Design and semantics of form and movement

DeSForM 2015

Aesthetics of interaction:
Dynamic, Multisensory, Wise

Edited by

Lin-Lin Chen

Tom Djajadiningrat

Loe Feijs

Jun Hu

Steven Kyffin

Lucia Rampino

Edgar Rodriguez

Dagmar Steffen

Ruben Post[1], Daniel Saakes[2], Paul Hekkert[1]

[1]Industrial Design Engineering, Delft University of Technology, Delft, The Netherlands

{r.a.g.post, p.p.m.hekkert}@tudelft.nl

[2]Department of Industrial Design, KAIST, Daejeon, Republic of Korea

saakes@kaist.ac.kr

A Design Research Methodology using 3D-Printed Modular Designs to Study the Aesthetic Appreciation of Form and Material

Abstract

Products are typically aesthetically appreciated using multiple of our senses. However, studying the aspects that influence multi-sensory product aesthetics is complicated because of the interaction of visual and tactile product properties, such as form and material, which underlie the aesthetic experience. Illustrated by our ongoing study on the tactile and visual aesthetic appreciation of tangible products, we demonstrate a design research methodology that is highly suitable for studying the influence of material and shape properties. Using state-of-the-art 3D-printing techniques, modular car keys were designed that systematically vary in unity and variety through changes in form and material. The modular approach of designing stimuli, in which form and material properties are customizable through the use of exchangeable components, offers a way in which multisensory aesthetics can be effectively experienced and researched. Such an approach follows the designer's natural methodology of designing, results in realistic stimuli, and gives high control over confounding factors. We argue that this novel design research method thus strongly benefits both practical and theoretical understanding of design aesthetics and related fields.

Keywords: Design Methodology, Modular Design, 3D-Printing, Visual-Tactile Aesthetics

1 Introduction

Knowledge of design aesthetics is central to the practice of designers as it informs the designer how form and material can be used to express meaning to the user [1]. At the same time, researching design aesthetics further develops our scientific understanding of how humans perceptually process sensory information and experience the world beyond that of product designs alone. Ideally, in the study of design aesthetics, a research methodology is used that supports the advancement of both these approaches to knowledge generation [2]. However, such research is made difficult by the different requirements these approaches have in their undertaking. While the practical application of design research requires studies to represent actual use and generalizability of research outcomes, progress on fundamental research is often facilitated by controlling as many confounding factors as possible. These somewhat opposing approaches can result in a considerable gap between theoretical knowledge and practical application when doing design research; does the isolated factor under experimental study reliably translate to the practice of design? Continuing in the line of previous studies using designers to create systematically manipulated stimuli [2-4], we present a design research methodology that uses state-of-the-art 3D-printing techniques to find the 'middle-way' between both approaches. In order to illustrate this methodology, we demonstrate the progress of our study which uses 3D-printed modular car keys to investigate the aesthetic principle of unity-in-variety.

1.1 Exploring Tactile Aesthetics

While our first impression of a product is often visual, tactile exploration is essential in fully perceptually grasping a tangible product. Properties such as weight, material and temperature, convey sensory information that can only be reliably assessed by touch. Understanding the way in which both form and material interact to create a multisensory, aesthetically appreciated, meaningful and emotional experience is therefore crucial when designing. Even more so considering that the importance of tactile interactions becomes dominant over visual ones after prolonged user-product interactions [5]. Despite this, knowledge about tactile aesthetic appreciation, and its interaction with visual aesthetics, is still limited.

In previous research we have shown that the principle of unity-in-variety, known to influence visual aesthetics, applies to tactile aesthetics as well [6]. Unity is the order, structure and coherence of what is felt, while variety is assessed by judging the degree and number of differences in tactile sensations. Using car keys which are in the market, we found that tactile aesthetic appreciation is dependent on the balance between the unity and variety felt and that, while unity and variety suppress each other's effect, they both contribute to aesthetic appreciation.

