Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

https://doi.org/10.57239/PJLSS-2024-22.2.001226

RESEARCH ARTICLE

Research on the Design Strategy of UAV Appearance Based on Kansei Engineering

Xiang Li [1], Tao Chen[2], Younghwan Pan[3*]

[1]Department of Smart Experience Design, Kookmin University, Seoul, South Korea
[2]Department of Image and Video, Dongguk University, Seoul, South Korea
[3]Department of Smart Experience Design, Kookmin University, Seoul, South Korea

ARTICLE INFO

Received: Sep 17, 2024

Accepted: Nov 29, 2024

Keywords

Drone Design

Innovativeness

Stylishness

Design Elements

Correlation Analysis

Material Optimization

Aesthetic Perception

***Corresponding Author:**

Younghwan Pan
peterpan@kookmin.ac.kr

ABSTRACT

With the increasing demand for drones in both commercial and recreational applications, design has become a critical factor in shaping user perceptions and enhancing market competitiveness. This study investigates the relationship between various design elements and their influence on the perceived innovativeness and stylishness of drones. By employing correlation analysis, the research identifies key design features, such as advanced materials, streamlined outlines, and optimized sizes, that strongly contribute to users' perceptions of innovation and modernity. Secondary factors, including color schemes and geometric shapes, are found to have a supplementary impact. The study aims to provide actionable insights for drone manufacturers to prioritize design elements that balance functionality and aesthetics effectively. The findings suggest that integrating high-impact design features can enhance user satisfaction and align with contemporary consumer preferences. This research offers a comprehensive framework for future exploration of emerging technologies and diverse user needs, paving the way for innovation in drone design.

INTRODUCTION

With the rapid development of intelligent technology, drones, as an emerging intelligent device, have gradually been widely used in many fields. From logistics and transportation to film and television production, the technological progress of drones has provided users with unprecedented convenience and experience. In the tourism industry, drones have become an innovative shooting tool, providing tourists with a unique perspective and immersive experience. In this context, the appearance design of drones is no longer just a carrier for functional realization, but also a key factor affecting users' emotional experience and willingness to use.

In recent years, users' demand for the appearance design of drones has gradually shifted from practicality to a comprehensive consideration of aesthetics and emotional experience. Studies have shown that appearance design directly affects users' visual perception and emotional connection with products, and thus affects users' purchasing decisions. In the appearance design of drones, design elements such as shape, material, and color can not only enhance the market competitiveness of products, but also meet users' emotional needs, thereby improving user satisfaction (Custers, 2016).

This study aims to explore a design method based on Kansei Engineering and analyze the impact of different design elements in drone appearance design on user emotions. Through questionnaire surveys and data analysis, the intrinsic relationship between drone appearance design and user perception is revealed. The goal of this study is to provide theoretical support and design suggestions for the appearance design of drones to optimize user experience and enhance market competitiveness.

Research Background and Significance

Emotional needs in smart device design: As consumers have higher and higher requirements for smart devices, the design method of sensory engineering can transform users' emotional needs into specific design indicators, and has wide application potential in the appearance design of drones.

The rapid development of the drone market: The functional design of drones has matured, but the role of appearance design in market differentiation and user attraction is becoming more and more important.

Application of sensory engineering in the field of design: As a systematic design method, sensory engineering can help designers deeply understand user needs and provide scientific support for product appearance design.

This study will combine the theory of sensory engineering to analyze users' emotional needs for drone appearance, and provide a reference for the optimization and innovative design of future drone appearance.

LITERATURE REVIEW

As a multidisciplinary research field, the development of UAV appearance design not only depends on technological progress, but is also deeply influenced by design theory and user needs. In recent years, Kansei engineering has gradually become an important tool for optimizing product appearance design, and its application in UAV appearance design is of great significance. This section will discuss three aspects: the theoretical background of Kansei engineering, the application of design in UAV appearance design, and the key elements of UAV appearance design.

Concept and Application of Kansei Engineering

Kansei engineering is a design method based on user emotions and experience needs. It originated in Japan in the 1970s and has been widely used in automobiles, home appliances and other fields. Its core lies in converting users' emotional needs into quantifiable design parameters, thereby helping designers develop products that better meet users' expectations (Schütte* et al., 2004).

