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Touch Matters: The Impact of Physical Contact on Haptic Product Perception in Virtual Reality

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Abstract: Nowadays, the presentation of products through virtual reality and other online media coexists with traditional means. However, while some products may be perceived correctly in digital media, others may need physical contact. In this scenario, this work analyses how presenting a product highlighted for its haptic properties and the presence or absence of physical contact during the presentation can influence the perception of its attributes and stimulate purchase intention. To this end, an experiment was designed in which each participant viewed and interacted with a chair presented in five different means that elicited a greater or lesser sense of presence. Participants evaluated the product's attributes on a semantic scale with bipolar pairs. No relation was found between the presentation means and users' purchase intention. However, results showed significant differences in the evaluation of some physical characteristics depending on the presentation means, and the product was generally more liked when presented in means in which it could be touched. We conclude that choosing means that allow a product to be touched and elicit a greater sense of presence may impact more positively on evaluations of haptic features when presenting a product with high haptic importance.

Keywords: virtual reality; product evaluation; passive haptics; presence; purchase intention

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1. Introduction

As e-commerce is rapidly rising [1,2], many sellers are opting to present their products by online digital means to make themselves known to bigger audiences and to reach more potential customers. Unlike traditional sales channels, these means take the product to users without them having to travel to physical stores. This gradual change in paradigm has recently accelerated in many countries with the COVID-19 pandemic, which has led many consumers to prefer online shopping [3–5]. Evidently, this makes the presentation of online products an extremely interesting theme for designers, dealers, and consumers.

However, while some products may be perceived correctly in entirely digital media, others may not be without physical contact, due to their inherent natures. In this scenario, it is necessary to deepen the knowledge of how the way of presenting these products and the presence or absence of direct physical touch can influence the perception of some of their attributes.

This work aims to determine which attributes of a product that stands out for its haptic properties may be perceived differently depending on the means used in its presentation. This will be performed by comparing the presentation of a product in five means: two allowed it to be touched (real setting and virtual reality with passive haptics) and three did not (virtual reality, non-interactive 3D animation, and interactive 3D image). This work also aims to study whether this perception can negatively affect product liking and if the means used to present the product may influence purchase intention.

The results of this study may help designers and e-commerce sellers know which means may be the most suitable for presenting certain products so that the perception of some meaningful attributes is not biased.

1.1. State of the Research Field and Research Hypotheses

Of all the presentation formats that are becoming interesting for presenting online products, there are interactive images, where users are able to intuitively turn a 3D image of a product to look at it from different viewpoints [6]; pre-recorded videos, which offer a product's animation [7]; and virtual reality (VR), which can offer users experiences by interacting with the product in a more immersive setting [8] and can even improve the shopping experience [9,10].

Several works have confirmed the interest shown in recent years in investigating VR in e-commerce and product presentation. For instance, Agost et al. [11] analyzed the influence of using virtual reality, augmented reality, and 360° display technologies on the perception of different aspects of products and on the overall shopping experience, comparing them with static 2D rendered images. Peukert et al. [12] studied the influence of being immersed in a VR setting on users' intention to use the shopping environment again. Su et al. [13] pointed out the importance of designing suitable user interfaces and user experiences to ensure that a VR setting applied to e-commerce is efficient by contemplating five themes: screen, operation and prompts, safety and experience of use, system functions, and transactions. Luna-Nevarez and McGovern [14] investigated the role that immersion, enjoyment, trust, and VR self-efficacy play in consumers' purchase intention in the virtual commerce (v-commerce) setting, and pointed out the role played by processing fluency, need for touch, propensity to trust, and gender in attitudes to these e-commerce platforms. Martínez-Navarro et al. [15] investigated the efficiency of using different VR formats and devices in a virtual store setting by analyzing the relations that link the sense of presence, remembering a brand, and purchase intention by demonstrating the advantages of e-commerce over physical stores to generate positive consumer responses, as well as the positive impact that head-mounted displays (HMD) have on users' purchase intention.

However, a recent review of 22 studies pointed out some limitations of VR in assessing user experience due to the lack of perceived realism and sensory feedback [16]. In this regard, none of the aforementioned visual presentation means offer the possibility of physically touching a real product, which limits product feedback to visual information only. This implies that the way some product properties are perceived can be affected, which could influence users' opinions. On material objects that stand out for their haptic properties, i.e., products with a high propensity to be touched during normal use (high haptic importance), some works have found that not being able to access haptic information can frustrate users [17,18]. This can be explained by the need for touch for the product (NFT), i.e., preference for the extraction and utilization of information obtained through the haptic system [19], regardless of it involving searches for useful information (instrumental touch) or purely hedonic information (autotelic touch).

Although some techniques may help simulate tangible properties in VR [20–22], they sometimes require expensive or complex tools and devices. However, by using passive haptics, i.e., the use of physical elements (proxies) capable of providing information to users through their shape [23], VR is able to bridge this gap in a simpler way. This can offer users a more complete product experience by allowing them to access information that might be relevant, such as temperature when touching materials, surface textures, or weight. Being able to touch a product sample during its presentation in physical stores, showrooms, or during the prototype evaluation stage of product design permits users to form a more correct opinion about its quality [24,25], which could increase their trust in the product. This means that users would be allowed to access multisensory (visual and haptic) information if a product is presented by VR systems with passive haptics, i.e., with a physical sample of the product, which could facilitate evaluation [26–28]. This can positively impact consumer attitudes towards the product [29].

Given the importance of accessing relevant product information to make coherent evaluations and that some products with high haptic importance need to be touched to be better understood, it is necessary to test to what extent some of the current presentation means can distort the perception of some attributes. Thus, for our study, we can establish the first three hypotheses:

- **H1:** *Evaluations of the product's characteristics are influenced by the presentation means.*
- **H2:** *The presentation means allowing a product to be touched or not influence the evaluation of the physical characteristics of material products with high haptic importance.*
- **H3:** *A material product with great haptic importance is most liked when it is presented by means that allow it to be touched.*

When we talk about presenting products by means of multisensory stimuli (visual + haptic) in immersive VR settings, it is worth mentioning the theme of the sense of presence. Sense of presence has often been defined, and in various forms [30], as a user's sense of "being there" [31], i.e., a feeling of being transported to a virtual setting. Several researchers have developed well-known questionnaires to measure it [32–34], and some have concluded that coherently adding multisensorial stimuli to a VR application (e.g., visual and haptic stimuli) can influence the sense of presence [35–37].

Some works have found that not being able to access haptic information can negatively impact the purchase intention of products with a high haptic importance [38], and demonstrated that users would prefer to touch and try them before buying them [39]. Some studies suggest that providing the possibility to touch the product and, thus, access multisensory information can even increase customers' purchase intention [40–42]. Others suggest that simply imagining touching a product also increases purchase intention [43], supporting the importance of tactile sensations.

Given the positive influence that combining visual and haptic stimuli can have on users' product evaluations and purchase intentions, we can think that those means capable of eliciting a greater sense of presence can, therefore, favor product evaluations. Therefore, to corroborate the level of presence that the presentation means used in this study can elicit, and its possible relation to more positive product evaluations and purchase intention, we propose the following hypotheses:

- **H4:** *Adding haptic stimuli to a product as a means of increasing users' sense of presence.*
- **H5:** *The presenting of a product by means capable of eliciting more presence can favor better product evaluations.*
- **H6:** *The purchase intention of a material product with high haptic importance is greater when it is presented in a means that allows physical contact.*

1.2. Main Aim of the Work and Principal Conclusions

Bearing in mind the questions set out above, the main objective of this work is to determine which attributes of a product that stands out for its haptic properties can be perceived differently depending on the means used in its presentation. This may help designers and e-commerce sellers to choose the most suitable means for presenting certain products so that the perception of some meaningful attributes is not biased.

Our study found that users who participated in the experiment seemed to perceive a greater sense of presence in those means that combined haptic and visual stimuli. The results showed, firstly, that physical characteristics related to comfort and weight were differently perceived depending on how the product was presented and, secondly, that the product was generally more liked when it was presented in means by which it could be touched. Therefore, although limited by the scope of this study, it is possible to argue that those means that allow touch and elicit a greater sense of presence might have a more positive impact on evaluations of haptic characteristics when presenting a material product with high haptic relevance.

