INTERNATIONAL DESIGN CONFERENCE – DESIGN 2022
https://doi.org/10.1017/pds.2022.222

Understanding the Role of Perceptual Haptic Conditions on Design Decision

K. V. Rakhin [1,✉], P. S. Onkar [1] and J. Hayavadana [2]

[1] Indian Institute of Technology Hyderabad, India, [2] Osmania University, India
✉ k.v.rakhin@gmail.com

Abstract

The haptic propositions derived from the textile prototypes often allow for more than one interpretation. It impacts the decision on design alternatives during the phase of design evaluation and validation. The present study aims to conquer this challenge with a haptic design case study of automotive upholstery fabric. It links experimental psychophysics with design decision-making. The study results show that visual cues influence haptic detection accuracy and constancy to choose a final design option.

Keywords: *design cognition, case study, experimentation, reliable haptic information, visual-haptic dual-task*

1. Introduction

Textile designers typically specialise in designing fabrics for specific end uses in textile industry segments such as garments, home textiles, and technical textiles. They create design patterns by sketching, using their visual senses to produce different fabric surface appearances. Thus, the visual appearance of the developed fabric surface may differ from its haptic sensitivity. It depends on how a designer has manipulated the fabric's surface character. However, it equally affects the performance of products such as towels, bed linen, and upholstery fabrics. It creates complications in the detection and categorisation of textile materials. In fact, the mismatch of visual look and feel with predicted haptic performance also leads to ambiguous design decisions for the designers. In this context, the current study examined the need for control over visual cues to assess the haptic properties of fabrics from the perspective of design decisions.

2. Related work

The term 'design' is defined in this study as the result of a course of action conceived in mind, either in the form of an artefact or a strategy aimed at solving problems for a specific purpose. Integral to this definition is that design results from high-level cognitive activity (Jonassen, 2000). Design cognition penetrates two states of the signalling process: (1) the processing of sensory information, called perception, and (2) the evaluation of representational content in the context of reasoning, known as cognition (Montemayor & Haladjian, 2017). Perception is the gateway to information from the outside world, while cognition makes sense of this perceived information. Cognitive processes depend on perceptual information, but cognition can also influence perceptual processes (Goldstone & Barsalou, 1998). It shows that perception and cognition share a common platform (Tacca, 2011). Also, perception is a mapping mechanism between function space and attribute space (Takeda et al., 1990). It incorporates different types of sensory information in order to perceive the product as a coherent whole. Therefore, sensory cues are highly correlated with the perceived desirability of a product.

Users integrate different types of sensory cues while interacting with a product. Generally, visual cues are the most common and open to product perception among the sensory cues. Nevertheless, it is not always necessary for visual cues alone to contribute to the overall product experience. Often, the judgement may depend on some other cues related to the product function. For example, the sound of a vacuum cleaner can indicate its performance (Schifferstein et al., 2010). So, when designing is considered as a process, the designer looks for a solution that corresponds to the superior design knowledge. From a cognitive point of view, the above aspects are driven by the designers' understanding of how the design fits into these sensory experiences. Haptic stimuli are the direct source of sensory information in the case of textile products, as they are primarily embedded in hands-on interactions with the whole human body. In comparison with vision, touch means feeling the body and becoming aware of product performance. Thus, touch allows one to feel boundaries between the self and the outside world, as well as the interaction between the two. However, visual stimuli are often the focus of attention for textile products. It shows that the haptic sense implies self-contact while the visual sense is more suited to creating social contact (Oh et al., 2020).

On the other hand, the visual-haptic dual condition (looking together with touch) facilitates reaction speed in task-related cognition activities more effectively (Shi & Mueller, 2013). At the same time, different dimensions of visual cues can lead to many mental representations (NEFS, 2011). It reduces the efficiency of selective attention and affects the subjective perception of the stimuli (Murphy & Greene, 2016). We focus on the above problem as a relationship gap between perceptual attention and cognitive activity since choosing a design option largely depends on the required sensory evidence. Therefore, when making design decisions, information from multiple senses must be translated into end-user perspectives. It requires designers to interpret meaningful information for each design option. It allows designers to ensure what is important while ignoring irrelevant perceptual information by maximising accuracy and minimising effort. In this regard, Tan et al. (2015) reported that the deployment of attention in visual space could be automatically directed to stimuli that correspond to working memory content.

