Research Article • DOI: 10.2478/ftee-2023-0041 FTEE • 31(5) • 2023 • 10–23

Fabric Attractiveness Using Four Sensory Evaluators

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Abstract
All senses elicit emotional responses to goods, services, and the environment. They also play an important role in the process of fashion design and its evaluation. This research is a continuation of several preliminary studies we conducted online to define three attractive and three unattractive colors, textures, smells, sounds, and tastes. In the present study, a sample of textile engineering and fashion design students and experts (N=54) assessed four groups of 6 fabric samples (sensory evaluators) selected based on the results of the preliminary studies. Each group of fabrics was assessed in one of four sensory modalities (except taste). Two semantic differentials were used to assess each sensory modality: attractive/unattractive and boring/interesting in the case of color, insensitive/sensitive in the case of texture, disturbing/calming in the case of sound, and cheap/luxurious in the case of smell. We found that among the fabrics in six different colors, the pink fabric was the most attractive. Of the six textures presented, the knitted rib texture was found to be the most attractive to touch. The scent of lemon essential oil was perceived as the most attractive among the six scents used, and the friction sound of suede leather was perceived as the most attractive among the six friction sounds of fabrics. Cluster analysis showed that the attractiveness of scents and colors of six fabric samples was highly differentiated and (almost) each sample was perceived as unique, while the attractiveness of the texture and sound of different samples was less differentiated and the samples were divided into only two groups. This suggests that discrimination of fabric attractiveness may be better in some sensory evaluators/modalities than in others. The results of this study will be useful for further research on the integration of different sensory modalities in fabric perception and garment preferences.

Keywords
Emotions, fabric, fashion, senses, attractiveness.

1. Introduction

All senses elicit emotional responses to goods, services, and the environment [1]. In terms of ranking the senses, previous research indicated the sense of sight as being the most powerful in detecting changes and differences in the environment [2] and the sense of smell as the one triggering the most vivid memories [3]. The five senses, commonly referred to as sight, touch, hearing, smell, and taste, play a role in many aspects of our daily lives. But do they? And how do they come into play in fashion? Fashion is an interdisciplinary field, drawing ideas from a plethora of sources. Most studies related to the senses have dealt with only one sense at a time, most often with the sense of sight. For example, Jastrow [4] conducted one of the first documented studies of color preferences at the World's Columbian Exposition in Chicago in 1893. Later many more studies on color preference phenomena with the aim of determining the preferences of the population were conducted [5-10].

After seeing a garment, sense of touch becomes equally important, and numerous studies on predicting the subjective feel of fabrics and the perception of fabric softness have been conducted, and they have shown that fabric feel and softness can be related to the compression and/or smoothness and flexibility of fabrics, depending on the fabrics being handled and their end-uses [11-14].

Some studies show that approximately 75 % of our emotions are influenced by smell [15], which makes this sense extremely important and interesting for research. Most of the scent-related research has focused on the effects of pleasant scent [16]. It has been shown that textiles are the holders and diffusers of the perfumes or colognes we apply on our bodies [17], and that the fragrance finishing of products can affect mood [18]. Angelucci et al. [19] reviewed the physiological effect of olfactory stimuli in humans, and discussed the inhalation effect of odorants based on an overview of major studies in humans.

Fabric sound is generated as the fibers or fabrics are rubbed against one another during the movement of the consumer, such as walking, jogging, and running [20], so most of the previous research on the sense of sound has focused on fabric friction [21-24].

Taste or gustation is an indispensable physiological sensation, essential for taste evaluation; for review see [25-27]. However, when it comes to fashion, sense of taste does not play a particularly important role and, therefore, is only mentioned in terms of "edible garments", on which no scientific literature exists, considering it mostly a witticism - like candy underwear.

Eicher [28] challenged scholars to explore how clothing relates to all five senses, not just sight, and to include the human emotions associated with wearing clothing [29]. In 1992, Eicher and Roach-Higgins [30] broke new ground by defining clothing ("dress") as a set of modifications and/or supplements to the body. In her latest work, Eicher [31] asserts that sight dominates many aspects of dress, such as design, volume, proportion, shape, texture, and color; sounds can be heard through the rustle of a dress or the click of high heels on a surface; scents are often associated with different textiles, such as wet wool or flowers in corsages; textures of fabrics and other materials can be touched and can vary from smooth leather or satin to rough and highly textured tweed; and taste, although the least involved, is found in some lip products.

A University of Minnesota symposium on the senses resulted in Dress Sense: Emotional and Sensory Experiences of the Body and Clothes [32]. Dress Sense explores the importance of the senses and emotions to the way people dress and how they attach value and meaning to clothing. Among the chapters, Welters [33] reported on sound as a factor; Breu [34] wrote about the role of scents and the body in Turkey; Becker [35] studied the awakening of the senses using a Moroccan Berber costume as an example; and Gott [36] analyzed the power of touching the waist beads of women in Ghana.

The aim of this study was to determine the attractiveness of different sensory attributes and to select the most and least attractive fabric colors, textures, scents, and sounds for the further steps of our research. The ultimate goal of our research was to combine four senses/modalities into a collective perception, and to determine which of the four modalities contributes most to the overall attractiveness of the garment. Due to the complexity of the research problem, it had to be divided into several phases. The results from the previous (preliminary) phase in which participants mostly assessed their mental representations of the sensations were published in [37,38]. The present paper presents the results of the second phase, in which the participants interacted with the fabrics. However, the present study does not yet address the complex interaction between the senses, but rather examines each sense individually - this will be done in further research (third phase).

