International Journal of Industrial Ergonomics 101 (2024) 103593

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

Revealing the synergy between formal aesthetics and product semantics: Exploring the impact of visual form on product perception

Frédérique N. Sunstrum [a,*], Oya Demirbilek [b], Nicole Gardner [b], Catherine Viengkham [c], Branka Spehar [d]

[a] Faculty of Design, Architecture and Building, University of Technology Sydney, Ultimo, NSW, Australia
[b] Faculty of Arts, Design and Architecture, University of New South Wales, Kensington, NSW, Australia
[c] Faculty of Medicine and Health, University of Sydney, Camperdown, NSW, Australia
[d] Faculty of Science, University of New South Wales, Kensington, NSW, Australia

ARTICLE INFO

Keywords:
Product perception
Formal aesthetics
Product semantics
Gestalt theory
Product personality
Industrial design

ABSTRACT

This study investigates the relationships between visual form attributes (height, shape, and curvature) and product perception, particularly exploring the dynamic interplay between formal aesthetics and product semantics. The challenge of effectively incorporating formal aesthetic characteristics into the design process is addressed by adopting Gestalt theory as a guiding framework. Drawing on the Gestalt principle of Prägnanz, this research investigates the role of primary visual attributes of form on perceived Complexity, Symmetry, Harmony, and Regularity of kettle images. A central aspect of this investigation is the recognition of a product's form, which possesses the potential to influence the symbolism associated with the product's personality traits attributed by users. To this end, the study aims to acquire deeper insights into the perception of familiarity, prototypicality, beauty, and attractiveness to comprehensively analyze the overall product perception while unravelling the underlying significance of emotional responses through the product's personality. The goal of this study is to deconstruct the form attributes exhibited by eight kettles of various designs. By doing so, we seek to understand how these form attributes synergistically contribute to creating a unified perceptual whole to convey a specific character or identity. The findings offer insights into the influence of form on a product's aesthetic perception and perceived personality and how form contributes to a product's symbolic meaning. By grasping the intricacies of product perception, designers can create products that cater to the diverse needs of different user groups, ultimately leading to increased market acceptance and commercial success.

1. Introduction

A product's aesthetics is an essential and complementary component of ergonomics (Liu, 2000). Product aesthetics, particularly a product's form, impacts how a product is identified, recognized, and explicitly classified (Bloch, 1995; Ching, 2014; Hekkert and Leder, 2008). From the moment users visually encounter a product, its form guides their initial impressions and establishes a sense of identity. The interplay between form and perception is complex, where subtle design changes can significantly impact user preferences and ultimately determine market success (Chumiran et al., 2021). The interplay has been of interest in psychology, marketing, and industrial design (Brunel & Kumar, 2007; Diego-Mas and Alcaide-Marzal, 2016; Govers and Schoormans, 2005), where Chumiran et al. (2021) underscores the essential need for designers to transform something from unstructured visual elements into a clearly defined, metaphorical, and explicit form.

Much like we attribute human-like characteristics to individuals, we instinctively project similar qualities onto objects based on their form. For example, a sports car may be associated with a sense of power, speed and success, leading individuals to perceive it as having a confident and ambitious personality. This personality, born from the interplay of form attributes, plays a crucial role in shaping our emotional connection with a product (Chowdhury et al., 2015; Govers and Schoormans, 2005).

Research by Valencia-Romero and Lugo (2016, 2017) demonstrates the tangible impact of form on user perception. Their studies reveal how even subtle adjustments to Gestalt principles of symmetry, parallelism, and continuity in 2-dimensional fragrance bottle silhouettes can significantly influence user preferences and product aesthetics. Similarly,

* Corresponding author.
E-mail address: frederique.sunstrum@uts.edu.au (F.N. Sunstrum).

https://doi.org/10.1016/j.ergon.2024.103593
Received 10 August 2023; Received in revised form 1 February 2024; Accepted 7 May 2024
Available online 17 May 2024

form attributes transcend aesthetics and convey deeper symbolic meanings influencing our judgments and emotional responses. For example, Chang (2008) found that consumers perceived rounded rectangular-shaped cameras as more comfortable. While Kapkın and Joines (2018) found that high curvature was perceived as safer and less serious. Their research further found that small changes in the degree of curvature in 2D and 3D product form significantly impact its meaning, while moderate changes led to confusion in its meaning, stressing that these changes should be designed carefully.

Understanding this intricate relationship is essential for designers seeking to create products that resonate with users' psychological needs. Drawing upon the established theoretical frameworks from Gestalt psychology and product semantics, this research bridges the gap between visual form and perception of product personality and symbolic meaning. By identifying the specific form attributes that contribute to distinct personalities and analyzing their influence on user experience, the study aims to understand the design language that shapes emotional responses.

1.1. Formal aesthetics and gestalt principles

The foundation of this research lies in the realm of formal aesthetics, specifically the captivating principles of Gestalt psychology. Formal aesthetics concerns how these forms are arranged and used to create a sense of order, unity and harmony, at a perceptual level to create aesthetic preference (Hekkert, 2014; Zuo and Jones, 2005). These forms are carefully selected and combined to create a product that is not only functional but also aesthetically pleasing (Te Vaarwerk et al., 2015). This framework provides a lens for understanding how individuals organize and interpret visual elements, offering valuable insights into a meaningful design language of form. The formal aesthetic principles included in the study were complexity, symmetry, harmony, and regularity (see Table 1).

When perceiving a product, form attributes, such as height, shape, and curvature, create a perceptual whole or overall design language. Central to Gestalt theory is the concept of Prägnanz (good form), which argues that individuals spontaneously group and interpret visual elements in terms of the most basic, simplest, and organized forms to understand them (Koffka, 1935; VandenBos, 2007). According to Corbett (2017), individuals use Gestalt principles to organize objects in memory to process stimuli efficiently.

Processing fluency refers to the ease and efficiency with which people process and understand information and can be comprised of perceived harmony, typicality, symmetry, and figure-ground contrast (Reber et al., 2004). Kumar and Garg (2010) revealed that the interaction between harmony and typicality significantly influences and emotionally impacts the evaluations of pleasantness. When an object is coded in a manner that creates a pleasing gestalt, it can be perceived as more beautiful (Kintsch, 2012). That is, when information is presented in a way that is easy to process, people tend to have more positive attitudes towards it, which is the essence of balance between complexity and order, where elements are perceived in their simplest, minimalistic form (Chou, 2011; Van Geert and Wagemans, 2023). Accordingly, Topolinski and Strack (2009) found that participants had a higher level of fluency in processing the objects with good Gestalt (coherency). The coherency creates a sense of harmony and balance that is pleasing to the eye and understood with less effort.

Table 1
Principles of visual perception.

Formal Aesthetic Principles	Explanation
Complexity	The level of detail present in the form influences user perception, with varying levels of complexity evoking different emotions and associations.
Symmetry	The balanced distribution of visual elements fosters a sense of order and stability, making products appear more aesthetically pleasing.
Harmony	The integration of different form attributes into a unified whole creates a sense of visual coherence and enhances aesthetic appeal.
Regularity	The repetition of patterns and geometric shapes contributes to a sense of order and predictability, evoking feelings of familiarity.

Wang and Hsu (2020) investigated symmetry, complexity, and shape in smartwatch interfaces and found that the visual elements influenced emotional arousal and valence. Additionally, Ke and Zou (2017) examined traditional Chinese porcelain vase shapes to quantify order in beauty, revealing a balance between symmetry, regularity and gradual change, including harmony and complexity. Understanding and addressing complexity is crucial for effective ergonomics solutions (Walker et al., 2010). Similarly, symmetry is considered an essential element of formal aesthetics, creating a sense of balance and harmony. Analyzing product form attributes within the context of complexity and symmetry can reveal insights into how design choices may introduce or mitigate complexities in product (or human-system) interactions.

Therefore, this study uses the Gestalt principle of Prägnanz as it provides a foundation and theoretical framework for formal aesthetics through good form. Accordingly, Ali and Liem (2014) argue that formal aesthetics and product semantics "can be used as a tool for analyzing and organizing form, but should be applied purposefully' (p. 517). The exploration of formal aesthetics becomes a crucial component of the frameworks of New Human Factors and cognitive ergonomics, a field dedicated to investigating the dynamics of cognitive processes to understand the emotions they evoke (Tosi, 2020). Understanding how formal aesthetics and good form influence product semantics can provide a more refined understanding of how a product is perceived.

1.2. Product semantics and symbolic meaning

While a product's aesthetics represent the first layer in the complexity of user perception, product semantics translates the design language of formal aesthetics into meaningful symbolic meaning and function and is how an object is communicated to the perceiver creating a language of expression (Chang, 2008; Krippendorff and Butter, 1984). That is, a product's form attributes, such as height, shape, and curvature, act as a symbolic design language that communicates certain qualities or characteristics through implicit cues, aiding in product anthropomorphism (Schoormans et al., 2010). These cues implicitly influence how consumers cognitively perceive, relate to, and attribute certain traits to products, informing how individuals make judgements (Pinson, 1986).

