Exploring the attractiveness of combinations of natural colors and contemporary shapes in fashion design

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ABSTRACT

In this research, the attractiveness of combinations of natural colors and contemporary shapes in fashion design is explored. This was done by means of a questionnaire survey. Four shapes of clothing and ten colors obtained from plant and insect pigments are proposed. The research was conducted in two phases – qualitative and quantitative analysis. The quantitative study confirmed the results of the qualitative study and using an appropriate data reduction method, the study results were analyzed graphically. The results showed that users rated designs with high-contrast color and shape combinations as more attractive than those with low-contrast combinations. The study also showed that in addition to the shape of the garment, the choice of natural color sources can also influence consumer preferences. This study aims to overcome the shortcomings of previous studies that only examined color without investigating its relationship to garment shape. The knowledge gained from this study can help fashion designers create garments that are both aesthetically pleasing and environmentally friendly. However, further research is needed to determine the relationship between natural colors, contemporary shapes and consumer behavior in selecting them.

1   Introduction

Color and shape are the two main elements of fashion design. The combination of these two components plays an important role in increasing consumer interest and the appeal of fashion products.

Color can be used to express emotions, moods and personality. Shape, on the other hand, can be used to create structure, movement and texture. Combining color and shape can therefore create visually stunning designs that are both attractive and expressive. It is important to note not only color and shape which are the main elements of fashion, but also aspects like tactility and the kind of textile.

Shape is important in fashion design because it can influence the overall esthetic of the garment. This characteristic of a garment refers to its structure, silhouette, and contour. When designers create a garment, they take shape into account to ensure that the garment is visually appealing and functional [1].

The shape of a garment can also affect how it is perceived by the wearer and his or her environment. For example, a tight-fitting dress may make the wearer feel confident and attractive, while a loose-fitting dress may make the wearer feel comfortable and relaxed [2]. The shape of a garment can also convey different messages. A sharp, angular silhouette can convey strength and power, while a soft, flowing silhouette can convey femininity and grace.

Designers can use shape to their advantage by manipulating it through various effects [3,4]. For example, they can use pleats, gathers, and drapes to add volume to the garment, or they can use ribbons and bastes to create a more fitted look. They can also use contrasting shapes to add interest, such as pairing a fitted jacket with a wide skirt. Computer simulation of fabrics is also important in this regard (https://vmod.xyz, accessed 2023-05-07). In addition to the aesthetics of the garment, its shape can also affect its functionality. For example, the silhouette of a garment can determine how it sits on the body and how it moves with the wearer. The shape of a garment can also affect its practicality [5].

Natural colors have been used in fashion design for centuries, but their use has declined in recent years due to the availability of synthetic dyes. Following the color trends is also important (https://www.edelkoort.us, accessed 2023-05-08). However, interest in the use of natural colors in fashion design is increasing due to their sustainability, health benefits, and unique esthetic qualities [6].

The use of natural colors in fashion design has several advantages. Natural colors are sustainable and environmentally friendly. They can be obtained from renewable sources and are biodegradable, unlike synthetic dyes, which are obtained from non-renewable sources and can have negative impacts on the environment.

In their analysis of trends in the sustainable use of natural dyes in fashion design, Che et al. [7] concluded that natural dyes can undoubtedly be used as promising substitutes for synthetic dyes for certain categories of textile products, while minimizing negative impacts on health and the environment. For example, H&M brand analyzes trends each week (https://www2.hm.com, accessed 2023-05-04).

Natural dyes have positive effects on the human health [8]. They are non-toxic and hypoallergenic, which makes them suitable for people with sensitive skin. Finally, natural colors have unique esthetic qualities. They offer a range of colors and shades that cannot be reproduced with synthetic dyes, and can produce subtle color variations depending on the textile fabric and dyeing method used.