2. Materials and Methods

2.1. Experimental Study

The experiment conducted for this research received the formal approval of the ethics committee named the Comisión Deontológica of the Universitat Jaume I institution, with the approval code CD/102/2021.

In order to check our hypotheses, an experiment was designed in which each participant viewed and interacted with the same product, which was presented by five different means: real setting (R), virtual reality (VR), virtual reality with passive haptics (VRPH), non-interactive 3D animation in a looped video (V), and 360-degree rotatable image or interactive 3D image (3Di). Two allowed the product to be touched (R, VRPH), and three did not (VR, V, 3Di). The order of viewing sequence was alternated to balance any possible resulting effects.

A chair was selected for the present study for two reasons: it is a usual product found in the domestic habitat and is, thus, known by users; and it presents enough formal characteristics for users to evaluate different aspects. To help users pay attention only to the product, it was placed in the middle of an empty white-walled room. The scene was prepared in five different presentation means, each inside a room (Figure 1).

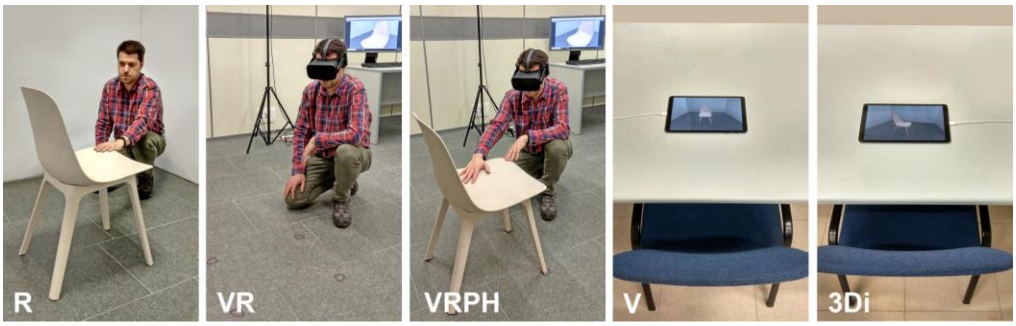


Figure 1. The five rooms used during the experiment.

1. Room 1 (R). A square set was built with white panels that simulated the walls of a room, and the real chair stood in the middle. White light was vertically projected onto the chair from the ceiling. Each panel measured 2.60 m long, except for one that measured only 2 m to leave an opening so that participants could enter and leave the setting. All the white panels were 2 m high. The participants could move around the chair, touch it, and sit on it.
2. Room 2 (VR). The chair and Room 1 setting were modelled and rendered with the same details, textures, and lighting. It was presented in VR. The participants could move around the chair, but not touch it or sit on it because there was no physical chair in this room.
3. Room 3 (VRPH). The scene was the same as in Room 2 and was presented in VR, but a physical chair was added by synchronizing its position with the viewed 3D model so that the participants could touch the chair and sit on it. For a correct use of passive haptics in VR, two criteria must be met: similarity between haptic proxies and virtual objects in both material and geometrical properties, and co-location, i.e., both must share the same position and alignment [44,45].
4. Room 4 (V). The same scene was rendered on a tablet screen. The chair and the scene automatically turned at constant speed in relation to the vertical axis that passed through the center of the chair. The scene took 12 s to turn 360 degrees. The participants could watch the animation, but could not interact with it.
5. Room 5 (3Di). The same scene rendered in Room 4 was created and presented on another tactile screen with the same characteristics. In this case, the participants could touch the screen and slide their fingers to the right or left, turning the scene around

the vertical axis that passed through the center of the chair. This allowed them to view the chair from multiple angles.

2.2. Semantic Differential

To evaluate the product presented in different means, we used the semantic differential method, which is commonly used to assess how products are perceived [46,47]. This method is used to measure the connotative meaning of words, concepts, or products. It involves presenting subjects with a series of bipolar adjective scales, such as good–bad or active–passive, and asking them to place a mark on the scale that reflects their evaluation of the concept being studied. We obtained the semantic pairs by selecting the most usual adjectives employed to describe a product, which were collected from related commercial websites, regular product users, and professional product designers, following the methodology described by [48]. To avoid making the chair evaluation process too long or tedious, and after checking that a large number of bipolar pairs for obtaining relevant product information was not necessary [47–49], only the 12 most usual adjectives were selected to form bipolar pairs. Three belonged to each pleasure category according to Tiger, namely, Physio-pleasure, Psycho-pleasure, Socio-pleasure, and Ideo-pleasure [50], to evaluate the product on several dimensions. This selection of adjectives belonging to Tiger's categories helps to evaluate the product in a very comprehensive way by providing representative information on the various aspects that define it. According to the recommendations of Al-Hindawe [51], a 7-interval scale was used to evaluate each bipolar pair (Table 1).

Table 1. Bipolar pairs used to evaluate the chair on a 7-interval scale.

Categories	Adjective	Interval Scale							Adjective (Opposite)
Physio	Comfortable	−3	−2	−1	0	1	2	3	Uncomfortable
	Heavy	−3	−2	−1	0	1	2	3	Light
	Resistant	−3	−2	−1	0	1	2	3	Fragile
Psycho	Useless	−3	−2	−1	0	1	2	3	Practical
	Simple	−3	−2	−1	0	1	2	3	Complex
	Versatile	−3	−2	−1	0	1	2	3	Invariable
Socio	Classic	−3	−2	−1	0	1	2	3	Modern
	Nice	−3	−2	−1	0	1	2	3	Ugly
	Overelaborate	−3	−2	−1	0	1	2	3	Minimalist
Ideo	Tasteful	−3	−2	−1	0	1	2	3	Tasteless
	Industrial	−3	−2	−1	0	1	2	3	Handmade
	Fun	−3	−2	−1	0	1	2	3	Boring

2.3. Stimulus

All the scenes created in Rooms 1 to 5 offered the same characteristics and presented the same product to be evaluated: the Odger chair from Ikea. The scenes in Rooms 2 to 5 were modelled and rendered by imitating the characteristics of the shapes, sizes, colors, textures, and lighting of the real scene in Room 1 (Figure 2) and were prepared with Unity 2019.2.8f1. To view the scenes in Rooms 2 and 3, an Oculus Rift VR headset and two position sensors were employed. To view the scenes in Rooms 4 and 5, two Galaxy Tab A 2019 tablets (2 GB RAM) were utilized with resolutions of 1920 × 1200. The screen size was 10.1 inches.

2.4. Sampling

We conducted an a priori power analysis with G*Power 3.1.9.7 [52], assuming an ANOVA with repeated measures within factors with the following input parameters: effect size: 0.25, $\alpha = 0.05$, $(1\text{-}\beta) = 0.85$, 1 group, 5 measurements, correlation among repeated measures = 0.5, and nonsphericity correction = 1. G*Power proposed a total sample size of 23.

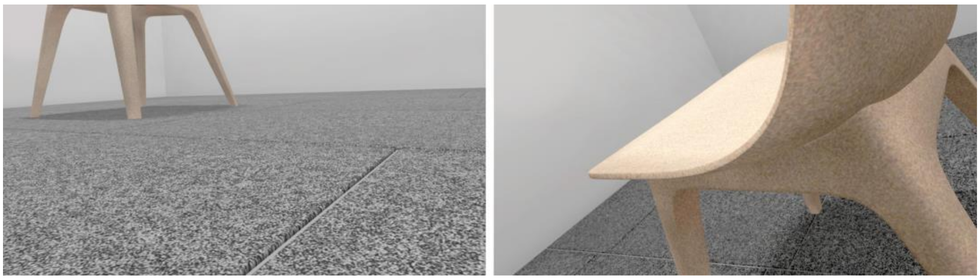


Figure 2. Chair and floor modelling, lighting and texture details (in Rooms 2 to 5).

