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Investigating Aesthetic Preferences in Wearable Devices via the Unified Model of Aesthetics: A Review

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Abstract

Over the past few decades, the aesthetics area of research has expanded beyond the realm of pure artistic judgment, encompassing the aesthetics of products. The Unified Model of Aesthetics (UMA), one of Europe's most expansive aesthetic research projects, is a design psychology model rooted in aesthetic perception. This model has given rise to numerous studies on product aesthetics. These widely disseminated studies form the foundation of this paper's comprehensive integration, serving as a theoretical cornerstone for prospective product aesthetics researchers and design developers. Within this review, we focus on wearable device aesthetics. Rapidly evolving wearable devices have secured a profound place in the hearts of consumers. However, the external design of these products has garnered limited research attention. This article illustrates the importance of aesthetics in wearables and its profound impact on user experience and purchasing behavior. We delve into the framework of the UMA model and its implications within the study of aesthetic preferences across diverse products. Additionally, we elucidate how this aesthetic model can be effectively employed to explore and comprehend the aesthetic inclinations of wearable devices. This comprehensive review provides a refined design framework and theoretical foundation that fosters forward-looking research and facilitates wearable product development efforts.

***Keywords**:* Wearable Devices; United Model of Aesthetics; Product Aesthetics; Aesthetic Preference

1. Introduction

Wearable devices are technological tools worn on the human body, either as a computer accessory or as part of clothing material (Tehrani & Michael, 2014). A diverse array of wearable devices exists, with smartwatches, Bluetooth headsets, and 3D glasses as notable examples of mainstream wearables. Due to their ability to establish communication and data-sharing in proximity to the user, wearable devices present novel user experiences (Lee, 2021). Typically, these products employ accelerometers, altimeters, sensors, and algorithms to track steps and measure calories burned (Schüll, 2016), utilizing optical heart rate sensors to monitor heart rate and sleep quality (Chow & Yang, 2020; Mehrabadi et al., 2020). The multifunctionality of these wearable devices contributes to consumers' well-being and enhances the quality of life, imbuing it with heightened interest.

Wearable devices are currently experiencing rapid development. Research firm IDC estimates that approximately 547 million wearable devices, including smartwatches and fitness trackers, will be sold globally in 2021, reflecting a 23 percent increase from 2020. IDC also forecasts that sales of wearable devices will escalate to 777 million units by 2025. This swiftly expanding wearable market has attracted an increasing company to focus on and enter this arena. In addition to annual updates from major mobile phone manufacturers, the engagement of renowned fashion brands has further elevated the design and aesthetics of wearable devices (Koo & Chae, 2022). As a result, wearable device designs have become more diverse, offering a more excellent range of options and product styles, elevating consumer preferences and aesthetic discernment. Aspects such as color, material, and shape have shown significant variation (Choi & Kim, 2016; Iftikhar et al., 2019; Peake et al., 2018; Perry, 2018; Perry et al., 2017). This transformation has heightened the significance of visual aesthetics in consumers' purchasing decisions concerning wearable devices and considerably enriched users' perceptions and experiences while using such devices. However, thus far, few studies have focused on this aspect (Lee, 2020; Lee, 2021; Muller & Klerk, 2020; Pateman et al., 2018).

The aesthetics of wearable products form the initial bridge to establish a visual connection with consumers. The allure or lack thereof in their beauty and design can decisively influence consumers' purchasing inclination. Previous research into wearable devices predominantly concentrated on the devices' functional and technical attributes. These research delved into topics such as user privacy safeguarding, data security assurance, as well as user experience and human-computer interaction dynamics (Aroganam et al., 2019; Ching & Singh, 2016; Hsu et al., 2019; Keum et al., 2020; Lee & Hui, 2018; Mencarini et al., 2019). This has left the exploration of the aesthetics of wearable devices in need of a more comprehensive examination. The theoretical foundation for this review on product aesthetics stems from the Unified Model of Aesthetic (UMA). This model corroborates that aesthetic preferences are forged through the equilibrium between two evolutionary origins and the motivational tensions they encompass (Berghman & Hekkert, 2017). This paper aims to provide an in-depth exploration of aesthetic preferences within wearable devices. It achieves this through thoroughly analyzing and synthesizing existing literature, employing the Unified Model of Aesthetic (UMA) as its guiding framework.

