Multisensory Analysis of Consumer–Product Interaction during Ceramic Tile Shopping Experiences

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Abstract

The need to design products that engage several senses has being increasingly recognised by design and marketing professionals. Many works analyse the impact of sensory stimuli on the hedonic, cognitive, and emotional responses of consumers, as well as on their satisfaction and intention to purchase. However, there is much less information about the utilitarian dimension related to a sensory non-reflective analysis of the tangible elements of the experience, the sequential role played by different senses, and their relative importance. This work analyses the sensorial dimension of consumer interactions in shops. Consumers were filmed in two ceramic tile shops and their behaviour was analysed according to a previously validated checklist. Sequence of actions, their frequency of occurrence, and the duration of inspections were recorded, and consumers were classified according to their sensory exploration strategies. Results show that inspection patterns are intentional but shifting throughout the interaction. Considering the whole sequence, vision is the dominant sense followed by touch. However, sensory dominance varies throughout the sequence. The dominance differences appear between all senses and within the senses of vision, touch and audition. Cluster analysis classified consumers into two groups, those who were more interactive and those who were visual and passive evaluators. These results are very important for understanding consumer interaction patterns, which senses are involved (including their importance and hierarchy), and which sensory properties of tiles are evaluated during the shopping experience. Moreover, this information is crucial for setting design guidelines to improve sensory interactions and bridge sensory demands with product features.

Keywords

Multisensory consumer–product interactions, sensorial and utilitarian experience dimensions, consumer behaviour, shopping experience

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1. Introduction

The need to design by engaging several senses so that they deliver a specific perpetual experience to the consumer is being increasingly recognised by professionals involved in the development of new products and services (e.g., Haverkamp, 2014; Scott and Uncles, 2018). Several studies show that the greater the number of senses involved, the richer the final user–product interaction, and this in turn affects the final product evaluations and resulting aesthetic pleasure (e.g., Krishna *et al.*, 2010; Vilches-Montero *et al.*, 2018). This fact has led to an unusual boom in research focused on sensory engineering in multiple sectors. The design and marketing literature contains many works dealing with the impact that sensory stimuli have on consumer perception and behaviour. Researchers started with analyses of the effects of single senses (e.g., Bellizzi *et al.*, 1983; Spangenberg *et al.*, 1996; Yalch and Spangenberg, 1990). The focus then evolved towards the analysis of cross-modal interactions among pairs of sensory perceptions (e.g., Etzi *et al.*, 2016;

Maggioni *et al.*, 2015; Tu *et al.*, 2016; Wright *et al.*, 2017; Xue *et al.*, 2016), and an increasing number of works are appearing that consider three or more senses (Alcántara-Alcover *et al.*, 2014; Elder and Krishna, 2010; Vilches-Montero *et al.*, 2018). Thus, it can be said that multisensory design and marketing are now an emerging focus of study (Haverkamp, 2014) that newly cognitive neuroscience contributions can support by providing reliable rules for stimulating consumer senses in a congruent manner (Gallace and Spence, 2014).

In the context of shopping experiences, a considerable number of works have been published analysing the impact of store ambience on the hedonic, cognitive, and emotional response of consumers, as well as in their perceived value, satisfaction, willingness to buy, and behavioural intentions (e.g., Aboubaker Ettis, 2017; Helmefalk and Hultén, 2017; Tantanatewin and Inkarojrit, 2018; Turley and Milliman, 2000). However, to date there is much less information about the utilitarian dimension related to the sensory non-reflective (without cognitive mediation) analysis of the tangible elements of the experience (Inès and Herbert, 2016). This dimension relates to the visceral/sensorial level of user experience proposed by Norman (2004), as well as direct physical pleasure (Jordan, 2000), given that both deal with immediate sensations triggered by physical product features. Likewise, sensory and utilitarian dimensions are related to two of the four experiential components defined by Giaccardi and Karana (2015): sensory and performative. The former has to do with the perception of sensory stimuli and the latter with the evaluation of what the material enables users to do. Herein the performative component will be considered as the utilitarian dimension. Together with the cognitive and emotional dimensions, these components enable designing a ‘materials experience’ — defined as the experiences that people have with and through interaction with a certain material (Karana *et al.*, 2008). It can be said that sensorial and utilitarian analysis enhances the study of consumer–product interaction in terms of the utilitarian, knowledge, and stimulation components of the perceived value of products (Aurier *et al.*, 2004). Given the lack of studies dealing with the role played by senses in the consumer's information-gathering process (Bloch *et al.*, 1989), the goal of this work is to analyse the sensory dimension of user experience by assessing the multisensory interaction occurring between consumers and products during the shopping process for ceramic tiles. Such analysis of the shopping experience could help designers better understand the effects of the stimuli caused by the tangible attributes of the product, not only in generating a pleasant visual appearance in general, but also to ensure that the information received by the other senses is coherent and contributes to providing greater aesthetic pleasure (Ludden and Rompay, 2015).

It is important to note that consumers gather sensory information in sequences (e.g., Biswas *et al.*, 2014; Helmefalk, 2019; Macpherson, 2011). However, to the knowledge of the authors, no studies that analyse the role played by the sequence in which the different sensory modalities occurred during consumer–product interactions exist. Sequence learning, here understood as sequential behaviour, is an inherent human ability because it is an integrated part of conscious and nonconscious learning. Recent works show that these learning abilities depend on sensory modalities and stimulus-specific constraints in a given domain (Milne *et al.*, 2018). In certain tasks information from one modality can influence learning in another (Onnis and Thiessen, 2013; Seitz *et al.*, 2007). In this sense, the sequence of actions performed during consumer–ceramic tile interactions are going to be recorded in order to gain insight about how multisensory cues provided by ceramic tiles are processed in shops. The objective is to evaluate exploration sensory patterns of consumer–product interactions to assess the relevant physical properties of the tiles from a multisensory perspective, providing designers with insights to manage multimodal stimuli. The analysis in this work will consist of direct inspections and actual behavioural measurements made in the presence of the product that the consumer is considering purchasing. This approach enables investigating interactions during shopping experiences while simultaneously considering all the sensory modalities — and so overcoming the limitations of non-realistic studies in which evaluations are made by independently analysing sensory modalities as pointed out by Fujisaki *et al.* (2015). Gallace and Spence (2014) noted that there is practically no field research based on the observation and recording of actions carried out by the consumer associated with the different senses during the purchase process. According to these authors, most studies have been carried out through questionnaires to assess people's attitudes regarding their senses towards specific products. However, the visceral response (based on simple reactions to specific stimuli, goal-driven behaviour, and choice) depends on mechanisms that act in part at an automatic and unconscious level of information processing (e.g., Fitzsimons *et al.*, 2002) and this makes observational analyses more appropriate than questionnaires for evaluating complex behavioural situations (e.g., Saunders *et al.*, 2000; Suen and Ary, 1989). In this context, the present study addresses the following research question:

RQ1. Is there an intentional and stable interaction pattern or is it changing throughout the different steps of the sequence?

In order to define a sensory exploration pattern it is necessary to relate exploring actions to sensory modalities. The physical properties of ceramic tiles can be perceived by multiple sensory modalities. Consumers can see and touch samples to feel the size, shape, roughness, and warmth of their surfaces. At the same time, the sound made when users tap them or slide their fingers over them can affect the way they perceive the physical properties (Krishna, 2012; Spence and Zampini, 2006). All these stimuli reaching senses are efficiently merged and integrated in a coherent multisensory percept (e.g., Rouby *et al.*, 2016). To extract information and build a robust image of the world, the human brain collects the incoming sensory information and generates an unambiguous representation of the world following two strategies: to maximize information coming from the different sensory modalities, and to reduce the variance in the sensory estimate to increase its reliability (Ernst and Bülthoff, 2004). Gathering as much information as possible is done because different modalities complement each other when it comes to deal with ambiguous situations derived from natural exploration behaviours (Newell *et al.*, 2001). In addition, in the sequence loop of sensation–perception–action sometimes prior knowledge (that might be unconscious) is needed to help sensory processing to deal with ambiguities (e.g., Kersten and Yuile 2003). Regarding integration, it is important to know sensory dominance and cross-modal effects, as humans integrate information both within and across sensory modalities (e.g., Johnston *et al.*, 1994; van Beers *et al.*, 1999). In this line, the response of users to products has been deeply studied in the past (e.g., Crilly *et al.*, 2004; Hagtvedt and Patrick, 2008; Reimann *et al.*, 2010; Yang *et al.*, 2010) and the sense of vision is mostly dominant (e.g., Hoegg and Alba, 2007; Schifferstein, 2006; Schifferstein and Desmet, 2007; Wastiels *et al.*, 2013). However, vision is not always the dominant sense (e.g., Shams *et al.*, 2000), as sensory dominance is defined by the ‘modality appropriateness’ as stated by Welch and Warren (1986), or by its ‘estimates precision’, as discussed by Ernst and Bülthoff (2004). In this functional approach of dominance among senses, one modality dominates the perception of a sensory cue if it is the most appropriate to perceive this sensory cue. However, and according to Schifferstein (2006) and Fenko *et al.* (2010), herein sensory dominance is defined as the relative importance of different sensory modalities for the description of the interaction with a specific product. Hence, the dominant sensory modality in this work is the modality that has the largest effect on the evaluation of physical properties and the inferred performance behind each performed action. In this sense, Fenko *et al.* (2010) found that sensory dominance depends on the stage in which the product–user interaction occurs and on the product category. It is important to note that sensory dominance has usually been analysed using subjective reports on product usage experiences (e.g., Schifferstein, 2006), or in isolated test rooms under controlled experimentation conditions (e.g., Wastiels *et al.*, 2013). Thus, little work has been done exploring sensory dominance in a real shopping context, despite many authors highlighting its relevance (e.g., Gallace and Spence, 2014; Schifferstein, 2006). In this context, evaluating the sensory dominance derived for exploring actions throughout the experience of shopping for ceramic tiles is another objective of the present work. Therefore, the following two research questions are added:

RQ2: What is the sensory dominance for the whole sequence of actions performed during the shopping experience?