Considering that the data we obtained in similar experiments did not present normality in previous works, instead of applying a 15% increase over the calculated sample size for Friedman test, as recommended by Williamson [53], a 30% increase was applied to ensure that the power of 0.85 was achieved. That means that a minimum sample size of 30 was required. To reach that number, a total of 39 volunteers were initially recruited. Only 33 finished the whole experiment, and then 3 were discarded as they were considered outliers. The 30 volunteers (18 men, 12 women) were students in some course in Industrial Design and Product Development Engineering at the Universitat Jaume I of Castellón (Spain). Their age ranged from 19 to 25 years, with a mean of 21 years (SD = 1.47).

2.5. Experiment Protocol

The experiment was performed in two phases. In Phase A (Figure 3) the participants worked with Rooms 1, 2, and 3 in alternating orders (1-2-3; 1-3-2; 2-1-3; 2-3-1; 3-1-2; 3-2-1). Phase B took place 10 months after Phase A. In Phase B (Figure 4), they worked with Rooms 4 and 5, also in alternating orders (4-5; 5-4). At the end, each participant had been in all 5 Rooms. The written protocol helped the researchers to always address the participants in the same way.

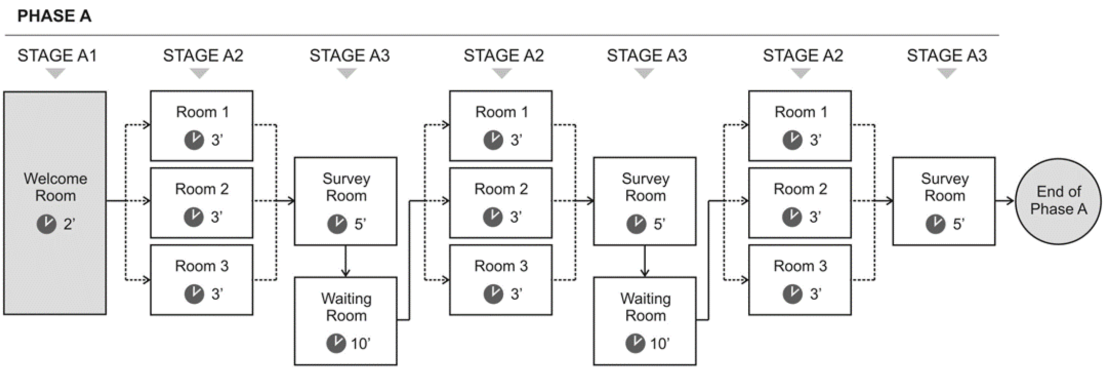


Figure 3. Flowchart for the experiment, showing all the stages in Phase A.

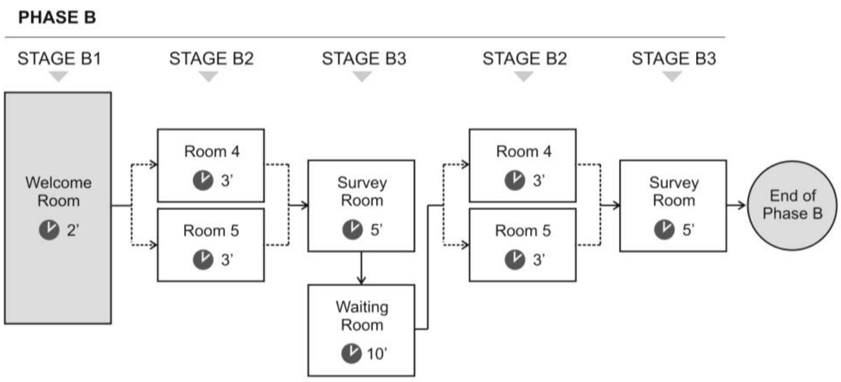


Figure 4. Flowchart for the experiment, showing all the stages in Phase B.

2.5.1. Phase A (Room 1: R, Room 2: VR, Room 3: VRPH)

Stage A1. Welcome room (2 min).

Step 1. The participants were welcomed. They were asked to read and sign an informed consent form prior to participating in the experiment. Then, they were accompanied to the room where they would view the first of the three scenes.

Stage A2. Room 1, 2 or 3 (3 min in each room). The viewing order was alternated to balance any possible resulting effects.

Step 2. The participants corresponding to Room 1 entered it directly. Those corresponding to Room 2 or 3 had to put on a VR headset when they entered and were helped by a research staff member.

Step 3. The researcher informed them that they were about to view a scene with a chair, and they would have to evaluate its characteristics later with a questionnaire. The researcher also explained the protocol to them, which varied according to each room: in all the rooms, the participants could move around the chair and look at it from different angles. In Rooms 1 and 3, they could also touch and sit on the chair.

Step 4. The participants were allowed to freely look at the chair for 2 min and could interact with it according to the conditions of each room.

Step 5. The participants in Rooms 2 and 3 removed their headsets when leaving the scene. The participants in all the rooms were handed a printed questionnaire and were shown the room wherein they had to go to complete it.

Stage A3. Survey room (5 min).

Step 6. The users sat down and filled in the questionnaire that included three lots of questions. The first lot included data about the participants' age, sex, and previous VR experiences. The second lot included the participants' evaluations of the chair using the 12 bipolar pairs shown in Table 1 and indicated if they were sure about their responses in each case ("Yes" or "No"). They also had to give an overall assessment of the chair on a scale between 1 ("I do not like it at all") and 5 ("I like it very much"). They were asked about what their intention of purchasing it would be ("Would you buy this chair?"). They had to answer with one of two options: "Yes" or "No". The third lot included a questionnaire adapted from the SUS model [33], in which the expression "office space" was substituted for "room".

Step 7. Having completed the questionnaire, each participant was told which room they had to go to next and waited 10 min before entering the next room.

Step 8. The procedure from Steps 2 to 5 was repeated.

Step 9. The procedure from Steps 6 to 7 was repeated.

Step 10. The procedure from Steps 2 to 5 was repeated.

Step 11. The procedure from Step 6 was repeated, the questionnaire was collected, and each participant was thanked for collaborating.

2.5.2. Phase B (Room 4: V, Room 5: 3Di)

Stage B1. Welcome room (2 min).

Step 1. The participants were welcomed and accompanied to the room where they would view the first of the two scenes.

Stage B2. Room 4 or 5 (3 min in each room). The viewing order was alternated to balance any possible resulting effects.

Step 2. The users had to sit on a chair in front of a table. A tablet was placed in the middle of the table. A researcher told them that a scene with a chair would be shown on the tablet, and they would later have to evaluate its characteristics with a questionnaire. The research also explained the protocol to them: in Room 4, they only viewed the looped animation, while the participants in Room 5 could interact with the scene by placing their fingers on the screen to turn it.

Step 3. The participants viewed the scene for 2 min and interacted with it according to the conditions of each room.

Step 4. The participants were given a printed questionnaire and were told the room they had to go to, to complete it.

Stage B3. Survey room (5 min).

Step 5. The same process from Step 6 in Stage A3 was repeated. In this case, answering the first lot of questions was not necessary because these data were already available.

Step 6. Having completed the questionnaire, each participant was told which room they had to go to next and waited 10 min before entering the next room.

Step 7. The process from Step 2 to Step 5 was repeated, the questionnaire was collected, and each participant was thanked for collaborating.

3. Results

The descriptive statistics and box plots for each semantic scale are shown in Table 2 and Figure 5, respectively, while the "I like it" question and presence and their box plots are presented in Table 3 and Figure 6a (all the statistical calculations were made with SPSS, ver. 22). Because of the non-normality of samples (verified by a Kolgomorov–Smirnov test), Friedman's test was applied to determine whether there were any statistically significant differences in the semantic scales scores among the five experimental conditions. The null hypothesis of Friedman's test stated that the mean ranks of semantic scales scores in the five experimental conditions were the same. The Friedman's test results, presented in Table 4, revealed that the null hypothesis was confirmed (significance level of 0.05) on all the semantic scales except for the "SD1 Comfortable–Uncomfortable" and "SD2 Heavy–Light" scales, which are shaded in grey in Table 4.

Table 2. Descriptive statistics for the semantic scales.