This article is organized into several sections for discussion. First, we will review the relevant literature on product aesthetics and aesthetic preferences to understand the current

research content in aesthetics. Then, the relevant theoretical concepts of the Unified Model of Aesthetics are introduced. Second, we will review the research results on the contrasting factors at each level described by the UMA model. The final focus is on the aesthetics of wearable devices in the existing literature. This comprehensive review will summarize the impacts and categorization of prevailing research on aesthetic preferences, uncovering their potential value in the design and advancement of wearable devices. Ultimately, we will address the limitations and research gaps found in the existing literature while offering suggestions and directions for future investigations. By meticulously analyzing and understanding aesthetic preferences in wearable devices, this paper aims to equip future designers, researchers, and policymakers with comprehensive insights into the significance and influence of aesthetic design within wearable technology. Through the explorations presented herein, we anticipate furnishing guidance for the aesthetic design of wearable devices, thus contributing to the stimulation of innovation and growth within the wearable technology domain.

2. Research Methodology

This review used a literature research method to identify literature articles using national search engines such as Google Scholar. The term aesthetic preference was entered into Google Scholar, which resulted in over a million articles. A restrictive term, product aesthetics, was added, reducing the number of articles to 236,000. Then, the restrictive terms wearable devices and unified model of aesthetics were added sequentially, and the final number of articles was reduced to 18,800, as shown in Table 1 below.

Database	Date	Keywords	Limiters	Number
Google Scholar	9/9/2023	Aesthetic Preference		1,710,000
			Product Aesthetics	236,000
			Wearable devices	19,100
			Unified Model of Aesthetics	17,400

Table 1. Search from Google Scholar.

Next, search based on this review's subject content and the article's quality. Of course, the quality of the literature is screened based on the journal impact factor and inclusion level. The entire literature search and selection process is shown in Table 2. A total of 121 journal articles related to the topic of this article were selected through keyword search and screening. The articles were assigned to individual chapter topics based on a review of the literature abstract and content. The topics are as follows: (1) Explain product aesthetics and related literature review. (2) Conceptualization of aesthetic preferences and literature review. (3) Explain the concept of the UMA model and the application of factors at various levels in the model, (4) Analyze the aesthetic research related to wearable devices and the UMA model, (5) Discuss the current research gaps and future research directions. This article is reviewed based on the key findings of previous scholars, how their work supports future research and areas that need strengthening.

Key points and steps	Notes and steps
Literature search strategy	Keyword definition Literature search tools Top journals and conference papers Timeliness
Literature selection criteria	Research topic relevance Data depth Journal/conference paper evaluation Integrity of methods of analyzing data and scientificity of conclusions
Evaluation and screening	Check out the article and select the criteria Eliminate non-compliance with documents and quality requirements Preliminary assessment, content, methods, accuracy of conclusions
Synthesis and analysis	Read in detail and extract key information Analyze topics and identify research gaps Article review, providing research overview

Table 2. Literature search and evaluation strategies.

3. Product Aesthetics

The development of enterprises requires the continuous upgrading of products to gain market attention and recognition, and product design is an essential driving force. Product design research encompasses multiple attributes such as ergonomics, performance, materials, and aesthetics. Visual product aesthetics is often a critical factor in the success of new products. It plays the first link in product and consumer recognition and is also crucial in promoting product technical capabilities and novel functions (Truong et al., 2014). In recent years, research on product aesthetics has focused on product aesthetics design methods to improve the design aesthetics of products (Alcaide-Marzal et al., 2020; Burnap et al., 2021; Guo et al., 2019). On the other hand, some researchers recognize that product aesthetics has a close relationship with consumers, and products with design aesthetics are more likely to gain consumers' attention and liking and eventually stand out in the market (Toufani et al., 2017; Workman & Caldwell, 2007; Xue, 2019; Yoo & Kim, 2014). A study by Bettels and Wiedmann (2019) explored consumers' perceptions of the relationship between brand logos and product design, relying on theories of self-consistency and spillover effects, which suggest that when a consumer's self-concept is aligned with the brand logo associations, the liking of the logo will have a positive impact. Consumers later transfer this positive spillover effect from their perception of logo liking to their inferences about the product design, which usually has a more substantial impact on product aesthetics than on product functionality (Bettels & Wiedmann, 2019). This also proves that although product function is the embodiment of product value, the need for consumers' emotional perception of product aesthetics cannot be ignored. Consumers make initial judgments through their senses and personal aesthetics, and this judgment of the product's design may influence the overall evaluation of the product's performance (Lin et al., 2016). The aesthetics of a product are often judged by the eye of the observer, who prefers designs that are visually pleasing to them (Kumar & Garg, 2010). Such pleasurable product aesthetics are often felt and judged from personal aesthetic preferences.

