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Tactility in perception of biobased composites

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Abstract

Biobased composites - sustainable alternatives to fossil-based materials, could gain better acceptance if their perceptual handicaps could be overcome. This paper considers the role of tactility in contrast with visual stimuli, as well as the perceptual qualities influenced by tactility. The analysis revealed a significant impact of tactility in forming attributes such as naturality, roughness and strength. Attributes like beauty and complexity remain less affected by touch, and more visual-dominant. These findings may help designers in creating desirable products with sustainable materials.

Keywords: materials, perception, sustainability, tactility, material engineering

1. Introduction

1.1. Tactility and perception

The trend of ocularcentrism, or the bias of considering vision superior to other senses, has been recorded in Western cultures (Chandler and Munday, 2011). This trend is also reflected in contemporary design, such that many current products and architecture focus on an ocularcentric design to attract consumers and generate revenue (El Moussaoui, 2020). This inclination also has limited the inclusion of tactility in frameworks for aesthetics and perception (Carbon and Jakesch, 2013). However, it has also been noted that tactility plays a significant role in tandem with vision in the formation of perception of materials and products, and this impact varies with context. In a study by Schifferstein and Desmet (2007) to assess the role of various senses in forming product perception, it was found that vision gave the most information about product functionality. Other senses, mainly tactility, produced richer sensory experiences in the absence of vision. Without tactility, visual signals alone failed to recreate the emotional dimension of the product experience. It has also been observed that vision supersedes touch in situations where there are sensory conflicts among these senses (e.g., a material which looks rough but feels smooth) (Miller, 1972; Johnson, Burton and Ro, 2006). This interplay of various senses could be synergistic, resulting in reinforced perception or conflicting, resulting in perceptual uncertainty; but when applied creatively, it can elicit positive emotions such as surprise and pleasure for the user (Hekkert, Snelders and Van Wieringen, 2003; Ludden, Schifferstein and Hekkert, 2012). It is noted that consumers have a strong "Need to Touch" to confidently assess the product experience before making purchase decisions (Peck & Childers, 2003; Marlow & Jansson-Boyd, 2011). Another aspect is the surface finish of the materials, with rougher surfaces perceived as soft and warm and smoother surfaces perceived as hard and cold; it was also noted that the impact of colour is higher on temperature perception than the effect of roughness (Wastiels et al., 2012; Schifferstein and Wastiels, 2014). In the context of product design, the primary senses involved are vision and tactility in tandem, and the literature points to the complex nature of intersensory interactions (Heller, 1982; Johnson, 2007; Schifferstein and Wastiels, 2014; Fleming, Nishida and Gegenfurtner, 2015; Delogu et al., 2021).

1.2. Tactility in the digital age

The role of visual and tactile senses is even more critical in the context of online shopping, where consumers have limited sensory inputs to assess a material or product. In 2021, global e-commerce sales (retail) stood at 4.9 trillion USD, with strong growth predicted over the next four years with over 50% cumulative annual growth rate (CAGR) (Chevalier, 2022). Online shopping and other e-commerce platforms facilitating the purchase of physical products provide only limited visual stimuli to users, which becomes the basis for consumer perception. It is noted that 75% of online shoppers depend solely on the product photograph to make the purchase choice (Ariella, 2022), as do the purchase decisions formed through window shopping. Additional information derived from these sources includes price and brand, which the consumers use to benchmark product quality (Spence and Gallace, 2011), but this does not divulge many clues about the product and material experience. Thus, many consumers receive visual-only stimuli with limited tactile interactions when selecting products and materials. This lack of tactility during online interactions generates intangibility in purchase transactions (Karan, Jain and Ramamurthy, 2000; Liu and Wei, 2003) and may result in a dissonant perception while physically interacting with the material. To avoid this dissonance and potential consumer disappointment in a product or brand experience, it is vital to understand the effect of tactility on material perception.

