

The beauty of efficiency in design

Da Silva Cardozo, Odette

DOI

[10.4233/uuid:2d8739e2-d56c-46f1-b050-ee5d5479e928](https://doi.org/10.4233/uuid:2d8739e2-d56c-46f1-b050-ee5d5479e928)

Publication date

2016

Document Version

Final published version

Citation (APA)

Da Silva Cardozo, O. (2016). *The beauty of efficiency in design*. [Dissertation (TU Delft), Delft University of Technology]. <https://doi.org/10.4233/uuid:2d8739e2-d56c-46f1-b050-ee5d5479e928>

Important note

To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Copyright

Other than for strictly personal use, it is not permitted to download, forward or distribute the text or part of it, without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license such as Creative Commons.

Takedown policy

Please contact us and provide details if you believe this document breaches copyrights.
We will remove access to the work immediately and investigate your claim.

THE BEAUTY OF EFFICIENCY IN DESIGN

Proefschrift

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus prof. ir. K.C.A.M. Luyben;
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op
donderdag 20 Oktober 2016 om 15.00 uur

door

Odette DA SILVA CARDOZO

Licenciada en Artes,
Universidad Central de Venezuela;
Magíster en Filosofía,
Universidad Simón Bolívar
geboren te Caracas

This dissertation has been approved by the promotor:

Prof. dr. P. Hekkert and Dr. N. Crilly

Composition of the doctoral committee:

Rector Magnificus	Chairman
Prof. dr. P. Hekkert	Delft University of Technology
Dr. N. Crilly	University of Cambridge

Independent members:

Prof. dr. Y. Saito	Rhode Island School of Design
Prof. dr. R. Reber	University of Oslo
Prof. dr. K. van Eijck	Erasmus University Rotterdam
Prof. ir. M.B. van Dijk	Delft University of Technology
Dr. P.E. Vermaas	Delft University of Technology

Reserve member:

Prof. dr. E. Giaccardi	Delft University of Technology
------------------------	--------------------------------

This research was funded by
The Netherlands Organization for Scientific Research
through the MAGW VICI grant number 453-10-004
awarded to Prof. dr. P. Hekkert

Cover art: *I Dreamed About Efficiency* by Odette da Silva

ISBN: 978-94-6186-729-2

© Odette da Silva, 2016

All rights reserved. No part of this book may be reproduced or transmitted
in any form or by any means without permission of the author.

CONTENTS

SUMMARY/SAMENVATTING	6/8
CHAPTER 1. <i>Encountering the beauty of designed things</i>	10
CHAPTER 2. <i>Appreciating a product in light of its intended effect</i>	20
STUDY 1	24
STUDY 2	32
DISCUSSION OF CHAPTER 2	40
CHAPTER 3. <i>Understanding MEMM</i>	44
THE BASICS OF THE MEMM JUDGMENT	49
THE COMPLEXITY OF THE MEMM JUDGMENT	53
DISCUSSION OF CHAPTER 3	58
CHAPTER 4. <i>Testing MEMM</i>	62
STUDY 3	68
STUDY 4	77
DISCUSSION OF CHAPTER 4	87

CHAPTER 5. <i>Designing for MEMM</i>	90
STUDY 5	94
STUDY 6	102
STUDY 7	111
DISCUSSION OF CHAPTER 5	120
CHAPTER 6. <i>Reflecting on findings and further research</i>	124
IMPLICATIONS OF FINDINGS	126
SUGGESTIONS FOR FURTHER RESEARCH	132
FINAL THOUGHTS: FROM HOLLOW BRICKS TO PARMESAN RISOTTO	136
REFERENCES	142
ACKNOWLEDGMENTS	156
ABOUT THE AUTHOR	160
AUTHOR'S PUBLICATIONS RELATED TO THIS DISSERTATION	161

SUMMARY

The aesthetic appreciation of a product is often described without taking into account that the product has been designed for a purpose; for instance, merely based on the product's appearance. This dissertation examines the kind of aesthetic appreciation that involves recognizing that the product has been designed (as a means) to achieve a particular effect and, more specifically, evaluating how the product achieves such effect. It focuses on the principle of efficiency or "MEMM", which indicates that people perceive beauty in a product when they perceive it to achieve "the maximum effect" with "the minimum means".

A combination of research methods is used to address the following four questions: (Q1) Is the appreciation of a product affected by knowledge of the product's intended effect and, if so, how? (Q2) How can the aesthetic appreciation of a product be understood based on the principle of MEMM? (Q3) Is the aesthetic appreciation of a product positively affected by the perception of the product as the minimum means achieving the maximum effect? (Q4) How can designers enhance a product's aesthetic appeal by considering the product as the means to achieve an intended effect?

A mixed-methods investigation of Q1 indicates that intention knowledge does affect product appreciation, partly insofar as it enables an (aesthetic) evaluation of the product as a means to achieve an intended

effect. A conceptual analysis of Q2 reveals how a product and its intended effect can be judged to be the minimum means and the maximum effect with grounds in a set of assumed alternatives for both the means and the effect. An experimental examination of Q3 provides evidence that a product is aesthetically appreciated when it is perceived to achieve more than other products from the same category (the maximum effect) by making an efficient use of resources (the minimum means). A mixed-methods study of Q4 finally suggests a set of qualities that designers can aim at when defining an intended effect and developing a product (means), and also indicates the aspects of the product that can be manipulated based on these qualities.

The findings here presented have a number of implications. For design research, they indicate that people's (aesthetic or non-aesthetic) experience of a product or service should be examined with attention to their knowledge of the designer's intended effect. For design practice, they propose a strategy for enhancing aesthetic appeal that involves manipulating aspects such as user interaction and that can, therefore, not just help develop a beautiful product, but a beautiful service too. For design education, they suggest the value of teaching that beauty and efficiency can be combined in designing and experiencing a product or service; they also trigger a reflection on means- and effect-based teaching approaches. For marketing, they identify several qualities that potential consumers might appreciate in a product or service, qualities that can thus guide the creation of an advertisement and that can make the advertisement, in itself, more appealing. With regards to the day-to-day experience of products and services, they offer an understanding of the reason why people might like a particular product or service, which in turn might help them make more knowledgeable consumer choices. Because MEMM can be applied to many other artifacts besides products and services, the findings here presented are also relevant to fields of knowledge and practice such as the arts.

SAMENVATTING

De esthetische waardering van een product wordt vaak beschreven zonder ermee rekening te houden dat het product ontworpen is met een doel; maar bijvoorbeeld alleen op basis van het uiterlijk. Dit proefschrift onderzoekt het soort esthetische waardering waarbij erkent wordt dat een product ontworpen is (als een middel) om een bepaald effect te hebben en, om preciezer te zijn, de evaluatie van hoe het product dit effect bereikt. Het richt zich op het principe van efficiëntie oftewel “MEMM”, dat stelt dat mensen schoonheid waarnemen in een product wanneer zij waarnemen dat “het maximale effect” bereikt wordt met “het minimale middel”.

Een combinatie van onderzoeksmethoden wordt gebruikt om de volgende vier vragen te behandelen: (Vraag 1) Wordt de waardering van een product beïnvloed door de kennis van het bedoelde effect van het product en, zo ja, hoe? (Vraag 2) Hoe kan de esthetische waardering voor een product begrepen worden door middel van het MEMM principe? (Vraag 3) Wordt de esthetische waardering voor een product positief beïnvloed door het waarnemen van een product als een minimaal middel om een maximaal effect te bereiken? (Vraag 4) Hoe kunnen ontwerpers de aantrekkelijkheid van een product verhogen door het product te zien als een middel om een voorgenomen effect te bereiken?

Een gemengde-methode onderzoek van Vraag 1 toont aan dat kennis van een intentie de waardering voor een product beïnvloedt, gedeeltelijk doordat kennis van

de intentie het toestaat dat een product (esthetisch) geëvalueerd kan worden als een middel dat een bedoeld effect bereikt. Een conceptuele analyse van Vraag 2 laat zien hoe een product en haar bedoelde effect beoordeeld kan worden als een minimaal middel en een maximaal effect, gebaseerd op een set van veronderstelde alternatieven voor zowel het middel als het effect. Een experimenteel onderzoek van Vraag 3 levert bewijs dat een product esthetisch gewaardeerd wordt wanneer het meer bereikt dan andere producten uit de productcategorie (het maximale effect) door efficiënt gebruik te maken van beschikbare bronnen (het minimale middel). Een gemengde-methode studie van Vraag 4 oppert tenslotte een set aan kwaliteiten waarop ontwerpers zich kunnen richten wanneer ze een bedoeld effect en product (middel) moeten definiëren, bovendien toont het aspecten van een product die gemanipuleerd kunnen worden op basis van die kwaliteiten.

De hierin gepresenteerde bevindingen hebben een aantal implicaties. Voor ontwerponderzoek tonen ze aan dat de (esthetische of niet-esthetische) beleving van een product of dienst onderzocht moet worden met aandacht voor de kennis van een ontwerper zijn of haar bedoelde effect. Voor de ontwerppraktijk stellen ze een strategie voor die de esthetische aantrekkingskracht versterkt door aspecten zoals de gebruikersinteractie te manipuleren en de bevindingen kunnen daardoor niet alleen helpen een mooi product te creëren, maar ook een mooie dienst. Voor ontwerponderwijs suggereren ze de waarde van het onderwijzen dat schoonheid en efficiëntie gecombineerd kunnen worden in het ontwerpen en beleven van een ontwerp of dienst; ze zetten ook aan tot een reflectie op middel- en effect-gebaseerde onderwijsbenaderingen. Voor marketing leggen ze verscheidene kwaliteiten bloot die potentiële consumenten mogelijk waarderen in een product of dienst, kwaliteiten die kunnen dienen een reclame te ontwikkelen en aantrekkelijker te maken. Met betrekking tot de dagelijkse beleving van producten en diensten bieden ze een beter begrip waarom mensen een bepaald product of dienst waarderen, wat vervolgens kan helpen beter geïnformeerde consumentenkeuzes te maken. Omdat MEMM toegepast kan worden op vele verschillende artefacten naast producten en diensten, zijn deze bevindingen ook relevant voor kennis- en praktijkgebieden zoals in de kunst.