RQ3: Does the role played by sensory modalities vary throughout the sequence?

Finally, numerous studies have been conducted to identify typologies of shoppers. Stone (1954) identified four main types: economic shopper, personalization seeker, ethical shopper, and apathetic shopper. Since Stone's pioneering work different studies appeared to classify shoppers according to different factors and criteria. For instance, some factors considered are patronage and shopping behaviour (Stephenson and Willett, 1969), personal and social motives (Tauber, 1995), consumers' rating of preferences (Darden and Ashton, 1974), shopping motives (Babin *et al.*, 1994; Dawson *et al.*, 1990; Westbrook and Black, 1985), and the link made by consumers between usage and shopping phases (Inès and Herbert, 2016). However, there little systematic study has been made of consumer typologies considering the sensory dimension of user experience.

Tversky and Kahneman's (1971) findings show that most decision makers tend to simplify heuristics when making judgements. On the other hand, there are consumers that plan more and have a clear purpose when it comes to search for product information (Bloch and Richins, 1983), and others tend to explore products via touch (Klazky and Peck, 2012). Browsing behaviours are also influenced by sensory cues, affecting the way consumers touch and move in shops, as well as the time they spend in there (Xia, 2010). Thus, the last objective of this present work is grouping consumers according to observed sensory patterns of interactions. Hence, the last research question is as follows:

> RQ4: Is it possible to classify consumers into different groups based on statistically significant differences in their sensory exploration pattern?

In summary, the present work is focused on the analysis of consumer reactions to ceramic tiles from the utilitarian and sensory dimensions of user experience. Thus, this study is only focused on the sensory qualities of products in order to understand how users test a product's perceivable features, what actions are performed to compare product reactions with their previous expectations, what product properties are behind every exploratory action, which senses are mostly involved in each case, and their relative importance. All of this together enables designers to understand the role played by each sense, making it easier to communicate a coherent message to consumers and so produce a pleasing multisensory impression. Thus, consumer interactions are assessed in the pre-purchase evaluation stage of the general purchase process described by Blackwell *et al.* (2001), in which the consumer checks if the product can satisfy all the expectations for its future use by consciously examining it in shops. Specifically, this study is focused on the functional dimension of browsing behaviour, defined as shopping behaviour that is not associated with an immediate purchase task (Bloch *et al.*, 1989, Jarboe and McDaniel, 1987). The final purchase decision, in which either the most suitable product is chosen or all the products are rejected, occurs once this stage is finished (Smith *et al.*, 2005) and is out of the scope of the present work.

2. Material and Methods

The work presented in this paper consisted of the following steps:

- Elaboration of a checklist of exploratory actions.
- Observational study of consumer actions during the shopping experience.
- Analysis of the pattern of exploring actions and sensory dominance throughout the whole interaction.
- Classification of consumers into groups according to their exploration pattern and strategy.

2.1. Elaboration of a Checklist of Exploratory Actions

Some 15 users and four experts on user–product interactions took part in a pilot study. The users were observed and recorded as they interacted with ceramic tiles simulating a shopping experience in a real shop for 30 minutes. Secondly, experts analysed the video and were asked to write down in 60 minutes a list of actions observed and others that they had seen previously. The experts then shared their opinions with users and experts by explaining their lists of exploratory actions. Users in this step helped experts to gain insight into the interactions and corroborate the motivation for their actions. Finally, and once the experts agreed on the terminology to use, they defined a checklist based on the most frequent and important exploratory actions performed by users. These actions were coded and defined to clarify and specify what kind of behaviour was being referenced.

Moreover, the exploratory actions were related to the main senses stimulated by the actions and to the most relevant product features involved in such actions.

A spreadsheet was developed with Microsoft Excel 2013 to gather the actions performed during the shopping experience. The spreadsheet contained a list of actions in rows with one column for each consumer (including two cells to record the corresponding start and finish times).

2.2. Observational Study of User Actions During Shopping Experience

Data were collected by observational registers during real shopping experiences in a field study lasting three months. Some 196 people took part in the study carried out in two ceramic tile shops (one in Valencia and the other in Barcelona). All the consumers were aged between 24 and 49 and 60% were women. Shops had more than 1.200 square meters, exclusively dedicated to sell ceramic tiles, and were located away from high streets in secondary locations, out-of-town in shopping centres, one of them being a multibrand shop. Both shops had a large central showroom of ceramic samples with areas dedicated to bathrooms and kitchens around it. No special arrangements were made in the shops for the study.

Two observational sources were used in every shop. The first consisted of two experts who registered every action on a checklist on their tablets, as well as the order followed in an ascending sequence and the start/finish time. The second source consisted in the use of videos recorded by the security cameras placed at different locations in the shop (each offering panoramic video recordings). Consumers were unaware of their exploring actions being observed, in order to not influence their shopping behaviour.

However, before leaving the shop, consumers were informed about the study objectives, sources of funding, methods, and institutional affiliations of the researchers, and were asked to sign an informed consent to use security recordings. They were told that participation in the study was voluntary and that their privacy and confidentiality was guaranteed in case they agreed to participate, according to national and international legal and regulatory standards. The visualization of videos by researchers was done in the shops under the supervision of the security personnel to ensure the work was properly undertaken in accordance with their norms and protocols to preserve consumer rights. The Ethics Committee of the Polytechnic University of Valencia approved this study.

2.3. Analysis of the Pattern of Exploring Actions and Sensory Dominance Throughout the Whole Interaction

This analysis aims to study the sequence pattern of exploring actions when considering the total number of gathered interactions. The goal is to know if exploring actions are intentional or arbitrary, and see if the sequence pattern remains stable or if it varies among steps. In addition, by relating exploring actions to sensory modalities, the sensory dominance and the sequential role played by senses is to be analysed.

For this purpose, actions were organised according to the order in which they were executed in each case, from the first to the last action. In this study, the last action was that performed in 31st place (consumers performing more than 31 actions numbered less than the 25% of the initial sample). Thus, at each step of the sequence (S1, S2, S3…. S31), the percentage of consumers performing each action was calculated. In addition, the percentage of actions performed at each step of the sequence was obtained, from the beginning (S1) to the end (S31), and the total frequency of occurrence of each exploring action throughout the whole shopping experience was calculated. Finally, a flowchart was drawn representing the concatenation of actions for the whole sequence, indicating for each action at a given step how many actions preceded it (inputs) and how many actions followed it after it was performed (outputs). The difference between the number of inputs and outputs was calculated for each action in the whole sequence to determine which actions increase/decrease the variability of the action patterns. Connections representing a switch between senses were highlighted in the graphics.

Moreover, to test if exploring actions were intentionally selected, discarding their arbitrary selection at each step of the sequence, the multinomial goodness-of-fit test with the Monte Carlo approach (number of trials = 10,000) and significance levels of differences set at $p < 0.05$ was used. Thus, the frequency of occurrence of each exploring action at each step of the sequence was calculated and compared with an hypothetical equiprobable selection of exploring actions with a probability of each exploring action equalling 0.058 (1/17). In addition, to see if an exploration pattern was repeated during more than one step of the sequence, the observed frequency of occurrence of exploring actions in each step was compared with their observed frequency of occurrence in the immediately preceding step. XLSTAT software by Addinsoft under Windows was used for this statistical analysis.

Finally, in order to assess the sensory dominance during the shopping experience a relationship between the exploratory actions and the predominant senses stimulated in each exploratory action was established. If a sensory modality is stimulated by doing an exploring action then it is coded with a value of one, a zero is coded otherwise, see Table 1.

Then, each row of Table 1 was multiplied by the number of times each consumer performed each action, and the sensory stimulation for each sense was calculated by adding up the resulting values for each sensory modality. Finally, a variable called Total Sensory Stimulation was defined to account for the sensory stimulation of all sensory modalities throughout the whole sequence.

Once sensory stimulation was calculated for each sensory modality, several ANOVAs with significance levels of differences set at $p < 0.05$ were conducted to analyse sensory dominance. First, a one-way ANOVA was conducted to evaluate the effect of the different sensory modalities on the sensory stimulation driven by explorative actions performed by users throughout the whole sequence. The sensory stimulation was selected as the dependent variable and the sensory modalities as the factor including four levels: vision, touch, audition, and olfactory. Second, to test if sensory dominance differs through time, the sequence was divided into three sections: section 1 (from S1 to S10), section 2 (from S11 to S20) and section 3 (from S21 to S31). Then three one-way ANOVAs, one for each sequence section, were conducted with sensory stimulation as the dependent variable and sensory modalities as the factor including four levels: vision, touch, audition, and olfactory. Finally, to test if there were differences in sense modality among the three sections, four one-way ANOVAs, one for each sensory modality, were conducted with stimulation in each sensory modality as the dependent variable and sequence section as the factor including three levels: section 1, section 2, and section 3.

In all conducted ANOVAs, Tukey's HSD multiple comparison test ($p < 0.05$) was used to assure confidence level correction and identify between which pair of levels of the factor variable the differences appeared. The mean values and 95% CI were also calculated. Finally, the η^2 value was calculated to measure the effect size, setting the size of the differences found. All data analyses were performed using the SPSS 16 statistical application for Windows (SPSS Inc., Chicago, IL, USA).