4. Aesthetic Preference

For product design, aesthetic preferences arise from the object's attractiveness, and preferences are realized when the stimulus exceeds the popularity of other objects. Aesthetic preference is influenced by many factors, such as image aesthetics, image-to-background contrast, stimulus repetition, symmetry, and archetypes" (Reber et al., 2004). Hekkert and Leder (2008) suggested that reaching a consensus on aesthetic pleasure is possible despite differences between individuals in social contexts such as culture and time. This illustrates that the characteristics of a designed product are studied and measured multiple times (e.g., proportional balance or preference familiarity) to produce a general agreement that can represent the aesthetic preferences of most people for a particular product (Suhaimi, 2021). The literature on preference studies from different aspects of a product is plentiful, and a study by Silvia and Barona (2009) measured product aesthetic preference by testing the product's angle as a specific element. Their experiments showed that people prefer arrays of circles and hexagons for angles for a particular product. Another study of its kind tested preference rates between curved and sharp objects and showed that sharp objects and angled profiles reduced participants' preferences (Bar & Neta, 2006). There are also studies investigating individual preferences for the physical elements of a product, such as its physical form and shape (Silvera et al., 2002).

Design novelty is also one of the critical factors influencing aesthetic preferences. The Liu et al. (2020) study found that consumers who focus on promotion (as opposed to prevention) should prefer novel product designs, an effect attributed to increased processing fluency. The same type of consumers will also make differentiated choices when faced with product types with different attributes. For utilitarian products (for example, vacuum cleaners), promotion (prevention) focused consumers prefer (less) novel designs, and for hedonic products (for example, smartphones), all consumers should prefer novel designs (Liu et al., 2020). Of course, an individual's aesthetic preferences are often related to their aesthetic experience. Experts in the design field are more likely to favor innovatively designed products than novice designers (Person & Snelders, 2011). In contrast, novice designers or consumers with no interest in aesthetics prefer traditional designs. This is also affirmed by previous Leder and Carbon (2005) research.

5. Unified Model of Aesthetics (UMA)

5.1 The Concept of the UMA Model

The origins of aesthetics can be traced back to ancient Greece, with the term "aesthetics" derived from the Greek word " *aisthetiko*," signifying sensory perception, comprehension, and perceptual knowledge (Hekkert, 2006). In its early stages, aesthetics predominantly focused on artistic domains encompassing areas like painting, music, and drama. After the 1980s, the concepts of "beauty" and "design" became intertwined, prompting scientific explorations into the aesthetics of products. These explorations sought to unravel the aspects of product design that can evoke heightened attraction. In this context, design aesthetics pertains to the beauty and visual delight produced by the design of objects (Baskerville et al., 2018). The theoretical foundation underpinning this review is sourced from the UMA Project, which harmonizes existing aesthetic theories across diverse disciplines. It compiles findings from numerous literature studies to forge a more systematic and scientific research trajectory (Hekkert, 2014).

The Project UMA is an international collaborative project that unites researchers from diverse disciplines spanning multiple universities, including engineering, industrial design, design, and psychology. This project aims to establish a unified aesthetic model, offering insights into the delicate equilibrium between opposing forces inherent in crafting products for aesthetic enjoyment (Yahaya, 2017). Figure 1. furnishes a schematic depiction of the unified aesthetic model. As gleaned from the figure, the aesthetic delight derived from a product emerges through a network of interactions between security needs and achievement desires. Nevertheless, given their involvement in distinct facets of stimulus processing, they can exert diverse influences on the aesthetics of product design (Berghman & Hekkert, 2017). As delineated in the figure, the aesthetics of product design primarily emanate from the holistic interplay of three levels: perceptual, cognitive, and social factors. The perceptual level emphasizes elements of unity and variety. The ensuing level, the cognitive level, delves into the dynamic between typicality and novelty. Lastly, the social level encompasses connectedness and autonomy. A more precise elucidation of the two factors within the social level is the visual manifestation of belonging to or differentiating from a group. The UMA model essentially evolves from Darwin's (1859) theory of evolution, integrated into aesthetics and growing into a contemporary expression of human instinct, striking a balance between safety and risk (Hekkert, 2006). This framework encompasses two forces existing across different tiers, wielding influence over human responses to aesthetic pleasure, preferences, and experiences (Suhaimi, 2021). We aspire to glean a deeper understanding of the intricate relationship between opposing factors and human aesthetic preferences by examining literature spanning distinct levels.

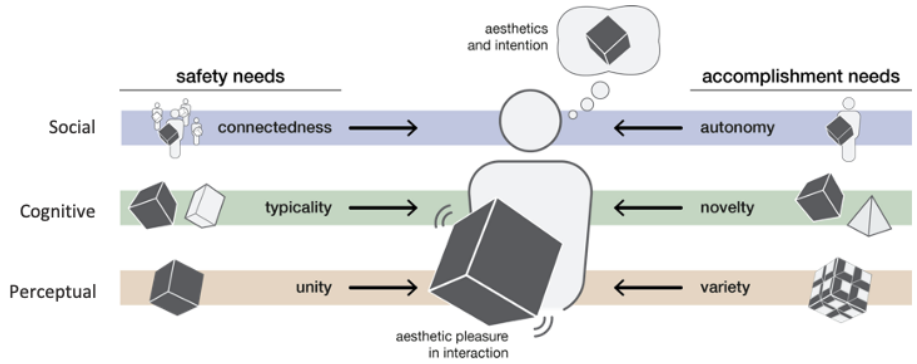

Figure 1. Unified Model of Aesthetics
[Online] Available: http://www.project-uma.com/the-uma-model