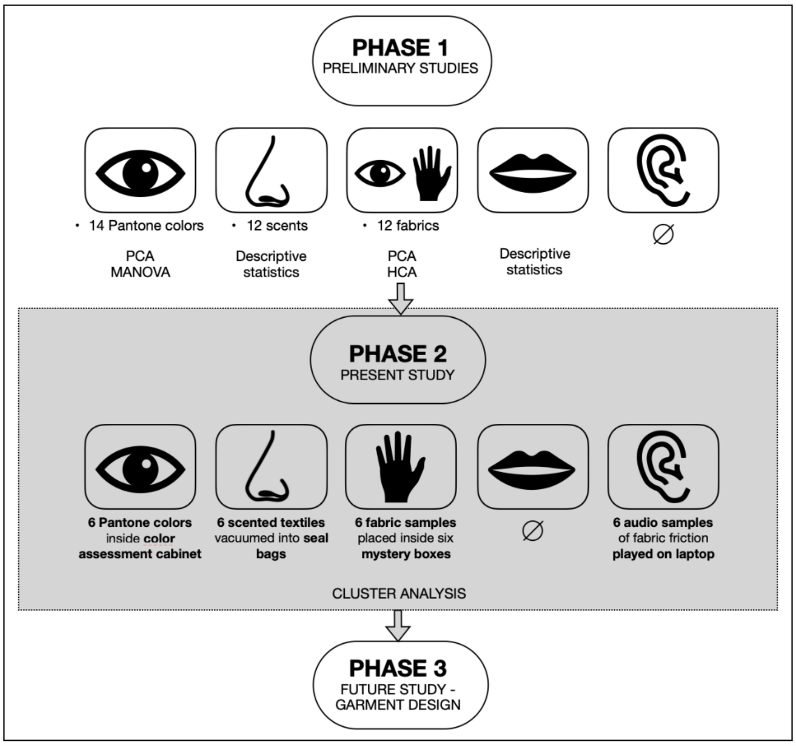

Fig. 1. Research framework

2. Method

The present study is the continuation of several preliminary studies conducted online. The first study was on color preference [37], the second on the visual texture of fabrics [38], the third on the odor preference of fabrics, and the fourth was a study on taste preferences. The goal of the preliminary studies was to narrow down the number of samples we ultimately used. Figure 1 shows the research framework. The activities in the research framework were divided into three phases - Phase I: preliminary studies with a defined number of samples and applied methodology (data analysis); Phase II: present study with reduced samples resulting from the previous preliminary studies; and Phase III: future study - garment design.

2.1. Samples

The six color samples used in Phase II, described in this paper, were selected according to the results of a preliminary study [37] conducted with the aim of determining the most attractive and least attractive colors among 14 Pantone colors. These colors were selected because they were the most frequently mentioned in previous color studies. The colors selected for research were coded according to the Pantone Matching System (in alphabetic order): Black, Blazing Yellow, Bright Green, Bright White, Caramel Cafe, Desert Sage, Freesia, Island Paradise, Lapis Blue, Orange Tiger, Pink Yarrow, Sand, Sulphur Spring, Ultra Violet. In an online study, among the colors used and presented on-screen, the three most attractive colors were Black, Pink Yarrow, and Blazing Yellow, while the three most unattractive colors were Caramel Cafe (brown), Desert Sage (gray), and Sulfur Spring (green yellow). The colors were coded according to the Pantone Matching System. A snapshot of the samples can be seen in Figure 2.

Six texture samples were selected according to the results of a preliminary study [38] of fabric visual texture preferences. The procedure for this study was adopted from Nagamachi [39] and Karlsson [40]. The visual texture database of stimuli used in the preliminary study consisted of photos of 12 types of commercially available

COLOR SAMPLES	Black HEX #101820 RGB (16,24,32) HSL (210°,33.3%,9.4%)	Blazing Yellow 12-0643 HEX #fee715 RGB (254,231,21) HSL (54°,99.1%,53.9%)	Caramel Cafe18-1148 HEX #8b5737 RGB (139,87,55) HSL (23°,43.3%,38%)
	Desert Sage 16-0110 HEX #a7ae9e RGB (167,174,158) HSL (86°,9%,65.1%)	Pink Yarrow 17-2034 HEX #d13076 RGB (209,48,118) HSL (334°,63.6%,50.4%)	Sulphur Spring 13-0650 HEX #fd5d717 RGB (213,215,23) HSL (61°,80.7%,46.7%)

Fig. 2. Color samples with accompanying information

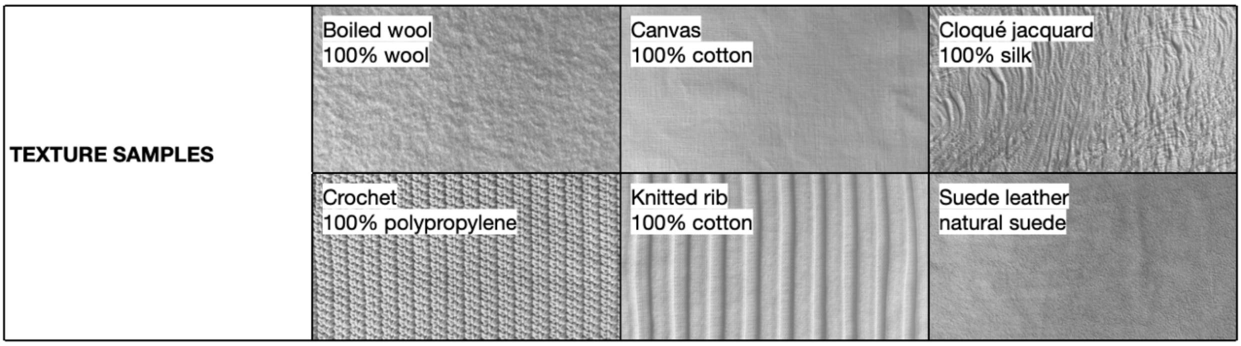

Fig. 3. Texture samples with accompanying information

fabrics with different structures. They were produced using different manufacturing technologies. The fabrics selected for research were (in alphabetic order) boiled wool, canvas, cloqué jacquard, crochet, faux fur, jersey, knitted rib, leather, nylon, satin, suede, and terry. The three most attractive visual textures of fabrics were crochet, knitted rib, and cloqué jacquard, while the least attractive were boiled wool, suede, and canvas. For Phase II of our research, these six fabrics were then produced using various manufacturing technologies; for the influential factors that define the textures see [38], while the fabric composition can be found in Figure 3.

The aforementioned six fabrics were also used to test sound preference in research Phase II. A professional sound recorder - Zoom H1 was used to record the sound produced by the friction of the material. Audio recordings of fabric friction are available in the link. Audio recording 1 is the friction of cloqué jacquard, 2 - canvas, 3 – suede leather, 4 - crochet, 5 – knitted rib, and 6 – boiled wool.