As product semantics reflects an individual's environment, experience and knowledge, the meaning and symbolism associated with the appearance of a product can influence the personality traits that individuals attribute to it, known as product personality (Burlamaqui and Dong, 2017; Chowdhury et al., 2015; You and Chen, 2003). Product personality refers to the visual features individuals use to describe and differentiate a specific product by attributing human characteristics to it (Govers, 2004, p. 190; Govers and Mugge, 2004; Mugge et al., 2009), and influences the emotional connection with the product (Govers and Schoormans, 2005; Karkun et al., 2018). For instance, Kuo et al. (2020) found that friendly, cute and traditional bicycle saddles increased the perceived emotional intensity in a multisensory study on vision and touch perception. Meanwhile, Wang and Zhou (2020) found that small and smart, and lovely and warm qualities, among others, were attractive and improved the likelihood of preference and satisfaction that contribute to the emotional needs of electric bicycle product forms. Mugge et al. (2009) developed a product personality scale by gathering descriptors from 48 participants assessing 12 products based on symbolic, utilitarian, or combined attributes. After refining through elimination and hierarchical clustering, they created a widely accepted 20-item scale, allowing logical alignment of products with personalities, validated for reliability by numerous scholars, demonstrating its

replicability.

The synergy between formal aesthetics (Gestalt principles) and product semantics lies in the fact that a product's visual and symbolic design language significantly influence and define the expressed product personality that shape the aesthetic emotion and product identity (Tyan-Yu et al., 2017). Gustav Johannes von Allesch (1922) argued that how an individual perceives and understands the aesthetic whole of an object or product is similar to how one becomes familiar with a person's personality. The relationship and connections between the individual elements of the product and the overall aesthetic 'whole' give the product its unique character and shapes the way it is viewed and understood (Carbon, 2019).

Mugge (2011) found that when confronted with uncertainty, individuals tend to make inferential judgments on a product's functional attributes based on a product's personality. Symbolic descriptors or traits are found to offer a more accurate depiction of the appearance of an object than a single-form description (Chang et al., 2006). For example, Min and Cunha (2019) found that 'competence' was a product trait consumers refer to when confronted with higher levels of purchasing risk. Accordingly, individuals are more motivated to pursue others (or products) that they find attractive and beautiful, associating positive personalities or stereotypes with them. For example, the perceived 'likeable' trait alone increased attractiveness (Nguyen et al., 2013; Reysen, 2005). Therefore, the relationship between the parts and the whole is essential in determining the meaning and significance of the object to create extrinsic value. Therefore, 'Competence' and 'likable' are important product traits that should be examined when investigating a product's personality as they are strong motivators for affective reactions and attitudes (Chowdhury et al., 2011; Kim, 2000).

Extrinsic value refers to external qualities that express the meaning of an object beyond its physical characteristics. These symbolic qualities, such as form attributes, are studied in Gestalt psychology and are known as tertiary/physiognomic properties. They include dynamic, expressive, and affective attributes that can add complexity to a product. As an example, the research conducted by Small et al. (2007) revealed that the absence of harmony was linked to attributes such as individuality, dynamism, toughness, masculinity, aggressiveness, and conflict. Understanding these qualities can inform industrial designers on how products are differentiated and used for evaluations to meet users' psychological needs. In Gestalt psychology, expressive (or symbolic) attributes are considered a central and pervasive component of our experiences across all sensory modalities and play a significant role in how individuals interact with the world. It assists in determining an individual's motivation and affective perceptions towards product attributes.

The study's significance lies in its exploration of how visual form attributes, particularly the impact of geometric shapes (i.e., height, shape, and curvature), synergistically serve as a reflection of a product's personality, leveraging insights from formal aesthetics and Gestalt theory to unveil the nuanced symbolic meanings embedded in product form. This knowledge not only enhances our understanding of the dynamic interplay between form and symbolism but also provides valuable guidance for designers aiming to create products that not only fulfil practical needs but also engage users on a profound and meaningful level within cognitive ergonomic research. The insights gained from this research contribute to the field's existing knowledge and hold significant implications not only for designers but marketers and psychologists aiming to understand how products captivate consumers on both an aesthetic and symbolic level.

2. Materials and methods

The current study combines the principles of formal aesthetics with product personality to investigate their connectedness. A product's shape can evoke different affective and emotional responses, contributing to its success (Hsiao and Chen, 2006). The aim is to deconstruct the primary visual form elements of eight commercial kettles in terms of Euclidean geometry to understand how a product's geometry combines to create a perceptual whole (Hallnäs, 2011, p. 76). The implication of the current study extends knowledge in revealing the symbolism associated with how product semantics is perceived through a product's formal aesthetics. *Furthermore*, understanding the implicit cues and symbolism can support the development of future conceptual models that industrial designers can consider within the design process.

The study was conducted through Millisecond's online testing lab, Inquisit Web 6 and is discussed in two parts. Part 1 included a basic demographic and gender identity questionnaire. Part 2 asked participants to evaluate the product on its formal aesthetic principles, followed by an evaluation of its product's personality. Discussion of the study's research procedures is as follows.

2.1. Participants

A total of 88 participants volunteered for the study (60 females; 27 males; 1 non-binary). The mean age of participant volunteers was 30 years, with a *SD* of 15.99 (62% between the ages of 18–34; 15% between 35 and 49; 15% between 50 and 64; 9% between 50 and 59, 10% over 65 years of age). The study assessed gender identity, in contrast to biological sex, using Bem's Sex Role Inventory (BSRI) identifying 18 androgynous, 20 feminine, 17 masculine, and 33 undifferentiated (Table 2). The participants applied to do the study via online recruitment channels and completed the study through the online testing lab Inquisit Web 6 b y Millisecond. The UNSW Human Research Ethics Advisory Panel approved the study procedures.

2.2. Stimuli

A total of 85 electric and stovetop kettles were collected from Google images. Each image was resized to fit on a plane 420 × 297 mm in size, with a 12.7 mm margin around the edge of the image. The next step was to categorize the kettles into dimensions. As a result, the kettles were grouped by their height (tall/short), shape (square/triangular), and curvature (angular/smooth), and one kettle was chosen for each category totaling to eight kettles for the study. Each kettle represented the physical attributes based on 2-Dimensional Euclidean geometry, where each kettle contains variations in height, shape, and curvature. Accordingly, each kettle was given a three-letter code where the first letter indicates whether the kettle was short (S) or tall (T). The second letter indicates its shape: square (S) or triangle (T), and the third letter indicates whether the kettle's curvature was less or more pronounced, angular (A) or smooth (S), respectively. The kettles chosen for this study can be seen in Fig. 1.

2.3. Research procedure

2.3.1. Demographic and gender identity questionnaire

To better understand the participants' backgrounds, the study began with a 2-min demographic questionnaire focusing on age, sex, and ethnicity. The participants then completed Bem's Sex Role Inventory (BSRI) to obtain the participants gender identity. In contrary to biological sex, gender identity shapes an individual's attitudes, behaviors, and personality traits that shape an individual's perceptions. Bem (1974) developed the BSRI to measure gender identity that categorized individuals as either feminine, masculine, androgynous (high on both feminine and masculine traits), or undifferentiated (low on both feminine and masculine traits).

2.3.2. Product personality likert scale

Part 2 consisted of the modified product personality scale by Mugge et al. (2009), comprising of 21-items and displayed on a 7-point Likert scale for each kettle image. 'Boring' and 'pretty' were removed from the original scale due to repetitiveness, and 'likable' and 'competent' were

Table 2
Participants by gender identity and biological sex, and age and ethnicity.

Gender Identity	Biological Sex				Ethnicity				
	Female	Male	Non-Binary	Total	Age Group	Caucasian	Other	Prefer not to say	Total
Androgynous	13	5	0	18	18–34	28	22	5	55
Feminine	13	6	1	20	35–49	10	3	0	13
Masculine	11	6	0	17	50–64	11	0	0	11
Undifferentiated	23	10	0	33	65+	9	0	0	9
Total	60	27	1	88	Total	58	25	5	88

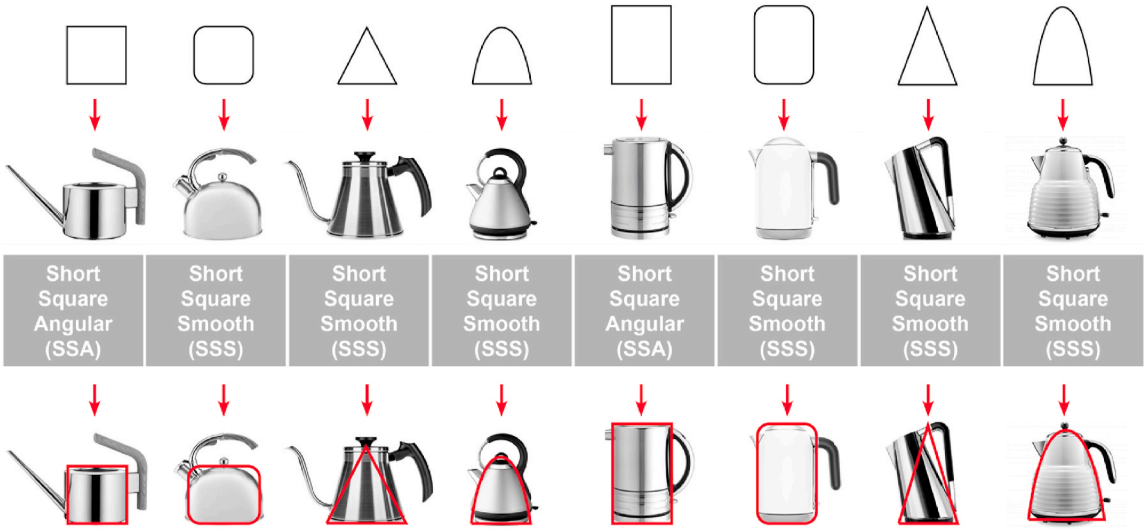

Fig. 1. Kettles chosen for study that dimensions of kettles in their categorization's primary visual elements.

added to the scale. 'Pretty' was removed as 'beauty' was measured instead. Similarly, 'boring' was removed as 'interesting' is measured on the same continuum and is included in the product personality scale. Instead, 'competence' and 'likable' were added to the scale. Finally, the adjective 'masculine' was also added to the scale to assess gender qualities. In addition, each kettle image is shown randomly on the left-hand side, simultaneously listing eight scales on the right-hand side of the screen.

