this research was to identify in what way and whether, the color information provided by SIT in the eating environment influences perceived flavor of food. Consequently, a study was designed to investigate the influence of colors on flavor perceptions of food they are associated with (the influence of: red color on perceived strawberry flavor of yogurt, blue color on perceived blueberry flavor of yogurt, yellow color on perceived banana flavor of yogurt). A control condition for the study was designed to explore the impact of perceived environmental information on perceptions of food in the frame of material-color influence. The control condition involved a lab experiment in a setting as close as possible to an everyday eating where differently colored bowls were used. An experimental condition for the study involved exploration of the effect of color on perceptions of food in the frame of environmental-color influence within SIT. Hence, the experimental condition (the SIT condition) researched the impact of projected colors on the surface of SIT, on perceptions of the provided food. The SIT condition was also explored for any influence of the plateware appearance on translating the color information on food perceptions in two concepts (one using white colored plateware and the other - transparent-glass plateware). Overall, the flavor perceptions of the variety of yogurt tested were enhanced in the SIT condition, in the transparent-glass plateware concept. The blue color enhanced perceptions of blueberry flavor in both conditions. Considering the

limitations of the study, the red color can be considered to also have enhanced the perceived strawberry flavor in the two conditions. The banana flavor was not found to be enhanced by the yellow color in the control condition, as well as in the white colored plateware concept within the SIT condition. However, in the transparent glass plateware SIT concept, regarding the results and the limitations of the study, the perceived banana yogurt can be considered to have been enhanced by the yellow color projected under the bowl. Thus, the color information perceived by SIT when a non-colored plateware is used (transparent-glass) is found to intensify the flavor perceptions among the majority of yogurt types tested.

1. Introduction

A report published by the World Health Organisation (2022) states that by now one in three school-aged children, one in four adolescents and almost 60% of adults in European countries are overweight or obese. Before 2016 the obesity rate had increased by 21% for a period of 10 years and crucially by 138% since 1975. The tendency of growing numbers in obesity rates through the years escalated in describing the condition as a 'global epidemic' worldwide (Haththotuwa et al., 2020). Emilien & Hollis (2017) address that the personal and societal health can be affected in many negative ways if eating behavior is not well understood. Obesity, overweight, type 2 diabetes and some types of cancer are some of the consequences of uncontrolled eating behavior, and, by controlling our food intake, the risk of developing these conditions can be reduced . One way to do this is dieting - a conscious approach for self-regulation that requires a lot of effort. According to Heshmat (2011), most of the time people make food choices unconsciously under the influence of the environment where the food is provided. Therefore, he suggests that changing the eating environment would change the eating behavior. Heshmat addresses that not only sensual cues that are directly related to the properties of food such as its sight and smell of food can guide eating behavior, but also cues that are not directly related to them. For example, the size and appearance of packaging can guide choices and nudge toward a desired behavior. In a study, Schuldt (2013) informs that consumers perceived a candy bar healthier when the color of its nutrition label was green rather than red or white, despite having the same calorie content. In this direction, altering visual information in the eating environment can change judgements toward the food and consequently, eating behavior can be affected.

1.1. Motivation

The domain of eating behavior is a broad one that encompasses food choices, motivation and practices of eating that in turn relate to many eating-related health conditions such as obesity, eating and feeding disorders (LaCaille et al., 2013). Eertmans et al. (2001) explore the factors that affect eating behavior and suggest that they can be manipulated in order for healthy eating to be stimulated. Their proposed model of eating behavior can be seen on Figure 1.

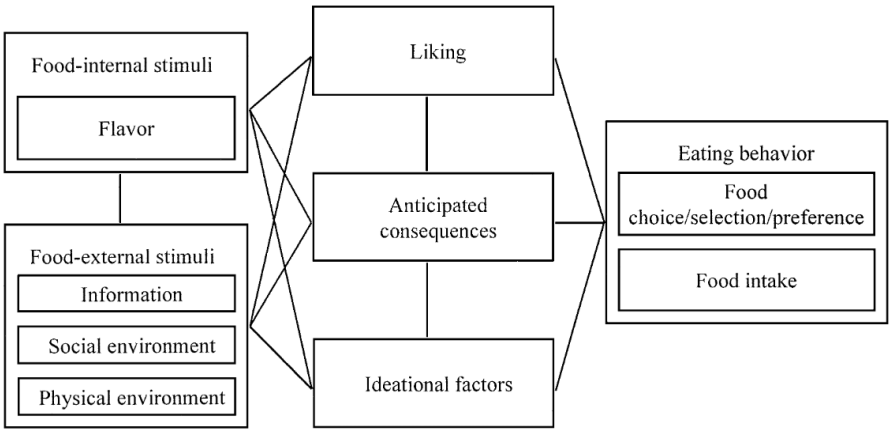


Figure 1: A hypothetical model of eating behavior. Eertmans et al, 2001

The researchers suggest that liking, anticipated consequences (for example expectations whether the food will lead to satiety) and ideational factors (how people perceive eating behavior in the sense of appropriateness regarding norms, beliefs, social facilitation) are determinant variables for food choice/selection/preference and consequently food intake (Eertmans et al., 2001). These variables depend on stimuli in the environment where food is available and stimuli related to the food itself. While anticipated consequences and ideational factors are variables perceived more consciously, liking on the other hand can be perceived on a more unconscious level and thus, it is easy to be manipulated.

Factors that influence liking are either internal - related to the sensory attributes of the food or external - cues and information in the social and physical environments. While external stimuli in the physical environment *(accessibility to stores and restaurants that can facilitate consumption of available foods and inaccessibility to specific ones can shift people's choice to other foods)*, the social environment *(eating rate, style and quantity of consumption that are changed when eating with others compared to when eating alone)* and received food-specific information *(food facts on labels and packages, information that signals nutritional qualities of food)* can influence attitude toward food, but are beyond one's abilities to control, the food-internal stimuli that guide our liking of food are easier to be manipulated on a personal level (Zellner et al., 2014).

1.1.1. Food-internal stimuli

We shape our attitude toward food (liking) by sensing its physical properties and also by forming expectations of its perceived taste and flavor (Spence, 2017).

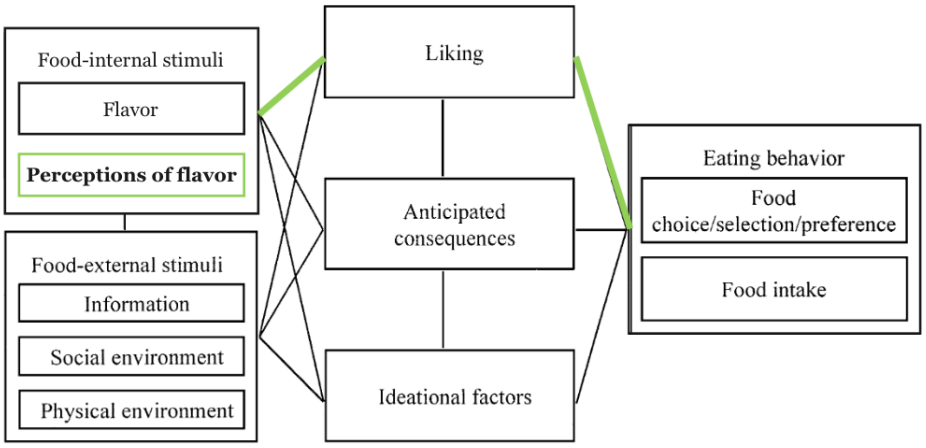


Figure 2: Perceptions of flavor influence liking of food and therefore, the eating behavior can be affected. Adapted from Eertmans et al, 2001

These expectations are guided by receiving visual information before eating (the color of the food, its saturation, the color of the plate where it is placed, the shape of the plate), which can continue to shape our liking even after tasting the food. For example, one can determine whether they will like a strawberry when looking at its color - a red one is expected to be sweet, while a green one is expected not to be ripe and ready for eating, a white jelly bean is expected and perceived to taste less like strawberry than a red one (Lupton & Lipps, 2018). In this sense, the visual information we perceive can signal properties of food and influence our attitude toward it and therefore, altering this information can affect our choice/selection/preference in a positive way as stimulating healthier eating choices.

In order for valuable interventions to be designed that stimulate healthier eating, eating behavior should be well understood with the different factors that influence it. The least control demanding way for that would be visually manipulating the perceptions of food flavor and taste. Example for such manipulation is the work of Kita and Rekimoto (2013) that use projection mapping on food and alter its saturation to enrich its appearance and make it more pleasurable to eat. On the other hand, Wheatley (1973) suggests that changing the color a specific food is associated with can lead to avoidance and negative reactions toward the respective food. Not only the color of the food itself, but also the color of the plateware, the contrast it makes with the food and its shape are found to have different impact on eating behavior (Tu et al., 2016; Piqueras-Fiszman et al., 2012; Piqueras-Fiszman & Spence, C., 2013; Piqueras-Fiszman et al., 2012; Spence & Deroy, 2014; Ngo et al., 2011). However, the researches that have inspected the impact of plateware color on flavor perception are still scarce and need further investigation.

1.2. Introduction of the Sensory Interactive Table

Designing concepts in the domain of impact of visual information on eating behavior is becoming a more and more popular field for researchers, especially in this era of constantly developing technology. Interventions within the human-computer interaction domain are being introduced that provide novel experiences to facilitate eating (Velasco and Obrist, 2020). One of these interventions is the Sensory Interactive Table developed by the researchers Juliet Haarman, Roelof de Vries, Hermie Hermens and Emiel Harmsen at the University of Twente, the Netherlands (Haarman et al., 2020). The surface of the table consists of sensors for measuring loads and a set of cells with LEDs that can be programmed to display specific visualizations. With the help of this table, different approaches for enhancing the eating experience can be created providing visual input to the user.

1.3. Objective of the research

The main objective of this research is to inspect whether the above mentioned Sensory Interactive Table can provide conditions for manipulating flavor perceptions by providing visual information to the user. To fulfill this objective, first the influence of plateware color on perception of flavor within a control condition without the facilitation of the intervention has been explored. Secondly, an experimental condition investigated the influence of color, projected on the surface of the Sensory Interactive Table. The results obtained within the two conditions are compared to conclude whether, and in what way, the intervention affects perceived food flavor. Findings can be used for future development of concepts within the Sensory Interactive Table in the domain of healthy eating.

2. Background

A literature study was performed to investigate the influence of visual information on eating behavior. Color was found to play an important role in shaping expectations and perceptions of taste and flavor and guide our liking of food. The color of the food itself can signal us its properties and form our judgment whether we will enjoy it before tasting and while eating it. The color of the plateware is also shown to affect perceived taste of food and flavor in different ways, as well as the contrast it makes with the color of the food. Furthermore, the shape of the plateware is suggested to enhance perceptions of taste. All these findings propose that visual information, which influences perceptions of flavor and taste, that in turn influences attitude toward food, can affect the eating behavior in either positive or negative way. Stewart & Gross (2013) address that sensory perceptions might be manipulated most profoundly, in order to guide eating behavior toward a desired direction, by altering visual input. An overview of the impact of visual information on perceptions of flavor can be seen in Figure 3.

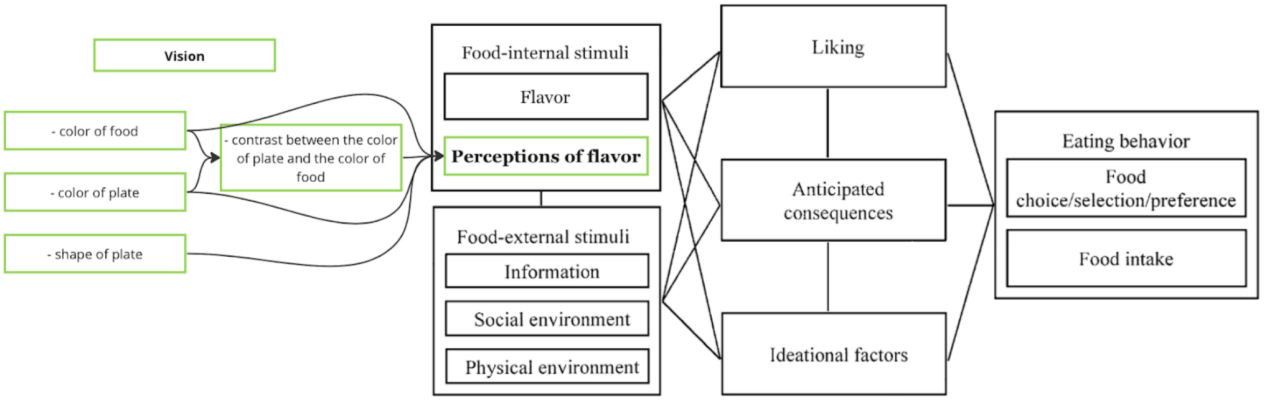


Figure 3: Perceptions of flavor can be influenced by the visual appearance of food and plateware and therefore, liking and eating behavior can be affected. Adapted from Eertmans et al, 2001

2.1. Visual appearance of food

Colors were found to affect liking of the food in different ways. Wheatley (1973) addresses that if the color, a specific food is associated with, is changed with a dissimilar one, perceptions of flavor and taste can be affected and negative reactions toward the food can be provoked. She experimented with changing the colors of steak (blue), chips (green) and peas (red) and dimming the light so the true color of the food could not be recognized and when the lights were turned-up, people started feeling sick. Lupton & Lipps (2018) also suggest that namely the color of food signals us its properties and judgments and expectations of

flavor and taste are formed. For example, according to Zampini et al. (2007), a green-colored beverage is expected to have lime flavor, an orange one - orange flavor, a blue one - spearmint flavor, etc.. Shankar et al. (2009) address that brown colored M&Ms are perceived to be more chocolatey than green ones, despite having the same contents. Spence (2017) also addresses that flavor is influenced by what is seen - one of his studies shows how expert wine tasters were fooled when a red-colored white wine was given to them and they reported to have noticed the red wine aroma.

2.2. Visual appearance of tableware

The visual appearance of plateware is proposed to have an impact on eating behavior as well. Differently colored plates are shown to have different effects on eating behavior regarding amount of consumption. In their researches Genschow et al. (2012) and Akyol et al. (2018b) show contradictory results in the impact of the red color on the quantity of food eaten by their participants. In the case of Genschow et al. (2012), people ate less food (pretzels) when served on a red plate compared to white and blue plates, while Akyol et al. (2018b) report more food (pasta with tomato sauce) consumed from red plates rather than from white and blue plates. It is suggested that the red color could have a different impact depending on whether healthy (pasta with tomato sauce) or unhealthy (pretzels) food is provided. Perceptions of flavor are also found to be affected by the color of tableware. Piqueras-Fiszman & Spence (2012) suggest that the perception of flavor of hot chocolate is enhanced by the darker color of the cup it is served in as it was expected to be sweeter in a red, orange and dark cream cup rather than in a white one. Also, perceptions of the spicy taste of spicy bean curd is shown to be enhanced if it is placed on a red rather than on a white plate (Tu et al., 2016). Harrar et al. (2011) address that colored bowls enhance perceptions of saltiness of sweet popcorn in comparison with white bowls.