CHAPTER I

Encountering the beauty of designed things

In a recent trip to New Zealand, I was astonished by the many faces of nature: from the see-through icebergs floating at the base of a glacier to the fluorescent, sulfur-tainted rocks surrounding an active volcano. I have a vivid memory of the geothermal pools at Waiotapu. They exhibit intense colors, beautifully bleeding into one another and into the shifting water steam. I was not surprised to learn that one of these pools was called Artist's Palette, since it reminded me of a painting that was waiting for me back home—so to speak (Figures 1 and 2). I find this pool and this painting beautiful for similar features, for their similar colors and the similar ways in which these colors come together and create a sense of harmony and dynamism. Yet, my perceptions of beauty in these two cases are fundamentally different. When I see the painting, I think of the artist who made it and his artistic skill to create that sense of harmony and dynamism; when I see the pool, I do not have an equivalent creator in mind. I take a certain stance towards the painting, I approach it as the work of an artist or intentional agent (see Vermaas, Carrara, Borgo, & Garbacz, 2013). While people might take this stance towards a natural object or organism, considering the agency of an entity such as Mother Nature or the Creator of the world, they are intuitively inclined to take it towards a thing that has been intentionally created or designed by a person or a group of people (as the studies reviewed by Kelemen & Carey, 2007, indicate). It is the aesthetic appreciation of this kind of thing—a designed thing—that concerns me as I write these pages.

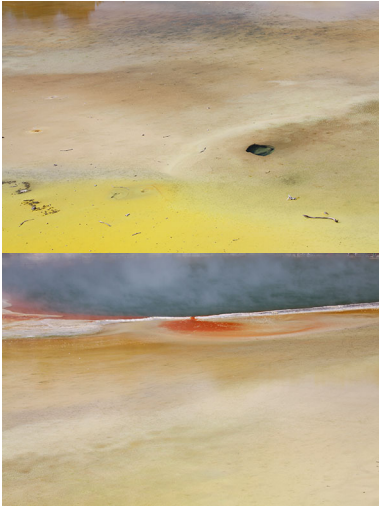


Figure 1. Photographs taken while visiting the Artist's Palette in New Zealand.

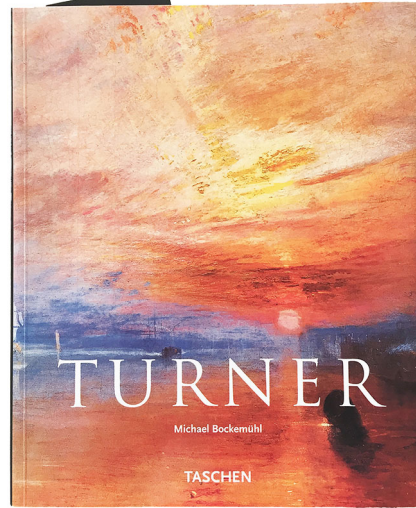


Figure 2. A book back home showing a detail of *The Fighting Temeraire Tugged to Her Last Berth to Be Broken Up* (1839) by J.M.W. Turner.

These days, my iPhone seems to be the most present designed thing in my life. I can appreciate it for its neat visual appearance and its intuitive touch-based interface. This kind of appreciation can be considered aesthetic because it involves perceiving the iPhone for its own sake, as opposed to evaluating it with an extrinsic interest or goal in mind (this is in line with a classic definition of the aesthetic judgment; see Goldman, 2001). I can, however, have a more complex appreciation of the iPhone if I take into account that its appearance and its interface have been intentionally developed by Apple's design team, if I consider that these features have a purpose. Whether my knowledge of this purpose is accurate or not (I might learn about it from a statement by Jonathan Ive, but also guess it; see Crilly, 2011a; 2011b), it can affect my appreciation of the iPhone. For example, if I assume that the design team's purpose was simply to enable people to communicate over a distance, then I can appreciate the iPhone for how it achieves this purpose, for allowing people to communicate over a distance through an easy-to-use interface. This appreciation can still be considered aesthetic because it still results from perceiving the iPhone for its own sake, from perceiving how its features achieve the effect that Apple's design team intended, as contrasted to an effect imposed by me or any other perceiver. Very

diverse things or artifacts, including physical objects and human performances (see Dipert, 1993; Hilpinen, 1992), can be appreciated in this way because they are intended to achieve certain effects regardless of their particularities.

Quite different from an iPhone, but still designed in the sense of intentionally created, lies *The Passion According to G.H.* (1964) by Clarice Lispector on one of my bookshelves. This novel focuses on the moment a woman enters a room of her Rio de Janeiro penthouse. In the room, she finds traces of a former maid and is confronted by the presence of everything she does not identify with. This presence takes the symbolic form of a cockroach that the woman first finds repulsive, but eventually puts in her mouth as in a rite of communion by which her sense of self disappears. I do not take pleasure in imagining anyone putting a cockroach in their mouth, nor do I take pleasure in thinking about the death of the self. Yet, I can appreciate how such a simple literary image provokes such an overwhelming thought. In line with this experience, several authors recognize that there is beauty in human creations or performances that—in contrast to Turner’s painting or the iPhone—are not necessarily appealing because of the form they exhibit or the effect they are intended to achieve. Besides literary metaphors such as the one just described (see Kaplan & Kris, 1948; Ramachandran & Hirstein, 1999), these creations or performances include certain line drawings (Boselie & Leeuwenberg, 1985), mathematical proofs (Hardy, 1967), science experiments (Crease, 2004; Johnson, 2009), buildings (Sullivan, 1979), tennis serves (Best, 1974), theories and argumentations (Orrell, 2012; Walsh, 1979), chess moves (Margulies, 1977), and even criminal acts (Black, 1991). Along with products like the iPhone, these creations or performances constitute a sphere of broadly understood “designed things” or artifacts (Figure 3), each of which can be aesthetically appreciated as such, that is, based on knowledge that it has been (intentionally) designed for a specific purpose.

People often describe their aesthetic appreciation of an artifact without (explicitly) considering that the artifact has been designed; for instance, they describe how much they like the artifact’s visual qualities, its particular shape or color. Throughout history, however, philosophers have accounted for a perception of artifact beauty that involves thinking

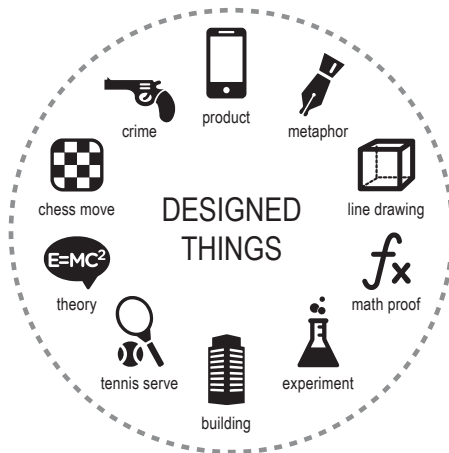


Figure 3. A sphere of designed things (where the dashed circumference indicates that the sphere expands to include many more things). Each of these things can be aesthetically appreciated as having been designed for a purpose.

about the purpose that the artifact is intended to fulfill. In Antiquity and the Middle Ages, they employed the terms *præpon*, *decorum*, and *aptum* to praise a thing for its aptitude to perform the task that it was meant to perform (see Tatarkiewicz, 1980). They closely related the perception of beauty to that of purposefulness during the Enlightenment. In *A Treatise of Human Nature*, Hume (2000 [orig. 1739]) claimed that the beauty of many human creations lies in the appropriateness of these creations to their ends. In *The Theory of Moral Sentiments*, Smith (2002 [orig. 1759]) asserted that a machine’s or system’s capacity to provoke the effect that it is designed to provoke makes the machine or system beautiful overall. With his *Critique of the Power of Judgment*, Kant (2000 [orig. 1790]) introduced the notion of dependent beauty, a perception of beauty that presupposes having knowledge of the purpose a thing is meant to accomplish. Building on this notion, Forsey (2013) recently proposed that the aesthetic judgment of an artifact is conceptually rich insofar as it involves thinking about the artifact’s purpose. Parsons and Carlson (2008) similarly reflect on functional beauty and, together with Saito (2007), distinguish an artifact’s capacity to function from *the way* in which it functions, arguing that an artifact can be aesthetically appreciated for *how* it performs a function.

Evolutionary thinkers also provide a basis for examining the aesthetic appreciation of a designed thing. From their perspective, people’s sense of beauty is an adaptive trait, developed to identify and approach those things that support the survival of the species—this is a good

explanation as to why beauty plays such an essential role in human experience (as argued by Pinker, 2002). The mind has adapted to find specific solutions to specific environmental problems, and thus the perception of beauty in natural things like landscapes and human bodies might be grounded in different criteria—different survival cues—than the perception of beauty in designed things (see Thornhill, 2003). Landscapes are appreciated when they provide shelter and water (Orians & Heerwagen, 1992), while human bodies are appreciated for qualities connected to strength and fertility (Etcoff, 2000). With regards to designed things, Dutton (2010) and Miller (2001) explain that an artifact—whether a primitive hand axe or a contemporary dance performance—can be aesthetically appreciated for what it conveys about the fitness of its creator or performer. The symmetry of the axe or the rhythm of the dance can be perceived as signs of mental and motor skills, which allow humans to overcome difficulties—hence survive—and are therefore attractive in potential (sexual) partners. Even the most ordinary human performances, such as telling a joke and braiding a strand of hair, can be appreciated in this sense when executed skillfully, that is, when they reveal how clever or fit the mind behind them is. They too can be included in the sphere of designed things that I already described (Figure 3).