2.4. Classification of Consumers into Groups According to Their Exploration Pattern and Strategy

The goal of this analysis is to classify consumers into groups with different exploration patterns when interacting with ceramic tiles during shopping experiences. To this end, a *k*-means cluster analysis was made to identify homogenous groups (e.g., Kaufman and Rousseeuw, 2005). Empirical studies on the performance of clustering algorithms in the marketing field suggest that iterative partition methods are preferable to hierarchical methods (Punj and Stewart, 1983). *K*-means, as a partitioning procedure, is more robust than hierarchical methods with respect to the presence of outliers, error perturbations of the distance measures, and the choice of the distance metric. In addition, the presence of non-relevant grouping variables is less severe with the *k*-means procedure (Punj and Stewart, 1983). In addition, *k* -means is useful for clustering a large dataset as it provides the values of the groups' centroids, which facilitates the interpretation. On the other hand, *k*-means procedure requires prior specification of the number of clusters desired.

The frequency with which each consumer performed each action included in the checklist during the interaction was considered for the consumer grouping. Only exploring actions with a total frequency of occurrence greater than 1% were considered. Several analyses were run until finding the solution with the most appropriate number of clusters. The criteria employed to set that solution were: maximum number of iterations until reaching convergence was set to 10; minimum cases in each group in the final solution were to be at least 10% of total cases; and finally, centres should be coherent and easy to interpret.

Each resulting cluster is considered as an exploration pattern resulting from different values achieved for each grouping variable. The exploration pattern is described according to the mean values of the grouping variables in the centres of the cluster.

In order to compare the sensory and utilitarian dimension of the resulting groups, these were statistically analysed using multiple univariate ANOVA with significance levels of differences set at $p < 0.05$. A one-way ANOVA was conducted for Total Sensory Stimulation and for each sensory modality individually (calculated as explained in Section 2.2), for total time employed for the inspection, and for total number of actions performed during the sequence as dependent variables, with resulting groups as the factor. The mean values and 95% CI were also calculated. The η^2 value was calculated to measure the effect size, setting the size of the differences found. All data analyses were performed using the SPSS 16 statistical application for Windows.

3. Results

3.1. Exploring Actions Belonging to the Checklist

Table 2 shows the codification and description of the exploring actions belonging to the checklist. Table 3 shows the way the explorative actions are related to the senses and to the most relevant product features involved in such actions.

3.2. Exploratory Sensory Pattern

Figures 1 and 2 show the whole sequence of actions performed by consumers and the percentage of actions performed at each step. Actions are grouped according to the involved senses with a colour coding. The thickness of the circle's outline is proportional to the percentage of people who perform the action. Within the circle, the number of actions that precedes each action (inputs) appears in the upper part, and the number of actions taken just after performing that action (outputs) appears in the lower one. The last row in Fig. 2 shows the difference between the inputs and outputs along the whole sequence in all actions. Dashed lines connect actions performed by less than 10% of consumers. The red lines are connections between actions of different senses. Finally, the background colour is white for the most frequent action in each step.

As can be seen in Figs 1 and 2, results show that interactions begin with a small number of actions; the number of actions grows until reaching a maximum at the two-thirds point of the whole sequence evaluation, the number of actions then declines to almost coincide with the number of actions at the start of the evaluation.

The obtained exploration sensory pattern shows that consumers start inspections using far and near vision. Consumers then employ touch and repeat touch and vision until finishing again with far-vision actions. Between touch and vision alternations, smelling may be stimulated during a close-up visual and tactile inspection near the face of consumers, and listening appears with sound produced by intensive tactile actions such as knocking a surface with the knuckles. An iterative process involving mainly the use of vision and touch successively appeared. Regarding this switching between senses, at the first third of the sequence there are more visual actions succeeded by tactile actions than vice versa, in the second third it is just the opposite, and in the last third the number of exchanges between both senses is the same. Finally, the difference between the inputs and outputs along the whole sequence in all actions (see Fig. 2) shows that the actions of crude touch (in yellow) decrease the dispersion of actions performed once they are executed. However, fine-touch actions (in green) increase the dispersion in the number of performed actions after its execution. Visual actions are practically preceded by the same number of actions as those that happen after them.

Tables 4 and 5 show the percentage of consumers performing each exploring action in each step of the sequence. In addition, Tables 4 and 5 show the *p* values obtained at each step after both testing equiprobability among performing actions, and the possibility of keeping an action-performing pattern for more than one step using a multinomial goodness of fit test with the Monte Carlo approach.

Tables 4 and 5 show that the sensory exploration pattern is intentional, as *p* (Equiprobab) shows significant differences in all the steps of the sequence. Moreover, it can be seen that consumers constantly change their exploration strategy, excluding those performed in S13 and S25, in which consumers repeat the same exploration pattern [p $T(n) - T(n-1) > 0.05$] used in the preceding step, S12 and S24 respectively.

The ANOVA carried out on the sensory stimulation for the whole sequence shows significant differences among sensory modalities ($F = 415.32$; $p = 0.000$; $\eta^2 = 0.656$). The results of Tukey's HSD multiple comparison test are shown in Table 6. Figure 3 shows the mean values and 95% CI in each sensory modality. As can be seen in Table 6, the clearly dominant modality is vision, showing statistical differences with all modalities, followed by touch, which shows statistical differences with both audition and olfaction.

The ANOVAs carried out on the sensory stimulation for the three sequence sections show significant differences among sensory modalities. *F* values, significance and η^2 values are shown in Table 7.

The results of Tukey's HSD multiple comparison test are shown in Table 8. Figure 4 shows the mean values and 95% CI in each sensory modality. As can be seen in Table 8 and Fig. 4, the sensory dominance differs from that obtained for the whole sequence in sections S1–S10 and S11–S20. Section S1–S10 differs from the whole sequence because there are significant differences between olfaction and audition. In S11–S20 there are no significant differences between vision and touch, showing dominance of both modalities over audition and olfaction. Finally, the last sequence section has the same dominance pattern among sensory modalities as the whole sequence.

The ANOVAs carried out for each sensory modality for the three sequence sections show significant differences in all sensory modalities, excluding olfaction. *F* values, significance and η^2 values are shown in Table 9.

The results of Tukey's HSD multiple comparison test are shown in Table 10. Figure 5 shows the mean values and 95% CI in each sensory modality. As can be seen in Table 10 and Fig. 5, vision is more stimulated in section S1–S10, then stimulation of vision decreases significantly to increase again in the last section. However, touch shows low stimulation at first, but then significantly rises in section S11–S20, maintaining high stimulation in the last sequence section. Similarly, stimulation of audition is low at the start, but then significantly rises in the second section, maintaining this stimulation until the end of the sequence.

3.3. Cluster Analysis to Group Consumers with Similar Exploration Patterns and Strategy

Fourteen exploration actions were used as grouping variables. ‘Bimanual exploration’, ‘measurement’ and ‘feeling the weight’ did not reach the minimum threshold (1%) in total frequency of occurrence throughout the whole sequence. The *k*-means cluster analysis identified a valid solution for two groups. These two groups are interpreted as two different consumer exploration patterns of ceramic tile properties during the shopping experiences. Table 11 shows the number of cases corresponding to each cluster, along with the percentage of men and the average age of consumers belonging to each cluster. The values of the final centres of cluster 1 and 2 for each variable can be seen in Table 12.

The ANOVAs carried out on the sensory and utilitarian dimension variables show significant differences among groups in all dependent variables analysed except vision and time of inspection. Figure 6 shows the mean values, 95% CI, F ratio, significance (p values), and η^2 value.

As can be seen in Fig. 6, there are statistically significant differences between the two groups in Total Sensory Stimulation, number of actions and in the stimulation of all sensory modalities except vision. In general, consumers belonging to cluster 2 stimulate the senses more than consumers in the cluster 1, as well as perform more exploring actions.

4. Discussion

The current work addressed the sensory dimension of users' shopping experiences, which has been the subject of little study in the literature despite designers, marketers and consumer researchers recognising the importance of understanding sensory stimulation and multisensory experiences in consumption processes (e.g,. Hultén, 2011; Scott and Uncles, 2018). This study enabled evaluating the sensory and utilitarian dimensions of the experience of buying ceramics from a multisensory point of view. Recording the actions carried out by a sample of consumers during the shopping experience, the exploration pattern and the role played by the different senses throughout the sequence have been analysed, as well as the main design features that consumers focus on when evaluating different designs at shops. In addition, the different sensory exploration patterns of consumers allowed classifying them into different groups of shoppers from the sensory dimension point of view.

Regarding the methodological approach followed in this present work, observation with a checklist enabled researchers to gather information by watching interactions, behaviours, actions, and physical features within their natural settings. The use of ethnographic methods allows designers and retailers to gather rich evidence-based insights into what consumers are really doing during shopping experiences. As stated by Priestner and Borg (2016), ethnography can be more time-consuming, expensive and complex, but it is very helpful to get more detailed, real-time, and in-depth qualitative data of what really happens. Thus, in this study, despite the aforementioned disadvantages, directly watching interactions rather than relying on what consumers say led to a more reliable analysis of the role played by different senses during shopping experiences.

This section will briefly relate the research findings to the research questions posed in the Introduction before discussing this study's limitations and practical implications.

4.1. Is There an Intentional and Stable Interaction Pattern or Is it Changing Throughout the Different Steps of the Sequence?

The observed interaction pattern, involving mainly the use of vision and touch successively, see Figs 1 and 2, aims at checking and confirming previous impressions. Vision enables consumers to make a quick 'visual preview' through which they infer the tactile properties of the product, which they then try to confirm through touch, as discussed by Lederman and Klatzky (2009). This switching between vision and touch is in line with previous works that analyse sensory dominance during different stages of user–product interactions (e.g., Fenko *et al.*, 2010; Inès and Herbet, 2016). Vision and touch interactions have also been analysed in multimodal perception of materials given their special importance in the earlier phases of conceptual design (e.g., Baumgartner *et al.*, 2013).