At the same time, prolonged exposure to certain stimuli alters judgement, which leads to modifications in the decision-making process (Witthoft et al., 2018). It occurs because a high cognitive load increases distraction due to a reduced ability to suppress irrelevant information (Forster & Lavie, 2009). From a design perspective, this argument shows that more significant sensory processing of task-irrelevant stimuli reduces the ability to maintain true design priorities due to competition for limited design alternatives.

However, the problem remains when the fabrics are judged subjectively by touch in a visual state. It occurs because visual estimation leads to constant variations in the appearance of surfaces (Marlow et al., 2012). From a psychophysical perspective, Klatzky et al. (1987) point out that haptic encoding relies solely on the visual, leading to an inherent bias towards how objects feel haptically, not how they might look. For example, vision is better when assessing geometric properties than testing material properties by touch (Lederman & Klatzky, 2009). We argue that this ambiguity ultimately leads a designer to neglect the choice of material and textile construction, the haptic information relevant to the end-user experience, and the proper haptic evaluation method of the textile product during the design decision processes. Also, the specific area of subjective evaluation conditions related to the textile design decision-making process has been neglected in many studies. Therefore, we hypothesise that the high reliance on visual-alone spatial knowledge overlooks calibrated haptic information that correlates with various design decisions. We also hypothesise that designers can amplify haptic stimuli without visual cues to improve the perception of the signal, thereby drawing attention to task-relevant information. The following sections contain empirical findings of our theoretical research as a case study.

3. Case study: Haptic design of automotive upholstery fabric

Seat comfort is an essential factor when driving a vehicle. The deprived seat surface schedules slip that stress the continuous monitoring of the driver's posture—the state of inertia and the up-and-down vibrations of travel increase the likelihood of being slippery. However, haptically designed upholstery prevents slipping while driving. Seat covers are exposed to high frictional forces during use.

https://doi.org/10.1017/pds.2022.222 Published online by Cambridge University Press

Therefore, the haptic design of upholstery fabrics must be grippy to improve the slip resistance of the fabric surfaces. The case study is shown in Figure 1. In this context, visual adaptation is usually an essential method of design representation. If so, how can the designer ensure that the cloth surface is suitable for the driver's posture for long-term seating comfort? Do the subjective assessment responses cause any modifications in the design decision-making process under a given stimulus condition? In order to better understand these phenomena, we conducted a series of experiments to identify and confirm the slip and grip properties of automotive upholstery fabrics.

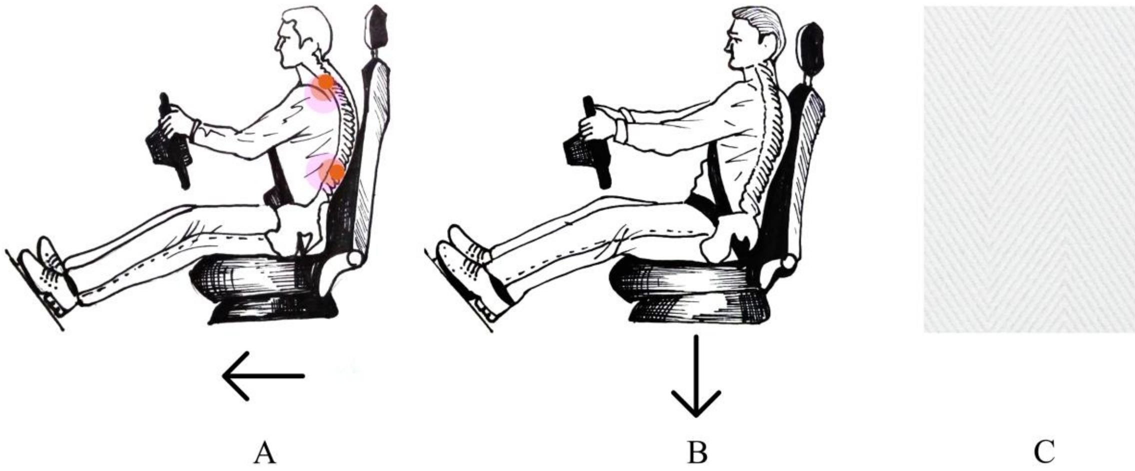

Figure 1. Haptic design problem: Seating comfort in the vehicle

A: Leftwards arrow shows tend to slip. It causes stress to the structures in the spine.
B: Downwards arrow shows a grip position toward the seat. It results in comfort while driving.
C: Close up view of upholstery fabric prototype.