To better explain people's aesthetic appreciation of an artifact, particularly in the context of product design, Hekkert (2014) has proposed a model based on the evolutionary claim that any organism has the primary tasks of preserving life and promoting the conditions for growth. This means that humans seek what is safe and demands little from their limited capacities, but they are also naturally inclined to take risks so as to develop these capacities. The model is thus based on the “general assumption that individuals seek both safety and accomplishment” (Shah, Higgins, & Friedman, 1998, p. 286). It indicates that these two evolutionary pressures or needs affect a person's appreciation of a product on three levels. On a perceptual level, the need for safety triggers an evaluation of the product's unity, while the need for accomplishment triggers an evaluation of its variety. On a cognitive level, the need for safety triggers an evaluation of the product's typicality, while the need for accomplishment triggers an evaluation of its novelty. On a social level, the need for safety triggers an evaluation of the

product’s capacity to convey the person’s connectedness to other people, while the need for accomplishment triggers an evaluation of its capacity to convey the person’s autonomy. The model further indicates that the aesthetic preference for a product emerges from satisfying both needs as much as possible on one or several levels, that is, from finding the highest possible degree of both unity and variety, typicality and novelty, or connectedness and autonomy, in the product. Hekkert’s Unified Model of Aesthetics (UMA) is illustrated in Figure 4.

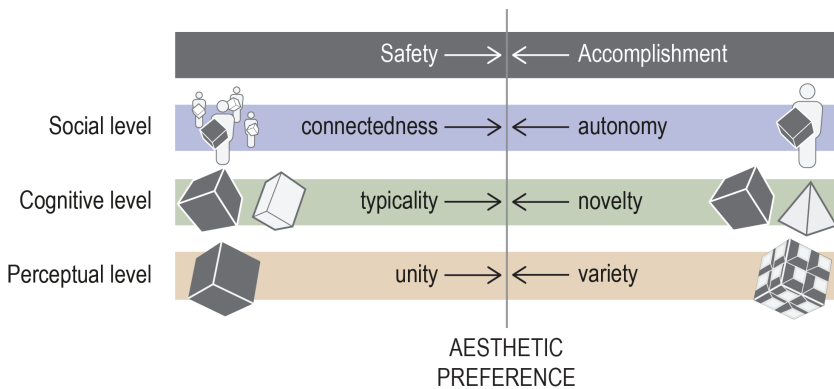


Figure 4. Hekkert’s UMA. The model explains people’s aesthetic preference for a product based on the evolutionary needs for safety and accomplishment.

UMA also aims at accounting for the kinds of aesthetic appreciation that result from either thinking about the intention of the product’s designer or (physically) interacting with the product (see Hekkert, 2014). While the kind that involves considering intention has not yet been investigated either theoretically or empirically, the kind that results from interaction has already been examined to an extent (for a literature review, see Lenz, Diefenbach, & Hassenzahl, 2014). Likewise, some principles have already been identified to explain people’s aesthetic preference for a product on the perceptual, cognitive, and social levels. Post, Blijlevens, and Hekkert (2016) offer evidence of the principle of unity in variety, while Hekkert, Snelders, and Van Wieringen (2003) offer evidence of the principle known as MAYA, which stands for “most advanced, yet acceptable” and involves a trade-off between typicality (what people find acceptable) and novelty (what people find advanced). Blijlevens and Hekkert (2014) have further examined a similar trade-off between connectedness and autonomy. By contrast, no principle is known to

explain the perception of beauty that involves thinking about the intention underlying a product's design. In this sense, existing research fails to provide a full account of people's (aesthetic) experience of products.

In this dissertation, I examine the kind of aesthetic appreciation that people have of a product when they consider—whether accurately or not—the product's intended purpose or effect.¹ More specifically, I examine the kind of appreciation that involves evaluating *how* a product achieves its intended effect, as contrasted to *if* the product achieves this effect. In reviewing theory on product aesthetics (Hekkert, 2006; Hekkert & Leder, 2008) and recommendations on product design (Lidwell, Holden, & Butler, 2010; Macnab, 2012; Zelanski & Fisher, 1984), I have identified a principle that might account for this kind of appreciation: maximum effect for minimum means. It suggests that a product is aesthetically appreciated when it achieves a lot with a little, that is, when it performs efficiently. This principle—to which I will often refer as MEMM for efficiency's own sake—should not be confused with effectiveness or efficacy. Effectiveness or efficacy implies that a thing achieves the effect that it is intended to achieve, while MEMM or efficiency implies that the thing achieves a relatively maximal effect by using relatively minimal means. MEMM might be the key to deepening the understanding of people's appreciation of a variety of designed things because it might explain their appreciation of *how* these things achieve their intended effects. By investigating this principle, I might provide the grounds to better comprehend the aesthetic appreciation of all these things, even if my investigation focuses on just one of them: the product.²

¹ Crilly, Good, Matravers, and Clarkson (2008) have justified why it is valid and useful to interpret a product based on design intent. Grounds for this justification can ultimately be found in the theory according to which a work of art or literature should be interpreted in accordance to the artist's or the author's intention (this position has been discussed by, for instance, Iseminger, 1992; Livingston, 2007). I do not adopt this normative position towards the appreciation of a product. Instead, my dissertation describes how people appreciate a product spontaneously when they have some knowledge of its intended effect.

² In this dissertation, I use the term *product* to refer to a physical or virtual, static or dynamic, outcome of the design process. This product might be connected to a service or integrated into a system, and it might only exist in the form of a design concept or a more undefined idea. To emphasize this flexible meaning and stress the relationship

In the forthcoming chapters, I address four fundamental issues with a combination of research methods, in an effort to develop knowledge with experimental exactitude, descriptive richness, and conceptual depth. In Chapter 2,³ I use a mixed-methods approach to studying if people's general appreciation of a product is affected by their knowledge of the product's intended effect or the designer's intention (Study 1) and, if so, in what way (Study 2), thereby exploring if such knowledge affects the aesthetic side of product appreciation. In Chapter 3,⁴ I offer a conceptual examination of people's aesthetic appreciation of a product based on MEMM, which involves not only judging the product (means) and its intended effect in relation to one another (section titled "The basics of the MEMM judgment"), but also in relation to a number of known or imagined means and effects that are assumed as alternatives (section titled "The complexity of the MEMM judgment"). In Chapter 4,⁵ I experimentally test the hypothesis that people's aesthetic appreciation of a product is positively affected by their perception of the product as the minimum means achieving the maximum effect, first with existing products that naturally vary in their intended effects and the resources that they use to achieve these effects (Study 3), and then with manipulated stimuli in an experimental design that allows me to control for the confounding influence of product appearance (Study 4). In Chapter 5, I use a mixed-methods approach to studying how designers can enhance the aesthetic appeal of a product by considering the product as the means to achieve an intended effect; I explore how they can maximize the effect and minimize the means (Study 5), particularly how they can minimize the means (Study 6), and further test if designers develop more aesthetically appealing artifacts when they consider a

between the product that I am referring to and many other designed things, in the coming chapters I will sometimes use the term *artifact* instead (implying designed thing in the broad sense that Figure 3 illustrates).

³This chapter has been previously published as: Da Silva, O., Crilly, N., & Hekkert, P. (2015). How people's appreciation of products is affected by their knowledge of the designers' intentions. *International Journal of Design*, 9(2), 21–33.

⁴This chapter has been previously published as: Da Silva, O., Crilly, N., & Hekkert, P. (2016). Maximum effect for minimum means: The aesthetics of efficiency. *Design Issues*, 32(1), 41–51.

⁵This chapter has been previously published as: Da Silva, O., Crilly, N., & Hekkert, P. (in press). Beauty in efficiency: An experimental enquiry into the principle of maximum effect for minimum means. *Empirical Studies of the Arts*.

relatively broad set of alternative means to achieve an effect (Study 7). To conclude, in Chapter 6, I discuss the implications that my findings have for design research, design practice, design education, marketing, and the everyday experience of products and services; I offer suggestions to continue this research, and finally reflect on why such continuation concerns fields as different as architecture and gastronomy.

CHAPTER 2

Appreciating a product in light of its intended effect⁶

Products result from processes that are guided by designers' intentions for what the products should be, what they should be like and what they should do. Design research has paid special attention to human-centered intentions, which have been the subject of various studies (Crilly, Moultrie, & Clarkson, 2009; Fokkinga, Hekkert, Desmet, & Özcan 2014; Tromp, Hekkert, & Verbeek, 2011). This research indicates that a product can be designed not only with the intention of making practical life easier, e.g., facilitating a routine task, but also with the further intention of eliciting a certain experience, attitude or behavior from people. For instance, a spoon is designed to bring food to the mouth, but also to enrich the sensory experience of dining by triggering perceptions of color, texture, and volume (Figure 5). A watch is designed to give the time of day, but also to stimulate a seize-the-day attitude by reminding people of their own mortality (Figure 6). A basin is designed to enable hand washing, but also to promote responsible water consumption behavior by making visible an immediate consequence of such consumption (Figure 7). People can infer such intentions directly from the products (Crilly, 2011a; 2011b), learn about them from statements made by the designers, or from press releases, marketing

⁶ This chapter is based on a co-authored article (Da Silva et al., 2015). I use the plural pronouns *we*, *us*, and *our* from now on to refer to this co-authorship, and not to deny that I take full responsibility for the ideas here presented. This applies to the coming chapters too, which are also based on co-authored articles.

campaigns, instruction manuals, critical reviews, word of mouth, and other sources of information. By *people*, we mean anyone who engages in product experience, whether this is an active user or simply a perceiver, recognizing that designers and others who professionally engage with designed products also take on the roles of user or perceiver. Irrespective of its source and accuracy, people's intention knowledge might affect their appreciation of a product. Yet, design research has not empirically addressed the questions of whether intention knowledge affects product appreciation and, if so, how. This chapter aims to fill this gap by examining the ways in which people appreciate products when they take into account the reasons underlying their design.



Figure 5. *Tableware as Sensorial Stimuli* (2012) by Jinhyun Jeon.



Figure 6. *The Accurate* (2007) by Crispin Jones.



Figure 7. *Poor Little Fish* (2009) by Yan Lu.

