HONG KONG JOURNAL OF SOCIAL SCIENCES

香港社會科學學報

第一的第 58 期 (2021 春/夏) Vol. 58 Autumn/Winter 2021

Open Access Article

Systematic Review: The Role of the Haptic Play in Aesthetic Evaluation

Li Tiantian[1], Dai Zetian[1], Xue Juan[2]

[1] *Faculty of Social Sciences and Liberal Arts, UCSI University, Kuala Lumpur, Malaysia*

[2] *Collage of Art, Suzhou University of Science and Technology, Suzhou, Jiangsu, China*

Received: October 25, 2021 ▪ Reviewed: November 21, 2021

▪ Accepted: December 18, 2021 ▪ Published: January 28, 2022

Abstract:
The tactile is an essential dimension in aesthetic evaluation but is gradually being ignored in today's mobile internet age because it is much less widely transmitted than hearing and vision. Moreover, most theories and explanations regarding aesthetics have focused on the visual and auditory senses, and there are only a few studies on tactile evaluation. Therefore, we collected studies on the tactile aesthetics in the framework of experimental aesthetics in the period 2000-2022. After statistical generalization, it was found that: 1. The criteria for evaluating tactile aesthetics were almost dichotomous, i.e., positive (like/appreciation/pleasure) and negative (dislike/disgust/poverty); 2. Tactile aesthetics mainly involved the toucher dimension (synaesthesia/need for touch/touch pattern) and the touch sample dimension (shape/type/texture), with Need for Touch (NFT) and Touch Pattern being ignored commonly; 3. Some studies also did not restrict the shape and material of the touch samples.

Keywords: tactile aesthetics, texture, aesthetic evaluation.

系统评价：触觉游戏在审美评价中的作用

摘要：
触觉是审美评价的一个重要维度，但在当今的移动互联网时代逐渐被忽视，因为它的传播远不如听觉和视觉广泛。此外，关于美学的大多数理论和解释都集中在视觉和听觉上，而对触觉评价的研究很少。因此，我们在 2000-2022 年的实验美学框架下收集了触觉美学的研究。经统计概括发现：1. 触觉美学的评价标准几乎是二分法的，即正面（喜欢/欣赏/愉悦）和负面（不喜欢/厌恶/贫穷）；2. 触觉美学主要涉及触摸维度（通感/需要触摸/触摸模式）和触摸样本维度（形状/类型/纹理），一般忽略需要触摸（NFT）和触摸模式；3. 一些研究也没有限制触摸样品的形状和材料。

关键词：触觉美学、质感、美学评价。

1. Introduction

In recent years, during the COVID-19 pandemic, the online shopping frenzy has increased (Koch et al., 2020). Yet, this limited approach of purchasing on a visual basis largely disregards the need to touch. Aesthetics, an influencing factor in the desire to buy, is a product of sight, touch, and sound (Peck & Childers, 2003a, 2003b). However, in contrast to touch, the visual and auditory senses are capable of collecting information across time and distance (Truax, 2012). The intensity of communication is far more powerful visually and auditorily than tactilely (Delogu et al., 2021; Coleman, 1965; Charters, 2006), which has allowed the tactile aesthetic to fade into obscurity today with the mobile web so advanced.

When "aesthetic" is mentioned, the first thing that comes to mind is artworks, songs, or movies. Our inner perception of aesthetics is habitually projected onto visual and auditory forms, while the perception of tactile aesthetics seems unfamiliar. A quick look in the dictionary reveals that most of the adjectives describing aesthetics (symmetrical, bright, elegant, etc.) are about the visual and auditory senses. However, touch is an important way of receiving information, and it is also the platform through which the human brain experiences and forms emotional and physical responses to textures (Nuszbaum et al., 2014). When tactile information is used in conjunction with visual exploration, it can lead to a more three-dimensional richness of perception and experience (Ernst & Banks, 2002). For example, modern museums are beginning to appreciate the impact of touch on the aesthetic experience as a way of educating and engaging audiences and attracting different groups, including the blind; exhibitions that allow for a tactile experience are becoming increasingly popular compared to traditional museums with glass walls (Candlin, 2008). In fact, artworks (especially sculptures) have been directly associated with the sense of touch since the Renaissance (Zuckert, 2009; Berenson, 1897; Etlin, 1998). Modern artists also seem to be focusing on the role of touch in aesthetic evaluation (Kemske, 2009; Lauwrens, 2019) as they realize that without the sense of touch, it is difficult for the public to truly feel the fascination of art such as sculptures, crafts, and prints (Gallace & Spence, 2011; Jakesch & Carbon, 2012).

Despite the importance of touch as a medium of aesthetic communication and information reception in fine art, the tactile element has not received the attention it deserves in studies related to aesthetic evaluation (Sonneveld & Schifferstein, 2008; Diaconu, 2003, 2006; Gallace & Spence, 2014). The idea that tactile sensations bring about aesthetic emotions is ambiguous (Schindler et al., 2017), which is also largely based on visual sensations (Ludwig & Simner, 2013). Even today, experimental aesthetics is so sophisticated, while theories of aesthetic assessment on the sense of touch are still fragmented (Gallace & Spence, 2011).

2. Definition of Key Term

2.1. Tactile

"Tactile" is defined as the physical stimuli perceived through contact with a target object by the skin of the hand or other parts of the body, providing information about the object's properties (James et al., 2007). The physical properties of haptic perception are diverse and include roughness, hardness, temperature, moistness, shape, and concavity (Gallace & Spence, 2014). In this study, "haptic" is defined as the perception caused by physical contact with an object through the skin.

2.2. Aesthetic and Aesthetic Evaluation

By reviewing the collected literature, we found that the concept of aesthetics is broad. Different studies have interpreted aesthetics in different ways. Although the term "aesthetic" is mentioned in the literature, the confusion of multiple related terms (e.g., beautiful, hedonistic, appreciative, pleasurable, happy, fond) and concepts does not contribute to the rigor and generality of aesthetic research (Delogu et al., 2021).

Although scholars have interpreted aesthetics differently, there is a pattern in the definition of aesthetic evaluation. Most studies have operationalized definitions under positive and negative feelings, e.g., good-bad, like-dislike, appropriate-inappropriate (Table 2). It is worth noting that even though the concept of pleasure is related to that of beauty, it is not the entire connotation of aesthetics.

3. Materials and Methods

It should be noted that the papers collected for this study are limited to the framework of experimental aesthetics, i.e., quantitative research (experiments) as the primary research method, with clear independent and dependent variables. Therefore, the review did not include the empirical aesthetics-based literature (e.g., presentation, observation, discussion, elaboration, conjecture). Moreover, the collected literature is based on perception, cognition, and experience studies in aesthetic evaluation. The literature related to studies on tactile perception only (e.g., materialogy, neuroscience, bioscience) is outside the scope of this study. We, therefore, targeted three databases rich in psychological studies: Elsevier, Springer, and Apa Psycnet, and supplemented this with other relevant literature from Google Scholar.

Aesthetic evaluation is the first essential element to limit the scope of the study, and we found Pleasure, Appreciate, and Enjoy all similar terms under Aesthetic as the base search term. Therefore ("Aesthetic" OR "Aesthetic Evaluation" OR "Pleasure" OR "Appreciate" OR "Enjoy") is used as the Search String for Aesthetic Evaluation. Use ("Haptic" OR "Tactile" OR "Touch"

OR "Tactus ") as a qualifying term for haptic, with ("Texture" OR "Textile" OR "Shape" OR "Outline" OR "Grain" OR "Material") as the third qualifying lexical item.

Table 1. Database - search string - article counts

Database	Search String	Result
Elsevier	(“Aesthetic” OR “Aesthetic Evaluation” OR “Pleasure” OR “Appreciate” OR “Enjoy”) and (“Haptic” OR “Tactile” OR “Touch” OR “Tactus”) and (“Texture” OR “Textile” OR “Shape” OR “Outline” OR “Grain” OR “Material”)	5
Apa Psycnet		3
Springer		3
Brill		2
Frontiers		1
SAGE		1
IEEE Xplore		1
Wiley Online		1
Ingenta		1

After further eliminating empirical aesthetics and qualitative studies by reading the abstracts, we ended up with only 18 literature articles that met the requirements. Of these, Elsevier had five, and APA PsycNet and Springer each had three. There were also seven literature sources in other databases, obtained through a Google Scholar search (Table 1).

4. The Overview of Research Content

All 18 studies were rated on a Likert scale or selected in positive and negative forms in terms of aesthetic assessment. This included pleasantness, bad/good, attractiveness, etc. (Table 2). Although the touch samples were diverse, the results presented mainly involved characteristics of the person touching (fluency/willingness to touch/style of touch) and characteristics of the touch samples (shape/product type/texture) (Table 2). In the following sections, these factors are analyzed and summarised in detail.