Kansei engineering uses tools such as semantic analysis and factor analysis to deeply explore users' perceived needs for product appearance. For example, in automobile design, Kansei engineering can help designers identify consumers' needs for "modernity" and "sportiness" for automobile appearance, thereby optimizing design elements such as shape, color, and material (Nagamachi, 1999a). In recent years, this method has also been widely used in electronic product design, such as smartphones and wearable devices (Nagamachi, 1999b).

However, in the design of drone appearance, there is relatively little research on sensory engineering, especially in terms of how to balance functionality and emotional needs. There is still a lot of room for research. This study hopes to explore how drone appearance design can meet the diverse needs of users through the theoretical framework of sensory engineering.

Application of Sensory Engineering in Drone Appearance Design

In the field of drone appearance design, sensory engineering can help designers transform users' emotional needs into design elements and optimize the visual impact and emotional appeal of products. As a smart device, the appearance design of drones is not only a reflection of engineering performance, but also needs to visually attract users and meet the needs of different usage scenarios.

Combination of Emotion and Function

The appearance design of drones needs to find a balance between functionality and emotional needs. For example, in response to consumers' pursuit of "futuristic" and "technological" feelings, sensory engineering can guide designers to choose streamlined design in the fuselage shape, while emphasizing the sense of technology in material and detail processing (Wojciechowska et al., 2019; Cureton, 2020).

Adaptation of Appearance Design to Usage Scenarios

Drones are used in a wide range of scenarios, including tourism photography, logistics and transportation, and industrial surveying. In different scenarios, users have different demands for appearance design. Studies have found that consumers prefer fashionable and lightweight designs in leisure and tourism scenarios, while they pay more attention to sturdiness and functionality in industrial scenarios (Lindlbauer et al., 2019).

User Grouping and Appearance Preference

Users can be grouped through sensory engineering methods. For example, individual consumers tend to choose small and portable drones, while commercial users pay more attention to high performance and professional appearance. Sensory engineering helps designers develop more targeted design solutions by quantitatively analyzing users' perception of appearance shape, color, and material (Lee & Koubek, 2011).

Optimization of Design Elements

The core elements of drone appearance design include body shape, wing design, material, and color. Sensory engineering can quantify the impact of these elements on user emotions through semantic difference experiments and factor analysis. For example, a lighter body and high-brightness color tend to make users think of "flexibility" and "modernity", while dark tones and metal materials convey "stability" and "professionalism" (Haftka & Gürdal, 2012).

Through the above analysis, Kansei Engineering can not only improve the scientific nature of UAV appearance design, but also help designers accurately meet the needs of different user groups and provide design support for the further development of the UAV market.

Key Elements of UAV Appearance Design

According to existing literature, UAV appearance design mainly includes the following key elements: shape, material, color and interactive interface.

Shape

Research shows that streamlined design can enhance the modern and technological sense of the product, while complex or bulky design may reduce the user's visual appeal (Sadraey, 2017).

Material

The material of the UAV not only affects its appearance, but is also directly related to the durability and user experience of the product. Lightweight and high-strength materials (such as carbon fiber and composite materials) are favored because they can enhance the high-end feel and ease of use of the product (Ramos, 2015).

Color

Color is an important factor that affects the user's first impression. Research has found that bright colors (such as silver and blue) are usually associated with "innovation" and "technology", while dark colors (such as black and gray) convey more "stable" and "professional" perceptions (Shi, 2023).

Interactive Interface

In the appearance design of UAVs, a simple and easy-to-use interactive interface is the key to improving user satisfaction. For example, by optimizing the layout and button design of the remote control, the user's operating experience can be significantly improved (Custers, 2016).

ESTABLISHMENT OF PRODUCT SAMPLE SPACE AND EXTRACTION OF DESIGN ELEMENTS

Determine the Research Field

This study takes the appearance design of drones as the main research object, focusing on the impact of shape, color and material on user perceived needs. Through market research, it is found that drones of different brands show significant differences in appearance design, material selection and functional application. In terms of color, most mainstream drones use calm tones such as black, white and gray, and a few products use bright blue or red to attract young users. In terms of material, drones generally use carbon fiber, composite materials or aluminum alloys, which not only improve the lightness and durability of the product, but also enhance the sense of technology and high-end.

Considering the diverse usage scenarios of drones, this study covers a variety of target groups such as consumer users, aerial photography enthusiasts and industrial users. Different user groups also have different focuses on the needs of appearance design. For example, ordinary consumers are more concerned about the portability and fashion sense of drones, while professional users give priority to the stability and functional integration of products.