The principle of unity-in-variety offers a way to theoretically and practically investigate tactile and visual aesthetic experiences of products. However, in our previous study, participants judged nine car keys from a variety of brands. While diversity in stimuli adds to the generalizability of results, it becomes difficult to assess how individual properties (e.g. form and material) influence aesthetic appreciation. For designers, it is often this specific knowledge that is needed to make informed decisions about a design. While traditional research has investigated some of these haptic properties, materials are often judged separately from shapes and without free exploration [e.g. 7]. Such methodologies make generalizing results to the design field problematic. Hence, we developed a research methodology that systematically studies the influence of small changes in form and material properties on aesthetic appreciation.

2 Research Methodology

In the following section we use our own study on aesthetic appreciation of tactile unity and variety to elaborate on the decisive factors of our research methodology.

2.1 3D-Printing for Stimuli Development

To accurately relate research outcomes to theoretical and practical knowledge in the design context, it is essential that stimuli are both realistic and diverse. It is mainly in this area that modern 3D-printing offers benefits over more traditional methods. Current suppliers of 3D-prints (e.g. Shapeways and i-materialise) allow for detailed (600-1200dpi), accurate (±0.3%), customizable and affordable ways of creating haptic stimuli (Fig. 1). Production of these models is available in a wide range of materials (e.g. polymers, rubbers, ceramics, metals and alloys) which can be finished in different ways (brushed, polished, dyed or coated with velvet) to mimic the haptic properties of market products.

Fig. 1. Examples of detailed variations in textures of 3D-printed cups

2.2 Choice of Stimuli

While vision allows for a quick impression of a product's form, the different nature of haptic exploration requires taking other aspects into account. Haptic exploration of a surface is done in a combination of six to eight actions [8]. By using a variety of hand movements, properties such as texture, hardness, elasticity, thermal conductance, weight, and global and exact form can be identified. When choosing stimuli to investigate tactile aesthetics, the degree to which these forms of haptic exploration can be performed should be carefully taken into account.

Our study into the factors that influence unity and variety uses car keys. The size of a car key allows for fully enclosing the product with one hand, making

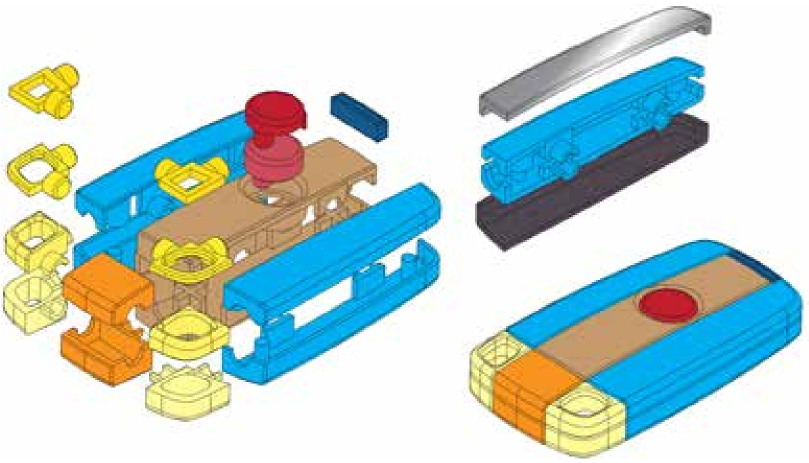

Fig. 2. Left: Exploded view of our modular car key. As indicated by their similar color tone, the key holes and buttons are made interchangeable to influence shape. Top-right: material variations are made by overmolding metal (top) or rubber (bottom). Lower-right: assembled version