4. Methodology

We need to understand how subjective fabric evaluation provides a radical design decision that facilitates the designing of haptically performed textile products such as automotive upholstery. In general, the well-understood experimental methods used in subjective fabric evaluation consist of the total hand value method, which calculates from a fabric's primary hand values (Ellis & Garnsworthy, 1980). However, full adoption of the total hand value method is inconsistent with our study for two reasons. (1) Typically, the judges are a panel of textile quality experts in the total hand value method that we do not want to follow, (2) the result obtained from such a method is more relevant to the quality interpretation of a textile fabric than a specific psychophysical phenomenon. Therefore, we have partially adhered to the primary hand value method with some strategic modifications.

We observed that the textile reinforcements do not have a flat surface. It extends to structural geometry and surface texture configuration. During haptic manipulation, finger forces apply across the fabric topography, which leads to an immediate reaction force from the surface and causes the coefficient of friction (Lederman & Klatzky, 2009). The tangential force-displacement process follows either stick-slip, slip-stick-slip, or permanent slip (Stronge et al., 2001). These arguments show that self-imposed force distribution causes slippage over the upholstery fabric. Thus, the feeling of gliding during skin contact time is subjectively perceived as slippery (reciprocal of grippy).

This framework enabled us to develop a psychophysical test method to evaluate the slip resistance of automotive upholstery fabrics. Our method describes the following evaluation process: Hold the single-ply fabric swatch between both hands' index finger and thumb. Gently press the fabric against the thumb with the tip of the index finger. Then pull the thumb and index finger of both hands in opposite directions simultaneously. Repeat this process and gently sense a *stick-slip phenomenon* with a jerky motion. The feeling of effortless gliding on the fabric surface indicates slipperiness. In contrast, if the figure movements feel an increased adhesion to the fabric surface, it suggests grippy.

https://doi.org/10.1017/pds.2022.222 Published online by Cambridge University Press

In our experiments, sixty naive participants (30 men and 30 women) between 18 and 40 ages volunteered. The background knowledge of the individual participants was different, for example, students, faculty, and staff. We deliberately did not recruit people with professional design knowledge, as we rely on the resulting response being free from possible designer bias. However, almost all participants have experience with long-distance driving or travel.

We have created a quantitative analysis with a definite rating using our slippery evaluation method. We used the semantic differential (SD) method (Osgood et al., 1957) to measure subjects' responses on a 1 to 5 scale. The rating scale provided 'one' as extraordinarily slippery and 'five' as exceptionally grippy. The scale must be interpreted so that no specifications are given between the 1–5 values. The perceived haptic modality signifies that increasing the value from 1 to 5 decreases the slipperiness of the upholstery fabric.

We have also integrated the slippery evaluation method into the visual prediction of slippery/grip with and without touch. Therefore, the experiment was conducted under three different task conditions: A. Touch alone, B. Vision alone (without contact against the skin), and C. Combined visual-haptic (exploring through vision with touch). The experimental conditions are shown in Figure 2. There was no time limit for feedback. In addition, an informal interview was conducted after the experiments. Minitab version 19 was used to calculate the data. A probability level of $p<0.05$ was considered statistically significant for all statistical tests.

4.1. Materials and Methods

Upholstery fabric was used for the study. A polyester filament fabric with a herringbone weave pattern (a yarn count of 113 Tex and 290 g/m^2) was developed as a test material for the experiment. The slipperiness evaluation was carried out using two specially designed boxes. One black box has two hand holes on the front side intended for the haptic-alone task. The other box was grey and had a front opening used for the visual-haptic combined task. Similarly, a hollow square frame to mount the fabric sample was used along with the grey colour box for the visual-alone task. A controlled lighting environment was provided in the room. Before the experiments, the participants washed both hands thoroughly with liquid soap and dried their hands with paper towels. A digital computer system was used for response feedback during the experiment. Participants were allowed to participate individually in all experimental conditions.