By analyzing the market data in the past three years, it is found that the market size of consumer drones has continued to expand, especially reaching a historical high in 2020, indicating that users' acceptance and demand for drones are constantly increasing. In addition, the sales of drones with specific design elements increased significantly in 2022, indicating that the market demand for appearance optimization is increasing (Edmondson & McManus, 2007).

Product Sample Screening

In order to ensure the scientificity and pertinence of the research, this study conducted a comprehensive survey of drone products on the market. By analyzing the sales data and user reviews of major e-commerce platforms (such as Amazon, Tmall and JD.com), 200 representative drone products were initially screened. These products cover different brands, functions and appearance design features to ensure the diversity and richness of the samples (Petersen & Amstutz, 2025).

Subsequently, the Delphi method was used to further screen the preliminary samples. Under the guidance of 5 experts in the field of appearance design, 10 typical drone products were finally selected as research samples based on core design elements such as shape, color and material. These samples represent different market positioning from entry-level to high-end, covering a variety of design styles and user needs.

In order to reduce the interference of brand effect and color on user preferences, all samples in the study removed brand information and were uniformly adjusted to neutral tones. This method ensures that users can focus more on core design elements such as shape and material in the study.

During the sample screening process, the following design dimensions were focused on:

Color

Dark colors (such as black and gray) dominate, showing professionalism and stability; bright colors (such as blue and red) are more used to attract young users.

Material

Lightweight and high-strength materials (such as carbon fiber and composite materials) dominate, and some high-end products introduce aluminum alloy materials to enhance the texture.

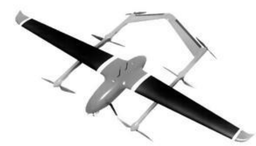
Shape

Streamlined drones are the mainstream due to their modernity and aerodynamic advantages, while wide-body designs are used for professional drones with higher functional requirements.
The typical samples screened can fully reflect market trends and design features, providing a reliable data basis for subsequent research.

Product sample classification

Through the screening and analysis of 86 drone samples, we further divided the samples into six main appearance types according to the appearance design characteristics of the drones. These categories focus on analyzing the appearance, material, color and other design elements of the drones to ensure that the design trends of drones in the current market are covered as shown in Table 1.

Table 1 Product Brochures

Sample Number	Figure	Sample Number	Figure
Sample 1		Sample 4	
Sample 2		Sample 5	
Sample 3		Sample 6	

Design Element Extraction of Smart Bracelets

The design elements of drones are divided into three categories: shape elements, material elements and color elements. The specific extracted design elements are shown in Table 2.

Table 2 Design Elements

Design Elements	Graphic Feature Analysis and Numbering
Drone Body	
Aspect Ratio	Elongated (A1), Balanced (A2), Compact (A3)
Outline	Streamlined (B1), Box-like (B2), Modular (B3)
Corners	Sharp (C1), Rounded (C2), Mixed (C3)
Shape	Square (D1), Rectangular (D2), Circular (D3), Polygonal (D4)

Thickness	Thin (E1), Medium (E2), Thick (E3)
Frame Design	Frameless (F1), Narrow Frame (F2), Wide Frame (F3)
Size	Large (G1), Medium (G2), Small (G3)
Propellers	
Type	Fixed (H1), Foldable (H2), Modular (H3)
Placement	Top-mounted (]1), Integrated (2), Side-mounted (]3)
Landing Gear	
Type	Fixed (K1), Retractable (K2), Skid-based (K3)
Material	
Drone Body	Carbon Fiber (L1), Composite Materials (L2), Aluminum (L3), Plastic (L4), Titanium（L5）
Propellers	Reinforced Plastic (M1), Aluminum Alloy (M2), Carbon Fiber (M3)
Landing Gear	Metal (N1), Rubber Coated (N2), Composite (N3)
Color	
Drone Body (Main Color)	Light (01), Dark (02)
Drone Body (Secondary Color)	Single Color (P1), Two-tone (P2), Gradient (P3)
Propellers	Solid Color (Q1), Patterned (Q2), Gradient (Q3)

PERCEIVED DEMAND MEASUREMENT AND TRANSFORMATION OF PERCEIVED DEMAND AND DESIGN ELEMENTS

Extraction of Perceptual Image Space

Perceptual Word Set

This study extracts perceptual words based on the design characteristics, user needs, functionality, emotional response, etc. of drones, and further screens and confirms them through the Delphi method, and finally formed a perceptual word set as shown in Table 3 (Marslen-Wilson & Warren, 1994).