2.3.3. Formal aesthetic semantic differential scale

Part 3 uses a semantic differential (SD) scale that aims to understand perceptual analysis of formal aesthetics using the Gestalt principle of Prägnanz. The perceptual analysis that is perceived as good form is implicit and perceived through the primary visual elements of the product. The Gestalt principle of Prägnanz was connected to the formal aesthetic principles of Complexity (simple–complex), symmetry (symmetrical–asymmetrical), Harmony (harmonious–inharmonious), and Regularity (regular–irregular) and measured using a 7-point semantic differential scale (as can be seen in Table 1). Beauty (beautiful–ugly), Attractiveness (attractive–unattractive), and Prototypicality (prototypical–atypical) were also added to the scale. Additionally, Familiarity (familiar–unfamiliar) was measured to investigate processing fluency. Each scale used the counter-balance approach to avoid the order-based bias.

3. Results and discussion

3.1. Product personality scale ratings and variation in form attributes

Using SPSS, a factor analysis was conducted to group product personality traits into dimensions within a principal component matrix. The principal component analysis yielded four dimensions corresponding to the big-five personality traits: *agreeableness*, *extroversion*, and *conscientiousness* (positive and negative) consistent with Govers (2004). The 'aloof' trait was eliminated from the analysis using the recommended factor loading of 0.5 (Hair, 2009). As a result, 19 items were evaluated and classified into one of the four dimensions (see Table 3). Gender identity revealed significant interaction effects on preference for the product's form attributes.

These dimensions were then analyzed using a 3-way ($2 \times 2 \times 2$) repeated measures ANOVA in Jamovi 1.8.1, with factors corresponding to the kettles' three main classification categories (Height, Shape, and Curvature). The two levels corresponding to each factor are short/tall (Height), square/triangle (Shape), and low/high (Curvature), which will allow the comparison of traits to the formal aesthetic principle scales using these dimensions (see Table 4 for results).

Agreeableness. The results suggest that perceived agreeableness traits (i.e., easy-going, relaxed, cute, likable, cheerful, open and modest) had a significant interaction with high curvature (Fig. 2a; $F_{1,\ 87} = 94.08$, $p < 0.001$), specifically when paired with short or square form attributes. In particular, androgynous participants rated high curvature kettles as slightly higher on agreeableness ($F_{1,\ 87} = 2.82$, $p = 0.044$) compared to other gender identities.

The significant interaction effects showed that short, triangular kettles were rated moderately higher on agreeableness than tall/triangular ones (Fig. 2b; $F_{1,\ 87} = 5.22$, $p = 0.025$). Also, short/high curvature kettles were rated higher on agreeableness than low curvature ones (Fig. 2c; $F_{1,\ 87} = 20.54$, $p < 0.001$) and square/high curvature kettles were rated higher on agreeableness than low curvature ones (Fig. 2d; $F_{1,\ 87} = 6.26$, $p = 0.014$).

Extroversion. Similar to agreeableness, perceived extroversion product personality traits (i.e., dominant, idiosyncratic, interesting, provocative, obtrusive, and lively) had a significant interaction with curvature, however, with low curvature kettles (Fig. 3a; $F_{1,\ 87} = 72.41$, p

Table 3
Principle component analysis of product personality adjectives using Varimax rotation method with Kaiser Normalization.

Variables	Agreeableness	Extroversion	Conscientious, Negative	Conscientious, Positive
Easy-going	0.898			
Relaxed	0.882			
Cute	0.880			
Likable	0.866			
Cheerful	0.855			
Open	0.834			
Modest	0.521			
Dominant		0.810		
Idiosyncratic		0.807		
Interesting		0.797		
Provocative		0.796		
Obtrusive		0.665		
Lively		0.658		
Childish			0.853	
Silly			0.848	
Untidy			0.830	
Serious				0.804
Competent				0.692
Honest				0.683

< 0.001). The results also showed that short kettles were rated, on average, more extroverted than tall kettles (Fig. 3b; $F_{1,\ 87} = 10.79$, $p = 0.001$) and triangular kettles were rated, on average, more extroverted than square ones (Fig. 3c; $F_{1,\ 87} = 57.82$, $p < 0.001$). Additionally, feminine identifying participants rated triangular kettles as slightly higher on extroversion than square kettles ($F_{1,\ 87} = 2.89$, $p = 0.04$).

A significant three-way interaction was also found to be significant (Fig. 3g; $F_{1,\ 87} = 21.54$, $p < 0.001$). This interaction showed that while low curvature kettles rated higher on extroversion than high curvature ones, this was more pronounced with triangular/short kettles. Still, this effect was more pronounced with tall/low curvature kettles, while tall/square and high curvature kettles rated lower on extroversion on average.

There were several significant two-way interactions for extroversion ratings between the above factors. The results revealed that tall/triangular and short/square kettles rated higher on extroversion (Fig. 3d; $F_{1,\ 87} = 51.71$, $p < 0.001$), short/high curvature were rated higher on extroversion (Fig. 3e; $F_{1,\ 87} = 24.94$, $p < 0.001$), and triangular/low curvature kettles were rated higher on extroversion (Fig. 3f; $F_{1,\ 87} = 7.92$, $p = 0.006$).

Conscientiousness, positive. The positive conscientiousness dimension (serious, competent, and honest) concerning kettles' shape, height, and curvature was similar to those for agreeableness. The main effects of Height, Shape, and Curvature on conscientiousness were insignificant. However, square kettles were rated slightly higher in positive conscientiousness than triangular kettles, mainly when they had high curvature (Fig. 4a; $F_{1,\ 87} = 7.18$, p = 0.009). Short/high curvature kettles were also rated higher in positive conscientiousness than those with low curvature, while the opposite was found for tall kettles (Fig. 4b; $F_{1,\ 87} = 12.98$, $p < 0.001$). Additionally, the tendency for square kettles to be rated higher in positive conscientiousness than triangular ones ($F_{1,\ 87} = 14.37$, $p < 0.001$) was more pronounced for tall kettles (Fig. 4c; $F_{1,\ 87} = 6.06$, p = 0.016).

Conscientiousness, negative. The results for the negative conscientiousness dimension (childish, silly, and untidy) were significantly affected by the factors of kettle Height (Fig. 5a; $F_{1,\ 87} = 6.12$, $p = 0.015$) and Shape (Fig. 5b; $F_{1,\ 87} = 21.31$, $p < 0.001$). On average, short kettles were rated slightly higher on negative conscientiousness than tall kettles, and triangular kettles were rated higher on negative conscientiousness than square ones.

There were also significant 2-way interactions, which further influenced the ratings. Specifically, square/tall kettles rated moderately lower on negative conscientiousness (Fig. 5c; $F_{1,\ 87} = 4.91$, $p = 0.029$), while short/low curvature kettles were rated higher on negative conscientiousness than tall/low curvature kettles (Fig. 5d; $F_{1,\ 87} = 18.76$, $p < 0.001$). Height and Shape were also slightly significant ($F_{1,\ 87} = 2.79$, $p < 0.046$) where tall and triangular kettles were perceived as moderately higher on negative conscientiousness by all but masculine participants, while masculine participants rated short, triangular kettles as negatively conscientious, and undifferentiated participants rated tall, square kettles as less negatively conscientious.

Masculinity. The results suggest that perceived masculinity had a significant interaction with height ($F_{1,\ 87} = 22.06$, $p < 0.001$) where tall kettles were perceived as more masculine than short kettles (Fig. 6a). Similarly, low curvature kettles were rated higher as masculine than high curvature kettles (Fig. 6b; $F_{1,\ 87} = 84.98$, $p < 0.001$). Finally, a moderate interaction was found where triangular kettles with high curvature were rated as less masculine overall (Fig. 6c; $F_{1,\ 87} = 7.49$, $p = 0.008$).

3.2. The effect of visual form attributes on the formal aesthetics ratings

The study found that the ratings of formal aesthetics attributes (regularity, harmony, symmetry, and complexity), as well as ratings of attractiveness, beauty, familiarity, prototypicality, and masculinity, were significantly influenced by the factors of height, shape and/or curvature of kettles. Table 5 illustrates the interactions of these semantic differentials in the three-way repeated measures ANOVA.

