Exploring the relationship between packaging's haptic sensations and sustainability perception within Virtual Reality Environments

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Abstract

Sensory marketing research aims to understand the effects of the five human senses (sight, hearing, taste, smell, touch) on consumer behaviour. Food product packaging is a primary source of information for consumers when purchasing, experienced through their sight and touch (Branca et al., 2022). Out of these two, the haptic (touch) sensation is not as commonly researched as visual factors alone (Krishna & Schwarz, 2014; Petit et al., 2015), despite haptic feedback being the second point of contact with the product for consumers. Moreover, the growing concern for sustainability prompts further interest into what extent consumption behaviours are driven by a product's perceived sustainability as demands for sustainable developments increase (Nguyen et al., 2020). Hence, this thesis aimed to investigate the effects of food packaging's haptic feedback, by means of visuo-tactile and vibrotactile cues, and its perceived sustainability on purchase choice in virtual reality (VR). A study was conducted that tested consumption preference for four haptic attributes (matte, rough, smooth, shiny) by placing participants in a virtual supermarket where they were tasked to shop for nine items. In accordance with the four haptic attributes, four variations of the same products were displayed on the shelf of which its visuo-tactile and vibrotactile differences were not explicitly stated, and participants were given freedom to choose for themselves. Then, a questionnaire was conducted that assessed sustainability perceptions and prior sustainability awareness using Gericke et al. (2018)'s SCQ-S. It was found that participants preferred 'rough' the most as expected, however, 'smooth' was the second preference instead of 'matte'. Sustainability perceptions was also found to be influential in consumer behaviour where participants preferred attributes they perceived as more sustainable but, unexpectedly, prior sustainability awareness was not found to be a mediating variable within the relationship.

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1 Introduction

Within the marketing field, sensory marketing is a subfield that pertains to research on the effects of consumer sensations (sight, hearing, taste, smell, touch) on consumption behaviour, examples of which are purchase intention and product appraisal. Its roots stem from the theory of embodied cognition, which emphasises the role of sensory experiences in cognitive processes and consequently, decision-making (Krishna & Schwarz, 2014). For food products specifically, the haptic (touch) sensation becomes more important in influencing general consumption behaviour (de Canio & Fuentes-Blasco, 2021; Spence & Gallace, 2011), with packaging specifically as a significant marketing tool. Packaging is the foremost, and oftentimes, only point of contact of food products in a supermarket and thus, is a primary source of information for consumers (Branca et al., 2022; Krishna et al., 2017). Subsequently, haptic cues of packaging tend to affect product appraisal which may (de)influence willingness to consume.

However, the influence of such textures may be attributed to something else entirely; perceived sustainability, cued by certain haptic attributes, may also be a determinant in consumption behaviours. There has been a recent global shift towards ecological sustainability, likewise, can be said for within the food industry where consumers are becoming increasingly concerned with sustainable development (Nguyen et al., 2020). Packaging is a primary concern as it stands as the largest contributor in waste accumulation from food products (Herbes et al., 2020, as cited in Branca et al., 2022) and thus, consumers want sustainable – "green" – packaging which they are often determining from haptic cues (Nguyen et al., 2020). Moreover, research has shown that higher perceived sustainability may positively influence consumption behaviours as perceived quality of the product is often raised alongside it (Kolppo, 2009; Branca et al., 2022; Wandosell et al., 2021). In example, when consumers deem a product as more sustainable, their expected taste evaluation and willingness to pay a higher price is increased as well (Krause, 2017; Branca et al., 2022). Therefore, a follow-up research topic is whether perceived sustainability of products is an underlying mediator in the relationship between packaging's haptic cues and consumption preference.

A preferred method to investigate the effects of haptic attributes of packaging on consumption behaviours is virtual reality (VR). This is because physical, real-life (RL) manipulation of variables (packaging) can incur high costs and time, whereas VR is an efficient alternative. Additionally, the benefit of virtual reality environments (VRE) stems from its simultaneous detachment from RL, in which Alcañiz et al. (2019) states the "fabrication of entirely new situations", those unimaginable or ineffable to adapt in RL, is one of the largest highlights for VRE's, yet retains the ability to replicate RL behaviours. To do so, VRE's must also facilitate a sense of immersiveness, oftentimes from stimulating sight, hearing, touch and in rarer cases, olfactory and taste (Krishna, 2010, as cited in Wedel et al., 2020), to create a realistic feeling — 'presence' — within the environment (Wang et al., 2021; Wedel et al., 2020). Given such benefits, virtual reality (VR) becomes a new method of study for optimising product design and manufacturing (Wedel et al., 2020). Moreover, Branca et al. (2022) found similar haptic evaluation of food packaging between VR and RL scenarios, however, saw that VR facilitated higher willingness to consume with increased leniency on price and products. Moreover, VREs are stated to be more indicative of natural human behaviours than that garnered from a computer screen, making them an apt instrument for human behavioural research (Hepperle & Wolfel, 2023), further supporting the use of VR as a beneficial instrument to gain insight into consumer behaviour.

1.1 Haptic Properties of Packaging

Despite the large variety in packaging, the most perceived haptic properties can be ascribed to two spectrums of *Rough – Smooth* and *Shiny – Matte*. The nuances within these two spectrums and its influence on consumption behaviours are explored in this section.

Smooth / Rough

The texture of packaging may be appraised as being either more rough or more smooth, referring to the exterior feel of certain packaging materials. Rougher textures are generally haptically cued by the sensation of more friction when gliding a finger across a surface. Haptic cueing can also occur, however, by simply touching a surface and perceiving it to have bumps. A smooth texture, on the other hand, is felt through decreased friction on a surface and is akin to a lack of texture in general. In example, paper-like, cardboard packaging is often denoted as rough whereas plastic packaging is smoother (Krause, 2017).

When packaging is perceived as rougher, consumers tend to believe the product as more 'natural' regarding both its content and packaging. As such, rough texture is associated with being more sustainable (Kolppo, 2009; Branca et al., 2022) which increases taste expectations and perceived healthiness (Krause, 2017; Spence & Badeka, 2021). Interestingly, however, the perceived naturalness of packaging is not enough to fully influence willingness to consume (Krause, 2017). Moreover, when packaging is rougher, a higher ease of handling is reported due to the grittiness of the texture which further drives purchase intention (Saastamoinen, 2012). Smoother textures, on the other hand, are more associated with generally non-environmentally friendly materials, such as plastic, which can negatively affect taste expectations (Spence & Badeka, 2021).

Shiny (Slipperiness) / Matte

Packaging may also be measured on how shiny (slippery) or matte they are. Note that 'shiny' and 'slipperiness' may be used interchangeably in this case, because 'shiny' is the visual descriptor while 'slipperiness' is its haptic form. When a packaging is deemed to be matte, it is often also correlated with being rough and therefore, is appraised similarly (Saastamoinen, 2012;). As such, matte packaging can be associated with more natural products as well, thus similarly increasing sustainability perceptions and purchase intentions (Spence & Badeka, 2021). The same article reports that highly shiny products, on the other hand, are more associated with unhealthy foods which decreases taste expectations and perceived quality of products. Moreover, although shiny products are often correlated with unsustainable materials (i.e: plastic), consumers still rely mainly on slippery haptic cues to determine, primarily, level of shine and, subsequently, sustainability (Kolppo, 2009). It should be noted that consumers also find a difference between products that are non-reflective and reflective to differentiate between plastic and glass. The latter is reported to be more environmentally sustainable (Branca et al., 2022; Kolppo, 2009).