Table 3 Perceptual Words Collection

Design Dimensions	Kansei Words
Form-Related Kansei Words	Aerodynamic, Modern, Balanced, Compact, Sleek, Functional
Material-Related Kansei Words	Durable, Lightweight, Premium, sturdy, Smooth, Advanced
Color-Related Kansei Words	Bold, Elegant, Futuristic, Professional, Vibrant, Neutral
Detail-Related Kansei Words	Minimalist, Cutting-edge, Ergonomic, User-friendly, Innovative

Next, the Delphi method was used to determine the final perceptual image space for drone design. We combined the final 8 perceptual words and their antonyms into contrasting perceptual image phrases to form a comprehensive perceptual image space: Aerodynamic - Inefficient, Modern - Outdated, Durable - Fragile, Compact - Bulky, Lightweight - Heavy, Futuristic - Conventional, Sleek - Clunky, Innovative - Ordinary. These contrasting pairs of words can be used to analyze users' emotional and perceptual responses to drone designs, aiding designers in making more informed and targeted decisions during the product development process.

Semantic Difference Experiment

We took the first drone sample as an example to construct the perceptual image evaluation and used the SD (Semantic Differential) experiment to establish the perceptual evaluation scale. A pair of perceptual words with opposite meanings were placed on the left and right ends of the scale. The subjects observed the drone sample image on the left and established their own perceptual evaluation based on the perceptual words and scoring criteria on the right. The scale was divided into 5 levels, from left to right: 2, 1, 0, -1, -2, where 2 points indicate "very left-leaning," 1 point indicates "relatively left-leaning," 0 points indicate "neutral," -1 point indicates "relatively right-leaning," and -2 points indicate "very right-leaning." The subjects scored each sample to express their intuitive preferences for the designs, as shown in Table 4.

A total of 150 subjects participated in this experiment, and 135 valid questionnaires were collected. These subjects were required to have experience using drones or a strong interest in drone-related applications such as aerial photography, logistics, or industrial inspections. Among them, 78 participants were male (about 57.8%), and 42 participants were female (about 31.1%). Regarding age distribution, 36 participants were aged 18-29 (26.7%), 54 participants were aged 30-39 (40.0%), 22 participants were aged 40-49 (16.3%), and 8 participants were over 50 years old (5.9%).

From the demographic data, we observe that the majority of participants were male, which aligns with the fact that drone usage often requires technical skills or specific operational experience, making it more popular among men. Additionally, the age distribution shows that individuals aged 30-39 formed the largest group, reflecting the professional and practical usage of drones among this demographic, such as for work-related tasks or advanced hobbies. This diversity in demographics ensures that the questionnaire data represents a broad spectrum of drone users, enhancing the credibility and validity of the experimental analysis and conclusions. Statistics of perceptual image evaluation results shown in Table 5.

Firstly, we used Cronbach's α reliability coefficient to assess the reliability and stability of the 135 collected questionnaires. In similar studies, a Cronbach's α value greater than 0.8 is generally considered to indicate good reliability. The reliability coefficient of this questionnaire was 0.844, indicating that the questionnaire and the collected data demonstrate good reliability.

Next, to ensure that there were no multicollinearity issues among the design elements, we performed a Variance Inflation Factor (VIF) test on all independent variables. VIF evaluates whether a particular independent variable can be linearly predicted by other independent variables. The calculated VIF values for the design elements in this study ranged from 1.376 to 4.135, all less than 5. This indicates that the correlation between these variables was low, and no significant multicollinearity issues were present. Therefore, each design element could independently influence users' perceptions of the innovation and functionality of the drones, ensuring the reliability of the results and the accuracy of interpretations.

Lastly, we imported the questionnaire data into Excel and used the average function to calculate the average score of each sample under each perceptual term, obtaining the statistical results of the perceptual image evaluation, as shown in Table 5 (Kolb, 2009; Schaeffer & Wallace, 1969).