Table 2. Tactile factors affecting aesthetic evaluation

No	Source	Toucher		Touch Samples			
		Synaesthesia	Need for Touch	Touch Pattern	Shape	Category	Texture
1	Delogu et al., 2021	√			√		√
2	Etzi et al., 2014			√		√	√
3	Jansson-Boyd & Marlow, 2007	√					√
4	Krishna et al., 2010	√					√
5	Jakesch & Carbon, 2012	√	√		√		√
6	Breitschaft & Carbon, 2021				√		√
7	Iosifyan et al., 2017	√				√	√
8	Jraissati et al., 2016	√					√
9	Ludwig & Simner, 2013	√			√		√
10	Guest et al., 2011			√		√	√
11	Grohmann et al., 2007		√		√		
12	Peck & Childers, 2003a, 2003b		√			√	
13	Ballesteros et al., 2005	√	√	√		√	√
14	Yazdanparast & Spears, 2012		√			√	
15	Faucheu et al., 2019						√
16	Hasegawa et al., 2018	√					
17	Hove et al., 2020	√					
18	Karim & Likova, 2018	√			√	√	

5. The Dimension of the Toucher

The participants' psychological and physiological factors play a considerable role in the tactile aesthetic. Out of 17 works, only the study by Faucheu et al. (2019) did not consider the participants' personal factors. This section analyses the influence of the toucher's characteristics (synesthesia, need for touch, touch pattern) on the tactile aesthetic experience.

5.1. Synaesthesia

Synaesthesia is explained as the interplay of sight, sound, smell, taste, and touch through artistic association and imagination (Galeyev, 1999; Baron-Cohen & Harrison, 1997). Under this theory, some scholars are keen to investigate the aesthetic assessment of visual and tactile interactions. For example, people subconsciously associate letter shapes with specific colors, which is more pronounced in early childhood, while some adults are more used to associating the sounds of letters with specific colors (Spector & Maurer, 2011). Similarly, in some tactile and specific color fixations, material roughness is significantly associated with black, white, and brown; brighter and purer colors tend to result in soft tactile textures; rich, smooth, soft, and light materials are associated with brighter visual experiences than colors associated with rough, hard, and heavy materials (Jraissati et al., 2016; Ludwig & Simner, 2013). Jraissati et al. (2016) have suggested that the aesthetic perception evoked by rough is similar to the aesthetic perception given by low brightness and low purity colors, while smoothness corresponds to high brightness and high purity colors. Whereas roughness is associated with lower brightness colors such as black, white, and brown, smoothness is only associated with red and is not significant (Ludwig & Simner, 2013). Jraissati et al. (2016) have suggested that the aesthetic perception evoked by rough textures is similar to that given by low lightness and low purity colors, while smooth textures correspond to high lightness and high purity colors. Indeed, there are objections: although roughness correlates with lower brightness colors such as black, white, and brown, smoothness is only related to red which is not significant (Ludwig & Simner, 2013).

Table 3. Aesthetic evaluation criteria and research results

No	Source	Stimuli	Aesthetic Evaluation	Result	
				Positive	Negative
1	Delogu et al., 2021	Plaster Sculptures	Pleasantness (1-10)	Sphere-like shapes sculpture	Cube-like shapes sculpture
2	Etzi et al., 2014	Oasis, Tulle, Cotton, Satin, Cling film, Sandpaper, etc.	Pleasantness (1-10)	Sandpaper, Satin, Cling	Oasis, sponge, Tulle
3	Jansson-Boyd & Marlow, 2007	DVD containers	Attractive (1-7)	Smooth plastic, Matte plastic	Rough plastic
4	Krishna et al., 2010	Blotting Paper	Good/Poor (1-9) Appropriate/Inappropriate (1-9)	Smooth paper with a feminine scent, rough paper with a masculine scent	Smooth paper with a masculine scent, Rough paper with a feminine scent
5	Jakesch & Carbon, 2012	Wood and stone	Like-Dislike (1-7)	Wood (simple modeling), stone (simple modeling)	Wood (complex modeling), stone (complex modeling)
6	Breitschaft & Carbon, 2021	Polycarbonate Plates	Fitting (1-7) Similarity (1-7)	Simple geometry association with on/off (e.g., ellipse, rectangle, square, triangle), Raise-line figure association with more/less	Complex geometry association Unspecified (e.g., trapezoid, cross, nested graphics)
7	Iosifyan et al., 2017	Silk, Wood, Fur, Aluminum, Glass, Leather, Rubber, etc.	Osgood's bipolar scales (1-7) (Osgood et al., 1957)	Fur, wood, silk,	Metal,sandpaper,rubber
8	Jraissati et al., 2016	Tactile imaging (Disembodied sample)	Luminance (1-7) Chroma (1-7)	/	/
9	Ludwig & Simner, 2013	Paper, wood	Luminance (1-7), Chroma (1-7)	Half-circle wood, smooth paper	Pointed wood, rough paper
10	Guest et al., 2011	Silky, Poly, Latex, Cotton, Hessian	Comfort (1-15) Arousal (1-15)	Silky, Poly	Hessian, Latex
11	Grohmann et al., 2007	Pillow, Washcloth Quality, Key chain, Ballpoint pen	Bad/good (1-9) Undesirable/desirable (1-9) Worthless/worthwhile (1-9) Useless/useful (1-9)	Pillow (high quality × high-NFT × haptic) Washcloth (high quality × high-NFT × haptic)	Pillow (Low quality × low-NFT×no touch) Washcloth (Low quality × low-NFT × no touch)
12	Peck & Childers, 2003a, 2003b	Sweater Cell Phone	Importance (1-7)	Sweater (low-NFT × visual × haptic) Cell phone (low-NFT × visual × haptic)	Sweater (High-NFT × haptic) Sweater (Low-NFT × haptic) Cell phone (Low-NFT × haptic)
13	Ballesteros et al., 2005	Wood, Tiles, Soap, Fur, Sponges, Sandpaper, Cotton, etc.	Pleasantness (1-5)	Fur, Angora wool, Coarse foam rubber, Acrylic fabric	Hard sandpaper, dishcloth, and harsh sponge

Continuation of Table 3

14	Yazdanparast, & Spears, 2012	Sweaters Laptop	Purchase Decision (Yes/No)	Laptop (high-NFT) Sweater (low-NFT)	Laptop (low-NFT) Sweater (high-NFT)
15	Faucheu et al., 2019	Resin	Like/Dislike (1-4)	Resin flat (slipper) Resin flat (vibrating × inter-dot distance)	Resin flat (rough) Resin flat (vibrating × inter-dot distance)
16	Hasegawa et al., 2018	Electricity	Pleasure/Misery	Electricity (High-frequency × rhythm)	Electricity (Low-frequency × rhythmless)
17	Hove et al., 2020	Song	Enjoyment (1-7) Groove (1-7) Ease of tapping (1-7)	New song (Auditory × haptic) Old song (Auditory)	New song (Auditory) Old song (Auditory × haptic)
18	Karim & Likova, 2018	Wood Sculptures, Plaster Sculptures	Pleasing (Yes/No)	Curved/Rounded/Symmetric Sculpture	Sharp/Pointed/Asymmetric Sculpture

From a cross-modal aesthetic perspective, visual and tactile sensations corroborate each other in aesthetic judgments. For example, participants were more confident in their aesthetic judgments when visuals (pictures) were used to supplement tactile descriptions. Otherwise, the participants appeared distrustful or even frustrated (Peck & Childers, 2003a, 2003b). Gail Martino and Marks (2001) explained such phenomena in terms of the semantic coding hypothesis, whereby different tactile stimuli generate corresponding abstract semantics, grouped with visual or auditory stimuli of similar semantics, thus evoking the perceptual recall of the other senses. However, the semantic coding hypothesis is based only on perception as a consequence, which is not the same as the aesthetic perception of multisensory interaction. Some case studies have also demonstrated that visual aesthetics can be captured with tactile contact only. For example, blind people were able to express how to appreciate paintings as well as learn to draw in reverse perspective after some tactile cognitive training (Kennedy & Juricevic, 2008; Kennedy, 2003), while some congenitally blind participants became proficient in using one-point perspective, as they practiced tactile drawing more frequently (Kennedy & Juricevic, 2008). Even the emotional evaluation of the smooth sculpture was almost identical between blind and sighted participants (Karim & Likova, 2018).

Of course, the existence of an aesthetic interaction between tactile and visual experiences has been questioned, and Jakesch and Carbon (2012) present a non-significant interaction between visual and tactile aesthetic experiences when controlling for visual contact with exposure effects. Similarly, a study of the aesthetic evaluation of sculptures showed no correlation between sculptures with higher levels of tactile sensory pleasantness and those with higher visual evaluations. Furthermore, there was no significant change in the aesthetic evaluation in the order of contact, either in the tactile-visual or visual-tactile order (Ballesteros et al., 2005; Delogu et al., 2021).