A research by Piqueras-Fiszman et al. (2012) suggests that the contrast between the plate and the food also plays a role in food perception. Their experiment shows that a strawberry mousse is judged more favorably when placed on a white plate rather than on a black one. The researchers suggest that the white color of the plate makes greater contrast with the color of the food, which enhances perceptions of its properties and influences liking.

2.3. The gap in the literature

Through the literature study that was performed (Dzhondzhorova, 2023), it was found that perceived colors play an important role in the domain of impact of visual information on eating behavior that is guided by attitude toward food. Color of the food it is associated with affects liking and judgements toward the respective food (Lupton & Lipps, 2018; Wheatley,

1973). The color of the plateware was also found to affect eating behavior. It is shown to affect consumption (Genschow et al., 2012; Akyol et al., 2018b), and suggested to influence perceptions of taste and flavor (Tu et al., 2016; Piqueras-Fiszman & Spence, 2012). However, evidence about the impact of plateware color on perception of flavor are scarce and need further research. For example, Huisman et al. (2016) found association of specific colors to specific tastes (red associated with sweet, green - with sour, etc.), although they did not find any correlation between color and perceptions of taste or flavor. Tu et al. (2016) addresses that the red color, that is associated with spiciness, if applied to a plate that serves spicy food, enhances the perceived spicy taste of the dish. However, they did not investigate whether there is any impact of the plate color on perception of flavor. Piqueras-Fiszman & Spence (2012) found that darker-colored cups enhance perceptions of the flavor of hot chocolate and therefore, people's liking of it. They suggest that the darker the color of the cup, the more intense the cocoa flavor is expected to be. Still, in order to draw convincing conclusions on the influence of differently colored plateware on perception of different flavors, and explore whether the Sensory Interactive Table can be used in the domain of manipulating food choice with changing perceptions of flavor, further research should be conducted. Therefore, this research investigates the possible impact of colors on food perceptions in two eating settings - one designed with the use of differently colored bowls in an everyday eating context and one designed within an eating context at the Sensory Interactive Table.

3. Research question

In order to fulfill the objectives of this research, that was earlier mentioned in this report - the influence of visual information on flavor perceptions within the Sensory Interactive Table, that from now on will be referred to as SIT, is explored. The research question of this report is provided below:

Main research question: ***Does SIT provide conditions for altering food perceptions by providing visual information to the user?***

In order to answer the research question a study was conducted. It was divided in two steps, the first of which explores the impact of visual information on food perceptions in an everyday eating setting, while the second one explores it in an eating setting within SIT. The two steps will be compared to answer the above given research question.

Since research in literature shows that the information translated from colors as part of received visual information in the domain of eating influences attitudes toward food, namely the influence of colors on perceptions of food is investigated. While the color of the food itself is found to affect judgments toward it, it is suggested that the color of the surface the food is placed on (the color of the plateware) also affects the perceptions of food in a way. Therefore, the first step of the study will explore the impact of colors in the environment on perceptions of food in an eating setting as close as possible to an everyday eating setting in the sense of impact of plateware color on food perceptions. This step of the study intends to inform whether the color of the plateware can alter perceptions of food flavor and serves as a control condition for the study. The second part of the study will investigate the impact of environmental colors on food perceptions in an eating setting within SIT. This part serves as an experimental condition, which from now on will be referred to as SIT condition. The two study conditions will be compared to inform in what way the visual information received by SIT reflects on food perceptions.

To assess perceptions of food, two variables were determined for exploration - *perceived intensity* of the flavor of the food and *liking* of the food. Liking toward food is a determinant variable that guides eating behavior, which is easy to manipulate (Eertmans et al., 2001, Zellner et al., 2014). Liking in turn can be affected by receiving visual information related to color perception signaling food properties that enhance flavor perceptions (Lupton & Lipps, 2018, Kita and Rekimoto, 2013, Piqueras-Fiszman & Spence, 2012). Intensity of perceived flavor was determined as the other variable for exploration since this was found to be the

most appropriate measurement for perception of flavor among other similar researches (DuBose et al., 1980b, Zampini et al., 2007). Therefore, the influence of color in the eating environment on perceptions of flavor intensity and liking of the food will be investigated.

In this direction, to compare findings in the domain of impact of color on food perceptions and liking of the food between the two conditions, lab experiments were conducted. The first experiment - within the control condition intends to examine the impact of visual information regarding colors associated with specific flavors on perceptions of the respective flavors and liking of them in a lab setting that is as close as possible to a real life eating setting. The research questions of the control condition are:

Research question 1: ***Does the color of the plateware, which is associated with a specific flavor, enhance perceptions of the respective food?***

Research question 2: ***Does the color of the plateware, which is associated with a specific flavor, enhance liking of the respective food?***

The analysis of the control condition of the study will provide answers to these questions that will be discussed in the Discussion section. Following, the influence of colors in the eating environment on perceptions of food will be researched in the SIT condition. The SIT condition involves exploring the impact of colors on flavor perceptions and liking of the food in an eating setting within SIT. However, it was unknown whether the appearance of the tableware on the surface of SIT would influence the dependent variables and, consequently, the SIT condition was divided in two concepts. One of them will research the influence of projected colors on the dependent variables, where the plateware the food is served in has a color that stays between the projections and the food. This concept will investigate the way color information received by SIT influences perceptions of food when white colored plateware is used to contain the food. The other concept will research the influence of the projected colors on the same variables when the projections under the food are directly visible and non-colored material lies in between. This way, the projections would affect the appearance of the yogurt and the lightning is supposed to enhance its color. This concept will involve the use of transparent glass plateware in the SIT condition. Therefore, the following research questions with sub-questions were formed to investigate the SIT condition of the study:

Research question 1: ***Does the visualized color on the table, which is associated with a specific flavor, enhance perceptions of the respective food?***

RQ 1.1. Does the visualized color on the table, which is associated with a specific flavor, enhance perceptions of the respective food if a neutral colored plateware (white) is used?

RQ 1.2. Does the visualized color on the table, which is associated with a specific flavor, enhance perceptions of the respective food if a non-colored plateware (transparent-glass) is used?

Research question 2: ***Does the visualized color on the table, which is associated with a specific flavor, enhance liking of the respective food?***

RQ 1.1. Does the visualized color on the table, which is associated with a specific flavor, enhance liking of the respective food if a neutral colored plateware (white) is used?

RQ 1.2. Does the visualized color on the table, which is associated with a specific flavor, enhance liking of the respective food if a non-colored plateware (transparent-glass) is used?

To answer the research questions of all conditions of the study, lab experiments with participants were performed. Results will be provided and discussed to inform about possibilities for altering perceptions of food when colored plateware in an everyday eating setting is used, as well as in an eating setting within the presence of technology (eating setting within SIT). The main research question of this report will be answered and evaluated to provide knowledge on whether visual information received by SIT is translated the way it is in an eating setting where technology is not present in the eating environment - in an everyday eating setting. This finding will contribute to designing new concepts of eating within SIT, where previous knowledge in literature regarding the influence of visual information on eating behavior can be used as a basis.

4. Methodology

To answer the research question of this report, three laboratory experiments were conducted. Individual sessions with participants were performed. The participants were asked to assess the intensity of flavor of the food that was provided and their liking of it on 9-point assessment scales.

4.1. Study design

To answer the research question of this report three laboratory experiments were conducted. The first one is a control condition that investigates the influence of the red, yellow and blue colors that are associated with specific fruit flavors on perception of the respective food. The other two are SIT condition that inspect the influence of the respective colors on the same variables in eating concepts within SIT. One of the SIT experiments involves the use of white colored plateware, while the other one - a transparent glass plateware. Overview of the three settings can be seen in Table 1.

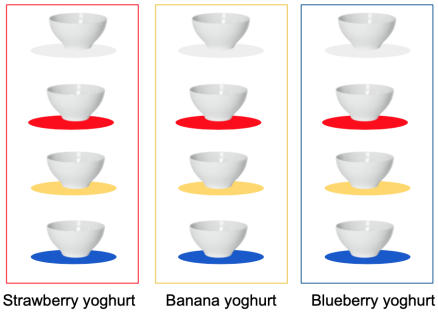
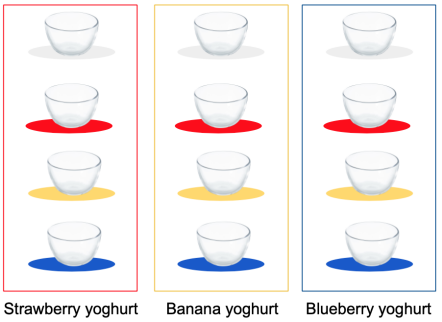
Control condition	**SIT condition**	
differently colored bowls used in an everyday eating setting	*white colored plateware on colored circles concept used in an eating setting within SIT*	*transparent-glass plateware on colored circles concept used in an eating setting within SIT*
		

Table 1. Overview of all experimental settings

4.1.1. Control condition study design

The experiment took place in the Interaction Lab at the University of Twente where the interactive dining table is. Participants were individually invited to take a seat at the interactive table and were presented with 3 sets of four bowls with flavored yogurt (strawberry, banana and blueberry yogurt). Each set of four bowls contained white, red, yellow and blue bowls. Participants were given four teaspoons for each set and were invited to taste the content of each bowl. A questionnaire asking about the perceived flavor intensity

and the liking of the yogurt on a nine-point likert scale was displayed on a laptop in front of the participants during the whole procedure. Participants were asked to first taste the yogurt of a bowl and right after that to assess their perceptions and liking of it. A glass of water was available to the participants to cleanse the palate after tasting each flavor of yogurt. The eating setting of the control condition and questions regarding each bowl of yogurt can be seen in figures 4 and 5 respectively.

Figure 4. Experiment setting in the control condition with strawberry yogurt. The blueberry and the banana flavors were presented using the same setting to the participants.

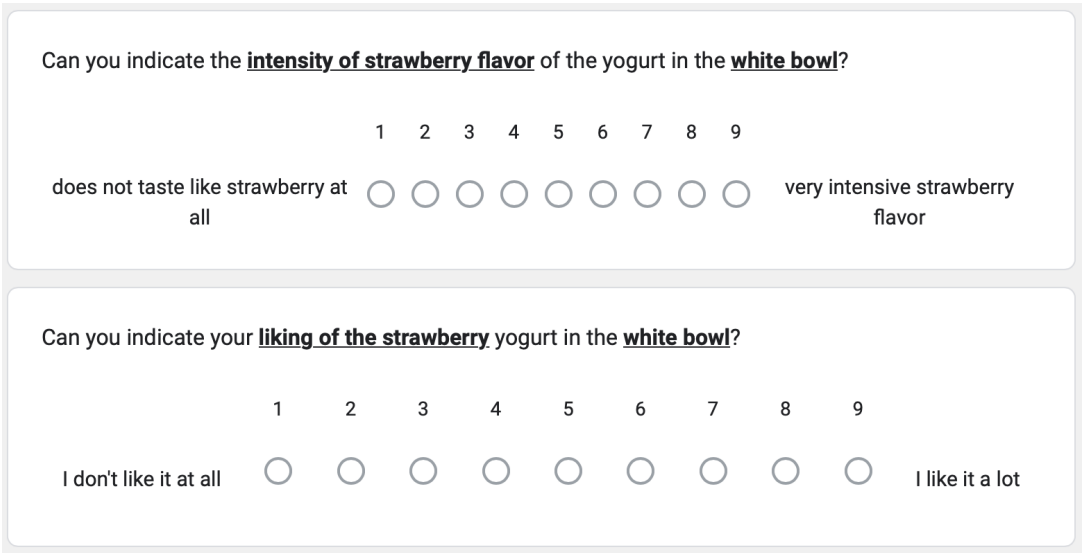


Figure 5. Questions regarding the specific flavor and the specific color of the bowl. Full questionnaire can be seen in Appendix 1.

4.1.2. SIT condition study design

4.1.2.1. White colored plateware concept

The independent variables used for the control condition of the study - the white, red, yellow and blue colors and the strawberry, banana and blueberry yogurt were used in the SIT condition to examine the dependency of perception of flavor intensity and liking toward the presented food within the SIT eating setting. Participants were invited one by one to the Interaction Lab at the University of Twente. They were seated at SIT and were presented with 3 sets of four bowls with flavored yogurt (strawberry, banana and blueberry fyogurt). The yogurt of each set was served in white bows under each of which a colored circle was visualized on the surface of the table. Under one of the bowls of each set a white circle was visualized and under the others - red, yellow or blue circles. Overview of the experimental setting can be seen in figure 6. Participants were given spoons for each set of bowls and after tasting the yogurt from each bowl they were asked to indicate the intensity of the perceived flavor of each bowl and their liking of it on a nine-point likert scale similar to the one used in the control condition.

Figure 6. Bowls of strawberry-flavored yogurt used in the SIT condition in the white colored plateware concept. The blueberry and the banana flavors were presented in the same manner

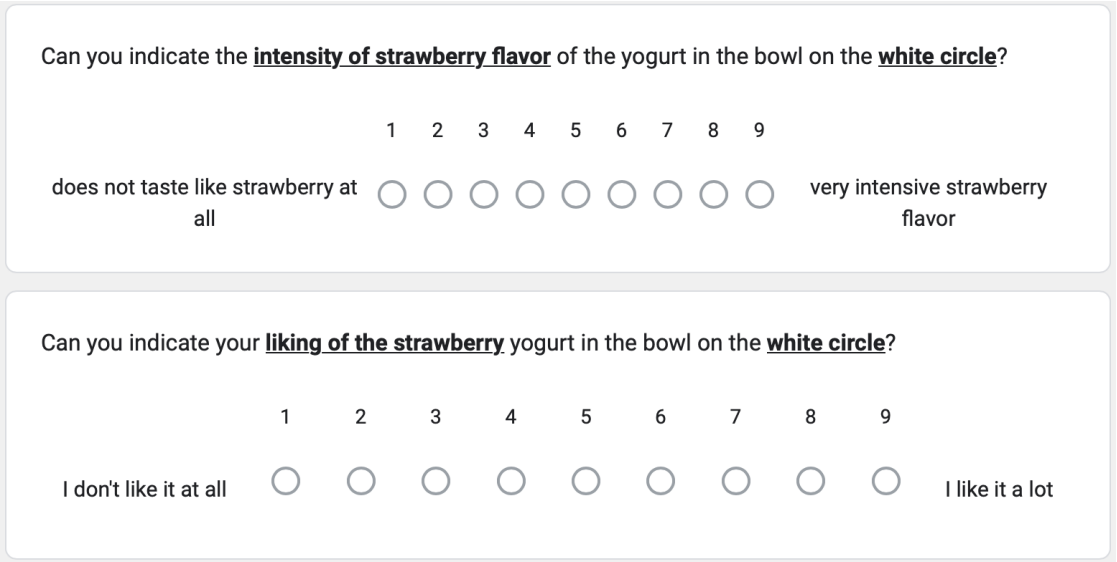


Figure 7. Questions regarding the specific flavor and the specific color of the circle displayed under the bowl. Full questionnaire can be seen in Appendix 2

4.1.2.2. Transparent glass plateware concept

The transparent glass plateware concept within SIT used the same setting as the white colored plateware one, with the only difference being the visual appearance of the bowls. They were transparent-glass instead of white. The second concept's setting within SIT can be seen in figure 8.