Tablet 4 Perceptual Image Evaluation

	Perceptual Image	2	1	0	-1	-2	Opposite Image
	Modern	2	1	0	-1	-2	Outdated
	Aerodynamic	2	1	0	-1	-2	Inefficient
	Durable	2	1	0	-1	-2	Fragile
	Compact	2	1	0	-1	-2	Bulky
	Lightweight	2	1	0	-1	-2	Heavy
	Futuristic	2	1	0	-1	-2	Conventional
	Sleek	2	1	0	-1	-2	Clunky
	Innovative	2	1	0	-1	-2	Ordinary

Table 5 Statistics of Perceptual Image Evaluation Results

Sample Number	Modern Outdated	Aerodynamic Inefficient	Durable Fragile	Compact Bulky	Lightweight Heavy	Futuristic Conventional	Sleek Clunky	Innovative Ordinary
Sample1	0.542	0.294	0.606	0.341	0.342	0.588	0.313	0.322
Sample2	0.781	0.625	0.671	0.616	0.762	0.671	0.661	0.781
Sample3	0.735	0.735	0.643	0.570	0.643	0.671	0.441	0.661
Sample4	0.625	0.496	0.542	0.414	0.432	0.533	0.386	0.542
Sample5	0.496	0.368	0.643	0.423	0.230	0.579	0.386	0.359
Sample6	0.625	0.560	0.661	0.487	0.560	0.597	0.331	0.716

Factor Analysis of Perceptual Image Space

In order to improve the efficiency of analysis, it is usually necessary to simplify a large amount of data. Dimensionality reduction of image space is an effective simplification method. Factor analysis (FA) is a statistical method for quantitative analysis of possible variables. Through factor analysis, quantitative data in image space can be compressed into several main factors, and the number of nutrient factors that can explain the maximum amount of information can be found. In addition, the pigments of each factor in different image spaces can be compared, and finally the key factors in the image space can be identified, so as to understand and interpret the data more comprehensively (Vavra, 1972).

Software and Programs

After importing the statistical results into SPSSAU, we rotated them through factor analysis and applied the maximum angle rotation method to clarify the corresponding relationship between each factor and the perceptual image space. Finally, we can obtain the rotation angle explanation rate table, shown in Table 6, and the factor loading after rotation, shown in Table 7.

Table 6 Variance Explanation

Factor number	Initial Eigenvalues			Interpretation rate of variance before			Variance interpretation rate after rotation		
	Eigenvalues	Variance explained rate%	Accumulation%	Eigenvalues	Variance explained rate%	Accumulation%	Eigenvalues	Variance explained rate%	Accumulation%
1	4.701	58.740	58.740	4.701	58.740	58.740	4.701	58.740	58.740
2	0.870	10.766	69.396	0.8700	10.766	69.406	1.161	14.410	69.457
3	0.802	9.910	79.296	-	-	-	-	-	-
4	0.586	7.805	86 491	-	-	-	-	-	-
5	0.393	4.800	91.282	-	-	-	-	-	-
6	0.313	3.792	95.064	-	-	-	-	-	-
7	0.229	2.750	97.805	-	-	-	-	-	-
8	0.186	2.205	100.000	-	-	-	-	-	-

Table 7 Factor loadings After Rotation

Adjective	Factor 1 Loading	Factor 2 Loading	Common Factor Variance
Modern - Outdated	0.756	0.562	0.871
Aerodynamic-inefficient	0.792	0.433	0.800
Durable- Fragile	0.737	0.367	0.666
Compact-Bulky	0.796	0.465	0.835
Lightweight -Heavy	0.770	0.537	0.865
Futuristic - Conventional	0.738	0.442	0.727
Sleek - Clunky	0.781	0.687	1.063
Innovative-Ordinary	0.831	0.269	0.751

Factor Extraction

The core purpose of factor analysis is to extract common factors that can explain the structure of the factor model. Extracting too many factors could dilute the practical significance of factor analysis. According to the standard of factor extraction, factors with eigenvalues greater than 1 and cumulative contribution rates exceeding 85% are typically considered significant common factors (Auerswald & Moshagen, 2019).

Additionally, factor loadings reflect the correlation between factors and analysis items. When the absolute value of a factor loading exceeds 0.4, it indicates a significant corresponding relationship between the factor and the analysis item; if the value is below 0.4, the relationship is weak. According to the results in Table 7, under Factor 1, "Innovative - Ordinary" has the highest loading value of 0.831, indicating the strongest relevance. None of the loadings under Factor 1 are below 0.4, suggesting a strong corresponding relationship for all eight perceptual phrases.