Our preliminary unpublished study on the taste of 30 participants, of whom most were female (73 %), had a bachelor (43 %) or master degree (53 %), were 25-34 years old (80 %), and were employed full time (53 %), showed that 97 % of respondents would not like to feel the smell of their favorite food on clothes, 87 % find licking a fabric repellent (causing disgust or distaste), 93 % think licking a fabric is unhygienic, and 60 % would never wear an edible garment (a piece of clothing which you can eat). Their food taste preferences were as follows: salty (47 %), sweet (43 %), sour (10 %), and bitter (0 %). When asked how likely they would wear a garment composed of different tastes or impregnations, all tastes proposed scored the highest value for "not likely at all": 83.3 % would never wear a garment composed of raw meat, 56 % would never lick a fabric with an impregnated salty taste on its surface, 53 % would never lick a fabric with an impregnated sour or bitter taste on its surface, 43 % would never lick a fabric with an impregnated sweet taste on its surface, 36 % would never wear a garment composed of vegetables, and 26 % would never wear a garment composed of edible materials containing high-grade protein. After these results we decided to disregard the sense of taste from further research investigation since our preliminary study showed we cannot expect respondents to lick fabrics due to the various reasons listed above. It should be noted that perhaps a different sample of participants would be more appropriate for further research on that sense, i.e., pre-school children, who often put textiles in their mouth. Further research could focus on designing clothing that is edible and has nutritional value appropriate for children. Pre-school children could not be included in the present study because they would not be able to assess the fabric attractiveness across different sensory modalities.

Finally, in another preliminary unpublished study, 12 scents were selected to investigate scent preferences. In accordance with Michael Edwards' Fragrance Wheel, the scents selected for research were (in alphabetic order):

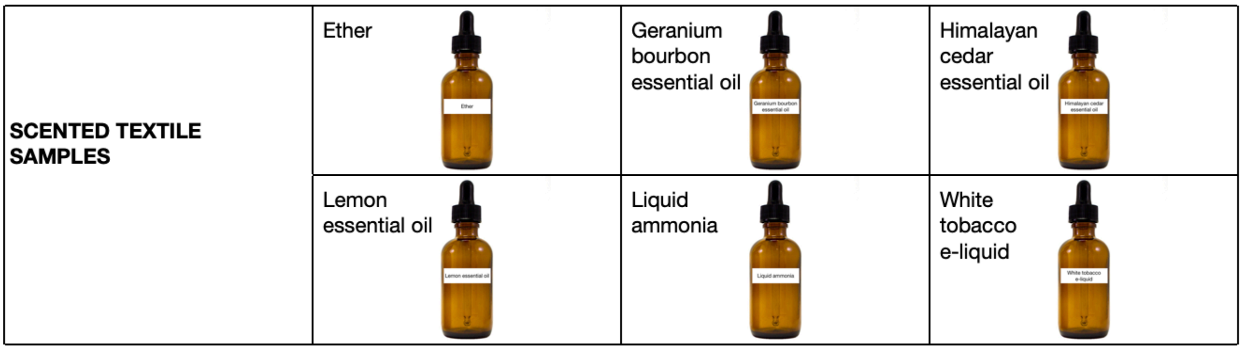

Fig. 4. Essential oils and liquids dripped onto textiles

aromatic woods, berries and fruit, cigarette smoke, citrus, fresh-cut flowers, fresh fish, gasoline, human sweat, lavender, urine, vanilla, and vomit. In an online study, 84 respondents evaluated their impressions of scents (since they did not have access to real samples). The respondents assessed that the three most attractive fragrances on clothes are floral + fresh (main notes include fresh-cut flowers), Woods (aromatic woods and vetiver), and citrus (bergamot and other citrus oils); and three most unattractive fragrances on clothes - urine, cigarette smoke, and vomit. In the present study (Phase II of our research), we used essential oils and liquids (Fig. 4) and dripped them onto textiles to test odor preferences. The chosen representative of the floral + fresh group was geranium bourbon essential oil, for woods - Himalayan cedar essential oil, and for citrus it was lemon essential oil. The chosen representative of the urine scent was liquid ammonia (NH_3) because it has a strong odor that smells like urine. Instead of cigarette smoke we used e-liquid with white tobacco flavor (vape juice), which is used inside an e-cigarette; and finally, we used ether ($(C_2H_5)_2O$) as a substitute for vomit.

2.2. Experiment design and procedure

For measuring color preferences, six selected colors were printed on canvas (plain-woven fabric) whose composition was 100 % cotton, and its weight was 165 g/m^2. The fabric was made from organic material that has the GOTS certificate, and water-based biodegradable dyes were used. All samples were cut into A5 format (148×210mm), and they were not hemmed, but instead had raw edges. A 100 % cotton/plain weave was chosen for color sensing because this textile material emerged from a preliminary study of visual texture preferences. Even though the color effect is influenced by the weave and varies from fiber to fiber, we believe that using all 6 fabric samples from the preliminary study and presenting each of them in six different colors would result in an excessive total number of samples to be evaluated. The 100 % cotton/plain weave was thus selected as the most common, simple, and basic of the three fundamental types of textile weaves. Colored fabric samples with numbers were placed inside a color assessment cabinet – standard D65 illuminants (see Figure 5 (right)).

For measuring scent preferences, six selected scents were applied on canvas (same textile sample as above) with a medicine dropper. The dropper for the bottles measured a 1 mL dose, and a single drop contained 0.05 mL. We applied 10 drops of each oil/liquid to a single position on the canvas, which then equated to roughly 0.5 mL per textile sample. Immediately after applying the liquids, the samples were vacuumed into seal bags and marked with numbers.

For measuring tactile preferences, six commercially available fabric samples (cloqué jacquard, knitted rib, suede leather, canvas, crochet, boiled wool) were cut into an A5 format (148×210 mm); they were not hemmed, but instead had raw edges. All samples were beige, but respondents were not able to see them. They could only touch them since they were placed inside six mystery boxes. The dimensions of each box were 180×250×150 mm, and those of the square cut hole were 90×90 mm (see Figure 5 (left)).

The same six fabrics were also used to test sound preference. Again, cloqué jacquard, knitted rib, suede leather, canvas, crochet, and boiled wool were cut into an A5 size (148×210mm); they were not hemmed, but had raw edges. Since the fabric friction tester (Martindale abrasion and pilling tester) was too loud, we had to make friction manually with uniform circular motions. Manual uniform circular motion is not a standard approach to generate friction noise. However, since we wanted to simulate the interaction of skin and fabric - a sound that is not loud and are accustomed to when dressing, we thought this approach was the most appropriate. We used a professional sound recorder - Zoom H1 to record the friction of the material. All recordings were saved as Waveform Audio File Format (WAV), and each one lasted eight seconds. Audio samples with numbers were exported to a laptop with stereo speakers.