A B C

Figure 2. Experimental conditions

4.2. Encoding perceptual cues

This study hypothesised that perceptual cues act as a mode of communication between the objects and the explorer. Verbal descriptions in the English language are taken in to encode the observed sensory cues. Accordingly, subjects can construct mental images from verbal descriptions and perceptions of geometric shapes (Cruse & Clifton, 1975; Denis et al., 1995; Lupyan & Lewis, 2019). The bipolar set of descriptions used in the current study as the tertiary quality of material would be appearances in subjective awareness. Tertiary qualities are metaphysically identical and are recognised simply by the nature of their related ideas (Smith, 1990). Verbal descriptions are classified into 'slippery' and 'grippy' of the fabric stimuli. The descriptive verbal index is presented in Table 1. The table shows

https://doi.org/10.1017/pds.2022.222 Published online by Cambridge University Press

that groups of descriptions contradicted each other. Single selected verbal descriptions were the most desirable choice of response through exploration. The same set of descriptions applied to all experimental conditions. When evaluating the answers, only the verbal descriptions selected by the subjects were analysed.

Table 1. Verbal Description Index

Haptic		Visual	
Grippy (Group-1)	Slippery (Group-2)	Grippy (Group-1)	Slippery (Group-2)
Friction	Slipping	Duller	Brighter
Abrasion	Sliding	Matt	Glossy
Rubbing	Skid	Dimmer	Shimmer
Grip	Glide	See-through	Opaque

5. Results

The first experiment (haptic alone) shows the regression results of observed haptic cues in Table 2. The results show that both groups are significantly sensitive towards 'slippery/grippy' modalities. Also, haptic cues contribute 46.69% variation on the responses feedbacks at a 95% confidence level in a haptic condition. According to the estimation for the degree of relationships, the haptic cues' friction', 'rubbing' and 'grip' are statistically significant (p=0.001< 0.05) from group 1. Similarly, cues 'skid' (p=0.029 < 0.05) and 'glide' (p=0.004 < 0.05) statistically significant from group 2. The Tally and Pareto chart analysis indicate that only one observation level (haptic cues) 1 (friction = 36.67%), of group-1, is highly influenced the perceptual responses. At the same time, observation levels (haptic cues- rubbing and grip) 3 and 4 affected the perception equally with 21.67% each.

Table 2. Regression analysis of haptic cues

Haptic cues	Coefficient	SE coefficient	T value	P value
1 - Friction (Group -1)	0.716	0.143	5.01	0.001
2 - Abrasion (Group -1)	0.171	0.213	0.80	0.426
3 - Rubbing (Group -1)	0.651	0.158	4.12	0.001
4 - Grip (Group -1)	0.568	0.165	3.44	0.001
5 - Slipping (Group - 2)	-0.298	0.310	-0.96	0.340
6 - Sliding (Group - 2)	0.048	0.425	0.11	0.910
7 - Skid (Group - 2)	-0.952	0.425	-2.24	0.029
8 - Glide (Group - 2)	-0.952	0.311	-3.06	0.004
R2 value	46.69%			

In the second experiment (visual alone), eight visual cues were observed by the participants. The regression results of the visual alone trial are provided in Table 3.

Table 3. Regression Analysis of Visual Cues

Visual cues	Coefficient	SE coefficient	T value	P value
1 - Duller (Group-1)	0.601	0.273	2.20	0.032
2 - Matt (Group-1)	0.389	0.350	1.11	0.271
3 - Dimmer (Group-1)	0.055	0.350	0.16	0.875
4 - See-through (Group-1)	0.555	0.350	1.59	0.118
5 - Brighter (Group-2)	-0.778	0.350	-2.23	0.030
6 - Glossy (Group-2)	-0.382	0.237	-1.61	0.113
7 - Shimmer (Group-2)	0.255	0.379	0.67	0.503
8 - Opaque (Group-2)	-0.695	0.418	-1.66	0.103
R2 value	25.44%			

https://doi.org/10.1017/pds.2022.222 Published online by Cambridge University Press

The regression results show that both groups are engaged in the determination of 'slippery/grippy' modalities. According to the analysis, about 25.44% of the variation on responses feedback in a visual condition is 95% confidence level. The analysis indicates that the visual cues 'duller', group 1 (p=0.032 < 0.05) and 'brighter', group 2 (p=0.030 < 0.05) are statistically significant. The Tally and Pareto chart analysis indicate that two observation levels (visual cues) 6 (glossy = 26.67%) of group-2 is highly influenced the perceptual responses flowing level 1 (Duller = 18.33%) of the same group. At the same time, observation levels 2, 3, 4, 5 affected the perceptual responses equally with 10.00% each.