For Factor 2, the phrase "Sleek - Clunky"has the highest loading value of 0.687, followed by "Durable-Fragile" at 0.367 and "Innovative-Ordinary" at 0.269. These lower loading values indicate weaker correlations with Factor 2 for some perceptual phrases.

According to Table 6, the variance explanation rate of Factor 1 after rotation is 58.740%, indicating that it explains most of the information and can be selected as the primary factor. However, based on expert opinion, a single factor may not fully reflect the multidimensional impact of design elements on user perception. Thus, the study further analyzed the number of retained factors using parallel analysis and scree plot assessments. It was decided to retain two factors, as the variance explanation rate of Factor 2 is 10.766%, bringing the cumulative variance explanation rate to 69.406%. By retaining these two factors, the study can more comprehensively explain the impact of different design elements on user perception.

Therefore, under Factor 1, "Innovative - Ordinary" was selected as the main item due to its highest loading value, and under Factor 2, "Sleek - Clunky" was chosen for the same reason.

File Format of Graphics

The corresponding transformation of design elements and perceptual image space can be divided into three main steps. First, assign a value to each design element for subsequent analysis. Second, analyze the partial correlation between design elements and perceptual vocabulary to determine the relationship between them. Finally, according to the correlation principle, reselect the appropriate number of design elements for further design optimization (Duce et al., 2002; Himsolt, 1997; Beddu et al., 2024).

Assignment

Based on the screened and coded design elements, different design element units were assigned to the 6 screened samples shown in Table 8 (a & b).

Table 8 Design Element Allocation (a)

Sample Number	Aspect Ratio (A)	Outline (B)	Comers (C)	Shape (D)	Thickness (E)	Frame Design (F)	Size (G)	Material (Body, L)
Sample 1	A1	B1	C1	D1	E1	F1.	G1	L1
Sample 2	A2	B2	C2	D2	E2	F2	G2	L2
Sample 3	A3	B3	C3	D4	E3	F3	G3	L3
Sample 4	A1	B1	C2	D3	E2	F1	G2	L4
Sample 5	A2	B2	C1	D4	E1	F3	G1	L5
Sample 6	A3	B3	C3	D1	E3	F2	G3	L3

Table 8 Design Element Allocation (b)

Sample Number	Material (Propeller, M)	Material (Landing Gear, N)	Main color (0)	Secondary Color(P)	Color Pattemn (Q)	Propeller Type(H)	Propeller Placement (J)	Landing Gear Type (K)
Sample 1	M1	N1	01	P1	Q1	H1	J1	K1
Sample 2	M2	N3	02	P2	Q3	H2	J3	K2
Sample 3	M3	N2	03	P3	Q2	H3	J2	K3
Sample 4	M2	N3	02	P2	Q3	H1	J1	K2
Sample 5	M1	N1	01	P3	Q1	H2	J2	K1
Sample 6	M3	N2	03	P1	Q2	H3	J3	K3

Partial Correlation Analysis

Using the design element allocation table in Table 8 as the analysis item and the perception word "innovation-ordinary" , "Sleek - Clunky" extracted from FA as the control variable, a partial correlation analysis was conducted in SPSSAU. The correlation between product design elements and the perception image space is shown in Table 9.

Table 9 Correlation Statistics Between Design Elements and Perceived Images

Design Elements	Innovative	Sleek
Aspect Ratio (A)	-0.101	0.112
Outline (B)	-0.567	-0.358
Comers (C)	0.0	0.032
Shape (D)	0.417	0.589
Thickness (E)	-0.733	-0.472
Frame Design (F)	0.079	0.581
Size (G)	-0.802	-0.623
Material (Body, L)	-0.224	0.541
Material (Propeller, M)	0.365	0.189
Material (Landing Gear, N)	0.333	0.262

Main Color (O)	-0.025	-0.208
Secondary Color (P)	-0.224	0.593
Color Pattern (Q)	-0.894	-0.714
Propeller Type (H)	-0.517	0.227
Propeller Placement (J)	-0.524	-0.466
Landing Gear Type (K)	0.345	0.254

RESULTS

According to the principle of correlation analysis, the correlation coefficient and correlation degree are classified as follows: when the absolute value of the correlation coefficient is less than 0.3, the correlation is considered irrelevant, and these design elements are eliminated in subsequent studies. Based on the table, design elements such as Rounded Corners (C) and Main Color (O) show correlation coefficients close to or below this threshold in both the "Innovative" and "Sleek" dimensions and are therefore excluded from further analysis.