In addition, several studies have used non-physical samples to assess aesthetics under synaesthesia (Faucheu et al., 2019; Hasegawa et al., 2018; Hove et al., 2020; Iosifyan et al., 2017). For example, research on the film has found that emotional changes induced by touching rough and hard textures, such as sandpaper and leather, are correlated with films that are filled with elements of violence, disgust, and sadness (Iosifyan et al., 2017). Equally, electrical current stimuli can evoke color perception, with high frequency and rhythmic current stimuli easily triggering strong visual perceptual recall and evoking aesthetic emotions similar to those observed for warm colors (e.g., red, orange, and yellow). In contrast, low frequency and slow current stimuli are considered less evocative and correspond to aesthetic emotions in cool colors (Hasegawa et al., 2018). In a study on the association between touch and taste, participants categorized rough and smooth textures according to male and female perfume scents. The results showed a significant association between multisensory semantic coherence and aesthetic perception (Krishna et al., 2010). In terms of music appreciation, some researchers claim that moving to music increases pleasure (Zatorre & Salimpoor, 2013) and that tactile (vibration) interventions significantly increase the amplitude of the participant's groove (swaying the body to the music), enhancing the tapping beat intensity (Hove et al., 2020). In general, multisensory interaction is one of the most critical conditions under which the sense of touch influences aesthetic evaluation; after all, the senses work together to receive information that helps us perceive objects (Baron-Cohen & Harrison, 1997). However, there is no agreed answer to the question of how tactile sensations evoke aesthetic evaluation between the senses of sight, hearing, and even taste.

The sense of touch and the other senses can evoke aesthetics independently or interactively based on synaesthesia theory. When this occurs, the forms of aesthetics between the different senses are correlated. Nevertheless, at least for now, "can tactile aesthetics be independent of the other senses, and what conditions are when tactilely dominated aesthetic assessment takes place?" is still controversial. Furthermore, we find that the results of most studies are still oriented towards a visual aesthetic evaluation, with the tactile only as an aid to determining the original visual perception, reinforcing the original aesthetic judgment when the perception is consistent, and weakening it when it is

not.

5.2. Need for Touch

Participants' willingness to touch is essential in influencing their tactile aesthetic (Grohmann et al., 2007; Peck & Childers, 2003b; Yazdanparast & Spears, 2012; Jakesch & Carbon, 2012). Peck and Childers (2003a, 2003b) invented the Need for Touch (NFT) scale, 12 test questions to measure participants' desire and need for touch. Of the 18 works in the collection that considered the willingness to touch influenced tactile aesthetics, almost all used the NFT as the sole instrument to quantify and measure it.

A 3 x 3 multifactorial ANOVA consisting of product quality, Need for Touch (NFT), and product category showed NFT as the multivariate main effect, with participants' willingness to touch indeed influencing the aesthetic evaluation of the product. Specifically, the High-NFT tended to give higher aesthetic ratings and desire to purchase when asked to touch the product (Grohmann et al., 2007). For low-NFT participants, the aesthetic evaluation does not depend on touch heavily, whereas the high-NFT are more likely to be deceived and have their aesthetic judgments influenced when they do not touch the product (Peck & Childers, 2003a, 2003b). On this footing, several other studies have discovered a highly significant positive correlation between NFT as a continuous variable and the processing of information features, and the correlation is very close to linear (Yazdanparast & Spears, 2012). Similarly, high-NFT consumers analyze product features and focus on product details on a case-by-case basis more frequently than low-NFT consumers, which subjectively emphasizes commonalities between pieces of information related to product categories and compares them to concepts in memory before encoding their features (Lee & Lee, 2011; Yazdanparast & Spears, 2012). Thus, we speculate that the addition of touch further magnified the extent to which product information was collected by both groups of participants by NFT, leading to differences in aesthetic evaluation.

We have found that the role of NFT is more consistent in the literature, where the product is the object being touched. However, this was not confirmed in studies with material or texture variation only. The impact of NFT intervention was more significant on products with a strong tactile function, which raises a discussion: whether haptic aesthetic studies that use only material or material as a sample ignore the impact of the overall construction of the aesthetic in its realistic context?

5.3. Touch Pattern

Some of the studies also expressly limited the way participants touched, including body site and the active/passive touch (Guest et al., 2011; Etzi et al., 2014; Ballesteros et al., 2005).

The tactile sensation of the skin is variable from a different site, which is reflected in sensory and emotional responses (Etzi et al., 2014). Typically, gentle and slow stimulation on hairy skin (forearms and calves) is more pleasant than smooth skin (Essick et al., 2010; Guest et al., 2011; Löken et al., 2009), where forearms, despite with a higher tactile threshold, eliciting a significant emotional response with appropriate stimulation (Löken et al., 2009; McGlone et al., 2007), whereas stimulation of the palm provides a more varied sensory and a less significant emotional description (McGlone et al., 2012), and fingers are very good at subtle textural variations compared to the palm as well (Sathian & Zangaladze, 1996; Goldreich & Kanics, 2003). This is due to the high threshold C-tactile (CT) dominance of smooth skin compared to hairy skin, which is less affected by low threshold CT (Essick et al., 2010; Guest et al., 2009). Interestingly, the study by Guest et al. (2009) was affected by CT, leading resulted in the Hessian, which was initially set to be rough, showing 'smooth' related feedback in a forearm touching. Therefore, it is necessary to specify the body site for touch to ensure the accuracy of aesthetic evaluation. However, only three of the 17 papers collected on this topic limited the mode of touch.

There was also variability in the aesthetic feedback evoked by active/passive contact. When subjects are touched by another person (passive touch) or an object, it brings about a more intense sense of pleasure than when their own body is stimulated in the same way (Guest et al., 2009, 2011). Moreover, artificially enhanced contact pressure in the passive touch state can reinforce feelings of pleasure and aversion, polarising aesthetic evaluations (Ballesteros et al., 2005). There is some evidence that when people actively touch objects, this leads to a decrease in tactile sensitivity, a phenomenon known as 'Sensory Suppression' (Gallace et al., 2010; Bays & Wolpert, 2007). However, there is no direct evidence to suggest that sensory suppression is the direct cause of the phenomenon of touch passivity in aesthetic assessment. Regardless, active/passive touch effects on aesthetic evaluation must be further tested.

6. The Dimension of Touch Samples

Category (material and product), texture, and shape are the three factors that influenced the aesthetic evaluation of the tactile samples (Table 2). Unlike the toucher attributes, the three dimensions overlap, and some studies take them into account. Rough-smooth and soft-hard were the two most frequent and influential pairs of factors in the material dimension. In terms of shape, sphere-tube, sharp-curved, and point-round are the three sets of variables that scholars set.

6.1. Texture

Nine studies mentioned roughness and smoothness as the main texture characteristics influencing the

aesthetic experience (Table 3). Furthermore, most studies suggest that rough-smooth has a much higher priority than hardness, temperature, and dryness for aesthetic experience (Guest et al., 2011; Faucheu et al., 2019; Jraissati et al., 2016; Arvidsson et al., 2017; Ludwig & Simner, 2013; Ballesteros et al., 2005).

A wrinkle spacing at 80 μm is a dividing line between perceived roughness and smoothness for the same material, and the perceived roughness increases significantly when this threshold is exceeded, while the perceived difference is not significant below 80 μm (Arvidsson et al., 2017). The researchers also elaborated on the conditions under roughness: the perceived roughness decreases with increasing width of the fold in the range of 0.1 ~ 2 mm in size (wrinkle) (Faucheu et al., 2019). As for the roughness when presented as particles, its roughness perception level is linearly related to the diameter of the particles (Faucheu et al., 2019). In addition to these effects, the intensity of perceived roughness and smoothness has a more significant relationship with the geometric features of the surface particles, their distribution, and the intensity of vibration (Ballesteros et al., 2005; Faucheu et al., 2019), where vibrations can reinforce opposing aesthetic evaluation (e.g., likes-dislikes) (Faucheu et al., 2019).

We found that most studies consistently confirm that the aesthetic evaluations of rough and smooth are opposite in general. For example, smooth silks and tinsel often evoke sensations of comfort and pleasure, while rough sandpaper and sponges bring about feelings of disgust (Etzi et al., 2014). In addition, participants often used negative words such as noisy, disgusting, and ugly to sink descriptions of roughness. In contrast, the smooth was described with positive words associated with beauty (Iosifyan et al., 2017). Some studies have also found a near-linear relationship between the smooth/rough dimension and pleasantness, both in tactile and visual perception, which is much more significant than other material characteristics (Ballesteros et al., 2005). Further, studies have examined the touch and taste and have identified that smooth materials are associated with feminine aesthetic qualities, while rough materials are consistent with masculine-like aesthetic perceptions (Krishna et al., 2010).