In the third experiment (visual-haptic), perceptual cues were grouped into two sets and provided to identify the slippery/grippy modalities of the given swatches. Pearson's correlation was used to calculate the association between each set of observations under haptic-visual conditions. The analysis result is shown in Table 4.

Table 4. Correlation matrix of visual-haptic condition

Condition	Method	Correlation	P value
Haptic-Visual	Feedback by look	-0.113	0.391
	Feedback by touch	-0.523	0.001

The results show that the correlation between 'look' and 'rating' is r -0.113, a weak negative correlation and statistically insignificant (p = 0.391> 0.05). The correlation between 'touch' and 'rating' is r = -0.523 (p = 0.001< 0.05) is a moderate negative correlation but statistically significant. A regression analysis of visual and haptic cues in the dual condition is given in Table 5.

Table 5. Regression analysis of visual-haptic condition

Feedback by Look

Visual cues	Coefficient	SE coefficient	T value	P value
1 - Duller (Group-1)	0.397	0.253	1.57	0.123
2 - Matt (Group-1)	0.288	0.178	1.62	0.111
3 - Dimmer (Group-1)	-0.366	0.293	-1.25	0.218
4 - See-through (Group-1)	0.634	0.293	2.16	0.035
5 - Brighter (Group-2)	-1.697	0.271	-6.27	0.001
6 - Glossy (Group-2)	0.257	0.293	0.88	0.384
7 - Shimmer (Group-2)	0.094	0.253	0.37	0.711
8 - Opaque (Group-2)	0.393	0.272	1.44	0.155
R2 value	52.53%			

Feedback by Touch

Haptic cues	Coefficient	SE coefficient	T value	P value
1 - Friction (Group -1)	0.454	0.312	1.46	0.151
2 - Abrasion (Group -1)	0.499	0.192	2.59	0.012
3 - Rubbing (Group -1)	1.383	0.219	6.33	0.001
4 - Grip (Group -1)	0.360	0.239	1.51	0.138
5 - Slipping (Group - 2)	-0.852	0.257	-3.31	0.002
6 - Sliding (Group - 2)	-0.872	0.354	-2.47	0.017
7 - Skid (Group - 2)	-0.206	0.354	-0.58	0.564
8 - Glide (Group - 2)	-0.766	0.293	-2.61	0.012
R2 value	57.05%			

According to the regression analysis, variation in feedback by look was about 52.53% in the visual condition. At the same time, about 57.05% variation in feedback by touch under haptic conditions. Both variations occurred at a 95% confidence level. The regression results of visual cues show that

https://doi.org/10.1017/pds.2022.222 Published online by Cambridge University Press

'see-through' of group-1 (p=0.035 < 0.05) and 'brighter' of group-2 (p=0.001< 0.05) are statistically significant. Whereas results of haptic cues analysis show that 'abrasion' (p=0.012 < 0.05) and 'rubbing' (p=0.001 < 0.05) of group 1 are statistically significant. Similarly, slipping (p=0.002), sliding (p=0.017), and glide (p=0.012) are at a 95% significance level. Also, from the analysis, it is observed that statistically significant visual cues (see-through vs. brighter) represented by the group shows the bipolar character (opposite each other). Similarly, haptic cues also have bipolar characters (abrasion and rubbing vs. slipping, sliding, and glide).

In addition, the coefficient differences between 'see-through' (visual cue of group 1, which indicate grippy) and 'abrasion' (haptic cue of group 1, which indicate grippy) is 0.135. It indicates that changes in the mean value of visual perceptual responses (see-through) increase the mean value of haptic cue (abrasion) also tends to increase by 0.135 differences since both are positive coefficients. In the same way, the coefficient differences between visual cue 'brighter' (visual cue of group 2 indicates slippery) and slipping, sliding, and glide (haptic cues of group 2 indicate towards slippery) are -0.845, -0.825, and -0.931. It suggests that as the changes in the mean value of visual perceptual responses (see-through) increase, the mean value of haptic cue (slipping, sliding, and glide) decreases by the above value differences since they are negative coefficients. The Tally and Pareto chart analysis indicate that 'matt' (30.00 %) of group 1 is the most agreed visual cue by the subjects. At the same time, the most agreed haptic perceptual response was 'abrasion' (33.33%) of group 1. However, according to the tally, 83.33% of the subjects depended on subjective fabric surface assessment of 'slippery/grippy' modalities compared with visual observation.