To participate in the study, respondents had to have a mobile phone that was sufficiently charged. They used their mobile phone first to scan a randomly chosen QR code which led them to an online questionnaire. Each participant received a different QR code, leading to a specific randomly generated order of four sensory modalities which they had to rate (e.g., one of the orders was color-texture-scent-audio, another was scent-texture-audio-color, etc.). Within each modality,

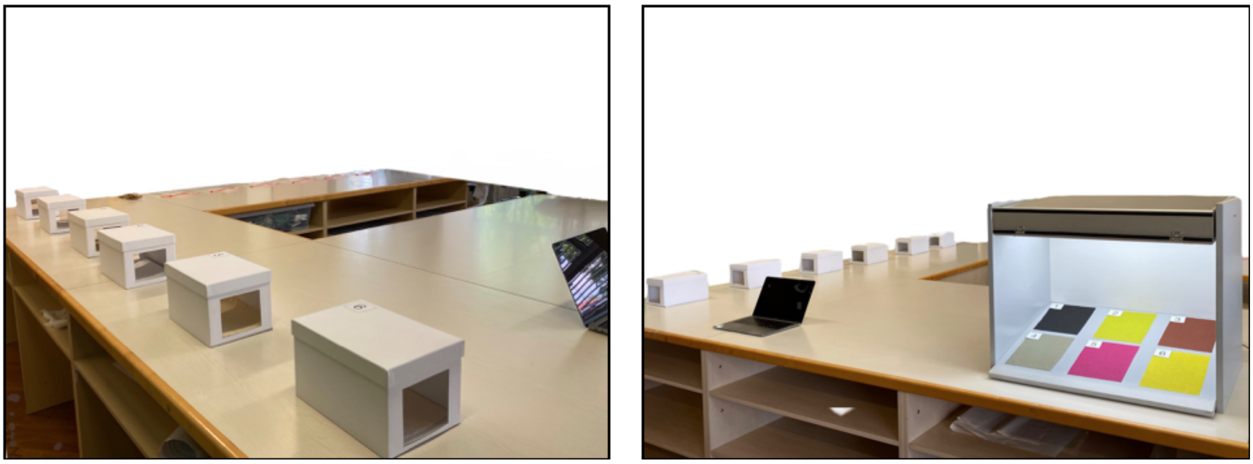

Fig. 5. Experimental setup

six samples were always presented in the same order (for example, the color black was under number 1 in the light box all the time). The exact layout of all the samples in the study was as follows:

- COLOR SAMPLES: 1 - black, 2 - sulfur spring (yellow green), 3 - caramel cafe (brown), 4 - desert sage (gray), 5 - pink yarrow, 6 - blazing yellow.
- TEXTURE SAMPLES: 1 - silk cloqué jacquard, 2 - knitted rib, 3 - suede leather, 4 - canvas, 5 - crochet, 6 - boiled wool.
- SCENT SAMPLES: 1 - lemon essential oil, 2 - white tobacco e-liquid, 3 - Himalayan cedar essential oil, 4 - liquid ammonia, 5 - ether, 6 - geranium bourbon essential oil.
- AUDIO SAMPLES: 1 - silk cloqué jacquard, 2 - canvas, 3 – suede leather, 4 - crochet, 5 – knitted rib, 6 - boiled wool.

The questionnaire had four segments of items, each related to a single sensory modality. Each sensory modality was rated by two 7-point semantic differentials, one being attractive-unattractive and the other boring-interesting in the case of color, insensitive-sensitive in the case of texture, disturbing-calming in the case of sound, and cheap-luxurious in the case of scent. The participants selected number 1 to indicate that the specific sample was most accurately described by the first adjective in a pair, and 7 to indicate that the sample was most accurately described by the second adjective in a pair. Number 4 was considered as a neutral response, hence the participant's evaluation of the sample was somewhere in between the two adjectives. The adjectives were adapted from Küller [41] and based on some other research using a semantic differential for measuring sensations in different areas (Table 1). No specific explanations were used to define the adjectives; they represent subjective qualities that evoke specific impressions, feelings, and emotions of the participants. After participants rated all the samples for two attributes, they also needed to select a sample exhibiting the largest amount of the attribute in each pole of the semantic differentials (e.g., in the case of color, they had to select among the six samples the most attractive and most unattractive one, and in the next step, they had to select among the six samples the most interesting and most boring one).

Semantic differential	Study
Boring-Interesting	Habyba et al. [42], Lokman et al. [43], Fischl G. [44]
Cheap-Luxurious	Habyba et al. [42], Lokman et al. [43]
Disturbing-Calm	Habyba et al. [42], Lokman et al. [43], Fischl G. [44], Janssens J. [45], Evensen et al. [46],
Insensitive-Sensitive	Lokman et al. [43]
Unattractive-Attractive	Lokman et al. [43], Santos M. [47]

Table 1. Distribution of adjectives in previous scientific articles and study areas

2.3. Participants

Fifty-four Slovenians participated in the study, most of whom were students (57 %), and the rest were staff of the Faculty of Natural Sciences and Engineering at the University of Ljubljana. Among the students, 55 % were studying textile engineering and 45 % fashion design. Participants were predominantly female (83 %). The majority (59 %) were 18-24 years old, 18 % were 25-34 years old, 11 % were 35-44, and 12 % were older than 45 years. The highest educational degree for most of the respondents was a high school diploma (55 %), 18 % had gained a bachelor's degree, 18 % had completed a master's degree, and 7 % had obtained a PhD. All respondents participated in the study voluntarily.

2.4. Data analysis

For each sensory modality, we first computed descriptive statistics of the ratings for the two semantic differentials for six samples and counted how often a given sample was selected as the most attractive/unattractive as well as the most interesting/boring (in the case of colors), insensitive/sensitive (texture), cheap/luxurious (scent), or calming/disturbing (sound). Pearson correlation coefficients between the ratings of two attributes of the six samples were calculated across participants (yielding 12×12 correlation matrices).

Next, we examined the (dis)similarity of the sensory experiences of the six samples using cluster analysis to identify homogeneous groups of ratings. We calculated the Euclidean distances between the 12 ratings (i.e., 2 ratings for each of 6 samples). Prior to this, the ratings were standardized among participants to ensure equal variability and weighting of data across all participants. The Silhouette method [48] implemented in the *NbClust* R package [49] and the Partitioning Around Medoids (PAM) method implemented in the *cluster* R package [50] were used to determine the optimal number of clusters. K-means cluster analysis with the determined optimal number of clusters was then performed to visualize the proximity and grouping of the rated samples.

3. Results and Discussion

3.1. Fabric color perception and preference

The descriptive statistics displayed in Table 2 gives an insight into how attractive and interesting each color was. The most attractive color in our study was Pink Yarrow, which was also perceived as the most interesting. Brown (Caramel Cafe) received the lowest ratings for attractiveness and for how interesting the color seemed, and was thus perceived as the most unattractive color. The rightmost column in Table 2 shows that most participants chose Black as the most boring color among the six samples (although Caramel café received average ratings closest to the "boring" pole of the semantic differential).