3.3. Correlations between individuals' ratings on scales

Pairwise correlations between each product personality dimension and formal aesthetic scales were conducted individually for every participant across all kettles. These correlations were then averaged to show the degree of correlation between the scales individually. For example, a high average correlation between two scales indicates that participants rated kettles high on one scale and similarly rated high on the other. The pairwise correlations into three sections: formal aesthetic correlations, product personality correlations, and correlations between formal aesthetics and product personality dimensions.

3.3.1. Formal aesthetic semantic differential scale correlations

The results of the pairwise correlations of formal aesthetic correlations can be found in Fig. 7. Harmony was strongly positively correlated with prototypicality, $r\ (86) = 0.55$, $p < 0.001$, familiarity, $r\ (86) = 0.44$, $p < 0.001$, and moderately with complexity, $r\ (86) = 0.27$, $p < 0.001$, which suggests that harmonious perceived kettles were also perceived as prototypical, familiar, and more simple. Attractiveness strongly correlated with harmony, $r\ (86) = 0.55$, $p < 0.001$, beauty, $r\ (86) = 0.73$, $p < 0.001$, and prototypicality, $r\ (86) = 0.52$, $p < 0.001$, which suggests that

Table 4
Three-way repeated measures ANOVA of product personality Likert scale.

Dimension	Form Attribute	Mean	F	p	η_p^2
Agreeableness	height	1.94	1.85	0.177	0.021
	shape	0.47	0.48	0.490	0.005
	curvature	162.78	94.08	<0.001***	0.520
	height * shape	4.78	5.22	0.025*	0.57
	height * curvature	10.71	20.54	<0.001***	0.067
	shape * curvature	4.69	6.26	0.014*	0.191
	height * shape * curvature	0.25	0.22	0.638	0.003
Extroversion	height	8.91	10.79	0.001**	0.110
	shape	44.74	57.82	<0.001***	0.399
	curvature	144.68	72.41	<0.001***	0.454
	height * shape	66.19	51.71	<0.001***	0.373
	height * curvature	16.13	24.94	<0.001***	0.223
	shape * curvature	5.047	7.92	0.006*	0.083
	height * shape * curvature	21.05	21.54	<0.001***	0.198
Conscientiousness (Pos)	height	2.00	2.04	0.156	0.023
	shape	9.33	14.37	<0.001***	0.142
	curvature	1.74	0.9	0.408	0.008
	height * shape	7.17	6.058	0.016*	0.065
	height * curvature	9.46	12.98	<0.001***	0.130
	shape * curvature	5.41	7.18	0.009*	0.076
	height * shape * curvature	2.16e-4	2.57e-4	0.987	0.000
Conscientiousness (Neg)	height	8.71	6.12	0.015*	0.066
	shape	21.23	21.31	<0.001***	0.197
	curvature	2.86	1.05	0.309	0.012
	height * shape	7.024	4.91	0.029*	0.053
	height * curvature	21.46	18.76	<0.001***	0.177
	shape * curvature	0.89	0.96	0.329	0.011
	height * shape * curvature	4.61	6.67	0.059	0.040
Masculinity	height	33.25	22.06	<0.001***	0.202
	shape	7.57	3.40	0.069	0.038
	curvature	339.66	84.98	<0.001***	0.494
	height * shape	2.63	1.71	0.195	0.019
	height * curvature	2.39	1.57	0.213	0.018
	shape * curvature	7.16	7.49	0.008*	0.079
	height * shape * curvature	7.16	4.29	0.041	0.047

participants that rated the kettle as attractive also rated it as harmonious, beautiful, and prototypical. Beauty also strongly positively correlated with harmony, $r\,(86) = 0.59, p < 0.001$, and prototypicality, $r\,(86) = 0.47$, $p < 0.001$, and moderately correlated with familiarity, $r\,(86) = 0.29$, $p < 0.001$, which indicates that individual perceptions of beautifully perceived kettles corresponded with being more harmonious, familiar, and prototypical. The perception of harmony, attractiveness, and beauty suggests that the visual elements are balanced and visually coherent, indicating that kettles with these visual elements possess appealing attributes that elicit positive emotional responses from consumers.

Similarly, regularity strongly correlated with prototypicality, $r\,(86) = 0.57$, $p < 0.001$; and familiarity, $r\,(86) = 0.56$, $p < 0.001$; suggesting that individuals perceived regular kettles as more prototypical and familiar. While complexity moderately correlated with perceived regularity, $r\,(86) = 0.45$, $p < 0.001$; and symmetry, $r\,(86) = 0.44$, $p < 0.001$, suggesting that regular kettles were perceived as more simple and symmetrical.

Additionally, prototypicality also positively correlated with familiarity, $r\,(86) = 0.44$, $p < 0.001$; complexity, $r\,(86) = 0.27$, $p < 0.001$, and symmetry, $r\,(86) = 0.31$, $p < 0.001$, suggesting that kettles perceived as prototypical were also perceived as more familiar, simple, and symmetrical. The perception of prototypicality implies that these kettles align with expected or traditional design standards within the context of kettles, making them recognizable and familiar to consumers. Familiarity was found to have moderate positive correlations with complexity, $r\,(86) = 0.45$, $p < 0.001$, and symmetry, $r\,(86) = 0.32$, $p < 0.001$. This result suggests that individuals who rated kettles as familiar also perceived them as less complex and symmetrical.

The findings revealed a relationship between attractiveness ratings and perceptions of beauty and prototypicality, while kettles rated as beautiful were highly perceived as regular and harmonious. Kettles that align with these expectations or norms for kettle designs are more likely to be seen as typical or representative of the product category. This relationship has always been meaningful for industrial designers to consider when creating new products, as deviating too far from the expected norms might impact consumer acceptance, aligning with the Most Advanced, Yet Accepted (MAYA) principle by Raymond Loewy (1951), perceptual fluency (Reber et al., 2004), and mere exposure paradigm and maximum effect for minimum means (Hekkert, 2006; Kumar and Garg, 2010).

3.3.2. Product personality likert scale correlations

The results of the pairwise correlations of personality dimensions can be found in Fig. 8, and suggests that individual perceptions of agreeableness correlate to positive conscientiousness, $r\,(86) = 0.44$, $p < 0.001$, and slightly correspond with extroversion, $r\,(86) = 0.13$, $p < 0.001$. While negative conscientiousness positively correlated with extroversion, $r\,(86) = 0.35$, $p < 0.001$, and slightly negatively correlated with positive conscientiousness, $r\,(86) = -0.12$, $p = 0.002$. Extroversion was strongly correlated with high ratings of masculinity, $r\,(86) = 0.46$, $p < 0.001$, as well as moderately with positive conscientiousness, $r\,(86) = 0.23$, $p < 0.001$, and negative conscientiousness, $r\,(86) = 0.35$, $p < 0.001$, indicating that individuals perceived these product personalities as masculine. No correlation was found between agreeableness product personality and negative conscientiousness, $r\,(86) = 0.00$, $p = 0.912$, or masculinity, $r\,(86) = -0.02$, $p = 0.518$.

3.3.3. Correlations between formal aesthetics and product personality dimensions

Correlations between formal aesthetics and product personality dimensions can be found in Fig. 9. The study found that the agreeableness and positive consciousness perceived product personalities were correlated and perceived as more attractive, beautiful, harmonious, and prototypical. Whereas, extroversion and negative consciousness perceived product personalities were perceived as irregular, inharmonious, atypical, and unfamiliar. These associations indicate that certain visual elements in kettles are linked to specific aesthetic perceptions that can evoke symbolic qualities and contribute to the overall impression of the kettles and will be discussed in more detail.

Accordingly, kettles perceived as attractive were strongly correlated with agreeableness, $r\,(86) = 0.55$, $p < 0.001$, and positive conscientiousness, $r\,(86) = 0.35$, $p < 0.001$. Whereas, extroversion slightly correlated with attractiveness, $r\,(86) = 0.14$, $p = 0.002$. On the other hand, unattractive perceived kettles were correlated with high negative

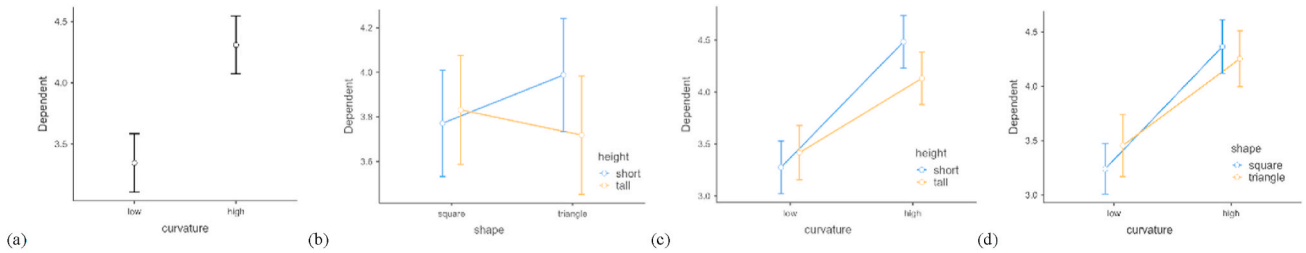

Fig. 2. Illustrates the plotted estimated marginal means for the perceived agreeableness product personality dimension, where the significant interactions were (a) Curvature, (b) Shape and Height, (c) Height and Curvature, and (d) Curvature and Shape.