Results show that the sequence of actions performed by consumers is intentional. That is to say, consumers, consciously or not, have a strategy when it comes to exploring sensory cues of ceramic tiles looking for relevant material information. However, consumers' sensory patterns change at every step, only in two steps (S12 and S24) the sensory exploration pattern is repeated once, see Tables 4 and 5. As can be observed in Figs 1 and 2, exploring actions can be carried out in several ways by different consumers. Even if the same consumer had to repeat the product exploration, probably he or she would do it differently. Once again, it is proven that consumer behaviours are complicated and diverse. The complexity of the exploration pattern demands a more in-depth analysis, going beyond the scope of the present exploratory study, to extract behavioural patterns from the sensed consumer activity data. The pattern recognition of actions and the subsequent analysis of interrelations, contradictions and wholeness of the derived sensory experiences demand that researchers use new techniques (Scott and Uncles, 2018), different from those traditionally used in the user experience field, briefly summarised by Vermeeren *et al.* (2010). Context-aware computing and learning algorithms are emerging fields whose methods could help multisensory research to face this challenge in the future.

Regarding the two steps in which exploring actions are repeated once, it is interesting to note that these repetitions appeared every other 11 steps. Maybe the amount of information gathered after a given number of actions and the noise of its variability forced consumers to perform actions to corroborate and treat the accumulated ambiguity of stimuli. After several steps combining signals, more time seems necessary to integrate them, a process that can be hampered if discrepancy among sensory modalities is large or if the sequence of actions is not appropriate (Ernst and Bülthoff, 2004). In any case, a more in-depth analysis seems necessary given the relevance that extracting a pattern may have in consumption processes. Based on these exploratory findings, the following proposition can be posed:

P1. Explorations looking for materiality and functionality information offered by ceramic tiles at shops are intentional and its exploration pattern varies practically at each step of the sequence.

4.2. What Is the Sensory Dominance for the Whole Sequence of Actions Performed During the Shopping Experience?

The results of actions performed by consumers along the whole sequence show the dominance of the vision. As discussed by Schifferstein (2006), there are several reasons that make vision the most important sense in product inspections: vision is able to perceive objects from a distance; it gathers a bigger amount of information on a product per time unit, and, most importantly in the context of the present study, vision guides product explorations made through the other modalities. Apart from vision, touch dominates the other senses. This result is in line with previous works as consumers acquire most of the information on products by vision and touch (Schifferstein and Cleiren, 2005; Wastiels *et al.*, 2013'). This fact is relevant as visual and touch modalities perceive different product characteristics, with vision being more able to measure 'macrogeometric characteristics' such as spatial distribution, geometric patterns, size, and gross shape; and touch being more accurate in the perception of 'microgeometric characteristics' such as differences between textures, porosity, and type of material (Woods and Newell, 2004). The detection of similarity between objects is mainly driven by shape when subjects are only able to see the objects, but detection is made by shape and texture when objects are touched or seen and touched (Yildirim and Jacobs, 2012). It could be said that the use of touch is dominant in the encoding of the substance of a product (Schifferstein and Hekkert, 2008). The work of Wastiels *et al.* (2013) shows that during the single use of touch when evaluating products' materials, the description made by the users contained significantly more sensory and descriptive attributes related to the physical behaviour of materials than those of users who were allowed to use vision or both vision and touch. This fact would be in line with the importance of touch discovered in this study when performing the sensorial and utilitarian evaluation of the materials in the purchase phase. Many works show that touch properties can be inferred from vision with relative accuracy (e.g., Xue *et al.*, 2016), and at the same time, touching products can also improve visual processing (e.g., Pesquita *et al.*, 2013). However, for some product attributes such as shape and texture, the use of both vision and touch does improve on the perceptions gathered when using only one of the senses (e.g., Helbig and Ernst, 2007; Klatzky and Lederman, 2010). Bergmann Tiest and Kappers (2007) argued that roughness is a multisensory property rather than exclusively a tactile one. Therefore, the following proposition can be posed:

P2. Vision is the most important sense when exploring material properties at shops, followed by touch.

4.3. Does the Role Played by Sensory Modalities Vary Throughout the Sequence?

Regarding the analysis of the sensory importance along the exploration sequence, results shows that sensory dominance changes over time, see Fig. 4. From S1 to S10 the importance hierarchy of modalities is vision, touch, olfaction and audition, matching the relative importance found by Schifferstein (2006) during the usage of a sample of products. However, from S11 to S21 touch equals vision in importance , being both more important than audition and olfaction. The importance of touch has gained increased interest within the multisensory research community (e.g., Gillmeister *et al.*, 2017) and it has also been highlighted in previous studies that it fulfils both utilitarian and hedonic consumer demands during shopping experiences (e.g., de Vries *et al.*, 2018; Krishna *et al.*, 2016; Peck, 2010). Grohmann *et al.* (2007) argued that touch positively affects in-store product evaluations, particularly in products where tactile input is diagnostically-based and product quality level is high. The steadily growing importance of touch as e-shopping is becoming the prevailing mode of consumption and touchscreens have shaped the mode of interacting with wearables and surroundings, has made many authors affirm that touch and vision are equally important in shaping consumer perceptions and behaviours (de Vries *et al.*, 2018; Xue *et al.*, 2016). Finally, from S21 to S31 the results are the same as those reported for the whole sequence, see Figs 3 and 4.

The results of the analysis of importance made for each sensory modality along the sequence (see Fig. 5) show that from S11 to S20 vision is less important than it is both at the beginning (S1–S10) and at the end of the sequence (S21–S31). As can be seen in Figs 1 and 2, consumers begin with an intense visual inspection, in which near vision prevails, then vision is less prominent in the middle to recover importance in the last section with far-vision actions. Interestingly, touch grows in importance from S11 and persist until the end. This fact can be explained because, for an accurate tactual perception of a product, tactual inspection should be done in a systematic way (Sonneveld and Schifferstein, 2008), thus forcing consumers to learn a strategy or exploratory procedure, which Turvey (1996) calls 'dynamic touch'. In addition, perception through touch is especially influenced by what has been perceived previously, a so-called after-effect. Tactual perception of shape, size and weight suffers from after-effect (Sonneveld and Schifferstein, 2008). Figures 1 and 2 show how touch connects sequentially several touch actions along the sequence. Spence *et al.* (2001) analysed the time cost of switching attention between senses, and found that the reaction time cost associated with shifting attention away from touch was larger than the cost associated with shifting away from any other sense. To some extent, it could be said that touch is one of the senses with more 'inertia': once tactile actions appear it is more difficult to give them up.

In the case of audition, its relative importance among sections of the sequence follows the same pattern as touch, growing in importance from S11 and retaining this importance until the end, although with much less presence in explorations, see Fig. 5. In any case, consumers also use sounds to identify properties of materials (Giordano and McAdamns, 2006; Hermes, 1998), playing a role that should be considered by designers too. Based on these findings it can be said that:

P3. Sensory dominance varies throughout the sequence of product exploration during the shopping experience. Differences appear among all senses throughout the sequence and within the senses of vision, touch and audition along the sequence. Touch is just as important as vision in the middle of the exploration sequence, and vision is less important in the middle section of the sequence than it is at the beginning and at the end.

4.4. Is it Possible to Classify Consumers into Different Groups Based on Statistically Significant Differences in Their Sensory Exploration Pattern?

Cluster analysis using sensory and utilitarian dimension variables allowed classifying consumers in two groups. Consumers in cluster 1, herein termed 'observers', perform a smaller number of actions during the product inspection process than those in cluster 2, herein termed 'sensory seekers', having a lesser Total Sensory Stimulation, see Fig. 6. Specifically, no differences were found in vision, but observers stimulate touch, audition and olfaction less than sensory seekers. Those differences are especially relevant in the touch sense, given the high value of the η^2 statistic (see Fig. 6). Interestingly, no differences were found between groups in the time spent in the shops. Many studies show the positive influence that time spent in shops has both on the probability to buy and on the amount of money spent (e.g., Soars, 2009). Thus, this finding indirectly suggests that the sensory and utilitarian dimension of this shopping experience might have no influence on ulterior purchasing. Maybe this kind of product left no room for the recreational dimension of purchase behaviour, and consumers attend shops knowing they need to buy the product. Obviously, this suggestion must be interpreted with caution and needs further work to know the real role played by the sensory dimension regarding willingness to buy at this pre-purchase stage.

The ‘observers’ belong to the larger cluster (see Table 11), which is in line with Tversky and Kahneman’s (1971) findings showing that most decision makers tend to simplify heuristics and rely on a small number of cues when making judgements. In contrast, sensory seekers made more thorough, numerous, and interactive actions than observers. Sensory seekers show an exploration pattern aimed at gathering as much information as possible from the properties of the ceramic products.