These results are not in complete accordance with our preliminary study [37], where Pink Yarrow was selected as the second most attractive color. Even though pink is often associated with the female gender, and in general females prefer pink more than males [51], today, everything from fashion to interior, and graphic design is shifting to a pink outlook [51]. One of the most recent examples is the all-pink Valentino collection debuted for Spring/Summer 2022 during Paris Fashion Week, or Jacquemus' Pink Catwalk in a lavender field for the Spring/Summer 2020 collection. From 2012, salmon pink started showing up everywhere, and in 2016 everyone started calling it "millennial pink". Millennials are the demographic cohort born between 1981 and 1996 [52]. They are currently between 26 and 41 years old, and 29 % of participants in our study were within this age group. Gen-Z are the demographic cohort born between 1995 and 2012, and 59 % of all respondents were within this age group. The older end of Gen-Z tends to follow millennial trends closely. Similar to millennial color preferences, Gen-Zers rely heavily on the 80s and 90s trends - they like bright and bold colors, but also pastels, in particular pinks [53].

Brown is the most unattractive color in our study, which is in accordance with Palmer and Schloss [54] ecological valence theory, but also in accordance with our preliminary study. The unattractiveness of brown color is most likely connected with all the unpleasant things it evokes (such as faeces and mud). According to public opinion surveys in Europe and the United States, brown is the least favorite color of the public, because it is often associated with plainness, rusticity, and poverty.

The finding that black was ranked as the most boring color differs from our preliminary study on color preference, where black was selected as the most attractive color, however, they are in accordance with most of the previous color preference research. The color black often has negative associations. The effects of its stereotypes are well documented in the literature [55-57]; for a review, see [58].

Next, we wanted to examine whether the ratings of different colors and attributes were correlated and whether we could determine groups of similar ratings. Correlations between 12 ratings are shown in Table A1 in the Appendix. The average correlation between the ratings of two attributes of the same sample across all participants was 0.56 (ranging from 0.45 to 0.64), indicating that, on average, those who rated a particular color as more attractive also rated the same color as more interesting. The average of the remaining correlations in the correlation matrix (i.e., between ratings of the same attribute in different samples or between ratings of different attributes in different samples) was 0.02 (with a range of -0.34 to 0.61).

The Silhouette method and Partitioning Around Medoids method (PAM) proposed five clusters of ratings, which are shown in Figure 6. Such a solution reduced the within-cluster sum of squares (WSS) by 66% (from 594.0 for a 1-cluster solution to 201.8 for a 5-cluster solution). The ratings of four samples (1, 3, 4, and 5) formed distinct clusters, while the ratings of samples 2 (Sulfur Spring) and 6 (Blazing Yellow) were relatively similar. In contrast, in the preliminary study, Sulfur Spring belonged to the most attractive color samples and Blazing Yellow to the least attractive. The different results obtained in the preliminary and present study may result from different perception of colored (dyed) fabrics and online color patches.

3.2. Fabric texture perception and preference

The most attractive texture in our study was knitted rib (see Table 3), which was also perceived as most sensitive texture. The most unattractive texture in our study was boiled wool. Boiled wool was also selected by a lot of participants as the most unattractive fabric (even though even more participants selected crochet as the most unattractive).

These results were similar to the ones of our preliminary study, where knitted rib was the second most attractive visual texture, which was semantically described as calm, appealing, and harmonious, with an emphasis on the homogenized structure, and boiled wool scored high results on the negative spectrum of

	Unattractive-Attractive		Boring-Interesting		Frequencies of choices			
Sample	***M***	***SD***	***M***	***SD***	**Most attractive**	**Most unattractive**	**Most interesting**	**Most boring**
1 - Black	4.6	1.8	3.6	2.1	5	8	0	21
2 - Sulphur Spring	4.3	1.7	5.3	1.5	4	10	11	4
3 - Caramel Cafe	3.8	1.6	3.4	1.5	3	20	2	16
4 - Desert Sage	5.3	1.6	4.7	1.5	17	5	9	8
5 - Pink Yarrow	5.8	1.4	6.1	1.0	19	4	20	2
6 - Blazing Yellow	4.5	1.8	5.2	1.4	6	7	12	3

Table 2. Mean values (M) and standard deviation (SD) of ratings for color samples, and the number of participants selecting a specific sample as having the highest attribute value

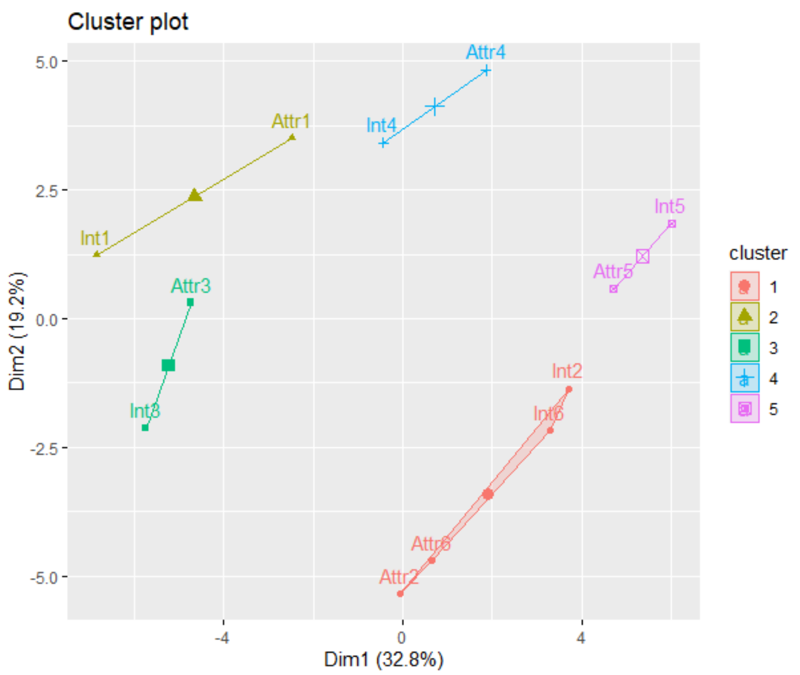

Fig. 6. Five clusters of ratings of sample color
Note. Attr = ratings for the attractive-unattractive semantic differential. Int = ratings for the interesting-boring semantic differential. 1 = Black. 2 = Sulphur Spring. 3 = Caramel Café. 4 = Desert Sage. 5 = Pink Yarrow. 6 = Blazing Yellow

study. Thus, the cluster solution showed relatively good agreement between the results of the two studies. Texture ratings were less differentiated and formed two clusters only, as compared to color ratings where five different clusters were observed. These results are consistent with sensory dominance, since perception in more dominant sensory modality may be more differentiated. The differentiation of the color attractiveness ratings was higher than that of the texture attractiveness ratings. Our results suggest that we evaluate textures as attractive or unattractive and do not distinguish much among different items within these two categories. The possible reason for grouping textures into two clusters in our study might be related to the fact that many tangible surface features are too small and too close to each other [59,60]. Kalantari et al. [61] conducted an experiment and found that out of 24 textures proposed to participants, only 3 were correctly recognized by all of them.

adjectives (unattractive, inharmonious, unsophisticated) [38].