		Conditions				
Semantic Scales		**R**	**VR**	**VRPH**	**V**	**3Di**
SD1 Comfortable–Uncomfortable	Mean	−1.57	−1.07	−1.97	−1.60	−1.63
	Median	−2.00	−1.00	−2.00	−2.00	−2.00
	Std. Deviation	1.36	1.20	1.13	0.97	1.10
SD2 Heavy–Light	Mean	0.70	0.87	0.40	1.17	1.27
	Median	1.00	1.00	1.00	1.50	2.00
	Std. Deviation	1.42	1.70	1.52	1.32	1.31
SD3 Resistant–Fragile	Mean	−1.27	−0.80	−1.53	−1.30	−1.27
	Median	−1.50	−1.00	−2.00	−1.50	−1.50
	Std. Deviation	1.41	1.42	1.25	1.24	1.14
SD4 Useless–Practical	Mean	2.07	1.73	1.80	1.83	1.83
	Median	2.00	2.00	2.00	2.00	2.00
	Std. Deviation	0.74	0.74	1.06	1.09	1.21
SD5 Simple–Complex	Mean	−1.93	−2.00	−1.83	−1.80	−1.63
	Median	−2.00	−2.00	−2.00	−2.00	−2.00
	Std. Deviation	1.11	1.17	1.51	1.13	1.40
SD6 Versatile–Invariable	Mean	−0.50	−0.47	−0.20	−0.20	−0.17
	Median	−1.00	−1.00	−0,50	−1.0	−1.00
	Std. Deviation	1.57	1.55	1.65	1.58	1.58
SD7 Classic–Modern	Mean	1.60	1.73	1.60	1.47	1.53
	Median	2.00	2.00	2.00	2.00	2.00
	Std. Deviation	1.10	1.05	1.13	1.25	1.04
SD8 Ugly–Nice	Mean	−1.10	−1.27	−1.17	−1.37	−1.27
	Median	−2.00	−1.50	−1.50	−2.00	−1.50
	Std. Deviation	1.62	1.26	1.39	1.10	1.31

Table 2. *Cont.*

Semantic Scales		Conditions				
		R	VR	VRPH	V	3Di
SD9 Ornate–Sober	Mean	2.47	2.36	2.43	2.17	2.30
	Median	3.00	3.00	3.00	2.00	2.00
	Std. Deviation	0.68	1.10	0.73	1.21	0.65
SD10 Elegant–Vulgar	Mean	−1.20	−1.33	−1.27	−1.03	−1.07
	Median	−1.50	−1.00	−1.00	−1.00	−1.00
	Std. Deviation	1.30	1.24	1.39	1.35	1.34
SD11 Industrial–Artisan	Mean	−2.27	−1.93	−2.17	−2.03	−2.30
	Median	−2.50	−2.00	−2.00	−2.00	−2.00
	Std. Deviation	0.91	1.11	0.99	1.16	0.65
SD12 Fun–Boring	Mean	0.50	0.33	0.07	0.56	0.80
	Median	1.00	0.00	0.50	1.00	1.00
	Std. Deviation	1.41	1.30	1.55	1.30	1.35

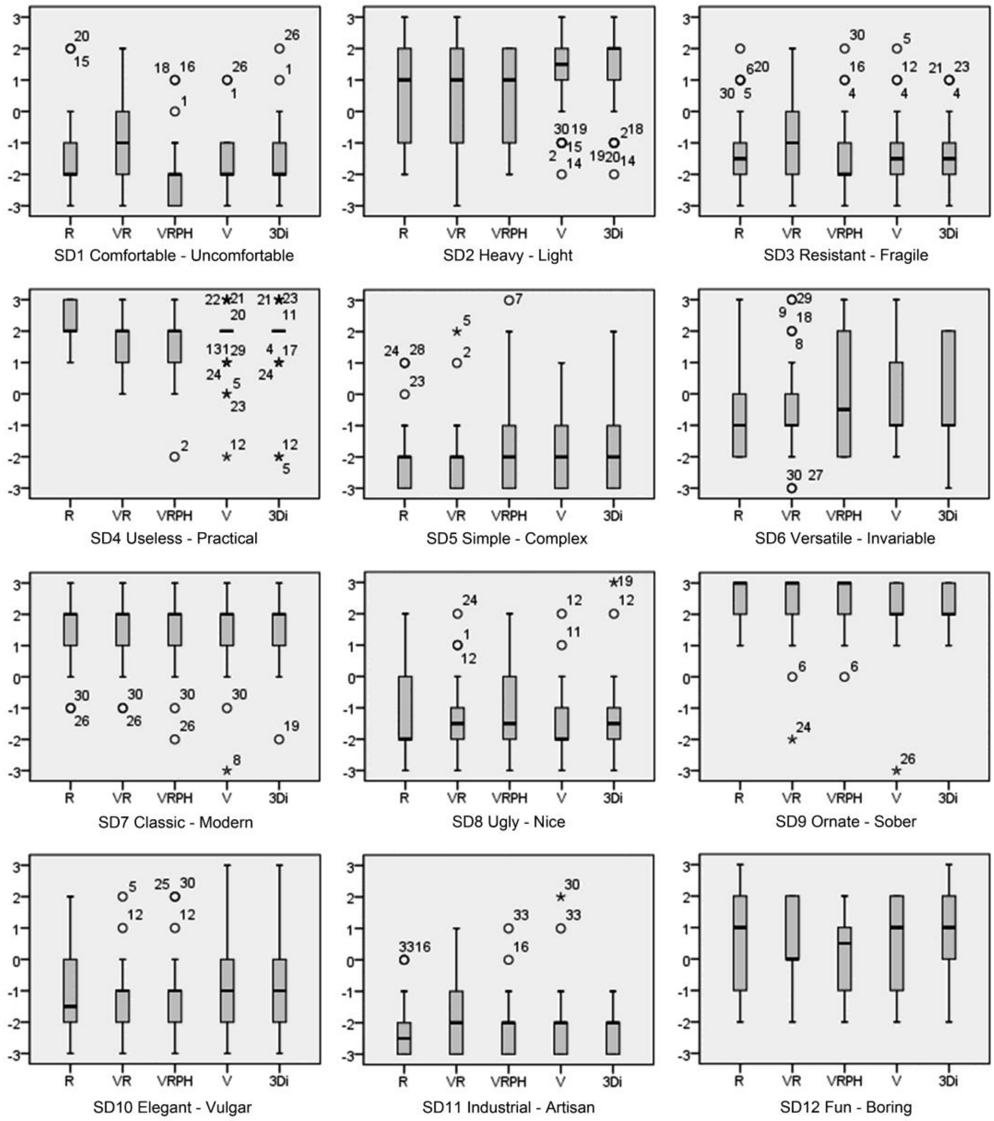
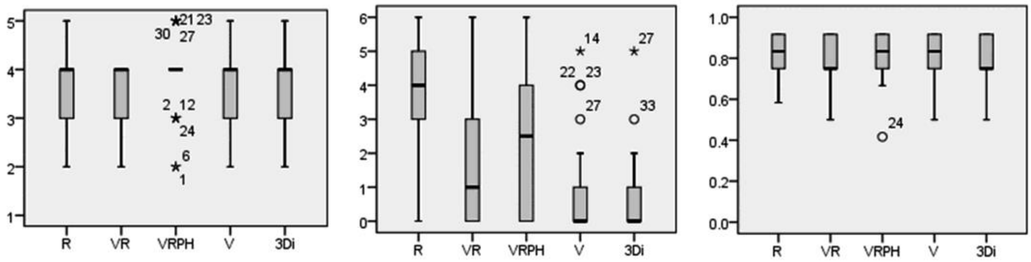


Figure 5. Box plots for the semantic scales. Outliers outside 1.5 times the interquartile range above the upper quartile and below the lower quartile are represented by an open circle. Extreme outliers are marked with an asterisk.

Table 3. Descriptive statistics for the "I like it" question, presence, and confidence.