While natural dyes are generally considered to be less harmful to human health than synthetic dyes, they can still pose risks if not properly handled and processed (https://textilevaluechain.in, accessed 2023-05-05). For example, some natural dyes may contain toxic substances such as heavy metals, which can have negative health effects if ingested or absorbed through the skin. In addition, natural dyes may be associated with allergies, skin irritation, or other adverse reactions in some individuals (https://www.biocoiff.com, accessed 2023-05-06). On the other hand, natural dyes may offer some potential health benefits compared to synthetic dyes. For example, some natural dyes, such as indigo or turmeric, are believed to have anti-inflammatory or antimicrobial properties, which could have positive effects on users' health. Moreover, the use of natural dyes may contribute to the development of local and sustainable textile industries, which can have broader social and economic benefits for communities.

Natural dyeing techniques can be subdivided into two categories [9]: traditional and modern methods. Traditional methods use plant materials such as roots, leaves, and flowers that are boiled and then used to dye fabrics. Modern methods use natural dyes obtained from plants, insects, and other sources, which are then processed into dyes.

Kodžoman et al. [10] conducted a study on the use of esthetic dyes for fashion design. The authors found that users prefer black, pink, and yellow. The choice of color also depends on gender and age. The relationship between the colors and the groups in which they are considered was established using the method of principal component analysis. A disadvantage of this development is that it considers the colors separately without having them on the garments, which would also lead to a preference of the color over garment shape [11].

From the review of available literature, it can be concluded that natural dyes have a good potential be used in the manufacture of contemporary clothing. They must be more stable and resistant and provide a wider range of colors. Natural methods for dyeing textiles also need to be constantly improved to be more efficient and cost-effective. Finally, new combinations between color and shape inspired by natural sources must be explored. However, the selection of color and shape in fashion design is a complex and subjective process. Fashion designers rely on their own taste, experience, and intuition to select color combinations that they believe will appeal to consumers. The experience of the designers is connected to trend forecasts and sales reports from previous collections. There is little scientific research to assist designers in this process. This paper aims to fill this gap by examining the attractiveness of color and shape combinations in fashion design. Also, by examining how different colors and shapes interact and influence each other, the research aims to contribute to our understanding of the aesthetics and design principles in fashion and product design.

2 Material and methods
2.1 Stages of the study

The study used a two-stage approach to determine the attractiveness of color-shape combinations in fashion design.

In the first stage, a qualitative study was conducted with the aim of identifying the most attractive color and shape combinations. For this purpose, a survey was conducted among fashion designers and consumers to determine their preferences for color and shape combinations. The data collected from this study will be analyzed using descriptive analysis to identify common clothing colors and patterns.

The second phase consists of conducting a quantitative analysis to confirm the results of the qualitative research. Survey participants rated the attractiveness of the shapes and their colors. The data collected during this study will be analyzed using statistical methods to determine the combinations of colors and shapes that are most attractive to consumers.

2.2 Tools

The following software products were used in this work:

- MS Excel spreadsheets (Microsoft Corp., One Microsoft Way Redmond, Washington, USA);
- Matlab 2017b software system (The Mathworks Inc., Natick, MA, USA.).