The average correlation between the ratings of two attributes of the same sample across all participants was 0.41, slightly lower than for color, and ranging from 0.01 for ratings of the attractiveness and sensitivity of sample 5 (crochet) to 0.62 for sample 1 (Cloqué jacquard) (see Table A2 in Appendix). Thus, for crochet, the ratings of the two attributes were unrelated, whereas for the other samples, the higher the ratings of sensitivity, the higher the ratings of attractiveness. The other correlations in the correlation matrix ranged from -0.27 to +0.50, with an average correlation of 0.07.

In the present study, the Silhouette and PAM methods yielded two clusters of semantic differential ratings (with a 33 % reduction in WSS, from 594.0 to 398.2), shown in Figure 7. One cluster consisted of samples 1, 2, and 3, the most attractive samples in the preliminary study, and the other consisted of samples 4, 5, and 6, the least attractive samples in the preliminary

The biggest contradiction in researching the fabric textures and the sense of touch is related to crochet, which was rated as the most insensitive texture in the present study (see Table 3). In contrast, in the preliminary study, crochet was found to be the most attractive visual texture, and was semantically described as interesting, good and happy. The contrasting results of the two studies could also be related to the finding of the present study that the ratings of the two attributes were unrelated only in the case of crochet among all texture samples, as stated

	Unattractive-Attractive		Insensitive-Sensitive		Frequencies of choices			
Sample	***M***	***SD***	***M***	***SD***	**Most attractive**	**Most unattractive**	**Most insensitive**	**Most sensitive**
1 - Cloqué jacquard	5.2	1.4	5.0	1.4	5	4	0	8
2 - Knitted rib	6.1	0.9	5.8	1.1	24	0	0	21
3 - Suede leather	5.3	2.0	4.9	1.7	18	5	7	15
4 - Canvas	4.0	1.9	3.9	1.7	3	9	6	6
5 - Crochet	3.7	2.0	3.0	1.9	3	22	32	2
6 - Boiled wool	3.5	1.6	3.9	1.6	1	14	9	2

Table 3. Mean values (M) and standard deviation (SD) of ratings for texture samples

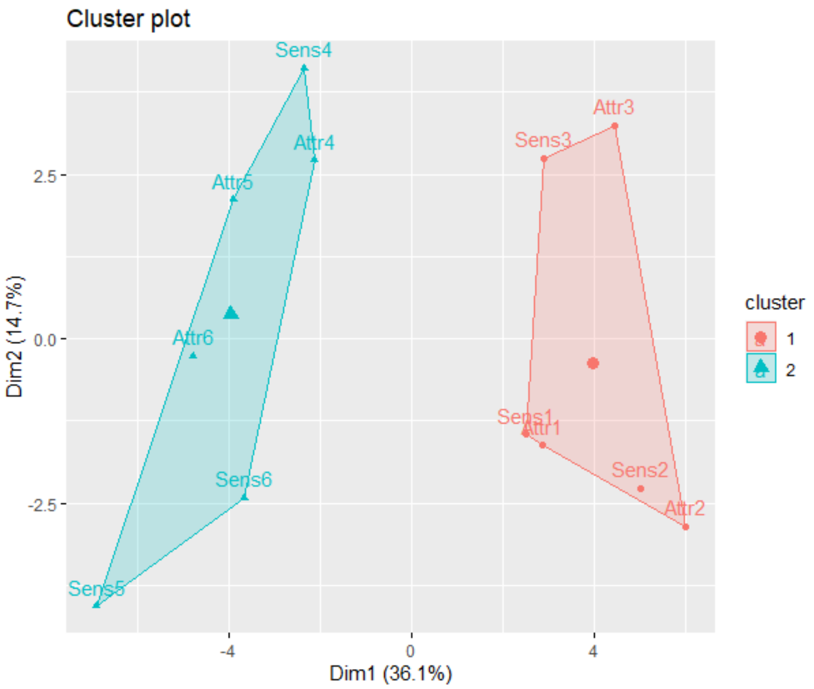

Fig. 7. Two clusters of texture attribute ratings
Note. Attr = ratings for the attractive-unattractive semantic differential. Sens = ratings for the insensitive-sensitive semantic differential. 1 = cloqué jacquard, 2 = knitted rib, 3 = suede leather, 4 = canvas, 5 = crochet, 6 = boiled wool

above (see also Table A2 in Appendix). It is important to note that the material composition of the crochet sample was 100% polypropylene, and it was the only synthetic textile fiber in our study. Also, for our study, the crocheted fabric was made of a thicker braided cord, which means that the crocheted structure examined was coarse, consisting of larger loops and having a pronounced surface. This may explain the interesting visual texture, on the one hand, and the coarse tactile texture, on the other.

Our preliminary study on texture preferences [38] was based on visual perception solely, so we did expect to obtain different results in this study since it was based on the haptic perception of textile surface modalities. When we look at woven fabrics, knitted fabrics, and lace, we perceive fine surface structures, textures, and patterns that are different in each of them. At the same time, they evoke feelings through diverse types of visual information [62]. However, some aspects of visual texture perception are a hindrance [63]. Lester at al. [64] argue that one of the major shortcomings is that we cannot touch the products. Physical texture differs from visual texture in that it has a physical quality that can be felt by touch [65].

3.3. Fabric scent perception and preference

To date, most of the scent-related research in marketing has focused on the effects of pleasant scent on memory [66]. Although some studies have been conducted in realistic (e.g., a casino [67], a mall [68]) or semi-realistic settings [69], most research has been conducted in artificial laboratory conditions [70,71]. Our study was conducted in a semi-realistic setting since the textile samples had to be vacuumed to keep the intensity of the scent. We checked both attractive (pleasant) and unattractive (unpleasant) scents and found that on average most of them have been rated on the negative spectrum (see Table 4, means were lower than 4).