1.1.2 Combinations between the four attributes

Generally, perceptions of packaging may be further influenced when consumers are made salient of a third, less commonly perceived attribute, rigidity. In example, matte is often associated with rough, typically occurring when a packaging is deemed more rigid as well. Paperboard packaging found in cereal boxes are often perceived as being both rough and matte, aided by the stiffness of the packaging (Saastamoinen, 2012). Matte and smooth may also occur for different material but are a less commonly used combination for food packaging and in either case, how matte a packaging is remains to be the largest factor in influencing perceived sustainability (Kolppo, 2019). Likewise, the differentiation between plastic and glass stems from the packaging's rigidity where despite both materials cueing smooth and shiny, consumers are also salient of the difference in rigidity of both. In this case, rigidity becomes the most important factor for purchase intention as consumers report better ease of handling and protection of the contents inside (Krishna et al., 2017; Ciavarello, 2021), oftentimes also because high rigidity is typically associated with higher sustainability

(Kolppo, 2009). Ciavarello (2021, however, found a complete mediation for the effect of perceived sustainability on purchase intention, where, if consumers are expressly told a product is more sustainable, then its rigidity loses value.

1.1.3 General conclusions

The literature shows that haptic cues are utilised to ascertain the packaging material, which is then used to further appraise the products. There is a consensus that rougher, matte, and harder packaging drives consumption behaviours. This is because such attributes of packaging are associated with naturalness, therefore, increasing perceived health and quality of the product itself. However, when a product is perceived as such, it does not necessarily increase purchase intention but rather increase taste expectations and quality which influences willingness to consume. Glossy, smoother products are appraised more often as non-environmentally friendly which is also typically associated with not healthy and decreased taste expectations. It also appears that sustainability perceptions take precedence over haptic cues.

1.2 Aim of Thesis: Research Questions and Scope of Inquiry

This thesis aimed to investigate the relationship between haptic feedback and sustainability perceptions of food packaging on consumption behaviours, namely purchase choices. First, it was mainly investigated whether haptic feedback, from visuo-tactile and vibrotactile cues, from food packaging affected purchase choices in VR. These effects were then compared to the literature found for RL. Secondly, perceived sustainability of the packaging was investigated as a possible influence in purchase choice given that literature indicates the tendency for consumers to assume a relation between haptic attributes rough, matte of packaging with sustainability. In addition, prior sustainability awareness, or ‘sustainability consciousness’, was tested alongside perceived sustainability as well to further investigate its interaction effects on purchase choices. To understand such effects, a VR study was conducted alongside a sustainability assessment, in which participants were tasked to go virtual grocery shopping, then completed a questionnaire that measured the two aforementioned constructs, sustainability perceptions and sustainability consciousness. It was hypothesised that participants would tend towards rough and matte products when they scored high on sustainability consciousness and perceptions. If sustainability and haptic feedback was found to be an underlying factor in purchase choice, then we may conclude that behaviour measured in VRE's is similar to RL to suggest VR's potential as a tool in studying consumer behaviour.

1.2.1 Research Questions

The primary and secondary research questions that guided this thesis are as follows:

1. Does haptic feedback, from visuo-tactile and vibro-tactile cues, affect purchase choices in a virtual environment?
2. Is perceived sustainability of haptic attributes alongside the individual's prior sustainability consciousness a mediating factor in purchase choice?

2 Methodology

2.1 Participants

The study comprised of 20 participants (9 females and 11 males), with the minimum age of 20 y.o. and maximum age of 28 y.o. (M = 22.65, SD = 2.3). Participants reported to have normal or corrected vision and moderate insensitivity to motion sickness. Both convenience and voluntary sampling was used to recruit participants. SONA (utwente.sona-systems.com) was utilised for voluntary participation, a platform available to all students of the Behavioural, Management, and Social Sciences (BMS) department at the University of Twente (UT). All participants gathered through SONA were granted credits for their participation, in line with their degree. This study was approved by the ethics committee of the BMS department at the UT, registered under the number 240226.

2.2 Materials

This study was conducted at the UT campus. The virtual environment was generated using Unity with scripting utilising C++ language, developed by Eren Akyürek and the BMS laboratory team at UT. For the two significant assets of the experiment, its textures were created specially for the study utilising Photoshop and Procreate then further modified within Unity itself. For the experimental setup, participants used a wired Oculus Rift 2 with the standard HMD Odyssey controllers to experience the virtual environment. The program was run from a local computer on an Intel Core i7-12700 processor with NVIDIA GeForce RTX 3060 video graphics. Additionally, the follow up questionnaire (Appendix A) was conducted on the local computer through Qualtrics.com. Similarly, informed consent forms were gathered digitally using Google Forms (Appendix B), a copy of which was sent to them.

2.3 Stimuli

This study made use of both visuo-tactile and vibrotactile feedback as stimuli for participants. Vibrotactile feedback was emulated through physical vibrations by the controllers, set at different intensity levels for each haptic attribute (Matte, Smooth, Shiny, Rough). Due to the software of the controllers, vibration-intensity was programmed with two values, a minimum amplitude value when the hand movement is slow and a maximum amplitude value for when the hand movement is fast. The values for the objects are stated in Table 1. Matte was given moderately high minimum and maximum values as it has high haptic feedback, much like rough, however does not vary as much. The smooth attribute has the smallest minimum and maximum values with the smallest variance between as well as it gives the least haptic feedback. Rough was given the highest difference in minimum and maximum values to emulate its highest haptic feedback. For shiny, a 0.5 difference was given between its minimum and maximum to emulate its high friction but not bumpy haptic sensation. The choice in values assumed that vibration amplitude decreased as attributes decreased in texture as well, in line with Nikolov et al. (2020), hence rough having the highest value and largest difference. Matte follows with the second largest values but a smaller difference, then shiny and finally, smooth.

Table 1

Vibration-intensity Values for HMD Controllers

Haptic Attribute	Minimum Value	Maximum Value
Matte	0.5	0.8
Shiny	0	0.5
Rough	0	1
Smooth	0.156	0.2

Objects were also ascribed different surface-textures to emulate visuo-tactile feedback. There were eight objects in total, four variations that matched a haptic attribute of two different products. These were potato chips and cereal. To exemplify ‘rough’, a cardboard-like appearance was given to the base designs with emphasised bumps on its surface to differentiate it from ‘matte’, which focused on wrinkles along its surface and monochromatic tones for a more paper-like appearance. Contrastingly, the ‘shiny’ surface textures were given fabricated light reflections and further enhanced on Unity itself. The ‘smooth’ surface textures used the initial, base designs which were vector images and therefore, rid of any texture. To give this variation more realism, its reflectiveness was increased on Unity to avoid a two-dimensional appearance. The haptic variation of the packaging designs is shown in Figure 1 for potato chips and Figure 2 for cereal.