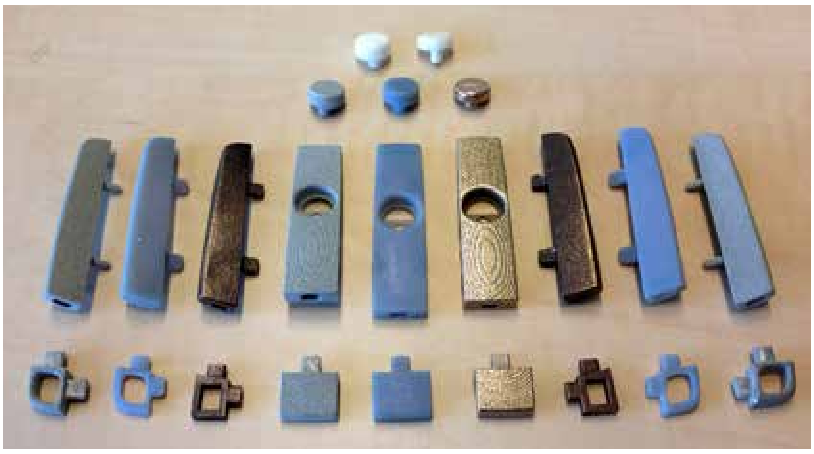

Fig. 3. 3D-printed components varying in shape (key holes and buttons) and material (gray: alumide, blue & white: plastic, brown & gold: steel).

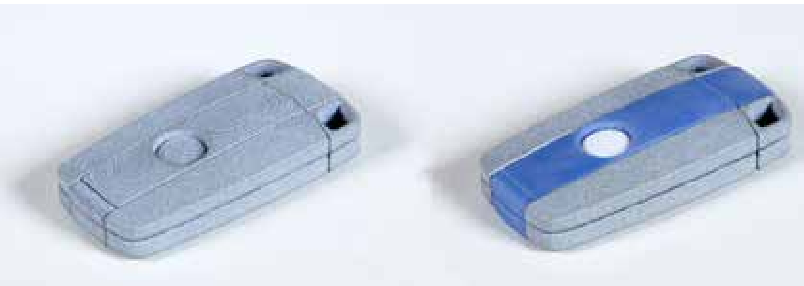

Fig. 4. Assembled model using 1 versus 3 different materials

it easy for people to assess the global shape of the product. When it comes to exact shape, modern car keys often include a certain degree of functionality that requires the presence of buttons. This creates a more interactive experience that stimulates active exploration. The weight of car keys is in a range in which subjects can reliably make comparisons. The accepted use of several different materials (e.g. plastic, rubber, metal, and in some cases wood and glass) make it possible to study large differences between texture, hardness and heat conductance. Furthermore, besides the immediate sensory impression that these products create, car keys communicate (brand) meaning through their form and material.

2.3 Modular Design

In order to study the effects of changes in material and form properties, it is essential that these changes are done systematically. This implies that principally the factors of interest are manipulated while other factors are being kept constant. Such can be achieved by creating modular stimuli.

The design of modular stimuli allows for small changes in form and material with high customizability. The car key we developed is a modular assembly consisting of 13 exchangeable components (Fig. 2). As our goal is to influence the degree of unity and variety that can be felt, we choose to manipulate variety by means of differences in material properties, while manipulating unity through form. Printing of each component in plastic, rubber and metal should affect variety because of differences in properties such as texture, hardness, conductance of heat and weight. Furthermore, to affect unity we manipulated the form of several components (button, keychain hole and gap spacing) along the lines of three Gestalt laws of grouping, which have been shown to also influence tactile grouping [9]. The modular design and variation of three material and shape manipulations lead to a wide range of possible designs (Fig. 3). Despite the high number of combinations, the designerly method of developing these stimuli ensures that none of these possible combinations are highly atypical, while at the same time retaining a high degree of control over the variables of interest (Fig. 4).

2.4 Other Considerations

The example we illustrated is based on a completely new design. This allows full customizability in which visual and tactile aesthetic appreciation of form and material can be systematically studied. We choose not to include more complex interactive dimensions of aesthetic appreciation, yet, our design methodology still allows for studying more interactive products as well. For example, custom 3D-printed optical elements can be embedded in interactive products to allow for use of sensors and optoelectronics [10]. Furthermore, although requiring a skilled modeler, it is possible to 3D-print relatively complex mechanical structures, such as joints, without having to assemble this afterwards [11]. Lastly, while we 3D-printed a full model, in some cases it might be beneficial to use prefabricated dynamic components of a market product and only print the exterior.