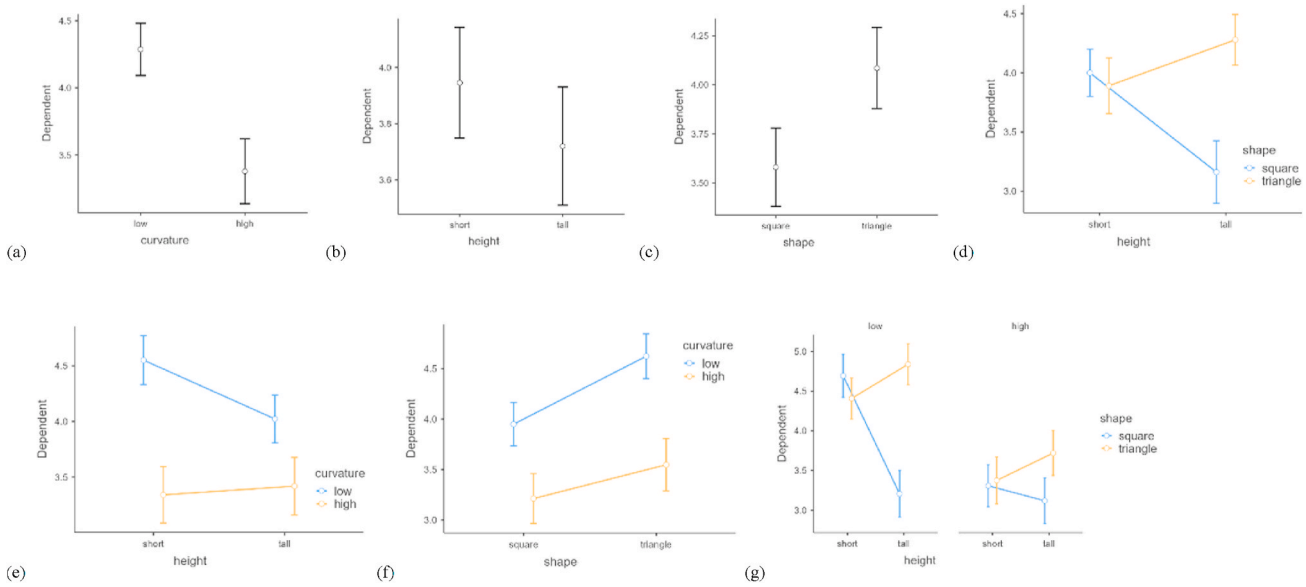

Fig. 3. Illustrates the plotted estimated marginal means for the perceived extroversion product personality dimension, where the significant interactions were (a) Curvature, (b) Height, (c) Shape, (d) Height and Shape, (e) Height and Curvature, (f) Shape and Curvature, and (g) Height, Shape, and Curvature.

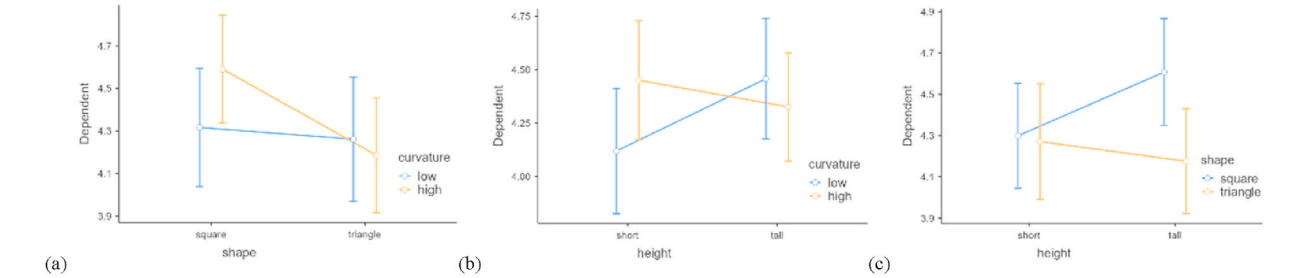

Fig. 4. Illustrates the plotted estimated marginal means for the perceived positive conscientiousness product personality dimension, where the significant interactions were (a) Shape and Curvature, (b) Height and Curvature, and (c) Height and Shape.

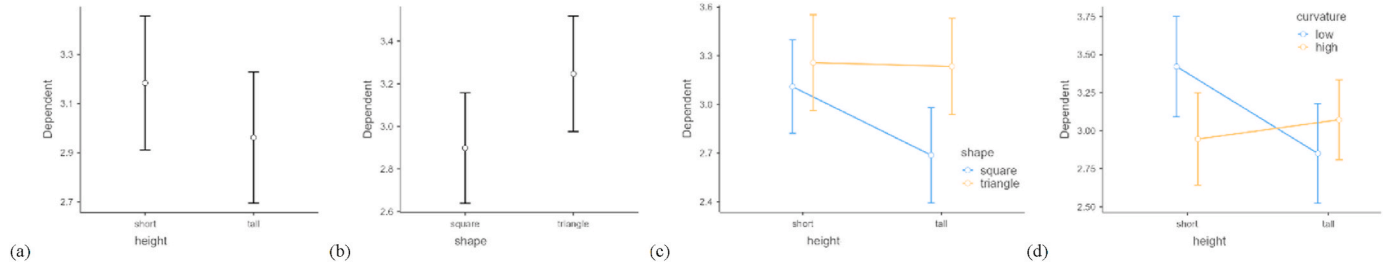

Fig. 5. Illustrates the plotted estimated marginal means for the perceived negative conscientiousness product personality dimension, where the significant interactions were (a) Height, (b) Shape, (c) Height and Shape, and (d) Height and Curvature.

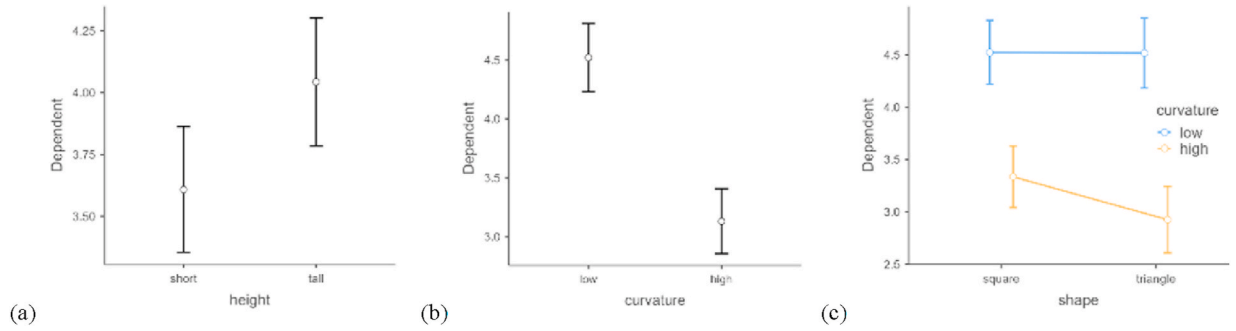

Fig. 6. Illustrates the plotted estimated marginal means for perceived masculinity, where the significant interactions were (a) Height, (b) Curvature, and (c) Shape and Curvature.

conscientiousness, r (86) = −0.18, $p < 0.001$. Ratings of beauty were also strongly correlated with the product personality dimensions of agreeableness, r (86) = 0.49, $p < 0.001$, and positive conscientiousness, r (86) = 0.31, $p = 0.001$, which suggests that agreeable perceived kettles were rated as harmonious and prototypical. In contrast, negative conscientiousness perceived product personality (i.e. childish, silly and untidy) were negatively correlated with beauty, r (86) = −0.19, $p < 0.001$, suggesting these perceived characteristics were rated as slightly ugly. Kettles rated highly as regular were strongly correlated with high agreeableness, r (86) = 0.40, $p < 0.001$, and positive conscientiousness, r (86) = 0.28, $p < 0.001$. While kettles rated as irregular were correlated with high extroversion, r (86) = −0.30, $p < 0.001$ and slightly correlated with negative conscientiousness, r (86) = −0.10, $p = 0.008$.

Kettles rated as harmonious correlated with agreeableness, r (86) = 0.41, $p < 0.001$, and positive conscientiousness, r (86) = 0.29, $p < 0.001$. On the other hand, kettles rated as inharmonious slightly correlated with extroversion, r (86) = −0.09, $p = 0.017$, and slightly correlated with negative conscientiousness, r (86) = −0.28, $p < 0.001$. The absence of harmony can be argued to be linked to triangular kettles which were associated with the negative conscientiousness dimension. This attribution of inharmonious perception can stem from triangular kettles' angular and edgy nature, which could be seen as less visually balanced. The association with negative conscientiousness suggests these kettles might be perceived as unconventional or nonconforming.

Prototypical perceived kettles were strongly correlated with high agreeableness, r (86) = 0.48, $p < 0.001$, and positive conscientiousness dimensions, r (86) = 0.32, $p < 0.001$. The perception of prototypicality implies that these kettles align with expected or traditional design standards within the context of kettles, making them recognizable and familiar to consumers. In contrast, atypical perceived kettles were marginally correlated with extroversion, r (86) = −0.08, $p = 0.028$, and negative conscientiousness, r (86) = −0.23, $p < 0.001$.