The growth in digital marketing co-exist in an industrial environment with an increasing emphasis on sustainable materials. Increasingly, policymakers are moving towards implementing regulations regarding sustainable production, use and disposal of materials, especially in the automotive sector (Agarwal et al., 2020). This advocacy, combined with the challenge of depletion of fossil resources, may force industries to shift their production towards materials, including biobased composites (Owen, Inderwildi and King, 2010). However, biobased composites, like many novel materials, may possess material characteristics that are unfamiliar to consumers, leaving them with an uncertain perception, especially during digital interactions. Materials such as biobased composites need to be able to communicate their sustainable credentials to consumers through intrinsic perceptual attributes to differentiate themselves in the marketplace. This need makes it vital to study the perception of biobased composites in the context of product design and consumer experience. Understanding the impact of tactility in material perception, specifically on various perceptual attributes and their correlations with material characteristics, would benefit materials engineers and product designers. Given the massive market value and influence of digital interactions on product sales, the impact of tactility in material perception deserves deeper examination.

1.3. Perception of biobased composites

A biobased composite is a material made by combining two (bi-material) or more (multi-material) distinct components. Combining the polymeric matrix, usually a bio-based resin with natural fibre reinforcement, produces a material with synergistically better properties like high tensile strength and strength-to-weight ratio. These materials are at least partially sourced from renewable resources, and many of them can biodegrade, offering better sustainability and functionality credentials than traditional biobased mono-materials. However, the application of biobased composites for product design is still limited due to their perceptual handicaps, such as low value, poor aesthetics and lack of character and material identity (Manu et al., 2022). Additionally, many biobased mono-materials such as wood, leather, and marble fall on the other end of the spectrum, being perceived highly for qualities such as beauty and value, even over functionality. Thus, it may be surmised that these materials possess specific characteristics that magnify their value, beauty and naturality. Understanding and replicating these characteristics in biobased composites could create desirable materials in this category, which can become widespread, viable and sustainable replacements for fossil-based materials. Lack of familiarity with these relatively novel biobased materials leads to an uncertain material identity (Kohllöffel, Luccarelli & Carbon, 2023; Rognoli, Salvia and Levi, 2011) and understanding the perception mechanism of biobased mono-materials could help solve this issue.

In prior studies (Thundathil et al., 2023a, 2023b), the influence of vision and tactility in forming material perception in biobased composites has been studied. These studies focused on material perception from a design perspective, where perception could significantly influence consumer experiences and product satisfaction. The impact of visual-only stimuli is high for novel biobased composites and other sustainable materials and products, as there is no prior interaction between the consumer and the material or product to facilitate a benchmark for perception (Schomaker and Meeter, 2012). Instead, consumers form the perception of these materials through visual perception (images or videos), verbal illustrations ("feels like metal") and consumer reviews based on personal experiences (Arsad, Setyohadi and Mudjihartono, 2021). Such restricted information may cause gaps in perceived material qualities and actual material experience, and this uncertainty may result in poor consumer satisfaction and product failure in the market. Hence, understanding the impact of visual and tactile signals on material perception will help product designers create consistent material experiences and help reduce the incongruity between the mental schema of the consumer and the actual material experience. While extreme differences are detrimental, mild to moderate incongruities could lead to better perceptual alignment, better acceptance of biobased composites by consumers and faster market penetration (Peracchio and Tybout, 1996).
Earlier studies in the perception of biobased composites have revealed a change in perception based on the mode of assessment (visual vs. visual-tactile) (Thundathil et al., 2023b). This change in perception requires closer attention, as this reveals that the influence of tactility is non-uniform, depending on sample materials and attributes under consideration. This study aims to address the significance of tactility in perceptual assessments and to uncover the critical emotional attributes influenced by tactility. This study also examines emotional attributes not influenced by tactility, and this will be key in designing materials/products suited for digital marketing and other non-physical sales channels. Another objective of this study is to understand the biobased composite characteristics influenced by tactility; this would help material designers create materials with emphasised or subdued tactile characteristics depending on the perceptual requirement. Understanding these aspects will significantly influence the material selection process in product design. This knowledge could enable designers to control the impact of material perception better, contributing to the overall product experience and allowing them to integrate materiality into the design process. Such a process will also help designers to incorporate more sustainable materials into product manufacturing by overcoming their perceptual handicaps.