Figure 8. Second concept setting within SIT in the transparent glass plateware concept with strawberry yogurt in the bowls. Blueberry and banana flavors were presented in the same manner

4.1.3. Materials

Four colored bowls were used in the control condition - white, red, yellow and blue. For the SIT condition transparent glass bowls and white bowls were used. For both conditions the same three kinds of flavored yogurt were used - strawberry, banana and blueberry.

4.1.4. Participants

A total sample size of 51 participants was determined. For calculating the power of the study the G*Power 3.1 software for computing statistical power analyses for different tests. A repeated measures design of the study with within factors was selected, where the effect size is 0.05, an alpha level of 0.05 and desired power value of 80%. For a number of groups a value of 1 was entered since each part of the whole study was planned to be conducted as an individual experiment and to be separately analyzed. Although the output for the calculation suggested a total sample size of 10 participants for each group, a larger sample of 17 people per group was determined.

Participants were reached through directly asking them for their willingness to take part in the study in the Interaction Lab and the surrounding buildings on the territory of the University of Twente.

4.1.5. Procedure

- Participants were given an information brochure explaining the procedure and objective of the study and informed consent form for signature for participation (Appendices 12 - 13).
- Participants were asked first to taste the yogurt from the first set of flavors (the strawberry one) and right tasting the yogurt of each bowl to assess its flavor intensity and their liking of it. After tasting and answering the questions regarding the first flavor, they were given the following one (blueberry yogurt in 4 bowls) and when finishing with assessment of it, they were provided with the last four bowls of yogurt (the banana flavor).
- Participants were thanked for their participation.

5. Data analysis

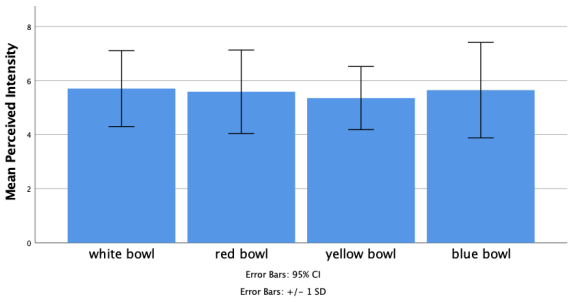
For analyzing the data collected from the experiments Microsoft Excel and SPSS software for statistical analysis were used. The coding of the variables can be seen in Appendix 3. Repeated measures ANOVA with within-subject factors - perceived intensity with 4 levels and liking with 4 levels (for the 4 different colors of the bowls/the 4 differently colored circles displayed under the bowls) for each of the flavors were performed. The tests results are presented in the following section with tables and graphs, while the individual scores of the participants, visualized in Excel, are given in the Appendices.

5.1. Results

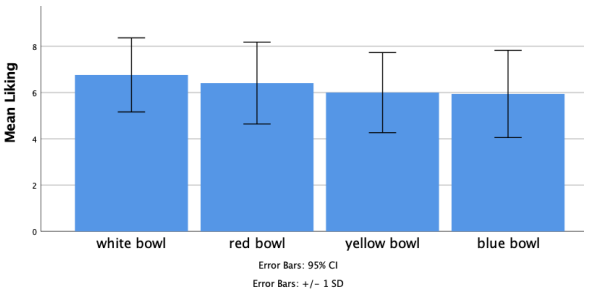
In this section the results of the study in the control condition and in the SIT condition will be presented. First, the following subsection will provide the results in the control condition where everyday materials (differently colored bowls) were used. After this, the results of the SIT condition will be presented and in the last subsection of this section an overview of the results for perceived flavor intensity and liking of the yogurt in the two experimental conditions will be provided.

5.1.1. Control condition study results

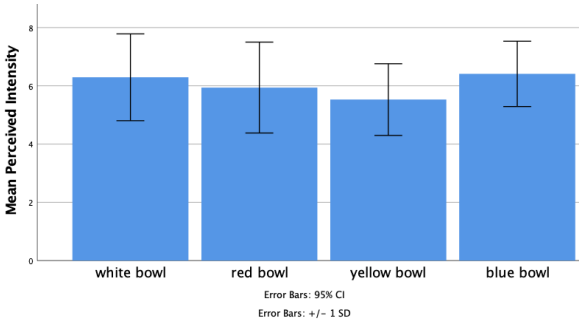
All the participants (n=17) in the control condition were invited to taste strawberry, blueberry and banana yogurt in 4 differently colored bowls (white, red, yellow and blue bowls) and to assess the perceived intensity of the flavored yogurt and their liking of it. The means of the two dependent variables (perceived intensity and liking) for each colored bowl containing each flavor of the yogurt are graphically visualized in figure 9, while the descriptives are shown in table 2. According to the results of the ANOVA only the perceptions of intensity of banana yogurt are significantly different when served in differently colored bowls (Wilks' Lambda = 0.558, $F(3,14)=3.703$, $p=0.038$, Appendix 8). Pairwise Comparisons inform that there are significant differences in perceptions of intensity of the yogurt between the white and the yellow bowls ($p= 0.41$) and the white and the blue bowls ($p= 0.027$).
The individual assessment of all participants and tables of ANOVA output can be seen in Appendices 4-8.



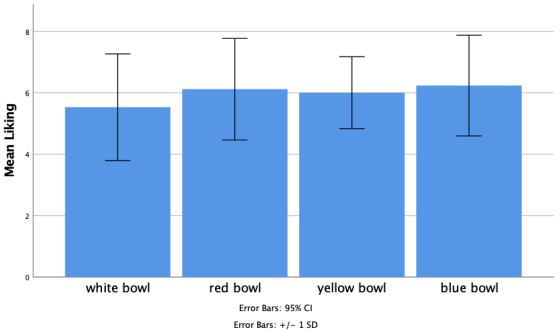
a) Perceived intensity of strawberry yogurt



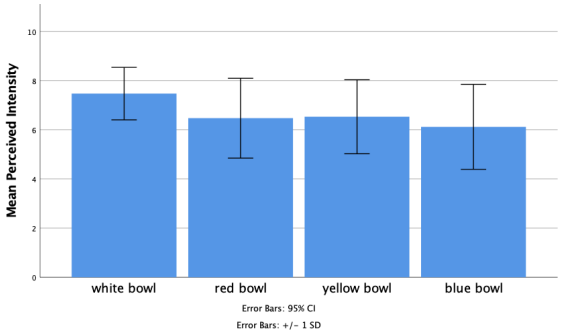
b) Liking of strawberry yogurt



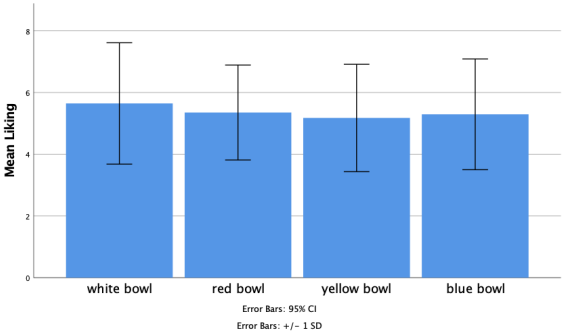
c) Perceived intensity of blueberry yogurt



d) Liking of blueberry yogurt



e) Perceived intensity of banana yogurt



f) Liking of banana yogurt

Figure 9. Means of perceived flavor intensity and liking of strawberry, blueberry and banana yogurt in 4 colored bowls

Perceived intensity of flavored yogurt in 4 colored bowls												
Yogurt flavor	In a white bowl			In a red bowl			In a yellow bowl			In a blue bowl		
	M	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*
Strawberry	5.71	1.404	6.00	5.59	1.543	6.00	5.35	1.169	5.00	5.65	1.766	6.00
Blueberry	6.29	1.490	6.00	5.94	1.560	6.00	5.53	1.231	6.00	6.41	1.121	6.00
Banana	7.47	1.068	7.00	6.47	1.625	7.00	6.53	1.505	7.00	6.12	1.728	6.00

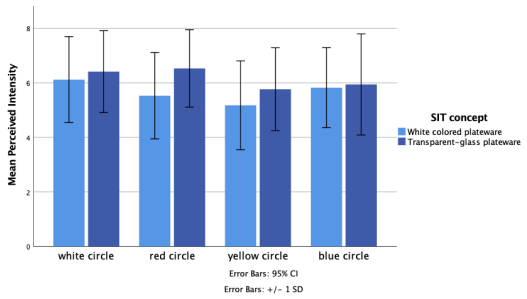
Liking of flavored yogurt in 4 colored bowls												
Yogurt flavor	In a white bowl			In a red bowl			In a yellow bowl			In a blue bowl		
	M	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*
Strawberry	6.76	1.602	7.00	6.41	1.770	7.00	6.00	1.732	6.00	5.94	1.886	6.00
Blueberry	5.53	1.736	6.00	6.12	1.654	7.00	6.00	1.173	6.00	6.24	1.640	7.00
Banana	5.65	1.967	6.00	5.35	1.539	5.00	5.18	1.741	5.00	5.29	1.795	6.00

Table 2. Descriptives of perceived intensity and liking of strawberry, blueberry and banana yogurt in 4 colored bowls

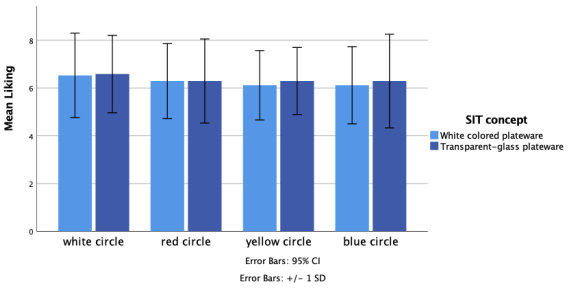
5.1.2. SIT condition study results

The results of the SIT condition are presented in this subsection. Differences between the two SIT concepts are graphically visualized, where the experimental setting with white bowls on displayed colored circles will be referred to as the white colored plateware concept and one with the use of transparent glass bowls will be referred to as the transparent glass plateware concept.

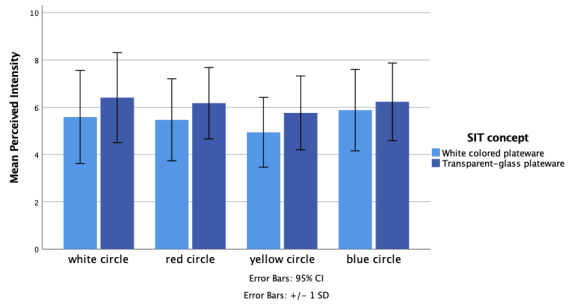
In the SIT condition all participants (n=34) were invited to taste strawberry, blueberry and banana flavored yogurt in 4 bowls positioned on visualized colored circles (white, red yellow and blue circles) on the surface of SIT, where one half (n=17) were assigned to the white colored plateware concept and the other half (n=17) were assigned to the transparent glass plateware concept. The mean scores of the dependent variables - perceived intensity and liking of the flavored yogurt in both SIT concepts are visualized in figure 10, while the values in the descriptives are given in tables 3 and 4. The output of the performed ANOVA shows significant differences in the mean scores of the perceived intensity of the blueberry yogurt in the white colored plateware concept (Wilks' Lambda = 0.440, F(3,14)=5.937, p=0.008, Appendix 10). Pairwise Comparisons do not show significant differences between the means of each pair of bowls on the colored circles (p>0.05).



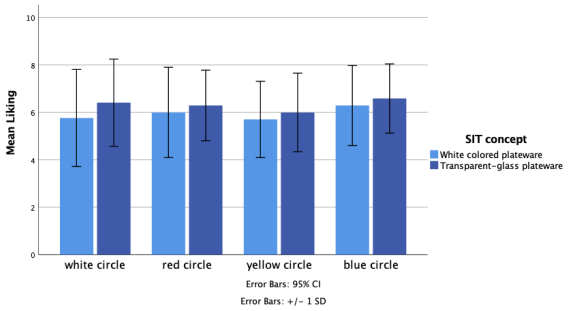
a) Perceived intensity of strawberry yogurt



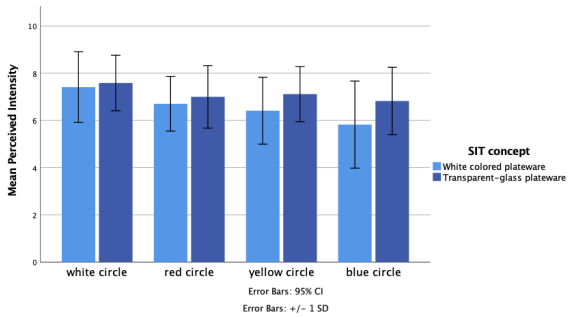
b) Liking of strawberry yogurt



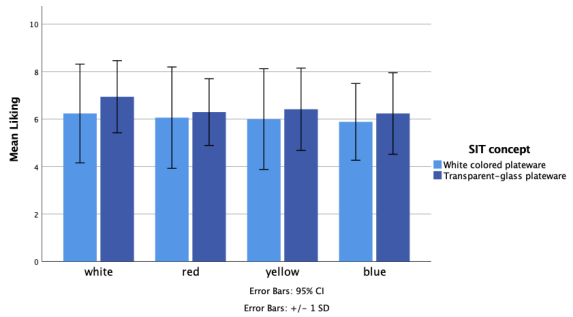
c) Perceived intensity of blueberry yogurt



d) Liking of blueberry yogurt



e) Perceived intensity of banana yogurt



f) Liking of banana yogurt

Figure 10. Means of perceived flavor intensity and liking of strawberry, blueberry and banana yogurt in 4 bowls on colored circles in both SIT concepts

Perceived intensity of flavored yogurt in 4 white bowls on colored circles												
Yogurt flavor	On a white circle			On a red circle			On a yellow circle			On a blue circle		
	M	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*
Strawberry	6.12	1.576	6.00	5.53	1.586	6.00	5.18	1.629	6.00	5.82	1.468	6.00
Blueberry	5.59	1.970	6.00	5.47	1.736	6.00	4.94	1.478	5.00	5.88	1.728	7.00
Banana	7.41	1.502	8.00	6.71	1.160	7.00	6.41	1.417	6.00	5.82	1.845	6.00
Liking of flavored yogurt in 4 white bowls on colored circles												
Yogurt flavor	On a white circle			On a red circle			On a yellow circle			On a blue circle		
	M	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*
Strawberry	6.53	1.772	7.00	6.29	1.572	7.00	6.12	1.453	6.00	6.12	1.616	6.00
Blueberry	5.76	2.047	6.00	6.00	1.904	6.00	5.71	1.611	6.00	6.29	1.687	7.00
Banana	6.24	2.078	7.00	6.06	2.135	6.00	6.00	2.121	7.00	5.88	1.616	6.00