Comparing consumer groups to previous consumer typologies and considering only shopping motives, ‘observers’ may be related to the apathetic style defined by Stone (1954) as consumers who might not have an intrinsic interest in shopping, whereas consumers seeking sensory stimulation as a personal motive (defined by Tauber, 1995) may form the ‘sensory seekers’ group. Apart from motivation, it is important to stress that the present study has been focused on the sensory and utilitarian dimensions of the shopping experience, stressing the product-centric functional perception and considering consumers as rational problem-solvers (e.g., Moschis, 1976; Rintamäki *et al.*, 2006). This approach leaves aside the hedonic, emotional, recreational, and social dimensions that also take place during shopping experiences (e.g., Babin *et al.*, 1994; Cox *et al.*, 2005; Darden and Reynolds, 1971). Thus, only practical reasons have been considered to link actions to consumers’ information-gathering strategy. Inès and Herbet (2016) made an interesting study linking usage and shopping experience stages and identified three consumer typologies: enthusiastic; pragmatic; and apathetic. The authors claim that pragmatic consumers highly value the usage experience and the utility dimension of the shopping experience. In this line, observer and sensory seeker typologies obtained in the present study could be considered as two subcategories of Inès and Herbert's (2016) pragmatic typology. Observers, being pragmatic, could be closer to the apathetic typology, and sensory seekers closer to the enthusiasts. In any case, it is worth stating that shopping behaviour depends on the type of product, the degree of perceived risk inherent to the type of product, and the level of knowledge that the consumer has about the alternatives. Thus, more studies seem necessary to find robust consumer behaviour typologies related to the role that sensory modalities play during shopping processes.

Traditionally, it has been found that gender influences multiple factors related to the shopping experience (e.g., Darley and Smith, 1995; Fisher and Arnold, 1994). According to the two basic dimensions of shopping experiences, women tend to better assess the emotional aspects of shopping (e.g., Carpenter and Moore, 2009, Chang *et al.*, 2004; Jackson *et al.*, 2011). Regarding the utilitarian dimension, previous studies show that this dimension is better valued by men (Deng *et al.*, 2010; Zhang *et al.*, 2017), although there are studies that find no differences among genders regarding utilitarian shopping values (Jackson *et al.*, 2011). Recent studies show that the roles played by men and women are mixed and it seems that the differences are attenuated or disappear in many cases (e.g., Hart *et al.*, 2007; Otnes and McGrath, 2001). For example, age seems to have no influence on the evaluation of relevant product information and consumer behaviour (Hervé and Mullet, 2009; Jackson *et al.*, 2011). The results obtained in this research seem to be in line with this new trend, as the clusters obtained show differentiated behaviour and exploring strategies despite being almost balanced in gender and having a similar average age. In any case, this study does not reveal the influence of gender and age in the sensory evaluation of the physical properties of products; aspects that should be studied in future works. Taken all together, the following proposition can be formulated:

P4. According to the sensory and utilitarian dimension of shopping experience, two groups of consumers are found with differentiated sensory stimulation and exploring strategies.

4.5. Limitations of the Present Study

Findings of the present study cannot be generalised without caution. In the present study only consumers belonging to western culture were observed. Different cultures have different ways of interacting with objects; the sensory dominance changes among them (e.g., Howes, 1991), as well as the associations between properties perceived by different senses (Spence, 2007). Designers need to bear this in mind when developing products for different countries or multi-cultural societies.

Likewise, the influence of interindividual differences on findings has not been considered in the present study. However, as several studies show, personality traits have an influence on consumer motivations and behaviours (e.g., He *et al.*, 2018; Yangui *et al.*, 2016). In this line, it could be interesting to assess the influence of consumer personality traits on the sensory dimension of shopping experiences. Aspects related to goal cognition and actions such as 'need for closure' (Kruglanski and Webster, 1996), 'need for achievement' and 'need to avoid failure' (Elliot and Church, 1997) should be monitored. Indeed, it could be interesting to monitor personality traits related to information processing: such as 'need for cognition' (NFC) (Cacioppo *et al.*, 1996) as high-NFC people process information more thoroughly and seek information actively; as well as ‘optimum stimulation levels’ regarding the amount of stimulation people prefer in life (Steenkamp and Burgess, 2002). Finally, regarding stimulation and due to the relevance of touch discovered during ceramic tile shopping experiences, the need for touch (NFT) should be assessed as well as consumer’s judgement of a product may differ as a function of their linking for haptic stimulation (Citrin *et al.*, 2003; Peck and Childers, 2003). Further studies, which take these variables into account, will need to be undertaken.

The present work is an attempt to analyse the non-cognitive inner world of consumers by mainly analysing sensory stimulation in their encounters with products during shopping experiences. However, to pattern such experiences a sensory stimulation analysis may be insufficient, given the rich, complex and interrelated nature of multisensory experiences in consumption contexts. Embodiment, referring to the lived experience of a person’s body, as well as the experience of life mediated through the body, could be an interesting field to complement sensory stimulation in consumer research studies by examining how our bodies interact with environments. The analysis of bodily experiences could enhance physiological, social, emotional and corporeal sources of multisensory experience, which help marketers to design sense-rich experiences in a holistic way. Scott and Uncles (2018) describe a framework for the embodiment of consumption experiences, with some examples of implementation under the umbrella of sensory anthropology, which might be interesting to consider in future works.

Finally, as has been discussed earlier, the exploratory analysis of the sequence pattern needs to be approached from a quantitative perspective. Such analysis might uncover latent interactions patterns, as well as classify consumers with different ways of performing exploratory actions. This is an important issue for future research, which is being addressed by the authors at present.

4.6. Practical Implications

Knowing which sensory modalities contribute most to the gathering of information at different stages of a shopping experience can be very useful for designers, marketers and retailers because it enables them to focus on the most important senses and product sensory properties to improve product–consumer interactions. To know the most important senses to be considered when designing a new product is very helpful in the early phases of product design (Nagai and Georgiev, 2011), helping to fix priorities to meet budget restrictions and guide the decision-making processes throughout product development. Alternatively, designers could enhance the product experience if they emphasise the design of product properties for any of the underestimated sensory modalities — avoiding overloading consumers with excessive stimulation as pointed out by Krishna (2012) and analysed by Kacprzak and Pawłowska (2017).

The present findings demand designers to expand their abilities to be able to devise the tangible properties of products from a multisensory perspective, integrating all the information from multiple sensory modalities in such a way that facilitates input information processing. To learn how to design tactile attributes to deliver the right emotional sensations modulating the multisensory shopping experience seems to be imperative in the ceramic sector. Despite the increasing relevance of touch in shopping experiences and its emotional connection to products (e.g., Schifferstein and Hekkert, 2008), the design of ceramic tiles is mainly focused on vision, as is still the case in many other design fields (Gallace and Spence, 2014). Tile attributes such as shape, size, joint size, texture, and roughness are currently designed to be interpreted only by consumer vision, however consumers in shops use both vision and touch to explore these properties (see Table 3). To this end, the multisensory basis of the product experience approach described by Desmet and Schifferstein (2011) and Schifferstein (2011) can be useful. Moreover, tools such as the material palette (Nijs *et al.*, 2010) and material-driven design methodology (Karana *et al.*, 2015) can be useful for designing experiences using material properties as a new and promising start point for design.

Moreover, result shows that the cross-modal effects of vision, touch and audition should be understood by designers in order to solve possible visual biases and sensory conflicts, as well as to reach enough sensory congruence to properly convey product messages and grounded emotion (Krishna, 2012).

Finally, the results of this work could be interesting for material retailers, as they offer the possibility of identifying the crucial and most frequent actions that consumers perform during the ceramic tile shopping process, as well as the role played by different senses, and consequently, which product properties are the most often assessed by consumers. This provides relevant information to the ceramic sector about how it could improve consumer–product interaction in a multisensory way, leading to a more active role in shaping user experiences and adapting product properties and presentation in stores appropriately.

It is important to stress, however, that industrial profitability of this kind of studies will depend of the companies' objectives and strategies, and on the way they integrate sensory and consumer data in their innovation and research projects (Talavera and Chambers, 2017). Spanish companies that participated in this work recognised that sensory studies help products succeed, and were prone to change the way they design and sell their products. However, the pace of introducing those changes varies among companies. Results of this study lead ceramic tiles companies to define eight new challenges related to touch, and three challenges related to shopping experience improvement. Depending on those companies' objectives and strategies, they selected which challenges to lead and develop in detail. All companies realized the importance of multisensory design, and changed their shopping experiences trying to demonstrate the non-visual properties of ceramic tiles. However, companies with their own R&D department had incorporated the changes before and are already leading the leap towards the economy of experiences in the sector, introducing pieces of multisensory ceramics in cutting-edge restaurant businesses and hospitality environments. One of them use ambience design at shops, adapting sensory cues in different corners in a congruent manner with the messages they are trying to convey with each design. Although it is still early to draw conclusions, in all cases sales at shops staging corners exceed those obtained in previous years. In any case, the sensory information analysis made in the sector helped all companies, regardless of their size and organizational management, to understand the marketplace, and uncover future needs by knowing existing sensory gaps that remain unmet.

5. Conclusion

The multisensory analysis of utilitarian and sensory dimensions during ceramic tile shopping experiences enables designers, marketers and retailers to understand exploration actions of consumers, the senses involved, their importance and hierarchy, and the physical properties of the product evaluated.

The use of observation as an ethnographic method allowed identifying an intentional and changing inspection pattern along practically all the sequence steps. Thus, the role played by sensory modalities, as well as sensory dominance, varies throughout the inspection sequence. The dominance differences appear between all senses and among the senses of vision, touch and audition. Vision dominates over the rest of senses at the beginning, but in the second third of the total interactions touch reached the same relevance. At the end, vision becomes dominant again. This fact evidences the need to analyse possible interactions between these two senses in order to design the communication of messages in a coherent manner and avoiding sensory conflicts or bias.

The results of cluster analysis classified consumers into two groups: (1) *sensory seekers* who were interactive and made intensive and thorough inspections; and (2) *observers* who, despite spending the same time, were more passive and basically acted as visual evaluators.

These findings contribute in several ways to understand consumer interaction patterns, and the senses relevant in consumption processes. Moreover, this information could be crucial to set sensory design guidelines to improve sensory interactions and bridge sensory demands with product features.