2. Methodology

This study evaluated eleven bio-based materials, out of which eight were biobased, bi-material composites (named Cellulose + Wood, Cordenka, Non-woven (NW) Coir, Non-woven (NW) Sisal, Twill-weave (TW) Cotton, Twill-weave (TW) Flax 1, Twill-weave (TW) Flax 2 and Unidirectional (UD) Flax, indicating the fibre reinforcement used) and three were biobased mono-materials (Leather, Poplar and Walnut) which served as references. These biobased mono-materials were selected due to their universally accepted associations with critical attributes such as naturality, beauty and value in the product design industry, evidenced by their use in many lifestyle products (e.g., interior components for luxury cars) (Overvliet and Soto-Faraco, 2011; Burnard et al., 2017; Strobel, Nyrud and Bysheim, 2017). These reference materials were used to test the experiment's validity and assess the comparative positioning of biobased composites in perceptual dimensions. Prior studies on material perception compared different material classes with stark contracts in identity (Karana, Hekkert and Kandachar, 2010; Tanaka and Horiuchi, 2015a; Lilley et al., 2016), whereas this study focuses on biocomposites to reveal the finer distinctions in material perception within a class of materials. These materials were presented to adult participants in two formats: (a) a visual-only study where only digital images of the samples were presented to the participants (113 participants) and (b) a visual-tactile study where physical samples were handed to the participants (51 participants) for assessment. The visual-tactile mode was preferred over the blind-tactile mode to create an experience akin to physical shopping. Flat, rectangular material samples (35 mm x 50 mm) were mounted on a cardboard frame and presented to participants. A detailed description of sample preparation, attribute selection and study settings are provided in prior publications (Thundathil et al., 2023a, 2023b). This study used the Semantic Differential method (Osgood, Suci and Tannenbaum, 1957) to analyse the perceptual attributes of

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biobased composites. The participants were asked to rate each material against ten bipolar attribute pairs using the semantic differential method. The attribute pairs which were used here are *Aged-New*, *Complex-Simple*, *Interesting-Boring*, *Natural-Artificial*, *Unusual-Ordinary*, *Beautiful-Ugly*, *Valuable-Worthless*, *Strong-Weak*, *Rough-Smooth* and *Hot-Cold* (Ashby & Johnson, 2014; Osgood & Suci, 1955; Trofimova, 2013). Each attribute pair was presented on a 5-point Likert scale with similar gradations, e.g., the five rating options on the *Aged-New* scale were *Definitely Aged*, *Looks like Aged*, *Can't Say*, *Looks like New* and *Definitely New*. The rating of each material against each attribute scale was then used to calculate attribute-attribute correlations and material-attribute correlations. To do so, average ratings, rankings, uncertainty ratings (percentage of *Can't Say* ratings) and percentage of favourable ratings were calculated along with the differences amongst them. The Mann-Whitney U-test revealed material-attribute pairs with significant rating changes, and Spearman's correlation coefficient was calculated for ratings in visual and visual-tactile studies to reveal attributes that were not affected by tactility.

3. Results and discussion

To examine the influence of tactility in perception, the difference between rating averages for each material-attribute combination under visual and visual-tactile study was calculated, and a Mann-Whitney U-test was conducted to identify significant rating changes. The rating scales with significant changes in visual-tactile mode are listed in Table 1. The change in average rating for significant perceptual change in this study corresponds to approximately ±0.4 variation in average rating values, yet this value cannot be held as an absolute qualifier. For example, a -0.38 change in rating average for TW Flax 2 on the *Hot-Cold* scale is considered statistically significant, but a +0.44 change for the same material on the *Natural-Artificial* scale is insignificant. One reason for this is the non-uniform variance in intra-material or intra-attribute ratings, e.g., the variance for *Hot-Cold* ratings (σ=0.41) is much smaller than *Natural-Artificial* (σ=0.75). This inequality may be because the effect of bimodal sensory assessment is uneven for various materials and attribute scales and because vision and touch have varying contextual significance.