Table 4. The top three factors in touch sample affecting the aesthetic evaluation

Source	**Stimuli**	**Touch Sample Dimension**		
		1	**2**	**3**
Delogu et al., 2021	Plaster Sculptures	Sphere—Tube[B]	Concavity—convexity[B]	/
Etzi et al., 2014	Oasis, Tulle, Cotton, Satin, Cling film, Sandpaper, etc.	Rough—smooth[A]	/	/
Jansson-Boyd & Marlow, 2007	DVD containers	Rough—smooth[A]	Thick—Thin[A]	Heavy—light[A]
Krishna et al., 2010	Blotting Paper	Rough—smooth[A]	/	/
Jakesch & Carbon, 2012	Wood and stone	Complex—simple[B]	/	/
Breitschaft & Carbon, 2021	Polycarbonate Plates	Concavity—convexity[B]	/	/
Iosifyan et al., 2017	Silk, Wood, Fur, Aluminum, Glass, Leather, Rubber, etc.	Rough—smooth[A]	Soft—hard[A]	/
Jraissati et al., 2016	Tactile imaging (Disembodied sample)	Rough—smooth[A]	Soft—hard[A]	Sticky—non-sticky[A]
Ludwig & Simner, 2013	Paper, wood	Rough—smooth[A]	Soft—hard[A]	Point—round[B]
Guest et al., 2011	Silky, Poly, Latex, Cotton, Hessian	Rough—smooth[A]	Concavity—convexity[B]	Bumpy—flat[B]
Grohmann et al., 2007	Pillow, Washcloth Quality, Key chain, Ballpoint pen	High—Low (quality)[3]	/	/
Ballesteros et al., 2005	Sweater, Cell Phone	Rough—smooth[A]	Slippery—adherent[A]	Soft—hard[A]
Faucheu et al., 2019	Resin	Rough—smooth[A]	Vibrating—stability[C]	/
Hasegawa et al., 2018	Electricity	Vibrating—stability[C]	Rhythmless—rhythmless[C]	/
Hove et al., 2020	Song	Vibrating—stability[C]	Rhythmless—rhythmless[C]	/

Continuation of Table 4

Karim & Likova, 2018	Wood Sculptures, Plaster Sculptures	Sharp—curved[B]	Point—round[B]	Symmetric—asymmetric[B]

Note: A for texture, B for shape, C for other

6.2. Category (Materials and Products)

Rather than limiting diverse textures under the same material, some studies have compared dissimilar materials' influences across textures to investigate aesthetic similarities and differences (Etzi et al., 2014; Iosifyan et al., 2017; Guest et al., 2011; Grohmann et al., 2007; Ballesteros et al., 2005). Although smoothness and softness are more likely to evoke feelings of affection and pleasure (Iosifyan et al., 2017), this may not necessarily hold true between different types of materials. Specifically, the perceived roughness intensity of the oasis and the abrasive sponge was almost identical for both forearm touches. However, the aesthetic feedback was bifurcated in terms of pleasure and disgust. However, the abrasive sponge was preferred to the sandpaper and oasis by face touching (Etzi et al., 2014). Similarly, silk is less smooth and softer than fur under active palm touch but far more pleasant (Iosifyan et al., 2017). Therefore, textural conclusions may not be valid between dissimilar materials, and the textural characteristics between different types of materials need to be further refined.

From a product design perspective, the product type is also one of the variables that influence the aesthetics of touch (Grohmann et al., 2007; Peck & Childers, 2003a, 2003b). Consumers favor products they can touch, especially when tactile input is important for assessment (e.g., clothing, portable electronics) (Grohmann et al., 2007). A product's tactile quality brings consumers closer to it; the proximity and the added physical dimension of information gathering (e.g., roughness, hardness, temperature and weight) enables them to achieve a better understanding of the product and arrive at a more three-dimensional judgment (Klatzky et al., 1993), effectively increasing their confidence in the product but also reducing their frustration at the point of consumption (Peck & Childers, 2003a, 2003b).

6.3. Shape

Shape is a relatively independent haptic influence. Regardless of visual intervention, the participants rated the haptic aesthetics of curved/rounded sculptures higher than that of the sharp/pointed sculptures (Karim & Likova, 2018; Delogu et al., 2021). As Jakesch and Carbon (2012) indicated, simple shapes receive more positive aesthetic assessments than complex shapes when exposed less than twice, and the difference in aesthetic feedback between complex and simple shapes is insignificant when exposed up to 10 times. Regarding specific shapes, the aesthetic associations created by squares, circles and triangles are relatively straightforward, while complex combinations—the raised-line figure, the horizontal line, the hollow circle and the cross—evoke a more complex perception (Breitschaft & Carbon, 2021). Moreover, in Karim and Likova's (2018) study, nearly 90% of the participants reported that tactile stimuli with symmetrical shapes were more attractive than those with asymmetrical shapes.

According to the aesthetic association principle (AAP), which Fechner established, an object's aesthetics is the associated cognition or recall evoked by the collection of information (Ortlieb et al., 2020). In the AAP framework, when the participants drew button shapes based only on tactile recall, the drawings closely resembled the presented stimuli. However, with more complex shapes, the similarity between the drawn shape and the original shape gradually decreases (Breitschaft & Carbon, 2021). The more complex the shape, the harder it is for drawing and recognition, and the lower discrimination of tactile recognition indirectly affects its associativity (Breitschaft & Carbon, 2021; Ueda et al., 2016).

Perhaps shapes, as an art form, are difficult to classify and categorize as effectively as textures. This is why Delogu et al. (2021) did not give the laws of concavity and convexity that affect aesthetics. Similarly, Jakesch and Carbon (2012) defined sculptural forms only as simple and complex, concluding that simple sculptures were more likely to win consumer favor after multiple tactile–visual encounters. In contrast, the mixed study of Breitschaft and Carbon (2021) concluded more specifically that simple concave and convex shapes—circles, squares and triangles—are more likely to be pressed. On the other hand, nested shapes with varying degrees of undulation evoked more complex aesthetic associations, and the participants were less able to recognize them by touch.

7. Conclusion

By reviewing the relevant studies on the feedback of aesthetic assessment in the haptic dimension, this study systematically summarized and concluded the tactile factors that influence aesthetic evaluation. Although some of the patterns and affective variables of tactile aesthetics have been summarized, some other issues that must be addressed remain, issues that can be expanded and deepened in future studies in the following ways.

7.1. Enriching the Semantics of Tactile Aesthetic Evaluation

Perhaps the difficulty in precisely defining the term

'aesthetics' is why aesthetics itself has been somewhat suppressed in contemporary psychological research. In research on tactile aesthetics, most scholars are reluctant to delve into the nature of aesthetics, resorting instead to using a more statistical dichotomy (like–disgust, good–bad, pleasurable–disgusting) to quantify aesthetic evaluation. Scholars are more inclined toward the dimension of beauty (the most frequent occurrence of pleasantness) while neglecting negative or neutral evaluations, which are, in fact, equally worth researching. For example, the Gothic tradition evolved in vampire horror films, where Dracula's mix of horror, elegance and mystery became a classic historical symbol (Grabias, 2017). The horror aesthetic, Connolly (2008) argues, is rooted in the erosion of boundaries, creating a fascination with the unknown and uncertain. Of course, according to Hillman and Ventura (2007), this is also a complex aesthetic feedback woven into the ideology of the form of cultural genetics, and it is difficult to define this state simply in terms of likes and dislikes.

Qualifying tactile aesthetics with a dichotomous choice alone might stifle the participants' original aesthetic feelings. Instead, conducting an interview first to identify multiple aesthetic semantics might be a relatively reasonable method. Evidently, a study that combines quantitative and qualitative analysis is capable of reflecting the tactile aesthetic feelings of its participants in greater detail (Iosifyan et al., 2017; Jraissati et al., 2016; Guest et al., 2011).

7.2. Paying Attention to the Influence of Touch Pattern and NFT

The absence of touch patterns and NFT in the control variables is highly detrimental to the accuracy of the data collection and research findings. This is because an aesthetic response is a multisensory experience, with different forms of sensory stimuli interacting with each other and potentially creating a multimodal representation of the overall aesthetic experience (Etzi et al., 2014). In studies related to aesthetic assessment, it is thus necessary to pay attention not only to the relationship between the tactile dimension and other dimensions but also to the impact of individual differences. Although the available evidence suggests that sensory connections appear to be innate rather than learned—just as both young children and adults make associations with meaningless sounds and shapes (e.g., kiki and bouba) (Lindauer, 1990; Maurer et al., 2006; Ramachandran & Hubbard, 2001)—this is limited to auditory and visual subsensory perception as the final settlement and does not rise to aesthetic denotations. Therefore, the validity of a similar Bobachiki effect in tactile aesthetic evaluation (i.e., whether aesthetic associations are innate and cross-cultural) requires further verification.

7.3. Deepening the Aesthetic Interaction between Tactile and Other Senses

In the case of synesthesia, most research has explored the relationship between tactile and visual aesthetics, specifically the association between color and material. Nevertheless, a limited number of studies have been conducted on tactile-auditory and tactile-taste interactions. One of the most common methods for this is the matching task, in which participants are instructed to categorize tactile sensations in terms of other perceived aesthetic experiences. The implicit association test (IAT) is the most definitive. However, there is also the go/no-go association test (GNAT) (Nosek & Banaji, 2001) or the single-category-IAT (SC-IAT) (Karpinski & Steinman, 2006), which are more specific. Also, as most tactile aesthetic studies have small sample sizes, it is significant for tactile aesthetics to allow different populations to define interactions under different senses to model cross-membrane state aesthetics.