Figure 1 shows an overview of the Google form (Google Inc., California, USA) used to conduct the survey. The form includes the title of the survey at the top of the page, followed by a brief explanation of the purpose of the survey. Combinations of colors and shapes are entered as images. In a text box with a checkbox, the respondent makes their choice for the color-shape combination. The respondent can skip options and go back to review and edit their answers.
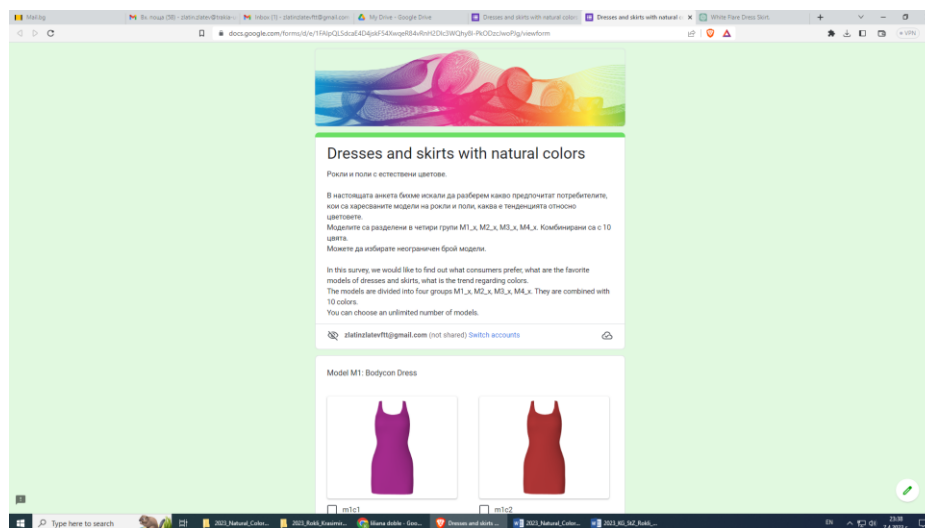
The questionnaire survey was conducted with 94 respondents who were aware of the purpose of the results. Demographic factors such as age, education level, and gender were not considered in the study. Participants were selected based on their knowledge of the research topic, which ensured that their responses were sound and relevant to the study. It should also be noted that the lack of demographic information may limit the generalizability of the results, as different groups of people may have different preferences and attitudes toward the research topic.

2.3 Materials

Table 1 shows the natural color sources suitable for dyeing textiles [12,13].

The data on pigments and the colors obtained from them can be summarized by analyzing the main characteristics of the pigment. One of these characteristics is the water and fat solubility of the pigment, which can affect the methods used to obtain and use it.

Table 1. Colors from natural pigments used in this study

Color number	Colorant	Main colors	Natural source	Description
C1	Anthocyanins	Red, purple, blue	Flowers, fruits and vegetables	Water soluble pigments. They are sensitive to pH changes.
C2	Betanin	Red, purple	Beet roots	Water soluble pigment. It is not stable to light, heat and oxygen.
C3	Carmine	Red	Cochineal	Water soluble pigment. Resistant to light, heat and oxygen.
C4	Chlorophyll	Green	Alfalfa, nettle, parsley, spinach	Water soluble pigment. Relatively resistant to light, heat and oxygen.
C5	Carotenoids	Yellow, orange, red	Carrots, oranges, red peppers, saffron, tomatoes	Fat soluble, unaffected by heat and pH changes.
C6	Curcumin	Yellow, red, pink	Turmeric	Soluble in oil, stable to heat but not to light.
C7	Riboflavin	Yellow	Eggs, milk, yeast	Water soluble pigment. Heat resistant.
C8	Carbon Black	Black	Charred plant materials	Resistant to light and heat.
C9	Caramels	Brown	Melanoidins	Resistant to light and heat.
C10	Phycocyanins	Blue	Algae *Spirulina*	Water soluble pigment. It is not stable to light, heat and oxygen. They are sensitive to pH changes.

Another important characteristic is the pigment's resistance to light, heat and oxygen [14-16]. Pigments that are highly resistant to these factors tend to be more stable and longer lasting, while pigments that are less resistant may fade or deteriorate over time. In addition, the resistance of the pigment to changes in active acidity is also important, especially when mordants are used in textile dyeing.

Mordants are substances used to fix the dye in the fabric and can affect the final color of the textile fabric [17]. Depending on the pigment used, a change in the active acid content can cause a change in the color of the pigment. Therefore, understanding the properties of the pigment and its response to different mordants can help ensure that the final color of the textile fabric is consistent and durable.