Figure 1

Potato Chips: Visual Haptic Designs

Figure 2

Cereal: Visual Haptic Designs

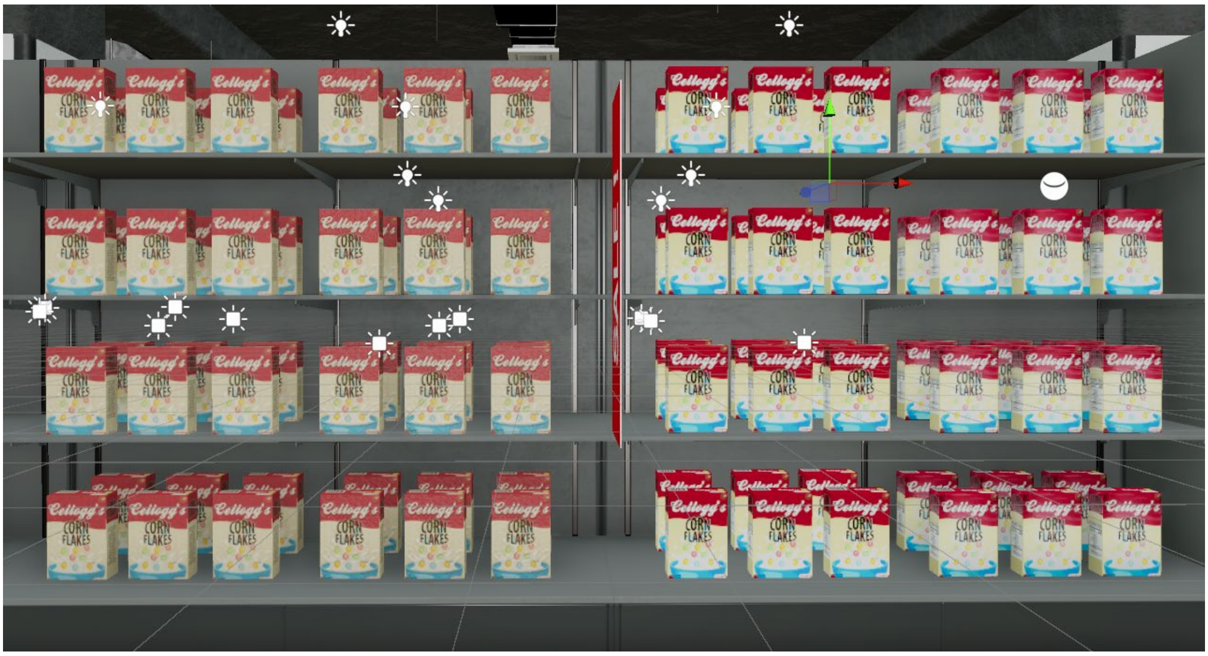
The layout of the stimuli was purposeful in enhancing participants' saliency of the differences in haptic feedback between the variations. First, products were placed on the same side of the same aisle to increase task focus, additionally accounting for participants that might have been inexperienced in VR through means of task simplification (Nikolov et al., 2020). All variations of potato chips were placed together, and all variations of cereal were placed together. Both were placed in the order Matte, Smooth, Rough, Shiny as can be seen in Figure 3 and 4.

Figure 3

Stimuli placement within the VRE, Depicting Potato Chips Placement on Shelves

Figure 4

Stimuli placement within the VRE, Depicting Cereal Placement on Shelves



2.3.1 Qualtrics Questionnaire

Participants were assessed through a questionnaire with three separate sections. The first section (Appendix A.1) consists of demographic related questions and a general inquiry into food consumption behaviours, totaling 6 items. Questions such as “How often do you visit the supermarket?”, “Do you visit the supermarket for food needs yourself?” were asked to ascertain an understanding of the sample that was relevant to the task.

The second section found in Appendix A.2 (15 items) appraised participants' VR experience and perceptions of the different haptic attributes. Within this section, participants indicated their perceived level of affect from the haptic feedback and level of experienced haptic feedback, in general and for each of the eight items individually, on a five-point scale from "not at all" to "very much". These were to determine the main research question which inquired the effects of visuo-tactile and vibrotactile cues on purchase choice, by measuring the effect both cues. To answer whether perceived sustainability influenced purchase choice, participants were asked to indicate their agreement on how much each attribute represents (1) sustainability and; (2) healthiness on a five-point scale from "strongly disagree" to "strongly agree". These ratings would be used to compute a 'perceived sustainability' score.

The last section was Gericke et al. (2018)'s Sustainability Consciousness Questionnaire-S (SCQ-S) which consisted of 27 items that measured sustainability awareness regarding both individual experiences and perceptions (Appendix A.3). Overall, the scale sought to measure the second-order constructs of sustainability attitudes, knowingness, and behaviour with each construct possessing 9 items each. From answers, a sustainability consciousness score could be computed for each participant.

2.4 Task

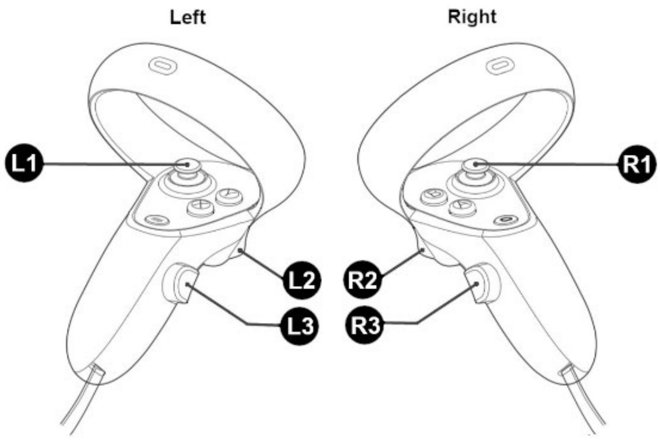
Participants were told to view the VR experiment as if they were going grocery shopping in real life but were given the explicit instruction to shop for nine items, one of which must be a potato chip product and another one of which must be a cereal product. In addition, they were instructed to take at least one minute to examine the products displayed on the shelves in front of their spawning position before placing anything inside their shopping baskets. To 'purchase' a product, participants simply had to pick up a product using their right hand from the shelf and drag it into the shopping basket hanging from their left hand. A blue box hovered over the left hand that displayed a counter for the items, for the participant to keep track of, and a timer that started as soon as the program was run and stopped once nine items were obtained. Two conditions were tested. Condition A, visuo-tactile, kept the vibration-intensity identical for all four haptic variations so that only visuo-tactile feedback was given. Condition B, visuo-tactile and vibrotactile, was the combined condition which set different vibration-intensity values for each haptic variation which are stated in Table 1 of Section 2.3.

2.5 Procedure

Once the participant arrived, they were first given a verbal introduction to the study, explaining the purpose and schedule of events for its duration, then talked through the contents of the consent form which they also read for themselves on the monitor. Any questions asked were answered first before the participant was made to digitally sign the informed consent form. Before beginning the VR portion, participants filled out the first section of the questionnaire. Afterwards, the researcher then explained the basics of VR and taught the participant relevant controls. To pick up products, they needed to press and hold R3 on their right-hand controller and drag it into the shopping basket held by their left hand. To move within the environment, the participant must use the thumb stick (L1) on their left hand. If their body in the real world was out of bounds, the virtual bounds appeared in a blue grid for the participant. They were given the option to physically move their head to look around the environment, but informed that they could also use R1 on the right controller which snapped 90° north, east, south, and west, according to the direction the thumb stick was moved in.

Figure 5

Oculus Rift Controllers: Diagram of Controls ("HMD controllers", n.d.)



Note: L1 and R1 are thumb sticks which function the same as joysticks, L2 and R2 are trigger buttons, L3 and R3 are grip buttons.

After the participant indicated understanding of the controls, the researcher informed them of their task and were told to voice any relevant sentiment they may have while performing it. This was for the researcher's qualitative notes. Then, the researcher aided them into position within the room and headgear, adjusting the headgear when necessary to ensure optimal VR conditions. The controllers were handed to participants and then, the program was run. During its duration, the researcher took notes on every item variation the participant picked up alongside any other relevant details gathered either through the display or participant statements. After the task was completed, the participant was helped out of the gear and asked to reseat themselves so that they can continue with the questionnaire. Upon landing on the end screen of the questionnaire, it marked the end of the study overall and the participant was thanked for their time. In total, the average length of each session was 25 minutes.