References

[1] ARVIDSSON, M., RINGSTAD, L., SKEDUNG, L., DUVEFELT, K., & RUTLAND, M.W. (2017). Feeling fine - The effect of topography and friction on perceived roughness and slipperiness. *Biotribology,* 11, 92–101. https://doi.org/10.1016/J.BIOTRI.2017.01.002

[2] BALLESTEROS, S., REALES, J.M., DE LEON, L.P., & GARCIA, B. (2005). The perception of ecological textures by touch: does the perceptual space change under bimodal visual and haptic exploration? First Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems. World Haptics Conference, Pisa, Italy, 18-20 March 2005, pp. 635-638. https://doi.org/10.1109/WHC.2005.134

[3] BARON-COHEN, S., & HARRISON, J.E. (eds.) (1997). *Synaesthesia: Classic and contemporary readings.* Oxford: Blackwell Publishing.

[4] BAYS, P.M., & WOLPERT, D.M. (2007). Predictive attenuation in the perception of touch. In: HAGGARD, P., ROSETTI, Y., & KAWATO, M. (eds.) *Sensorimotor foundations of higher cognition*. Oxford: Oxford University Press, pp. 339–358. https://doi.org/10.1093/acprof:oso/9780199231447.003.0016

[5] BERENSON, B. (1897). *The Venetian painters of the Renaissance: with an index to their works*. New York: G.P. Putnam's Sons.

[6] BREITSCHAFT, S.J., & CARBON, C.C. (2021). Function Follows Form: Using the Aesthetic Association Principle to Enhance Haptic Interface Design. *Frontiers in Psychology,* 12, 2619. https://doi.org/10.3389/fpsyg.2021.646986

[7] CANDLIN, F. (2008). Touch and the Limits ofthe Rational Museum, or Can Matter Think. *The Senses and Society,* 3(3), 277–292.

https://doi.org/10.2752/174589308X331323

[8] CHARTERS, S. (2006). Aesthetic products and aesthetic consumption: A review. *Consumption, Markets and Culture*, 9(3), 235-255. http://dx.doi.org/10.1080/10253860600772255

[9] COLEMAN, F.J. (1965). Can a smell or a taste or a touch be beautiful? *American Philosophical Quarterly*, 2, 319–324.

[10] CONNOLLY, A. (2008). Jung in the twilight zone: The psychological functions of the horror film. In: ROWLAND, S. (ed.) *Psyche and the arts*. London: Routledge, pp. 128–138. Retrieved from https://www.taylorfrancis.com/chapters/edit/10.4324/9780203929797-20/jung-twilight-zone-psychological-functions-horror-%EF%AC%81lm-angela-connolly

[11] DELOGU, F., GRAVINA, M., DONG, X., FROLKA, M., KUHN, D., & YU, N. (2021). Tactile beauty is in the hand, but also in the eye of the beholder: Interaction between haptic and visual experiences in aesthetic judgement. *Psychology of Aesthetics, Creativity, and the Arts*, 15(4), 725–734. https://doi.org/10.1037/aca0000327

[12] DIACONU, M. (2003). The Rebellion of the 'Lower' Senses: A Phenomenological Aesthetics of Touch, Smell, and Taste. In: CHEUNG, C.-F., CHVATIK, I., COPOERU, I., EMBREE, L., IRIBARNE, J., & SEPP, H.R. (eds.) *Essays in Celebration of the Founding of the Organization of Phenomenological Organizations*.

[13] DIACONU, M. (2006). Reflections on an aesthetics of touch, smell and taste. *Contemporary Aesthetics*, 4(1), 8. Retrieved from https://contempaesthetics.org/newvolume/pages/article.php?articleID=385

[14] ERNST, M.O., & BANKS, M.S. (2002). Humans integrate visual and haptic information in a statistically optimal fashion. *Nature*, 415(6870), 429–433. https://doi.org/10.1038/415429a

[15] ESSICK, G.K., MCGLONE, F.P., DANCER, C., FABRICANT, D., RAGIN, Y., PHILLIPS, N., JONES, T., and GUEST, S. (2010). Quantitative assessment of pleasant touch. *Neuroscience and Biobehavioral Reviews*, 34, 192–203. https://doi.org/10.1016/j.neubiorev.2009.02.003

[16] ETLIN, R.A. (1998). Aesthetics and the spatial sense of self. *The Journal of Aesthetics and Art Criticism*, 56(1), 1-19. https://doi.org/10.2307/431943

[17] ETZI, R., SPENCE, C., & GALLACE, A. (2014). Textures that we like to touch: An experimental study of aesthetic preferences for tactile stimuli. *Consciousness and Cognition*, 29, 178–188. http://dx.doi.org/10.1016/j .concog.2014.08.011

[18] FAUCHEU, J., WEILAND, B., JUGANARU-MATHIEU, M., WITT, A., & CORNUAULT, P.H. (2019). Tactile aesthetics: textures that we like or hate to touch. *Acta Psychologica*, 201, 102950. https://doi.org/10.1016/j.actpsy.2019.102950

[19] GALEYEV, B.M. (1999). What is synaesthesia: Myths and reality. *Leonardo Electronic Almanac*, 7(6), 1-16. Retrieved from https://www.leoalmanac.org/wp-content/uploads/2012/07/LEA-v7-n6.pdf

[20] GALLACE, A., & SPENCE, C. (2011). Tactile aesthetics: Towards a definition of its characteristics and neural correlates. *Social Semiotics*, 21, 569–589. http://dx.doi.org/10.1080/10350330.2011.591998

[21] GALLACE, A., & SPENCE, C. (2014). In touch with the future: The sense of touch from cognitive neuroscience to virtual reality. Oxford: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780199644469.001.0001

[22] GALLACE, A., ZEEDEN, S., RÖDER, B., & SPENCE, C. (2010). Lost in the move? Secondary task performance impairs tactile change detection on the body. *Consciousness and Cognition*, 19, 215–229. https://doi.org/10.1016/j.concog.2009.07.003

[23] GOLDREICH, D., & KANICS, I.M. (2003). Tactile acuity is enhanced in blindness. *Journal of Neuroscience*, 23(8), 3439-3445. http://dx.doi.org/10.1523/JNEUROSCI.23-08-03439.2003

[24] GRABIAS, M. (2017). Gothic and Horror in Contemporary Cinema and Television: Aesthetic Experience and Emotional Impact. In: CRIȘAN, M.M. (eds.) *Dracula. Palgrave Gothic*. Cham: Palgrave Macmillan, pp. 227-242. https://doi.org/10.1007/978-3-319-63366-4_13

[25] GROHMANN, B., SPANGENBERG, E.R., & SPROTT, D.E. (2007). The influence of tactile input on the evaluation of retail product offerings. *Journal of Retailing*, 83(2), 237-245. http://dx.doi.org/10.1016/j.jretai.2006.09.001

[26] GUEST, S., DESSIRIER, J.M., MEHRABYAN, A., MCGLONE, F.P., ESSICK, G., GESCHEIDER, G., FONTANA, A., XIONG, R., ACKERLEY, R., & BLOT, K. (2011). The development and validation of sensory and emotional scales of touch perception. *Attention, Perception & Psychophysics*, 73, 531–550. https://doi.org/10.3758/s13414-010-0037-y

[27] GUEST, S., ESSICK, G.K., DESSIRIER, J.M., BLOT, K., LOPETCHARAT, K., & MCGLONE, F.P. (2009). Sensory and affective judgments of skin during inter- and intrapersonal touch. *Acta Psychologica*, 130, 115–126. https://doi.org/10.1016/j.actpsy.2008.10.007

[28] HASEGAWA, H., ITOH, K., OKAMOTO, S., ELFEKEY, H., & YAMADA, Y. (2018). Colorful Tactile Stimuli. Association Between Colors and Tactile-Display Stimuli on Russell's Psychological Plane. In: HASEGAWA, S., KONYO, M., KYUNG, K.U., NOJIMA, T., & KAJIMOTO, H. (eds.) *Haptic Interaction. AsiaHaptics 2016. Lecture Notes in Electrical Engineering*, Vol. 432. Singapore:

Springer, pp. 47–52. https://doi.org/10.1007/978-981-10-4157-0_8

[29] HILLMAN, J., & VENTURA, M. (2007). *We've had a hundred years of psychotherapy – and the world's getting worse.* New York: Harper-Collins.