Table 1. Differences between average rating values (on the Likert Scale) of various attribute scales; (Visual + Tactile) - (Visual only) ratings

	No. of Changes	Aged-New	Complex-Simple	Interesting-Boring	Natural-Artificial	Unusual-Ordinary	Beautiful-Ugly	Valuable-Worthless	Strong-Weak	Rough-Smooth	Hot-Cold
No. of Changes		5	4	8	6	8	5	7	5	10	5
Cellulose + Wood	3	-0.54	0.10	-0.31	-0.04	0.02	0.23	0.54	0.25	-0.41	0.21
Cordenka	6	-0.25	0.15	0.44	-0.07	-0.04	0.63	0.82	0.79	-1.38	-0.72
Leather	4	-0.11	1.10	0.60	-0.07	1.51	-0.13	-0.33	0.12	1.57	0.05
NW Coir	7	0.89	-0.33	-0.58	0.75	-0.64	-0.53	-0.22	-0.96	2.34	0.34
NW Sisal	7	0.09	0.25	0.55	1.06	-0.29	0.75	0.63	-0.40	1.76	0.52
Poplar	7	0.28	0.99	0.78	-0.73	0.91	-0.43	0.43	0.14	0.66	0.13
TW Cotton	6	0.44	-0.01	0.18	1.51	-0.48	0.26	0.38	-0.11	1.83	0.53
TW Flax 1	4	-0.17	-0.03	0.12	1.35	-0.52	0.27	0.40	-0.01	1.62	0.26
TW Flax 2	7	-0.40	0.26	0.57	0.44	0.41	0.10	0.86	0.57	-0.72	-0.38
UD Flax	5	-0.48	-0.52	-0.46	0.09	-0.72	-0.32	0.13	0.17	-0.17	-0.50
Walnut	7	-0.13	0.88	0.50	-0.59	0.86	-0.66	-0.12	-0.56	1.13	0.13

Note: The highlighted cells (in yellow) denote the material-attribute pairs with significant differences in rating behaviour.

The number of significant changes across each category was also calculated to identify materials and attributes most impacted by tactility. Amongst the biobased composites, NW Coir, NW Sisal and TW Flax 2 presented the highest visual versus visual-tactile incongruence (7 changes), while Cellulose+Wood showed the least number of changes, illustrating the little effect of tactile inspection on the material. The attribute pairs most reflecting the impact of tactility are *Rough-Smooth* (10 changes), *Unusual-Ordinary* (8), *Interesting-Boring* (8) and *Valuable-Worthless* (7). While the impact on roughness and value perception was expected based on previous studies (Thundathil et al., 2023a, 2023b), the observed changes to unusualness and interestingness are notable. These changes indicate that unusualness and interestingness may also be found in tactile characteristics such as surface texture, friction, and smoothness of the material. This effect was anticipated as tactility offers higher clarity on these attributes (Karlsson and Velasco, 2007) but also suggests that visual perception of tactile characteristics may be inaccurate. The most significant variation in visual-tactile mode was observed for NW Coir, where 67.2% more people rated it as *Smooth* (from 5.3% in the visual study to 72.5% in the visual-tactile study). This perception may be attributed to the highly chaotic and fibrous nature of coir fibres dominating visual perception, prompting respondents to anticipate a rough surface.

3.1. Effect of tactility in the perception of key material attributes

While the perceptual assessments of material samples against various attribute scales offer valuable insights into consumer perception, characteristics such as naturality, value, strength, and beauty deserve special attention. These key attributes form the prescription to create high-value biobased composites, enabling their wider acceptance in the product manufacturing industry (Manu et al., 2022).