5.2 Application of the UMA model in aesthetic research

5.2.1The perceptual level: unity and variety

With the emergence of evolutionary psychology, perceptual systems have continually adapted to human life's evolving environment and characteristics. The foundation of perceptual systems stems from the ancestral imperative for survival. These systems were developed to perceive dangers and safety within the surrounding environment, and humans have now extended this ability to evaluate objects. At the core of perceptual aesthetics lies the fulfillment of our pleasure and preferences through the perceptual experiences of particular items (Hekkert, 2006; Ramachandran & Hirstein, 1999). For humans to derive enjoyment from interactions with objects, the perception of order and coherence between the attributes of the whole and its constituent parts is essential. This ability, known as unity, contributes to this perception (Berlyne, 1972; Veryzer & Hutchinson, 1998). Among the

factors influencing unity, Gestalt laws assume a significant role (Post et al., 2013, August). Empirically, the Gestalt laws of similarity, continuity, symmetry, contrast, and proximity unveil how properties of specific elements manipulate the perception of unity. For instance, people associate aspects of the same category with similar shapes, sizes, and colors. Prior research has established that unity can positively influence diverse domains. Instances include visual patterns (Berlyne, 1972; Berlyne & Boudewijns, 1971; Moore, 1986), polygonal graphics (Eysenck, 1968), product drawings (Veryzer & Hutchinson, 1998), artistic and non-art images of varying complexity (Nadal et al., 2010), and interactive media (Graham, 2008; Post et al., 2017; Wagemans et al., 2012).

The counterpart to the unity factor is variety, which pertains to the quantity and intensity of perceived distinctions among attributes and elements (Berlyne, 1972; Berlyne & Boudewijns, 1971). The presence of variety disrupts the sense of order among features, introducing unforeseen visual stimulation to individuals. As a result, the pursuit of variety is a natural inclination driven by the desire to explore and acquire new information (Berlyne, 1966). Studies on variety are equally extensive, spanning domains like patterns (Berlyne, 1970; Berlyne, 1972; Berlyne & Boudewijns, 1971; Moore, 1986), paintings (Hekkert & Van Wieringen, 1990), marketing (Kahn, 1995; Wu & Kao, 2011), music (Brattico et al., 2009), and even the arrangement of flowers in gardens (Lindemann-Matthies & Marty, 2013). To a certain extent, diversity can be viewed as fostering our acquisition of knowledge and abilities that we haven't yet mastered. It fuels a learning drive, enhancing our happiness during the learning process (Berlyne, 1971; Biederman & Vessel, 2006; Hekkert, 2014). However, the existence of anything, including a factor, requires a mastery of moderation, and unity and diversity are no exceptions. An excessive degree of uniformity can diminish people's enthusiasm to explore the unknown. At the same time, an excess of variation can disturb our sensory perception, resulting in visual confusion and a decline in interest.

Satisfying the aesthetic preference of maximizing both variety and unity may be one of our most sought-after desires, which gives rise to the concept of 'unity-in-variety.' This principle has a longstanding history, dating back to ancient Greek times (Kim, 2006). Perceptual unity and variety have been affirmed in prior studies to influence aesthetics positively and encompass various research domains. These domains include general psychology (Eysenck, 1942), aesthetics (Berlyne, 1971; Fechner, 1876), art (Cupchik et al., 1996), computer science (Eskenazi et al., 2021), museum specimen data (Woodburn et al., 2020), and music (Brattico et al., 2009; Tan & Spackman, 2005). Early literature relevant to aesthetics that we have focused on is predominantly centered around abstract stimuli (Berlyne, 1972; Berlyne & Boudewijns, 1971). Subsequent research focused on product aesthetics (Logkizidou, 2021; Loos et al., 2022; Post et al., 2017; Post et al., 2013, August). In these studies, a negative correlation between unity and variety was observed, yet both factors positively impacted the aesthetic appreciation of the product. Naturally, varying product stimuli, research subjects, and influencing factors can lead to differing conclusions. In the realm of website aesthetics, research has demonstrated that the opposing elements of unity and variety independently and positively enhance aesthetic preferences, with diversity exerting a more significant impact on aesthetic appreciation than unity (Post et al., 2017). In topology optimization aesthetics, augmenting unity is central to heightening aesthetic appreciation (Loos et al., 2022). Hence, it becomes essential to continually expand the range of stimuli to explore the ramifications of this principle. Participants' design backgrounds can also exert diverse effects on the balance between unity and diversity in aesthetic preferences, necessitating further scrutiny in future research (Post et al., 2013, August). This section shows

that research into the aesthetic perception of wearable devices represents a significant gap, with no pertinent investigations into the influence of unity and variety on aesthetic preferences. Subsequent research could center on the impact of perceptual traits such as appearance, shape, color, material, and texture of wearable devices on assessing aesthetic preferences. For instance, manipulating the proportions of unity and variety variables could be employed to explore how different device shapes affect users' attractiveness perception and liking, discerning their relationship with aesthetic preferences.