[30] HOVE, M.J., MARTINEZ, S.A., & STUPACHER, J. (2020). Feel the bass: Music presented to tactile and auditory modalities increases aesthetic appreciation and body movement. *Journal of Experimental Psychology: General,* 149(6), 1137–1147. https://doi.org/10.1037/xge0000708

[31] IOSIFYAN, M., KOROLKOVA, O., & VLASOV, I. (2017). Emotional and semantic associations between cinematographic aesthetics and haptic perception. *Multisensory Research,* 30, 783–798. https://doi.org/10.1163/22134808-00002597

[32] JAKESCH, M., & CARBON, C.C. (2012). The mere exposure effect in the domain of haptics. *PLoS ONE,* 7, e31215. https://doi.org/10.1371/journal.pone.0031215

[33] JAMES, T.W., KIM, S., & FISHER, J.S. (2007). The neural basis of haptic object processing. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale,* 61(3), 219-229. http://dx.doi.org/10.1037/cjep2007023

[34] JANSSON-BOYD, C., & MARLOW, N. (2007). Not only in the eye of the beholder: Tactile information can affect aesthetic evaluation. *Psychology of Aesthetics, Creativity, and the Arts,* 1(3), 170–173. https://doi.org/10.1037/1931-3896.1.3.170

[35] JRAISSATI, Y., SLOBODENYUK, N., KANSO, A., GHANEM, L., & ELHAJJ, I. (2016). Haptic and tactile adjectives are consistently mapped onto color space. *Multisensory Research,* 29, 253–278. https://doi.org/10.1163/22134808-00002512

[36] KARIM, A.K.M., & LIKOVA, L.T. (2018). Haptic aesthetics in the blind: A behavioral and fMRI investigation. *Electronic Imaging,* 30, art00032. https://doi.org/10.2352/ISSN.2470-1173.2018.14.HVEI-532

[37] KARPINSKI, A., & STEINMAN, R.B. (2006). The single category implicit association test as a measure of implicit social cognition. *Journal of Personality and Social Psychology,* 91, 16–32. https://doi.org/10.1037/0022-3514.91.1.16

[38] KEMSKE, B. (2009). Embracing sculptural ceramics: a lived experience of touch in art. *The Senses and Society,* 4(3), 323-345. http://dx.doi.org/10.2752/174589209X12464528171932

[39] KENNEDY, J.M. (2003). Drawings from Gaia, a blind girl. *Perception,* 32, 321–340. https://doi.org/10.1068/p3436

[40] KENNEDY, J.M., & JURICEVIC, I. (2008). Drawings by a blind woman: Copies of shapes or linear and inverse perspective. In: HUBER, J., NEUNER, S., & GELSHORN, J. (eds.) *Tactility: Sensory Experience as a Limit Experience.*

[41] KLATZKY, R.L., LEDERMAN, S.J., & MATULA, D.E. (1993). Haptic exploration in the presence of vision. *Journal of Experimental Psychology: Human Perception and Performance,* 19(4), 726–743. https://doi.org/10.1037/0096-1523.19.4.726

[42] KOCH, J., FROMMEYER, B., & SCHEWE, G. (2020). Online shopping motives during the COVID-19 pandemic—lessons from the crisis. *Sustainability,* 12(24), 10247. http://dx.doi.org/10.3390/su122410247

[43] KRISHNA, A., ELDER, R.S., & CALDARA, C. (2010). Feminine to smell but masculine to touch? Multisensory congruence and its effect on the aesthetic experience. *Journal of Consumer Psychology,* 20(4), 410-418. http://dx.doi.org/10.1016/j.jcps.2011.03.004

[44] LAUWRENS, J. (2019). Touch as an aesthetic experience. *Journal of Visual Art Practice,* 18(4), 323-341. http://dx.doi.org/10.1080/14702029.2019.1680510

[45] LEE, B.-K., & LEE, W.-N. (2011). The impact of product knowledge on consumer product memory and evaluation in the competitive ad context: The item-specific-relational perspective. *Psychology and Marketing,* 28(4), 360–387. https://doi.org/10.1002/MAR.20360

[46] LINDAUER, M.S. (1990). The meanings of the physiognomic stimuli taketa and maluma. *Bulletin of the Psychonomic Society,* 28, 47–50. https://doi.org/10.3758/BF03337645

[47] LÖKEN, L.S., WESSBERG, J., MORRISON, I., MCGLONE, F.P., & OLAUSSON, H. (2009). Coding of pleasant touch by unmyelinated afferents in humans. *Nature Neuroscience,* 12, 547–548. https://doi.org/10.1038/nn.2312

[48] LUDWIG, V.U., & SIMNER, J. (2013). What colour does that feel? Tactile–visual mapping and the development of cross-modality. *Cortex,* 49, 1089–1099. https://doi.org/10.1016/j.cortex.2012.04.004

[49] MARTINO, G., & MARKS, L.E. (2001). Synesthesia: Strong and Weak. *Current Directions in Psychological Science,* 10(2), 61-65. https://doi.org/10.1111%2F1467-8721.00116

[50] MAURER, D., PATHMAN, T., & MONDLOCH, C.J. (2006). The shape of boubas: Sound-shape correspondences in toddlers and adults. *Developmental Science,* 9(3), 316–322. https://doi.org/10.1111/j.1467-7687.2006.00495.x

[51] MCGLONE, F., OLAUSSON, H., BOYLE, J.A., JONES-GOTMAN, M., DANCER, C., GUEST, S., & ESSICK, G. (2012). Touching and feeling: differences in pleasant touch processing between glabrous and hairy skin in humans. *European*

Journal of Neuroscience, 35(11), 1782-1788. https://doi.org/10.1111/j.1460-9568.2012.08092.x

[52] MCGLONE, F.P., VALLBO, Å., OLAUSSON, H., LOKEN, L., & WESSBERG, J. (2007). Discriminative touch and emotional touch. *Canadian Journal of Experimental Psychology,* 61, 175–183. https://doi.org/10.1037/cjep2007019

[53] NOSEK, B.A., & BANAJI, M.R. (2001). The go/no-go association task. *Social Cognition,* 19, 625–666. http://dx.doi.org/10.1521/soco.19.6.625.20886

[54] NUSZBAUM, M., VOSS, A., & KLAUER, K.C. (2014). Assessing Individual Differences in the Need for Interpersonal Touch and Need for Touch. *Social Psychology,* 45(1), 31–40. https://doi.org/10.1027/1864-9335/a000157

[55] ORTLIEB, S.A., KÜGEL, W.A., & CARBON, C.C. (2020). Fechner (1866): the aesthetic association principle—A commented translation. *i-Perception,* 11(3), 204166952092030. https://doi.org/10.1177/2041669520920309

[56] OSGOOD, C., SUCI, G., & TANNENBAUM, P. (1957). *The measurement of meaning.* Urbana, Illinois: University of Illinois.

[57] PECK, J., & CHILDERS, T.L. (2003a). Individual differences in haptic information processing: The "need for touch" scale. *Journal of Consumer Research,* 30(3), 430-442. http://dx.doi.org/10.1086/378619

[58] PECK, J., & CHILDERS, T.L. (2003b). To have and to hold: The influence of haptic information on product judgments. *Journal of Marketing,* 67(2), 35-48. http://dx.doi.org/10.1509/jmkg.67.2.35.18612

[59] RAMACHANDRAN, V.S., & HUBBARD, E.M. (2001). Synaesthesia: A window into perception, thought and language. *Journal of Consciousness Studies,* 8(12), 3–34. Retrieved from http://cbc.ucsd.edu/pdf/Synaesthesia%20-%20JCS.pdf

[60] SATHIAN, K., & ZANGALADZE, A. (1996). Tactile spatial acuity at the human fingertip and lip: Bilateral symmetry and interdigit variability. *Neurology,* 46, 1464–1466. https://doi.org/10.1212/wnl.46.5.1464

[61] SCHINDLER, I., HOSOYA, G., MENNINGHAUS, W., BEERMANN, U., WAGNER, V., EID, M., & SCHERER, K.R. (2017). Measuring aesthetic emotions: A review of the literature and a new assessment tool. *PLoS ONE,* 12(6), e0178899. https://doi.org/10.1371/journal.pone.0178899

[62] SONNEVELD, M.H., & SCHIFFERSTEIN, H.N.J. (2008). The tactual experience of objects. In: SCHIFFERSTEIN, H.N.J., & HEKKERT, P. (eds.) *Product Experience.* Amsterdam: Elsevier, pp. 41-67. https://doi.org/10.1016/B978-008045089-6.50005-8

[63] SPECTOR, F., & MAURER, D. (2011). The colors of the alphabet: naturally-biased associations between shape and color. *Journal of Experimental Psychology: Human Perception and Performance,* 37(2), 484-495. https://doi.org/10.1037/a0021437

[64] TRUAX, B. (2012). Sound, listening and place: The aesthetic dilemma. *Organised Sound,* 17(3), 193-201. https://doi.org/10.1017/S1355771811000380

[65] UEDA, A.U., SAWADA, Y., MURAKAMI, T., SAITO, M., & TSUTSUI, S. (2016). Preliminary investigation of the optimal size on tactile pictogram for visually impaired persons. *Bulletin of Japanese Society for the Science of Design,* 63, 29–36. https://doi.org/10.11247/jssdj.63.3_29

[66] YAZDANPARAST, A., & SPEARS, N. (2012). Need for touch and information processing strategies: An empirical examination. *Journal of Consumer Behaviour,* 11(5), 415-421. http://dx.doi.org/10.1002/cb.1393