		Conditions				
Semantic Scales		**R**	**VR**	**VRPH**	**V**	**3Di**
I like it (1–5)	Mean	3.70	3.60	3.97	3.63	3.63
	Median	4.00	4.00	4.00	4.00	4.00
	Std. Deviation	0.79	0.62	0.81	0.76	0.76
Presence	Mean	3.70	1.87	2.40	0.77	0.60
	Median	4.00	1.00	2.50	0.00	0.0
	Std. Deviation	1.84	2.10	2.27	1.43	1.13
Confidence	Mean	0.81	0.78	0.81	0.81	0.79
	Median	0.83	0.75	0.83	0.83	0.75
	Std. Deviation	0.10	0.12	0.12	0.12	0.11



(**a**) (**b**) (**c**)

Figure 6. Box plot and histogram for the (**a**) "I like it" question, (**b**) sense of presence, and (**c**) confidence. Outliers outside 1.5 times the interquartile range above the upper quartile and below the lower quartile are represented by an open circle. Extreme outliers are marked with an asterisk.

Table 4. Friedman's Test—Grey areas depict statistically significant differences.

			Mean Rank				
	Semantic Scales	**Friedman's Test**	**R**	**VR**	**VRPH**	**V**	**3Di**
Physio	SD1 Comfortable–Uncomfortable	$X^2(4) = 17.60$ $p = 0.001$	2.85	3.77	2.35	3.03	3.00
	SD2 Heavy–Light	$X^2(4) = 11.27$ $p = 0.024$	2.75	3.07	2.42	3.33	3.43
	SD3 Resistant–Fragile	$X^2(4) = 7.27$ $p = 0.12$	2.88	3.57	2.67	2.88	3.00
Psycho	SD4 Useless–Practical	$X^2(4) = 7.00$ $p = 0.14$	3.32	2.57	3.03	3.07	3.02
	SD5 Simple–Complex	$X^2(4) = 0.57$ $p = 0.97$	3.02	2.93	2.90	3.03	3.12
	SD6 Versatile–Invariable	$X^2(4) = 1.73$ $p = 0.78$	2.77	2.90	3.15	3.07	3.12
Socio	SD7 Classic–Modern	$X^2(4) = 2.93$ $p = 0.57$	3.05	3.25	3.05	2.85	2.80
	SD8 Ugly–Nice	$X^2(4) = 0.87$ $p = 0.93$	2.93	3.13	3.08	2.92	2.93
	SD9 Ornate–Sober	$X^2(4) = 2.51$ $p = 0.64$	3.08	3.15	3.13	2.83	2.80
Ideo	SD10 Elegant–Vulgar	$X^2(4) = 6.03$ $p = 0.20$	2.97	2.72	2.77	3.33	3.22
	SD11 Industrial–Artisan	$X^2(4) = 3.26$ $p = 0.51$	2.83	3.22	3.03	3.13	2.78
	SD12 Fun–Boring	$X^2(4) = 5.91$ $p = 0.21$	3.08	2.90	2.55	3.11	3.33

In order to follow up Friedman's test, a pairwise comparison was performed to determine which pairs of interaction conditions (Real, Virtual Reality, Virtual Reality with Passive Haptics, and Video and 3D interactive image) significantly differed from one another. Conover tests were used for the pairwise comparison. The adjusted significance levels, shown in Table 5, were calculated using Bonferroni correction by multiplying the unadjusted significance values by the number of comparisons (10) and setting the value to 1 if the product was higher than 1. There were significant differences between the VR vs. VRPH conditions for the "SD1 Comfortable–Uncomfortable" scale and the VRPH vs. 3Di conditions for the "SD2 Heavy–Light" scale.

Table 5. Adjusted significance levels for the SD1 and SD2 pairwise comparisons. Grey areas denote statistically significant differences.

	SD1 Comfortable–Uncomfortable				SD2 Heavy–Light			
Pair	**R Mean**	**t Stat.**	**Sig.**	**Adj. Sig.**	**R Mean**	**t Stat.**	**Sig.**	**Adj. Sig.**
R-VR	0.92	2.85	0.01	0.052	0.32	0.92	0.36	1.00
R-VRPH	0.50	1.55	0.12	1.00	0.33	0.97	0.33	1.00
R-V	0.18	0.57	0.57	1.00	0.58	1.70	0.09	0.91
R-3Di	0.15	0.47	0.64	1.00	0.68	1.99	0.05	0.48
VR-VRPH	1.42	4.40	0.00	0.00	0.65	1.90	0.06	0.60
VR-V	0.73	2.28	0.02	0.25	0.27	0.78	0.44	1.00
VR-3Di	0.77	2.38	0.02	0.19	0.37	1.07	0.29	1.00
VRPH-V	0.68	2.12	0.04	0.36	0.92	2.68	0.01	0.09
VRPH-3Di	0.65	2.02	0.05	0.46	1.02	2.97	0.00	0.04
V-3Di	0.03	0.10	0.92	1.00	0.10	0.29	0.77	1.00

Regarding evaluation with the "I like it" question, the descriptive statistics and box plots are shown in Table 3 and Figure 6a. There was a statistically significant difference between the experimental conditions when Friedman's test was applied: $X^2(4) = 10.13$, $p = 0.038$. Conover post hoc tests were used for the pairwise comparison and showed a significant difference between the VR vs. VRPH conditions. The adjusted significance levels, found in Table 6, were calculated by Bonferroni correction.

Table 6. Adjusted significance levels for the "I like it" question, sense of presence, and pairwise comparisons. Grey areas depict statistically significant differences.

	I Like It				Presence			
Pair	**R Mean**	**t Stat.**	**Sig.**	**Adj. Sig.**	**R Mean**	**t Stat.**	**Sig.**	**Adj. Sig.**
R-VR	0.27	0.95	0.35	1.00	1.10	3.60	0.00	0.00
R-VRPH	0.60	2.13	0.04	0.35	0.87	2.84	0.01	0.053
R-V	0.07	0.24	0.81	1.00	1.95	6.39	0.00	0.00
R-3Di	0.02	0.06	0.95	1.00	2.00	6.55	0.00	0.00
VR-VRPH	0.87	3.08	0.00	0.03	0.23	0.76	0.45	1.00
VR-V	0.20	0.71	0.48	1.00	0.85	2.78	0.01	0.06
VR-3Di	0.25	0.89	0.38	1.00	0.90	2.95	0.00	0.04
VRPH-V	0.67	2.37	0.02	0.19	1.08	3.55	0.00	0.01
VRPH-3Di	0.62	2.19	0.03	0.30	1.13	3.71	0.00	0.00
V-3Di	0.05	0.18	0.86	1.00	0.05	0.16	0.87	1.00

Regarding the sense of presence, the descriptive statistics and box plot are shown in Table 3 and Figure 6b. A statistically significant difference appeared between the experimental conditions when Friedman's test was applied: $X^2(4) = 40.59$, $p < 0.001$. Conover post hoc tests were used for the pairwise comparison and showed a significant difference between the R vs. VR, R vs. V, R vs. 3Di, VR vs. 3Di, VRPH vs. V, and VRPH vs. 3Di conditions. The adjusted significance levels in Table 6 were calculated by Bonferroni correction.

Regarding the confidence on the response, the descriptive statistics and box plot are shown in Table 3 and Figure 6c. No statistically significant difference was found between the experimental conditions after applying Friedman's test: $X^2(4) = 45.62$, $p = 0.23$.

4. Discussion

Friedman's test showed that statistically significant differences appeared in the evaluations made for the semantic differential scales SDI (Comfortable–Uncomfortable) and SD2 (Heavy–Light). This revealed that the comfort and weight characteristics can be perceived differently depending on the means selected to present the product. Thus, we can state that H1 is met. Former works have also concluded that presentation means and differences in stimuli can have a certain influence on the evaluation of some product characteristics, which reinforces our thesis. Artacho-Ramírez et al. [54] compared the presentations of loudspeakers by four different means (photography, static infographic image, 3D navigable model, 3D navigable stereographic model) and found differences in the evaluations of three characteristics. Similarly, in [49], Rojas et al. presented bottles using two different visual stimuli (a real image and a virtually simulated image) and found significant differences in 4 of the 15 tested characteristics.

Our results also revealed that significant differences appeared when comparing two of the pairs of presentation means: VR vs. VRPH for Comfortable–Uncomfortable and VRPH vs. 3Di for Heavy–Light. Here, the results indicate that the chair was evaluated as being more comfortable in VRPH (−1.97) and more uncomfortable in VR (−1.07). The chair was also evaluated as being heavier in VRPH (0.40) and lighter in 3Di (1.27). These findings indicate that evaluations of haptic-type qualities (comfort) and physical attributes (weight) can be distorted if the product is presented by a means that does not allow any physical contact with it (VR, 3Di). Therefore, we can state that H2 is met.