5.2.2 The cognitive level: typicality and novelty

The second tier in the UMA model is the cognitive level. Cognitive processes inherently rely on sensorimotor functions, recognizing and categorizing meaningful sensory inputs (Berghman & Hekkert, 2017). Throughout object cognition, we encounter feedback from stimuli, influencing the fluidity of our object processing based on personal experiences. When we are familiar with a specific type of object in our cognition, we promptly recognize it. Conversely, quick judgment and recognition become challenging if we haven't encountered that type of object before. This distinction arises from the interplay of two opposing factors at the cognitive level—typicality and novelty. Typicality is the extent to which an item is perceived to embody a category, a categorical principle derived from taxonomic theory (Rosch, 1978). In the aesthetic evaluation of product design, typicality relates to familiar experiences, recognizable features or functions, and the inclination to prioritize safety over risk (Hekkert, 2006; Whitfield, 1983). Earlier research has demonstrated that humans generally lean towards the familiar or typical, as it aligns with our existing knowledge (Veryzer & Hutchinson, 1998). This inclination manifests the evolutionary instinct rooted in our sense of security, aiming to avoid needless hazards. The determinants of typicality were also examined in earlier studies, and attitude was deemed one of these determinants (Loken & Ward, 1990). Although familiarity plays a role in influencing typicality, it is not solely responsible for determining it (Malt & Smith, 1982). Typicality has been identified as a pivotal factor affecting aesthetic preferences in product aesthetics research. Its immediate recognizability accelerates consumer acceptance of products, thereby imbuing them with greater significance and value (Hekkert & Leder, 2008; Whitfield & Slatter, 1979).

However, human beings are inherently contradictory. Remaining safe for prolonged periods can lead to losing the spirit of exploration. Conversely, seeking out different challenges and encountering novel stimuli can also provide us with enjoyment. Research indicates that people are also inherently drawn to novel designs (Hekkert et al., 2003; Mugge & Schoormans, 2012; O'Neal et al., 1997). Novelty embodies the discovery of new experiences, unfamiliar processing, and the enjoyment of aesthetic judgment (Mugge & Schoormans, 2012; Tyagi et al., 2013). Early research unveiled that design novelty can be assessed from three perspectives: 1. by comparing design distinctions and performance against competing products, 2. by evaluating the design novelty within product-brand portfolios, 3. by contrasting the designs of the latest products with those of their predecessors (Talke et al., 2017). This underscores that novel design is often rooted in typical design forms. The concept of novelty's nature was introduced by Berlyne (1960), who posited that stimuli could initially seem exceedingly unfamiliar and stimulating, but repeated exposure renders them more familiar, comfortable, and appealing. This phenomenon demonstrates that novelty transitions into typicality after prolonged exposure to stimuli.

Upon retrospection, we appear to encounter two contradictory opposites: "We like what we can identify with" and "We are also attracted to novelty." To reconcile this inherent

contradiction, Hekkert et al. (2003) introduced the "most advanced, yet acceptable" (MAYA) design principle, effectively addressing this paradox. This principle has been tested across various products and has consistently revealed a negative correlation between typicality and novelty, while both aspects positively influence the aesthetic appreciation of a product (Ceballos et al., 2019; Suhaimi et al., 2023; Thurgood et al., 2014, January). The simultaneous maximization of typicality and novelty is particularly interesting (Hekkert et al., 2003). This concept stems from Berlyne's (1974) proposal of an inverted U-shaped relationship between typicality, novelty, and aesthetic preference. Objects with moderate novelty tend to be preferred over those extremely typical or highly novel. However, an alternative viewpoint has emerged. According to Whitfield's research (1983), people prefer products with typical designs. These differing perspectives could arise from selecting stimulus category attributes, which prompted Whitfield (1983) to introduce the Categorical-Motivational Model. In subsequent aesthetic studies that tested multiple product designs, including toothbrushes and computer mouse (Yahaya, 2017), industrial boiler (Suhaimi, 2021), furniture (Hung & Chen, 2012; Tyagi, 2017), and lamps (Christensen et al., 2015; Tyagi et al., 2013), these stimuli verified that product category attributes indeed influence the connection between typicality, novelty, and aesthetic preference. However, no specific research is currently delving into the link between product design typicality, novelty, and aesthetic preference in wearable devices. This represents a promising research direction for the future.