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Figure Captions

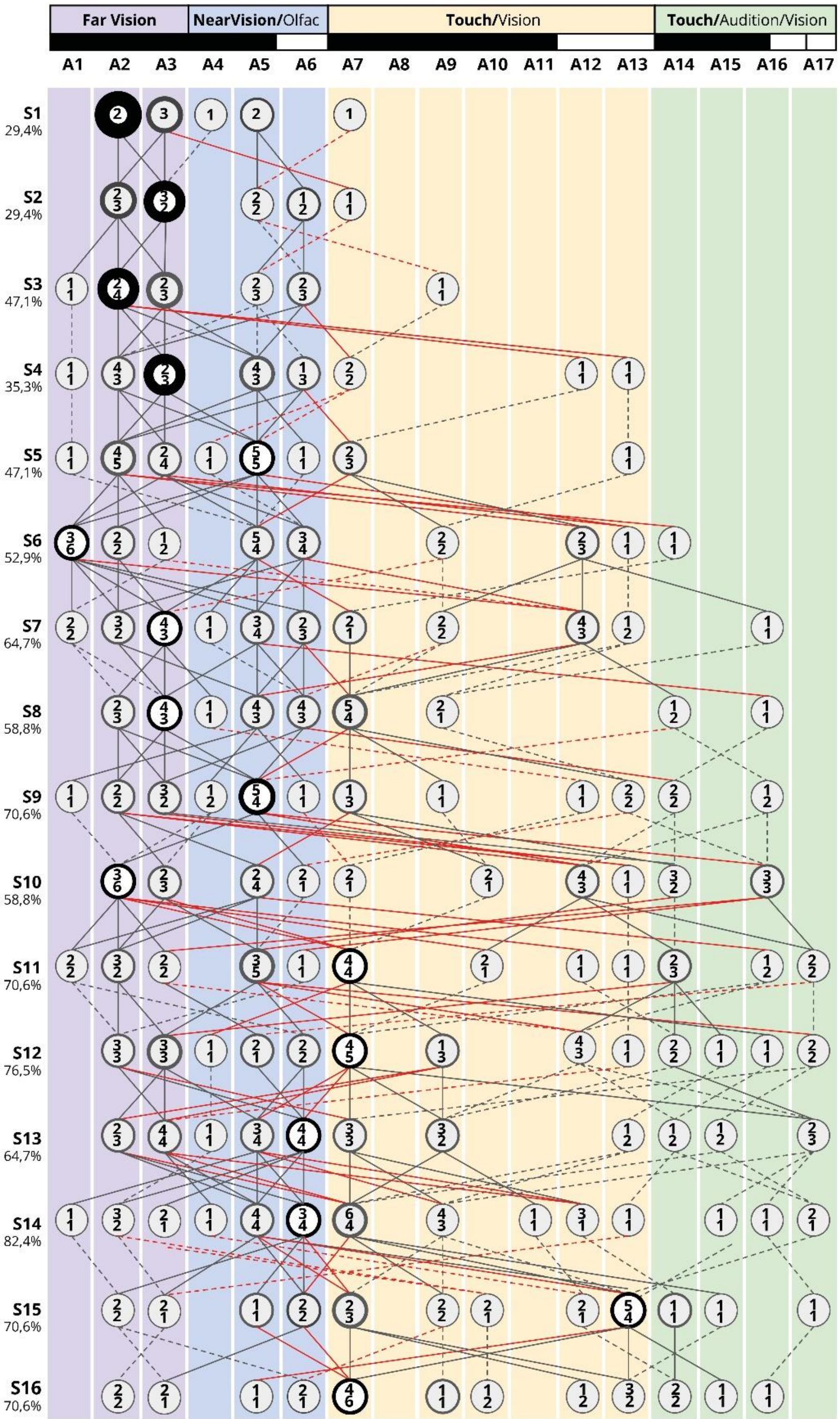


Figure 1. Flowchart of the action sequence from S1 to S16.

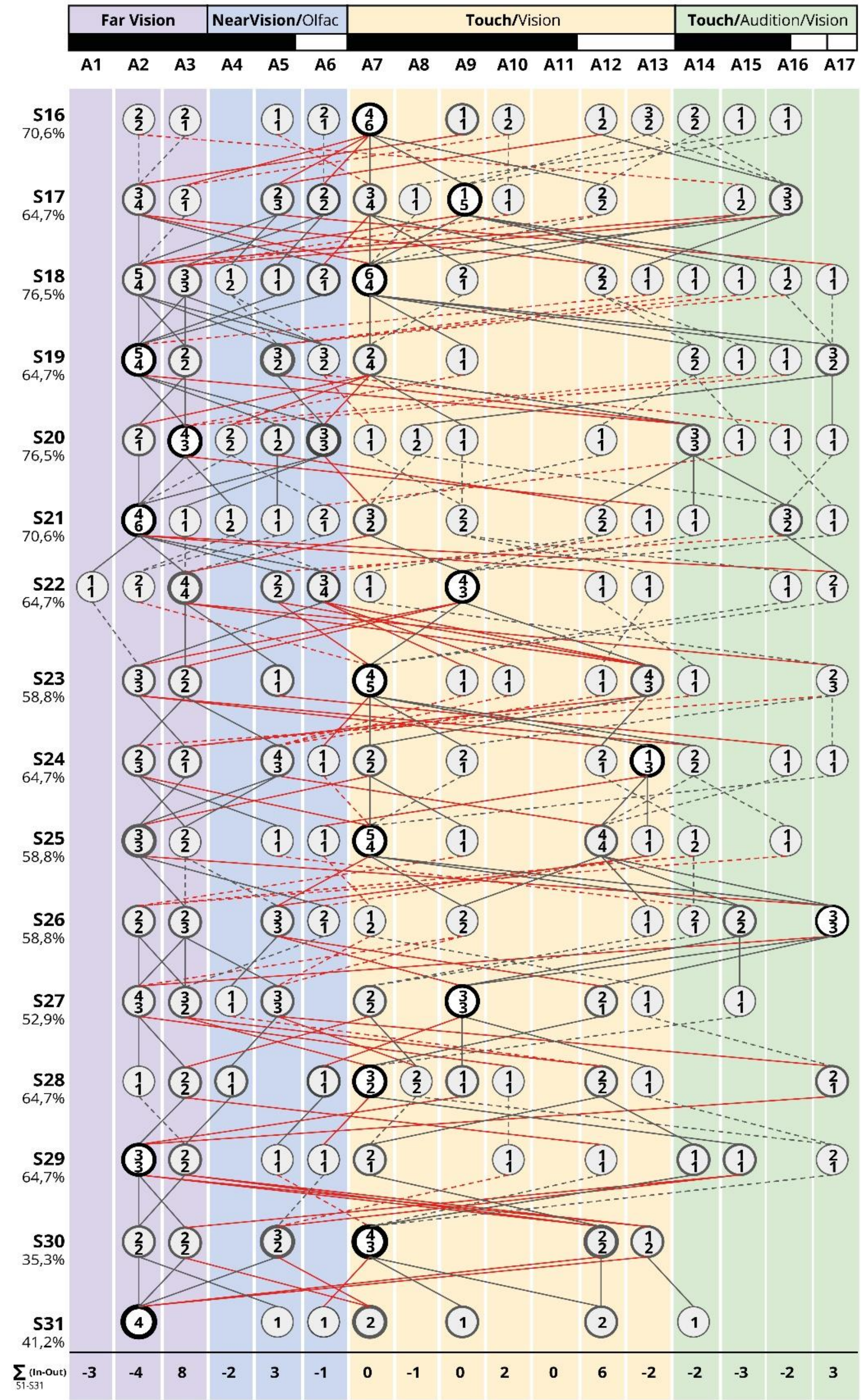


Figure 2. Flowchart of the action sequence from S16 to S31.

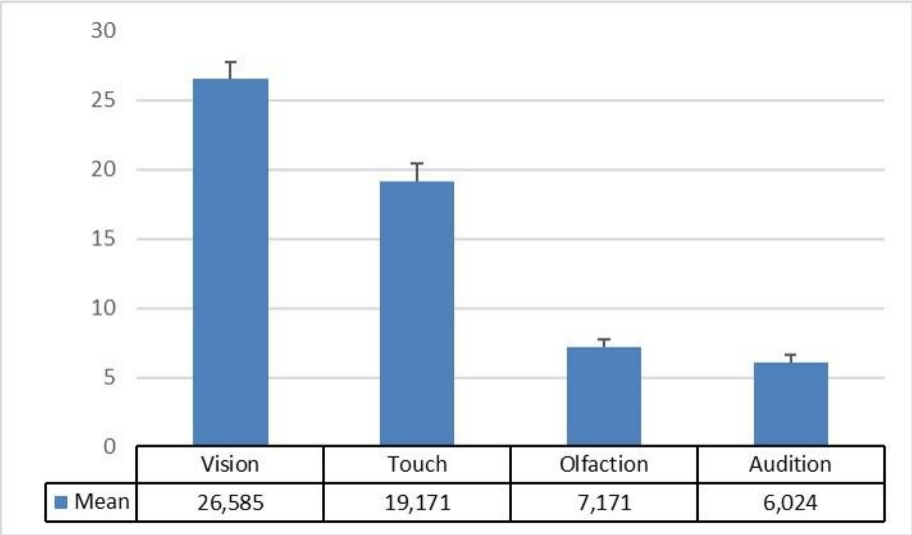


Figure 3. Mean values and 95% CI of sensory stimulation per sensory modality for the whole sequence.