Moreover, kettles rated as familiar had positive correlations with the product personality dimensions of agreeableness, r (86) = 0.32, $p < 0.001$, and positive conscientiousness, r (86) = 0.15, $p < 0.001$. On the other hand, kettles rated as unfamiliar had positive correlations with the product personality dimensions of extroversion, r (86) = −0.37, $p < 0.001$, and negative conscientiousness, r (86) = −0.19, $p < 0.001$. While rated as unfamiliar, extroversion and negative conscientious product personalities were associated with short, low curvature kettles and were also perceived as more masculine, irregular, and asymmetrical. The perception of irregularity, unfamiliarity, and asymmetry in these kettles indicates that they deviate from typical or expected design standards and can suggest that they are perceived as more distinctive or unconventional. The association with extroversion might be due to the kettles' less formal and approachable appearance. In contrast, the association with negative conscientiousness suggests they may be perceived as less reliable or orderly.

Complexity revealed a correlation between kettles rated as complex and high levels of extroversion, r (86) = −0.34, $p < 0.001$, and negative conscientiousness, r (86) = −0.18, $p < 0.001$, while kettles rated as simple slightly correlated with high levels of agreeableness, r (86) = 0.13, $p < 0.001$. Finally, ratings of symmetry showed a correlation between symmetrical kettles and high levels of agreeableness, r (86) = 0.25, $p < 0.001$, and positive conscientiousness, r (86) = 0.21, $p < 0.001$, while asymmetrical kettles correlated with high levels of extroversion, r (86) = −0.18, $p < 0.001$, and slightly with negative conscientiousness, r (86) = −0.12, $p < 0.002$.

3.4. Summary of results

The findings from the study provide valuable insights into the relationship between a product's physical attributes and its perceived personality and good form. These insights can be generalized and used as a foundation for designing a wide range of products by considering how specific design elements influence user perceptions. Designers can apply short and high curvature attributes to products when aiming for associations with agreeableness, positive conscientiousness, attractiveness, beauty, harmony, and prototypicality. This design approach may be suitable for products where a friendly and conscientious image is desirable, such as household appliances or personal gadgets. Products rated highly on attractiveness were also perceived as beautiful and prototypical, and there was a positive correlation between beauty, regularity, and harmony. Designers may prioritize elements that contribute to attractiveness, as it seems to positively influence perceptions of beauty and prototypicality. While emphasizing regularity and harmony can further enhance the overall appeal.

Products with short and low curvature may be suitable for those targeting extroversion and negative conscientiousness dimensions. However, it's important to note that these attributes may be associated with perceptions of unfamiliarity, irregularity, and asymmetry. This design may be effective for products meant to stand out, attract attention, or appeal to individuals who appreciate unconventional and unique designs. Whereas, triangular shapes are perceived as inharmonious and may be associated with negative conscientiousness. This suggests that this shape may not be universally appealing. Designers might consider using triangular shapes sparingly and in contexts where a bold, unconventional aesthetic is acceptable or desired. However, further research on triangular products is needed.

Tall, square shapes were not specifically associated with a product's personality, but they were perceived as regular, prototypical, familiar, simple, and symmetrical, illustrating elements of good form. This design approach may be ideal for products that aim to convey a traditional, conventional, and reliable image. The perceived regularity, simplicity, and symmetry suggest a classic, straightforward design suitable for those seeking timeless and dependable products.

The findings provide a nuanced understanding of how specific design attributes influence perceived personality and good form. Designers can leverage this information to create products tailored to specific target audiences, considering factors like personality traits, aesthetic

Table 5
Three-Way repeated measures ANOVA of semantic differential scale.

Dimension	Form Feature	Mean	F	p	η_p^2	Findings
Complexity	height	17.82	9.15	0.003*	0.095	Square perceived as simpler
	shape	100.51	40.34	<0.001***	0.317	Tall perceived as simpler
	curvature	248.19	71.48	<0.001***	0.451	High curvature perceived as simpler
	height * shape	140.05	53.16	<0.001***	0.379	Tall, square perceived as simpler than tall, triangular
	height * curvature	60.28	28.20	<0.001***	0.245	Short, high curvature perceived as simpler, compared to short, low curvature
	shape * curvature	12.02	9.76	0.002**	0.101	Square, high curvature perceived as simpler than triangular, low curvature
	height * shape * curvature	0.57	0.21	0.647	0.002	NS
Symmetry	height	13.64	4.35	0.040	0.048	NS
	shape	54.57	29.97	<0.001***	0.253	Square perceived as more symmetrical
	curvature	174.01	59.84	<0.001***	0.408	High curvature perceived as more symmetrical
	height * shape	112.96	46.24	<0.001***	0.347	Tall, square perceived as more symmetrical compared to tall, triangular
	height * curvature	8.20	5.09	0.027*	0.055	Short, low curvature perceived as asymmetrical compared to tall, high curvature
	shape * curvature	22.55	9.37	0.003*	0.097	Square, high curvature perceived as more symmetrical compared to triangular, low curvature
	height * shape * curvature	23.27	10.59	0.002**	0.108	Tall, triangular perceived as asymmetrical, yet more pronounced with low curvature
Harmony	height	13.64	3.59	0.061	0.040	NS
	shape	4.78	2.67	0.106	0.030	NS
	curvature	129.55	35.09	<0.001***	0.287	High curvature perceived as more harmonious
	height * shape	15.36	8.131	0.005*	0.085	Tall, triangular perceived as more inharmonious
	height * curvature	21.84	10.99	0.001**	0.112	Short, high curvature perceived as more harmonious
	shape * curvature	1.45	0.96	0.330	0.011	NS
	height * shape * curvature	1.28	0.477	0.491	0.005	NS
Regularity	height	22.51	7.94	0.006*	0.084	Tall perceived as more regular
	shape	102.02	61.33	<0.001***	0.413	Square perceived as more regular
	curvature	451.84	149.52	<0.001***	0.632	High curvature perceived as more regular
	height * shape	211.64	88.90	<0.001***	0.505	Tall, square perceived as more regular than tall triangular
	height * curvature	53.46	31.37	0.025*	0.265	Short, high curvature perceived as more regular Short, low curvature perceived as more irregular
	shape * curvature	0.21	0.09	0.771	0.001	NS
	height * shape * curvature	8.64	4.91	0.029*	0.053	Tall, square perceived as more regular, but more pronounced with high curvature.
Attractiveness	height	25.51	9.36	0.003*	0.097	Short perceived as more attractive
	shape	0.05	0.03	0.861	0.000	NS
	curvature	81.82	22.30	<0.001***	0.204	High curvature perceived as perceived as more attractive
	height * shape	8.68e-30	2.57e-30	1.000	0.000	NS
	height * curvature	45.01	20.13	<0.001***	0.188	Short, high curvature perceived as perceived as more attractive than tall, high curvature.
	shape * curvature	0.28	0.17	0.682	0.002	NS
	height * shape * curvature	14.20	4.65	0.034	0.034	NS
Beauty	height	29.46	9.00	0.004*	0.094	Short perceived as more beautiful
	shape	0.82	0.43	0.515	0.005	NS
	curvature	56.82	13.24	<0.001***	0.132	High curvature perceived as more beautiful
	height * shape	1.28	0.46	0.500	0.005	NS
	height * curvature	47.05	25.55	<0.001***	0.227	Short, high curvature perceived as more beautiful than short, low curvature
	shape * curvature	6.19	4.24	0.043	0.046	NS
	height * shape * curvature	21.84	6.78	0.011*	0.072	Short, square and triangular, high curvature perceived as more beautiful
Prototypicality	height	0.07	0.03	0.863	0.000	NS
	shape	17.50	6.79	0.011*	0.072	Square perceived as more prototypical
	curvature	137.39	34.32	<0.001***	0.283	High curvature perceived as more prototypical
	height * shape	44.50	20.26	<0.001***	0.189	Tall, square perceived as more prototypical than tall, triangular
	height * curvature	45.51	32.69	<0.001***	0.273	Short, high curvature perceived as more prototypical than short, low curvature
	shape * curvature	2.39	2.03	0.158	0.023	NS
	height * shape * curvature	0.41	0.15	0.701	0.002	NS
Familiarity	height	0.36	0.137	0.713	0.002	NS
	shape	23.27	12.25	<0.001***	0.123	Square perceived as more familiar
	curvature	501.19	136.77	<0.001***	0.611	High curvature perceived as more familiar
	height * shape	194.46	93.19	<0.001***	0.517	Tall, square perceived as more familiar compared to tall, triangular
	height * curvature	50.21	41.48	<0.001***	0.323	Short, high curvature perceived as more familiar compared to short, low curvature
	shape * curvature	12.02	8.44	0.005*	0.088	Square, high curvature perceived as more familiar than square or triangular, low curvature
	height * shape * curvature	31.96	16.60	<0.001***	0.160	Tall, square perceived as more familiar, yet more pronounced with high curvature

Notes: Significance of correlations are represented as $p \leq 0.001$ (***), 0.002 (**), 0.033 (*), and NS = a non-significant result.