Regarding a product as resulting from intentions involves acknowledging that the product is not just an object, but an artifact (Dipert, 1993; Hilpinen, 1992). People are thought to adopt a design stance and take an essentialist perspective when encountering an artifact. Dennett (1989) introduced the notion of a design stance to describe how people predict the behavior of an object on the assumption that the object will behave as it is supposed to behave. One interpretation of this is that people consider that an artifact performs a function because it has been designed for a purpose by a designing agent (Vermaas et al., 2013). People intuitively see the intention of this agent as defining the artifact's essence, the deeper causal property that justifies the objective features of the artifact (Bloom, 1996; see also Bloom, 2000). Furthermore, when regarding an artifact, people attain pleasure from thinking about its essence and not just from perceiving those features (Bloom, 2011). Several studies provide evidence of people's essentialist understanding of

artifacts (for a review, see Kelemen & Carey, 2007). There is evidence that this understanding emerges in the early stages of a child's development (Preissler & Bloom, 2008) and that it operates across cultures (Barrett, Laurence, & Margolis, 2008). Based on these studies, we assume that a designer's intention can intuitively be regarded as the essence of a product and that knowledge of this intention can therefore affect how that product is appreciated.

Design research has not empirically examined the influence of intention knowledge on product appreciation, but studies in art and literature indicate that knowledge about an artifact affects the perception of the artifact in a number of ways. Some evidence has already been provided that knowing the intention of an artifact's creator affects the assessment of the artifact's quality; for example, whether the artifact is judged to be art (Jucker, Barrett, & Wlodarski, 2014) or good art (Hawley-Dolan & Young, 2013). However, previous studies have not focused on the relationship between artifact *appreciation* (as contrasted to any kind of artifact perception) and *intention* knowledge (as contrasted to any kind of knowledge). On the one hand, they have shown that the general perception of an artifact can be affected by intention knowledge. For instance, there is evidence that people find a literary metaphor more meaningful when the metaphor is credited to an intentional poet, rather than to a computer program acting randomly (Gibbs, Kushner, & Mills, 1991), and that the understanding of a satirical text is enhanced by inferential knowledge about the author's intentions (Pfaff & Gibbs, 1997). On the other hand, these studies have shown that artifact appreciation can be affected by general knowledge provided to participants in various forms of information. For instance, there is evidence that people appreciate a painting more when they are also provided with the artist's verbal statement (Specht, 2010), and that the appreciation of abstract artworks in particular, which are more difficult to interpret than figurative artworks, increases when the artworks are presented with titles (Leder, Carbon, & Ripsas, 2006). A subset of these studies has shown that providing people with titles or with contextual or stylistic information about an artwork affects their appreciation of the work aesthetically (e.g., Cupchik, Shereck, & Spiegel, 1994; Millis, 2001; Temme, 1992). Building on this previous research, we examine the

prediction that people's appreciation of an artifact is influenced by their knowledge of the intentions underlying the artifact's creation.

In conceptualizing how intention knowledge influences appreciation, we consider both the previously mentioned empirical studies and also a developmental theory of art understanding (Parsons, 1987). Based on this theory, a distinction can be made between appreciating a product because of *what* intention it fulfills and appreciating a product because of *how* it fulfills that intention. While the former involves judging the intention as defining the essence of the product, thus extending this judgment of the intention to a judgment of the product itself, the latter involves judging the product as a means to fulfill the intention independently of any judgment of the intention. Hence, intention knowledge might affect product appreciation by enabling either an evaluation of the intention or an evaluation of the product as a means to achieve the intention, i.e., an evaluation of the product-intention relationship. The design literature acknowledges that a product can be appreciated in the latter sense as it identifies MEMM as a core principle of aesthetic appreciation (Hekkert, 2006; Hekkert & Leder, 2008). According to this principle, a product is aesthetically pleasing when it is perceived to be the minimum means to achieve a maximum effect. Even without consideration of this minimum–maximum ratio, the means–effect relationship is considered to be an important criterion for aesthetic appreciation (Boselie & Leeuwenberg, 1985). Thus, by enabling an evaluation of the product as a means, intention knowledge (knowledge of the intended effect) might influence product appreciation in an aesthetically relevant way.

To test the prediction that intention knowledge affects product appreciation and to further investigate this phenomenon, we conducted two studies that addressed the research questions: does intention knowledge influence the appreciation of products?, and, if so, how? As a whole, these studies were conceived according to a mixed-methods approach in the form of a sequential explanatory design (see Creswell, 2009). First, a quantitative study (Study 1) was conducted to find experimental evidence of the influence of intention knowledge. Second, a qualitative study (Study 2) was conducted to explain the results of Study 1 with interview data. This mixed-methods approach thus

combines the benefits of experimental exactness and descriptive richness, both of which are necessary to measure and understand the phenomenon we are interested in.

We had to make a number of decisions with regards to the many variables that define products, intentions, and people. In making these decisions, we focused on consumer products and on the designers' intentions for how those products should elicit certain experiences, attitudes or behaviors. Since different people might infer different design intentions from a product, the effect of inferred intentions is difficult to assess experimentally. As such, we provided our participants with explicit information about the designers' intentions, thus eliminating the need for inference, even if not preventing it. The intention information was provided in the form of textual statements and the products were represented with images. This is in line with studies in art appreciation that have used texts and images to represent artworks and the stories behind them (e.g., Bordens, 2010; Leder et al., 2006; Specht, 2010). We required our participants to have a minimum level of design literacy because reflecting on designers' intentions and being articulate about them is a more difficult task for those unused to thinking and talking about the processes from which designed products result. To that end, we selected design students as participants.

STUDY I

METHOD

Participants. Sixty students in Industrial Design Engineering from Delft University of Technology took part in this study in return for 10 Euros each. There were 20 males and 40 females, with an average age of 20.00 years ($SD = 1.70$).








Design. To examine if intention knowledge influences product appreciation, we used a pre-test/post-test control-group experimental design, combining a 2 by 2 between-subjects design and a within-subjects design. The procedure involved random assignment of each participant to one of two intention-knowledge conditions: knowledge and no knowledge. In both conditions, the participants pre-rated and

post-rated products on a product-appreciation scale. Participants in the knowledge condition first rated the products without being provided with statements about the designers' intentions and then gave a second rating after being informed about those intentions. Participants in the no-knowledge condition rated the products twice without being provided with any statements about the designers' intentions.

Materials. Fifteen pairs of product images and intention statements were used as stimulus materials in the study. These materials were selected from projects developed between 2002 and 2011 by students in Industrial Design Engineering from Delft University of Technology. The selection was made with consideration to three factors. Firstly, the projects had been developed with the Vision in Product design method (Hekkert & Van Dijk, 2011), for which students have to explicitly define and record their intentions in writing and then translate them into a product solution. Secondly, the projects represented a wide range of design domains and product kinds (physical and virtual, static and dynamic). Thirdly, the projects were expected to be unknown to the participants, thereby avoiding the influence of prior knowledge.

The research team made the intention statements consistent in length and informational content. Each of the resulting texts comprised between 35 and 45 words divided into two sentences. One sentence presented the designer's intention and the other emphasized the properties that described the product as a means to fulfill that intention. The product images comprised computer renderings and photographs of physical prototypes. The images and statements were printed on A4 paper in portrait orientation, with the images measuring 10 by 15 cm and the statements presented in 12-point font. Thumbnails of these images and the accompanying statements are presented in Table 1. For the remainder of this chapter, we refer to these materials as *the product(s)* and *the intention(s)*, and identify them with letters from A to O as in Table 1.

Table 1. Stimulus materials used in Study 1.

Details	The product	The intention
<i>Airmail</i> (2010) by Novi Rahman	A 	This is a smart phone application that delivers messages to their intended recipients when they arrive at locations specified by the senders. It was designed with the aim of helping people to feel closer to each other.
<i>Cross-Cultural Memory Game</i> (2007) by Sara Emami	B 	This is a memory game in which pairs of cards are not identical, but feature similar elements of the Dutch and Middle Eastern cultures. It was designed with the aim of making inhabitants of The Netherlands aware of their similarities instead of their differences.
<i>De Goedzak</i> (2009) by Simon Akkaya	C 	This is a partially transparent bag where things that are no longer used, but are still in good condition, can be left on the street for anyone to pick them up. It was designed with the aim of enabling people to be generous towards strangers.
<i>Feet and Greet</i> (2009) by Willem Lysen	D 	This is a cover that can be pulled over the train seat to put one's feet up and then removed to offer the seat to a fellow traveler. It was designed with the aim of transforming train travelers' antisocial behavior into a social act.
<i>Kook Bord</i> (2011) by Merel Pick	E 	This is an online application in which meals can be planned and cooked together in a virtual kitchen environment. It was designed with the aim of inspiring people to build a social community by sharing and cooperating with each other.
<i>Packaging Box</i> (2010) by Radoslav Gulekov	F 	This is a postal packaging box whose side and bottom panels are biodegradable flowerpots filled with earth and grass. It was designed with the aim of encouraging people to respectfully integrate nature in their daily life.
<i>Patroon</i> (2004) by Asako Takahashi	G 	This is a kitchen cupboard where everyday products can be stored in separate compartments according to their exact shapes. It was designed with the aim of helping people appreciate the comfortable predictability of daily household tasks.

Steentjes
(2009) by
Anna Noyons

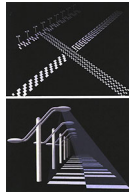
H



This is a range of natural maternity products whose bio-based packages can be turned into safe toys. It was designed with the aim of encouraging new parents to build a trustworthy base for raising their child.

Street Lighting
(2002) by
Rogier
Hartgring

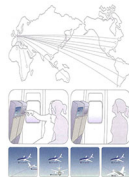
I



This is a street lighting system that projects different patterns on different roads and city areas. It was designed with the aim of enabling people to find their way home comfortably and safely during nighttime.

The Iflyer
(2005) by
Karen Zeiner

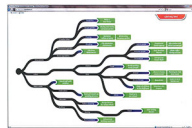
J



This is a seat-integrated display that shows the planes crossing the current flight path and their destination. It was designed with the aim of enabling flight passengers to experience the freedom of mental traveling within the limited space of an aircraft.