5.2.3 The social level: connectedness and autonomy

The final level is the social level, where product design holds a particular social significance. Products are social and cultural cues, bridging connectedness and autonomy (Belk, 1988; Dittmar, 1992; Kleine III et al., 1993). The need for connection is an inherent social requirement encompassing the desire to establish relationships with others (Deci & Ryan, 2000) and the sense of belonging within a social group (Baumeister & Leary, 2017; Brewer, 1991). This sentiment enables one to attain a comprehensible identity at the social level, representing a yearning for a sense of security. The group typically confers This sense of security, serving as an identity label within the social collective (Axelrod & Hamilton, 1981). This rationale may also be rooted in the evolutionary progress of our species, where groups offer advantages such as resource sharing and survival protection. Consequently, this dynamic influences the aesthetic appreciation and assessment of individuals who are, or aspire to be, part of a given group (Markus & Kitayama, 1991). Conversely, there are instances where we seek to distinguish ourselves from the group, yearning for autonomy. Autonomy involves an individualized existence that sets one apart from others, embodying freedom, and self-control (Bettencourt & Sheldon, 2001; Deci & Ryan, 2000; Lynn & Harris, 1997). From an evolutionary perspective, this need facilitates swift recognition of an individual within the group. Hence, some autonomous individuals strive to manifest their uniqueness through distinctive expression. While such distinctiveness may carry certain risks, such as social exclusion, it does not deter people's pursuit of it under specific circumstances.

At the social level, a design principle exists that concurrently satisfies the opposing needs of security and accomplishment - 'Autonomous yet Connected.' Consumers want to connect with people through safe product choices to show they are in social groups (Brewer, 1991; Deci & Ryan, 2000). On the other hand, to present their unique autonomy, consumers seek social accomplishment (Bettencourt & Sheldon, 2001; Deci & Ryan, 2000; Lynn & Harris, 1997). The optimal equilibrium between consumer connectedness and autonomy is the crux of this principle, resolving this inherent tension. A product attains its highest aesthetic appeal

when its design characteristics strike an aesthetic equilibrium that instills consumers' sense of connection and autonomy (Blijlevens & Hekkert, 2015). Previous studies reveal that different product categories entail varying social risks, influencing the correlation between product connectedness and autonomy (Blijlevens & Hekkert, 2014). This concept encapsulates the social value intrinsic to product design, a product of harmonizing the social dimensions of safety and accomplishment. Effects associated with more significant social risks amplify the desire for connectedness, while those linked to lower social risks prompt a more vigorous quest for autonomy (Blijlevens & Hekkert, 2014). Of course, consumer attributes also play a role in product choice. Those with a "prevention-focused" orientation favor high-fluency stimuli compared to individuals with a "promotion-focused" exposure (Blijlevens & Hekkert, 2014; Freitas et al., 2005). Such inclinations may be rooted in individual living environments and cultural distinctions, where diverse values and personal beliefs lead to information processing deviations. This underscores that everyday aesthetic preferences, aside from being influenced by general psychophysical attributes, also intersect with situational organization and cultural contexts (Hekkert & Leder, 2008; Richerson & Boyd, 2008).

While relatively few previous studies have been conducted at the social level, there is sufficient evidence to illustrate the significant impact of connectedness and autonomy on aesthetic preferences. Products such as sunglasses, bicycles, staplers, sneakers, and backpacks have been examined in these studies (Blijlevens & Hekkert, 2014, 2015). The results of these investigations consistently affirm the positive influence of the two contrasting factors at the social level on product design. Yet, it remains uncertain whether this relationship holds for wearable devices, a direction that could be explored in future research. Regarding the social level, the research could delve into the correlation between aesthetic preferences for wearable devices and individuals' social needs, group identity, and sociocultural factors. For instance, studies could investigate potential variations in the aesthetic preferences of distinct user groups for wearable devices and how personal identities and cultural inclinations find expression through a device's external design and symbolic elements.

6. Aesthetic Research of Wearable Devices

With the ongoing evolution of the wearable device market, both high-end brands and low-end enterprises have invested considerable resources and effort in the wearable market, aiming to capture consumers' attention. Given that consumers are the primary recipients of these products, understanding consumer preferences has consistently remained a central concern for wearable device designers. In today's market, the array of wearable devices is extensive, and consumer expectations for products have expanded beyond mere functionality to encompass design alignment with their personal aesthetics. Design factors are pivotal in determining a product's hedonic appeal and significantly influence the adoption of wearable devices (Krey et al., 2019; Sohn & Kwon, 2020). Notably, visual design serves as the initial gateway through which consumers rapidly perceive the beauty of wearable products, thus playing an indispensable role in attracting consumers and driving purchase decisions. In the upcoming sections, we will meticulously examine pertinent literature on the aesthetics of wearable devices within visual design, categorizing our review into three levels: perceptual, cognitive, and social.