Figure 3 illustrates a combination diagram of the haptic-visual coefficient. In the plotted diagram, the straight line indicates the corresponding haptic coefficient values. The dashed line connects the visual coefficient. The comparison reveals that haptic cues are more dominant than visual cues, although visual cues almost followed the haptic path.

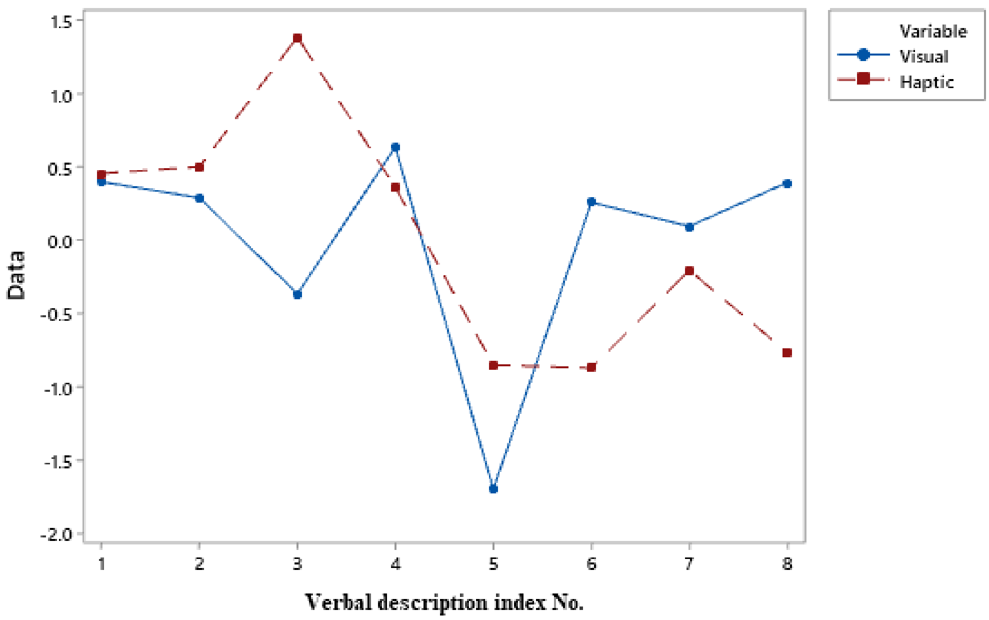

Figure 3. Comparison of Visual - Haptic Coefficient

6. Discussion

From the perspective of the textile industry, haptic assessment by touch provides insight into overall fabric quality and its professional practices. Generally, it is represented by a total reflection of the fabric handle. The concept of sensational experienced while handling a cloth is referred to as fabric hand (Hatch, 1993, p. 472). The term fabric hand (also known as fabric handle) is frequently used in the textile industry to denote the sensory properties of fabrics obtained through subjective evaluation (Makinen et al., 2005). Therefore, most textile brands consider fabric handle evaluation is indisputable

https://doi.org/10.1017/pds.2022.222 Published online by Cambridge University Press

in quality assurance. According to Valentine et al. (2017), textile design is distinctive in that haptic qualities guide its process. It is also critical to figure out how to use touch interfaces to progress a textile product (Hale & Stanney, 2004). Customers are more likely to shop in-store than online, as they prefer to look, touch, and try on clothes before buying (Eckman et al., 1990; Blazquez, 2014). Poor haptic qualities often justify why a consumer rejects the textile product. Thus, many successful fashion designers pay particular attention to the feel of fabrics. Hence, subjective fabric assessment falls into the phase of evaluating and validating the haptic properties of the design. In addition, the evaluation results can lead to an alternative solution to the existing design decision.

Design decision-making is an activity of specifying, evaluating, validating, navigating, and unifying the current decision into alternatives and solutions as a whole in order to decide (Hansen & Andreasen, 2000). The current study results provide important insights into the influence of perceptual conditions on design decisions. We found that without the full awareness of the perceiver, visual cues can quickly dominate design judgments. In such cases, it affects the competence and performance of the desired design when choosing alternatives. Our study also shows that vision regulates relevant spatial information through hand-finger movements. Also, the high cognitive load tries to divert the focus of selective design attention, resulting in poor decision-making. To overcome this difficulty, we propose that designers subjectively evaluate the fabric prototypes for better haptic performance. Making design decisions prior to a final design choice for a specific end-use is an effective practice.