The most attractive (and perceived as most luxurious) scented textile sample in our study was lemon essential oil. It is the only sample rated on the positive spectrum in terms of attractiveness, but also luxury. We should be aware that essential oils were used in our study instead of odor notes. Notes is a term used in perfumery to describe the category a scent falls into based on its odor and staying power, while essential oil was perfume before the invention of artificial fragrance; thus, they are assigned notes that describe where they fall on the perfumer's scale. For instance, citrus notes are fresh, rendering perfumes extremely airy and light. They are subtle, rather than potent and pure, lively, fresh and light. Citrus oils can help reduce feelings of anxiety and irritability. Except for lemon many other oils belong to the citrus family, for instance bergamot,

Sample	Unattractive-Attractive		Cheap-Luxurious		Frequencies of choices			
	M	*SD*	*M*	*SD*	Most attractive	Most unattractive	Most luxurious	Cheapest
1 - Lemon essential oil	5.6	1.3	5.0	1.4	28	2	20	3
2 - White tobacco e-liquid	3.5	1.9	3.2	1.7	7	8	5	12
3 - Himalayan cedar	2.5	1.6	2.8	1.8	4	9	6	10
4 - Liquid ammonia	1.9	1.2	2.3	1.4	1	32	2	17
5 - Ether	4.0	1.9	3.6	1.7	10	2	9	7
6 - Geranium bourbon es.oil	3.6	1.7	3.7	1.6	4	1	12	5

Table 4. Mean values (M) and standard deviation (SD) of ratings for scented textile samples

blood orange, citronella, lemongrass, lime, mandarin orange, neroli, pink grapefruit, sweet orange and tangerine essential oils [72].

The most unattractive scented textile sample was liquid ammonia. This sample was selected as a representative of and substitute for urine odor. The same sample was perceived as the cheapest. Ammonia is a corrosive, colorless gas with a sharp odor. It is often compressed into a liquid form to be transported or stored, since it is formed by the bacterial decomposition of urea. Moreover, it has a pungent smell [73].

The correlations of attractiveness and sense of luxury were high, ranging from 0.64 to 0.74 for different samples, with an average correlation of 0.70; the other values in the correlation matrix were low, ranging from -0.28 to 0.37, with an average correlation of 0.06 (see Table A3 in Appendix). The average ratings for both attributes, shown in Table 4, indicate that the two types of ratings were nearly parallel.

In cluster analysis, the Silhouette method proposed 7 and the PAM method 6 clusters of ratings. We decided to use a solution with 6 clusters (Figure 8), reducing the WSS by 76 % (from 594.0 to 98.4). In this solution, each sample formed a separate cluster, indicating that the perceptions of the selected samples were specific and different from each other. In humans, about 300 active olfactory receptor genes are involved in the recognition of thousands of different odor molecules via a large family of olfactory receptors [74]. Scents are recognized thanks to the memory effect of previous olfactory experiences, which explains the high subjectivity of odor perception [75,76], which also explains why in our study each textile scented sample formed a separate cluster.

3.4. Fabric sound perception and preference

The descriptive statistics for the ratings of the two attributes are shown in Table 5. The friction of fabric sample 4 (crochet) and fabric sample 6 (boiled wool) has been rated on the negative spectrum, while all other samples - 1, 2, 3, 5 (cloqué jacquard, canvas, knitted rib, suede leather) - received ratings on the positive spectrum.

For this sensory modality, the average ratings of the two attributes were also nearly parallel, indicating that the perception of the two attributes was homogeneous (the higher the rating of disturbance, the higher the rating of the unattractiveness of sound). The correlations of the attractiveness and calming feeling of fabrics were high, ranging from 0.34 to 0.84 for different samples, with an average correlation of 0.72. The other correlations in the correlation matrix ranged from -0.21 to 0.59, with an average correlation of 0.15 (see Table A4 in the Appendix). The Silhouette method also proposed two clusters of ratings and the PAM method - five. Figure 9 shows a 2-cluster solution in which the WSS was reduced by 49 % from 594.0 to 302.8. This figure shows that in a 5-cluster solution, some fabric samples would be very close to each other, and that the 2-cluster solution may be a good enough description of the differentiation within this sensory modality. The first cluster contained fabric samples 1, 2, 3, and 5 (the more attractive and calming sounds), and the second cluster contained samples 4 and 6 (the less attractive and more disturbing sounds). Fabric samples 4 and 6 were strongly audible, noticeably louder, and they had exceptional intensity compared to other samples (find links to audio recordings here). The most unattractive audio recording was for sample 4 - crochet, which was also perceived as most disturbing audio recording, followed by boiled wool. At the same time, these two samples were also found to be the least attractive, and from a technical point of view, they both have the most compact and course structure and surface. On the other hand, the most attractive audio recording was for sample 3 - suede leather, which was also the most calming recording.

4. Conclusion

4.1. Implications for future research

This study was conducted as an intermediate phase to reduce the number

	Unattractive-Attractive		Disturbing-Calming		Frequencies of choices			
Sample	***M***	***SD***	***M***	***SD***	**Most attractive**	**Most unattractive**	**Most calming**	**Most disturbing**
Audio recording 1 - cloqué jacquard	4.4	1.6	4.4	1.7	9	1	11	1
Audio recording 2 – canvas	4.0	1.5	4.1	1.5	9	1	8	1
Audio recording 3 – suede leather	5.3	1.5	5.6	1.5	20	3	18	2
Audio recording 4 – crochet	2.2	1.4	1.9	1.0	2	22	2	18
Audio recording 5 – knitted rib	4.3	1.7	4.3	1.7	14	2	15	3
Audio recording 6 – boiled wool	2.5	1.5	2.0	1.3	0	25	0	29

Table 5. Mean values (M) and standard deviation (SD) of ratings for audio samples

