Which Photographic Features of Product Images Impact Consumer Attractiveness?

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Abstract: The determinants influencing online shopping decisions have long been a focal point of interest for both business practitioners and academic researchers. Among these factors, product imagery stands out as a critical element. However, there remains a notable research gap in understanding the specific features of product images that significantly impact consumers' purchasing decisions in the online context. While the role of product imagery is acknowledged, further investigation is needed to identify which particular aspects of these images are most influential in shaping consumer decision-making processes. The majority of previous research about product images used survey-based methods to measure image quality based on interviewee's satisfaction and rating instead of data-based analysis. Hence, this research paper aims to investigate the relationship between product photography and customer attractiveness on e-commerce platforms by exploring what photographic characteristics could contribute to better designing product images that captivate consumers and ultimately enhance sales. Additionally, this study aims to explore potential differences in purchasing behavior between male and female consumers, providing a complementary dimension to the research findings. The analysis is conducted using data-driven methodologies, with a specific focus on key features of product images. These include aesthetic appeal, embedded messaging, and social presence, all of which are central to the investigation's scope. The author collects data through a crawler tool and organizes it into a raw dataset (both for males and females). Next, image-processing techniques and feature engineering are applied to conduct the final dataset used for linear regression. Then, backward elimination contributes to determining the best-performed linear regression model, which illustrates the photographic features which are significant to the impingement of sales numbers. As a result, it is confirmed that male clients are more affected by the amount of information contained and the proportion of the products in the product image. In contrast, female clients take notice of the appearance of human models.

Keywords: Image-processing, Machine Learning, Product Photography, Consumer Behavior, E-Commerce

1.   Introduction

In contemporary society, technological advancements have made online shopping an increasingly popular choice for consumers. With numerous e-commerce platforms available, the overwhelming variety of similar products often bewilders consumers. Factors such as product images, descriptions,

reviews, prices, and more could influence consumer decisions. Among these, product images are particularly complex. They not only directly help customers access the product visually but also convey essential information, implications, and even concepts of consumption between sellers and buyers [1]. The aesthetic elements considerably influence consumer attractiveness to a product, and that makes the form of displaying the product prominent to the product's financial achievement [2]. Therefore, this study will mainly focus on visual presentation elements on e-commerce platforms.

However, previous related papers still have limitations, which brings the intention of this study to try to resolve them. On the one hand, respondents' rating was treated as an essential measurement to evaluate product images by past research [3]. On the other hand, during 2019-2022, the coronavirus impacted global business, specifically causing a tremendous and long-term persistent boost trend in online shopping [4]. Consequently, this surge in e-commerce has made it essential for businesses to adapt their strategies to the digital environment. In particular, the role of product images has become more significant than ever. As physical interaction with products becomes increasingly unavailable to many consumers, online retailers are increasingly dependent on high-quality, engaging product images to communicate key product attributes and foster trust and desirability [5]. Modern consumers expect not only clear and accurate depictions of products but also visually captivating experiences that capture their attention and motivate them to make a purchase. These images play a critical role in bridging the gap between the online and physical shopping experience, influencing consumer perceptions and decisions.

Therefore, this research explores the impact of specific photographic features of product images on consumer attractiveness and sales, focusing on clothing items. The decision to focus on clothing in this study stems from several key factors that make apparel one of the most significant and compelling categories in the e-commerce space. Clothing is a necessity and a powerful element of personal expression, making it highly dependent on visual appeal. This study seeks to examine how different photographic elements—such as image saturation, entropy, and product positioning—affect consumer behavior, while also exploring potential gender-based differences in these preferences. By analyzing these variables, the research aims to uncover how specific visual characteristics impact decision-making and whether these effects vary between male and female consumers. Through this exploration, the research seeks to offer insights into how e-commerce businesses can optimize product image design to enhance consumer appeal and ultimately drive sales.

2. Literature Review

This research is intended to fill the existing research gap by studying product images during e-commerce purchasing after COVID-19 spread. The gap of past studies is concentrated in three aspects: 1. They mainly happened before 2022, and papers about this concept in the last two years are barely any. 2. They mainly use the survey approach. 3. They only cover a small part of image features. This intention is coming across due to the past study about this area of knowledge having dubious applicability in the post-Covid era. Online shopping will continue to increase after 2020. That will directly result in dilating the market size and consumers being enriched and diversified [6]. Therefore, the phenomena explored in previous studies may no longer fully address the complexities of the current landscape. Moreover, product photography plays a crucial role in reducing both the physical and emotional distance between buyers and sellers in online transactions, enhancing the overall consumer experience. By creating more immersive and relatable visuals, product images can foster a sense of connection and trust, which is vital in the absence of direct, face-to-face interactions. Compared to the traditional commercial channel, online shopping involves more doubts and suspects [5]. Therefore, focusing on product images, which are the media to eliminate the unsharp and uncertain information process, contributes to attracting consumers. Moreover, preceding correlative projects firmly reply to customer satisfaction surveys [3]. This method is highly affected by biases