Design decision-making is also often viewed as a collaborative process (Badke-Schaub & Gehrlicher, 2003). For example, a textile designer's design decisions can be replaced by the decisions of a car interior designer. However, both have to compromise adequate seating comfort through fabric design. On such occasions, interpretations based on subjective fabric evaluation under haptic-alone task conditions become critical in a designer's decision-making.

7. Conclusion

This study discriminates sensory judgments of a vehicle seat cover between three haptic assessment conditions. According to the experimental results, the present study provides clear evidence that visual cues influence detection accuracy and the constancy of judgement about the given specimen's 'slippery/grippy' modality. In contrast, whenever the haptic perception increases, the accuracy in feedback also increases. We have attempted to account for these effects in pre-and post-adaptation judgments of the design decision-making process. The reliable sensory interpretations bring about a physical change in an existing design or lead to selecting one or more design options. Optimising the prolonged haptic interaction is essential when designing upholstery fabrics for automobiles. This reliable interpretation helps the designer conceptualise the desired design and robust a designer's specific domain knowledge related to a design decision.

References

Badke-Schaub, P. Gehrlicher, A. (2003). "Patterns of decisions in design: Leaps, loops, cycles, sequences and meta processes", Proceedings International Conference on Engineering Design, ICED 03 Stockholm, pp. 1-10, 2003.

Blázquez, M. (2014). Fashion shopping in multichannel retail: The role of technology in enhancing the customer experience. International Journal of Electronic Commerce, 18(4), 97-116. https://doi.org/10.2753/JEC1086-4415180404

Cruse, D., and Clifton, C. (1975). Constructing visual images from verbal descriptions. Bulletin of the Psychonomic Society, 6(6), 585-588. https://doi.org/10.3758/bf03337573

Denis, M., Gonc, M. R., and Memmi, D. (1995). Mental scanning of visual images generated from verbal descriptions: Towards a model of image accuracy. Neuropsychologia, 33(11), 1511-1530. https://doi.org/10.1016/0028-3932(95)00078-h

Eckman, M., Damhorst, M. L., and Kadolph, S. J. (1990). Toward a model of the in-store purchase decision process: Consumer use of criteria for evaluating women's apparel. Clothing and Textiles Research Journal, 8(2), 13-22. https://doi.org/10.1177/0887302X9000800202

Ellis, B. C., and Garnsworthy, R. K. (1980). A review of techniques for the assessment of hand. Textile Research Journal, 50(4), 231-238. https://doi.org/10.1177/004051758005000406