The Tree of
Talents (2010)
by Femke
Heikamp

K



This is a website that allows people to articulate their skills and get in contact with those who are in need of them. It was designed with the aim of making inhabitants of unprivileged neighborhoods see the value of their talents.

Ticket Game
(2009) by
Chetan
Shivarama

L



This is a train ticket with a visual puzzle that can only be played while traveling. It was designed with the aim of stimulating train travelers to experience happiness by being focused on the present rather than on the time of arrival to their destination.

Time-Wrap
(2009) by Jay
Yoon

M



This is a digital display that is integrated to train windows and occasionally shows movie clips of the outside scenery from another season. It was designed with the aim of triggering memories and self-reflection in people.

Venturi Tunnel
(2002) by
Mark van der
Woning

N



This is a bicycle path that submits bikers to something unexpected by either pushing or pulling them suddenly depending on the wind direction. It was designed with the aim of giving neighbors a reason to talk to each other again.

Water
Transport Hub
(2011) by
Eleni Soerjo



This is a water transport hub where travelers are not isolated from the surrounding wind, water and sky. It was designed with the aim of making people in Rotterdam feel connected with the environment and rediscover the essence of things.

Procedure. To ensure close supervision of the participants, the study was conducted in groups of four to eight participants, requiring 12 groups in total. The study was conducted in the research labs of the Faculty of Industrial Design Engineering at Delft University of Technology. When entering the labs, the participants were taken through a standard procedure to establish their informed consent and were randomly assigned to one of the two intention-knowledge conditions, while balancing age and gender between the conditions. A scale was provided to participants to rate each of the products from 1 (*not at all*) to 7 (*very much*) on the following five items: liking, beauty, attractiveness, pleasingness, and niceness. These five items were taken from an existing scale of aesthetic appreciation (developed by Blijlevens, Thurgood, Hekkert, Leder, & Whitfield, 2014), which was adapted to measure general product appreciation for the purpose of this study. Five distractor items were also used to prevent ratings being affected by the participants' awareness of the focus of the study. All participants first rated the products only, which took between 20 and 25 minutes. When all the participants had completed the ratings, they were instructed to perform a distraction task for 5 minutes with the purpose of preventing memorization or recall of the stimuli and the ratings. Following this, the participants in the knowledge condition rated all products again, but this time the products were presented together with the intention statements. This rating task also took 20 to 25 minutes. Participants in the no-knowledge condition rated the products again without the statements, which took between 15 and 20 minutes. The order in which the products and scale items were presented was randomized between the participants to prevent order effects. In both conditions, the whole procedure took no more than 60 minutes.

RESULTS

The ratings of the scale items were averaged for each participant to obtain composite ratings of product appreciation. This data was analyzed according to the methodological requirements specific to a pre-test/post-test control-group experimental design (see Kumar, 2005). This involved subtracting pre-ratings from post-ratings for each of the conditions and conducting the core statistical analyses with the resulting difference ratings.

To examine if intention knowledge had an effect on product appreciation, absolute values of the product-appreciation difference ratings were submitted to an independent-samples *t*-test. The test revealed a significant difference in the ratings between the knowledge ($M = .80$, $SD = .81$) and the no-knowledge ($M = .48$, $SD = .54$) conditions; $t(777.85) = -7.06$, $p < .001$. This indicates that intention knowledge did have an effect on product appreciation. The effect size for this analysis ($d = .47$) was found to exceed Cohen's (1998) convention for a small effect ($d = .20$).

To learn if the effect was positive or negative, relative values of the product appreciation difference ratings were submitted to another independent-samples *t*-test. This test revealed that the ratings in the knowledge condition ($M = .21$, $SD = 1.12$) were significantly higher than the ratings in the no-knowledge condition ($M = -.11$, $SD = .71$); $t(758.57) = -5.17$, $p < .001$. Thus, intention knowledge had an overall positive effect on product appreciation. The effect size for this analysis ($d = .34$) was also found to exceed Cohen's (1998) convention for a small effect ($d = .20$).

With the aim of examining the distribution of the effect across the 15 products, we averaged the difference ratings obtained per product in each condition and subsequently subtracted the average difference ratings in the no-knowledge condition from those in the knowledge condition. In this way, we obtained a measure of the effect that intention knowledge had on the appreciation of each of the products. Figure 8 illustrates how the effect varied across products, from larger to smaller. It also shows that the effect was negative for only two products (A and E).

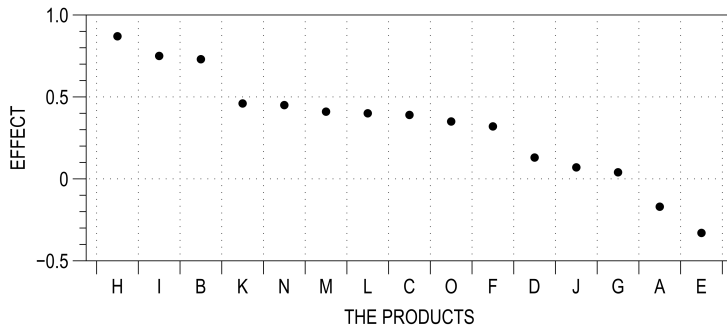


Figure 8. Effect of intention knowledge on product appreciation (Study 1).

In addition, a simple regression analysis was performed with ratings in the knowledge condition to examine if pre-ratings predicted difference ratings, i.e., if the extent to which products were appreciated when just looking at their images predicted the extent to which their appreciation was affected by intention knowledge. A preliminary paired-samples *t*-test conducted for the no-knowledge condition revealed a significant difference between pre-ratings and post-ratings. We therefore corrected the difference ratings of the knowledge condition with the use of average difference ratings obtained per product in the no-knowledge condition (ratings from the no-knowledge condition were only used as a corrective to the ratings from the knowledge condition; they were not used directly in the regression analysis). The analysis revealed that the pre-ratings were a significant predictor of the (corrected) difference ratings ($\beta = -.50, p < .001$); $R^2 = .25, F(1, 448) = 147.29, p < .001$. The lower the pre-ratings were, the more product appreciation increased.

DISCUSSION

In support of our prediction, Study 1 provided experimental evidence that intention knowledge has an effect on product appreciation. It further revealed that this effect was positive, in line with studies in which knowledge about a literary or artistic work enhanced the perception of the work in terms of comprehension (e.g., Leder et al., 2006; Pfaff & Gibbs, 1997) and meaningfulness (e.g., Gibbs et al., 1991; Russell, 2003), particularly when the work was relatively difficult to interpret. The increase in product appreciation might be understood along these lines; its distribution across the products might be explained not only in

relation to how much the products were appreciated by just looking at their images, as the regression analysis showed, but also in relation to how difficult they were to interpret by just looking at their images. Take, for instance, products B and G, which were respectively the subjects of relatively large and small increases in appreciation (see Figure 8). If the image of product B was more difficult to interpret than that of product G, the appreciation of product B could increase more than that of product G as a result of intention knowledge.

The increase in product appreciation might also be explained by a general positive evaluation of the intentions as such, or by a general positive evaluation of the products as means to fulfill the intentions. Since the former evaluation is easier to make than the latter, as it requires evaluating *what* intention a product fulfills and not *how* the product fulfills that intention, the increase in product appreciation could most likely be explained by it. This would imply that the participants appreciated the intentions and extended this appreciation to the products, without examining if or how the products could fulfill those intentions. Specht (2010) provides evidence of a similar process. He found that the same artist's statement increased the interestingness and liking of the artwork with which it was paired, regardless of which artwork this was. We mentioned that the intentions used as stimuli included the aim of eliciting certain experiences, attitudes, and behaviors from people. The increase in product appreciation might therefore be explained by an overall positive judgment of these intended experiences, attitudes, and behaviors. The effect distribution across the products could also be interpreted in these terms. Experiences, attitudes, and behaviors associated with social integration (intention B) might have been judged more positively than those associated with the predictability of everyday life (intention G). This would explain why the appreciation of product B increased more than the appreciation of product G. To explore these possible ways in which intention knowledge influences product appreciation, we conducted an interview study using a subset of the stimuli from Study 1.

STUDY 2

METHOD

Participants. Thirty-three students in Industrial Design Engineering from Delft University of Technology took part in this study voluntarily. There were 22 males and 11 females, with an average age of 23.80 years ($SD = 1.73$). None of the participants had been involved in Study 1.

Design. Each participant was interviewed individually using an approach that included both closed and open questions. Closed questions were used to collect data that would permit quantitative analysis and could therefore be compared with data collected in Study 1. Open questions were used to explore the ways in which intention knowledge affects product appreciation. We adopted a semi-structured approach (see Breakwell, 2006), which provided the opportunity to explore unanticipated themes by asking questions that were driven by the participants' responses to the stimuli (see Törrönen, 2002). When a participant brought up an unexpected and potentially relevant theme, the interviewer would explore this theme by asking unscripted, follow-up questions. As such, although the overall structure of the interviews was consistent across all the participants, there was also the flexibility to pursue and clarify responses that were unique to individual participants.

Materials. This study reused the stimulus materials identified B, C, and G in Table 1. This selection was made on the basis of three criteria. Firstly, Study 2 aimed at explaining the general finding of Study 1, i.e., a positive effect of intention knowledge on product appreciation, which was recorded for all cases except for A and E (see Figure 8). Secondly, products B, C, and G varied in the degree to which their appreciation ratings increased after intention knowledge was provided: for B, the increase was relatively large; for C, medium; and for G, small (see Figure 8). Thirdly, in comparison to other products for which appreciation increased to similar extents, they were better represented by the images used as stimuli, partly because they were physical and static rather than virtual or dynamic, and partly because they had been built and photographed as prototypes rather than only rendered in software.