2.6 Data Analysis

All data analysis (Appendix C) was conducted using R (version 4.2.3, R Core Team, 2023). To answer the main research question (RQ) of "Does haptic feedback, from visuo-tactile and vibro-tactile cues, affect purchase choices in a virtual environment?", Conditions A and B were first tested for a significant difference. Initially, the data for vibration experience was to be tested utilising an independent samples t-test, to observe whether a significant difference exists in the distribution between the two conditions. Vibration experience was the dependant variable (DV) and the condition was the independent variable (IV). However, when testing for normality of the DV, it was found to be of not normal distribution. Therefore, the Wilcoxon-Mann-Whitney test was used instead to test the alternative hypothesis that Condition A and B are independent samples of independent distributions. Then, a Wilcox Rank-Sign test was conducted which used the number of items selected per haptic attribute as its DV and the conditions as its IV. When it was found that the null hypothesis is true, Conditions A and B were assumed to be one condition and treated as such for all subsequent analysis.

Afterwards, the data for the number of items purchased across the four attributes was assessed through means of central tendencies and a Kruskal Wallis test. This tested the alternative hypothesis that a significant difference existed in number of items selected (DV) across attributes (IV).

Next, the second RQ “Is perceived sustainability of haptic attributes alongside the individual’s prior sustainability consciousness a mediating factor in purchase choice?” was analysed through participants” rating of ‘sustainability’ and ‘healthiness’ of the four attributes. Wilcoxon-Signed-Rank tests were conducted to understand the relationship between sustainability and healthiness ratings of each attribute. It was hypothesised that the ratings between both should be similar for each attribute. Then, a ‘perception’ score was created for each participant, for each attribute, using the aggregates of the two ratings. Sustainability consciousness was calculated by aggregating means of the three scales (knowingness, attitude, behaviour) among items, resulting in a single overall score that represented ‘sustainability consciousness’ for the participant as suggested by Gericke et al. (2018). A Kruskal Wallis test was conducted to find a significant difference amongst selection frequency (DV) across the four attribute levels (Matte x Smooth x Rough x Shiny), as a result of Sustainability Consciousness (IV). A secondary Kruskal Wallis test was ran that tested for a significant difference amongst the selection frequency (DV) across the four attribute levels (Matte x Smooth x Rough x Shiny), as a result of Sustainability Consciousness (IV). The aims of both tests were to understand the relationship between participants' sustainability consciousness, sustainability perceptions on the frequency of haptic attributes they selected. Then, three correlation analyses were run to further understand, using Kendall's Tau given the ordinal nature of the data. The first analysis tested the correlation between participants' sustainability consciousness (IV) and the sustainability perception of each attribute (DV). The second analysis tested the correlation between participants' sustainability consciousness (IV) and their selection frequency of items for each attribute (DV). The third analysis tested the correlation between participants' sustainability perceptions (IV) and their selection frequency of items for each attribute (DV).

3 Results

3.1 The effect of visuo-tactile and haptic cues on consumption preferences

A Wilcoxon-Mann-Whitney test was conducted to test the hypothesis that there was a significant difference in reported vibration experience between Condition A and Condition B. Though the Z-value, Z = -1.92, revealed a tendency for lower values for Condition A then Condition B, this difference is not significant at $\alpha = 0.05$ (p = .70). Therefore, the alternative hypothesis that the median vibration experience between Condition A and Condition B cannot be supported. Additionally, the Wilcoxon Rank-Sum test on distribution of items selected amongst attributes and condition, further visualised in Figure 6, found non-significant p-values for each attribute (Matte: p = 94; Rough: p = .88; Shiny: p = .49; Smooth: p = .35). This means there was no difference in the distribution in items selected for each variable between conditions.

Figure 6

The Distribution of Mean Items Selected per Attribute, According to Condition with Error Bars

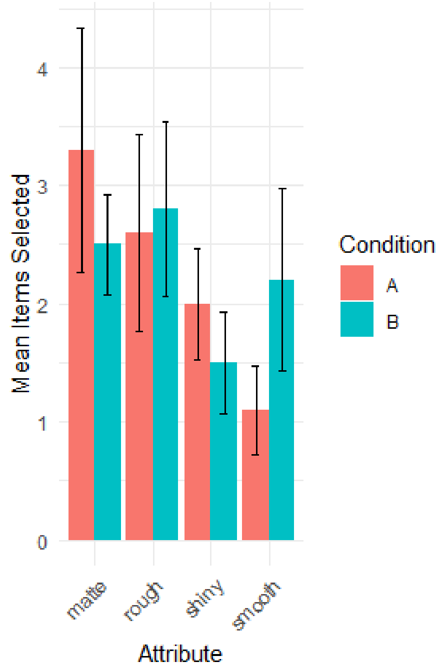


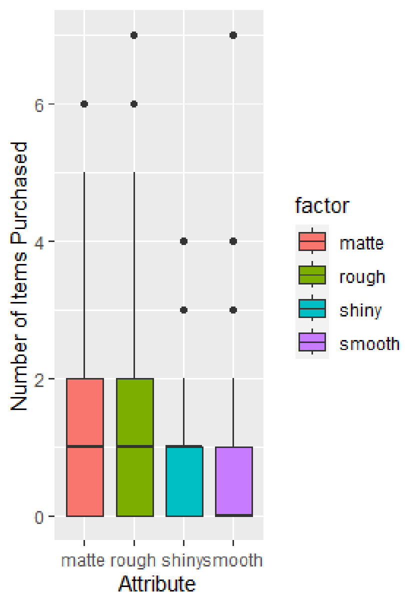
Table 2

Mean Number of Items Purchased by Participants Across Attributes

Attribute	Mean Number of Items Selected	Standard Deviation
Matte	4.3	2.75
Shiny	4.1	2.67
Rough	5.4	2.93
Smooth	4.65	3.15

Figure 7

The Distribution of Items Selected by Participants Across Attributes with Error Bars



Descriptive statistics revealed consistent or little variations in items purchased between the four attributes. Table 2 shows consumption preference through mean number of items selected per attribute, which ranked them in descending order from rough, matte, smooth, shiny. Figure 7 shows the distributions of items purchased across the attributes, revealing a possible difference in items selected between attributes matte and rough with shiny and smooth. However, the Kruskal-Wallis Rank Sum test conducted at significance $\alpha = 0.05$ supported the finding that no significant difference was found in items selected across attributes ($X^2(3) = 6.59, p = 0.086$). The reported mean level of effect from vibration experience on consumption preference is $\bar{x} = 1.95, s = 1.05$.

3.2 Sustainability Perceptions of Attributes

Wilcoxon Signed-Rank tests were run to analyse differences between participants' rating of sustainability and healthiness across the four attributes. Table 1 describes its results, from the *V*-values, *p*-values, and degrees of freedom. Attributes matte, rough, and smooth were found to have no significant differences in ratings of sustainability and healthiness, whereas participants rated the sustainability and healthiness of smooth significantly different ($V = 0, p < .05$). When observed through boxplots (Figure 8 and 9), participants appear to have rated smooth's healthiness significantly higher than its sustainability.