Forster, S., and Lavie, N. (2009). Harnessing the wandering mind: The role of perceptual load. Cognition, 111(3), 345-355. https://doi.org/10.1016/j.cognition.2009.02.006
Goldstone, R. L., and Barsalou, L. W. (1998). Reuniting perception and conception. Cognition, 65(2-3), 231-262. https://doi.org/10.1016/S0010-0277(97)00047-4
Hale, K. S., and Stanney, K. M. (2004). Deriving haptic design guidelines from human physiological, psychophysical, and neurological foundations. IEEE computer graphics and applications, 24(2), 33-39. 10.1109/MCG.2004.1274059
Hansen, C. T., and Andreasen, M. M. (2000). Basic thinking patterns of decision-making in engineering design. In H. Meerkamm (Ed.), MCE 2000 - International Workshop on Multi-Criteria Evaluation (pp. 1-8)
Hatch. K.L. 1993, Textile Science, West Publishing Company, New York, NY, USA.
Jonassen, D. H. (2000). Toward a design theory of problem solving. Educational technology research and development, 48(4), 63-85. https://doi.org/10.1007/BF02300500
Klatzky, R. L., Lederman, S. J., and Reed, C. (1987). There's more to touch than meets the eye: The salience of object attributes for haptics with and without vision. Journal of Experimental Psychology: General, 116(4), 356–369. https://doi.org/10.1037/0096-3445.116.4.356
Lederman, S.J., Klatzky, R.L. (2009) Haptic perception: A tutorial. Attention, Perception, and Psychophysics 71, 1439–1459. https://doi.org/10.3758/APP.71.7.1439
Lupyan, G., and Lewis, M. (2019). From words-as-mappings to words-as-cues: The role of language in semantic knowledge. Language, Cognition and Neuroscience, 34(10), 1319-1337. https://doi.org/10.31234/osf.io/ysp5b
Makinen, M., Meinander, H., Luible, C., Magnenat-Thalmann, N. Influence of physical parameters on fabric hand. Proceedings of the HAPTEX'05 Workshop on Haptic and Tactile Perception of Deformable Objects. Hanover, December, 2005.
Marlow, P. J., Kim, J., and Anderson, B. L. (2012). The perception and misperception of specular surface reflectance. Current Biology, 22(20), 1909-1913. https://doi.org/10.1016/j.cub.2012.08.009
Montemayor, C., and Haladjian, H. H. (2017). Perception and cognition are largely independent, but still affect each other in systematic ways: arguments from evolution and the consciousness-attention dissociation. Frontiers in psychology, 8, 40. https://doi.org/10.3389/fpsyg.2017.00040
Murphy, G., and Greene, C. M. (2016). Perceptual load affects eyewitness accuracy and susceptibility to leading questions. Frontiers in psychology, 7, 1322. https://doi.org/10.3389/fpsyg.2016.01322
NEFS, H. T. (2011). On the visual appearance of objects. In Schifferstein, H. N., and Hekkert, P. (Eds.). Product experience (pp. 11-39). Elsevier Ltd., The Netherlands. https://doi.org/10.1016/B978-008045089-6.50004-6
Oh, D., Shafir, E., and Todorov, A. (2020). Economic status cues from clothes affect perceived competence from faces. Nature human behaviour, 4(3), 287-293. https://doi.org/10.1038/s41562-019-0782-4
Osgood, C. E., Suci, G. J., and Tannenbaum, P. H. (1957). The measurement of meaning. Urbana: University of Illinois press.
Perry P., Kent A., Bonetti F. (2019) The Use of Mobile Technologies in Physical Stores: The Case of Fashion Retailing. In: Piotrowicz W., Cuthbertson R. (Eds) Exploring Omni channel Retailing. Springer, Cham. https://doi.org/10.1007/978-3-319-98273-1_8
Prinz, J. J. (2004). Furnishing the mind: Concepts and their perceptual basis. MIT press.
Schifferstein, H. N. J., Otten, J. J., Thoolen, F., and Hekkert, P. (2010). The experimental assessment of sensory dominance in a product development context. Journal of Design Research, 8(2), 119. https://doi.org/10.1504/JDR.2010.032074
Shi, Z., and Mueller, H. J. (2013). Multisensory perception and action: development, decision-making, and neural mechanisms. Frontiers in integrative neuroscience, 7, 81. https://doi.org/10.3389/fnint.2013.00081
Smith, A. D. (1990). Of primary and secondary qualities. The Philosophical Review, 99(2), 221-254. https://doi.org/10.2307/2185490
Sonneveld, M. H., and Schifferstein, H. N. (2008). The tactual experience of objects. In Schifferstein, H. N., and Hekkert, P. (Eds.). Product experience (pp. 41-67). Elsevier Ltd., The Netherlands. https://doi.org/10.1016/B978-008045089-6.50005-8
Stronge, W. J., James, R., and Ravani, B. (2001). Oblique impact with friction and tangential compliance. Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences, 359(1789), 2447-2465. https://doi.org/10.1098/rsta.2001.0903
Tacca, M. C. (2011). Commonalities between perception and cognition. Frontiers in psychology, 2, 358. https://doi.org/10.3389/fpsyg.2011.00358
Takeda, H., Veerkamp, P., and Yoshikawa, H. (1990). Modeling design process. AI magazine, 11(4), 37-37. https://doi.org/10.1609/aimag.v11i4.855

Tan J, Zhao Y, Wang L, Tian X, Cui Y, Yang Q, et al. (2015) The Competitive Influences of Perceptual Load and Working Memory Guidance on Selective Attention. PLoS ONE 10(6): e0129533. https://doi.org/10.1371/journal.pone.0129533

Valentine, L., Ballie, J., Bletcher, J., Robertson, S., and Stevenson, F. (2017). Design Thinking for Textiles: let's make it meaningful. The Design Journal, 20 (sup1), S964-S976. https://doi.org/10.1080/14606925.2017.1353041

Witthoft, N., Sha, L., Winawer, J., and Kiani, R. (2018). Sensory and decision-making processes underlying perceptual adaptation. Journal of vision, 18(8), 10-10. https://doi.org/10.1167/18.8.10