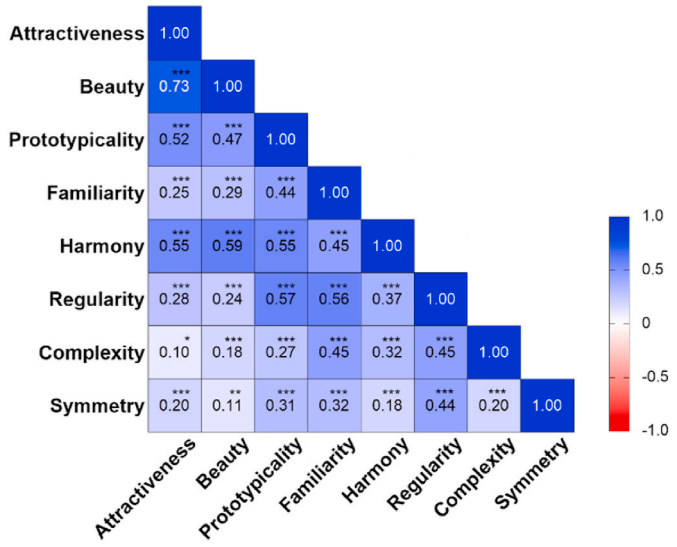

Fig. 7. Illustrates the correlations between the formal aesthetic ratings. Notes: The bar on the right illustrates the pairwise correlations of each rating, where 1.0 indicates a significant positive correlation, −1.0 indicates a significant negative correlation, and 0 indicates no correlation. Significance of correlations are represented as p ≤ 0.001 (***), 0.002 (**), 0.033 (*), 0.12 (ns).

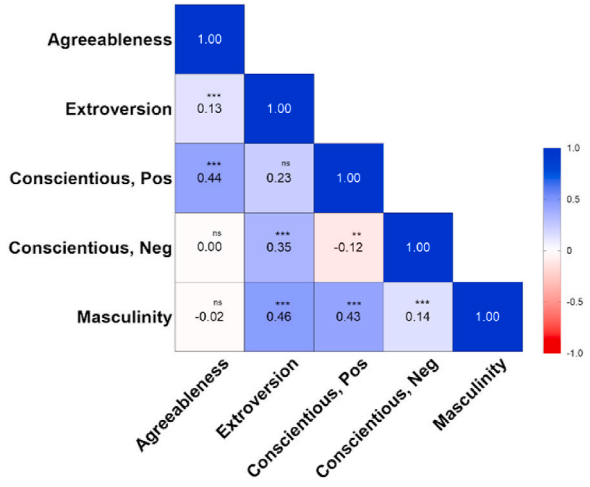

Fig. 8. Illustrates the correlations between the product personality dimensions and masculinity ratings. Notes: Significance of correlations are represented as p ≤ 0.001 (***), 0.002 (**), 0.033 (*), 0.12 (ns).

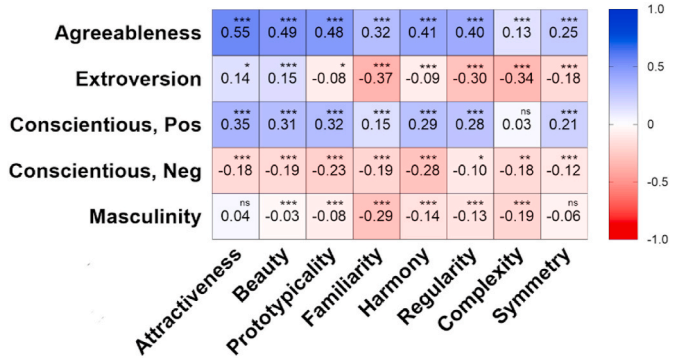

Fig. 9. Illustrates the correlations between the personality dimension rating and semantic differential scales. Notes: Significance of correlations are represented as p ≤ 0.001 (***), 0.002 (**), 0.033 (*), 0.12 (ns).

preferences, and the desired emotional impact. With the vast advancement of AI, the study provides insights into how specific design parameters, such as height, shape, and curvature, can be leveraged to optimize design parameters and offers a basis for tailoring designs to specific personality traits to meet specific criteria related to product goals, expectations, and user preferences.

4. Conclusion

This research aimed to understand the relationship between formal aesthetics and product semantics. The implications of this study can assist industrial designers in understanding the implicit evaluations and needs associated with product semantics and formal aesthetics through a product's visual form.

Using firstly the formal aesthetic principles, guided by Gestalt principle of Prägnanz, to analyze kettle products, the study then deconstructed the kettle's primary visual elements (Euclidean geometry) through height, shape, and curvature to reveal the implicit evaluations associated with its form attributes. The study then examined the kettles perceived symbolic qualities through product personality. A factor analysis of the product personality attributes revealed four dimensions of product personality: Agreeableness, Extroversion, Positive Conscientiousness, and Negative Conscientiousness, which revealed implications of visual elements of height, shape, and curvature have on how they are perceived and associated with specific formal aesthetic and symbolic qualities.

Nevertheless, a notable limitation of the study is the use of solely one type of one product category, kettles, which limits the generalizability of the study's findings. Further research on different product categories is needed to validate the results. The small number of kettles included in the analysis is another notable limitation of the study. Due to time constraints, the study only examined eight kettles. This limited sample size may restrict the generalizability of the findings and the extent to which they can be applied to a broader range of kettle designs. The study aimed at focusing solely on the form attributes of height, shape and curvature and did not discuss other factors, such as hedonic, color, social, and cultural factors, which can have significant implications on user perception. Including a more extensive and diverse set of products would provide a more comprehensive understanding of how different visual elements contribute to aesthetic perceptions and product personalities. Furthermore, the kettle's analyzed had different surface finishes and should be taken into consideration in future research as this can impact results.

Secondly, further research with more extensive and diverse samples is necessary to validate and expand upon these findings as there was an unbalance of participants' biological sex and age in the sample analyzed, which can impact results, and the study did not collect data on participants' cultural backgrounds. Cultural factors can significantly influence individuals' preferences, aesthetic judgments, and interpretations of product designs. By omitting this information, the study misses an opportunity to explore how cultural backgrounds may interact with the perceived aesthetic qualities of the kettles. Assessing participants' cultural backgrounds in future research would help elucidate the role of cultural influences on product evaluations and judgments.

Despite these limitations, the study is a valuable foundation, providing industrial designers with insights into the implicit evaluation of product semantics and formal aesthetics to enable the creation of visually appealing and emotionally engaging products that resonate with consumers. The study's replicability is encouraging, allowing further investigations to validate and expand upon the results. Future studies with larger sample sizes, diverse participant backgrounds, and a broader range of product designs would strengthen the generalizability and applicability of the findings. By addressing these limitations, researchers can gain a more nuanced understanding of the associations between visual elements, aesthetic perceptions, and product personalities in the context of kettle design.

In conclusion, this study contributes to knowledge on the relationship between formal aesthetics and product semantics and how visual elements influence implicit product evaluations and judgments. The study revealed implicit evaluations associated with a product's personality by deconstructing the primary visual elements of height, shape and curvature. The implications of this study can assist industrial designers in understanding the implicit evaluations associated with product semantics and formal aesthetics, which can support the development of future conceptual models within the design process that better meet the psychological needs of consumers. By understanding how specific visual elements and formal aesthetics influence perceived product personalities, the findings can inform user-centered design strategies as designers can make informed decisions to prioritize certain design form attributes, enhancing the product's overall usability, functionality, and user experience. This approach ensures that the product not only appeals aesthetically but also aligns with users' preferences and values, resulting in a more intuitive and satisfying interaction between users and the product.

CRediT authorship contribution statement

Frédérique N. Sunstrum: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Oya Demirbilek:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing. **Nicole Gardner:** Conceptualization, Investigation, Methodology, Supervision, Writing – original draft. **Catherine Viengkham:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Software, Validation. **Branka Spehar:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

The authors affirm that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data availability

Data will be made available on request.

References

Ali, A., Liem, A., 2014. Creating a Reflective Understanding of Use of Formal Aesthetics in Product Semantic Frameworks. NordDesign. Finland, Espoo, 27-29th August 2014.

Bem, S.L., 1974. The measurement of psychological androgyny. J. Consult. Clin. Psychol. 42 (2), 155–162. https://doi.org/10.1037/h0036215.

Bloch, P.H., 1995. Seeking the ideal form: product design and consumer response. J. Market. 59 (3), 16–29. https://doi.org/10.1177/002224299505900302.

Brunel, F., Kumar, R., 2007. Design and the Big Five: Linking Product Aesthetics to Product Personality. ACR North American Advances.

Burlamaqui, L., Dong, A., 2017. Eye gaze experiment into the recognition of intended affordances. In: International Design Engineering Technical Conferences and Computers and Information in Engineering Conference. ASME 2017.

Carbon, C.-C., 2019. Psychology of design. Des. Sci. 5, e26. https://doi.org/10.1017/dsj.2019.25. Article e26.

Chang, C.-C., 2008. Factors influencing visual comfort appreciation of the product form of digital cameras. Int. J. Ind. Ergon. 38 (11), 1007–1016. https://doi.org/10.1016/j.ergon.2008.04.002.