Table 3

Results for Wilcoxon Signed-Rank test on Sustainability and Healthiness Ratings Across Attributes

Attribute	Test Statistic (V)	P-value	Degrees of Freedom
Matte	29	.92	19
Shiny	16	.78	19
Rough	43	.39	19
Smooth	0	<.05	19

Figure 8

Sustainability Scores by Attribute

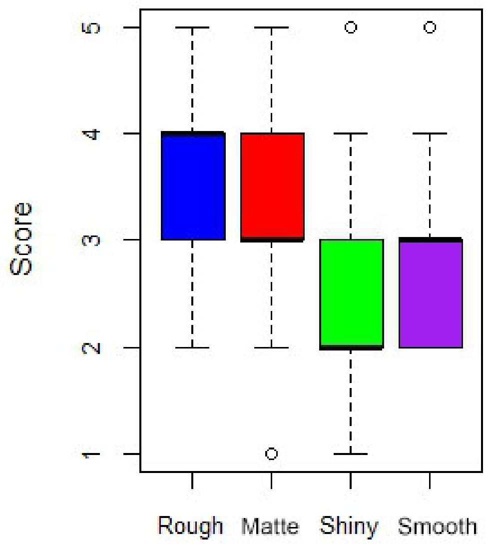
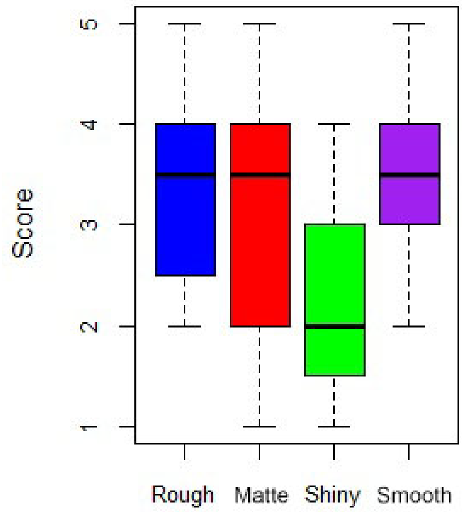


Figure 9

Healthiness Scores by Attribute



3.3 Sustainability Perceptions and Sustainability Consciousness

In average, participants rated the highest sustainability perception of rough ($\bar{x} = 3.6$, $s = .18$) and shiny as lowest ($\bar{x} = 2.35,\ s = .04$), trends of which can be found in Figure 10. The average sustainability consciousness score is $\bar{x} = 3.92$, with $s = .32$ amongst all participants, with higher scores on knowingness ($\bar{x} = 4.06,\ s = .45$) and attitude ($\bar{x} = 4.12$, $s = .27$) but a lower score on behaviour ($\bar{x} = 3.59,\ s = .57$). A visual representation is given in Figure 11, showing most participants clustering around 3.6 and 4.2.

Figure 10

Participants' Sustainability Perceptions Across the Four Attributes

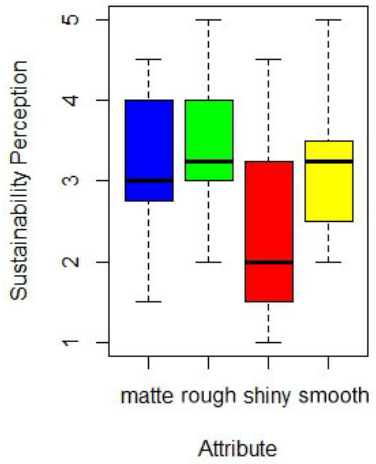
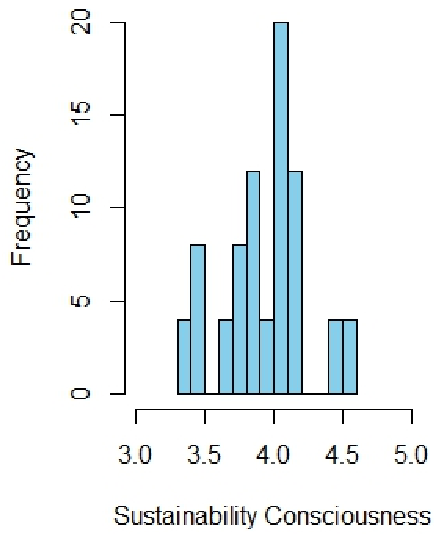


Figure 11

Participants' Sustainability Consciousness Scores



3.3.1 The Effects Between Sustainability Perceptions, Sustainability Consciousness on Consumption Preference

The Kruskal Wallis test conducted to compare the effect of Sustainability Consciousness among the four attributes revealed a non-significant difference across the four levels ($X^2(3) = 0, p = 1$). The second Kruskal Wallis test conducted to compare the effect of Sustainability Perceptions among the four attributes found a significant difference ($X^2(3) = 13.228, p = < .05$). There is at least one attribute's selection frequency that is significantly different than the rest in relation to Sustainability Perception, but there is no significant difference for selection frequency in relation to Sustainability Consciousness.

Table 4

Correlation Coefficients and P-values between Sustainability Consciousness and Sustainability Perceptions for each Attribute

Attributes	Test Statistic (τ)	P-value
Matte	.1124	.52
Shiny	.1470	.40
Rough	-.0831	.64
Smooth	.1172	.50

Correlation analyses between Sustainability Consciousness and Sustainability Perceptions were ran for each attribute. Table 4 shows all correlations found were relatively weak, though no p-values were significant either. The highest correlation was for the shiny attribute ($\tau = .1470, \mathrm{p} = .40$), showing a slight tend for participants to perceive shiny as more sustainable when they had higher sustainability consciousness scores. The rough attribute had the weakest correlation ($\tau = -.0831, \mathrm{p} = .64$).

Table 5

Correlation Coefficients and P-values between Sustainability Consciousness and Frequency of Items Selected for each Attribute

Attributes	Test Statistic (τ)	P-value
Matte	.1946	.27
Shiny	.0355	.84
Rough	-.0115	.95
Smooth	-.2360	.18

Correlation analyses between Sustainability Consciousness and frequency of items selected were ran for each attribute. Table 5 shows all correlations found were relatively weak, though no p-values were significant either. The highest correlation was for the matte attribute ($\tau = .1946, p = .27$), showing a slight tend for participants to select more matte items when they had higher sustainability consciousness scores. The rough attribute had the weakest correlation ($\tau = -.0115, p = .95$).

Table 6

Correlation Coefficients and P-values between Sustainability Perceptions and Frequency of Items Selected for each Attribute

Attributes	Test Statistic (τ)	P-value
Matte	.1841	.32
Shiny	.0063	.97
Rough	.0684	.71
Smooth	-.1936	.30

Correlation analyses between Sustainability Perception and frequency of items selected were ran for each attribute. Table 6 shows all correlations found were relatively weak, though no p-values were significant either. The highest correlation was for the smooth attribute ($\tau = -.1936, p = .30$), showing a slight tend for participants to select less smooth items when they perceived smooth as more sustainable. The highest, positive correlation was for 'matte' attribute ($\tau = .1841\ p = .32$) ; participants tend to select more matte items when they perceived matte as more sustainable. The shiny attribute had the weakest correlation ($\tau = .0063, p = .97$).

4 Discussion and Conclusion

4.1 The Effect of Haptic Feedback on Purchase Choice in Virtual Reality

The first research question posed in this thesis was "Does haptic feedback, from visuo-tactile and vibro-tactile cues, affect purchase choices in a virtual environment??", which was hypothesised that consumers would prefer the attributes ‘rough’ and ‘matte’, due to higher sustainability ratings, as opposed to ‘smooth’ and ‘shiny, which were lower. It should be noted that although the mean difference analysis ran did not find a conventional statistically significant result (typically, <.05), the p-value of 0.086 may be considered as slightly significant given the small sample size (n = 20) utilised in this study. Moreover, the findings showed that participants indeed possessed an attribute preference for, from highest to lowest — rough, smooth, matte, then shiny. Such results are slightly in line with the literature found (Kolppo, 2009; Spence & Badeka, 2021; Wandosell et al., 2021), in which participants had the highest preference for the rough attribute; however, instead of matte as the second highest preference as hypothesised, it was smooth. Plausibly, the frequency of smooth items selected may be inflated due to spawn location being right in front of them, thus participants tending to pick up the closest item. Moreover, a low mean level of effect from vibration experience was reported which suggests that participants might have relied more on visuo-tactile cues instead of vibro-tactile in VR.