and semantic differences, so there is a lack of reliability to explain the variability in the modern market. In contrast, this study will employ big data analysis combined with pre-trained models, allowing for greater variability in the results. Big data offers a more accurate reflection of actual user behaviors and interactions, providing objective insights that are less prone to biases. In contrast, surveys often rely on self-reported data, which can be influenced by factors such as memory bias, social desirability bias, or respondents' misinterpretations of questions, thus limiting the reliability of the findings. Finally, bygone product-photo researchers merely cover limited graphical features to study on. For example, these two papers both zoomed in on the lightning elements during the photo designing process [6]. However, in this investigation, trying to cover more aspects of photographic characteristics is a priority. The overall evaluation would be more comprehensive by keeping the price and number of fans for the store as control variables.

3.   Hypothesis

For this research, two hypotheses are introduced to achieve the purpose of investigating the relationship between product photography and customer attractiveness on e-commerce platforms:

Hypothesis 1:

The photographic features of clothing product will have significance impact on Sales. In addition to that, finding the particular photographic features which are significant is the key target.

Hypothesis 2:

The impact of the photographic features of clothing product might differ depend on the genders of customers (Male/Female).

4.   Table of Variables

Table 1: Table of Variables.

Variable Name	Description	Detail
Shannon Entropy	Property of image: the entropy of product image, but with difficult measurements.	The higher the entropy value, the more information the product image contains. High entropy means the information provided by the image is complex and detailed; low entropy means the information provided by the image is clean and concise.
Average Entropy		
Saturation	Properties of image: the saturation of product image	The higher the saturation, the fuller the color of the product image.
Lightness	Properties of image: the lightness of product image	The higher the lightness, the lighter the product image.
Width Ratio	Position of product: product width divided by image width	
Height Ratio	Position of product: product height divided by image height	
Proportion	Position of product: Width Ratio times Height Ratio	
Center X Ratio	Position of product: Center of the product at horizontal axis	
Center Y Ratio	Position of product: Center of the product at vertical axis	

Table 1: (continued).

Background	To detect how background is displayed	-0: no background.; -1: solid color background or easy background display; -2: designed background (the background could be seen clearly like a natural environment in real life, such as studio, forest or road).
Appearance of Human Model	To detect how human model is displayed	-0: contain none; -1: contain but without face; -2:contain and with face.
Appearance of Logo	To detect whether the logo is displayed	-0: contain none; -1: contain.
Price	The price of product	
Fans	The number of fans of the e-commerce shop	These are treated as control variables.
Sales	The sales number of the product	This is the dependent variable.

5. Method

In this section, the methodology of this research will be mainly introduced and discussed. The method for proceeding with this research can be classified into the following four steps. The first step involves collecting the raw dataset for the research target. The research target is settled as male shirts and female shirts released after 2023 on Taobao with each 200 sets of data. Taobao was chosen as the focus e-commerce platform because it is one of the most popular platforms globally. Clothing has been selected as the focal product category for this e-commerce product image investigation due to its significance within the online retail sector. Among various product types, clothing has been extensively studied, and its visual representation is particularly relevant as it resonates with a diverse range of consumer preferences. The perception of clothing, influenced by product imagery, is highly varied, making it an ideal category for examining how different visual elements impact consumer behavior. Hence, clothing product evaluation can reflect the presentation of consumer behaviors [7]. Shirts were selected to represent clothing because they rank among the top three best-selling clothing types for males and females in the Taobao website category. The data collection process was carried out using Octoparse by entering keywords ("male shirt" and "female shirt"). This choice is because Taobao has an anti-scraping system, and it is difficult to crawl data from the platform directly. The resulting dataset contains various feature columns, but only four are relevant for this research: store link, product price, number of sales, and image URL. These four feature columns were extracted to form the raw dataset. Notably, while each product link contains multiple images, the image URL included corresponds to the first image, which is the image that consumers see directly on the website.

The second step is to utilize feature engineering to create the final dataset containing all the measurement features. The final linear regression dataset contains 15 variables: The dependent variable is sales. Since finding the photographic features of product images which significantly impact consumer attractiveness is the key purpose of this research, sales can be a reliable quantized measurement to reflect consumer attractiveness. The control variables are the price and number of fans for the store. Although this research is about photographic features, the price and fan number of the store have been widely shown to have a direct impact on sales. Hence, these two will be controlled during the investigation. The purpose of them is to check if the linear regression model is valid since