It is important to note that the process of capturing and representing colors on digital screens, such as computer monitors or mobile devices, involves converting them from physical to digital signals, which can introduce a range of color discrepancies and variations. These discrepancies can arise due to differences in color gamut, resolution, and calibration between devices, as well as the effects of ambient lighting conditions and other environmental factors.

Figure 2 shows an overview of the colors used, according to the numbers presented in Table 1.
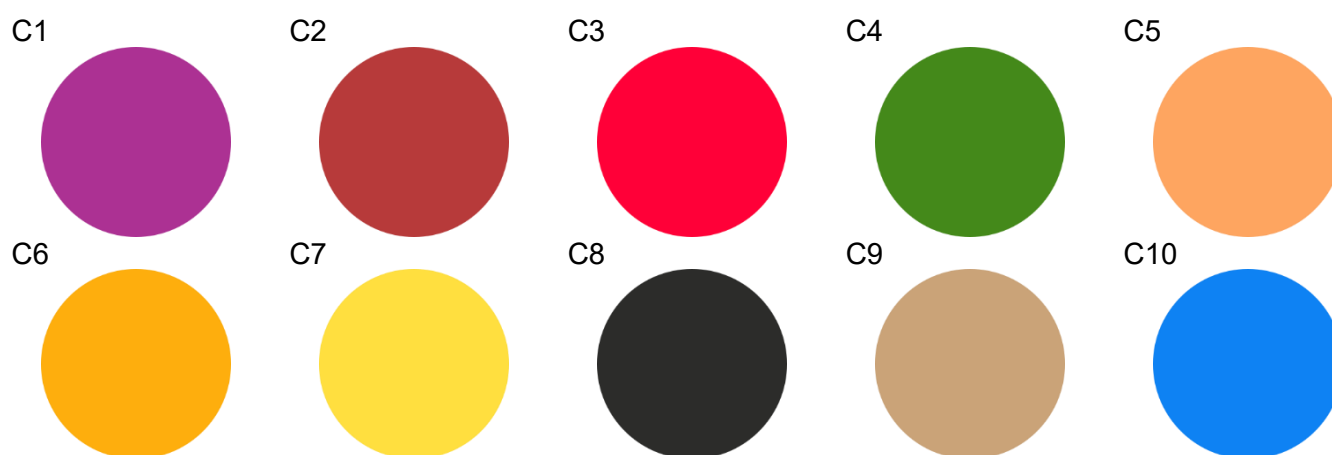

Fig. 2   Natural colors used in this study.

Table 2 shows the values of the color components for the selected natural colors. The data refer to the RGB and Lab color models. RGB values represent the intensity of the red, green, and blue components of each color, with values ranging from 0 to 255. Lab values represent the luminance (L) and the opposite color, of which: "a" (green-red) and "b" (blue-yellow) with values ranging from -128 to 127.

Table 2. Color values of natural colors.

Color component / Color	R	G	B	L	a	b
C1	172	49	147	42,87	59,51	-27,02
C2	183	58	58	43,36	50,23	28,68
C3	255	0	56	53,54	80,95	45,13
C4	68	137	26	50,91	-41,01	48,47
C5	254	165	96	75,34	26,54	48,71
C6	254	174	13	76,90	18,92	78,78
C7	255	223	63	89,11	-4,72	76,90
C8	44	44	42	17,94	-0,47	1,29
C9	202	163	120	69,55	8,58	27,77
C10	14	130	243	54,59	13,28	-64,50

Figure 3 shows the dress patterns used, with which the natural colors were combined. Dress and skirt patterns available in the online app Digital Fabrics were used (https://www.digitalfabrics.com.au, accessed 2023-04-08). The types of garments do not differ in style, but rather in shape.

The dress, model M1, has a tight-fitting silhouette that hugs the body and accentuates the curves. It is usually made of a stretchy material that allows for a comfortable fit while maintaining an elegant look. The dress is designed to accentuate the figure with a high neckline and a knee-length hemline. A suitably chosen color adds a touch of sophistication and purity to the overall look.