Table 3. Descriptives of perceived intensity and liking of strawberry, blueberry and banana yogurt

in 4 bowls in the white colored plateware SIT concept

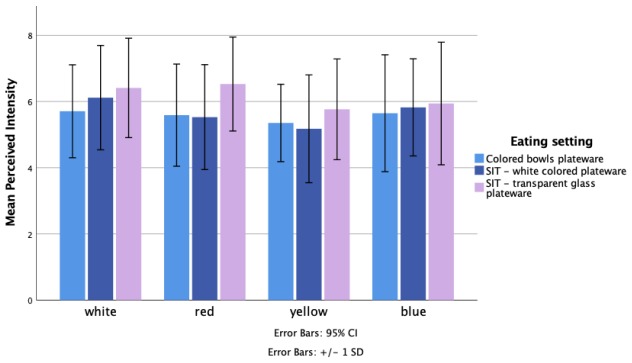
Perceived intensity of flavored yogurt in 4 transparent glass bowls on colored circles												
Yogurt flavor	On a white circle			On a red circle			On a yellow circle			On a blue circle		
	M	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*
Strawberry	6.41	1.502	7.00	6.53	1.419	7.00	5.76	1.522	6.00	5.94	1.853	6.00
Blueberry	6.41	1.906	7.00	6.18	1.510	6.00	5.76	1.562	6.00	6.24	1.640	6.00
Banana	7.59	1.176	8.00	7.00	1.323	7.00	7.12	1.166	7.00	6.82	1.425	7.00
Liking of flavored yogurt in 4 transparent glass bowls on colored circles												
Yogurt flavor	On a white circle			On a red circle			On a yellow circle			On a blue circle		
	M	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*	*M*	*SD*	*Median*
Strawberry	6.59	1.622	7.00	6.29	1.759	7.00	6.29	1.404	6.00	6.29	1.961	7.00
Blueberry	6.41	1.839	7.00	6.29	1.490	6.00	6.00	1.658	6.00	6.59	1.460	7.00
Banana	6.94	1.519	7.00	6.29	1.404	6.00	6.41	1.734	7.00	6.24	1.715	7.00

Table 3. Descriptives of perceived intensity and liking of strawberry, blueberry and banana yogurt in 4 bowls in the transparent glass plateware SIT concept

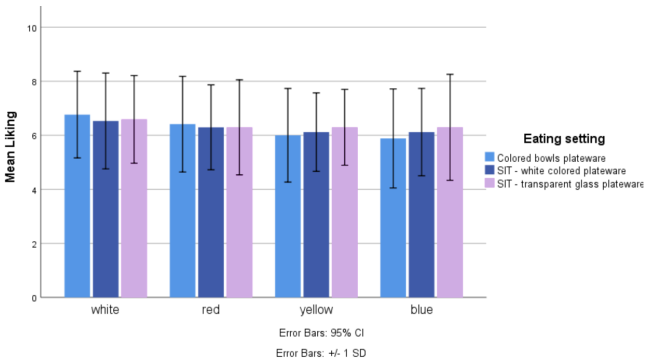
5.1.3. Overview of both experimental conditions results

In this subsection an overview of the results for perception and liking of the yogurt in the two experimental conditions is visualized and commented on. The labels for the colors under the bars relate to the color of the bowls in the control condition and to the color of the circles under the bowls in the SIT condition.

- Strawberry flavored yogurt



a) Perceived intensity of strawberry yogurt

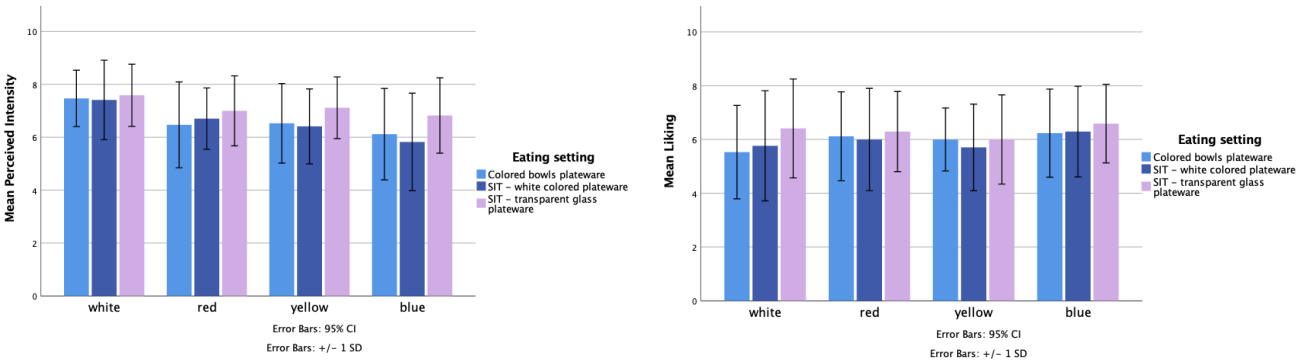


b) Liking of strawberry yogurt

Figure 11. Means of perceived intensity and liking of strawberry yogurt in the control condition and in the SIT condition

The strawberry flavor of the yogurt is shown to be overall perceived more intensely when served in transparent glass bowls in the SIT eating concept than in the other two eating settings (figure 11a). What is more, it can be noticed that the yogurt in the bowl on the red circle was perceived to be the most intense among all. The liking of the yogurt that is visualized in figure 11b shows very slight differences in mean scores among all bowls in the 3 experiments. As already presented in the previous two subsections where the results are shown in detail, the yogurt was liked the most in the white and red bowls in the control condition as well as in the bowls on the white and red circles in both SIT concepts.

- Blueberry flavored yogurt

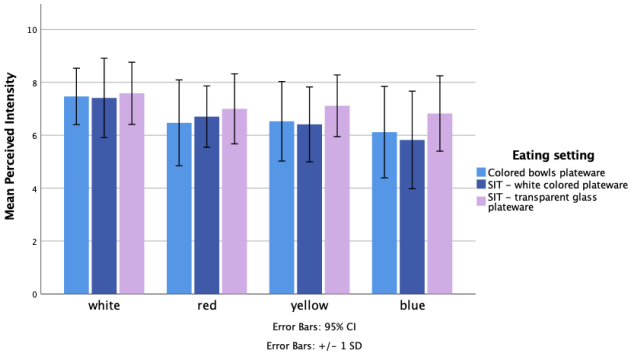


a) Perceived intensity of blueberry yogurt *b) Liking of blueberry yogurt*

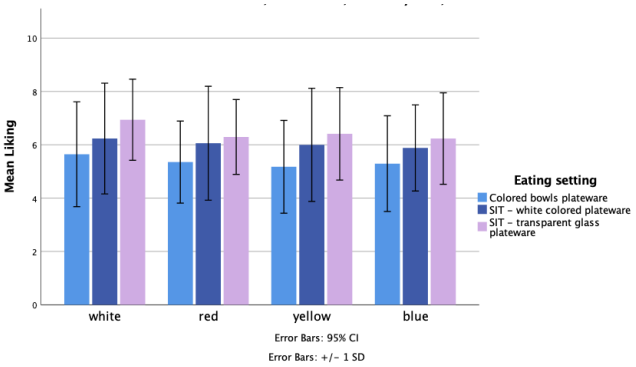
Figure 12. Means of perceived intensity and liking of blueberry yogurt in the control condition and in the SIT condition

The blueberry flavor is also shown to be overall perceived most intensely and to be liked the most in the transparent glass SIT concept among the experimental conditions (figure 12). The yogurt in the blue colored bowl in the control condition and the one in the bowl on the blue circle in the white colored plateware SIT concept have the highest mean scores for perceived intensity of flavor in the respective conditions. In the transparent glass SIT concept the most intense flavor is assessed to be in the bowl on the white circle followed by the one on the blue circle. However, the highest median score is assigned to the bowl on the blue circle, as well as the number of individual scores for perceived intensity above the average in all bowls (see the previous subsections where the results of each study are presented). The liking of the flavor in both conditions is the highest for the yogurt in the blue bowl/in the bowl on the blue circle.

- Banana flavored yogurt



a) Perceived intensity of banana yogurt



b) Liking of banana yogurt

Figure 13. Means of perceived intensity and liking of banana yogurt in the control condition and in the SIT condition

The banana flavor is shown to be overall perceived most flavor intensely and to be liked the most within the SIT concept when transparent glass bowls were used (figure 13). The flavor is assessed with highest scores for intensity and liking in the white bowl in the control condition and in the bowls on the white circle in both SIT concepts. It can be noticed that for the control condition and the white colored plateware SIT concept the perception of intensity decreases gradually with every next respective bowl for tasting. In the transparent glass SIT concept the most intense flavor is in the bowls on the white and yellow circles with slight differences. Similar trend in the data is shown for the liking of the flavor among the bowls in the 3 eating settings. Figure 13b visualized the decrease of liking of the yogurt in every subsequent bowl for tasting for the control condition and the white colored plateware SIT concept.

6. Discussion

The main research question for this thesis is - "*Does SIT provide conditions for altering food perceptions by providing visual information to the user?*". To answer it, first the influence of visual information on flavor perceptions in an everyday eating setting was investigated in order to compare whether the visual information received by SIT in the same context has the same impact on perceived flavor and liking of the food. Hence, research questions were formulated regarding the influence of visual information within an everyday eating setting and an eating setting within SIT. The visual appearance of the plateware in the eating setting within SIT was also questioned to influence perceived information from colors. Therefore, sub-research questions for the SIT eating setting were formed to investigate the impact of visualized colors that are associated with the flavor of the available food when they were directly visible (when transparent glass plateware was used) and when there a neutral color of the plateware between the food and the visuals (white colored plateware). Thus, three experiments were executed - one with the use of everyday eating materials (control condition) and two within SIT (SIT condition) - one with the use of white colored bowls and colored circles displayed under them (white colored plateware concept) and one with the use of transpired-glass bowls and visualized colored circles (transparent glass plateware concept). In this section, in order to answer the main research question of the report, first the research questions and their sub-questions that were answered by the performed experiments will be discussed.

First of all, the research questions for the control condition within an everyday eating setting will be discussed. They are as follow:

Research question 1: ***Does the color of the plateware, which is associated with a specific flavor, enhance perceptions of the respective food?***

Research question 2: ***Does the color of the plateware, which is associated with a specific flavor, enhance liking of the respective food?***

The results for the strawberry yogurt among the 4 colored bowls in the everyday eating setting show that the perceived intensity of flavor and liking of it are the highest for the white and red bowls respectively. Although the means for both variables are higher for the white bowl, the red color of the bowl can be suggested to enhance them (regarding median and individual assessment of participants that are provided in the Appendices). The higher score in the mean of perceived intensity and liking of the flavor in the white bowl might be a result

of the order for tasting the yogurt of each colored bowl that was the same for every participant which might have diminished the perceived intensity with each consecutive taste. Hence, considering this limitation together with some other limitations that are further explained in the Limitations section, an impact of the red color of the bowl on perceptions of flavor intensity and liking of the strawberry yogurt can be suggested.

The perception of blueberry flavor and liking of it are found to be enhanced by the blue color of the bowl it was served in. As expected, the differences in the mean scores for perceived intensity and liking of the flavor among the differently colored bowls were not found to be significant (since the yogurt in all bowls for all of the participants was from the same brand and kind). However, in the Results section it can be seen that regarding the means, medians and the individual assessment of the participants in the Appendices, the yogurt in the blue bowl was perceived to be the most flavor intense and to be liked the most among the one in the other bowls. Tus, visual information perceived through the environment where food is served and consumed in this case, the color of the plateware that was associated with the specific flavors, is shown to influence our judgements on food properties. Similar findings demonstrate the work of Spence et al. (2014), where red wine is found to be significantly more fruity and to be liked more when the lightning in the room was red, rather than when it was white or green. Their research proposes the influence of the perceived color in the environment, that is associated with the ripeness/unripeness of the respective flavor of the drink.

On the other hand, the perceptions of intensity of banana flavor and liking of the yogurt were not found to be enhanced by the yellow color of the bowl. One possible reason for this might be that the specific flavor might not be very much associated with the specific color in general. For instance, a study by Wan et al. (2016), shows that the yellow color is mostly associated with lemon, pineapple and lime. Another study by Zampini et al. (2007) shows that the color is mostly associated with lemon, pear, apple and melon. Hence, this could be a reason why it did not show any impact on the variables that were measured.

The other part of the study (the SIT condition) that investigated the influence of colors on food perceptions within SIT intended to answer the following questions:

Research question 1: ***Does the visualized color on the table, which is associated with a specific flavor, enhance perceptions of the respective food?***

Research question 2: ***Does the visualized color on the table, which is associated with a specific flavor, enhance liking of the respective food?***

The results of the conducted experiments within both SIT concepts show that the blue color of the circle projected on the surface of SIT enhances the perceptions of blueberry flavor of the yogurt in the bowl and its liking, regardless of the appearance of the bowl (white or transparent glass). The visual information received by the blue color in both the everyday eating setting and in the eating setting within SIT is found to possess the most convincing results for the suggestion that the color a food is associated with enhances the perceived food properties. This is an interesting finding, since very little is known and researched about the influence of the blue color in the domain of food and drinks perceptions. For example, most of the consumers associate it with sweet fruit flavors, most often - raspberry (Shankar et al., 2010, Velasco et al., 2016b). Spence (2021b) suggests that the blue color captures our attention in the domain of eating, since it is quite a rare food color compared to other colors. If this is the case, and knowing that the color of ripeness of fruit influences judgements about the properties of the food, and, considering the influence of perceived environmental visual information on food perceptions, an impact of the blue color in the plateware and the projected blue color on the surface of SIT on perceptions of the provided food can be noted.

For the strawberry flavor in both SIT concepts, when discussing the results it should be taken into account the limitation of the study for the same order for tasting the yogurt from all bowls for the participants and some other limitations that are further explained in the Limitations section. Thus, an influence of the red color of the projected circle on the perceptions of flavor and liking of the yogurt can be suggested. What is interesting, the transparent glass concept shows higher scores for the assessment of both variables, which suggests a greater influence of the visual information perceived through SIT when it is directly visible (there is no color of the plateware in between the surface of SIT and the available food). This could be a result of the already discussed impact of perceived color of ripeness on judgements of food properties, that might be enhanced when visual information from SIT is directly received.

Interesting finding about the banana flavor of the yogurt is that in the white colored plateware concept in the SIT condition, no impact of the yellow color on perceptions of the flavor and liking is found, as no such is found in the everyday eating setting, however, such an impact is suggested in the SIT setting with the transparent glass plateware. In the transparent glass bowls concept, when considering the limitation for the same order for tasting the yogurt in the bowls, and other limitations, an impact of the yellow color on

perceptions of flavor and liking can be suggested. This is interesting, since the experiment with the control condition did not reveal such insights, what is more, it even informed about significance in the results for the strongest intensity of flavor in the white bowl. This possible influence of the yellow color on flavor perceptions on banana flavor when the yogurt is served in a transparent glass bowl is worth further investigating.

Interesting insight for the SIT condition where transparent glass pateware was used is that for all the flavors (strawberry, blueberry and banana) the perceptions of flavor intensity and the liking of them are higher than in the other two experimental eating settings (the everyday eating one and the white colored plateware SIT one). This suggests that the visual information perceived through SIT has a greater impact when it is directly received and the color of the plateware, even a neutral one (white) can be an obstacle for translating it. What is more, the information received by colors through SIT has a greater impact on perceptions of food than the one received by colors of plateware in an everyday eating setting. Therefore, further research of the impact of visual information in the domain of eating within SIT is worth conducting. However, some limitations in this research should be considered.