Procedure. The 33 interviews were conducted in a well-lit, private meeting room in the Faculty of Industrial Design Engineering at Delft University of Technology. After being taken through a standard procedure to establish their informed consent, the participants were shown one of the products and asked (Q1) “do you like or dislike this product?” After answering, they were provided with the corresponding intention. Once they had read it, they were asked (Q2) “does this [intention] change how much you like this product: yes or no?” If they answered yes, they were asked (Q3) “does it [the intention] make you like the product less or more?” After answering, they were asked (Q4) “why?” Finally, they were confronted with the question (Q5) “what do you think of this product as a means to achieve this [intention]?” This last question was included to prompt the evaluation of the product as a means, a theme that we did not expect to emerge automatically from Q4. Unscripted questions were asked when unanticipated themes emerged. This procedure was repeated for each of the three products, the presentation order being counterbalanced across participants to avoid order effects. The average duration of the interviews was 27 minutes. The interviews were audio-recorded and transcribed verbatim.

RESULTS

In total, 248 answers to the closed questions were recorded: 99 (3 products times 33 participants) for Q1, 99 (3 products times 33 participants) for Q2, and 50 (cases in which Q2 was answered affirmatively) for Q3. These answers were coded in a binary manner: *like* and *dislike* for Q1, *yes* and *no* for Q2, and *more* and *less* for Q3. The results, as presented in Table 2, were consistent with those of Study 1. Product appreciation was high to begin with and increased with intention knowledge. Furthermore, appreciation was initially very similar between the products, but increased the most for B and the least for G.

The transcripts of the open questions Q4 and Q5 were reviewed iteratively and submitted to thematic analysis (see Braun & Clarke, 2006). This analysis was conducted following a general inductive approach (see Thomas, 2006), with less interest in the prevalence of responses and more interest in the relevance of those responses to the research question of how intention knowledge influences product appreciation.

The following themes were identified: (a) *perception of the product*, (b) *evaluation of the intention*, and (c) *evaluation of the product as a means to fulfill the intention*. The first and second themes were derived from answers to Q4, while the third was mainly derived from answers to Q5. These three themes were used to structure the literature review presented earlier, but they are not explicitly identifiable in the literature itself.

Table 2. Results obtained from the closed questions in Study 2.

Question	Prevalent answer	Counts per product (prevalent answer/total)			Total counts
		B	C	G	
(Q1) Do you like or dislike this product?	<i>like</i>	30/33	30/33	29/33	89/99
(Q2) Does this [intention] change how much you like this product: yes or no?	<i>yes</i>	21/33	16/33	13/33	50/99
(Q3) Does it [the intention] make you like the product less or more?	<i>more</i>	18/21	13/16	6/13	37/50

In the following analysis, we describe the themes with reference to the participants' statements. During the interviews, the participants made gestures towards the stimuli and used pronouns such as *it*, *this*, and *that* to refer to them. These partial utterances left an incomplete audio record and transcript. To address this, we substitute the relevant gestures and pronouns in the statements quoted according to the meaning intended by the participants. These and other editorial substitutions or additions appear within square brackets. At the end of each quotation, the statements are identified with a combination of a number and a letter provided within parentheses. Numbers from 1 to 33 identify the participants who are speaking. Letters B, C, and G are used to identify the stimulus materials to which they are referring in each of their statements. For instance, (17B) identifies an utterance by participant 17 about materials B. Whether the participant is referring to the product or the intention is evident in the quotation itself.

(a) *Perception of the product*. The participants often explained increased product appreciation in terms of the products becoming more

interesting, comprehensible, and meaningful. This indicates that intention knowledge influences product appreciation because it affects the perception of a product in various ways.

Increased interestingness, which participants reported for product B only, was described in statements such as: “that’s really interesting, I didn’t see that at first [...] I think I like [the product] more because it has an element of surprise that I wasn’t expecting [...] [the intention] is opening my mind to something new” (17B); “[the product] is more interesting now [...] this [intention] makes me look at it in a different way, so I want to look at it more” (19B). Intention knowledge triggered the participants’ interest because it revealed something unforeseen about the product.

Increased comprehension, which participants reported more frequently for product B and less frequently for products C and G, was expressed in utterances like: “you appreciate [the product] more because you know what it’s for” (24B); “[the product] makes more sense to me” (5C); “first I thought [the product] was just a nice shelf and now, you understand it better” (13G). Intention knowledge improved the participants’ comprehension of the products insofar as it revealed their purpose. This is in line with the theory that people’s understanding of artifacts is based on an understanding of the intention motivating the artifact’s creation, since this intention explains the artifact’s objective features.

Increased meaningfulness, which participants reported for all three products, was described in statements such as: “[the product] really has a deeper meaning behind [it]” (18B); “[the intention] gives [the product] a more positive meaning” (6C); “[the product] seems to have a hidden significance now” (23G). It seems that intention knowledge generally enhanced the meanings that the participants had attributed to the products when just looking at their images. At times, however, when product appreciation decreased, the participants explained this decrease in terms of a change in the meaning of the products. For instance, one participant explained:

[The intention] kind of takes away the liberty of this chaotic shape, which is beautiful in itself [...] It’s like a piece of art: if you let it speak for itself, whoever can see it can attribute [their] own meaning, but then if you get another meaning

that you weren't expecting or that you didn't want, it kinds of ruins [the piece]... It takes something away from it. (17G.)

This statement suggests that intention knowledge can decrease product appreciation when it reveals something about the product that contradicts people's initial perception of it, including their expectation of what the product should be and what it should do.

(b) *Evaluation of the intention.* The participants frequently explained increased product appreciation in terms of a positive evaluation of the intentions. They generally judged intention B and especially C to be good, as revealed in the utterances: “[the intention] is a good cause” (15B); “the product supports a good cause [intention]” (24C); “I really like the good intentions behind [the product]” (14C). In these statements, the term good has a moral connotation; it indicates that the experiences, attitudes, and behaviors suggested by the intentions were judged to be morally virtuous. By extension, the intentions were judged to be morally virtuous too. Some other statements further revealed that this judgment of the intentions evoked happiness:

The word you'd put with such a function [the intention] would be *beautiful* or *good* because it elicits some feeling... It's connected with something you want to cherish or how you want to help people, and those are all things that make you feel happy. I'd say helping people is a very beautiful thing, so in such a way it would be a very beautiful product. (10C.)

By contrast, when explaining decreased product appreciation, the participants referred to intention G in the following way: “I kind of dislike the purpose [intention] because I don't like to be that predictable” (14G); “I don't understand why you want to have this aim [intention]” (2G); “I'm not sure if that [intention] is a good thing” (18G). In these cases, the experiences, attitudes, and behaviors suggested by the intention were questioned and judged negatively. Consequently, the intention was also evaluated negatively.

The participants projected their evaluation of the intention onto the product as if they perceived the intention to be the defining essence of the product. If the intention was judged positively, the product was also judged positively, as in the following statements: “I'd say [the product is] also beautiful because the thought [the intention] behind it is beautiful, what you want to achieve with it” (2B); “I like [the product] more

because I really like the idea [the intention]” (11C). If the intention was judged negatively, the product was also judged negatively, as in the statement: “if [the product] has an aim [intention] like this, I don’t like it [...] I don’t like the aim” (32G). This simple correspondence between the evaluation of the intention and the evaluation of the product characterizes this second theme and distinguishes it from the third, which is more complex and therefore requires lengthier explanation.

(c) *Evaluation of the product as a means to fulfill the intention.* When explaining increased product appreciation, the participants evaluated the products on how well they realized the intentions from which they had resulted. The participants often used the term *good* to characterize all three products in this sense. For instance, they stated: “I think [the product] achieves [the intention] very good” (11B); “I think [the product] is a good means” (3C); “[the product] is a good design to achieve this goal” (8G). In these cases, *good* did not necessarily imply that the product or the intention was judged to be virtuous, but rather that the product had the capacity to fulfill the intention, i.e., to work. This capacity was frequently mentioned by the participants in utterances like “this [product] works” (7C) and “I think [the product] works really well” (3G).

The participants further explained their increased product appreciation by saying that the products would work efficiently. This is evident in statements such as: “I think efficiency can be beautiful [...] an efficient use of material is aesthetically pleasing [because] you’re sure that [the product] is optimized” (15C); “efficiency can be beautiful [...] it gives you a certain feeling of satisfaction” (33C). These comments on efficiency suggest that one of the key principles governing the evaluation of the product as a means is, as anticipated, MEMM. Other comments, such as “[the product is] innovative” (32B) and “[the product is] a new, fresh, funny way of dealing with a known problem” (24C) revealed that the participants’ increased product appreciation was also based on a judgment of the products as novel or unusual means to realize the intentions behind them.

The participants revealed that the evaluation of the product as a means was independent of the evaluation of the intention as such. Some of

them judged the product positively even when they judged the intention negatively, as the following statements show: “I like the product, but not especially the goal, [still] I think [the product] is a good way of doing it [fulfilling the intention]” (4G); “the aim itself is not one that I specifically like, but more the idea that [the product] is designed for this goal, it’s more that I like the link between the design [the product] and the idea [the intention]” (31G). In cases where product appreciation decreased, the participants made clear that this decrease did not necessarily involve a negative evaluation of the intention. For instance, some uttered: “I dislike [the product] a bit more now [...] I don’t see this aim being achieved [...] I think it’s a good idea [intention], but this [product] won’t really work” (28C); “if this is the goal, I would dislike [the product] a bit more because I don’t see this purpose translated [...] the aim [the intention] is good, the aim is purposeful, but the product doesn’t fulfill the aim” (15C). In each case, the participants accepted the intentions as goals and then assessed the products as the means to achieve those goals.