6.1Perceptual aspects

At the perceptual level, researchers are concerned with how wearable device design attributes influence users' aesthetic preferences. Chuah et al. (2016) investigated the potential drivers behind consumers' choices of wearable devices. They affirmed that perceived usefulness and visibility are significant factors influenced by consumers' preferences, as demonstrated by the Technology Acceptance Model (TAM). This study validates that consumers evaluate wearable devices along two dimensions: technology and fashion, highlighting the equal importance of design alongside technology (Chuah et al., 2016).

Chunyan and Hu (2015) examined general design patterns of intelligent clothing and identified four core design elements in wearable devices: technology, material, structural model, and color. Notably, color plays a role in influencing visual perception of product aesthetics. Color psychology can be strategically employed in wearable device design to convey design intentions accurately (Adapa et al., 2018). A later study by Muller and Klerk (2020) confirmed this effect of color. This study found that consumers perceive design aesthetics through the shape, color, and style of exterior design, using these cues to assess the devices' attractiveness. Branded wearable devices showcasing specific design aesthetics bolster consumers' purchasing inclination (Muller & Klerk, 2020). In subsequent studies, design aesthetics has also proved its essential position in wearable devices.

Wang and Hsu's (2020) exploration of smartwatch interface design further affirms the critical role of design aesthetics in wearable devices. Their study delved into the interaction effects of screen shapes (square and circular), symmetry, and interface complexity. The aesthetic attributes of interface design (symmetry-asymmetry, complex-simple, square and round) influence users' emotional responses, subsequently shaping user preferences and purchase decisions (Wang & Hsu, 2020). Since symmetry aligns with the Gestalt laws, contributing to the unity aspect of the perceptual level, it validates the notion that unity profoundly influences the aesthetic preference of wearable devices.

Similarly, another study investigated the design aesthetics of smartwatches, assessing the impact of design aesthetics as a critical non-functional hedonic consumption factor on perceived product value (Lee, 2020). The findings underscored that design aesthetics substantially affect wearable technology's practical and hedonic value (Lee, 2020). This highlights the profound emotional effect of design aesthetics on consumers, solidifying that wearable device design and functionality hold equivalent significance for consumers during purchase decisions (Perry et al., 2017).

Through reviewing aesthetic research in the wearable device perception field, we find that there needs to be a specific study focusing on the influence of the balanced relationship between unity and diversity on the aesthetic preference of wearable devices. Under the UMA model, the interaction between opposing factors at the perceptual level necessitates further exploration within wearable devices.

6.2 Cognitive aspects

At the cognitive level of wearable device design, research centers on the interplay between product typicality and novelty. Lee (2021) investigated how visual typicality, a crucial cognitive factor for wearable devices, influences consumers' purchase decisions. In this specific study, Lee (2021) utilized four psychological factors—effort expectation, performance expectation, social influence, and enjoyment—to gauge whether visual typicality affects consumers' smartwatch decisions. The study measured the visual typicality of wearable devices by varying product colors to assess the extent of consumer preference. Results

revealed that the perceived visual typicality of the smartwatch design negatively impacted participants' purchase choices, significantly diminishing perceived performance and enjoyment of the watch (Lee, 2021). This counterintuitive cognitive finding contrasts the idea that more typical product designs are better liked. Possible factors for this discrepancy could be attributed to the specific category of wearable devices, warranting further investigation, or to the potential limitations of color as a measurement variable. Historical research attempted to establish harmonious color preferences through experiments and data analysis, yielding inconclusive results (Whitfield & Wiltshire, 1990).

Another study, employing a smartwatch stimulus, examined consumer purchase intentions, using design, uniqueness, and screen size as determinants of aesthetic appeal (Dehghani & Kim, 2019). Findings affirmed that design aesthetics significantly influence consumers' intentions to purchase smartwatches, with screen size and uniqueness equally impacting purchase intentions (Dehghani & Kim, 2019). In another study, uniqueness emerged as a pivotal predictor of purchasing behavior (Choi & Kim, 2016). This underscores consumers' pursuit of distinctiveness and novelty in smartwatch design, suggesting a preference for novelty over typicality. A recent study incorporated traditional cultural elements in smartwatches to determine consumers' preferences based on their familiarity with the cultural elements. (Yang et al., 2021). The appropriate use and combination of cultural elements in a product will increase consumers' goodwill and cultural identity towards the product, which also provides a new design style direction for wearable devices.