[67] ZATORRE, R.J., & SALIMPOOR, V.N. (2013). From perception to pleasure: Music and its neural substrates. *Proceedings ofthe National Academy of Sciences of the United States of America,* 110(Suppl. 2), 10430–10437. http://dx.doi.org/10.1073/pnas.1301228110

[68] ZUCKERT, R. (2009). Sculpture and touch: Herder's aesthetics of sculpture. *The Journal of Aesthetics and Art Criticism,* 67(3), 285-299. http://dx.doi.org/10.1111/j.1540-6245.2009.01359.x

参考文:

[1] ARVIDSSON, M.、RINGSTAD, L.、SKEDUNG, L.、DUVEFELT, K. 和 RUTLAND, M.W. (2017)。感觉良好 - 地形和摩擦对感知的粗糙度和滑度的影响。生物摩擦学，11，92–101。https://doi.org/10.1016/J.BIOTRI.2017.01.002

[2] BALLESTEROS, S., REALES, J.M., DE LEON, L.P. 和 GARCIA, B. (2005)。触觉对生态纹理的感知：视觉和触觉双峰探索下的感知空间是否发生变化？第一次欧洲触觉联合会议和虚拟环境和远程操作系统触觉接口研讨会。世界触觉会议，意大利比萨，2005 年 3 月 18-20 日，第 635-638 页。https://doi.org/10.1109/WHC.2005.134

[3] BARON-COHEN, S., & HARRISON, J.E. (编辑。) (1997)。通感：经典和当代读物。牛津：布莱克威尔出版社。

[4] 贝斯，下午和沃尔珀特，D.M.（2007 年）。触觉感知的预测衰减。在：HAGGARD, P., ROSETTI, Y., & KAWATO, M. (编辑。) 更高认知的感觉运动基础。牛津：牛津大学出版社，第 339-358 页。https://doi.org/10.1093/acprof:oso/9780199231447.003.0016

[5] 贝伦森，B. (1897)。文艺复兴时期的威尼斯画家：

附有他们作品的索引。纽约：全科医生普特南之子。

[6] BREITSCHAFT, S.J. 和 CARBON, C.C.（2021 年）。功能追随形式：使用美学关联原则增强触觉界面设计。心理学前沿，12，2619. https://doi.org/10.3389/fpsyg.2021.646986

[7] 坎德林，F.（2008 年）。理性博物馆的触觉和极限，或者可以思考。感官与社会，3（3），277-292。https://doi.org/10.2752/174589308X331323

[8] 宪章，S.（2006 年）。审美产品和审美消费：回顾。消费、市场和文化，9（3），235-255。http://dx.doi.org/10.1080/10253860600772255

[9] 科尔曼，F.J. (1965)。气味、味道或触摸可以是美丽的吗？美国哲学季刊，2, 319–324。

[10] 康诺利，A.（2008 年）。暮光区的荣格：恐怖片的心理功能。在：ROWLAND, S. (编。) 心理与艺术。伦敦：劳特利奇，第 128-138 页。取自 https://www.taylorfrancis.com/chapters/edit/10.4324/9780203929797-20/jung-twilight-zone-psychological-functions-horror-%EF%AC%81lm-angela-connolly

[11] DELOGU, F., GRAVINA, M., DONG, X., FROLKA, M., KUHN, D., & YU, N. (2021)。触觉美在手中，也在旁观者的眼中：审美判断中触觉和视觉体验之间的相互作用。美学、创造力和艺术心理学，15（4），725-734。https://doi.org/10.1037/aca0000327

[12] DIACONU, M. (2003)。“低级”感官的反叛：触觉、嗅觉和味觉的现象学美学。在：CHEUNG, C.-F., CHVATIK, I., COPOERU, I., EMBREE, L., IRIBARNE, J., & SEPP, H.R. (编辑。) 庆祝现象学组织组织成立的论文.

[13] DIACONU, M. (2006)。对触觉、嗅觉和味觉美学的思考。当代美学，4(1), 8. 检索自 https://contempaesthetics.org/newvolume/pages/article.php?articleID=385

[14] ERNST, M.O., & BANKS, M.S.（2002 年）。人类以统计上最优的方式整合视觉和触觉信息。自然，415（6870），429-433。https://doi.org/10.1038/415429a

[15] ESSICK, G.K., MCGLONE, F.P., DANCER, C., FABRICANT, D., RAGIN, Y., PHILLIPS, N., JONES, T. 和 GUEST, S. (2010)。愉快触摸的定量评估。神经科学和生物行为评论，34, 192–203。https://doi.org/10.1016/j.neubiorev.2009.02.003

[16] 埃特林，R.A.（1998 年）。美学与自我的空间感。美学与艺术批评杂志，56（1），1-19。https://doi.org/10.2307/431943

[17] ETZI, R.、SPENCE, C. 和 GALLACE, A. (2014)。我们喜欢触摸的纹理：触觉刺激审美偏好的实验研究。意识和认知，29, 178–188。http://dx.doi.org/10.1016/j .concog.2014.08.011

[18] FAUCHEU, J., WEILAND, B., JUGANARU-MATHIEU, M., WITT, A., & CORNUAULT, P.H.（2019）。触觉美学：我们喜欢或讨厌触摸的纹理。心理学报，201，102950。https://doi.org/10.1016/j.actpsy.2019.102950

[19] 加利耶夫，B.M. (1999)。什么是联觉：神话与现实。莱昂纳多电子年鉴，7（6），1-16。取自 https://www.leoalmanac.org/wp-content/uploads/2012/07/LEA-v7-n6.pdf

[20] GALLACE, A. 和 SPENCE, C. (2011)。触觉美学：对其特征和神经相关性的定义。社会符号学, 21, 569–589。http://dx.doi.org/10.1080/10350330.2011.591998

[21] GALLACE, A. 和 SPENCE, C. (2014)。与未来的联系：从认知神经科学到虚拟现实的触觉。牛津：牛津大学出版社。http://dx.doi.org/10.1093/acprof:oso/9780199644469.001.0001

[22] GALLACE, A., ZEEDEN, S., RÖDER, B., & SPENCE, C. (2010)。迷路了？次要任务性能会损害身体的触觉变化检测。意识与认知，19, 215–229。https://doi.org/10.1016/j.concog.2009.07.003

[23] GOLDREICH, D. 和 KANICS, I.M. (2003)。失明时触觉敏锐度增强。神经科学杂志，23（8），3439-3445。http://dx.doi.org/10.1523/JNEUROSCI.23-08-03439.2003

[24] 格拉比亚斯，M.（2017 年）。当代电影和电视中的哥特式和恐怖：审美体验和情感影响。在：CRIşAN，M.M.（编辑）德古拉。帕尔格雷夫哥特式。查姆：帕尔格雷夫•麦克米伦，第 227-242 页。https://doi.org/10.1007/978-3-319-63366-4_13

[25] GROHMANN, B.、SPANGENBERG, E.R. 和 SPROTT, D.E.（2007 年）。触觉输入对零售产品评估的影响。零售杂志，83（2），237-245。http://dx.doi.org/10.1016/j.jretai.2006.09.001

[26] GUEST, S., DESSIRIER, J.M., MEHRABYAN, A., MCGLONE, F.P., ESSICK, G., GESCHEIDER, G., FONTANA, A., XIONG, R., ACKERLEY, R., & BLOT, K.（2011 年）。触觉感知的感官和情感量表的开发和验证。注意力、感知与心理物理学，73, 531–550。https://doi.org/10.3758/s13414-010-0037-y

[27] GUEST, S., ESSICK, G.K., DESSIRIER, J.M., BLOT, K., LOPETCHARAT, K., & MCGLONE, F.P.（2009 年）。在人际和人际接触中对皮肤的感觉和情感判断。心理学报，130, 115–126。https://doi.org/10.1016/j.actpsy.2008.10.007

[28] HASEGAWA, H.、ITOH, K.、OKAMOTO, S.、ELFEKEY, H. 和 YAMADA, Y.（2018 年）。多彩的触觉刺激。罗素心理平面上颜色与触觉显示刺激之间的关联。在：HASEGAWA, S., KONYO, M., KYUNG, K.U., NOJIMA, T., & KAJIMOTO, H.