In relation to sustainability perceptions of the four attributes, the findings from this study corroborate to the literature found. Namely, attribute shiny scored the lowest in perceived sustainability, corroborating Spence and Badeka (2021), while rough scored the highest, in line with Kolppo (2009). This may be attributed to the sample’s moderate sustainability consciousness score, which placed a higher emphasis on constructs ‘knowingness’ and ‘attitudes’. Higher ‘knowingness’ and ‘attitudes’ suggests overall greater and positive sentiments, such as ideas, emotions, towards sustainable concepts (Gericke et al., 2018). Interestingly, however, participants rated the sustainability and healthiness of ‘smooth’ very differently, in which the healthiness ratings of ‘smooth’ was similar to that of ‘rough’ and ‘matte’ despite its sustainability rating being lower and more similar to ‘shiny’ (see Section 3.2, Figure 8 and 9). It may have been worth it to investigate further whether participants appraised the 'smooth' items as 'matte' as well, which Kolppo (2019) describes can affect preference. In general, the trend of 'rough' being more preferable and 'shiny' least preferable was observed among participants, however, 'smooth' and 'matte' may be more interchangeable than the literature found.

4.2 The Influence of Sustainability Perceptions on Purchase Choice in Virtual Reality

The second research question asked whether perceived sustainability is an underlying factor in consumption preference, and whether this relationship is further mediated by an individual's prior sustainability consciousness. This thesis found evidence that supports the hypothesis that perceived sustainability does affect purchase choices, as seen in the significant difference found between selection frequency of items for the four attributes in relation to participants' sustainability perception score of that attribute. Moreover, a slight positive correlation was found between sustainability perceptions of 'matte' and selection frequency of matte items. These findings are in line with the literature found which posited that sustainability perception of an item influences consumption behaviour, with consumers preferring products they deem more sustainable (Kolppo, 2009; Branca et al., 2022; Wandosell et al., 2021).

However, prior sustainability consciousness does not play a mediating role in this relationship as no difference at all was found between the selection frequency of items across the four attributes. The contents of the SCQ-S, which is the basis of how sustainability consciousness was measured, primarily deals with worldly sustainability attitudes and not health sustainable attitudes (Gericke et al., 2018). Therefore, the non-significant finding may suggest that purchase preference could be more driven by perceived healthiness instead of overall sustainability. Participants' second-highest preference being 'smooth', the attribute rated much higher for healthiness than sustainability, may further support this claim. Overall, sustainability perceptions were found to positively influence consumption preference, in which consumers prefer the haptic attributes deemed as more sustainable, but this is not further affected by prior general sustainability awareness. As such, it might suggest that perceived healthiness of a product is just as important as perceived sustainability.

4.3 Limitations

There were some limitations within this study that might have affected the results. Firstly, a technical limitation that restricted the level of depth to the vibrotactile feedback given, which diminished participants' ability to differentiate the variations between attributes from cues. Additionally, comments from participants suggests dissonance between the quality of haptic feedback felt in the VR space and RL, because RL offers more cue dimensions, such as hardness, for appraisal and ascertaining material. Lastly, it is important to consider the sample size being on the lower end (N = 20) with large variability in VR experience amongst participants. As such, this may have caused discrepancies between participants' behaviour in VR and RL as the immersion factor is decreased (Loureiro et al., 2019).

4.4 Conclusion

The present thesis sought to investigate the effects of food packaging's haptic feedback, cued from both the visuo-tactile and vibrotactile, and perceived sustainability on purchase choice in VR. The rough attribute was rated highest in perceived sustainability and, thus, was in line with expectations when it was also the highest preferred attribute. Contrasting the posited hypothesis, however, 'smooth' was the second-highest preferred attribute yet its overall perceived sustainability still falls short of its successor, matte. This might suggest interchangeability between 'smooth' and 'matte' in terms of purchase preference. Findings are consistent that 'shiny' is the least preferred attribute with the lowest overall perceived sustainability. Surprisingly, prior sustainability awareness did not affect consumption preference and only sustainability perceptions did. In conclusion, this thesis found similarities between consumption behaviours in VR and literature that describes consumption behaviours in RL alongside slight differences, suggesting the benefits of further utilising VR to study consumer behaviour. Future research should work on expanding the technical limitations for more robust applications of VR in sensory marketing research. Moreover, perceived healthiness may be investigated separately to perceived sustainability to better understand the discrepancies and similarities between both constructs regarding haptic attributes.

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Appendix A

Questionnaire

Participants were given a questionnaire to complete during the duration of the study.

Appendix A.1: 6 Items

1. Please write your age.
   a. *[OPEN-ENDED]*
2. Please write your nationality/country of origin.
   a. *[OPEN-ENDED]*
3. Please indicate your gender
   a. *Male*
   b. *Female*
   c. *Other*
   d. *Prefer not to say*
4. Do you have any dietary restrictions?
   a. *No*
   b. *Yes (Please specify)*
   c. *Vegetarian*
   d. *Vegan*
5. Do you go to the supermarket yourself to purchase groceries for food needs?
   a. *Yes*
   b. *No*
   c. *I share this responsibility with other people*
6. How often do you visit the supermarket?
   a. *More than once a week*
   b. *Once a week*
   c. *Once every two weeks*
   d. *Once a month*
   e. *I rarely do*

Appendix A.2: 15 Items

The following questions were answered on a scale of 1 – 5 (1 = Not at all, 2 = Slightly, 3 = Moderately, 4 = Very, 5 = Extremely)

1. Did you notice the vibrations from the controllers when touching the products?

2. Did you notice a difference in vibration-intensity from the controllers when touching different products?
3. To what extent did this sensation influence your choice to pick up a product?

The following two questions was asked four times for each one of the haptic attributes of *rough, matte, shiny, smooth*, answered on a scale of 1 – 5 (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

1. To what extent do you agree that the feeling of '**haptic attribute**' packaging represents sustainability?
2. To what extent do you agree that the feeling of '**haptic attribute**' packaging represents healthiness?

Appendix A.3: 27 Items

The following statements are from the SCQ-S (Gericke et al., 2018), for which participants needed to indicate their level of agreement to on a scale of 1 – 5 (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

1. Reducing water consumption is necessary for sustainable development.
2. Preserving the variety of living creatures is necessary for sustainable development (preserving biological diversity).
3. For sustainable development, people need to be educated in how to protect themselves against natural disasters.
4. A culture where conflicts are resolved peacefully through discussion is necessary for sustainable development.
5. Respecting human rights is necessary for sustainable development.
6. To achieve sustainable development, all the people in the world must have access to good education..
7. Sustainable development requires that companies act responsibly towards their employees, customers and suppliers.
8. Sustainable development requires a fair distribution of goods and services among people in the world.
9. Wiping out poverty in the world is necessary for sustainable development.
10. I think that using more natural resources than we need does *not* threaten the health and well-being of people in the future.
11. I think that we need stricter laws and regulations to protect the environment.
12. I think that it is important to take measures against problems which have to do with climate change.
13. I think that everyone ought to be given the opportunity to acquire the knowledge, values and skills that are necessary to live sustainably.
14. I think that we who are living now should make sure that people in the future enjoy the same quality of life as we do today.
15. I think that women and men throughout the world must be given the same opportunities for education and employment.
16. I think that companies have a responsibility to reduce the use of packaging and

disposable articles.

17. I think it is important to reduce poverty.
18. I think that companies in rich countries should give employees in poor nations the same conditions as in rich countries.
19. I recycle as much as I can.
20. I always separate food waste before putting out the rubbish when I have the chance.
21. I have changed my personal lifestyle in order to reduce waste (e.g., throwing away less food or not wasting materials).
22. When I use a computer or mobile to chat, to text, to play games and so on, I always treat others as respectfully as I would in real life.
23. I support an aid organization or environmental group.
24. I show the same respect to men and women, boys and girls.
25. I do things which help poor people.
26. I often purchase second-hand goods over the internet or in a shop.
27. I avoid buying goods from companies with a bad reputation for looking after their employees and the environment.