These studies indicate that typicality and novelty have been evaluated as separate variables to gauge consumer aesthetic preferences. However, whether these factors are interdependent or opposing ends of a continuum remains uncertain and necessitates further investigation. Moreover, striking a balance between typicality and novelty to satisfy varying user groups' aesthetic preferences remains an avenue for future exploration.

6.3 Social aspects

At the societal level, there is limited research on the influence of wearable device connectivity and autonomy on aesthetic preferences, and the relevant literature is relatively sparse. Given the current popularity of mobile devices, wearable devices have the potential to establish an identity for the wearer and display their affiliation with preferred social groups (Aspers & Godart, 2013; Johnson et al., 2008). Similarly, individualistic wearable device designs can make the wearer stand out within their social circle.

A study by Pateman et al. (2018) delved into wearable devices' profoundly personal nature, aesthetics, and form factors to comprehend the role of aesthetics and personalization. The research revealed that participants favored personalization, which could potentially encourage manufacturers to incorporate this aspect in future product development (Pateman et al., 2018). Such personalized designs can reflect participants' cultural backgrounds and personal preferences, enabling them to differentiate themselves in social interactions and embrace autonomy. This also highlights the positive impact autonomy can have on wearable devices.

Ouverson et al. (2017) conducted a study investigating the connection between aesthetic factors and the social acceptability of wearable devices. The research indicated that aesthetics and social acceptability are related, although not synonymous. The study examined Bluetooth headsets, smartwatches, and Bluetooth glasses as wearable stimuli and found subtlety to be the most critical aesthetic consideration (Ouverson et al., 2017). It's important to note that aesthetic appeal cannot wholly alleviate social concerns and apprehensions tied

to wearable devices. Although the relationship between aesthetics and social aspects might not be as direct as anticipated, a connection still exists.

In the next phase, the social dimension of the UMA framework can be further explored in wearable device aesthetics research. To comprehensively analyze this domain, in-depth investigations are required, spanning various cultural contexts and social settings.

7. Discussions

Reviewing the literature reveals that current aesthetic research on the UMA model predominantly concentrates on a single level, whether perceptual, cognitive, or social. These studies investigate the impact of selecting a specific level of opposing factors or focusing on a single aspect of aesthetic preferences. There needs to be more studies examining wearable devices through the lens of the UMA theoretical framework, and a comprehensive exploration of the alignment of multi-level factors is lacking. Future research has the potential to delve into the intricate interplay between various factors spanning different levels. This research could shed light on the aesthetics of wearable devices by simultaneously considering all three levels – perceptual, cognitive, and social. Such an approach would provide a more comprehensive understanding of users' aesthetic preferences for wearable devices.

Most participants in previous studies on the UMA model have been from Western populations (Blijlevens & Hekkert, 2014; Post et al., 2016; Post et al., 2014, August; Tyagi, 2017; Yahaya, 2017). However, there is a notable absence of relevant investigations into the aesthetic preferences of individuals from Eastern cultures. Recognizing that disparities between Eastern and Western cultures can lead to aesthetic variations is essential. Additionally, considering the attributes of individual users, such as gender, age, and cultural background, could influence aesthetic preferences. Future research can delve into the relationship between user characteristics and aesthetic preferences. This exploration could provide insight into various user groups' distinctive aesthetic inclinations and requirements. Ultimately, this understanding could guide the development of tailored wearable devices.

Numerous studies have revealed that aesthetics holds an equivalent significance to functionality and technology in wearable devices, prompting an emergence of research into the aesthetics of these devices. This aesthetic inquiry centers on wearable devices' design aspects and user experience. However, there is a growing need for parallel research exploring how product aesthetic design influences user acceptance and satisfaction in real-world scenarios. In the coming times, further research should be directed towards substantiating the impact of aesthetic design in practical contexts. This could be achieved through user testing, evaluations of user experience, and other relevant methodologies.

8. Conclusion

This paper comprehensively reviews aesthetic research concerning wearable devices and the Unified Model of Aesthetics (UMA). It delves into the UMA model's concept and examines the correlation between opposing factors at different levels and aesthetic preferences. The review found that the current relevant research on the UMA model only focuses on aesthetic research at a single level, and there is a lack of pertinent literature on simultaneous analysis on three levels. Although current research has yielded specific insights, we still need more clarification and in-depth attention to the interactions between various factors at different levels. Notably, this review uniquely concentrates on the aesthetics of wearable devices, which have gained popularity among consumers in recent times. Furthermore, it undertakes the novel endeavor of integrating these stimuli into the UMA

aesthetic model, a previously unexplored avenue. Discover the aesthetics of wearable devices by considering all three levels (perceptual, cognitive, and social) simultaneously. Future research could delve into various factors, user characteristics, practical applications, and more to deeply probe the core of wearable device aesthetics. This could offer helpful guidance and inspiration for future product design and user experiences.

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