The participants revealed that the evaluation of the product as a means was relative, but not just because it involved an assessment of the product in relation to the intention to be fulfilled. On the one hand, they further assessed the product in relation to alternative known or imagined products (or means) by which the same (or a similar) intention could presumably be fulfilled. For example, they said: “I think there are multiple ways to do that [fulfill the intention], this [product] is one of them” (20C); “there must be a better way [to fulfill the intention]” (2G); “this is a nice topic [intention], but I would implement it in a different way” (17G). On the other hand, they further assessed the product in relation to alternative known or imagined intentions that could presumably be fulfilled by the same (or a similar) product (or means). For instance, although product C is not an ordinary trash bag, one of the participants categorized it as such and thought of an intention relevant to products of that category, i.e., recycling, which could be contrasted with the original designer’s intention, i.e., altruism. This participant said:

I would imagine that this [product] would cost more [than an ordinary trash bag]. I would imagine that this would be more eco-unfriendly, and I think that the big aim or the big thing you aim for with trash bags [the most relevant intention is] that you recycle as good as possible [...] For the goal as a trash bag, [the product] doesn’t correspond. (15C)

The previous statements indicate that the evaluation of the product as a means is grounded in a set of perceived alternatives for both the product and the intention.

DISCUSSION

Through interview data, Study 2 revealed that intention knowledge affects product appreciation in at least three ways. It influences the perception of the product, enables an evaluation of the intention, and enables an evaluation of the product as a means to fulfill the intention. Study 2 also explained the reason why the effect of intention knowledge on product appreciation was found to be positive in Study 1. In general, intention knowledge enhanced the participants' perception of the products as it made them perceive the products to be more interesting, comprehensible, and meaningful. It also led them to make positive judgments of both the intentions as such and the products as means to realize these intentions. Since products B, C, and G were all judged to be good means, the differences in the extent to which appreciation increased across them can be explained by how much their perception was enhanced and how valuable the corresponding intentions were found to be. The perception of product B was enhanced the most, probably because the image of this product was the hardest to interpret with no intention knowledge. Intention G was the only one judged negatively as the participants did not embrace or support the experiences, attitudes, and behaviors associated with it. Although the stimulus materials for this study were chosen attending to the overall positive effect identified in Study 1, the appreciation of products B, C, and G did not always increase. In this sense, Study 2 further clarified why intention knowledge does not necessarily affect product appreciation positively (see products A and E in Figure 8). Gaining knowledge of design intentions might diminish the perception of a product. It might even make the product less comprehensible. Alternatively, the intention itself might be evaluated negatively or knowledge of that intention might permit a negative evaluation of the product as a means to achieve it.

We have examined how intention knowledge affects product appreciation considered as a whole, but the results of Study 2 suggest

that this knowledge can lead to distinct kinds of appreciation or judgments of liking. Firstly, an enhanced perception of the product, which entails a better understanding of what the product is meant to be and do, seems to lead to a cognitive appreciation of it. This kind of appreciation emerges from being able to make more sense of the product, perhaps by categorizing it taking into account the designer's intended purpose. In a similar way, Russell (2003) has acknowledged that part of the pleasure attained from looking at a painting emerges from interpreting it successfully by picking up the artist's message. Secondly, an evaluation of the intention as being morally virtuous seems to lead to an appreciation of the value that the product embodies, i.e., to a moral appreciation of the product. Jordan (2000) has argued that people can attain pleasure from perceiving products in this way, as embodiments of their values; for example, from perceiving a product made from biodegradable materials as an expression of environmentalism. Thirdly, a positive evaluation of the product as a means seems to lead to an appreciation of the product that can be considered aesthetic as this kind of appreciation is linked to a perception of qualities that are known to cause aesthetic pleasure, i.e., aptitude or the capacity to perform a task (Parsons & Carlson, 2008; Tatarkiewicz, 1980), efficiency or MEMM (Hekkert, 2006; Hekkert & Leder, 2008), and novelty (Berlyne, 1971; Hekkert et al., 2003). Even though the appropriateness of the labels *cognitive*, *moral*, and *aesthetic* could be disputed, these labels serve to emphasize the very different ways in which intention knowledge affects product appreciation.

DISCUSSION OF CHAPTER 2

Research in the design field had not empirically addressed the questions of whether intention knowledge affects product appreciation and, if so, how. We addressed these questions by conducting two studies using a mixed-methods approach. Study 1 provided experimental evidence that intention knowledge has an effect on product appreciation. Study 2 explained this effect with interview data showing that intention knowledge affects product appreciation in three ways. It influences the perception of the product, enables an evaluation of the intention, and also an evaluation of the product as a means to fulfill the intention.

These findings provide an understanding of the role that intention knowledge plays in product appreciation and this understanding can in turn open new perspectives on design practice.

Our findings suggest that designers, marketers, and others involved in product development should consider what design intentions are to be communicated and what media might best be used for this communication, whether that is the products themselves, advertisements or other channels. Organizations should not take for granted that people engaging with their products perceive their intentions, but should instead evaluate whether those people can infer those intentions directly from the products' properties or interpret them successfully when explicit sources of information are available. Furthermore, they should assess whether knowledge of their intentions supports or jeopardizes the comprehension of their products, whether their intentions are in line with people's personal or social values, and whether their products can be aesthetically appreciated as means to realize these intentions, e.g., for their efficiency. This last issue questions the traditional assumption that aesthetics only concerns the visual properties of products, rather than the way these properties, and even those that are not visual, relate to perceived intentions.

The findings from our studies should be interpreted with respect to the decisions we made concerning the operationalization of variables, the use of stimulus materials and the selection of participants. Since intention knowledge gained through inference would be difficult to control experimentally, we focused on intention knowledge that resulted from explicit statements of intent. This improves the consistency and internal validity of our findings and further enhances the ecological validity of the results when considering contexts in which intention knowledge is provided by adverts or other media. However, we cannot make specific claims about the effect that inferential knowledge has on product appreciation, particularly when this knowledge contradicts that gained through explicit sources of information. In addition, we cannot make very specific claims about the components of product appreciation because we treated this as an overall appreciation. We would like to emphasize that, although some liking judgments are very broad or general, others could be interpreted as more specifically cognitive, moral

or aesthetic. With regards to stimuli, we used products and intentions with certain qualities and we represented them with images and texts. Our participants were, for example, unable to assess the true effectiveness of the products; they simply made a judgment of that effectiveness on the basis of the product images. The extent to which our findings were influenced by factors such as these is unknown. As for the participants, we selected design students because we were confident that they would be able to consider and describe products in intentional terms. Whether our findings also hold for lay people's evaluations of products requires further study. Nevertheless, by examining an articulate and design-literate group in the first instance, we were able to derive and explore themes relevant to product appraisals and those themes can now be used to structure or analyze studies with other groups.

Considering the specific decisions upon which our studies were based, a number of studies could be conducted to challenge or extend our findings. These studies could adopt a variety of methodological approaches, including experimental, observational, and introspective methods. Such studies should take into account the sources of intention knowledge, the different aspects of product experience that can be affected by such knowledge, the perceived qualities as well as the representations of both products and intentions used as stimuli, the level of design literacy of the participants, and the expertise they have in specific product categories. These studies could address a variety of research questions, relevant to various areas of design research and practice. For example, a possible question for social design is: does knowledge of the intentions behind products that are designed to influence behavior make those products more or less likely to trigger the intended response? A question for design aesthetics might be: how does the principle of maximum effect for minimum means explain the aesthetic appreciation of products where the product is the means and the designer's intention is the (intended) effect? By addressing such questions, we will learn more about how people perceive and evaluate products when they recognize that those products are not just objects that exhibit certain properties, but artifacts that have been intentionally designed.

CHAPTER 3

Understanding MEMM⁷

The aesthetic judgment of an artifact is typically interpreted as an evaluation of the artifact's sensory properties. In this sense, the light switch shown in Figure 9 can be aesthetically appreciated for its color contrast; the drinking cups in Figure 10 for their smooth texture; the wall clock in Figure 11 for its soft surface; and the water bottle in Figure 12 for its visual unity. However, these products can also be appreciated, and still aesthetically, because of an understanding of the relationship between the product itself and its purpose (or function, or effect). Existing design theory does not provide the concepts required for describing this aspect of aesthetic appreciation and so cannot fully explain what people mean when they say a product is beautiful. In this chapter, we develop an understanding of the role of product effects in design aesthetics.

Contemporary literature in philosophical aesthetics acknowledges that the aesthetic appreciation of an artifact can be influenced by knowledge of the artifact's purpose (Forsey, 2013; Parsons & Carlson, 2008; Saito, 2007). This idea follows a strand of thought that can be traced back to

⁷ This chapter is based on a co-authored article (Da Silva et al., 2016). To keep the style consistent in this dissertation, the article's footnotes have been turned into in-text citations whenever possible.



Figure 9. *Aware Puzzle Switch* (2007) by Looe Broms and Karin Ehrmberger (The Aware Project, The Interactive Institute, Sweden).



Figure 10. *Social Cups II* (2005) by Kristina Niedderer (The Argentium Project, made with support from The Arts Council England).



Figure 11. *Doing Time* (2013) by Sara Ferrari (made in collaboration with long-sentenced inmates of the Rebibbia prison, Italy).



Figure 12. *Dopper* (2010) by Rinke van Remortel (based on an idea by Merijn Everaarts, founder of Dopper, The Netherlands).

the Enlightenment and further back to Antiquity—a strand that relates beauty to an artifact’s aptitude to perform a task (for a historical overview, see Tatarkiewicz, 1980; about 18th-century aesthetics and Kant’s notion of dependent beauty, see Guyer, 2002; Mallaband, 2002; Wicks, 1997). From this perspective, the products presented in Figures 9 through 12 can be aesthetically appreciated not just for their sensory properties, but also for the effects that they are intended to achieve through these properties.⁸ The light switch encourages energy

⁸ Products can be appreciated for having been designed as means to achieve certain effects—whether these effects are realized in practice or just intended. In many circumstances, actual effects might be taken as an indication of intended effects, or intended effects might be all that is known if the actual effects are not observable (e.g., because of time delays). As such, we do not distinguish here between actual and intended effects. In any case, the aesthetic appreciation of products, as we discuss it, depends on products’ effects as perceived by people in any possible way, including first-

conservation by showing a disrupted visual pattern when the light is on, thus stimulating people's innate need for order, which makes them rearrange the pattern and so turn the light off (Broms, 2011). The drinking cups trigger human interaction because they are unstable unless rearranged all together, thus requiring people to collaborate with each other if they are to put the cups down without spillage (Niedderer, 2007). The wall clock encourages prison inmates to express themselves creatively by providing them with "a skin to tattoo" (i.e., leather to draw on); in addition, it stimulates those who are not in jail to better appreciate time by prompting reflection on life behind bars (Ferrari, 2013). The water bottle reduces plastic waste by being robust and cleanable, thus permitting reuse and encouraging people to avoid buying bottled drinks; it also promotes drinking of tap water by having a large opening and providing an in-built cup—features that facilitate refilling ("Dopper: The bottle is the message", 2010). As these descriptions suggest, all these products can be perceived to be beautiful in light of their effects.