Appendix B

Informed Consent

Page 1

Informed Consent

Thank you for signing up to be a part of my study. This study has been approved by the BMS Ethics Committee at the University of Twente. The ethics approval number is 240226. With this approval, it shows the commitment and intent of the study's researcher to protect the privacy, rights, and well-being of all participants involved.

This study is carried out as a part of my bachelor's assignment at the University of Twente, with its purpose being to investigate consumption behaviours under various contexts. Your participation will contribute in understanding how different factors can influence consumer preferences and choices. Should you have any more questions, the researcher may respond; otherwise, you may ask them after completion of your study and the researcher will provide more information.

Please read the following terms carefully and indicate whether you agree to them.

I have read and understood the study information presented and described to me. I have also been able to ask questions about the study and my questions have been answered to my satisfaction

[] I Agree

[] I Disagree

I consent voluntarily to be a participant in this study and understand that should I wish to withdraw from the study, I can notify researchers at any point in time without an explicit reason.

[] I Agree

[] I Disagree

I understand that the data I provide will be used by the student present, alongside faculty members involved in the research.

[] I Agree

[] I Disagree

I understand that my identity is confidential to only the researcher and a faculty member but will be processed anonymously. No personal identifiers will be recorded to the data.

[] I Agree

[] I Disagree

I consent for the data I provide to be archived in Qualtrics anonymously, with the possibility that it may be used in future research.

[] I Agree

[] I Disagree

Sign your name to indicate your agreement with the form.

[Participant Response]

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Contact Details

Please write your email address, which will only be contacted for a copy of this form, and if it is indicated that you would like to receive follow-up information regarding the study once it has been published.

[Participant Response]

Do you wish to receive further information and details after the study has been completed?