(编辑。) 触觉交互。亚洲触觉 2016。电气工程讲义，卷。 432. 新加坡：施普林格，第 47-52 页。 https://doi.org/10.1007/978-981-10-4157-0_8

[29] 希尔曼, J. 和文图拉, M. (2007)。我们已经进行了一百年的心理治疗——世界变得越来越糟。纽约：哈珀-柯林斯。

[30] HOVE, M.J., MARTINEZ, S.A. 和 STUPACHER, J. (2020)。感受低音：以触觉和听觉形式呈现的音乐增加了审美和身体运动。实验心理学杂志：一般，149（6），1137-1147。https://doi.org/10.1037/xge0000708

[31] IOSIFYAN, M., KOROLKOVA, O., & VLASOV, I. (2017)。电影美学和触觉感知之间的情感和语义关联。多感官研究，30, 783–798。https://doi.org/10.1163/22134808-00002597

[32] JAKESCH, M., & CARBON, C.C.（2012）。触觉领域中的单纯曝光效应。公共科学图书馆一号，7，e31215。https://doi.org/10.1371/journal.pone.0031215

[33] JAMES, T.W., KIM, S., & FISHER, J.S.（2007 年）。触觉对象处理的神经基础。加拿大实验心理学杂志/加拿大实验心理学评论, 61(3), 219-229。http://dx.doi.org/10.1037/cjep2007023

[34] JANSSON-BOYD, C., & MARLOW, N. (2007)。不仅在旁观者的眼中：触觉信息会影响审美评价。美学、创造力和艺术心理学，1（3），170-173。https://doi.org/10.1037/1931-3896.1.3.170

[35] JRAISSATI, Y.、SLOBODENYUK, N.、KANSO, A.、GHANEM, L. 和 ELHAJJ, I. (2016)。触觉和触觉形容词始终映射到色彩空间。多感官研究，29, 253–278。https://doi.org/10.1163/22134808-00002512

[36] KARIM, A.K.M. 和 LIKOVA, L.T.（2018 年）。盲人的触觉美学：行为和功能磁共振成像调查。电子成像，30，art00032。https://doi.org/10.2352/ISSN.2470-1173.2018.14.HVEI-532

[37] KARPINSKI, A. 和 STEINMAN, R.B. (2006)。单一类别内隐关联测试作为内隐社会认知的量度。人格与社会心理学杂志，91，16-32。https://doi.org/10.1037/0022-3514.91.1.16

[38] KEMSKE, B. (2009)。拥抱雕塑陶瓷：艺术触觉的生活体验。感官与社会，4（3），323-345。http://dx.doi.org/10.2752/174589209X12464528171932

[39] 肯尼迪，J.M. (2003)。盲女盖亚的画作。知觉，32, 321–340。https://doi.org/10.1068/p3436

[40] KENNEDY, J.M. 和 JURICEVIC, I. (2008)。盲女的绘画：形状或线性和反向透视的副本。在：HUBER, J., NEUNER, S., & GELSHORN, J. (编辑。) 触觉：作为极限体验的感官体验。

[41] KLATZKY, R.L., LEDERMAN, S.J. 和 MATULA, D.E.（1993 年）。视觉存在下的触觉探索。实验心理学杂志：人类感知和表现，19（4），726-743。https://doi.org/10.1037/0096-1523.19.4.726

[42] KOCH, J., FROMMEYER, B., & SCHEWE, G. (2020)。新冠肺炎大流行期间的在线购物动机——危机的教训。可持续性，12（24），10247。http://dx.doi.org/10.3390/su122410247

[43] KRISHNA, A., ELDER, R.S. 和 CALDARA, C. (2010)。闻起来有女人味，但摸起来有男人味？多感官一致性及其对审美体验的影响。消费者心理学杂志，20（4），410-418。http://dx.doi.org/10.1016/j.jcps.2011.03.004

[44] LAUWRENS, J. (2019)。触摸是一种审美体验。视觉艺术实践杂志，18（4），323-341。http://dx.doi.org/10.1080/14702029.2019.1680510

[45] LEE, B.-K., & LEE, W.-N.（2011）。竞争广告背景下产品知识对消费者产品记忆和评估的影响：项目特定关系视角。心理学和市场营销，28（4），360-387。https://doi.org/10.1002/MAR.20360

[46] 林道尔，M.S.（1990）。面相刺激竹田和马鲁玛的含义。心理社会公报，28, 47-50。https://doi.org/10.3758/BF03337645

[47] LÖKEN, L.S.、WESSBERG, J.、MORRISON, I.、MCGLONE, F.P. 和 OLAUSSON, H. (2009)。人类无髓传入神经对愉快触摸的编码。自然神经科学，第 12 页，第 547–548 页。https://doi.org/10.1038/nn.2312

[48] LUDWIG, V.U. 和 SIMNER, J. (2013)。那是什么颜色的感觉？触觉-视觉映射和跨模态的发展。皮质，49, 1089–1099。https://doi.org/10.1016/j.cortex.2012.04.004

[49] G.马丁诺和马克，L.E.（2001 年）。联觉：强和弱。心理科学的当前方向，10（2），61-65。https://doi.org/10.1111%2F1467-8721.00116

[50] MAURER, D., PATHMAN, T., & MONDLOCH, C.J. (2006)。布巴的形状：幼儿和成人的声音形状对应。发展科学，9（3），316-322。https://doi.org/10.1111/j.1467-7687.2006.00495.x

[51] MCGLONE, F., OLAUSSON, H., BOYLE, J.A., JONES-GOTMAN, M., DANCER, C., GUEST, S., & ESSICK, G. (2012)。触觉和感觉：人类无毛和有毛皮肤之间愉快的触觉处理差异。欧洲神经科学杂志，35（11），1782-1788。https://doi.org/10.1111/j.1460-9568.2012.08092.x

[52] MCGLONE, F.P., VALLBO, Å., OLAUSSON, H., LOKEN, L., & WESSBERG, J. (2007)。辨别性触摸和情感触摸。加拿大实验心理学杂志，61，175-183。https://doi.org/10.1037/cjep2007019

[53] NOSEK, B.A. 和 BANAJI, M.R. (2001)。去/不去关联任务。社会认知，19，625-666。http://dx.doi.org/10.1521/soco.19.6.625.20886

[54] NUSZBAUM, M., VOSS, A., & KLAUER, K.C.（2014）。评估人际接触需求和接触需求的个体差异。社会心理学，45（1），31-40。

https://doi.org/10.1027/1864-9335/a000157
[55] ORTLIEB, S.A., KÜGEL, W.A., & CARBON, C.C.（2020 年）。费希纳(1866): 审美联想原则——评论翻译。知觉，11(3), 204166952092030. https://doi.org/10.1177/2041669520920309
[56] OSGOOD, C., SUCI, G., & TANNENBAUM, P. (1957)。意义的测量。伊利诺伊州厄巴纳：伊利诺伊大学。
[57] 佩克，J.和儿童，T.L.（2003 一种）。触觉信息处理的个体差异：“触摸需求”量表。消费者研究杂志，30（3），430-442。http://dx.doi.org/10.1086/378619
[58] 佩克，J.和儿童，T.L.（2003b）。拥有和持有：触觉信息对产品判断的影响。营销杂志，67（2），35-48。http://dx.doi.org/10.1509/jmkg.67.2.35.18612
[59] RAMACHANDRAN, V.S. 和 HUBBARD, E.M. (2001)。通感：感知、思想和语言的窗口。意识研究杂志，8（12），3-34。取自 http://cbc.ucsd.edu/pdf/Synaesthesia%20-%20JCS.pdf
[60] SATHIAN, K. 和 ZANGALADZE, A. (1996)。人类指尖和嘴唇的触觉空间敏锐度：双边对称性和指间变异性。神经病学，46, 1464–1466。https://doi.org/10.1212/wnl.46.5.1464
[61] 辛德勒, I., 细亚, G., 门宁豪斯, W., 比尔曼, U., 瓦格纳, V., EID, M., & SCHERER, K.R.（2017 年）。测量审美情感：文献综述和新的评估工具。公共科学图书馆一号，12（6），e0178899。https://doi.org/10.1371/journal.pone.0178899
[62] SONNEVELD，M.H. 和 SCHIFFERSTEIN，H.N.J.（2008 年）。物体的触觉体验。在：SCHIFFERSTEIN, H.N.J. 和 HEKKERT, P.（编辑）产品体验。阿姆斯特丹：爱思唯尔，第 41-67 页。https://doi.org/10.1016/B978-008045089-6.50005-8
[63] SPECTOR, F. 和 MAURER, D. (2011)。字母表的颜色：形状和颜色之间的自然偏见关联。实验心理学杂志：人类感知与表现，37（2），484-495。https://doi.org/10.1037/a0021437
[64] TRUAX, B. (2012)。声音、聆听和场所：审美困境。有组织的声音，17（3），193-201。https://doi.org/10.1017/S1355771811000380
[65] UEDA, A.U., SAWADA, Y., MURAKAMI, T., SAITO, M., & TSUTSUI, S. (2016)。视觉障碍者触觉象形图最佳尺寸的初步调查。日本设计科学学会公报，63，29-36。https://doi.org/10.11247/jssdj.63.3_29
[66] YAZDANPARAST, A., & SPEARS, N. (2012)。触摸和信息处理策略的需求：实证检验。消费者行为杂志，11（5），415-421。http://dx.doi.org/10.1002/cb.1393
[67] ZATORRE, R.J., & SALIMPOOR, V.N.（2013）。从感知到愉悦：音乐及其神经基质。美利坚合众国国家科学院院刊，110（增刊 2），10430–10437。http://dx.doi.org/10.1073/pnas.1301228110
[68] 扎克特，R. (2009)。雕塑与触觉：赫尔德的雕塑美学。美学与艺术批评杂志，67（3），285-299。http://dx.doi.org/10.1111/j.1540-6245.2009.01359.x