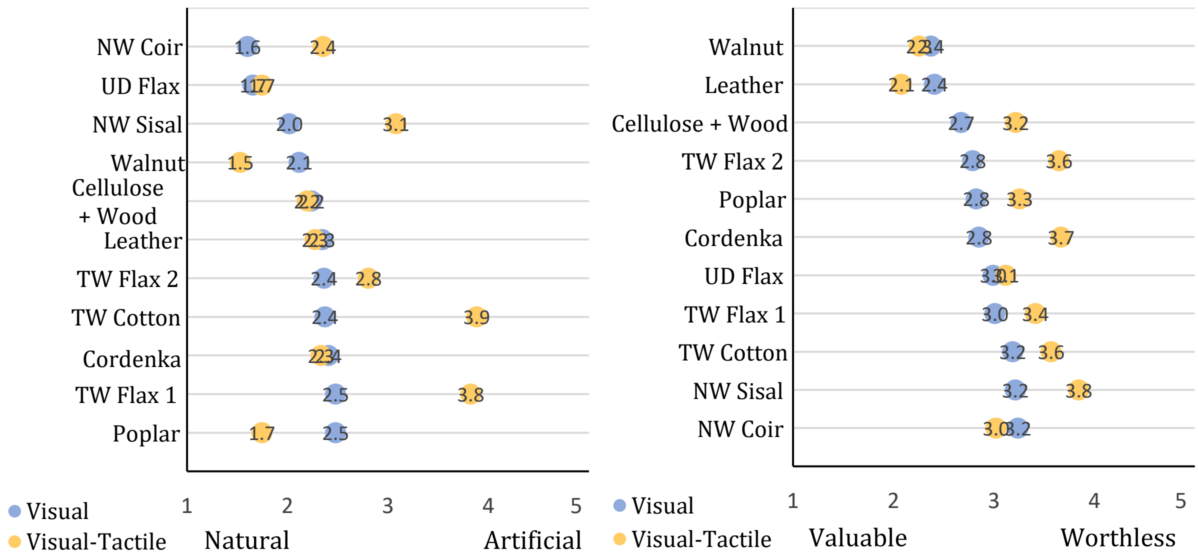

Figure 1. Comparison of average ratings on the natural-artificial and valuable-worthless scales in two modes of assessments

While the correlation analysis of the study data demonstrates that tactility influences material perception, comparing rating averages for *Natural-Artificial* (Figure 1) reveals that this effect is more substantial in some materials. NW Coir, NW Sisal, TW Cotton, and TW Flax 1 were assessed as more artificial, while Walnut and Poplar were rated more natural. The first four materials being rated artificial may be because of the difference in their perceived tactility; all these materials were visually assessed to be rough but were rated as smooth in visual-tactile mode. Roughness has been correlated with naturality (Labbe, Pineau and Martin, 2013), and the apparent loss of roughness in visual-tactile mode may have also caused a subsequent change in naturality.

The improved accuracy in detecting Walnut and Poplar as natural materials may be due to the richer nature of sensory information from both visual and tactile senses. This observation aligns with the prior findings that natural materials are easier to cognitively process and identify (Sharan, Rosenholtz and

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Adelson, 2009). This effect may also be attributed to the familiarity of wood-like substrates in participants, which makes it easier to identify these materials in visual-tactile mode. However, the absence of an equivalent change in naturality for leather implies that even within biobased mono-materials, the apparent naturality or the ability to communicate naturality may differ between various material classes. A reason for this may be the abundance of artificial leather in the market and familiarity with such imitation leather products, which can lead to difficulty recognising the genuine material. This context provides a valuable insight that while naturality has bimodal influence, tactility and physical interaction are significant in forming a material perception. This aspect becomes crucial to consider while marketing and selling products aimed to possess natural attributes through digital channels. While 8 out of 11 materials had higher *Worthless* ratings in visual-tactile mode (with most materials in the uncertain range (2.5-3.5) in visual mode), Walnut, Leather and NW Coir had slight improvements in value attribution (Figure 1). The most significant average change observed was +0.9, pointing to tactility's meaningful but limited influence on value assessment. This observation establishes that valuation is bimodal, generating more accuracy in visual-tactile assessments. The assessments for strength (*Strong*-*Weak*) displayed a change similar to value, with most materials near the uncertain range in visual mode, with some minor changes in visual-tactile mode. The surface smoothness and hardness have been correlated with material strength in prior studies, and a similar result is also observed in this case.