Model M2 is a flare dress that is a more flowing and relaxed option. It features a loose design that flared from the waist down, creating a fun and flirty silhouette. Typically, such a dress is made of a lightweight material that moves with the body, making it suitable for dancing and other activities that require more freedom of movement. The properly chosen color gives the dress a touch of brightness and freshness.

The M3 model is a wrap skirt that is versatile and stylish. It can be worn in a variety of ways. It features a simple design that consists of a long, rectangular piece of fabric that wraps around the body and comes together at the waist. The skirt can be adjusted to fit any body type, making it a great choice for a variety of occasions. The suitably chosen color adds a touch of elegance and sophistication to the skirt.

Model M4 is a flare skirt that is a playful and feminine option. It has a full flared design. It has a high waist and falls just above the knee, creating a flattering and youthful silhouette. The skirt is made of a lightweight material that conforms to the body, making it suitable for free movement and dancing. The skirt is completed with a belt with hanging ribbons on the right side, which adds a touch of style and whimsy to the overall look. The properly chosen color gives the skirt a touch of purity and innocence.

M1   M2   M3   M4

Fig. 3   Fashion models used in this study.

2.4 Data analysis method

The processing of the survey data was done with the Principal Component Analysis (PCA) method [18-20]. It is a multivariate statistical method used to reduce the dimensionality of a data set while retaining most of the variability present in the data. PCA achieves this by creating new variables known as principal components, which are linear combinations of the original variables. These principal components are ordered based on the amount of variation that describes the original data set, with the first principal component describing the most variation and subsequent components describing progressively less. PCA is particularly useful in cases where the data set contains a large number of variables or when the variables are highly correlated.

When processing the data with the PCA method, the following steps are performed:

- Data normalization: This involves scaling the variables so that each has a mean of zero and a standard deviation of one;
- Calculating a covariance matrix: This is a square matrix that describes the relationships between each pair of variables in the data set;
- Calculating the eigenvalues and eigenvectors of the covariance matrix: The eigenvalues represent the amount of variance explained by each principal component, while the eigenvectors represent the direction of the principal components;

- Determining the number of principal components to represent the data: The number of principal components to retain is usually based on the amount of variation described and a chart can be used to determine this;
- Compute the scores for each observation: The scores represent the values of each observation in the new principal component space;
- Interpretation of results: Principal components can be analyzed. In this step, the relationships between the variables are identified.

3   Results and discussion
3.1 Results from qualitative study

The results of the study for models M1 and M2 are shown in Figure 4. Figure 5 shows the survey results for models M3 and M4.
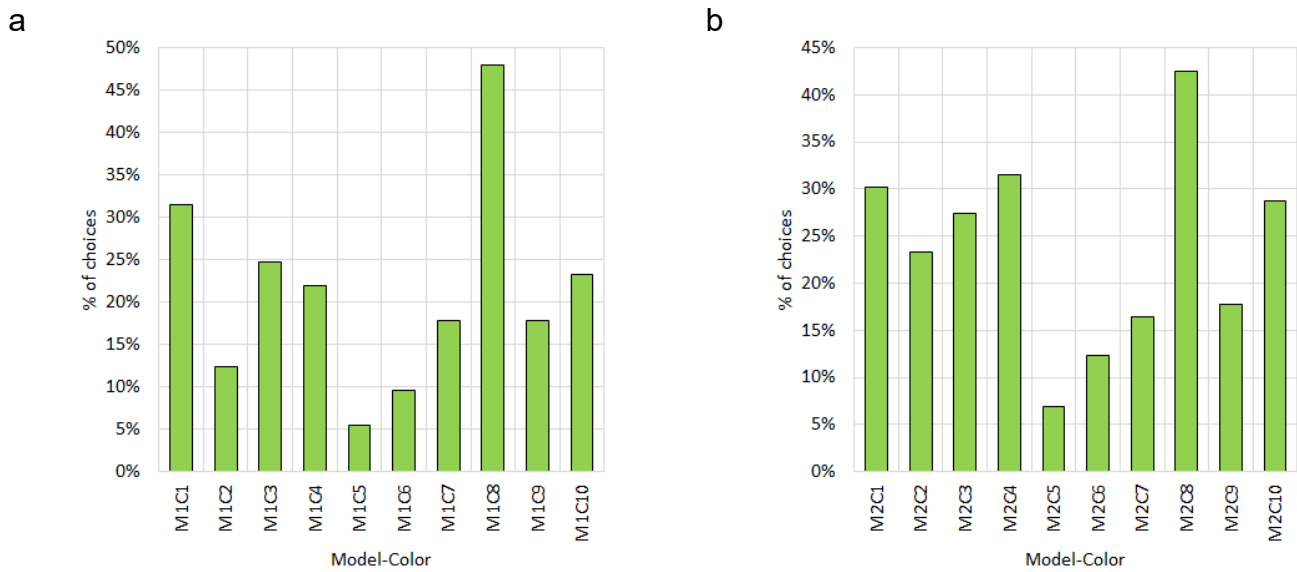
a