6.1. Limitations

Some of the limitations of the study were recognised during or after a procedure within an experiment, that should be taken into consideration when further research is executed.

To begin with, as mentioned in the previous section, the order for tasting the yogurt of the bowls for all of the participants in each study setting was the same - the participant was asked to first taste the yogurt in the white bowl (bowl on the white circle), followed by the yogurt in the red, yellow and blue bowls (by the bowls on the red, yellow and blue circles). What is more, the order of providing the flavors for tasting was also the same - first they were asked to taste the strawberry flavor, then the blueberry flavor and lastly, the banana flavor. This might have biased their assessment in the sense that they might have become more familiar with the taste with each subsequent spoon of yogurt and might have perceived the flavor less intensely.

Limitation of the SIT condition design can be considered the arrangement of the visualized circles on its surface. The bowl on the circle that had to be tasted and assessed the last - the one on the blue circle in some cases happened to be too far from the participant and they had to pick it up from the surface of the table. This might have diminished the impact of the color on their perceptions, if any.

Another limitation of the study is the time of the day of the procedure. The participants were not asked whether they did have a meal beforehands and this might have influenced their perceptions and liking - if some people were hungry, they might have assigned higher scores, or if they were sated, they might have assigned lower scores).

The specific type of the food used in the experiments was found to have an impact on judgements. The yogurt used for the tree studies is from the same brand, which is produced with fruit pieces in it. One of the participants mentioned that they did not like the yogurt in the bowls where there were more fruit pieces. Thus, the unequal distribution of the fruit pieces in the yogurt in each bowl might have influenced the assessment of the participants in a way.

Lastly, the personal scores of the participants presented in the Appendices show that some people assigned very low scores for their perceptions of flavor intensity and/or liking of a flavor. This might be because of their personal preferences, for instance, they might not like the respective flavor in general or they might not like the one used in the study specifically.

6.2. Implementation in the domain of HCI

The information that derived from this research regarding the affected food perceptions of the blueberry yogurt by the blue color as well as the suggested impact of the red and yellow colors on perceived flavor and liking of strawberry and banana flavors respectively shows that SIT can be a tool for enhancing sensory experiences when eating.

Recently a growing body of research in the domain of HCI regarding eating is done. Example for this is the work of Velasco and Obrist (2020) that demonstrates designing multisensory eating experiences for space travels. They suggest that, since the food in space can be bland and the whole experience of eating islating, concepts that support perceptions of food and eating experiences should be developed. They address that it is important not only to research and design ways to enhance this vital domain for current space travelers, but also for futuristic scenarios where eating in space is a possible common experience.
Another example of research and design for user experiences when eating is the extensive work of Charles Spence. In many of his studies, together with other researchers they investigate the impact of changes in the environment when eating on the eating behavior. For example, from the way of influencing perceptions of wine taste by changing the light in a room (Spence et al., 2014) all the way to enhancing perceptions of freshness of chips using

headphones for ‘crispy sounds’ (Zampini & Spence, 2010). Many of his experiments in the domain of eating keep the presence of technology in the background, while the work of other researchers make it much more visible. For instance, a study by Narumi et al. (2011) shows how different flavors can be augmented into a plain cookie with the help of AR technology.

This research adds to the space of HCI where the impact of visual information, perceived through the surface of a sensory interactive dining table, on perceived food properties was examined. The findings derived regarding the impact of colors, associated with particular foods, in the sense of them enhancing the perceptions of the food can be used for further research and development of concepts in the domain of eating. For example, knowing that the perceptions of flavor and liking of food are enhanced by the colors it is associated with, that are perceived by SIT, concepts nudging toward healthier eating choices can be developed. For example, this finding can be used as a basis for further research on whether the visualized color on SIT, that is associated with a food that is healthy, will enhance its properties and in the presence of another unhealthy food, healthier choice will be stimulated. What is more, not only these findings can be used in stimulating healthy eating choices, but also, they can serve to enhance experiences when eating in different contexts (e.g. for enhancing flavor perceptions for space travels). Velasco and Obrist (2020) also address that as we age, our senses go through changes and we are less likely to enjoy the food we eat because it is perceived as less tasteful. Knowing that colors perceived through SIT can enhance perceptions of the food, concepts that make the experience of eating more delightful can be further researched. In this direction, the impact of colors on eating behavior within SIT is worth further investigating.

7. Conclusion

Since the presence of technology in our everyday lives is spreading rapidly, concepts within the HCI field are constantly developing. Findings in literature are used as a heading point to design interactions between the human and the computer. In the domain of eating, the sensory interactive table (SIT) might be a powerful solution to problems related to eating disorders and a mean for nudging toward healthier eating choices. Hence, the objective of this thesis was to investigate whether visual information received through SIT influences perceptions of flavor and liking of the food that is available. More specifically, it was investigated whether the color that a specific flavor is associated with, when displayed on the surface of SIT, will enhance the perceptions of flavor of the food and the liking toward it.

Therefore, the impact of the plateware color on flavor perceptions and liking was first explored in an everyday eating setting (a control condition). Later, the impact of the same colors within SIT eating setting (SIT condition) was investigated to identify whether the information received by SIT is perceived the same way as in an everyday eating setting. It was also examined whether the color of the plateware within the SIT condition will have any impact on perceptions of food. Therefore, the SIT condition explored two eating concepts - white colored plateware concept where white bowls for containing the yogurt were used and transparent glass plateware concept where transparent bowls for the yogurt were used. The control condition revealed that the blue color of the plateware enhanced the perceptions of flavor and liking toward the food (the blueberry yogurt), the red colored plateware is suggested to also enhance perceptions of food flavor it is associated with (the strawberry yogurt), whereas, the yellow color was not found to have an impact on perceived banana flavor and liking of it. It was discussed that in previous research the yellow color is mostly associated with other fruits such as lemon, pineapple, pear, etc., (Wan et al., 2016, Zampini et al., 2007) which is a possible reason why it did not show an impact on perceptions of banana flavor.

The SIT condition showed roughly the same results for the impact of the red and blue colors on the respective flavors, regardless of the color of the plateware that was used (white or transparent-glass). Interestingly, the banana flavor is suggested to have been enhanced by the yellow color on SIT, only in the transparent glass plateware concept. What is more, the perceived intensity of flavor and liking among all flavors are generally higher in the transparent glass plateware concept than in the other two experimental settings in the study. This opens up space for further research in the domain of perceived food properties within a SIT eating setting and suggests that the impact of visual information received by SIT might be even more powerful than that received in an everyday eating setting.

7.1. Recommendations for future research

According to the findings of this thesis and the above mentioned limitations of the studies, some recommendations for future research follow.

Considering the impact of the blue color on the perceptions of blueberry yogurt, the suggested influence of the red color on perceptions of the strawberry yogurt and the suggested impact of the yellow color on perceived banana flavor, it would be worth further investigating the impact of the colors on other food flavors related to them. The influence of other colors on flavor perceptions would be interesting to examine as well. Taking into account the limitations of the studies, the design of future studies can be improved according to the type of food to be used, the arrangement of the setting, the time of day of the procedure and the personal preferences of the participants (see the Limitations subsection). It would be also interesting to further explore the impact of colors when a variety of food is available. What is more, knowing that the color that is projected on the surface of SIT can enhance perceptions of the provided food, it would be worth exploring whether it would stimulate healthier choice when healthy and unhealthy food is available. This would enrich knowledge in the field of effect of colors on food perceptions and its impact on eating behavior.

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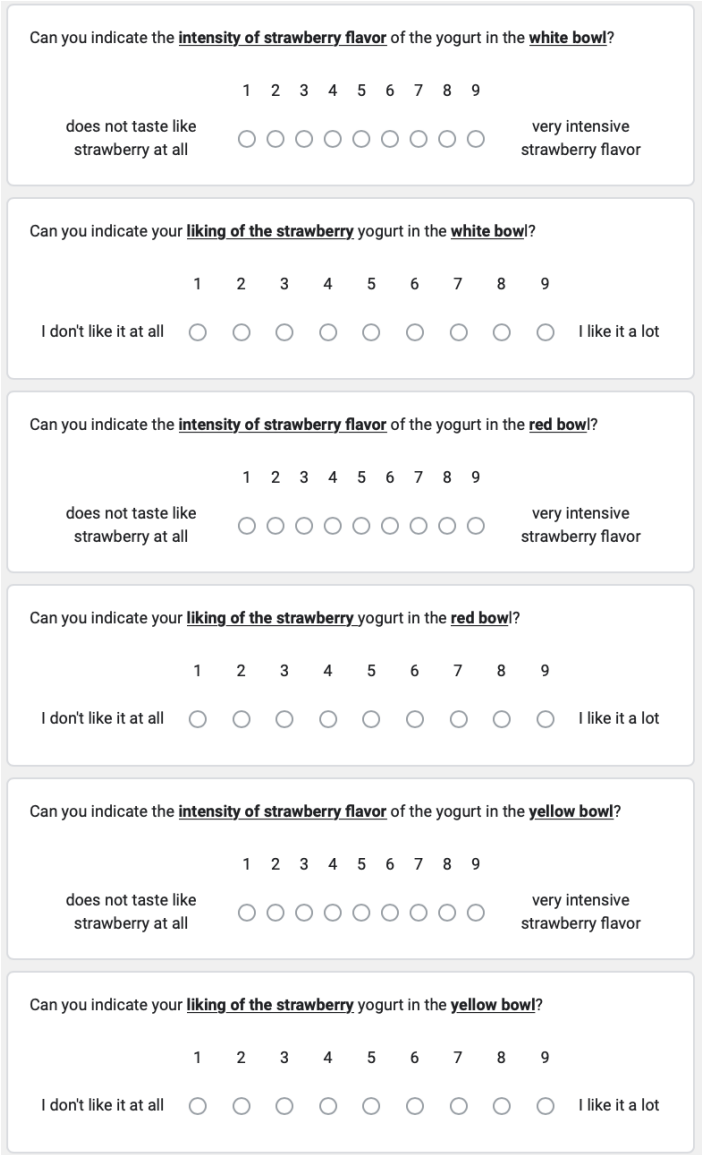
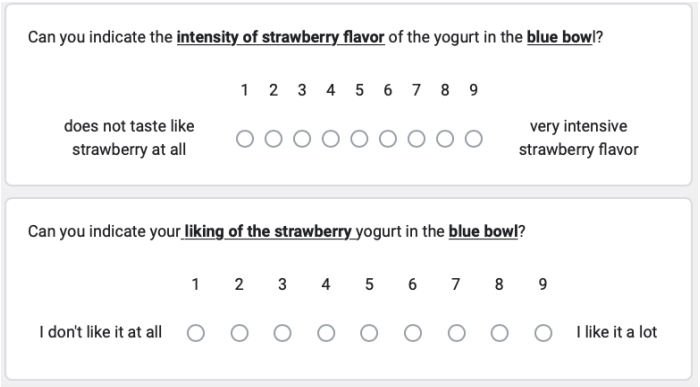
Appendices

Appendix 1: Questionnaires for the differently colored bowls study





Can you indicate the **intensity of blueberry flavor** of the yogurt in the **white bowl**?

	1	2	3	4	5	6	7	8	9	
does not taste like blueberry at all	○	○	○	○	○	○	○	○	○	very intensive blueberry flavor

Can you indicate **your liking** of **blueberry flavor** of the yogurt in the **white bowl**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of blueberry flavor** of the yogurt in the **red bowl**?

	1	2	3	4	5	6	7	8	9	
does not taste like blueberry at all	○	○	○	○	○	○	○	○	○	very intensive blueberry flavor

Can you indicate **your liking** of **blueberry flavor** of the yogurt in the **red bowl**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of blueberry flavor** of the yogurt in the **yellow bowl**?

	1	2	3	4	5	6	7	8	9	
does not taste like blueberry at all	○	○	○	○	○	○	○	○	○	very intensive blueberry flavor

Can you indicate **your liking** of **blueberry flavor** of the yogurt in the **yellow bowl**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of blueberry flavor** of the yogurt in the **blue bowl**?

	1	2	3	4	5	6	7	8	9	
does not taste like blueberry at all	○	○	○	○	○	○	○	○	○	very intensive blueberry flavor

Can you indicate **your liking** of **blueberry flavor** of the yogurt in the **blue bowl**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of banana flavor** of the yogurt in the **white bowl**?

	1	2	3	4	5	6	7	8	9	
does not taste like banana at all	○	○	○	○	○	○	○	○	○	very intensive banana flavor

Can you indicate **your liking** of **banana flavor** of the yogurt in the **white bowl**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of banana flavor** of the yogurt in the **red bowl?**

	1	2	3	4	5	6	7	8	9	
does not taste like banana at all	○	○	○	○	○	○	○	○	○	very intensive banana flavor

Can you indicate **your liking** of **banana flavor** of the yogurt in the **red bowl**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of banana flavor** of the yogurt in the **yellow bowl**?

	1	2	3	4	5	6	7	8	9	
does not taste like banana at all	○	○	○	○	○	○	○	○	○	very intensive banana flavor

Can you indicate **your liking** of **banana flavor** of the yogurt in the **yellow bowl?**

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

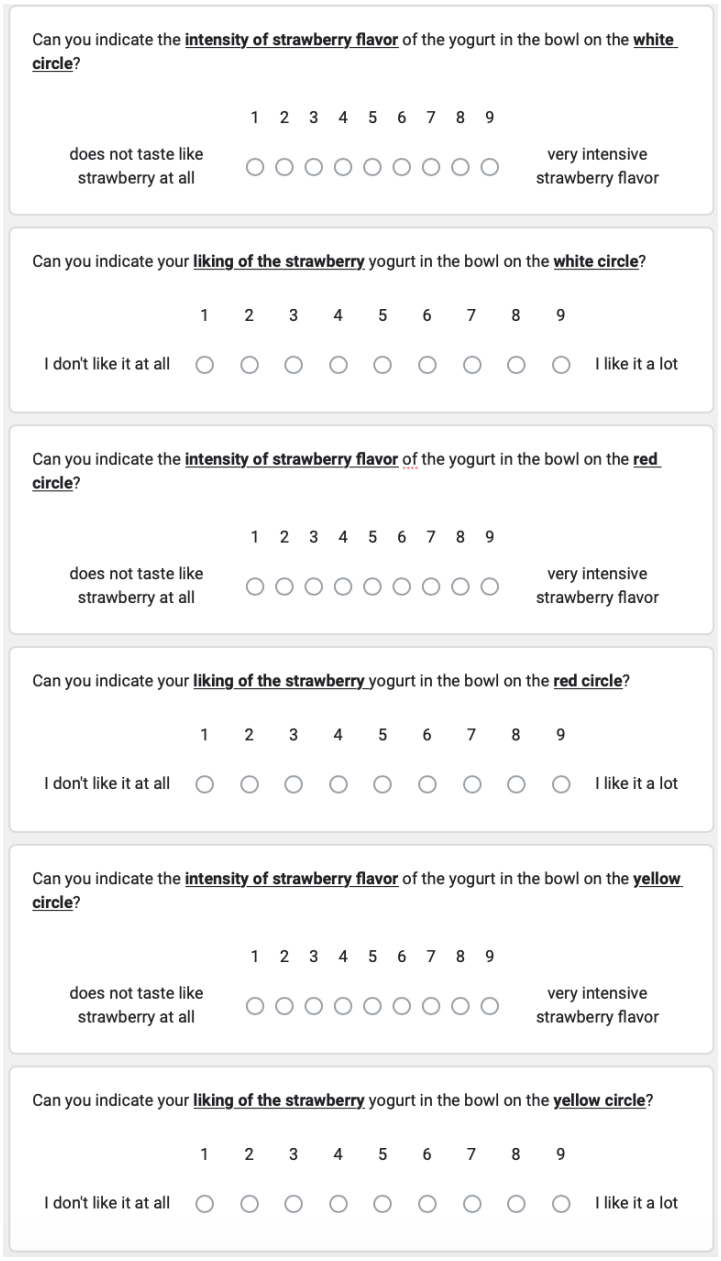
Can you indicate the **intensity of banana flavor** of the yogurt in the **blue bowl**?