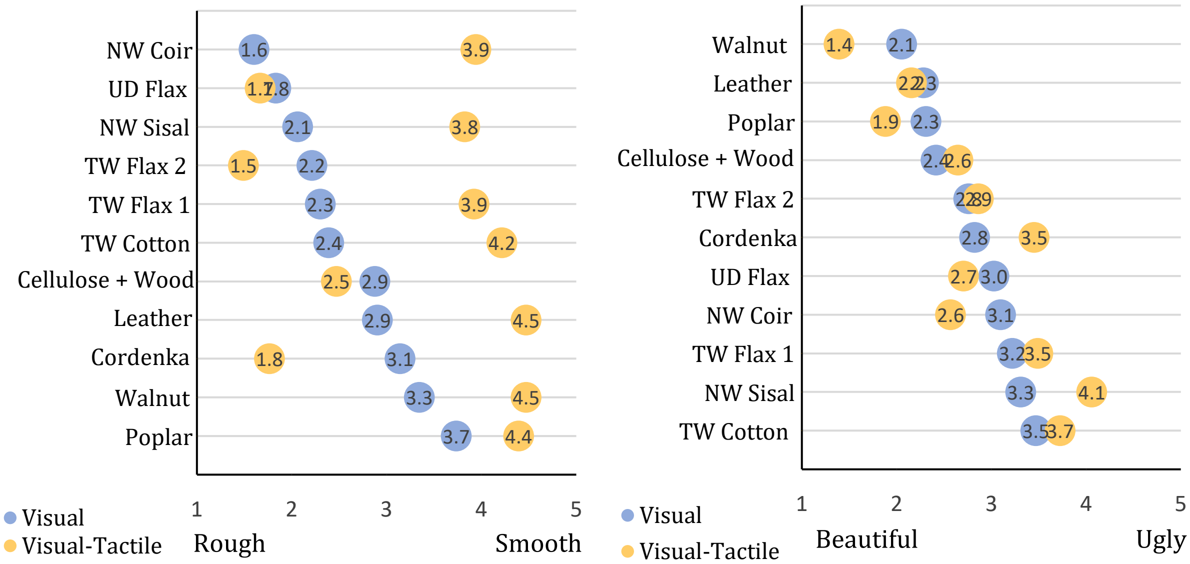

Figure 2. Comparison of average ratings on the rough-smooth and beautiful-ugly scales in two modes of assessments

The *rough-smooth* scale also deserves consideration, as significant perceptual changes were observed for most materials (Figure 2). *Rough-Smooth,* as expected, demonstrated the most considerable changes due to tactility; this underscores the observation that visual assessment of roughness is often inaccurate, and this translates to attributes dependent on roughness (like naturality and strength). Naturality, value and strength are core attributes that contribute to a desirable and distinguishable material perception, and the significant impact of tactility in these attributes alludes that it is integral to any material perception framework.

As illustrated in Figure 2, minimal changes were observed for the *Beautiful-Ugly* scale. The general trend remains the same for perception assessment in comparative assessments, with tactility having a meagre impact. The visual-tactile study also recorded fewer uncertain ratings in attribute assessment. Materials assessed to be smoother in visual-tactile mode had a slight improvement in beauty, pointing to the visually dominant nature of this attribute. A reason for variances in this visual attribute may be the richer sensory information available in physical mode compared to digital images (Tanaka and Horiuchi, 2015b).