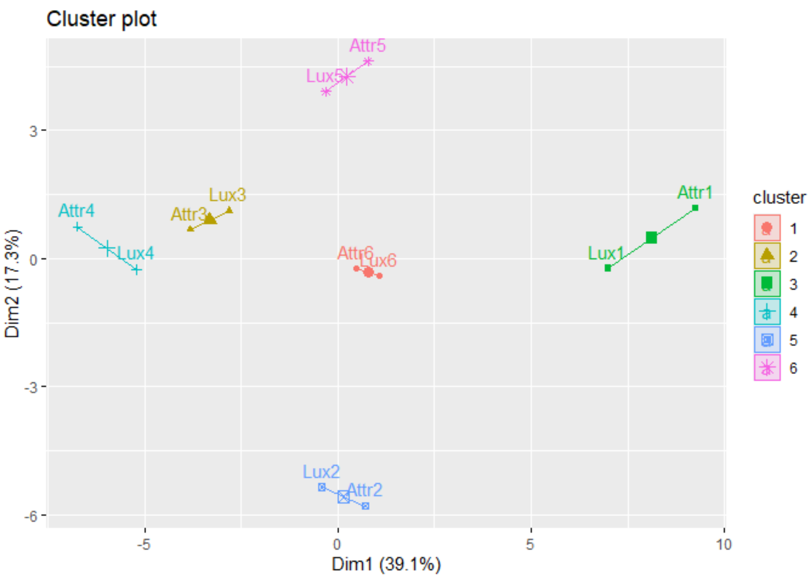

Fig. 8. Six clusters of scent attribute ratings
Note. Attr = ratings for the attractive-unattractive semantic differential. Lux = ratings for the luxurious-cheap semantic differential. 1 = lemon essential oil. 2 = white tobacco e-liquid. 3 = Himalayan cedar. 4 = liquid ammonia. 5 = ether. 6 = geranium bourbon essential oil

of samples that would later be used in a study on how the four senses/modalities combine into an integrated perception. In the next phase, clothing prototypes with different fabric colors, textures, scents and friction sounds will be produced to test and measure customer reactions. The ultimate goal of our research is to determine which of the four modalities contributes the most to the overall attractiveness of the garment. Since each sensory modality/evaluator was assessed on the basis of two semantic differentials, one being attractive/unattractive, and the other being boring/interesting in the case of color, insensitive/sensitive in the case of texture, disturbing/calming in the case of sound, and cheap/luxurious in the case of scent, the research results suggest the use of the following samples for further research on the integration of the four sensory modalities: Black, Pink Yarrow and Caramel Cafe (brown) to be used as colors; knitted rib and crochet as textures, liquid ammonia and lemon essential oil as odors, and finally crochet and suede leather to be used for fabric sound preference.

The results suggest the following conclusions that may be useful for future research:

- COLOR: The most attractive color in our study was Pink Yarrow. The same color was the most interesting because those who rated a particular color as more attractive also rated the same color as more interesting, on average. Brown (Caramel Cafe) was perceived as the least attractive color in our study, while participants chose Black as the most boring color. The difference between the results of our preliminary study and the present study suggests that color preferences for fabric samples may differ from color preferences for online patches.
- TEXTURE: The most attractive texture in our study was knitted rib, which was also perceived as the most sensitive. Ratings of attractiveness and sensitivity were nearly parallel - the higher the ratings of sensitivity, the higher the ratings of attractiveness. Crochet was perceived

Fig. 9. Two clusters of sound attribute ratings
Note. Attr = ratings for the attractive-unattractive semantic differential. Calm = ratings for the calming-disturbing semantic differential. 1 = cloqué jacquard, 2 = knitted rib, 3 = suede leather, 4 = canvas, 5 = crochet, 6 = boiled wool

both as unattractive and the least sensitive texture in our study.

– SCENT: The correlations of attractiveness and luxury perception were high, almost parallel. The most attractive and luxurious-smelling textile sample in our study was lemon essential oil, while the least attractive and cheapest-smelling textile sample was liquid ammonia. Each sample formed a separate cluster, indicating that the perceptions of the selected samples are specific and differ from each other.
– SOUND: The correlations of attractiveness and the calming feeling of fabric sounds were high, indicating that the perception of the two attributes was homogeneous (the higher the rating of disturbance, the higher the rating of the unattractiveness of the sound). The most attractive audio recording was the friction sound of suede leather, which was also the most calming, while the most unattractive and disturbing audio recording was the friction sound of crochet.

The combination of these samples results in a total of 18 different garments. Some of the 18 combinations are, for example, pink, ribbed-knit, lemon scented garment; pink, ribbed-knit, ammonia scented garment; black, suede leather, lemon scented garment; black, suede leather, ammonia scented garment, etc. The friction sound preferences seem to be merged with the texture preferences, however, instead of testing suede leather and crochet, the future study (Phase III) will test 3 different fabrics with associated friction sound, 3 colors, and 2 scents. In the future study, friction preferences will be investigated in relation to the interaction between skin and fabric when putting on a garment. Ultimately, the goal is to combine the four senses/modalities into a collective perception and determine which of the four modalities best contributes to the overall attractiveness of the sample. This study does not yet address this complex interaction, but rather examines each sense individually.

4.2. Limitations of the study

In the present study, we were interested in investigating the response of different senses to textile samples. Our selection was limited and based on preliminary studies; therefore, a study with more samples might elicit a different response from participants. Although a larger group of participants would likely make the assessments more diverse and the selection of fabric samples less reliable, this could also be beneficial because it would increase the statistical power of the study, and a larger sample could provide more reliable results and make it easier to detect meaningful differences between variables. In all our studies, we used a sample of fashion design students and experts to exclude the influence of fabric knowledge on the results. Our results related to olfaction are limited to a single type of fabric - canvas (plain-woven fabric) whose composition was 100 % cotton, and weight was 165 g/m^2. In addition, fabric attractiveness was investigated using only four senses (sight, hearing, smell, and touch). The fifth sense was disregarded after our preliminary study on taste showed that respondents found licking a fabric repulsive and unhygienic. Still, the role of taste in fabric attractiveness would be important to study in the future, especially in younger children.

4.3. Fashion related research – new practices

Fashion and senses are inextricably linked. What we wear, how we wear it, the fabrics and colors we choose, even the smells and textures of our clothes affect how we perceive ourselves and how we are perceived by others. Fashion research is important because the fashion industry is a vast and profitable business. This research has potential applicability to key stakeholders, primarily fashion theorists and designers. It can enhance designers' ability to create more appealing and comfortable clothing by understanding how different materials influence the senses. Furthermore, it contributes to the enhancement of fabric and garment quality, aiding manufacturers in comprehending sensory impacts on sight, smell, touch, and hearing. Although we believe our results are scientifically informative; they are primarily of interest to artists and fashion designers whose work focuses on the intersection between functionality (usability) and creative expression, and the results obtained may serve as a launching point for new artistic practices.

Acknowledgments

This work was supported by the Slovenian Research Agency (Research Programs No. P2-0213, Textiles and Ecology, and P5-0110, Psychological and Neuroscientific Aspects of Cognition).

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