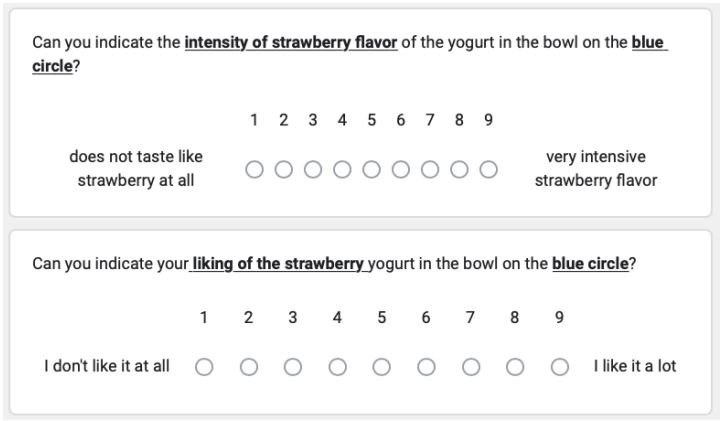
	1	2	3	4	5	6	7	8	9	
does not taste like banana at all	○	○	○	○	○	○	○	○	○	very intensive banana flavor

Can you indicate **your liking** of **banana flavor** of the yogurt in the **blue bowl**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Appendix 2: Questionnaires for both SIT concepts study





Can you indicate the **intensity of blueberry flavor** of the yogurt in the bowl on the **white circle**?

	1	2	3	4	5	6	7	8	9	
does not taste like blueberry at all	○	○	○	○	○	○	○	○	○	very intensive blueberry flavor

Can you indicate **your liking** of **blueberry flavor** of the yogurt in the bowl on the **white circle**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of blueberry flavor** of the yogurt in the bowl on the **red circle**?

	1	2	3	4	5	6	7	8	9	
does not taste like blueberry at all	○	○	○	○	○	○	○	○	○	very intensive blueberry flavor

Can you indicate **your liking** of **blueberry flavor** of the yogurt in the bowl on the **red circle**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of blueberry flavor** of the yogurt in the bowl on the **yellow circle**?

	1	2	3	4	5	6	7	8	9	
does not taste like blueberry at all	○	○	○	○	○	○	○	○	○	very intensive blueberry flavor

Can you indicate **your liking** of **blueberry flavor** of the yogurt in the bowl on the **yellow circle**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of blueberry flavor** of the yogurt in the bowl on the **blue circle**?

	1	2	3	4	5	6	7	8	9	
does not taste like blueberry at all	○	○	○	○	○	○	○	○	○	very intensive blueberry flavor

Can you indicate **your liking** of **blueberry flavor** of the yogurt in the bowl on the **blue circle**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of banana flavor** of the yogurt in the bowl on the **white circle**?

	1	2	3	4	5	6	7	8	9	
does not taste like banana at all	○	○	○	○	○	○	○	○	○	very intensive banana flavor

Can you indicate **your liking** of **banana flavor** of the yogurt in the bowl on the **white circle**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of banana flavor** of the yogurt in the bowl on the **red circle?**

	1	2	3	4	5	6	7	8	9	
does not taste like banana at all	○	○	○	○	○	○	○	○	○	very intensive banana flavor

Can you indicate **your liking** of **banana flavor** of the yogurt in the bowl on the **red circle**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of banana flavor** of the yogurt in the bowl on the **yellow circle**?

	1	2	3	4	5	6	7	8	9	
does not taste like banana at all	○	○	○	○	○	○	○	○	○	very intensive banana flavor

Can you indicate **your liking** of **banana flavor** of the yogurt in the bowl on the **yellow circle?**

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Can you indicate the **intensity of banana flavor** of the yogurt in the bowl on the **blue circle**?

	1	2	3	4	5	6	7	8	9	
does not taste like banana at all	○	○	○	○	○	○	○	○	○	very intensive banana flavor

Can you indicate **your liking** of **banana flavor** of the yogurt in the bowl on the **blue circle**?

	1	2	3	4	5	6	7	8	9	
I don't like it at all	○	○	○	○	○	○	○	○	○	I like it a lot

Appendix 3:

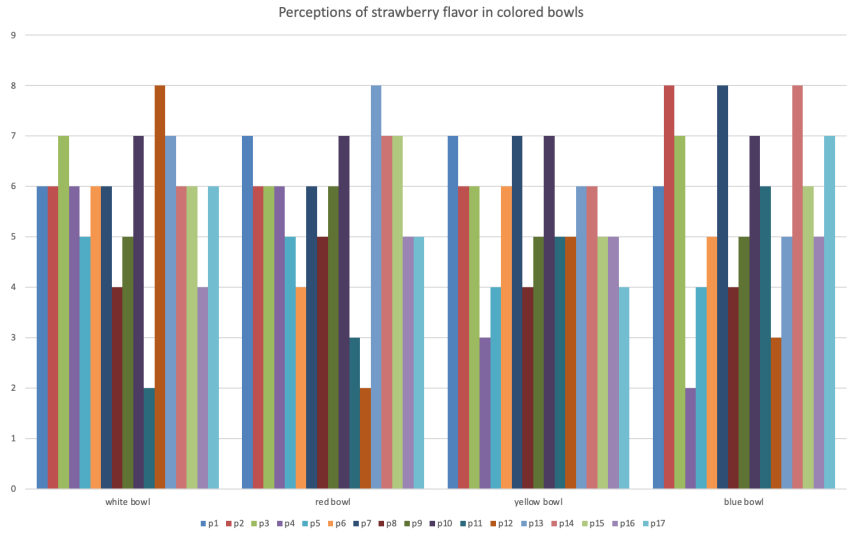
Everyday eating setting study data	
Name of Variable	Description of variable
measurement	0=Liking of the yogurt, 1=Perceived intensity of flavor
white	Yogurt in a white bowl
red	Yogurt in a red bowl
yellow	Yogurt in a yellow bowl
blue	Yogurt in a blue bowl
SIT eating setting study data for intensity of flavor	
Name of Variable	Description of variable
measurement	0=white colored plateware, 1=transparent glass plateware
white	Yogurt in a bowl on a white circle
red	Yogurt in a bowl on a red circle
yellow	Yogurt in a bowl on a yellow circle
blue	Yogurt in a bowl on a blue circle
SIT eating setting study data for liking of flavor	
Name of Variable	Description of variable
measurement	0=white colored plateware, 1=transparent glass plateware
white	Yogurt in a bowl on a white circle
red	Yogurt in a bowl on a red circle
yellow	Yogurt in a bowl on a yellow circle
blue	Yogurt in a bowl on a blue circle

Appendix 4:

a) Multivariate test on differences in mean scores of perceptions of strawberry intensity of flavor in white, red, yellow and blue bowls.

Effect		Value	F	Hypothesis of df	Error df	Sig.
strawberry_colors	Pillai's Trace	0.125	0.668	3.000	14.000	0.585
	Wilks' Lambda	0.875	0.668	3.000	14.000	0.585
	Hotelling's Trace	0.143	0.668	3.000	14.000	0.585
	Roy's Largest Root	0.143	0.668	3.000	14.000	0.585

b)

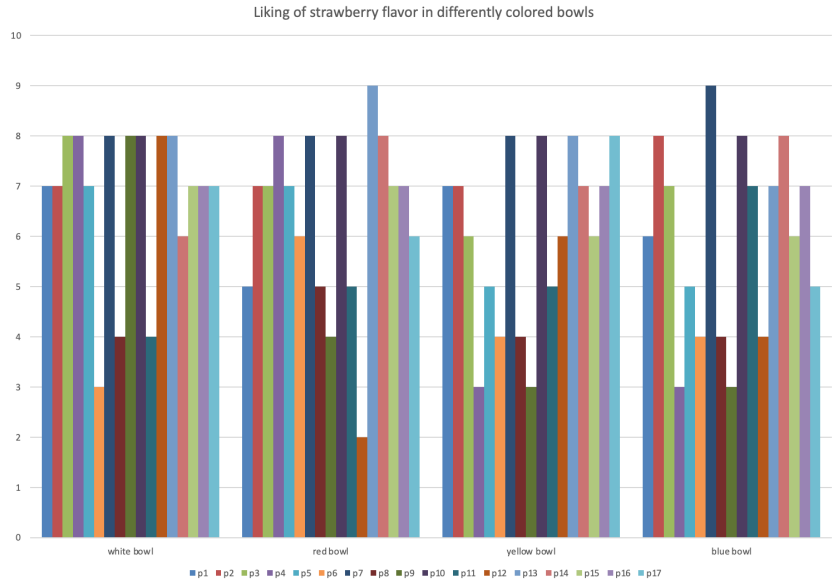


Appendix 5:

a) Multivariate test on differences in mean scores of liking of strawberry flavor in white, red, yellow and blue bowls

Effect		Value	F	Hypothesis of df	Error df	Sig.
strawberry_liking	Pillai's Trace	0.156	0.862	3.000	14.000	0.484
	Wilks' Lambda	0.844	0.862	3.000	14.000	0.484
	Hotelling's Trace	0.185	0.862	3.000	14.000	0.484
	Roy's Largest Root	0.185	0.862	3.000	14.000	0.484

b)



Appendix 6:

a) Multivariate test on differences in mean scores of perceptions of blueberry intensity of flavor in white, red, yellow and blue bowls.

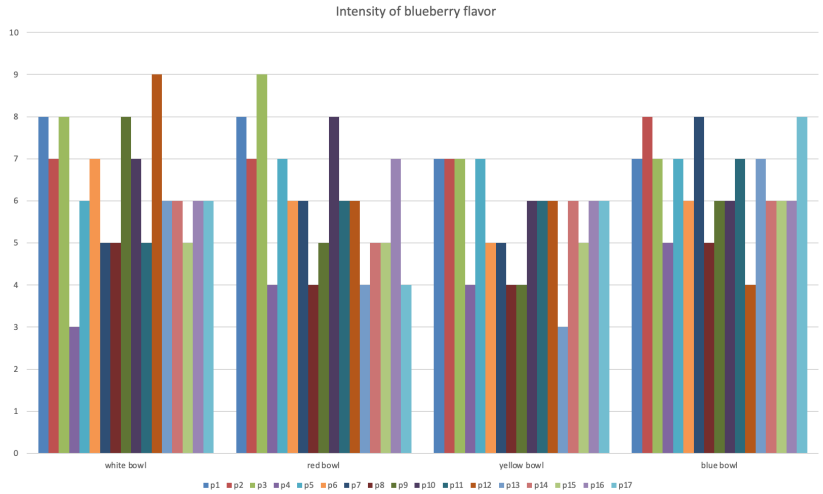
Effect		Value	F	Hypothesis of df	Error df	Sig.
blueberry_colors	Pillai's Trace	0.424	3.434	3.000	14.000	0.047
	Wilks' Lambda	0.576	3.434	3.000	14.000	0.047
	Hotelling's Trace	0.736	3.434	3.000	14.000	0.047
	Roy's Largest Root	0.736	3.434	3.000	14.000	0.047

b) Pairwise comparisons between the mean scores of the intensity of blueberry flavor in colored bowls.

(I) blueberry_intensity	(J) blueberry_intensity	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	0.353	0.353	1.000	-0.709	1.415
	3	0.765	0.359	0.294	-0.315	1.845
	4	-0.118	0.461	1.000	-1.504	1.269
2	1	-0.353	0.353	1.000	-1.415	0.709
	3	0.412	0.243	0.661	-0.321	1.144
	4	-0.471	0.412	1.000	-1.711	0.770
3	1	-0.765	0.359	0.294	-1.845	0.315
	2	-0.412	0.243	0.661	-1.144	0.321

	4	-0.882	0.331	0.101	-1.878	0.113
4	1	0.118	0.461	1.000	-1.269	1.504
	2	0.471	0.412	1.000	-0.770	1.711
	3	0.882	0.331	0.101	-0.113	1.878

c)

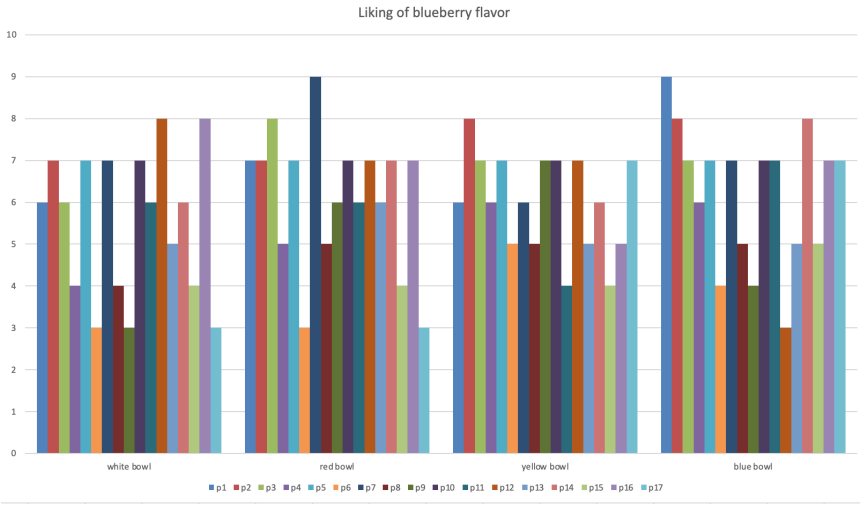


Appendix 7:

a) Multivariate test on differences in mean scores of liking of blueberry flavor in white, red, yellow and blue bowls.

Effect		**Value**	**F**	**Hypothesis of df**	**Error df**	**Sig.**
blueberry_liking	Pillai's Trace	0.268	1.710	3.000	14.000	0.211
	Wilks' Lambda	0.732	1.710	3.000	14.000	0.211
	Hotelling's Trace	0.366	1.710	3.000	14.000	0.211
	Roy's Largest Root	0.366	1.710	3.000	14.000	0.211

b)



Appendix 8:

a) Multivariate test on differences in mean scores of intensity of banana flavor in white, red, yellow and blue bowls.