b

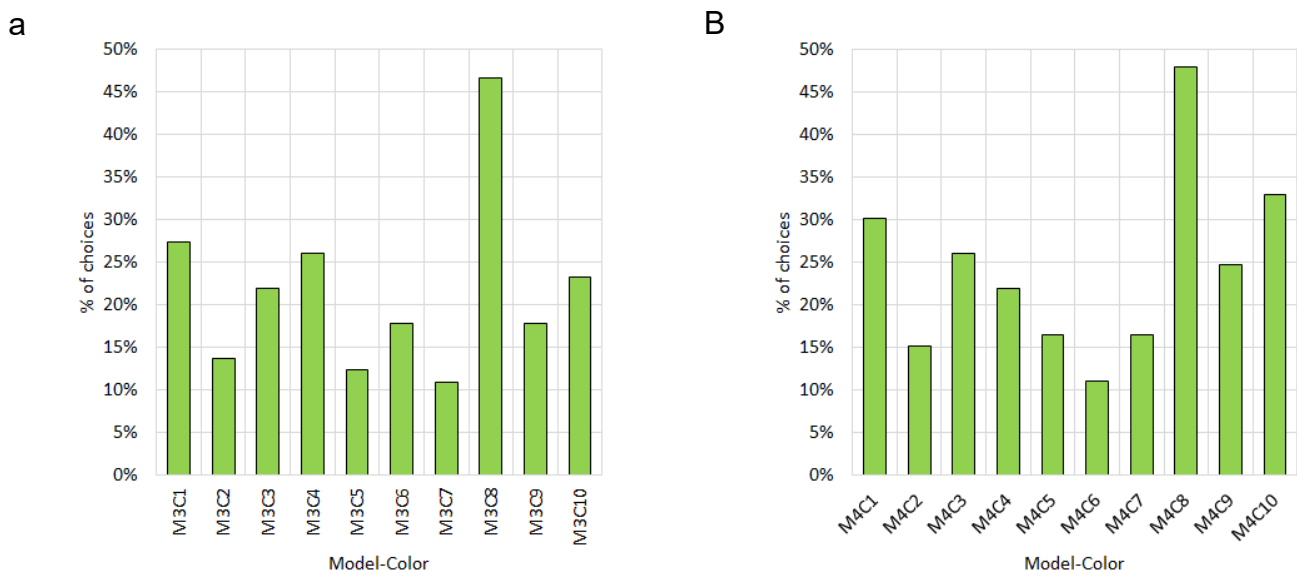*Fig. 4   Survey results for models (a) M1 and (b) M2.*

a

B

Fig. 5   Survey results for models (a) M3 and (b) M4.