[] Yes

[] No

Appendix C

R-Code

```
library(tidyr)
library(tidyverse)
library(dplyr)
library(coin)
library(openxlsx)
library(broom)
library(lme4)
library(ggplot2)
library(stats)

#PART 1 : finding the difference between conditions through self-report
data <- read_csv("vr_experience2.csv")
data <- data %>%
  mutate(vibration_experience = as.numeric(vibration_experience),
         vibration_difference = as.numeric(vibration_difference),
         vibration_effect = as.numeric(vibration_effect))
data$condition <- factor(data$condition)

data_summary <- data %>% #mean summary, grouped
  group_by(condition) %>%
  summarise(
    mean_vibration_experience = mean(vibration_experience, na.rm = TRUE),
    mean_vibration_difference = mean(vibration_difference, na.rm = TRUE),
    mean_vibration_effect = mean(vibration_effect, na.rm = TRUE),
    sd_vibration_experience = sd(vibration_experience, na.rm = TRUE),
    sd_vibration_difference = sd(vibration_difference, na.rm = TRUE),
    sd_vibration_effect = sd(vibration_effect, na.rm = TRUE)
  )

dataUngrouped_summary <- data %>% #mean summary, ungrouped
  summarise(
    mean_vibration_experience = mean(vibration_experience, na.rm = TRUE),
    mean_vibration_difference = mean(vibration_difference, na.rm = TRUE),
```

```
    mean_vibration_effect = mean(vibration_effect, na.rm = TRUE),
    sd_vibration_experience = sd(vibration_experience, na.rm = TRUE),
    sd_vibration_difference = sd(vibration_difference, na.rm = TRUE),
    sd_vibration_effect = sd(vibration_effect, na.rm = TRUE)
  )

#assumptions check
shapiro_test_experience <- data %>%
  group_by(condition) %>%
  summarise(shapiro_p_value = shapiro.test(vibration_experience)$p.value)
shapiro_test_difference <- data %>%
  group_by(condition) %>%
  summarise(shapiro_p_value = shapiro.test(vibration_difference)$p.value)
shapiro_test_effect <- data %>%
  summarise(shapiro_p_value = shapiro.test(vibration_effect)$p.value)
print(shapiro_test_experience)
print(shapiro_test_difference)
print(shapiro_test_effect)

#sig test - wilcox mann whitney

exact_wilcox_test <- wilcox_test(vibration_experience ~ condition, data = data, distribution
= "exact")
print(exact_wilcox_test)

#PART 1.1 : finding difference between conditions through dv

data <- read.csv("item_conditions.csv")
long_data <- data %>%
  pivot_longer(cols = matte:smooth, names_to = "Variation", values_to = "Items_Selected")
str(long_data)
long_data$Items_Selected <- as.numeric(long_data$Items_Selected)
long_data$Variation <- as.factor(long_data$Variation)
long_data$condition <- as.factor(long_data$condition)

#sig test - wilcox rank sign
wilcox_results <- long_data %>%
  group_by(Variation) %>%
  summarise(Wilcox_P_Value = wilcox.test(Items_Selected ~ condition, exact =
FALSE)$p.value)

wilcox_results

#data visualisation
```

```
summary <- long_data %>%
  group_by(Variation, condition) %>%
  summarise(Mean_Items = mean(Items_Selected),
            SD_Items = sd(Items_Selected),
            Count = n())
ggplot(summary, aes(x = Variation, y = Mean_Items, fill = condition)) +
  geom_bar(stat = "identity", position = position_dodge()) +
  geom_errorbar(aes(ymin = Mean_Items - SD_Items/sqrt(Count), ymax = Mean_Items +
SD_Items/sqrt(Count)),
                position = position_dodge(width = 0.9), width = 0.25) +
  labs(x = "Attribute", y = "Mean Items Selected", fill = "Condition") +
  theme_minimal() +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))

#PART 1.2 ; descriptive stats
items <- read.csv("item_score.csv")
glimpse(items)
colnames(items)

items_long <- items %>%
  pivot_longer(cols = rough_chip:shiny_cereal,
               names_to = "item",
               values_to = "num_picked") %>%
  mutate(
    factor = case_when(
      str_detect(item, "rough") ~ "rough",
      str_detect(item, "smooth") ~ "smooth",
      str_detect(item, "matte") ~ "matte",
      str_detect(item, "shiny") ~ "shiny"
    )
  )
items_long <- items_long %>%
  mutate(proportion_picked = num_picked / 9)
glimpse(items_long)

#distribution of items picked per attribute
ggplot(items_long, aes(x = factor, y = num_picked, fill = factor)) +
  geom_boxplot() +
  labs(title = "Distribution of Items Purchased by Attribute",
       x = "Attribute",
       y = "Number of Items Purchased")

#total number of items picked
summary_by_factor <- data_long %>%
```

```
  group_by(factor) %>%
  summarize(
    mean_picked = mean(num_picked, na.rm = TRUE),
    sd_picked = sd(num_picked, na.rm = TRUE),
    total_picked = sum(num_picked, na.rm = TRUE)
  )
print(summary_by_factor)

#sig test - kruskal wallis

kruskal_test <- kruskal.test(num_picked ~ factor, data = items_long)

print(kruskal_test)

#PART 2.1 ; sustainability perceptions and consciousness
#perception
survey <- read.csv("survey_score.csv")
survey_scores <- survey %>%
  summarize(
    mean_rough_sustainability = mean(rough_sustainability, na.rm = TRUE),
    mean_rough_healthiness = mean(rough_healthiness, na.rm = TRUE),
    mean_matte_sustainability = mean(matte_sustainability, na.rm = TRUE),
    mean_matte_healthiness = mean(matte_healthiness, na.rm = TRUE),
    mean_smooth_sustainability = mean(smooth_sustainability, na.rm = TRUE),
    mean_smooth_healthiness = mean(smooth_healthiness, na.rm = TRUE),
    mean_shiny_sustainability = mean(shiny_sustainability, na.rm = TRUE),
    mean_shiny_healthiness = mean(shiny_healthiness, na.rm = TRUE)
  )

print(survey_scores)

#sig test - wilcox sign rank
shapiro_test <- shapiro.test(survey$rough_sustainability)
print(shapiro_test)
num_paired <- sum(!is.na(survey$sustainability) & !is.na(survey$healthiness))

wilcox_test <- wilcox.test(survey$rough_sustainability, survey$rough_healthiness, paired =
TRUE, exact = FALSE)
print(wilcox_test)
wilcox_test_matte <- wilcox.test(survey$matte_sustainability, survey$matte_healthiness,
paired = TRUE, exact = FALSE)
print(wilcox_test_matte)
wilcox_test_smooth <- wilcox.test(survey$smooth_sustainability,
survey$smooth_healthiness, paired = TRUE, exact = FALSE)
```

```
print(wilcox_test_smooth)
wilcox_test_shiny <- wilcox.test(survey$shiny_sustainability, survey$shiny_healthiness,
paired = TRUE, exact = FALSE)
print(wilcox_test_shiny)

# calculate aggregated scores for each attribute
survey$Rough_Score <- rowMeans(survey[, c("rough_sustainability", "rough_healthiness")],
na.rm = TRUE)
survey$Matte_Score <- rowMeans(survey[, c("matte_sustainability", "matte_healthiness")],
na.rm = TRUE)
survey$Smooth_Score <- rowMeans(survey[, c("smooth_sustainability",
"smooth_healthiness")], na.rm = TRUE)
survey$Shiny_Score <- rowMeans(survey[, c("shiny_sustainability", "shiny_healthiness")],
na.rm = TRUE)


#sustainability consciousness
sustainability <- read.csv("aggregate_survey.csv")

str(sustainability)
sustainability$matte_total <- as.numeric(sustainability$matte_total)
sustainability$shiny_total <- as.numeric(sustainability$shiny_total)
sustainability$rough_total <- as.numeric(sustainability$rough_total)
sustainability$smooth_total <- as.numeric(sustainability$smooth_total)

sus_long <- sustainability %>%
  pivot_longer(cols = starts_with("perception_"),
               names_to = "perception_type",
               values_to = "perception_score")
sus_long <- sus_long %>%
  pivot_longer(cols = "sustainability_c",
               names_to = "sustainability_c_type",
               values_to = "sustainability_c_score")
sus_long$Items_chosen <- sus_long$matte_total + sus_long$rough_total +
sus_long$shiny_total + sus_long$smooth_total




#plots  - ggplot not working?
#health/sustain, separate
score <- read.csv("survey_score.csv") #same dataset as above

score_long <- score %>%
```

```
  pivot_longer(
    cols = -participant_id,
    names_to = c(".value", "attribute"),
    names_pattern = "(.*)_(.*)"
  )

sustainability_data <- score[, c("rough_sustainability", "matte_sustainability",
"shiny_sustainability", "smooth_sustainability")]
healthiness_data <- score[, c("rough_healthiness", "matte_healthiness", "shiny_healthiness",
"smooth_healthiness")]

par(mfrow = c(2, 1))
options(repr.plot.width=6, repr.plot.height=12)
names(sustainability_data) <- c("Rough", "Matte", "Shiny", "Smooth")
names(healthiness_data) <- c("Rough", "Matte", "Shiny", "Smooth")

boxplot(sustainability_data,
        main = "",
        names = c("Rough", "Matte", "Shiny", "Smooth"),
        col = c("blue", "red", "green", "purple"),
        ylab = "Score",
        cex.axis = 0.8)

boxplot(healthiness_data,
        main = "",
        names = c("Rough", "Matte", "Shiny", "Smooth"),
        col = c("blue", "red", "green", "purple"),
        ylab = "Score",
        cex.axis = 0.8)
title(main = "Healthiness Scores by Attribute", cex.main = 1)

title(main = "Healthiness Scores by Attribute", cex.main = 1) #titles aren't printed auto due to
sizing error, hafta switch manually

title(main = "Sustainability Scores by Attribute", cex.main = 1)

#perceptions across attributes
sustain <- read.csv("long_data.csv")
str(sustain)

boxplot(perception_score ~ attribute, data = sustain,
        col = c("blue", "green", "red", "yellow"),
        main = "",
        xlab = "Attribute",
```

```
    ylab = "Sustainability Perception"
)

#consciousness score overview
hist(sustain$sustainability_c,
   main = "",
   xlab = "Sustainability Consciousness",
   ylab = "Frequency",
   col = "skyblue",
   border = "black",
   xlim = c(3, 5),
   ylim = c(0, 20), # X-axis limits
   breaks = 10
)

#PART 3 ; effects between conc., perc., and freq.
#uses same dataset as above
kw_test_overall <- kruskal.test(sustainability_c ~ attribute_items, data = sustain)
print(kw_test_overall)

kw_test_perception <- kruskal.test(perception_score ~ attribute_items, data = sustain)
print(kw_test_perception)

#corr. analysis - kendall's tau-b
sustainN <- read.csv("aggregate_survey.csv")
kendall_perception_matte <- cor.test(sustainN$sustainability_c, sustainN$perception_matte,
method = "kendall")
kendall_perception_shiny <- cor.test(sustainN$sustainability_c, sustainN$perception_shiny,
method = "kendall")
kendall_perception_rough <- cor.test(sustainN$sustainability_c, sustainN$perception_rough,
method = "kendall")
kendall_perception_smooth <- cor.test(sustainN$sustainability_c,
sustainN$perception_smooth, method = "kendall")
print(kendall_perception_matte)
print(kendall_perception_shiny)
print(kendall_perception_rough)
print(kendall_perception_smooth)

kendall_perception_matte <- cor.test(sustainN$sustainability_c, sustainN$perception_matte,
method = "kendall")
kendall_perception_shiny <- cor.test(sustainN$sustainability_c, sustainN$perception_shiny,
method = "kendall")
kendall_perception_rough <- cor.test(sustainN$sustainability_c, sustainN$perception_rough,
method = "kendall")
```

```
kendall_perception_smooth <- cor.test(sustainN$sustainability_c,
sustainN$perception_smooth, method = "kendall")

kendall_item_matte <- cor.test(sustainN$sustainability_c, sustainN$matte_total, method =
"kendall")
kendall_item_shiny <- cor.test(sustainN$sustainability_c, sustainN$shiny_total, method =
"kendall")
kendall_item_rough <- cor.test(sustainN$sustainability_c, sustainN$rough_total, method =
"kendall")
kendall_item_smooth <- cor.test(sustainN$sustainability_c, sustainN$smooth_total, method
= "kendall")

print(kendall_item_matte)
print(kendall_item_shiny)
print(kendall_item_rough)
print(kendall_item_smooth)

kendall_perception2_matte <- cor.test(sustainN$perception_matte, sustainN$matte_total,
method = "kendall")
kendall_perception2_shiny <- cor.test(sustainN$perception_shiny, sustainN$shiny_total,
method = "kendall")
kendall_perception2_rough <- cor.test(sustainN$perception_rough, sustainN$rough_total,
method = "kendall")
kendall_perception2_smooth <- cor.test(sustainN$perception_smooth,
sustainN$smooth_total, method = "kendall")

print(kendall_perception2_matte)
print(kendall_perception2_shiny)
print(kendall_perception2_rough)
print(kendall_perception2_smooth)
```