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3.2. Influence of vision and touch on biomaterial perception

While Table 1 highlights that tactility affects all the materials in various attribute scales, the change in ranking is more beneficial to interpret the dominance of tactility on individual attribute scales. Since ranking is comparative, this reveals the relative effect of tactility in attribute perception. The sorted list of attributes with their corresponding number of rank shifts is illustrated in Figure 3. This arrangement shows that *Beautiful-Ugly* has the least perception changes comparatively, and *Natural-Artificial* had the most impact. It may be assumed that the attributes with fewer rank changes (e.g., beauty, complexity) are less impacted by tactility and are visually dominant. The other end of the spectrum consists of tactilely dominant attributes and a mix of both in the middle. This ordering implies that we assess the beauty of materials primarily based on visual signals, while it is tough to assess the naturality of materials purely by looking at them. This correlation between roughness and naturality has also been observed earlier (Karana and Nijkamp, 2014). Visually dominant attributes will have less uncertainty in digital-physical sensory disparity, while tactilely dominant materials possess high uncertainty. This effect is because while tactilely dominant attributes are expected to have perceptual dissonance (difference in visual and visual-tactile assessments), they might also have no differences due to erroneous perception in visual mode.

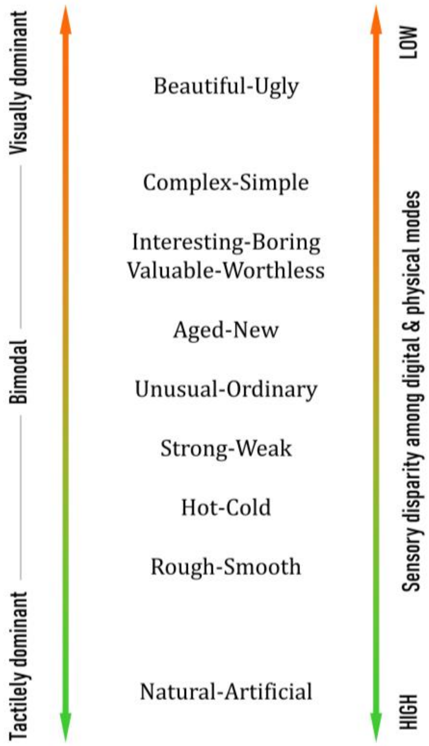

Figure 3. List of attributes ordered (ascending from top to bottom) in terms of the number of significant rank changes; visually dominant attributes will have less digital-physical sensory disparity

The effect of tactility on the perception of various materials is uneven; some materials have little change in perception (visually dominant materials, e.g., Walnut, Leather), some are partially affected (bimodal materials, e.g., NW Coir, Cellulose + Wood) and some are heavily affected by tactility (tactile-dominant materials, e.g. NW Sisal, TW Flax 2) (Thundathil et al., 2023b). From this study, it can be inferred that while visually dominant materials are least affected by tactility, the impact of tactility on the perception of bimodal and tactile-dominant materials is unpredictable. A comparison of uncertainty among visual and bimodal perception revealed that the bimodal (visual-tactile) assessment results in less uncertainty in material perception. The most significant changes were observed for *Aged-New* and *Hot-Cold*, indicating the crucial role of tactile perception for these attributes. While diminishing uncertainty with tactility is the general trend across the pairs, only *Natural-Artificial* stood out with slight increases in

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uncertainty for six materials. These results indicate that, in general, the assessment of material perception in a bimodal format offers richer stimuli to the users, which is evidenced by the reduction in uncertainty. This finding aligns with the argument made by Tanaka and Horiuchi (2015a) about the reduction in the quality of perception when materials were presented as images.

The favourable rating percentages for each material-attribute combination from the visual and bimodal modes were compared to check for correlations between both study modes. The correlations of ratings in visual and bimodal modes were calculated using Spearman's rank correlation method to compare attribute ratings from both study modes. It is seen that ratings for attributes such as *Aged-New, Natural-Artificial, Valuable-Worthless, Strong-Weak, Rough-Smooth* and *Hot-Cold* do not correlate, indicating variations in perception based on the sensorial mode used. Many of these attributes are tactile-dominant (Figure 3), which explains this disagreement. This effect highlights the tactile sub-components in the perception of naturality (roughness and warmth) and value (strength and smoothness), as evidenced by attribute-attribute correlations in the visual-tactile study (Thundathil et al., 2023b).