The results of the "I like it" question indicate statistically significant differences in the pair VR vs. VRPH. The evaluations showed that the liking of the chair was scored 3.97 in VRPH and 3.60 in VR. Therefore, we can state that H3 is met. Likewise, other studies have also highlighted the positive effect that being in physical contact with the product has on its evaluation, especially in products with characteristics best explored by touch [55,56].

For the participants' perceived sense of presence (Tables 3 and 6), this study obtained statistically significant differences in pairs: R (3.70) vs. VR (1.87); R (3.70) vs. V (0.77); R (3.70) vs. 3Di (0.60); VR (1.87) vs. 3Di (0.60); VRPH (2.40) vs. V (0.77); and VRPH (2.40) vs. 3Di (0.60). These results seem to confirm H4 because presenting a product by combining haptic and visual stimuli can lead to a greater sense of presence for users. Indeed, the values obtained in the means VR, V, and 3Di (visual stimuli) were lower than those obtained in R and VRPH (visual and haptic stimuli).

Following the recommendation of previous works [44,45], for the correct implementation of passive haptics, both the chromatic and geometric features of the proxy (the Odger chair) and its position in space were recreated in the VR environment. The intention was to make the VR scenario convincing for the participants. As already mentioned, the sense of presence may be greater in means that combine visual and haptic sensations; using products that stand out for their haptic properties, i.e., products with a high propensity to be touched during normal use, may even further increase this sensation. Using the a passive haptics of a chair, which presents a large surface to touch to which the participant could sit on, could explain the differences in the ratings of the sensation of presence that occurs between the means described above.

Our result coincides with other recent works: Servotte et al. [57] used an adaptation of Witmer and Singer's Presence Questionnaire [32] and concluded that multisensory congruent cues, such as visual, auditory, and haptic cues, enhance presence; Goncalves et al. [58] employed a questionnaire about presence, which had been adapted from Schubert, Friedmann, and Regenbrecht [34] and confirmed that adding and combining passive haptics with other stimuli in a means can enhance presence. Nonetheless, the explanation of the results obtained for the pair VR (1.87) vs. 3Di (0.60), where neither of the two means allowed the product to be touched, comes over in another direction. One possible explanation for why the sense of presence in VR means is greater than in 3Di may be because VR allows more varied interactivity with the scene [59], which users may perceive more profoundly than with the flat display employed with 3Di [60], and these characteristics could have contributed to a greater sense of presence in this means.

Thus, once H4 is confirmed, and taking into account, as mentioned above, that the chair was rated as more comfortable and more liked by the participants in VRPH than in VR, we can affirm that H5 is also met: presenting a product by means capable of eliciting more presence could favor better product evaluations.

Finally, as this study was unable to determine if a statistically significant difference existed in the proportion of participants who intended to purchase the product, we cannot state that H6 was met. Yet, despite statistically significant differences lacking, the obtained data showed that the purchase intention for the chair was slightly higher when the product was presented in haptic means (R: 80%, VRPH: 76.7%) and was somewhat lower when non-haptic means were employed (V: 70%, 3Di: 70%). An explanation of this result could lie in the conclusions reached by previous works. Haptic information can positively influence many users' purchase decisions [38,40,61,62]. Conversely, not being in physical contact with the product can lead to frustration for some users, a factor that can negatively affect both purchase decisions and product evaluations [63], which the results in this work showed because, as mentioned above, the chair was less liked when presented in VR, a means that does not allow users to come into physical contact with the product.

5. Conclusions

In summary, our study ran an intrasubject experiment with a sample of 33 young people who viewed a piece of furniture presented in the middle of a white-walled room by five different means and in alternating orders to evaluate it on a semantic scale with 12 bipolar pairs. Each participant indicated their purchase intention and evaluated the sense of presence that they perceived in each mean. The results appear to indicate that physical characteristics related to comfort and weight were differently perceived depending on how the product was presented. The product obtained a higher score when presented in the means that allowed coming into physical contact with the product. We also observed that the product was generally liked more when presented in VR means that allowed it to be touched (VRPH) than in the other presentation means. Our results seemed to indicate that users perceived a greater sense of presence in those means that combined haptic and visual stimuli, which falls in line with previous works. Finally, our study was unable to determine that the presentation means significantly influenced users' purchase intention, although the latter was slightly higher when the product was presented in those means allowing physical contact.

Thus, we conclude that when a material product with high haptic importance (in this case, a chair) is presented, the means that allow it to be touched to elicit a greater sense of presence may more positively impact evaluations of haptic characteristics such as comfort and weight. This may explain why, in general, users liked this product more when presented in these means.

These findings, interpreted with caution, may be useful and could be considered by retailers when choosing appropriate means of presenting certain products so that the means distort the perception of the attributes as little as possible. Similarly, they could guide designers to include VRPH in the presentation and evaluation process of some haptic products in the prototyping phases, allowing for a more complete user experience.

Nonetheless, this study has two limitations. The first relates to the number of products evaluated. Although it is normal to include the evaluation of a single product [64–66] in studies of this type, it would be desirable in the future to compare these results with those that would be obtained by presenting other furniture products with equivalent haptic properties, such as other models of chairs, stools, or similar seating products. This would allow more generalizable conclusions to be drawn. Another limitation is the sample used, limited in this case to young people with a very homogeneous academic background. In this case, the results may not apply to other populations, such as older people or people with different educational backgrounds. Therefore, they should be treated with caution.

Despite these limitations, this work indicates advances in understanding the role that physical contact with a product plays in evaluating its characteristics and purchase intention when the product is presented in different means that elicit a greater or lesser sense of presence.

Future research directions are to test other products from different categories with a high propensity to be touched during normal use, such as clothing (gloves or shoes) or hand tools, to compare the results with those obtained in this study. By measuring the impact of means that elicit a greater or lesser sense of presence on evaluations of other haptic features, such as texture or temperature, the results could be generalized or not to other product categories. Another interesting area for the development of future studies is the analysis of the impact that active haptic technology, which allows for more dynamic and realistic tactile interactions, could have on product evaluation.

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References

1. Chandna, V.; Salimath, M.S. Peer-to-peer selling in online platforms: A salient business model for virtual entrepreneurship. *J. Bus. Res.* **2018**, *84*, 162–174. [CrossRef]
2. Cheba, K.; Kiba-Janiak, M.; Baraniecka, A.; Kołakowski, T. Impact of external factors on e-commerce market in cities and its implications on environment. *Sustain. Cities Soc.* **2021**, *72*, 103032. [CrossRef]
3. Tran, L.T.T. Managing the effectiveness of e-commerce platforms in a pandemic. *J. Retail. Consum. Serv.* **2021**, *58*, 102287. [CrossRef]
4. Guthrie, C.; Fosso-Wamba, S.; Brice Arnaud, J. Online consumer resilience during a pandemic: An exploratory study of e-commerce behavior before, during and after a COVID-19 lockdown. *J. Retail. Consum. Serv.* **2021**, *61*, 102570. [CrossRef]
5. Solanki, M.S. A Review on Impact of COVID-19 on E-Commerce. In *International Conference on Intelligent Emerging Methods of Artificial Intelligence & Cloud Computing. IEMAICLOUD 2021. Smart Innovation, Systems and Technologies*; García Márquez, F.P., Ed.; Springer: Cham, Switzerland, 2022. [CrossRef]
6. Park, J.; Choi, J.; Rhee, C. Futuristic VR image presentation technique for better mobile commerce effectiveness. *Virtual Real.* **2021**, *25*, 341–356. [CrossRef]
7. Jiang, Z.; Benbasat, I. The Effects of Presentation Formats and Task Complexity on Online Consumers' Product Understanding. *MIS Q.* **2007**, *31*, 475–500. [CrossRef]
8. Israel, K.; Zerres, C.; Tscheulin, D.K.; Buchweitz, L.; Korn, O. Presenting Your Products in Virtual Reality: Do not Underestimate Cybersickness. In *HCI in Business, Government and Organizations. eCommerce and Consumer Behavior. HCII 2019. Lecture Notes in Computer Science*; Fui-Hoon Nah, F., Siau, K., Eds.; Springer: Greer, SC, USA, 2019; pp. 206–224. ISBN 978-3-030-22334-2.
9. Su, K.W.; Chen, S.C.; Lin, P.H.; Hsieh, C.I. Evaluating the user interface and experience of VR in the electronic commerce environment: A hybrid approach. *Virtual Real.* **2020**, *24*, 241–254. [CrossRef]