For correlation coefficients between 0.3 and 0.5, the correlation is deemed weak. Design elements such as Propeller Placement (J) and Landing Gear Type (K), with absolute values falling in this range, are considered to have minimal but notable influence on user perception.

Correlation coefficients between 0.5 and 0.8 indicate a moderate correlation. Elements like Shape (D) and Material (Body, L) show moderate correlation in the "Sleek" dimension, highlighting their significant role in influencing this perception. Conversely, Frame Design (F) and Propeller Type (H) fall into this category under the "Innovative" dimension.

When the absolute value of the correlation coefficient is between 0.8 and 1.0, the correlation is considered strong. In this study, elements such as Aspect Ratio (A) and Thickness (E) in the "Sleek" dimension, and Propeller Type (H) in the "Innovative" dimension, exhibit strong correlation coefficients, making them the most influential in shaping user perception in their respective categories.

These categorizations guide the prioritization of design elements in subsequent analysis, ensuring focus on those with moderate to strong correlations while eliminating irrelevant ones.

DISCUSSION AND SUMMARY

This study analyzed the correlation between various design elements and their impact on the perception of innovativeness and stylishness in drone design. The findings provide valuable insights into how specific design features influence user perception, guiding future product development.

Key Insights on Innovativeness

Strong Correlation

Material (Body, -0.894): High-end materials, such as carbon fiber or lightweight composites, significantly enhance the perception of innovation, as they convey advanced technology and modernity.

Size (G, -0.802): Compact yet functional designs enhance user impressions of innovation, as they balance usability with cutting-edge aesthetics.

Moderate Correlation

Thickness (E, -0.733): Slimmer drone bodies are strongly associated with innovation, aligning with modern preferences for minimalism and advanced engineering.

Outline (B, -0.567): Streamlined and aerodynamic shapes improve the perception of innovation by creating a futuristic and modern impression.

Weak Correlation

Shape (D, 0.417): While geometric and unconventional shapes are seen as modern, their overall impact on innovativeness is limited.

Propeller Type (H, 0.365): Different propeller configurations contribute minimally to innovation, despite their functional importance.

Key Insights on Sleek

Strong Correlation

Material (Body, -0.714): Premium materials such as carbon fiber and titanium significantly enhance the perception of sleekness, reinforcing a high-quality and refined image. These materials convey sophistication and modernity, making the drone visually appealing.

Size (G, 0.623): Larger drones with bold and expansive designs are perceived as sleeker and more contemporary, resonating with user preferences for modern aesthetics and impactful designs.

Moderate Correlation

Shape (D, 0.589): Aerodynamic and streamlined forms contribute to the drone's sleekness, reflecting user preferences for designs that are both elegant and functional.

Frame Design (F, 0.581): Minimalist and narrow frame designs add a sense of sleekness by creating a refined and polished aesthetic.

Weak Correlation

Thickness (E, -0.472): Thinner designs slightly enhance the drone's sleekness, though their influence is less significant compared to other factors.

Main Color (O, -0.466): Darker tones suggest elegance and stability, while brighter colors add vibrancy and modernity. However, their overall impact on sleekness is secondary.

Implications for Design

The findings suggest that to maximize perceptions of innovativeness and sleek, designers should prioritize high-quality materials, streamlined outlines, and optimized size and thickness. While some elements, such as shape and color, contribute less to these perceptions, they still play a supporting role in enhancing overall user experience. By focusing on the elements with the strongest correlations, future drone designs can effectively align with user expectations and market trends, ensuring both functional excellence and aesthetic appeal.

CONCLUSION

This study analyzed the impact of various design elements on the perceived innovativeness and sleek of drones, providing valuable insights for design optimization. The findings highlight that advanced materials, optimized sizes, and streamlined outlines strongly enhance innovation and sleek, while secondary elements such as color and shape play supporting roles. Prioritizing these key design features can effectively align drones with user expectations, balancing functionality and aesthetics. Future research could explore emerging technologies and broader demographic preferences to further refine design strategies and enhance the appeal of drones in diverse markets.