The results from both studies correlate for attribute pairs like *Complex* ($\rho=0.82$) - *Simple* ($\rho=0.79$), *Interesting* ($\rho=0.89$) - *Boring* ($\rho=0.77$), *Unusual* ($\rho=0.71$) -*Ordinary* ($\rho=0.72$) and *Beautiful* ($\rho=0.84$)-*Ugly* ($\rho=0.90$), indicating the little effect of tactility in forming perceptions for these attributes. This observation may also imply that these attributes are predominantly visual, and vision dominates tactility in forming these perceptual attributes. Amongst all the attributes, *Beautiful-Ugly* presents a unique relationship: beauty correlates with value in visual and visual-tactile studies, but beauty does not show any significant rating behaviour in the visual-tactile mode, like value or naturality. In Thundathil et al. (2023b), it was assumed that beauty is bimodally influenced, which should indicate the impact of tactility in assessing beauty. The fact that there is no significant change may mean that though bimodally influenced, the effect of visual stimuli is greater on the perception of beauty. Another explanation may be that the relationship between beauty and value is unidirectional, i.e., while an increase in beauty results in increased value, an increase in value need not result in increased beauty.

While the correlation analysis helps to isolate attributes impacted by tactility, a deeper analysis of these changes will help understand the material characteristics that drive such changes. Amongst the attributes impacted by tactility, *Aged-New* and *Hot-Cold* are not examined due to the high levels of uncertainty in the assessment and limited correlations with other attributes (Thundathil et al., 2023b, 2023a).

4. Conclusion

Tactile senses provide significant information required in the formation of material perception. While the role of various senses in perception formation cannot be isolated explicitly, the current study examines the role of vision and tactility in material perception in the context of biobased composites. From the comparison of attribute assessments with visual and visual-tactile modes, attributes most affected by tactility were identified. It is noted that the impact of tactility varies for different attributes, e.g., the variance is higher for tactile-dominant attributes such as *Rough-Smooth* and *Natural-Artificial*. This relationship indicates that the dominance of senses in perception formation varies with the type of attributes, with varying proportions of influences.

Perception of beauty enhances value perception but not vice versa; further exploring the proportion of *aesthetic value* versus *functional value* in value perception of various biobased composites will be interesting. While beauty is visually dominant, naturality is tactility-based; both senses influence other attributes. This discovery is significant for e-commerce as there could be substantial perception differences between online products and physical ones. Though tactility influences beauty less, maintaining consistency of visual attributes between digital and physical is vital. If images and reality diverge, perceptions of beauty may shift. Tactility influences attributes like naturality and value for biobased composites, so incorporating physical interaction into their marketing can positively impact consumer perception. Given today's massive online sales and reliance on digital marketing, minor upgrades in consumer experience could yield substantial merchant revenue. Understanding the influence of visual/tactile feedback on perception will help designers to choose appropriate materials for their target consumer segments. This knowledge can also improve verbal product descriptions online (i.e., highlighting the tactile characteristics that may be lost in visual perception), thereby reducing perceptual incongruity for consumers. The influence of tactility and its relative dominance on various attributes may be used in the design of novel biobased composites which can meet the requirements for sustainable materials. This knowledge could also alter the traditional role of a designer from an applicator of materials in products to a designer of materials. A composite material could be designed to have stronger perceptual associations with specific attributes, and the understanding of parameters to modify (visual or tactile) would make this process easier. Though various sensory stimuli influence all perceptual attributes, identifying the fundamental properties that influence the targeted attributes will support the creation of biobased composites with recognisable identities and characteristics desirable and acceptable for consumers. This potential reinforces the ability of designers to predict consumer perception better and to design or select materials that will appeal to the perceptual needs of the consumer segment in any product context. A process where material scientists and product designers collaborate to 'design' novel sustainable materials is bound to stimulate the adoption of sustainable biobased materials in product manufacture.

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