10. Grewal, D.; Noble, S.M.; Roggeveen, A.L.; Nordfalt, J. The future of in-store technology. *J. Acad. Mark. Sci.* **2020**, *48*, 96–113. [CrossRef]
11. Agost, M.J.; Vergara, M.; Bayarri, V. The Use of New Presentation Technologies in Electronic Sales Environments and Their Influence on Product Perception. In *Human Interface and the Management of Information. Information Presentation and Visualization. HCII 2021. Lecture Notes in Computer Science*; Yamamoto, S., Mori, H., Eds.; Springer: Cham, Switzerland, 2021; Volume 12765, pp. 3–15. ISBN 978-3-030-78321-1. [CrossRef]
12. Peukert, C.; Pfeiffer, J.; Meißner, M.; Pfeiffer, T.; Weinhardt, C. Shopping in Virtual Reality Stores: The Influence of Immersion on System Adoption. *J. Manag. Inf. Syst.* **2019**, *36*, 755–788. [CrossRef]
13. Su, K.W.; Liu, C.L.; Hsieh, C.I.; Chen, Z.R. The design criteria of virtual reality in e-commerce. In Proceedings of the 50th Nordic Ergonomics and Human Factors Society Conference, Elsinore, Denmark, 25–28 August 2019; Broberg, O., Seim, R., Eds.; DTU Management: Kongens Lyngby, Denmark, 2019; pp. 231–233. [CrossRef]
14. Luna-Nevarez, C.; McGovern, E. The Rise of the Virtual Reality (VR) Marketplace: Exploring the Antecedents and Consequences of Consumer Attitudes toward V-Commerce. *J. Internet Commer.* **2021**, *20*, 167–194. [CrossRef]
15. Martínez-Navarro, J.; Bigné, E.; Guixeres, J.; Alcañiz, M.; Torrecilla, C. The influence of virtual reality in e-commerce. *J. Bus. Res.* **2019**, *100*, 475–482. [CrossRef]
16. Kalantari, S.; Neo, J.R.J. Virtual environments for design research: Lessons learned from use of fully immersive virtual reality in interior design research. *J. Inter. Des.* **2020**, *45*, 27–42. [CrossRef]
17. Peck, J.; Childers, T.L. To Have and to Hold: The Influence of Haptic Information on Product Judgments. *J. Mark.* **2003**, *67*, 35–48. [CrossRef]
18. Gerald, A.; Batliwala, R.; Ye, J.; Hsu, P.; Aihara, H.; Russo, S. A Soft Robotic Haptic Feedback Glove for Colonoscopy Procedures. In Proceedings of the 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2022), Kyoto, Japan, 23–27 October 2022; Available online: https://sites.bu.edu/mrl/files/2022/10/IROS22_Gerald_Haptic_Glove_OK_2-1.pdf (accessed on 23 December 2022).
19. Peck, J.; Childers, T.L. Individual differences in haptic information processing: The "need for touch" scale. *J. Consum. Res.* **2003**, *30*, 430–442. [CrossRef]
20. Gao, Z.; Wang, H.; Feng, G.; Guo, F.; Lv, G.; Li, B. RealPot: An immersive virtual pottery system with handheld haptic devices. *Multimed. Tools Appl.* **2019**, *78*, 26569–26596. [CrossRef]
21. See, A.R.; Choco, J.A.G.; Chandramohan, K. Touch, Texture and Haptic Feedback: A Review on How We Feel the World around Us. *Appl. Sci.* **2022**, *12*, 4686. [CrossRef]
22. Sun, Z.; Zhu, M.; Shan, X.; Lee, C. Augmented tactile-perception and haptic-feedback rings as human-machine interfaces aiming for immersive interactions. *Nat. Commun.* **2022**, *13*, 5224. [CrossRef]
23. Lindeman, R.W.; Sibert, J.L.; Hahn, J.K. Hand-held windows: Towards effective 2D interaction in immersive virtual environments. In Proceedings of the IEEE Virtual Reality, Washington, DC, USA, 13–17 March 1999; IEEE: Piscataway, NJ, USA, 1999; pp. 205–212, ISBN 0-7695-0093-5.
24. Schwarz, N. Feelings-as-Information Theory. In *Handbook of Theories of Social Psychology*; Van Lange, P.A.M., Kruglanski, A.W., Higgins, E.T., Eds.; Sage Publications Ltd.: New York, NY, USA, 2012; Volume 1, pp. 289–308. [CrossRef]
25. Krishna, A.; Schwarz, N. Sensory Marketing, Embodiment, and Grounded Cognition. *J. Consum. Psychol.* **2014**, *24*, 159–168. [CrossRef]
26. Li, H.; Daugherty, T.; Biocca, F. The role of virtual experience in consumer learning. *J. Consum. Psychol.* **2003**, *13*, 395–407. [CrossRef]
27. Velázquez, R.; Pissaloux, E.; Del-Valle-Soto, C.; Arai, M.; Valdivia, L.J.; Del Puerto-Flores, J.A.; Gutiérrez, C.A. Performance Evaluation of Active and Passive Haptic Feedback in Shape Perception. In Proceedings of the IEEE 39th Central America and Panama Convention (CONCAPAN XXXIX), Guatemala City, Guatemala, 20–22 November 2019; IEEE: Piscataway, NJ, USA, 2019; pp. 1–6. [CrossRef]
28. Rakhin, K.; Onkar, P.; Hayavadana, J. Understanding the Role of Perceptual Haptic Conditions on Design Decision. *Proc. Des. Soc.* **2022**, *2*, 2193–2202. [CrossRef]
29. Zenner, A.; Kosmalla, F.; Ehrlich, J.; Hell, P.; Kahl, G.; Murlowski, C.; Marco Speicher, M.; Daiber, F.; Heinrich, D.; Krüger, A. A Virtual Reality Couch Configurator Leveraging Passive Haptic Feedback. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*; ACM: New York, NY, USA, 2020; pp. 1–8. ISBN 978-1-4503-6819-3/20/04.
30. Sadowski, W.; Stanney, K. Presence in virtual environments. In *Handbook of Virtual Environments: Design, Implementation, and Applications*; Stanney, K.M., Ed.; CRC Press: Boca Raton, FL, USA, 2002; pp. 791–807. ISBN 9780429163937.
31. Heeter, C. Being there: The subjective experience of presence. *Presence Teleoperators Virtual Environ.* **1992**, *1*, 262–271. [CrossRef]
32. Witmer, B.G.; Singer, M.J. Measuring presence in virtual environments: A presence questionnaire. *Presence Teleoperators Virtual Environ.* **1998**, *7*, 225–240. [CrossRef]
33. Usoh, M.; Catena, E.; Arman, S.; Slater, M. Using Presence Questionnaires in Reality. *Presence Teleoperators Virtual Environ.* **2000**, *9*, 497–503. [CrossRef]
34. Schubert, T.; Friedmann, F.; Regenbrecht, H. The Experience of Presence: Factor Analytic Insights. *Presence Teleoperators Virtual Environ.* **2001**, *10*, 266–281. [CrossRef]