REFERENCE

Auerswald, M., & Moshagen, M. (2019). How to determine the number of factors to retain in exploratory factor analysis: A comparison of extraction methods under realistic conditions. *Psychological Methods, 24*(4), 468–491. DOI: 10.1037/met0000200

Beddu, S., Ahmad, M., Kamal, N. L. M., Mohamad, D., Itam, Z., Min, Y. H., & Zailani, W. W. A. (2024). A State-of-the-Art Review of Hydronic Asphalt Solar Collector Technology for Solar Energy Harvesting on Road Pavement. In Proceedings of MATEC Web of Conferences (pp.1-21). EDP Sciences. DOI: 10.1051/matecconf/202440003007

Cureton, P. (2020). Drone Futures: UAS in Landscape and Urban Design. Routledge.

Custers, B. (2016). Drones here, there and everywhere: Introduction and overview. In B. Custers (Ed.), *The future of drone use* (pp. 1–18). Asser Press. DOI: 10.1007/978-94-6265-132-6_1
Duce, D., Herman, I., & Hopgood, B. (2002, March). Web 2D graphics file formats. Computer Graphics Forum, 21(1), 43–64. DOI: 10.1111/1467-8659.00565
Edmondson, A. C., & McManus, S. E. (2007). Methodological fit in management field research. Academy of management review, 32(4), 1246-1264. DOI: 10.5465/amr.2007.26586086
Haftka, R. T., & Gürdal, Z. (2012). Elements of structural optimization. Springer.
Himsolt, M. (1997). GML: A portable graph file format (Technical Report). Universität Passau.
Kolb, P. (2009, May). Experiments on the difference between semantic similarity and relatedness. In K. Jokinen & E. Bick (Eds.), NODALIDA 2009 Conference Proceedings (pp. 81–88). Universität Potsdam.
Lee, S., & Koubek, R. J. (2011). The impact of cognitive style on user preference based on usability and aesthetics for computer-based systems. International Journal of Human-Computer Interaction, 27(11), 1083-1114. DOI: 10.1080/10447318.2011.555320
Lindlbauer, D., Feit, A. M., & Hilliges, O. (2019, October). Context-aware online adaptation of mixed reality interfaces. In Proceedings of the 32nd annual ACM symposium on user interface software and technology (pp. 147-160). ACM Digital Library. DOI: 10.1145/3332165.3347945
Marslen-Wilson, W., & Warren, P. (1994). Levels of perceptual representation and process in lexical access: Words, phonemes, and features. *Psychological Review, 101*(4), 653–675.
Nagamachi, M. (1999). Kansei engineering and its applications in automotive design. SAE Transactions, 108(6), 2275–2282.
Nagamachi, M. (1999, October). Kansei engineering: The implication and applications to product development. In IEEE SMC'99 Conference Proceedings. In Proceedings of 1999 IEEE International Conference on Systems, Man, and Cybernetics (pp. 273–278). IEEE. DOI: 10.1109/ICSMC.1999.816439
Petersen, F., & Amstutz, R. (Eds.). (2025). Natural compounds as drugs. Birkhäuser.
Ramos, M. H. S. (2015, November). Construction and analysis of a lightweight UAV wing prototype [Master's thesis, Instituto Superior Técnico]. Instituto Superior Técnico.
Sadraey, M. (2017). Unmanned aircraft design: A review of fundamentals. Morgan & Claypool Publishers.
Schaeffer, B., & Wallace, R. (1969). Semantic similarity and the comparison of word meanings. Journal of Experimental Psychology, 82(2), 343-346. DOI: 10.1037/h0028287
Schütte*, S. T., Eklund, J., Axelsson, J. R., & Nagamachi, M. (2004). Concepts, methods and tools in Kansei engineering. Theoretical issues in ergonomics science, 5(3), 214-231. DOI: 10.1080/1463922021000049980
Shi, J. (2023, July). Application of color in appearance of agricultural UAV. In *Proceedings of the International Conference on Frontier Computing* (pp. 364–370). Springer.
Vavra, T. G. (1972). Factor analysis of perceptual change. Journal of Marketing Research, 9(2), 193-199. DOI: 10.1177/002224377200900212
Wojciechowska, A., Frey, J., Mandelblum, E., Amichai-Hamburger, Y., & Cauchard, J. R. (2019). Designing drones: Factors and characteristics influencing the perception of flying robots. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 3(3), 1-19. DOI: 10.1145/3351269