Model M1, a dress with a tight-fitting silhouette, is preferred in black, purple, and red. Model M2, a loose-fitting dress, is preferred in black, green, and purple. The results show that consumers may have specific color preferences for each clothing style, and that offering a variety of color options for each style can play an important role in consumers' purchasing decisions. Therefore, it is important for designers and

manufacturers to consider these color preferences in their product offerings to better match the tastes and preferences of their target customers.

The survey results show that among the skirt models, model M3, a wrap skirt in black, purple, and green, is the most popular. This indicates that consumers have a particular preference for these colors when it comes to this particular style of skirt. Conversely, the M4 model, which represents the flare skirt, proved to be preferred in the colors black, blue and purple.

3.2 Results from quantitative study

Before applying the PCA method, the data were normalized to the interval [0,1] to ensure uniformity of the data set. Table 3 shows the resulting normalized values, which consist of 10 columns and 4 rows. PCA can be used to reduce the data to 9 principal components by column and 3 principal components by row. A significant portion of the variance in the data can be explained by only 3 principal components, which account for over 95% of the total variance. This suggests that most of the variance in the data can be efficiently explained by a small subset of principal components. These results suggest that the PCA method may be an appropriate tool for analyzing and summarizing complex data sets and may facilitate the identification of key patterns and trends in determining relationships between garment color and shape.

Table 3. Normed data of color-shape combinations.

Color Model	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
M1	0.13	0.00	0.10	0.00	0.00	0.00	0.38	0.11	0.00	0.00
M2	0.09	0.47	0.20	0.30	0.08	0.15	0.31	0.00	0.00	0.17
M3	0.00	0.06	0.00	0.13	0.42	0.46	0.00	0.09	0.00	0.00
M4	0.09	0.12	0.15	0.00	0.67	0.08	0.31	0.11	0.28	0.29

Figure 6 shows a three-dimensional diagram of the first three principal components, illustrating the relationships between color and shape of clothing patterns. The figure shows that model M1 is most preferred in purple, red, yellow and black colors, while model M2 is popular in dark red, green and dark yellow shades. Model M3 is preferred in caramel and blue, while Model M4 is most often chosen in orange. These results suggest that color is a critical factor in determining consumer preferences for different clothing styles and that specific color preferences may vary depending on the type of clothing considered. Visualizing these relationships using PCA provides a sufficiently clear and accurate way to understand the patterns underlying the data and can help designers and manufacturers make informed decisions regarding the development of new apparel lines or product offerings.
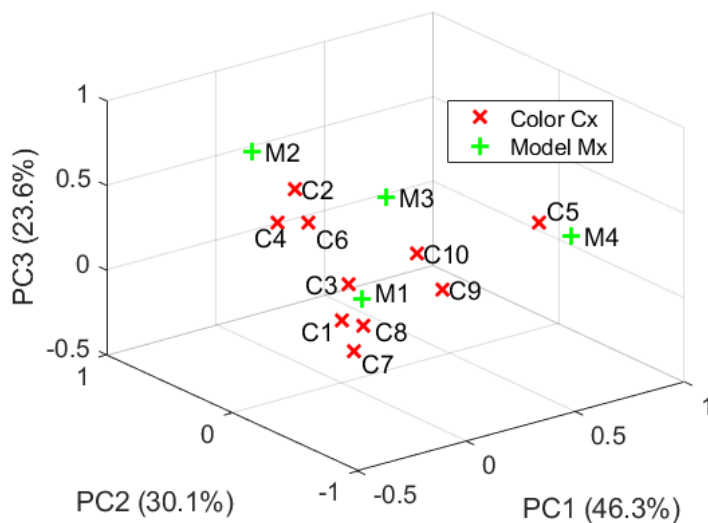

Fig. 6   Results from PCA.

Figure 7 provides an overview of the clothing patterns preferred by consumers, highlighting the specific colors that are most popular for each pattern. This completes the PCA results.

Fig. 7   Models and colors, preferred by survey respondents.