Chang, H.-C., Lai, H.-H., Chang, Y.-M., 2006. Expression modes used by consumers in conveying desire for product form: a case study of a car. Int. J. Ind. Ergon. 36 (1), 3–10. https://doi.org/10.1016/j.ergon.2005.06.004.

Ching, F.D.K., 2014. Architecture: Form, Space, & Order, fourth ed. Wiley, Hoboken, New Jersey.

Chou, J.-R., 2011. A Gestalt–Minimalism-based decision-making model for evaluating product form design. Int. J. Ind. Ergon. 41 (6), 607–616.

Chowdhury, R.M., Olsen, G.D., Pracejus, J.W., 2011. How many pictures should your print ad have? J. Bus. Res. 64 (1), 3–6.

Chowdhury, A., Reddy, S.M., Chakrabarti, D., Karmakar, S., 2015. Cognitive theories of product emotion and their applications in emotional product design. ICoRD'15–Research into Design across Boundaries Volume 1: Theory, Research Methodology, Aesthetics, Human Factors and Education.

Chumiran, M.H., Abidin, S.Z., Rahim, W.N., Vermol, V.V., 2021. Cognitive ergonomics of formgiving as unstructured approaches in furniture design practice. Environ.Behav. Procee. J. 6 (SI5), 27–32.

Corbett, J.E., 2017. The whole warps the sum of its parts: gestalt-defined-group mean size biases memory for individual objects. Psychol. Sci. 28 (1), 12–22.

Diego-Mas, J., Alcaide-Marzal, J., 2016. Single users' affective responses models for product form design. Int. J. Ind. Ergon. 53, 102–114. https://doi.org/10.1016/j.ergon.2015.11.005.

Govers, P.C., 2004. *Product Personality* Delft University of Technology. Delft, Netherlands.

Govers, P.C., Mugge, R., 2004. I love my Jeep, because its tough like me: the effect of product-personality congruence on product attachment. In: Proceedings of the Fourth International Conference on Design and Emotion, Ankara, Turkey.

Govers, P.C., Schoormans, J.P., 2005. Product personality and its influence on consumer preference. J. Consum. Market. 22 (4), 189–197.

Hair, J.F., 2009. Multivariate Data Analysis.

Hallnäs, L., 2011. On the foundations of interaction design aesthetics: revisiting the notions of form and expression. Int. J. Des. 5 (1).

Hekkert, P., 2006. Design aesthetics: principles of pleasure in design. Psychol. Sci. 48 (2), 157.

Hekkert, P., 2014. Aesthetic Responses to Design: a Battle of Impulses.

Hekkert, P., Leder, H., 2008. Product aesthetics. Prod.ex. 259–285.

Hsiao, K.-A., Chen, L.-L., 2006. Fundamental dimensions of affective responses to product shapes. Int. J. Ind. Ergon. 36 (6), 553–564. https://doi.org/10.1016/j.ergon.2005.11.009.

Kapkın, E., Joines, S., 2018. An investigation into the relationship between product form and perceived meanings. Int. J. Ind. Ergon. 67, 259–273.

Karkun, P., Chowdhury, A., Dhar, D., 2018. Effect of baby-like product personality on visually perceived pleasure: a study on coffeemakers. In: Ergonomics in Caring for People. Springer, pp. 273–279.

Ke, W., Zou, X., 2017. Rational elegance: aesthetic analysis of the shape of the traditional plum vase. In: 2017 International Conference on Art Studies: Science, Experience, Education (ICASSEE 2017).

Kim, H.S., 2000. Examination of brand personality and brand attitude within the apparel product category. J. Fash. Mark. Manag.: Int. J. 4 (3), 243–252. https://doi.org/10.1108/eb022593.

Kintsch, W., 2012. Musings about beauty. Cognit. Sci. 36 (4), 635–654.

Koffka, K., 1935. Principles of Gestalt psychology. Harcourt, Brace.

Krippendorff, K., Butter, R., 1984. Product semantics-exploring the symbolic qualities of form. Dep. Pap.(ASC) 40.

Kumar, M., Garg, N., 2010. Aesthetic principles and cognitive emotion appraisals: how much of the beauty lies in the eye of the beholder? J. Consum. Psychol. 20 (4), 485–494.

Kuo, J.-Y., Chen, C.-H., Roberts, J.R., Chang, D., 2020. Evaluation of the user emotional experience on bicycle saddle designs via a multi-sensory approach. Int. J. Ind. Ergon. 80, 103039 https://doi.org/10.1016/j.ergon.2020.103039.

Liu, Y., 2000. Engineering aesthetics and ergo-aesthetics: theoretical and methodological foundations. In: Proceedings of the 5th Annual International Conference on Industrial Engineering-Theory, Applications and Practice, Hsinchu, Taiwan.

Loewy, R., 1951. *Never Leave Well Enough Alone*, 1st ed ed. Simon and Schuster.

Min, D.-J., Cunha Jr., M., 2019. The influence of horizontal and vertical product attribute information on decision making under risk: The role of perceived competence. J. Bus. Res. 97, 174–183.

Mugge, R., 2011. Product appearance as a cue for performance quality. The influence of product personality. ACR. Eur. Adv. 5 (3), 67–76.

Mugge, R., Govers, P.C., Schoormans, J.P., 2009. The development and testing of a product personality scale. Des. Stud. 30 (3), 287–302. https://doi.org/10.1016/j.destud.2008.10.002.

Nguyen, B., Melewar, T., Chen, J., 2013. A framework of brand likeability: an exploratory study of likeability in firm-level brands. J. Strat. Market. 21 (4), 368–390.

Pinson, C., 1986. An implicit product theory approach to consumers' inferential judgments about products. Int. J. Res. Market. 3 (1), 19–38. https://doi.org/10.1016/0167-8116(86)90040-6.

Reber, R., Schwarz, N., Winkielman, P., 2004. Processing fluency and aesthetic pleasure: is beauty in the perceiver's processing experience? Pers. Soc. Psychol. Rev. 8 (4), 364–382.

Reysen, S., 2005. Construction of a new scale: the Reysen likeability scale. SBP (Soc. Behav. Pers.) 33 (2), 201–208. https://doi.org/10.2224/sbp.2005.33.2.201.

Schoormans, J., den Berge, M.E.-v., van de Laar, G., van den Berg-Weitzel, L., 2010. Designing packages that communicate product attributes and brand values: an exploratory method. Des. J. 13 (1), 31–47.

Small, J., Melewar, T., Pittard, N., Ewing, M., Jevons, C., 2007. Aesthetic theory and logo design: examining consumer response to proportion across cultures. Int. Market. Rev. 24 (4), 457–473.

Te Vaarwerk, M., Van Rompay, T., Okken, V., 2015. Under cover and close at hand: embodied metaphor in packaging design. Int. J. Des. 9 (1).

Topolinski, S., Strack, F., 2009. The architecture of intuition: fluency and affect determine intuitive judgments of semantic and visual coherence and judgments of grammaticality in artificial grammar learning. J. Exp. Psychol. Gen. 138 (1), 39–63. https://doi.org/10.1037/a0014678.

Tosi, F., 2020. Design for Ergonomics, 1 ed. Springer, Cham. https://doi.org/10.1007/978-3-030-33562-5.

Tyan-Yu, W., Chueh-Yung, T., Cian-Yu, S., 2017. Unity enhances product aesthetics and emotion. Int. J. Ind. Ergon. 59, 92–99. https://doi.org/10.1016/j.ergon.2017.02.003.

Valencia-Romero, A., Lugo, J.E., 2016. Part-worth utilities of Gestalt principles for product esthetics: a case study of a bottle silhouette. J. Mech. Des. 138 (8).

Valencia-Romero, A., Lugo, J.E., 2017. An immersive virtual discrete choice experiment for elicitation of product aesthetics using Gestalt principles. Des. Sci. 3, e11.

Van Geert, E., Wagemans, J., 2023. Prägnanz in Visual Perception and Aesthetic Appreciation: Interactions between Stimulus, Person, and Context.

VandenBos, G.R., 2007. APA Dictionary of Psychology. American Psychological Association.

von Allesch, G., 1922. Psychologische Bemerkungen zu zwei Werken der neueren Kunstgeschichte. Psychol. Forsch. 2 (1), 368–381.

Walker, G.H., Stanton, N.A., Salmon, P.M., Jenkins, D.P., Rafferty, L., 2010. Translating concepts of complexity to the field of ergonomics. Ergonomics 53 (10), 1175–1186. https://doi.org/10.1080/00140139.2010.513453.

Wang, J., Hsu, Y., 2020. The relationship of symmetry, complexity, and shape in mobile interface aesthetics, from an emotional perspective—a case study of the smartwatch. Symmetry 12 (9), 1403. https://www.mdpi.com/2073-8994/12/9/1403.

Wang, T., Zhou, M., 2020. A method for product form design of integrating interactive genetic algorithm with the interval hesitation time and user satisfaction. Int. J. Ind. Ergon. 76, 102901 https://doi.org/10.1016/j.ergon.2019.102901.

You, H.C., Chen, K., 2003. A comparison of affordance concepts and product semantics. In: Asian Design Conference.

Zuo, H., Jones, M., 2005. Exploration into formal aesthetics in design: (material) texture. In: Proceeding of 8th Generative Art Conference, Milan.