Effect		Value	F	Hypothesis of df	Error df	Sig.
banana_intensity	Pillai's Trace	0.442	3.703	3.000	14.000	0.038
	Wilks' Lambda	0.558	3.703	3.000	14.000	0.038
	Hotelling's Trace	0.793	3.703	3.000	14.000	0.038
	Roy's Largest Root	0.793	3.703	3.000	14.000	0.038

b) Pairwise comparisons between the mean scores of the intensity of banana flavor in colored bowls.

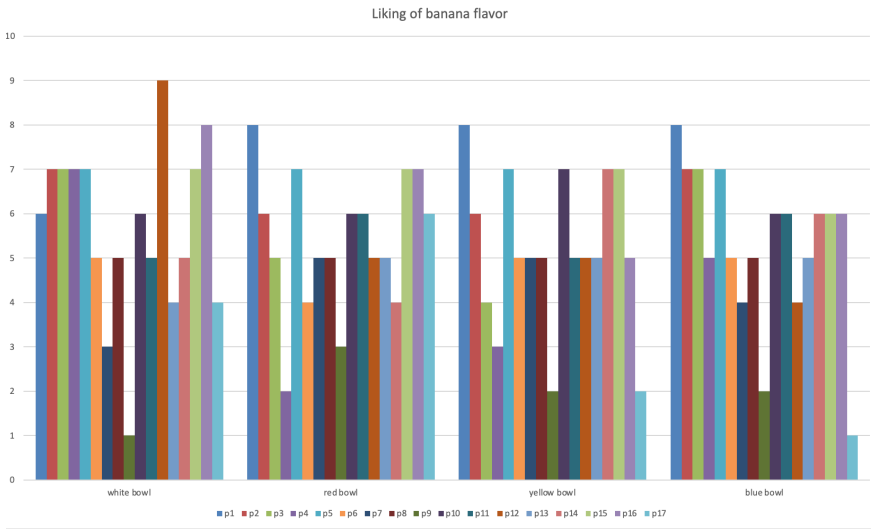
(I) blueberry_intensity	(J) blueberry_intensity	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1 (white)	2 (red)	1.000	0.402	0.146	-0.210	2.210
	3 (yellow)	0.941	0.303	0.041	0.030	1.852
	4 (blue)	1.353	0.411	0.027	0.117	2.589
2 (red)	1 (white)	-1.000	0.402	0.146	-2.210	0.210
	3 (yellow)	-0.059	0.348	1.000	-1.106	0.988
	4 (blue)	0.353	0.420	1.000	-0.909	1.615
3 (yellow)	1 (white)	-0.941	0.303	0.041	-1.852	-0.030
	2 (red)	0.059	0.348	1.000	-0.988	1.106
	4 (blue)	0.412	0.298	1.000	-0.484	1.308

4 (blue)	1 (white)	-1.353	0.411	0.027	-2.589	-0.117
	2 (red)	-0.353	0.420	1.000	-1.615	0.909
	3 (yellow)	-0.412	0.298	1.000	-1.308	0.484

c) Multivariate test on differences in mean scores of liking of banana flavor in white, red, yellow and blue bowls.

Effect		Value	F	Hypothesis of df	Error df	Sig.
banana_liking	Pillai's Trace	0.055	0.273	3.000	14.000	0.844
	Wilks' Lambda	0.945	0.273	3.000	14.000	0.844
	Hotelling's Trace	0.059	0.273	3.000	14.000	0.844
	Roy's Largest Root	0.059	0.273	3.000	14.000	0.844

d)



Appendix 9:

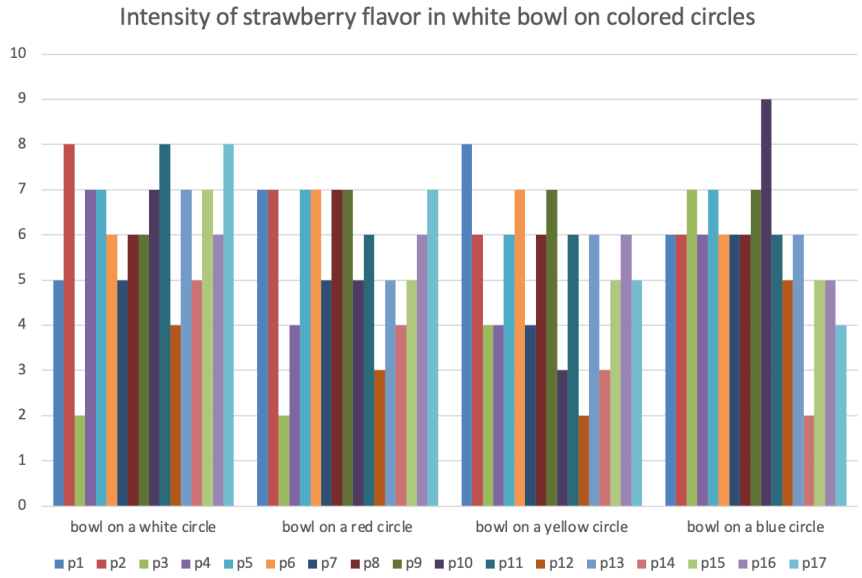
a) Multivariate test on differences in mean scores of perceptions of strawberry intensity of flavor in 4 white bowls on colored circles.

Effect		Value	F	Hypothesis of df	Error df	Sig.
strawberry_intensity	Pillai's Trace	0.220	1.320	3.000	14.000	0.307
	Wilks' Lambda	0.780	1.320	3.000	14.000	0.307
	Hotelling's Trace	0.283	1.320	3.000	14.000	0.307
	Roy's Largest Root	0.283	1.320	3.000	14.000	0.307

b) Multivariate test on differences in mean scores of perceptions of strawberry intensity of flavor in 4 transparent-glass bowls on colored circles.

Effect		Value	F	Hypothesis of df	Error df	Sig.
strawberry_ colors	Pillai's Trace	0.281	1.820	3.000	14.000	0.190
	Wilks' Lambda	0.719	1.820	3.000	14.000	0.190
	Hotelling's Trace	0.390	1.820	3.000	14.000	0.190
	Roy's Largest Root	0.390	1.820	3.000	14.000	0.190

c)



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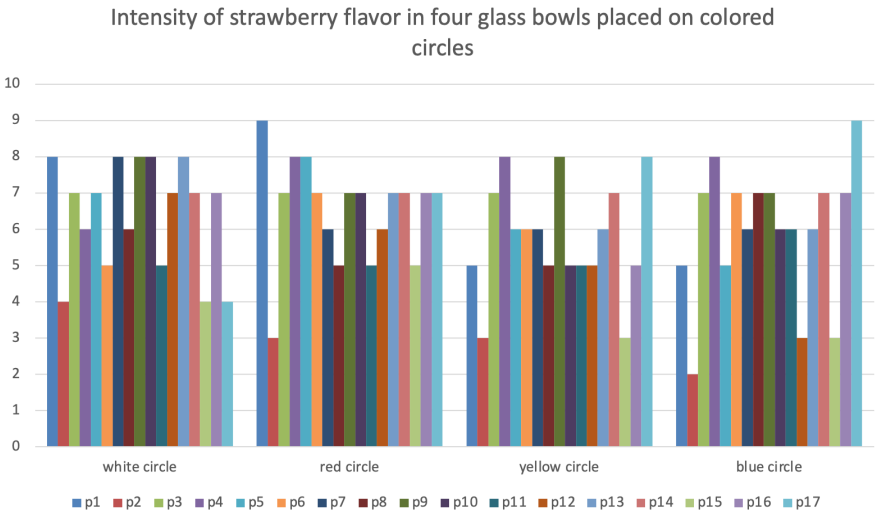


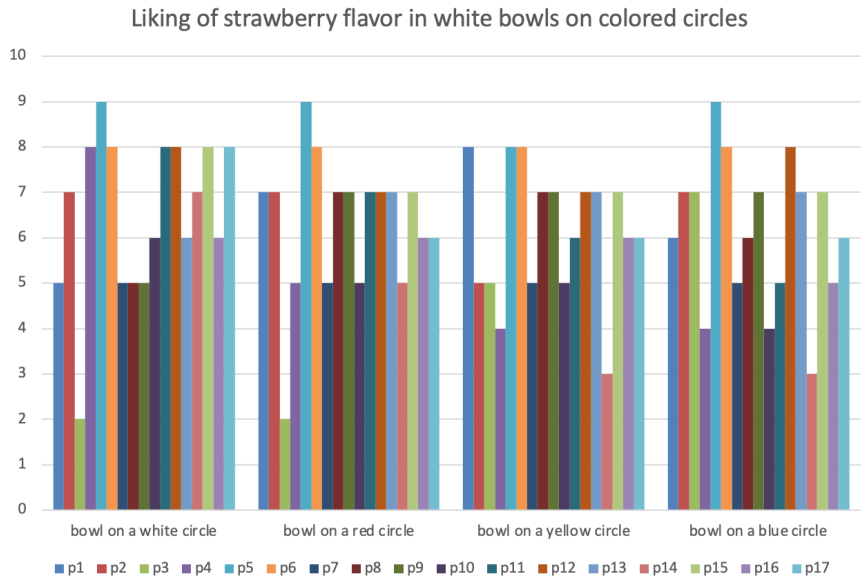
e) Multivariate test on differences in mean scores of liking of strawberry flavor in four white bowls placed on colored circles

Effect		Value	F	Hypothesis of df	Error df	Sig.
strawberry_ Liking	Pillai's Trace	0.039	0.190	3.000	14.000	0.901
	Wilks' Lambda	0.961	0.190	3.000	14.000	0.901
	Hotelling's Trace	0.041	0.190	3.000	14.000	0.901
	Roy's Largest Root	0.041	0.190	3.000	14.000	0.901

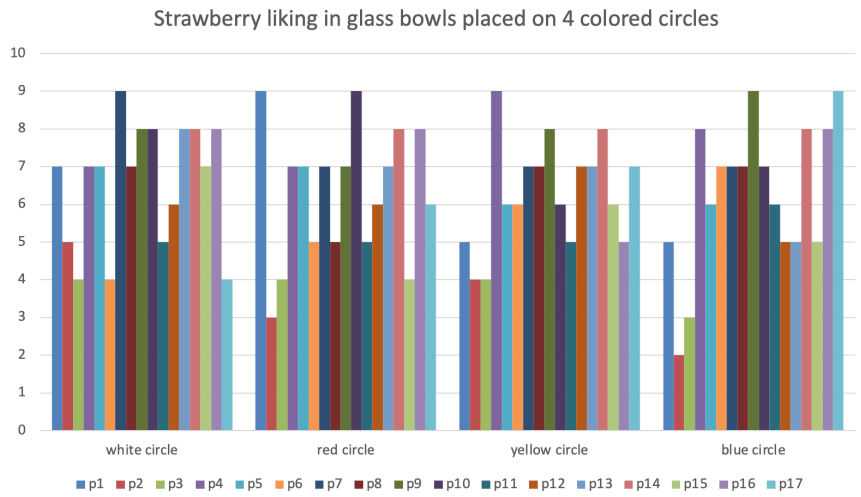
f) Multivariate test on differences in mean scores of liking of strawberry intensity of flavor in 4 transparent-glass bowls on colored circles.

Effect		Value	F	Hypothesis of df	Error df	Sig.
strawberry_l iking	Pillai's Trace	0.066	0.328	3.000	14.000	0.805
	Wilks' Lambda	0.934	0.328	3.000	14.000	0.805
	Hotelling's Trace	0.070	0.328	3.000	14.000	0.805
	Roy's Largest Root	0.070	0.328	3.000	14.000	0.805

g)



h)



Appendix 10:

a) Multivariate test on differences in mean scores of perceptions of blueberry intensity of flavor in 4 transparent-glass bowls on colored circles.

Effect		Value	F	Hypothesis of df	Error df	Sig.
blueberry_colors	Pillai's Trace	0.156	0.863	3.000	14.000	0.483
	Wilks' Lambda	0.844	0.863	3.000	14.000	0.483
	Hotelling's Trace	0.185	0.863	3.000	14.000	0.483
	Roy's Largest Root	0.185	0.863	3.000	14.000	0.483

b) Multivariate test on differences in mean scores of perceptions of blueberry intensity of flavor in 4 white bowls on colored circles.

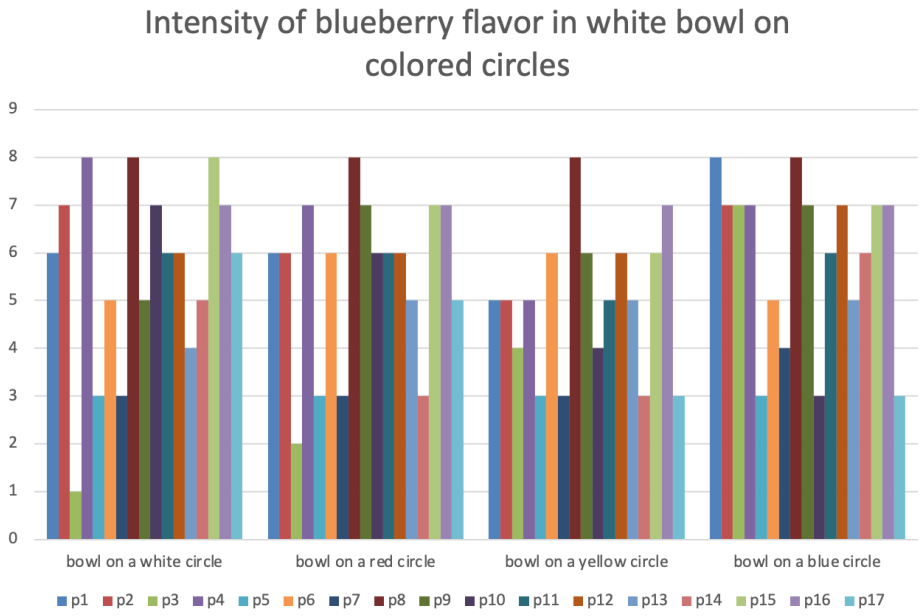
Effect		Value	F	Hypothesis of df	Error df	Sig.
blueberry_intensity	Pillai's Trace	0.560	5.937	3.000	14.000	0.008
	Wilks' Lambda	0.440	5.937	3.000	14.000	0.008
	Hotelling's Trace	1.272	5.937	3.000	14.000	0.008
	Roy's Largest Root	1.272	5.937	3.000	14.000	0.008

c) Pairwise comparisons between the mean scores of the intensity of blueberry flavor in white bowls on colored circles.