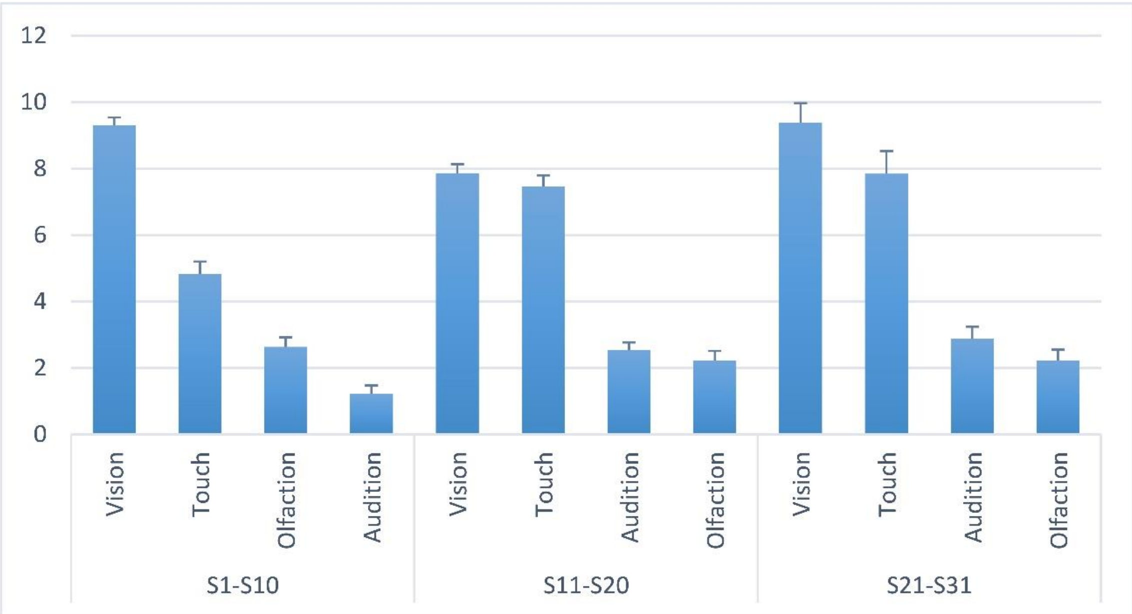


Figure 4. Mean values and 95% CI of sensory stimulation per sensory modality for the sequence sections.

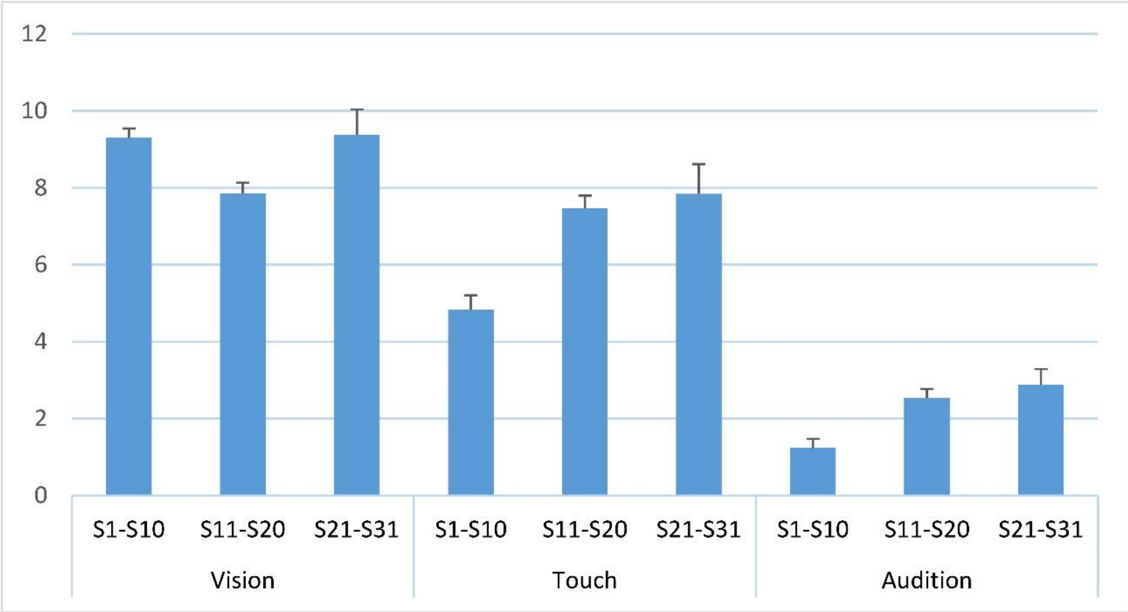
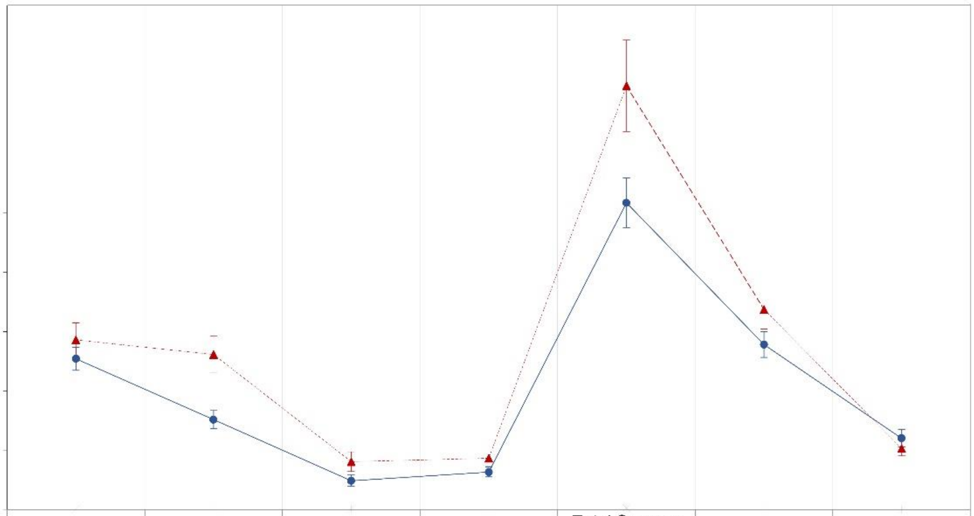


Figure 5. Mean values and 95% CI of sensory stimulation per sensory modality for the sequence sections.



	Vision	Touch	Audition	Olfaction	Total Sensory Stimulation	Nº of Actions	Time
Cluster_1	25,42	15,154	4,85	6,31	51,731	27,81	12,02
Cluster_2	28,60	26,133	8,07	8,67	71,467	33,73	10,29
F-ratio	3,630	51,562	13,554	10,110	24,961	10,072	2,587
Sig.	0,060	0,000	0,000	0,002	0,000	0,002	0,112
Eta Squared	,043	,392	,145	,112	,238	,112	,031

Figure 6. Comparison of the sensory and utilitarian dimension variables between the two groups.

Table 1.

Sensory stimulation derived from the execution of the exploring actions

Action code	Exploring action	Vision	Touch	Audition	Olfaction
1	Far–middle lateral visual exploration	1	0	0	0
2	Far–middle frontal visual exploration	1	0	0	0
3	Far–middle dynamic visual exploration	1	0	0	0
4	Near–lateral visual exploration	1	0	0	1
5	Nea–frontal visual exploration	1	0	0	1
6	Near dynamic visual exploration	1	0	0	1
7	Static contact	1	1	0	0
8	Bimanual exploration	1	1	0	0
9	Joint inspection	1	1	0	0
10	Measurement	1	1	0	0
11	Feeling the weight	1	1	0	0
12	Lateral exploration	1	1	1	0
13	Stepping on	1	1	1	0
14	Friction assessment	0	1	1	0
15	Knocking surface with nails	0	1	1	0

16	Knocking surface with knuckles	0	1	1	0
17	Scratching with nails	0	1	1	0

Table 2.

Codification and description of the exploratory actions

Action code	Exploring action	Description
1	Far–middle lateral visual exploration	Far–middle visual inspection (>25 cm) of the ceramic system profile
2	Far–middle frontal visual exploration	Far–middle visual inspection (>25 cm) of the front part of the ceramic system
3	Far–middle dynamic visual exploration	Far–middle visual inspection (>25 cm) changing observation angle
4	Near–lateral visual exploration	Near–lateral visual inspection (<25 cm) of the ceramic system profile
5	Near–frontal visual exploration	Near–lateral visual inspection (<25 cm) of the front part of the ceramic system
6	Near dynamic visual exploration	Near–lateral visual inspection (<25 cm) changing observation angle
7	Static contact	Set palm on the ceramic surface for a while
8	Bimanual exploration	Exploration of the shape with both hands
9	Joint inspection	Sliding along the ceramic joints with the fingertips
10	Measurement	Measure the pieces using hands, fingers, or metric tools
11	Feeling the weight	Lifting the ceramic material
12	Lateral exploration	Lateral movement with the fingertips
13	Stepping on	Walk on the pavement (with shoes)

14	Friction assessment	Slide on the ceramic surface with fingers or palm
15	Knocking surface with nails	Knocking surface with nails on ceramic surface
16	Knocking surface with knuckles	Knocking surface with knuckles on ceramic surface
17	Scratching with nails	Scratching with nails on ceramic surface

Table 3.