35. Fröhlich, J.; Wachsmuth, I. The Visual, the Auditory and the Haptic—A User Study on Combining Modalities in Virtual Worlds. In *Virtual Augmented and Mixed Reality. Designing and Developing Augmented and Virtual Environments*; Shumaker, R., Ed.; Springer: Berlin, Germany, 2013; pp. 159–168. ISBN 978-3-642-39405-8.
36. Feng, M.; Dey, A.; Lindeman, R.W. An initial exploration of a multi-sensory design space: Tactile support for walking in immersive virtual environments. In Proceedings of the 2016 IEEE Symposium on 3D User Interfaces (3DUI), Greenville, SC, USA, 19–20 March 2016; Thomas, B.H., Lindeman, R., Marchal, M., Eds.; IEEE: Piscataway, NJ, USA, 2016; pp. 95–104, ISBN 9781509008421.
37. Gibbs, J.K.; Gillies, M.; Pan, X. A comparison of the effects of haptic and visual feedback on presence in virtual reality. *Int. J. Hum.-Comput. Stud.* **2022**, *157*, 102717. [CrossRef]
38. Citrin, A.V.; Stem, J.D.E.; Spangenberg, E.R.; Clark, M.J. Consumer need for tactile input: An internet retailing challenge. *J. Bus. Res.* **2003**, *56*, 915–922. [CrossRef]
39. McCabe, D.B.; Nowlis, S.M. The effect of examining actual products or product descriptions on consumer preference. *J. Consum. Psychol.* **2003**, *13*, 431–439. [CrossRef]
40. Balaji, M.S.; Raghavan, S.; Jha, S. Role of tactile and visual inputs in product evaluation: A multisensory perspective. *Asia Pac. J. Mark. Logist.* **2011**, *23*, 513–530. [CrossRef]
41. Keng, C.J.; Liao, T.H.; Yang, Y.I. The effects of sequential combinations of virtual experience, direct experience, and indirect experience: The moderating roles of need for touch and product involvement. *Electron. Commer. Res.* **2012**, *12*, 177–199. [CrossRef]
42. Kukar-Kinney, M.; Yazdanparast, A. Haptic Information Impacts Online Purchase Behavior: The Role of Price Framing and Consumer Characteristics: An Abstract. In *From Micro to Macro: Dealing with Uncertainties in the Global Marketplace. AMSAC 2020. Developments in Marketing Science: Proceedings of the Academy of Marketing Science*; Pantoja, F., Wu, S., Eds.; Springer: Cham, Switzerland, 2022; ISBN 978-3-030-89883-0. [CrossRef]
43. Inoue, Y. Effects of haptic imagery on purchase intention. *Res. Sq.* **2022**. [CrossRef]
44. Nilsson, N.C.; Zenner, A.; Simeone, A.L. Propping up virtual reality with haptic proxies. *IEEE Comput. Graph. Appl.* **2021**, *41*, 104–112. [CrossRef] [PubMed]
45. Zenner, A.; Ullmann, K.; Krüger, A. Combining dynamic passive haptics and haptic retargeting for enhanced haptic feedback in virtual reality. *IEEE Trans. Vis. Comput. Graph.* **2021**, *27*, 2627–2637. [CrossRef] [PubMed]
46. Hsiao, S.W.; Chiu, F.Y.; Chen, C.S. Applying aesthetics measurement to product design. *Int. J. Ind. Ergon.* **2008**, *38*, 910–920. [CrossRef]
47. Perez, M.; Ahmed-Kristensen, S.; Brunn, P.; Yanagisawa, H. Investigating the influence of product perception and geometric features. *Res. Eng. Des.* **2017**, *28*, 357–379. [CrossRef]
48. Achiche, S.; Maier, A.; Milanova, K.; Vadean, A. Visual Product Evaluation: Using the Semantic Differential to Investigate the Influence of Basic Geometry on User Perception. In Proceedings of the ASME 2014 International Mechanical Engineering Congress and Exposition. Volume 11: Systems, Design, and Complexity, Montrealm QC, Canada, 14–20 November 2014; ASME: New York, NY, USA, 2014; pp. 1–10, ISBN 978-0-7918-4960-6.
49. Rojas, J.C.; Contero, M.; Bartomeu, N.; Guixeres, J. Using combined bipolar semantic scales and eye-tracking metrics to compare consumer perception of real and virtual bottles. *Packag. Technol. Sci.* **2015**, *28*, 1047–1056. [CrossRef]
50. Tiger, L. *The Pursuit of Pleasure*; Little, Brown & Company: Boston, MA, USA, 1992; ISBN 0-316-84543-4.
51. Al-Hindawe, J. Considerations when constructing a semantic differential scale. *La Trobe Pap. Linguist.* **1996**, *9*, 41–58.
52. Faul, F.; Erdfelder, E.; Lang, A.-G.; Buchner, A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods* **2017**, *39*, 175–191. [CrossRef]
53. Williamson, M. Sample Size Calculation with GPower. Available online: https://med.und.edu/research/daccota/_files/pdfs/berdc_resource_pdfs/sample_size_gpower_module.pdf (accessed on 10 February 2023).
54. Artacho-Ramírez, M.A.; Diego-Mas, J.A.; Alcaide-Marzal, J. Influence of the mode of graphical representation on the perception of product aesthetic and emotional features: An exploratory study. *Int. J. Ind. Ergon.* **2008**, *38*, 942–952. [CrossRef]
55. Grohmann, B.; Spangenberg, E.R.; Sprott, D.E. The influence of tactile input on the evaluation of retail product offerings. *J. Retail.* **2007**, *83*, 237–245. [CrossRef]
56. Childers, T.L.; Peck, J. Informational and affective influences of haptics on product evaluation: Is what say how I feel? In *Sensory Marketing: Research on the Sensuality of Products*; Krishna, A., Ed.; Taylor and Francis: New York, NY, USA, 2010; pp. 63–72. ISBN 9781841698892.
57. Servotte, J.C.; Goosse, M.; Hetzell Campbell, S.; Dardenne, N.; Pilote, B.; Simoneau, I.L.; Guillaume, M.; Bragard, I.; Ghuysen, A. Virtual Reality Experience: Immersion, Sense of Presence, and Cybersickness. *Clin. Simul. Nurs.* **2020**, *38*, 35–43. [CrossRef]
58. Goncalves, G.; Melo, M.; Vasconcelos-Raposo, J.; Bessa, M. Impact of Different Sensory Stimuli on Presence in Credible Virtual Environments. *IEEE Trans. Vis. Comput. Graph.* **2020**, *26*, 3231–3240. [CrossRef] [PubMed]
59. Slater, M.; Usoh, M. Representations systems, perceptual position, and presence in immersive virtual environments. *Presence Teleoperators Virtual Environ.* **1993**, *2*, 221–233. [CrossRef]
60. Nichols, S.; Haldane, C.; Wilson, J.R. Measurement of presence and its consequences in virtual environments. *Int. J. Hum. Comput. Stud.* **2000**, *52*, 471–491. [CrossRef]
61. Shu, S.; Peck, J. To hold me is to love me: The role of touch in the endowment effect. In *Advances in ConsumerResearch—North American Conference Proceedings Volume 34*; Fitzsimons, G., Morwitz, V., Eds.; Association for Consumer Research: Duluth, MN, USA, 2007; pp. 513–514.

62. Peck, J.; Wiggins Johnson, J. Autotelic need for touch, haptics, and persuasion: The role of involvement. *Psychol. Mark.* **2011**, *28*, 222–239. [CrossRef]
63. Yazdanparast, A.; Spears, N. Can consumers forgo the need to touch products? An investigation of nonhaptic situational factors in an online context. *Psychol. Mark.* **2013**, *30*, 46–61. [CrossRef]
64. Min, X.; Zhang, W.; Sun, S.; Zhao, N.; Tang, S.; Zhuang, Y. VPModel: High-fidelity product simulation in a virtual-physical environment. *IEEE Trans. Vis. Comput. Graph.* **2019**, *25*, 3083–3093. [CrossRef]
65. Faust, F.G.; Catecati, T.; de Souza Sierra, I.; Araujo, F.S.; Ramírez, A.R.G.; Nickel, E.M.; Ferreira, M.G.G. Mixed prototypes for the evaluation of usability and user experience: Simulating an interactive electronic device. *Virtual Real.* **2019**, *23*, 197–211. [CrossRef]
66. Zheng, M.; Zhao, D.; Barbic, J. Evaluating the Efficiency of Six-DoF Haptic Rendering-Based Virtual Assembly Training. *IEEE Trans. Haptics* **2021**, *14*, 212–224. [CrossRef]