the price and fan number of the store are supposed to have significant impact on sales numbers. The independent variables are the photographic features of the product, which are Shannon Entropy, Average Entropy, Saturation, Lightness, Width Ratio, Height Ratio, Proportion, Center X ratio, Center Y ratio, Background, Appearance of Human Model, and Appearance of Logo. A basic description of these variables is provided in the Table of Variables. Accordingly, the methodology for conducting the feature engineering process, which ultimately extracts the relevant values from these variables, will be primarily recommended. This process ensures a systematic and rigorous analysis of how each feature contributes to the overall model. For Shannon Entropy, Average Entropy, Saturation, and Lightness. These are the aesthetic properties of images, which are collected from image URL using package skimage measure. For Width Ratio, Height Ratio, Proportion, Center X ratio, and Center Y ratio. These are related to built-in messages about how the product is positioned for each image, which are collected from image URL using the package ultralytics and yolov5s model from YOLO package. For Background, Appearance of Human Model, and Appearance of Logo. These are social presence elements artificially designed by online merchants, which are collected from image URL manually. The yolov3 model from YOLO package is tried to classified Appearance of Human Model into those three mentioned labels. However, the accuracy by using this model is around 90% compared to the manual collection. Hence, in this research, due to the sample size is relatively small, the cost of time by manual collection is acceptable. For sales and prices, they are the product price, number of sales columns in the raw dataset, which can directly put in to use. For the number of fans, it is manually collected from store link column in raw dataset due to the anti-scraping function of Taobao.

The third step establishes linear regression models and applies backward elimination to identify the best model, which includes all significant variables related to the dependent variable: sales. The final step is to interpret the results from the third step to determine whether the hypotheses are supported and provide business insights derived from the findings. Those content will be expanded in the Result and Discussion.

6.   Result and Discussion

At this stage, all the variables have been collected and summarized into a final dataset. The upcoming step is to proceed with linear regression analysis and aim to find the best-performed model.

Table 2: Linear regression results with all variables.

Variable	Female		Male	
	coef	$P > |t|$	coef	$P > |t|$
Intercept	-4701.0724	0.629	-3951.5951	0.236
Shannon_Entropy	713.1344	0.455	584.2246	0.121
Average_Entropy	317.1006	0.167	-103.3017	0.370
Saturation	19.8973	0.297	-6.2229	0.654
Lightness	-302.7457	0.185	108.5603	0.346
Width_Ratio	-8426.4536	0.630	7357.1854	0.349
Height_Ratio	5090.3952	0.347	4038.1637	0.118
proportion	2094.6210	0.910	-1.107e+04	0.208
Center_X_Ratio	-3413.7898	0.548	-51.9836	0.985
Center_Y_Ratio	2009.4359	0.788	-1442.3652	0.666
Price	-19.2398	0.017	-3.1704	0.065
fans	0.0031	0.000	0.0008	0.000
Background	-882.6476	0.479	320.8029	0.425
Appearance_of_human_model	1502.4345	0.138	261.2384	0.543
Appearance_of_logo	1726.8788	0.152	813.9899	0.177

By fitting the final dataset for both male and female datasets with all the variables to the linear regression model, the results are shown in Table 2 above. From the results shown in the table, for both males and females, except for the variables of price and store fans, the remaining variables are insignificant, as the p-values are much greater than 0.05. In this case, backward elimination is utilized to resolve this issue. Backward elimination is an algorithm that does not evaluate all possible variables simultaneously, but instead considers a stepwise approach. It iteratively examines the variables, removing the least significant ones at each step based on their performance, and checks the overall significance of the model as variables are excluded. This process continues until only the most relevant variables remain, optimizing the model's predictive power. The operation procedure of backward elimination is shown as follows: The whole model initially contains all the n potential variables. The variable with the highest p-value is identified and removed from the model at each step. The model is then re-fitted using the remaining $n-1$ variables. This procedure is repeated iteratively, removing the variable with the highest p-value and re-fitting each step, until all remaining variables in the final model have p-values less than α, defined as one minus the confidence level. Finally, the backward elimination is operated, and the final "best" linear regression model is shown as following tables:

Table 3: Final linear regression results for males

Variable	coef	$P > |t|$
Intercept	-2855.5783	0.160
Shannon_Entropy	509.0201	0.035
Height_Ratio	3456.2268	0.069
proportion	-3729.5635	0.054
Price	-3.4728	0.043
fans	0.0009	0.000

Table 4: Final linear regression results for females

Variable	coef	$P > |t|$
Intercept	1585.8592	0.320
Price	509.0201	0.021
fans	-17.3564	0.000
Appearance_of_human_model	0.0030	0.014

In Table 3 and Table 4, it can be seen that, these are the final linear regression model for males and females. Then, the significant variables and their coefficients are extracted to the below tables:

Table 5: Results details for males

Variable Name	Coefficient	Sign of Coefficient
Shannon Entropy	509.0201	positive
Height Ratio	3456.2268	positive
Proportion	-3729.5635	negative
Price	-3.4728	negative
Fans	0.0009	positive