3 Conclusion

Design research is often performed on the challenging border between practical applicability of design knowledge and theoretical progress in fundamental research. In researching the influence of form and materials on tactile and visual aesthetic appreciation of tangible products, we demonstrated a design research methodology that attempts to make reliable progress on both fields at the same time. Our use of 3D-printed modular car keys acts as an illustration of the way in which comparable design research can be performed. The design research methodology we offer here has several benefits that make it highly suitable to research design aesthetics. First, product designs can be studied in a systematic way that combines scientific rigor with a designer's natural method of product design, narrowing the gap between design theory and design practice. Second, it facilitates researching how different senses together affect design aesthetics, enabling designers to make more informed decisions. Examples of these are creating (in)-congruency between visual and tactile domains, which can heighten emotional engagement or elicit surprise [4, 12], or communicating brand identity through form and material [13]. Third, while we have looked at the way in which a modular and systematic design method of haptic stimuli can aid in researching multisensory aesthetics, the use of this approach can of course be extended to other products and design theories such as the experience of emotion [14].
The design method thus offers a way of systematically researching the influence of form and material in a wide variety of domains.

References

1. Bloch, P.H.: Seeking the ideal form: Product design and consumer response. The Journal of Marketing 59, 16-29 (1995)
2. Hekkert, P., van Wieringen, P.C.W.: The impact of level of expertise on the evaluation of original and altered versions of post-impressionistic paintings. Acta Psychologica 94, 117-131 (1996)
3. Schifferstein, H.N.J., Otten, J.J., Thoolen, F., Hekkert, P.: The experimental assessment of sensory dominance in a product development context. Journal of Design Research 8, 119-144 (2010)
4. Ludden, G.D., Schifferstein, H.N., Hekkert, P.: Visual-tactual incongruities in products as sources of surprise. Empirical Studies of the Arts 27, 61-87 (2009)
5. Fenko, A., Schifferstein, H.N.J., Hekkert, P.: Shifts in sensory dominance between various stages of user–product interactions. Applied Ergonomics 41, 34-40 (2010)
6. Post, R.A.G., Blijlevens, J., Hekkert, P.: Aesthetic Appreciation of Tactile Unity-in-Variety in Product Designs. In: Kozbelt, A. (ed.) 23rd Biennial Congress of the International Association of Empirical Aesthetics, pp. 358-360, New York, United States of America (2014)
7. Essick, G.K., James, A., McGlone, F.P.: Psychophysical assessment of the affective components of non-painful touch. Neuroreport 10, 2083-2087 (1999)
8. Lederman, S.J., Klatzky, R.L.: Hand movements: A window into haptic object recognition. Cognitive psychology 19, 342-368 (1987)
9. Gallace, A., Spence, C.: To what extent do Gestalt grouping principles influence tactile perception? Psychological Bulletin 137, 538 (2011)
10. Willis, K., Brockmeyer, E., Hudson, S., Poupyrev, I.: Printed optics: 3d printing of embedded optical elements for interactive devices. In: Proceedings of the 25th annual ACM symposium on User interface software and technology, pp. 589-598. ACM, (Year)
11. Calì, J., Calian, D.A., Amati, C., Kleinberger, R., Steed, A., Kautz, J., Weyrich, T.: 3D-printing of non-assembly, articulated models. ACM Transactions on Graphics (TOG) 31, 130 (2012)
12. Salgado-Montejo, A., Velasco, C., Olier, J.S., Alvarado, J., Spence, C.: Love for logos: Evaluating the congruency between brand symbols and typefaces and their relation to emotional words. J. Brand Manage. 21, 635-649 (2014)
13. Ashby, M.F., Johnson, K.: Materials and design: the art and science of material selection in product design. Butterworth-Heinemann (2013)
14. Desmet, P.M., Hekkert, P.: Framework of product experience. International Journal of Design 1, 57-66 (2007)