Relationship between the exploring actions, senses and product parameters

Action code	Exploring action	Involved senses	Properties of the ceramic system
1	Far–middle lateral visual exploration	Far vision	Texture/colour/brightness/lightness
2	Far–middle frontal visual exploration	Far vision	Visual texture/colour/brightness/lightness/visual pattern (entropy)
3	Far–middle dynamic visual exploration	Far vision	Visual texture/colour/brightness/lightness/visual pattern (entropy)
4	Near–lateral visual exploration	Near vision	Texture/colour/brightness/lightness/smelling properties
5	Near–frontal visual exploration	Near vision	Visual texture/colour/brightness/lightness/visual pattern (entropy)
6	Near dynamic visual exploration	Near vision	Visual texture/colour/brightness/lightness/visual pattern (entropy)
7	Static contact	Vision/touch	Temperature/thermal effusivity/cleaning/footprints
8	Bimanual exploration	Vision/touch	Shape/size/thickness/weight/visual texture/ brightness/lightness

9	Joints inspection	Vision/touch	Joints size/lining up of tiles
10	Measurement	Vision/touch	Shape/size
11	Feeling the weight	Vision/touch	Weight/thickness/
12	Lateral exploration	Vision/touch	Texture/roughness
13	Stepping on	Vision/touch	Grip/stability/timbre
14	Friction	Vision/touch/audition	Grip/stability/texture/roughness/timbre/pitch
15	Knocking surface with nails	Vision/touch/audition	Texture/roughness/timbre/pitch/hardness
16	Knocking surface with knuckles	Vision/touch/audition	Texture/roughness/timbre/pitch/hardness
17	Scratching with nails	Vision/touch/audition	Texture/roughness/timbre/pitch/hardness

Table 4.

Percentage of consumers performing each action, and *p* values for equiprobability [*p* (Equiprobab)] and for keeping action being performed [$p\ T(n)/T(n-1)$] from S1 to S16 (steps keeping action being performed in the immediately preceding step in bold)

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	**S12**	**S13**	S14	S15	S16
A1			4,08%	4,08%	3,57%	20,41%	8,67%		3,06%		9,18%			7,65%		
A2	53,57%	33,16%	42,86%	13,27%	23,47%	13,27%	11,22%	9,69%	13,27%	23,47%	10,20%	**10,20%**	**10,20%**	6,63%	6,63%	6,88%
A3	27,04%	46,94%	33,16%	33,67%	15,82%	6,63%	20,41%	23,47%	16,84%	10,20%	6,63%	**16,33%**	**13,27%**	3,06%	6,63%	6,88%
A4	3,06%				3,57%		3,06%	3,57%	6,63%			**3,06%**	**3,06%**	3,06%		
A5	13,27%	6,63%	7,14%	23,47%	36,73%	17,35%	13,78%	13,78%	20,41%	14,80%	18,88%	**9,18%**	**17,35%**	13,78%	11,22%	6,88%
A6		10,20%	10,20%	11,22%	3,57%	16,84%	10,20%	13,27%	3,06%	6,63%	3,06%	**10,20%**	**20,41%**	21,43%	11,73%	7,41%
A7	3,06%	3,06%		6,12%	10,20%		10,71%	19,90%	10,20%	8,67%	23,47%	**16,84%**	**12,24%**	18,37%	14,29%	27,51%
A8																
A9			2,55%			6,63%	2,55%	3,57%	3,06%	6,12%	3,57%	**8,67%**	**7,65%**	4,59%	6,63%	13,23%
A10															5,10%	3,17%
A11														2,55%		
A12				5,10%		9,69%	10,20%		3,06%	11,22%	3,57%	**3,06%**		5,10%	5,61%	6,88%
A13				3,06%	3,06%	6,12%	6,12%		6,63%	3,06%	3,06%	**3,06%**	**3,06%**	3,06%	16,84%	5,29%
A14						3,06%		6,12%	6,63%	5,61%	8,67%	**6,12%**	**3,06%**		9,18%	8,99%
A15												**3,57%**	**3,06%**	3,57%	3,06%	3,17%
A16							3,06%	3,57%	7,14%	10,20%	3,57%	**3,57%**		4,08%		3,70%
A17								3,06%			6,12%	**6,12%**	**6,63%**	3,06%	3,06%	
p (Equiprob)	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*
pT(n)-T(n-1)		*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,004*	*0,000*	*0,000*	***0,071***	*0,000*	*0,000*	*0,000*

Table 5.

Percentage of consumers performing each action, and *p* values for equiprobability [*p* (Equiprobab)] and for keeping action being performed [*p* $T(n)/T(n-1)$] from S17 to S31 (steps keeping action being performed in the immediately preceding step in bold)

	S17	S18	S19	S20	S21	S22	S23	**S24**	**S25**	S26	S27	S28	S29	S30	S31	Total
A1						3,53%							5,93%			2,44%
A2	13,76%	16,93%	20,63%	10,93%	22,94%	7,65%	12,27%	**12,27%**	**17,31%**	12,67%	16,06%	5,65%	19,49%	12,38%	33,67%	16,97%
A3	3,70%	13,76%	10,58%	18,03%	4,12%	19,41%	12,27%	**11,66%**	**8,33%**	12,67%	14,60%	15,32%	15,25%	12,38%		15,34%
A4		6,88%		7,10%	7,06%						4,38%	4,84%				1,98%
A5	11,64%	4,23%	16,40%	10,38%	6,47%	12,94%	12,27%	**13,50%**	**4,49%**	13,33%	15,33%	0,00%	6,78%	20,00%	7,14%	13,29%
A6	11,11%	6,88%	7,94%	17,49%	8,82%	11,76%		**3,68%**	**7,69%**	8,67%		9,68%	5,08%		6,12%	8,94%
A7	10,58%	20,63%	13,76%	4,92%	16,47%	3,53%	28,22%	**12,27%**	**25,00%**	4,00%	9,49%	17,74%	11,02%	24,76%	23,47%	12,88%
A8	2,12%			2,19%								4,03%				0,24%
A9	23,81%	6,88%	3,17%	5,46%	5,88%	23,53%	3,68%	**6,75%**	**3,85%**	8,67%	20,44%	10,48%			10,20%	6,39%
A10	2,65%		2,65%				3,68%					4,84%	5,08%			0,81%
A11																0,09%
A12	6,88%	6,88%		3,83%	6,47%	3,53%	4,29%	**7,98%**	**14,10%**		9,49%	12,10%	5,08%	19,05%	13,27%	5,24%
A13		3,17%			3,53%	3,53%	13,50%	**16,56%**	**7,05%**	4,00%	5,11%	4,84%		11,43%		4,28%
A14		3,17%	6,88%	9,29%	3,53%		3,68%	**7,98%**	**8,33%**	8,67%			11,02%		6,12%	4,03%
A15	3,17%	3,17%	3,17%	3,28%						12,00%	5,11%		10,17%			1,72%
A16	10,58%	4,23%	4,23%	3,83%	11,76%	7,06%		**4,29%**	**3,85%**							3,03%
A17		3,17%	10,58%	3,28%	2,94%	3,53%	6,13%	**3,07%**		15,33%	0,00%	10,48%	5,08%	0,00%	0,00%	2,87%
p (Equiprob)	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	
p T(n)-T(n-1)	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	***0,091***	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	*0,000*	

Table 6.

Significant differences in 'Sensory Stimulation' from Tukey's HSD comparison test

Sensory Modality		Means difference
(I)	(J)	(I) – (J)
Vision	Touch	7,414***
	Olfaction	19.414***
	Audition	20.561***
Touch	Olfaction	12.000***
	Audition	13.114***

*** $p < 0.001$

Table 7.

F values, significance and η^2 values for sequence sections ANOVAS's

	S1–S10	S11–S20	S21–S31
F	575.06	463.79	190.8
Significance	0.000	0.000	0.000
η^2	0.784	0.745	0.526

Table 8.

Significant differences in 'Sensory Stimulation' from Tukey's HSD comparison test for sequence sections

S1–S10			S11–S20			S21–S31		
Sensory Modality		Means difference	Sensory Modality		Means difference	Sensory Modality		Means difference
(I)	(J)	(I) − (J)	(I)	(J)	(I) − (J)	(I)	(J)	(I) − (J)
Vision	Touch	4.467***	Vision	Audition	5.333***	Vision	Touch	1.538***
	Olfaction	6.667***		Olfaction	5.633***		Audition	6.500***
	Audition	8.0767***					Olfaction	7.154***
Touch	Olfaction	2.200***	Touch	Audition	4.933***	Touch	Audition	4.962***
	Audition	3.600***		Olfaction	5.233***		Olfaction	5.615***
Olfaction	Audition	1.400***						

*** $p < 0.001$.

Table 9.

F values, significance and η^2 values for the sequence sections' ANOVAs

	Vision	Touch	Audition	Olfaction
F	17.57	42.47	34.45	2.82
Significance.	0.000	0.000	0.000	0.104
η^2	0.093	0.199	0.168	0.013

Table 10.

Significant differences in sensory modalities from Tukey's HSD comparison test for the sequence sections

Vision			Touch			Audition		
Sequence section		Means difference	Sequence section		Means difference	Sequence section		Means difference
(I)	(J)	(I) − (J)	(I)	(J)	(I) − (J)	(I)	(J)	(I) − (J)
S1–S10	S11–S20	1.433***	S1–S10	S11–S20	−2.633***	S1–S10	S11–S20	−1.300***
S11–S20	S21–S31	−1.518***		S21–S31	−3.013***		S21–S31	−1.651***

*** $p < 0.001$.

Table 11.

Number of cases in each cluster and consumer demographics

		Cases	% Men	Average age
Cluster	1	125	37	35.6
	2	71	45	37.2
Valid		196		

Table 12.

Final centre values of exploring actions per cluster

	Cluster	
	1	2
Static contact	2	6
Lateral exploration	1	2
Near dynamic visual exploration	2	3
Far–middle dynamic visual exploration	6	2
Friction assessment	1	2
Knocking surface with nails	0	1
Knocking surface with knuckles	1	1
Joints inspection	1	3
Stepping on	1	2
Scratching with nails	0	2
Near–frontal visual exploration	3	5
Far–middle frontal visual exploration	6	4
Near–lateral visual exploration	1	1
Far–middle lateral visual exploration	1	1