Table 6: Results details for females

Variable Name	Coefficient	Sign of Coefficient
Appearance of human model	509.0201	positive
Price	-17.3564	negative
Fans	0.0030	positive

First, besides photographic features, Price and Fans show significant influence on Sales. Since in both tables, the signs of coefficient for Price are negative, and the signs of coefficient for Fans are positive. That indicates Price and Fans have negative and positive linear correlation with Sales, respectively, for male and female customers. In addition to that, female customers seem to be affected more by these two factors while making online purchase decision, due to the reason that the coefficients for these two are relatively higher in Table 6. This part of the result matches with Theory of Price and Social Proof Theory. That supports the reliability of the result because the act of these two control variables performs as expected.

Second, for male customers, Shannon Entropy with positive sign of coefficient, Height Ratio with positive sign of coefficient, and Proportion with negative sign of coefficient are the variables significantly impacted Sales. For female customers, Appearance of human model with positive sign of coefficient is the variable significantly impacted Sales.

7. Limitation and Future Outlook

This section will primarily discuss the existing limitations of this research and the possible future outlook that could be established based on this study. There are certain limitations to this investigation. First, the sample size is small, which is 200 sets for both males and females. That could be improved by increasing the sample size. Second, most of the gathered variables depend on package accuracy; some require manual collection. In the Method section, Shannon Entropy, Average Entropy, Saturation, Lightness, Width Ratio, Height Ratio, Proportion, Center X ratio, and Center Y ratio are collected through Python packages. Fans, Background, Appearance of Human Model, and Appearance of Logo are collected manually. Hence, the improvement to this matter is to use manually collected datasets to train models and develop algorithms for specific purposes. By cross-checking the results, the algorithm precision can be better ensured, and the model will be able to process larger sample sizes, which is more time-saving. Third, this paper still lacks generality, which means that more related variables can be introduced and evaluated in an entirety. For example, comments in the product link can be also put into consideration as well.

This article is a preliminary study on online shopping in the post-pandemic era, focusing on analyzing the impact of image characteristics on sales. It provides a foundational framework for future research in related fields. Building on this framework, future scholars can concentrate on focused analyses of specific products. For example, some noteworthy phenomena were observed during the data collection process. For down jackets, product images often feature human models in snowy mountain or snowfield backgrounds, with hand gestures such as pocketing or displaying their hands. These elements within the context of the product imagery of down jackets raise questions about their role and how they influence sales. These aspects warrant further exploration and could yield results contributing to informed business decision-making.

8. Conclusion

The findings of this study confirm both two proposed hypotheses and provide valuable insights into the influence of visual characteristics in product images on consumer behavior.

For male consumers, Shannon Entropy, reflecting the diversity or complexity of information in an image, shows a positive correlation with purchasing decisions. Supported by Information Richness Theory, the results suggest that men prefer images with high information density, which helps them make confident decisions. Additionally, Visual Priority Theory highlights the importance of geometric properties like Height Ratio and Proportion in shaping first impressions. A higher ratio of height conveys power, elegance, or professionalism, while balanced proportions evoke harmony and authenticity, aligning with Imitation Hypothesis and Social Identity Theory, as male consumers associate high height ratios with authority and success, fostering identification and purchase intent.

Hence, in future business decision-making, these results could contribute to several market insights and potential strategies for commercial enhancement. First, in future efforts to promote men's clothing and other male-oriented products, incorporating more textual information into product images can be a valuable strategy. For instance, adding detailed descriptions to clothing product images, such as fabric composition, waterproofing capabilities, durability, and other relevant characteristics, can enhance the appeal and informativeness of the visuals. Second, to optimize product appeal in male-oriented markets, businesses should select models with higher height for product photography, particularly in men's fashion and formalwear. For example, featuring tall models in tailored suits can project an image of confidence, professionalism, and authority, which aligns with male consumers' preferences and enhances their purchase intent. Additionally, product images should maintain balanced proportions between height and width to evoke a sense of harmony and authenticity. On e-commerce platforms, for instance, strategic framing techniques can highlight the vertical elegance of items like long coats or trousers without distorting their natural dimensions, creating a more visually appealing presentation.

For female consumers, the Appearance of Human Models in product images significantly impacts their preferences. Backed by Social Identity Theory, women tend to relate the model's appearance to their own, imagining themselves wearing the product, which enhances purchase intention. Furthermore, Emotion-Driven Consumption Theory suggests that human models create emotional connections, adding lifestyle context and trustworthiness to the product. Empirical evidence shows that female customers respond more positively to images featuring models, strengthening product appeal and consumer confidence. Together, these findings underscore the pivotal role of visual features in tailoring e-commerce strategies to gender-specific consumer preferences. Hence, same for the males, several prospective approaches for business optimization could be inspired by the result.

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