(I) blueberry_intensity	(J) blueberry_intensity	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	0.118	0.241	1.000	-0.607	0.842

	3	0.647	0.411	0.808	-0.589	1.883
	4	-0.294	0.520	1.000	-1.858	1.270
2	1	-0.118	0.241	1.000	-0.842	0.607
	3	0.529	0.244	0.274	-0.206	1.264
	4	-0.412	0.438	1.000	-1.729	0.905
3	1	-0.647	0.411	0.808	-1.883	0.589
	2	-0.529	0.244	0.274	-1.264	0.206
	4	-0.941	0.315	0.052	-1.888	0.006
4	1	0.294	0.520	1.000	-1.270	1.858
	2	0.412	0.438	1.000	-0.905	1.729
	3	0.941	0.315	0.052	-0.006	1.888

d)



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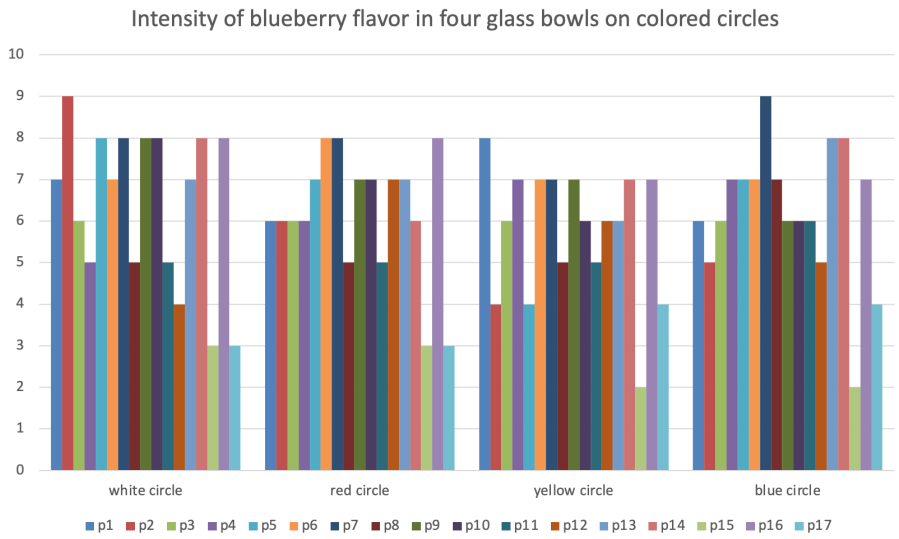


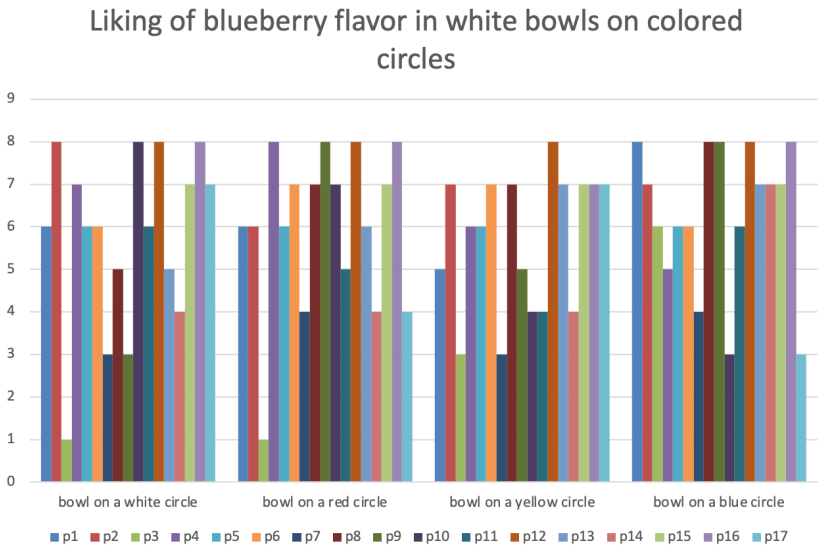
f) Multivariate test on differences in mean scores of liking of blueberry flavor in four white bowls placed on colored circles

Effect		Value	F	Hypothesis of df	Error df	Sig.
strawberry_ Liking	Pillai's Trace	0.107	0.560	3.000	14.000	0.650
	Wilks' Lambda	0.893	0.560	3.000	14.000	0.650
	Hotelling's Trace	0.120	0.560	3.000	14.000	0.650
	Roy's Largest Root	0.120	0.560	3.000	14.000	0.650

g) Multivariate test on differences in mean scores of liking of blueberry intensity of flavor in 4 transparent-glass bowls on colored circles.

Effect		Value	F	Hypothesis of df	Error df	Sig.
blueberry_li king	Pillai's Trace	0.328	2.274	3.000	14.000	0.125
	Wilks' Lambda	0.672	2.274	3.000	14.000	0.125
	Hotelling's Trace	0.487	2.274	3.000	14.000	0.125
	Roy's Largest Root	0.487	2.274	3.000	14.000	0.125

h)



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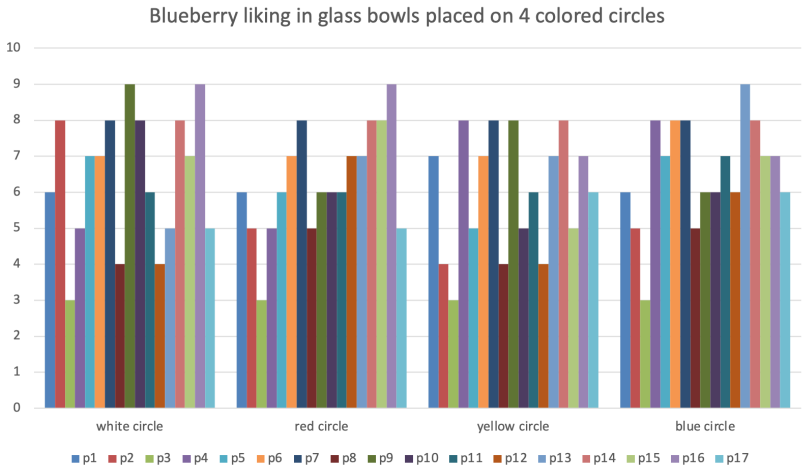


Appendix 11:

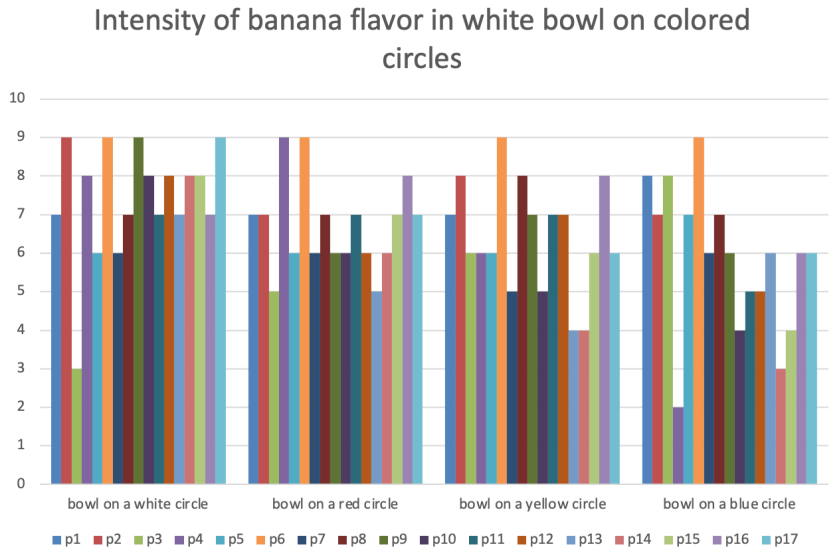
a) Multivariate test on differences in mean scores of perceptions of banana intensity of flavor in 4 white bowls on colored circles.

Effect		Value	F	Hypothesis of df	Error df	Sig.
banana_intensity	Pillai's Trace	0.297	1.975	3.000	14.000	0.164
	Wilks' Lambda	0.703	1.975	3.000	14.000	0.164
	Hotelling's Trace	0.423	1.975	3.000	14.000	0.164
	Roy's Largest Root	0.423	1.975	3.000	14.000	0.164

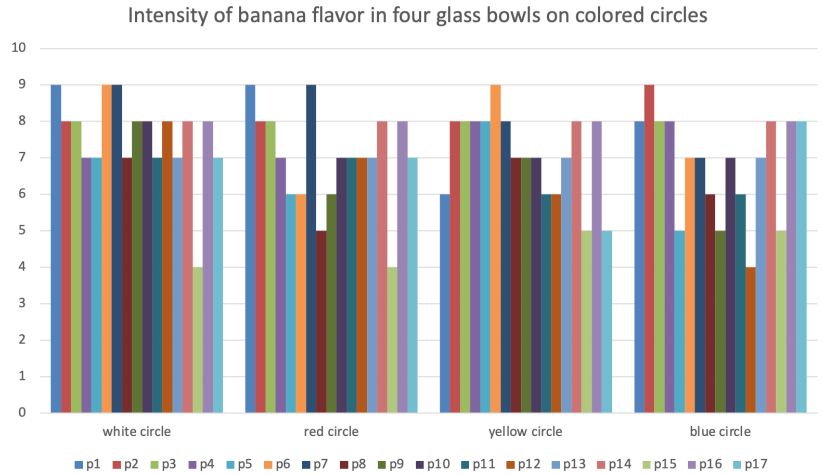
b) Multivariate test on differences in mean scores of perceptions of banana intensity of flavor in 4 transparent-glass bowls on colored circles.

Effect		Value	F	Hypothesis of df	Error df	Sig.
banana_colors	Pillai's Trace	0.386	2.939	3.000	14.000	0.070
	Wilks' Lambda	0.614	2.939	3.000	14.000	0.070
	Hotelling's Trace	0.630	2.939	3.000	14.000	0.070
	Roy's Largest Root	0.630	2.939	3.000	14.000	0.070

c)



d)



e) Multivariate test on differences in mean scores of liking of banana flavor in four white bowls placed on colored circles

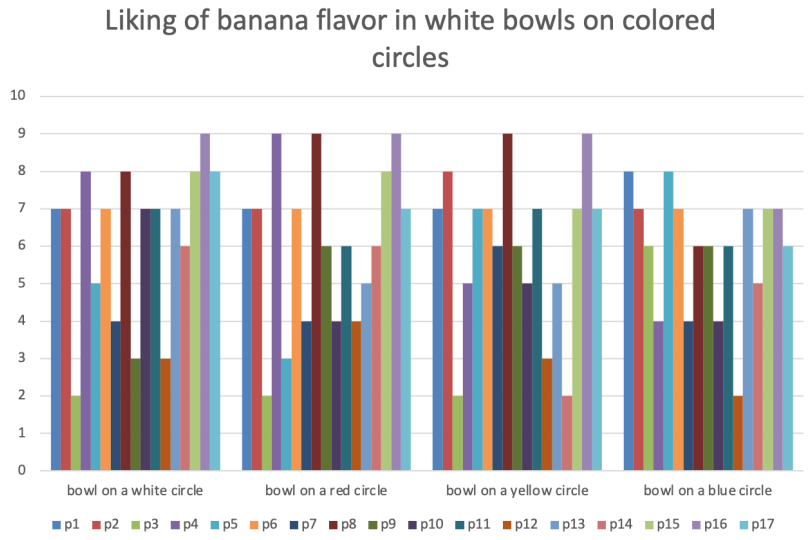
Effect		Value	F	Hypothesis of df	Error df	Sig.
banana_Liki	Pillai's Trace	0.039	0.189	3.000	14.000	0.902

ng	Wilks' Lambda	0.961	0.189	3.000	14.000	0.902
	Hotelling's Trace	0.040	0.189	3.000	14.000	0.902
	Roy's Largest Root	0.040	0.189	3.000	14.000	0.902

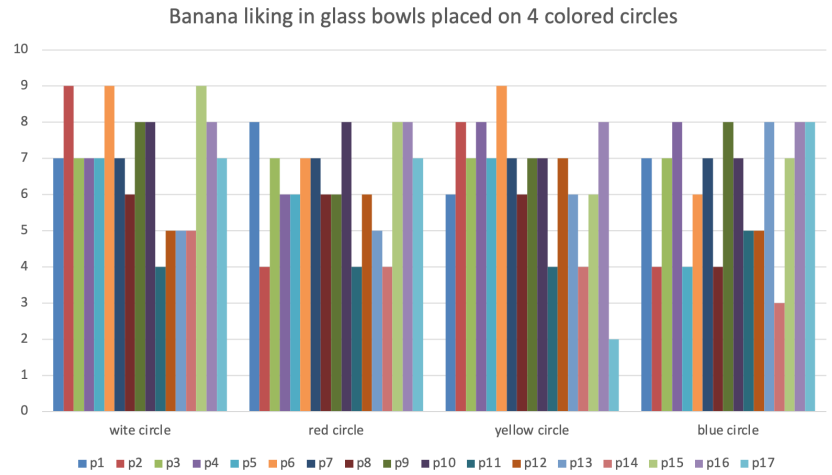
f) Multivariate test on differences in mean scores of liking of banana flavor in 4 transparent-glass bowls on colored circles.

Effect		**Value**	**F**	**Hypothesis of df**	**Error df**	**Sig.**
banana_liking	Pillai's Trace	0.234	1.425	3.000	14.000	0.277
	Wilks' Lambda	0.766	1.425	3.000	14.000	0.277
	Hotelling's Trace	0.305	1.425	3.000	14.000	0.277
	Roy's Largest Root	0.305	1.425	3.000	14.000	0.277

g)


Liking of banana flavor in white bowls on colored circles
10
9
8
7
6
5
4
3
2
1
0
bowl on a white circle
bowl on a red circle
bowl on a yellow circle
bowl on a blue circle
p1 p2 p3 p4 p5 p6 p7 p8 p9 p10 p11 p12 p13 p14 p15 p16 p17

h)


Banana liking in glass bowls placed on 4 colored circles
10
9
8
7
6
5
4
3
2
1
0
wite circle
red circle
yellow circle
blue circle
p1 p2 p3 p4 p5 p6 p7 p8 p9 p10 p11 p12 p13 p14 p15 p16 p17

Appendix 12:

Information brochure

The purpose of this research is to collect information about flavor perceptions in the domain of eating. During the session you will be presented with 3 four-bowl sets of fruit flavored yoghurt (strawberry, banana and blueberry flavored yoghurts). You will be asked to taste each of them and to assess the intensity of flavor and your liking of the respective flavor. The session will take no more than 6 minutes of your time.

If you have any allergies to the food that will be used in the study or to any of its contains you will be excluded from participation.

The research does not bring any risks for your physical and psychical well-being.

If you want to withdraw from the study, you can do it at any time by saying you do not want to continue further without giving any reason for your decision to the researcher.

The only personal information that will be collected from you is about your age and gender, that will not be associated with your identity in any way. You will be asked to provide this information to the researcher in the questionnaire where you will be assessing the intensity of the yogurt flavors and your liking of them. After the results from the experiment are analyzed the questionnaires will be deleted.

If you have any questions related to the study, you can ask at any time before and during the session.

This research was reviewed by the Ethics Committee Computer Science and Information in the University of Twente.

Contact details of the researcher: Gergana Dzhondzhorova, g.dzhondzhorova@student.utwente.nl

Contact details of the Ethics Committee Computer Science and Information in the University of Twente: EthicsCommittee-CIS@utwente.nl

Appendix 13:

Consent Form for Master ITECH final project study participation

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I do not have allergies to the food that will be used in the study, or to any of its contains.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that I will be asked about my age and gender, and this information will not be associated with my identity in any way.	○	○
Use of the information in the study		
I understand that information I provide will be used for a ITECH Master final project report	○	○

Signatures

Participant

_____	_____	_____
Name of participant [printed]	Signature	Date

Researcher

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Name of researcher [printed]	Signature	Date

Study contact details for further information: Gergana Dzhondzhorova, g.dzhondzhorova@student.utwente.nl

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl