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Why we like to touch: Consumers' tactile esthetic appreciation explained by a balanced combination of unity and variety in product designs

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Abstract

Tactile experiences are a pivotal part of consumer behavior and choice. However, very little is known about why consumers esthetically appreciate touching products. The principle of Unity-in-Variety, stating that consumers like to perceive variety but only when this variety is presented as a coherent whole, has been shown to partly explain consumers' esthetic appreciation in the visual domain. We theorize that the psychological mechanisms underlying the esthetic principle of Unity-in-Variety are modality-independent, and therefore that this principle also applies to consumers' *tactile* esthetic appreciation. Across three studies, using existing products and novel 3D printed product designs systematically manipulated along the perceptual dimensions of unity and variety, we show that both unity and variety independently contribute to tactile esthetic appreciation. Furthermore, because unity and variety are inherently partial opposites, esthetic appreciation of products is highest when both unity and variety are simultaneously maximized.

KEYWORDS

esthetic appreciation, Gestalt laws, product design, tactile perception

1 | INTRODUCTION

Esthetic appreciation is a ubiquitous part of the consumer experience (Leder & Nadal, 2014; Schifferstein & Hekkert, 2008; Shi et al., 2021). Esthetically pleasing products have an edge on those that are perceived as bringing less esthetic value (Bloch et al., 2003; Hagtvedt & Patrick, 2008). Because consumers' assessment or evaluation of products is almost invariably multisensory (Spence & Gallace, 2014), the fact that *tactile* design esthetics—and not only visual (Ceballos et al., 2021) or auditory (Barkho, 2019) esthetics—influences consumers' responses to a product comes as no surprise. Touch is the second most important sensory modality for pleasurable experiences with products, and even becomes the dominant one during usage (Fenko et al., 2010). Properties such as weight (Lindstrom, 2012), shape (Spence & Gallace, 2014; Yang & Raghubir, 2005), texture (Etzi et al., 2014; Underhill, 1999), or hardness (Underhill, 1999) bring about esthetically pleasing tactile experiences when interacting with products and then play a vital role in the persuasive efforts marketers engage in (Spence & Gallace, 2014). Indeed, a recent metanalysis assessing whether touch (vs. no touch) does have favorable effects on consumer responses confirms its importance to consumers' decision-making processes (W. Liu, Cao et al., 2022)

Despite the importance of esthetic stimulation for consumer behavior, tactile design of products is often overlooked in favor of other sensory modalities—for example, visual and olfactory (e.g., Ellison & White, 2000; Spence & Gallace, 2011, 2014). Indeed, academic research is just starting to "highlight the forgotten sense of touch" (Williams & Ackerman, 2011). Even though a limited number of studies have explored tactile esthetics and consumer responses, they have very little to offer in terms of a principled explanation of why some tactile experiences are more satisfying than others. For instance, it has been reported that consumers prefer certain shapes over others in familiar products (e.g., the characteristic shape of a Coca-Cola bottle), but it is not clear why (Spence & Gallace, 2014). Similarly, other studies indicate that consumers value touch itself (e.g., Streicher & Estes, 2015), but they have not specified what features of an object make the experience pleasant. As Spence and Gallace (2014) rightly point out, however, "if a given product is designed to appeal to the customer's sense of touch, it is critical to know *under what specific forms of stimulation* people report pleasant tactile experiences" (p. 274, emphasis added). Furthermore, methodologies in the study of tactile esthetics so far greatly limit the generalizability of the findings to the marketing field because of their employment of artificial stimuli and/or the mostly passive role of participants—where, for example, stimuli are rubbed onto skin (e.g., Etzi et al., 2014) rather than that they get to tactually experience product designs as a whole.

In contrast, research in the domain of visual esthetics has provided these deeper psychological insights into understanding what underlying mechanisms guide consumers' esthetic appreciation for product designs utilizing real product designs as stimuli, and multiple different esthetic principles have been identified as a result. One well known principle, Most Advanced, Yet Acceptable (MAYA) is a principle that predicts that consumers will find products that can be easily categorized into a certain product category but that are nonetheless novel as more esthetically pleasing (Hekkert et al., 2003; Loewy, 1951). This principle operates on a cognitive level (capturing how stimuli are cognitively processed) (Berghman & Hekkert, 2017), but when it comes to the tactile experience it is more likely that any esthetic pleasure is derived from perceptual processes. Esthetic principles belonging to the perceptual category, explain esthetic appreciation as resulting from the perceptual processing of design elements such as shapes, materials, and other more tangible design elements. One such "tangible" esthetic principle is that of "Unity-in-Variety" (UiV), according to which entities that strike the right balance between unity and variety while maximizing these features simultaneously are perceived as more esthetically pleasing (R. A. G. Post et al., 2016). For instance, R. Post et al. (2017) found that increasing the colorfulness of a website (a way of increasing variety) only results in a more esthetically pleasing experience if unity is also increased (e.g., by increasing symmetry). We know of one study that has extended this principle to a modality other than the visual, and have offered support for UiV in the taste perception domain (e.g., Paulsen et al., 2015) suggesting that this principle may be universal across modalities. Hence, in our research, we offer the principle of UiV as one that explains *tactile* esthetic appreciation and test this hypothesis empirically.

We contribute to the literature by showing that tactile esthetic appreciation of products results from perceiving how a variety of shape and material properties are organized to form a unified coherent whole and thereby provide a deeper insight into what mechanisms explain consumers' tactile esthetic appreciation. More specifically, we propose that tactile esthetic appreciation is maximized when the tactile experience of the seemingly opposing dimensions of unity and variety are simultaneously present in a product. Our practical contribution is to offer product managers a straightforward principle that they can follow to make products more esthetically pleasing for consumers. In particular, we offer a principle that, if followed in product design, can boost the esthetic pleasure consumers might derive from their tactile experiences.

2 | TACTILE CONSUMER EXPERIENCES

The focus on understanding principles that explain consumers' tactile esthetic experiences is relevant to marketers as online shoppers return between 15% and 40% of the products they buy (Reagan, 2019), and research has identified *touching/feeling* as one of the categories explaining returns (Saarijärvi et al., 2017). Also, touch is associated with higher purchase intentions (Streicher & Estes, 2015) and, indeed, consumer perception and product choice are influenced by how pleasant a tactile experience is (Ranaweera, 2022). Research in multisensory marketing and, specifically, research on the effect of touch on consumer behaviors, has established that merely touching in and of itself already has a positive effect on purchase intentions (W. Liu, Cao et al., 2022; Peck & Shu, 2009). For example, consumers who are allowed to touch products in store show higher purchase intentions than consumers who are not allowed to touch the same products (McCabe & Nowlis, 2003). Other research has found that consumers' preferences for certain products can be primed haptically (Streicher & Estes, 2015). Individual differences in the need to touch have also been shown to affect consumer responses to products in interaction with the freedom to touch products on display, and it appears that women have a higher need for touch than males (Citrin et al., 2003). Indeed, an extensive survey showed a correlation of a higher need for touch with lower purchase intentions in the online retail environment. Resulting from this understanding that touch is an important predictor of consumers' responses, recent research has started looking at how marketers may overcome the inability to touch in the online retail environment and show solutions in providing touch cues in the form of descriptions of how the material of a product design feels (e.g., "soft leather"; Yazdanparast & Kukar-Kinney, 2023), or through augmented reality (Gatter et al., 2022). An extrinsic moderator influencing the effect of touch on consumer responses include choice set size, where touch is typically preferred for smaller sized choice sets, rather than larger choice sets, explained by perceived choice difficulty (S. Liu, Kaikati et al., 2022). All of these studies clearly indicate that touch is important for consumers, but they do not provide insights into what it is about the product designs that affects the consumer responses to touching them. We lack rigourous insights into the mechanisms that explain the positive effect of touching products on consumer responses.

To gain insights into what mechanisms may explain the positive effect of touching products on purchase intentions; however, we have to direct our attention to materials research. For example, Chen et al. (2009) created an extensive taxonomy of material property and consumers' affective responses such as playfulness, precious, and sophisticated. The exact relationship of smoothness/roughness with pleasantness has been the most widely replicated and validated (e.g., Essick et al., 2010; Karlsson & Velasco, 2007). Extending this to product design evaluations, Sousa et al. (2022) found that roughness/slippery indeed showed a significant relationship with affective perceptions of smooth, modern, elegant, and comfortable in relation to materials applied in car interiors. Note, however, that in this experiment participants were asked to rate materials for car interiors, but these materials were presented as square samples of material to feel, rather than that they directly touched car interiors. Even if highly contextual, further research suggests that consumers have an esthetic preference for smooth, rather than rough, textures (Etzi et al., 2014) and for softer, rather than harder, materials (Ripin & Lazarsfeld, 1937).

While many of these materials studies have looked at how tactile perception and evaluation is moderated by visual perception (or vice versa), they have largely ignored the reality that products come in combinations of shapes, surfaces, textures, and other physical properties that may affect the pleasantness experienced. Indeed, we have knowledge of how specific material properties may affect pleasantness and other affective consumer responses, but we do not know how tactile perception influences pleasantness in more realistic scenarios where consumers interact with products that have a combination of materials and physical properties. To gain more applicable and realistic insights into the esthetic appreciation experienced when consumers' touch products as a whole, we must look at esthetic principles that can capture the perception and appreciation of combinations of physical properties. This is where the esthetic principle of UiV becomes relevant as this principle is strongly underpinned by perceptual psychology.

The well-established perceptual esthetic principle UiV states that people appreciate perceiving variety if it is ordered and structured such that they experience it as a unified whole (Fechner, 1876). Variety refers to the *number* and *intensity* of perceived differences between perceptual properties and elements (Berlyne, 1972) and can be achieved by increasing the number of elements, or the number of combined property differences among elements (Fechner, 1876; Lauer & Pentak, 2012). Perceiving variety is enjoyable because it challenges our perceptual capacities and offers the prospect of learning information and potentially discovering new relationships (Berlyne, 1972). However, for this information to be successfully apprehended, and to aid discovering new relationships in the presented information, variety needs to be ordered and structured to facilitate fluent processing and allow the perceptual challenge to be successfully met (Armstrong & Detweiler-Bedell, 2008; Reber et al., 2004). Research in the visual domain shows that both unity and variety—despite being partial opposites—positively contribute to the *visual* esthetic appreciation of a wide range of artefacts (R. A. G. Post et al., 2016; R. Post et al., 2017).

The principle of UiV has received a significant amount of empirical support in the visual domain. The principle has been found to apply in the esthetic visual experience produced by things such as abstract patterns (Muth et al., 2021), web pages (Deng & Poole, 2012; W. Liu, Wu et al., 2022; R. Post et al., 2017), atmospherics of stores (Jang et al., 2018; Logkizidou, 2021), arrangements of objects (Van Geert & Wagemans, 2021), and a variety of products, such as chairs (Loos et al., 2022), clothes (Gray et al., 2014), and motorcycles (Nasar, 1987; R. A. G. Post et al., 2016). While UiV has not been empirically tested in the tactile domain fundamental psychological and brain research provides some indication that perceptual processes related to UiV in the visual domain may be shared with the tactile domain.

3 | EXPANDING UiV TO THE TACTILE DOMAIN

We argue that the body of foundational neuropsychological research in perception provides support for the contention that UiV can be extrapolated to the research field of *tactile* esthetics. First, there is substantial evidence for shared perceptual organization mechanisms and neural substrates between vision and touch, and possibly the other senses (Gallace & Spence, 2008; Lacey & Sathian, 2014). While a detailed description is outside the scope of this paper, amodal probabilistic inference processes are possible mechanisms explaining how our brain perceptually groups elements within and between the senses (Fiser, 2009). Simply put, a probabilistic inference process is a statistical model explaining how elements are linked together into single units as a result of their likelihood of cooccurrence. Evidence for our ability to unify visual shapes, sounds, and tactile patterns in terms of probabilistic inference processes suggests that these unitization mechanisms are shared between the senses (Conway & Christiansen, 2005). Such unitization processes are thought to already occur in infants and are argued to help form sensitivity for the Gestalt laws (Bhatt & Quinn, 2011; Wagemans et al., 2012).

Secondly, Hsiao and Wang (1998) found that two neurological systems play similar roles in vision and touch. These systems seem to be relevant for processing information concerning form and texture in both the visual and tactile domains. In fact, many of the Gestalt laws well known to influence visual perceptual grouping have recently been suggested to also facilitate grouping and processing in tactile perception (Gallace & Spence, 2011). Gestalt laws have been shown to determine the way we *tactually* group shapes, materials, and lines (Chang et al., 2007a, 2007b; Heller et al., 2003) and Gestalt laws have been shown to influence perceived unity and variety in the visual domain (R. Post et al., 2017). Finally, UiV has been found to apply beyond the visual domain, particularly to auditory (Fletcher, 2012) and gustatory experiences (Paulsen et al., 2015). It would seem arbitrary to suppose that there is something special about the tactile modality that precludes UiV from working in such a case.

Summarizing, with this research, we contribute by investigating whether a well-established perceptual principle known to influence esthetic appreciation in other modalities can also be applied to the tactile domain and account for consumers' tactile esthetic appreciation and provide an explanation for why consumers' like to touch products. We argue that tactile esthetic appreciation of products can result from perceiving how a variety of shape and material properties are organized in a product design to form a unified coherent whole. More specifically, we propose that tactile esthetic appreciation is maximized when the tactile experience of the seemingly opposing dimensions of unity and variety are simultaneously present in a product design.

H1: Product designs that are perceived as maximizing *tactile* unity and variety simultaneously will be experienced as more esthetically pleasing (Study 1).

We test this hypothesis in Study 1 by asking participants to rate existing product designs (car remotes) on their perceived tactile unity and variety and esthetic appreciation. In Study 2, we explore whether we can systematically manipulate tactile unity and variety using Gestalt laws of perceptual grouping (see Study 2 for the reasoning behind this approach) and design products that vary on these dimensions. Then in Study 3 we use those systematically manipulated product designs to test hypothesis 1 again, but now in a more controlled manner allowing us to establish cause and effect. For a visual overview of the studies, please refer to Figure 1 below.

4 | STUDY 1

4.1 | Methods

4.1.1 | Ethics (Studies 1, 2, and 3)

The University Human Research Ethics Committee Checklist deemed all studies in this research of minimal risk.

4.1.2 | Participants

Thirty international students from a Dutch university were invited to voluntarily participate in the study as part of a university course. They were informed that they would rate nine products on their tactile appearance. Four participants of the invited 30 did not attend the experiment. Responses from the remaining 26 participants (mean age = 21.5, SD = 1.4, 6 females) were recorded, generating 234 data points as participants rated nine stimuli. A power analysis determined a sample size of 25 gives a power of approximately 80% to detect a large effect ($f^2 = 0.35$) for an $\alpha_{\text{one-tailed}}$ of 0.05 (Faul et al., 2007). Previous studies have shown large effect sizes for unity and variety in contributing to visual esthetic appreciation in a positive direction (R. A. G. Post et al., 2016). Hence with 234 data points we consider this study to have enough power to detect an effect.

4.1.3 | Stimuli

Tactile exploration of a surface is done in a combination of six to eight actions (Lederman & Klatzky, 2009). By using a variety of hand movements, properties such as texture, hardness, elasticity, thermal conductance, weight, and global and exact form can be identified. Nine car key remotes ("remotes" from now on) were selected as stimuli (Figure 2). Remotes were used because all the aforementioned tactile properties could be perceived in the stimuli, allowing for a complete assessment of unity and variety. For example, their size allows for fully enclosing the product with one hand, making it possible to assess the global form. The presence of buttons and component spacing requires identification of the exact form. The weight of remotes is in a range where participants can make reliable comparisons between stimuli (17–59 g). Furthermore, a variety of materials are commonly used in remotes (e.g., plastic, rubber, metal), thereby taking into account differences in material properties such as texture, hardness, and heat conductance.

Two design experts were instructed to reduce a set of 20 remotes to nine while retaining as much spread as possible on the tactile aspects of unity and variety (Figure 1). All remotes were duplicates of

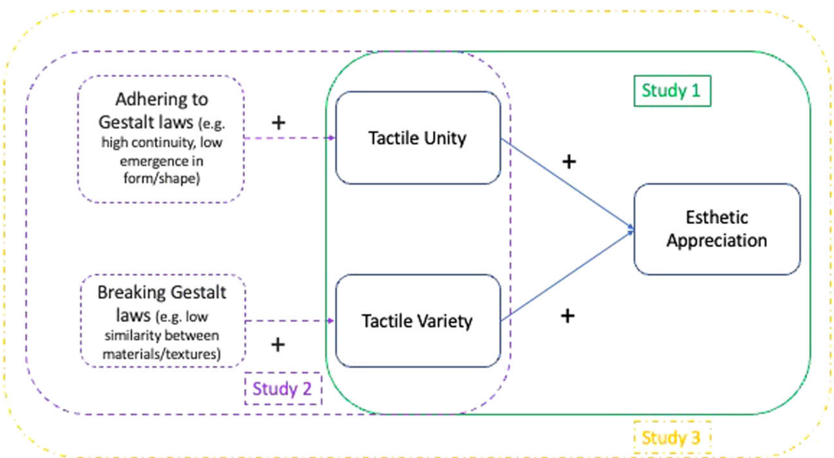

FIGURE 1 Conceptual framework: overview of Studies 1, 2, and 3.

FIGURE 2 Example of two stimuli used in Study 1.

originals and came from the same supplier (WVO Trading BV). Buttons on the remotes were glued into a fixed position to prevent a possible interaction experience to have an effect on the tactile esthetic appreciation ratings. Because no electronics were present in the duplicates, weights were glued on the inside to increase rigidity and realism. Because exit interviews indicated that weight may have influenced people's appreciation, weight was measured and used as a covariate.

4.1.4 | Procedure

In this experiment, participants were invited into the laboratory one by one, and scheduled such that they did not physically meet, to avoid any cross-influence on ratings by participants. In a laboratory, participants were seated in front of a table with nine adjacent identical trays, each containing one remote. A large black curtain was suspended in the air approximately 25 cm in front of participants' faces to prevent participants from seeing the remotes. Some room was left between the table and the curtain's hem enabling the participants from tactually exploring the remotes without the curtain touching their arms. Participants were informed that they were to rate remotes whose functionality had been disabled. Instructions explicitly specified rating the tactile experience of the products and not the expected functionalities or the differences in the physical quality of their construction. An initial familiarization trial allowed participants to tactually explore all the remotes at their own pace before the ratings round started. This exploration and familiarization is important when it comes to tactile perception, as precision is improved upon being able to compare stimuli (Metzger & Drewing, 2020). Participants rated all nine remotes one by one on 7-point Likert scales (1: fully disagree, 7: fully agree) measuring tactile unity, tactile variety, and tactile esthetic appreciation. The items were adaptations (to pertain to the experience of touch) of those validated by Blijlevens et al. (2017), which measured the same factors in the visual domain. Unity was measured using the items: "*This design feels unified*," "*This design feels orderly*," and "*This design feels coherent*" (Cronbach's $\alpha = 0.84$). Variety was measured using the items: "*This design conveys variety*," "*This design is made of different parts*," and "*This design is rich in elements*" (Cronbach's $\alpha = 0.68$). Esthetic appreciation was measured using the items: "*This product is attractive to touch*,'" "*This product is pleasing to touch*," and "*I like touching this product*" (Cronbach's $\alpha = 0.92$). Both the item order and stimuli order were fully randomized. Participants rated remotes using a paper-and-pencil questionnaire after exploring each remote. They were free to use either one or two hands when feeling the remotes and had unlimited time to complete the task.

4.2 | Results

All subsequent data analyses were performed on non-aggregated and standardized data. As expected, unity and variety negatively correlated with each other ($r = -0.39$, $p < 0.001$), indicating that unified remotes were generally perceived as less varied, and vice versa. We ran linear mixed-model analyses (LMM) to determine how unity and variety together predict tactile esthetic appreciation ratings. Unity and variety were entered as fixed-effect covariates predicting esthetic appreciation with by-participants and by-stimuli crossed random intercepts. Exit interviews with the participants revealed that they regarded differences in weight as important in judging esthetic appreciation. We, therefore, compared a model with and without weight (measured in grams), which was added as a covariate, and then performed a χ^2 likelihood ratio test on the AICs—obtained by the maximum likelihood estimation—to determine whether the models significantly differed in fit. The model with weight showed a better fit with the data than the model without weight (χ^2 (1) = 4.56, $p < 0.05$). Hence, we report the results of our LMM including weight as one of the variables. In line with our expectations, both unity ($\beta = 0.64$, $t = 11.37$, $p < 0.001$, 95% CI = [0.53–0.76]), and variety ($\beta = 0.14$, $t = 2.40$, $p < 0.05$, 95% CI = [0.03–0.26]), significantly and positively predicted tactile esthetic appreciation. Weight was also found to positively predict esthetic appreciation ($\beta = 0.16$, $t = 3.02$, $p < 0.01$, 95% CI = [0.06–0.27]).

4.3 | Discussion

This study shows that the principle of UiV contributes to esthetic appreciation in the tactile domain. Similar to the visual domain, tactile unity and variety both positively influence esthetic appreciation. Furthermore, unity and variety are partial opposites and, therefore, a trade-off takes place wherein an optimum balance between unity and variety will lead to the highest esthetic appreciation (Figure 3). H1 is then supported.

While knowing the mechanism explaining tactually pleasant experiences is valuable, knowing how to create UiV in a products' design provides a guide for creating a competitive edge in the market to marketers and product managers. In the next study, we contribute by investigating a neglected area: Gestalt grouping principles in relation to esthetic appreciation, more specifically, in the tactile domain. Some authors hypothesized that esthetic appreciation is generated from being able to group elements and detect the properties that bring order and unity to them (R. A. G. Post et al., 2016; Ramachandran & Hirstein, 1999). In fact, Koffka (1940) already

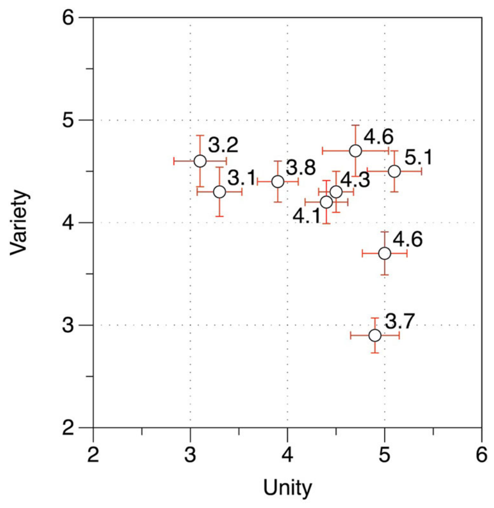

FIGURE 3 Mean esthetic appreciation ratings of remotes in relation to their average unity and variety ratings in Study 1. Maximizing both unity and variety leads to the highest esthetic appreciation.

described a link between Gestalt psychology and esthetic appreciation (Koffka, 1940; recently revisited by Spehar & van Tonder, 2017). Nonetheless, somewhat surprisingly perhaps, not much empirical research has systematically investigated the role of the grouping principles in relation to esthetic appreciation (Van Geert & Wagemans, 2020; p. 140). We do this more explicitly, and further extend this effort to the tactile domain (Williams & Ackerman, 2011).

5 | STUDY 2

Gestalt laws (Wertheimer, 1912) are a set of rules describing how humans perceptually organize and structure stimuli. The laws, which have been mostly studied in vision (for a review, see Wagemans et al., 2012) state that, for instance, objects that are alike (law of similarity), close to each other (law of proximity), and/or located in the same region (law of common region) are perceived as a group thereby facilitating perceptual processing by the brain. The coherence, order, or unity provided by elements that abide by the Gestalt laws has been associated with esthetically pleasing experiences (Cupchik, 2007). In contrast, we can imagine that breaking such Gestalt laws can increase perception of variety. Indeed, research shows that Gestalt laws can be applied to influence *visual* unity and variety within one design (R. Post et al., 2017)

The perceptual, and esthetic effects of Gestalt laws have also been studied in the tactile domain and research has shown that these determine the way we tactually group shapes, materials, and lines (Chang et al., 2007a, 2007b; Heller et al., 2003). These previous studies investigating tactile perception using Gestalt laws used raised line drawings (Heller et al., 2003) or shape layouts on which different materials were placed (Chang et al., 2007a, 2007b). They, however, did not explicitly assess whether Gestalt laws can be applied to systematically influence tactually perceived unity and variety. Further, these studies did not use objects, such as designed products, that consumers would tactually explore for esthetic appreciation in real-life and, then, some external validity concerns remain.

Given that we have been able to generalize the UiV principle from the visual to the tactile domain, and Gestalt laws are known to influence tactile perception and have been used successfully to manipulate UiV in visual product design, we explore whether Gestalt laws can be used to systematically influence tactile unity and variety. To investigate this, we developed 3D printed versions of new remotes that were systematically manipulated in unity and variety by applying Gestalt laws. Besides increasing control over the variable of interest, careful systematic manipulations keep other factors constant (such as brand association, the degree of typicality or novelty, and weight), which are known to play a role in forming affective responses to products (Hekkert et al., 2003; Page & Herr, 2002). To maximally separate the influence of our manipulations on unity and variety, the manipulations were applied to either form or material respectively. This study is of an exploratory nature wherein we try to answer the following research question in an experiment:

RQ: Can Gestalt laws be applied systematically to manipulate both tactually perceived unity and variety in product designs simultaneously?

5.1 | Method

5.1.1 | Participants

Twenty-nine students (mean age = 23.8, SD = 1.6, 6 females) from a Dutch university responded to an online call for participation. We performed a power analysis that determined that a sample size of 31 participants gives a power of approximately 80% to detect a large effect ($W = 0.50$) for an $\alpha_{\text{one-tailed}}$ of 0.05 (Faul et al., 2007).[1] Participants were informed that they would judge products through haptic interaction. They received 10 euros for 45 min of participation. All participants were included for further analyses.

5.1.2 | Stimuli development

For the design of our systematically manipulated stimuli we stayed with the product category of remotes. The common use of different materials, shapes, and textures in remotes allows for manipulating these properties without creating ecologically unusual designs.

The new stimuli were manufactured using 3D printers (Object 500 Connex3 by Stratasys, Ltd. for printing in plastic and rubber; Shapeways, Inc. for printing in metal). 3D printers enable the creation of highly detailed (600–1600 dpi), accurate (20–85 µ), and

[1]A previous study assessing the use of Gestalt laws to manipulate visual unity and variety showed large effect sizes for design properties aligning with Gestalt laws in contributing to unity and variety perceptions (R. A. G. Post et al., 2016).

customizable stimuli. The ability to print in a wide range of materials (e.g., polymers, rubbers, ceramics, metals, and alloys), which can be finished in different ways (brushed, polished, dyed, or coated with velvet), increases their resemblance to products in the market.

In line with our efforts to create realistic stimuli, and through multiple phases of sketching and prototyping, a professional designer developed a modular remote assembly comprising 13 exchangeable components (Figure 4). The modular nature of the remotes allowed for high customizability and control over our manipulations.

Unity was manipulated in form along *continuity* and *emergence*, and applied to minimize the influence on other Gestalt laws (e.g., symmetry and proximity). The Gestalt law of continuity implies that elements are grouped together if they are interpreted as continuing in line or form. Continuity in form was manipulated by designing three versions of the remote's keychain hole (Figure 5). In the most unified component, the keychain hole was identical in thickness to the rest of the remote and its contour followed the line of its surrounding parts. In the medium-unified component, the keychain hole still followed the contour on the horizontal plane, but continuity was lowered in the vertical plane by decreasing the thickness compared to the rest of the remote. In the least unified component, continuity was lowered even more by also breaking the contour on the horizontal plane. The second unity manipulation was the emergence of the button. The Gestalt law of emergence implies that parts are separated if they differ from their background. In the most unified version, the button height was the same as the rest of the remote's body. In the medium and least unified versions, the button protruded deeper, thereby making it stand out more from its surroundings.

Variety was manipulated through *(dis)similarity* in component material by using either one, two, or three different materials (plastic, rubber, and metal). Tactile sensations of materials include hardness, elasticity, plasticity, and temperature, as well as the surface properties of textures and patterns (Nagano et al., 2012; Sonneveld & Schifferstein, 2008). The three materials chosen all differ in three of these properties. Printed metal is a good conductor, and therefore considered cold at room temperature, and is hard and smooth if polished. Plastic is less of a heat conductor, and therefore feels slightly warmer than metal, and is lower in hardness and smoothness. Finally, rubber is relatively warm, elastic, and sticky or rough (Ashby & Johnson, 2013).

Increasing the number of different materials used in the remotes from one to two, and from two to three, should systematically increase the number and intensity of differences tactually experienced by our participants. All components of the low-variety remotes were therefore printed in plastic. Medium-variety remotes incorporated rubber printed components in the middle (Figures 5 and 6) with the rest remaining in plastic. High-variety remotes consisted of polished-metal printed components on the outside, while the top-middle was rubber and the bottom-middle plastic.

As our previous study indicated that weight influenced the esthetic appreciation of the remotes, we controlled for this by adding small pieces of metal inside the models until all remotes weighted equal (71 g).

Our design of the manipulations and highly accurate manufacturing assured that the construction of all remotes was of identical quality. The result was a set of nine realistic stimuli (three levels of unity × three levels of variety) that systematically varied in form through the Gestalt laws of continuity and emergence and in the number of materials through (dis)similarity (Figure 5).

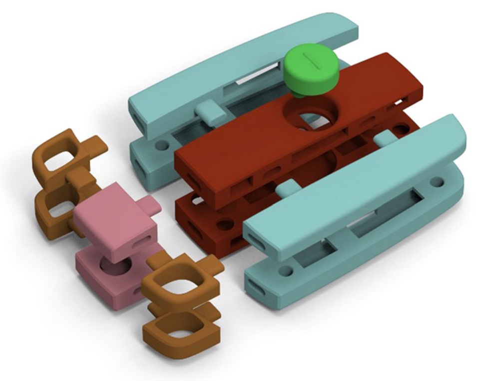

FIGURE 4 Render of the modular remote assembly for Study 2.

5.1.3 | Procedure

In this experiment, participants were invited into the laboratory one by one, and scheduled such that they did not physically meet, to avoid any cross-influence on ratings by participants. Participants were informed that they were to rate nine concept versions of a remote solely by touch. The study started with a familiarization trial, followed by forced choice paired comparisons where all remotes

FIGURE 5 Different versions of the keychain manipulated in unity through continuity of form (low to high unity) used in Study 2 and 3.

FIGURE 6 Overview of all nine 3D printed remotes systematically manipulated in unity (*x*-axis) and variety (*y*-axis) used in Study 2 and 3.

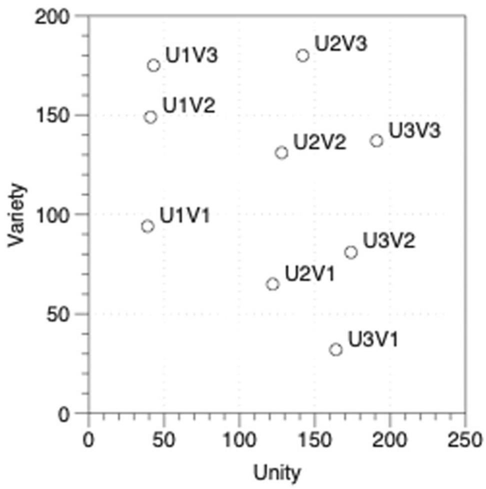

FIGURE 7 Plotted unity and variety frequencies for the respective manipulated levels of the remotes in Study 2.

were compared on tactile unity or variety in two separate rounds. Paired comparisons were used to maximize judgment accuracy resulting in 36 comparisons for unity and 36 comparisons for variety. It is a typical experimental approach in tactile perception to use paired comparisons, rather than single judgments only, as perceptual precision increases when one is allowed to switch between objects (Metzger & Drewing, 2020). Participants were seated in a laboratory setting in front of a table with a black curtain suspended in the air to block their view, similar to the set-up used in Study 1. They were allowed to have both hands underneath the curtain to inspect the remotes tactually. In the familiarization trial, all nine remotes were presented in nine adjacent trays, randomized in order, and behind the curtain to prevent participants from visually inspecting the remotes. Participants were allowed to briefly explore all remotes tactually (1–2 min depending on the participant's feedback). To encourage participants to form complete impressions of the remotes, participants were informed to take their time to carefully explore the remotes in any way they wanted to (e.g., use their nails to scratch across surfaces or press on materials).

After the familiarization trial, participants were tasked with two rounds of forced choice paired comparisons (i.e., 36 comparisons per round). In one round participants were informed to select which remote of the presented pair was highest in tactile unity ("*The product feels ordered, unified, coherent, and like a whole*"), and in the other round which remote of the presented pair was highest on tactile variety ("*The product is made of different parts, it is varied and rich in elements*"). The test administrator handed each pair of remotes to the participant in a tray. The order of the 36 remote combinations in each round, and the hand in which the remotes were given (left vs. right), were also fully randomized (no left-handed participants participated in the experiment). Participants were instructed to make each comparison while holding a remote in each hand. Depending on the unity or variety round (randomized starting order for both), participants indicated for each comparison (by raising their hand) which of the two remotes was highest in either unity or variety. The test administrator recorded their responses.

5.2 | Results

We calculated the frequencies of how often a remote was chosen as more unified or more varied and created four contingency tables: (1) frequency with which a remote was chosen as more unified compared with the other remotes against the three levels of manipulated unity (1: high emergence/low continuity, 2: medium emergence/continuity, 3: low emergence/high continuity), (2) frequency with which a remote was chosen as more unified against the three levels of manipulated variety (1: high similarity, 2: medium similarity, 3: low similarity), (3) frequency with which a remote was chosen as more varied against the three levels of manipulated variety (1: high similarity, 2: medium similarity, 3: low similarity), (4) frequency with which a remote was chosen as more varied against the three levels of manipulated unity (1: high emergence/low continuity, 2: medium emergence/continuity, 3: low emergence/high continuity).

In line with the intended direction, visual inspection of the frequencies revealed unity frequencies to increase with stronger unity manipulations, whereas unity frequencies remained stable for variety manipulations (Figure 7). Also, in line with the intended direction, variety frequencies increased with stronger variety manipulations, although there was a tendency for variety frequencies to also decrease with stronger unity manipulations.

To statistically assess the relationship between our manipulations and the dependent unity and variety frequencies, we performed χ^2 tests on the frequencies. In line with the intended unity manipulation, results showed a significant association between unity frequencies (yes vs. no) and manipulated unity levels ($\chi^2_{(2)} = 490.36$,

$p < 0.001$; $\eta^2 = 0.24$). Unity frequencies were also associated with manipulated variety levels, but to a much smaller degree ($\chi^2_{(2)} = 7.69$, $p < 0.05$; $\eta^2 = 0.004$). In line with the intended variety manipulations, variety frequencies were significantly associated with manipulated variety levels ($\chi^2_{(2)} = 261.81$, $p < 0.001$; $\eta^2 = 0.12$). Variety frequencies were also significantly associated with unity manipulations but to a lesser degree ($\chi^2_{(2)} = 87.86$, $p < 0.001$; $\eta^2 = 0.04$). We conclude that we have successfully manipulated unity and variety employing Gestalt principles and found support for H2.

5.3 | Discussion

Our results show that Gestalt laws can be used to systematically manipulate perceived unity and variety in product design stimuli. More specifically, we systematically varied perceived unity in form through the Gestalt laws of continuity and emergence and perceived variety in the number of materials through the Gestalt law of (dis) similarity. As continuity increased, and emergence decreased across three levels the stimuli were perceived to be more unified. As similarity decreased across three levels, the stimuli were perceived to be more varied.

We attempted to manipulate unity and variety as independently as possible, since we argue that they are not opposites of a single dimension, but two distinct dimensions both uniquely contributing to esthetic appreciation. However, unity and variety are inherently linked by the (material) properties from which they originate. This presents itself in a negative correlation between both dimensions that was found in the first tactile study and research on visual unity and variety (R. A. G. Post et al., 2016). This inherent relationship prevents completely disentangling their effects; nevertheless, our manipulations mainly influenced the intended dimensions and in the correct direction, as we predicted. Furthermore, the properties chosen to manipulate either unity or variety differed objectively by separating material and form characteristics. This study's goal was to create reliable stimuli to assist us in assessing the effect of tactile UiV on esthetic appreciation and to provide a practical contribution showing that product managers can use Gestalt laws to inform the product designs they want to bring to market if wishing to manipulate unity and variety for increased consumer appreciation. Therefore, we consider unity and variety as successfully manipulated using Gestalt laws and continue to use these stimuli in the third study with the aim to replicate our findings from Study 1 in a more systematic and controlled manner.

In the final study, we link manipulated UiV (based on the Gestalt laws) with tactile esthetic appreciation in a methodical manner that allows us to directly and experimentally test the causal effect of UiV on consumers' tactile esthetic appreciation using product designs that have been systematically manipulated on their levels of unity and variety. Our expectations are that products that have been designed according to the Gestalt laws to maximize unity and variety will produce the most esthetically pleasing tactile experiences, in line with Hypothesis 1, here repeated:

Product designs that are perceived as maximizing *tactile* unity and variety simultaneously will be experienced as more esthetically pleasing (Study 3).

6 | STUDY 3

Study 3 aimed to assess how manipulated tactile unity and variety separately and jointly influence esthetic appreciation. Similar to the first study, we hypothesize that unity and variety both positively influence esthetic appreciation and, secondly, that there is an optimum balance between unity and variety where esthetic appreciation is highest. This time, however, we test this hypothesis employing stimuli that have been designed according to the Gestalt principles to provide such a balance.

6.1 | Method

6.1.1 | Participants

We calculated the required minimum sample size to find a large effect ($f = 0.40$) with a power of 80% (Faul et al., 2007). Approximately 26 participants were required, assuming the strongest nonsphericity correction of 0.125 given the nine measurements, a correlation among repeated measurements of 0.3, and $\alpha_{\text{one-tailed}}$ set to 0.05. Thirty-two international students from a Dutch university participated in the experiment (mean age = 24.0, SD = 2.7, 8 females), of which none had participated in the previous studies, and were paid 8 euros for 30 min. All participants were included in further analyses.

6.1.2 | Stimuli

Stimuli were the same as those used in Study 2.

6.1.3 | Procedure

A similar experimental laboratory setup was used as in Study 2. Participants were seated in a laboratory setting in front of a table with a black curtain suspended in the air to block their view. They were informed that they were going to evaluate nine concept versions of a remote by touch alone. An initial familiarization trial allowed participants to explore all nine remotes tactually for a couple of minutes. Next, the test administrator handed participants one remote at a time, in random order, and asked to verbally rate each of the nine remotes on the three esthetic appreciation items used in the first study using 7-point Likert scales (Cronbach's $\alpha = 0.92$). They were instructed to explore remotes for at least 40 s to allow sufficient time to detect details and to standardize the time between stimuli and participants.

Perceived roughness of materials has been shown to negatively relate to preference ratings (e.g., Ekman et al., 1965). The use of different materials prevents us from physically keeping this aspect constant between remotes. To statistically control for it, we included the item "*The material of this car key remote feels rough*" (7-point Likert scale). Because we aimed to create credible stimuli for external validity purposes, the exit questionnaire included the following question: "*How realistic were these car key remotes to feel/touch?*" Participants rated the remotes as sufficiently realistic (mean = 4.9, SD = 1.1, on a scale 1–7). The session ended after all nine remotes were rated on the above scales.

6.2 | Results

Data analyses were performed on non-aggregated and standardized data. A LMM with REML estimation was performed to test our first hypothesis that tactile unity and variety separately influence esthetic appreciation. Levels of manipulated unity and variety were entered together with perceived roughness of the material as fixed-effects predicting esthetic appreciation with by-participants random intercepts.

In line with our first study, unity ($\beta = 0.21$, $t = 3.88$, $p < 0.001$, 95% CI = [0.10–0.31]) and variety ($\beta = 0.21$, $t = 3.62$, $p < 0.001$, 95% CI = [0.10–0.32]) significantly and positively predicted esthetic appreciation. Despite significant differences in the roughness ratings of the remotes—as assessed in a separate ANOVA, $F(8, 279) = 11.34$, $p < 0.001$—material roughness did not significantly influence esthetic appreciation ($\beta = -0.09$, $t = 1.37$, $p = 0.173$, 95% CI = [−0.21 to 0.04]).

Increasing levels of unity and variety were shown to positively contribute to tactile esthetic appreciation ratings. However, this does not automatically imply that remotes combining both are esthetically appreciated the most. It is conceptually possible that some remotes are solely appreciated because of their unity, while others for their variety.

We performed a second LMM to assess the hypothesis stating that maximizing unity and variety leads to a design for which esthetic appreciation is highest (approach adopted from R. Post et al., 2017). The nine remote versions were entered as a fixed-effect factor with by-participants random intercepts predicting esthetic appreciation. In line with our hypothesis, the results revealed remote U3V3 to be rated significantly higher in esthetic appreciation than all the other remotes except U2V3 (Table 1). This supports H3: objects that have been designed according to the Gestalt principles to maximize tactile unity and variety are perceived as more esthetically pleasing.

6.3 | Discussion

The results showed that tactile unity and variety both positively influence esthetic appreciation and that maximizing both unity and variety simultaneously leads to the highest esthetic appreciation. We found that the remote maximizing both unity and variety received higher esthetic appreciation scores than all other remotes except one of medium unity combined with high variety. However, overall, we

TABLE 1 Comparisons of the mean esthetic appreciation ratings for each remote used as stimulus in Study 3.

	Mean AA	95% CI Lower	95% CI Upper
U1V1	3.59**	3.04	4.14
U2V1	4.17*	3.62	4.73
U3V1	4.13*	3.58	4.68
U1V2	3.20**	2.68	3.77
U2V2	4.10*	3.55	4.65
U3V2	3.95*	3.40	4.51
U1V3	4.11*	3.57	4.66
U2V3	5.19	4.64	5.75
U3V3[a]	4.85	.	.

[a]Remote maximizing unity and variety as the reference category.
*$p < 0.05$; **$p < 0.001$.

see that, as expected, esthetic appreciation is maximized when both unity and variety are increased through the application of the Gestalt laws to product design.

7 | GENERAL DISCUSSION AND CONCLUSION

7.1 | Theoretical contributions

In our three studies, we empirically investigated the principle of UiV in the tactile domain. The studies revealed that tactile unity and variety both positively influence consumers' esthetic appreciation of product designs and that, due to their inherent negative relationship, maximizing both unity and variety leads to the highest esthetic appreciation. In Study 1, we showed that objects that are *perceived* as maximizing both unity and variety are more esthetically pleasing to touch for consumers. Additionally, in Study 2, we established that designing products according to the Gestalt principles is an effective method to manipulate unity and variety in the tactile domain. Particularly, we demonstrated that product designs that respect the Gestalt laws tend to be perceived as more unified and less diverse and vice versa—that is, designs that violate the Gestalt laws tend to be perceived as more diverse and less unified. Finally, in Study 3, in a controlled experiment, we showed that designs that have been manipulated to maximize both unity and variety on the basis of the Gestalt laws result in tactile consumer experiences that are more pleasing.

In response to calls to expand knowledge in the psychology of tactile esthetics and its role in consumer decision making (Jacobsen, 2014; Leder & Nadal, 2014; Spence & Gallace, 2014), we have successfully extrapolated to the tactile domain the principle of UiV. We contribute by providing new theoretical insights into tactile esthetic appreciation of designed products. By using 3D printed stimuli that resemble real products, we demonstrated that Gestalt laws can be applied to systematically manipulate *tactile unity* through changes in continuity and emergence of form, and *tactile variety* through (dis)similarity in materials. Our research thereby informs theoretical models of tactile perception by showing how the organization of tangible low-level features relates to more global aspects (e.g., symmetry and coherence) and their subsequent esthetic evaluation by consumers (Carbon & Jakesch, 2013).

The finding that UiV also applies to the tactile domain, and that Gestalt laws of perceptual grouping underlie it, provides first support for the idea that mechanisms facilitating perceptual understanding are likely shared between touch and other senses (Gallace & Spence, 2011). From this, it seems very plausible that other Gestalt laws, such as proximity or closure, can also be used to influence tactile UiV. Future research efforts in the tactile domain, and more specifically in consumer behavior contexts, should explore this possibility, ideally using stimuli closely matching products found in the marketplace, rather than abstract shapes and relying on passive touch for insights into consumers' tactile esthetic experiences.

7.2 | Limitations and further research

The set-up of Study 2 does not allow us to separately indicate the different Gestalt laws of continuity and emergence as independent variables as they were applied to the stimuli in a compounded manner (i.e., when emergence increased, also continuity decreased). Since tactile perception is so subtle, we chose to maximize our manipulations of UiV by compounding multiple Gestalt law manipulations in one. If we had separately manipulated Gestalt laws, we risked the scenario that differences between stimuli were so small that they were effectively not perceptible to the human touch. Our choices enabled us to test our main hypotheses around UiV, and establish that Gestalt laws in general can be used to manipulate UiV and as such informing marketers and product managers in how they might design for this principle and providing an understanding of the perceptual mechanisms that underly the effect of tactile UiV on estetic appreciation. It also allowed us to test the principle of UiV in a controlled manner with systematically manipulated stimuli. However, we cannot discern which one of the two unifying Gestalt laws (emergence or continuity) had the largest effect on perceptions of unity and variety, and thus should be preferred when designing for UiV. Future research could specifically focus on which Gestalt laws influence tactile UiV and to what degree.

Our study participants were all students. The use of students sometimes presents as a concern in consumer and marketing research as they are not always representative of the general population of consumers. However, we believe that, because we are investigating universal principles of esthetic appreciation based on perceptual psychological processes, results would not have been different had we used a different sample from a different population. However, we do think that there are potential individual differences as well as external moderators that may sway the balance that is preferred between unity and variety. For example, research has shown individual differences in need for touch and this affecting the retail experience for consumers. Further, some research has suggested that when people are more risk-averse they may prefer unity more (Hekkert, 2014; R. A. G. Post et al., 2016), while when they are sensation seekers, they may prefer variety more. These individual differences may be more prominent with certain consumer groups than others and hence future research could look at differences in the preferred balance of tactile UiV for consumer groups that differ along these individual differences.

We used within-subjects designs for our experiments, while some may argue that between-subjects designs are better to reduce confounding effects on the dependent variable. In our experiments, we explicitly chose to use within-subject designs as the literature on tactile and haptic perception suggests that multiple comparisons facilitate tactile perception (Metzger & Drewing, 2020). The ability to compare is required if we are asking participants questions of a certain complexity. We believe that a question such as "this feels like a unified whole" is more easily answered if participants can compare across stimuli that have a variation in unity and variety. In addition, other esthetic principles in the visual domain, such as MAYA (Hekkert et al., 2003) and Autonomous, yet Connected (Blijlevens & Hekkert, 2019), have been established using within-subjects experiments. Hence, we follow common practice of both tactile/haptic perception research as well as research on esthetic principles. We used Linear Mixed Models in our analyses to statistically account for any dependence in our data.

We acknowledge that the sample sizes of our experiments are smaller than what seems typical in marketing research nowadays. We are met with a few constraints in obtaining a very high sample size that other experiments are not typically faced with. Our experiments required in-person, one by one testing, while most visual experiments can either be done online, or in larger computer laboratories where multiple participants can attend experiments at once. However, we do point to our a priori power estimations indicating our sample size is enough to detect a significant effect. Further, our experiments are relatively simple in that there are no moderators or mediators, which in other quantitative research often inflates the sample size required to test complex models. Moreover, we find consistent effects across multiple studies, and in line with what has been found in the visual domain. Nevertheless, to our knowledge, we are the first to establish that UiV influences esthetic pleasure in the tactile domain, and hence invite replication studies, as is required for theory testing and building in general.

7.3 | Practical contribution

Lastly, there is practical value for product managers in knowing how consumers tactually explore and appreciate the products around them. The intimacy of the tactile sense generates unique and lasting experiences and it is a fundamental source of information for consumers engaged in product evaluation processes that are almost invariably multisensory (Candlin, 2003; Etzi et al., 2014). Given our numerous interactions with products and the omnipresent evaluation of them by tactile means (Raghubir & Greenleaf, 2006; Ranaweera, 2022), the knowledge about how they can be made more esthetically pleasing translates into a competitive advantage. In today's dynamic and highly competitive markets, companies are expected to greatly benefit from a solid grasp of the tactile esthetic design of products, an underexplored area that in the short and medium term is not expected to suffer the diminishing returns impacting other design efforts (e.g., visual). Indeed, a car model from one year to another does not typically change a lot visually which would result in diminishing returns. However, product managers could easily refresh their designs in the tactile domain which could lead to a significant return on investment.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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