The results show that model M1 is preferred in the purple color produced by the pigment anthocyanin, a naturally occurring compound in purple cauliflower. For model M2, users preferred a dark red color. M3 is preferred with algae blue color. M4 is preferred with color obtained from plants that have carotenoid pigment.

These results suggest that consumers have a strong preference for natural colors derived from plant pigments and are more likely to choose garments that match this preference. The use of such natural pigments could also be of interest to consumers who value sustainability and environmentally friendly production methods in their purchasing decisions.

3.3 A comparative analysis between qualitative and quantitative studies

The qualitative study revealed several common themes related to the attractiveness of color-shape combinations. These themes include the importance of contrast and balance between color and shape. Specifically, the study participants preferred combinations of colors and shapes that create contrast between elements and have a balanced relationship between these two components.

The quantitative study confirmed the results of the qualitative study. Participants rated designs with high-contrast color and shape combinations as more attractive than those with low-contrast combinations. Designs that have a balanced relationship between color and shape are rated as more attractive than those that emphasize one element over another. Personal preferences and cultural influences can also play a role in how people perceive and evaluate visual designs. Some people may indeed prefer high-contrast designs or those that emphasize one element over another. This research aims to contribute to the understanding of general design principles and trends, but it is important to acknowledge individual differences and subjective preferences.

3.4 Discussion

The results of this study contribute to the existing literature regarding the influence of clothing shape and color on consumer preferences. The obtained results complement the work of Entwistle [2], who found that the shape of a garment can significantly influence how it is perceived by the wearer and those around them. Furthermore, the findings are consistent with previous research that has found a strong relationship between garment shape and consumer color choice.

According to Kosinkova-Stoeva [4], designers can manipulate clothing shapes through various effects, including geometric ones such as draperies and pleats. This study adds to the literature by demonstrating that the choice of natural color sources can also influence consumer preferences.

This study also addresses some of the shortcomings of previous studies, such as those of Kodžoman et al. [10] who consider colors separately without representing them on the garment. In contrast, this study

presents the influence of clothing shape on consumer color choice. This is supported by the findings of Kazlacheva [11] and Spahiu et al. [5], who suggest that garment shape plays a crucial role in influencing color preferences among consumers.

4 Conclusion

In the present study, the attractiveness of combining natural colors and contemporary shapes in fashion design was investigated. For this purpose, a survey was developed in which four shapes of clothing were presented in combination with 10 different colors derived from plant and insect pigments. The survey was conducted online using mobile-friendly tools.

The survey was conducted in two phases, qualitative and quantitative. The objective of the qualitative phase was to identify consumer preferences, while the quantitative phase aimed to confirm the results of the first phase. The results showed that the survey responses could be analyzed graphically using an appropriate data reduction method. It was found that high-contrast color and shape combinations were rated as more attractive than low-contrast combinations.

The study also showed that, in addition to the shape of the garment, the choice of natural color sources can also influence consumer preferences. This aspect was neglected in previous studies, which looked at color in isolation without examining its relationship to the shapes of the garment.

Further research is needed to investigate the performance and characteristics of different natural dyes in terms of color fastness, washability, and consistency. Also, have to consider the potential trade-offs between the use of natural dyes and synthetic dyes in terms of environmental impact, cost, and availability, and examine ways to optimize the use of natural dyes while minimizing their drawbacks.

The results of this development have practical implications for fashion designers, which they can use to design garments that are visually appealing and environmentally friendly. However, more research is needed to more fully investigate the relationship between natural colors, contemporary shapes, and consumer behavior. This could include collecting demographic data such as age, gender, and education level of participants.

Author Contributions

J. Ilieva: conceptualization, methodology, visualization, supervision; L. Doble and G. Böhm investigation, resources; I. Ruseva and K. Genova: formal analysis, investigation; Z. Zlatev: software, writing – original draft preparation, writing – review and editing. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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