Although an artifact can be appreciated for its effect, a difference does exist between appreciating an artifact because it achieves a given effect and appreciating it because of *the way* it achieves that effect. A candle can be appreciated because it lights up a room, regardless of whether it is simply shaped or intricately carved—regardless of its particular sensory properties. But it can also be appreciated because of the way it lights up the room, which cannot be dissociated from the way it is shaped, from the qualities that it presents to the senses. As Faraday (2011) observed, a candle can only light up a room in a steady manner if it is simply shaped. He saw great beauty in an ordinary candle for this reason, arguing that beauty does not necessarily lie in the best *looking* things, but in the best *acting* ones. The appreciation of the way in which an artifact achieves an

hand experience and knowledge of designers' intentions. For the four main product examples in this chapter, the effects described were intended by the designers (as the coming four in-text citations indicate). In the absence of direct statements by the designers, people might infer the designers' intended effects directly from the products (see Crilly, 2011a; 2011b).

effect necessarily involves a sensory appreciation of the artifact. This sensory basis for the appreciation is what makes it aesthetic.⁹

Many design principles explain aesthetic appreciation in the traditional sense (e.g., symmetry, the golden ratio, the rule of thirds), but no such set of principles has been offered to account for the judgment of the way a product achieves a certain effect. In searching for a basis from which such a set might be developed, we first turn to literature in design aesthetics (Hekkert, 2006; Hekkert & Leder, 2008), which points at the principle of maximum effect for minimum means. This principle is also referred to as *economy*, *efficiency*, and *Occam's razor* in product design and design methodology handbooks (Lidwell et al., 2010; Macnab, 2012; Zelanski & Fisher, 1984). These sources, however, do not provide a deep examination of the principle; they only indicate that a product is aesthetically appreciated when it is perceived to be an efficient solution to a given problem. Meanwhile, a body of related literature suggests that MEMM governs people's aesthetic appreciation of a wide range of things, including line drawings, literary metaphors, logical arguments, chess moves, architectural works, tennis serves, science experiments, and mathematical demonstrations. Just like products, all these things can be understood as artifacts because they are made with a certain effect in mind or are intended to perform in a certain way.¹⁰

⁹ Forsey (2013), Parsons & Carlson (2008), and Saito (2007) stress that the way in which an artifact performs a function can be aesthetically appreciated. Taking a knife as an example, Saito explains: "The appreciation here is not simply directed toward the fact that the knife functions well; it rather concerns the way in which all its sensuous aspects converge and work together to facilitate the ease of use" (p. 27). We distinguish the attitude underlying aesthetic appreciation from an instrumental one. As Stolnitz (1969) indicates, an instrumental attitude leads people to perceive artifacts "in terms of their usefulness for promoting or hindering [their] purposes", whereas an aesthetic one allows for a disinterested contemplation (pp. 18-19; see also Goldman, 2001). With an instrumental attitude, people appreciate a product for achieving an effect that is in line with their interests, as discussed by Gutman (1982). In contrast, with an aesthetic attitude, people appreciate a product independently of their own interests, for how it achieves a given effect.

¹⁰ This broad notion of artifact is based on the definitions offered by Hilpinen (1992) and Dipert (1993). Hilpinen describes artifacts as "physical objects which have been manufactured for a certain purpose or intentionally modified for a certain purpose" (p. 58). Dipert further argues that artifacts can include "certain types of intentional events (e.g., utterances and performances)" (p. 11).

Artifacts are aesthetically praised in MEMM terms when they achieve a lot with a little—“the most” with “the least”. Drawings are found to be aesthetically pleasing when a limited number of lines allows for many non-contradictory interpretations (Boselie & Leeuwenberg, 1985). Metaphors are aesthetically pleasing because they economically relate two apparently dissimilar concepts (Ramachandran & Hirstein, 1999), thus also allowing for multiple non-exclusory readings (Kaplan & Kris, 1984). Arguments are thought to be elegant when they provide a comprehensive explanation briefly and without any redundancy (Walsh, 1979; see also Orrell, 2012). Likewise, a checkmate is considered to be beautiful when it is achieved without capturing a piece (Margulies, 1977). Beauty is perceived in a simple building that fulfills an important social function or many such functions (Sullivan, 1979), just as it is perceived in the economical movement by which a tennis player serves a clean ace (Best, 1974). Eratosthenes’s measurement of the circumference of the Earth by means of a tiny shadow is found to be aesthetically pleasing (Crease, 2004; see also Johnson, 2009), as is Euclid’s demonstration of the infinitude of prime numbers by means of a short mathematical proof (Hardy, 1967). All these examples suggest that MEMM has a universal capacity to explain the aesthetic appeal of artifacts.

Any artifact can be understood as a designed product. Whether a mathematical proof or a light switch, an artifact is intentionally designed as a *means* to achieve a certain *effect* (e.g., demonstrating the infinitude of primes or promoting energy conservation). The aesthetic appreciation of an artifact can therefore involve the appreciation of a means–effect relationship. MEMM indicates that this relationship is aesthetically pleasing when it is perceived to be “minimum–maximum”, where minimum is the magnitude of the means and maximum is the magnitude of the effect. These magnitudes can be interpreted in different ways. For instance, minimum can be interpreted as *small* (e.g., Eratosthenes’s shadow) or *few* (e.g., Euclid’s lines of math), whereas maximum can be interpreted as *big* (e.g., the size of the Earth) or *many* (e.g., the prime numbers). *Small* or *few* and *big* or *many* can only be considered *minimum* (the least) and *maximum* (the most) in relation to other options. Thus, when we are not making relative claims, we use the terms *minimal* and *maximal* to be grammatically correct.

We must acknowledge that a means–effect relationship can be aesthetically appreciated for reasons other than MEMM. Some sources indicate that artifacts are also appreciated for their unexpectedness and inevitability. For instance, Poe (1846) believes that there is an element of surprise in the perfect rhythm, while Goethe admires the Strasbourg Cathedral for its structural necessity (see Bernstein, 1999). Together, these qualities have been used to describe the beauty of architecture (see Parsons & Carlson, 2008) and mathematics (Hardy, 1967).¹¹ But in contrast to unexpectedness and inevitability, MEMM provides the grounds to examine the aesthetic judgment of an artifact as that of a means–effect relationship—a relationship that can be aesthetically appreciated for being efficient (i.e., minimum–maximum), but also unexpected or inevitable, among other possible qualities. Hence, MEMM not only accounts for the aesthetic appeal of many different artifacts, but also offers a basis for identifying the different factors that explain such appeal.

Having introduced the concept of MEMM and discussed its wide applicability, we proceed to explore the principle in the context of design aesthetics. We first explain how the means–effect relationship can be established between a product and its effect or purpose, and how the product and the effect can be perceived to be minimal and maximal. Next, we explain how the appreciation of the relationship between a given product or means and a given effect depends on a set of assumed alternatives for both the means and the effect. Finally, we provide some directions for future research into design aesthetics.

THE BASICS OF THE MEMM JUDGMENT

MEMM indicates that the aesthetic judgment of a product is a judgment not just of the product itself, but of the relationship between the product and the effect that it has (this effect can be of any kind, as suggested by the categorizations provided by Crilly et al., 2009; Fokkinga et al., 2014). If a certain effect is desired in the world, then a product can be designed

¹¹ Furthermore, unexpectedness characterizes the appeal of dance moves (as suggested by Boselie & Leeuwenberg, 1985), and inevitability that of musical compositions (Howard, 1923), science experiments (Crease, 2004; Johnson, 2009), and scientific theories (Orrell, 2012).

as the means by which that effect is realized. Designers exploit various resources to achieve the effects they want. The light switch we have taken as an example exhibits a particular sensory property (showing a disrupted pattern when the light is on), exploits a particular working principle (stimulating the inherent human need for order), and elicits a particular interaction from people (making them turn off the light intuitively) to ultimately encourage the conservation of energy (the final effect that we are considering). All these resources (the property, the principle, and the interaction) describe the product as a means.

A product can be perceived to be a minimal means in different senses. In the sense of *few* (or even as *one*), it can be perceived to be minimal if it has few distinct sensory properties (e.g., colors), if it functions on the basis of a single principle or a mechanism comprising a few parts, or if it elicits an interaction requiring just one action or a few steps. In these cases, *minimal* stands for uncomplicated or simple. In the sense of *small*, a product can be perceived to be minimal if its properties (e.g., materials) indicate a small investment of resources in its making, if its functioning requires a small investment of resources (e.g., electricity), or if it elicits an interaction requiring little mental or physical effort from people. In these cases, *minimal* stands for inexpensive or undemanding.

The perception of just one salient aspect of a product as being minimal can suffice for the product to be judged minimal overall. For example, we interpret the light switch to be minimal fundamentally because it stimulates people's innate need for order and therefore makes them turn off the light intuitively, without requiring conscious mental effort. The drinking cups manage to stimulate human interaction without redundancy—without adding anything extra to a social occasion, which usually requires some sort of cup for drinking anyway. With only its simple “tattooed” face, the wall clock bridges the gap between two seemingly distant groups of people. The water bottle makes cleaning it, refilling it, and drinking from it easy, partly because it has only a few components that are simply shaped.

To explain how an effect can be perceived to be maximal, we must recognize that products can have more local *proximal* effects and more global *distal* effects, where the distal effects might result from the

proximal ones (this distinction is based on Crilly, 2013). The proximal effect of a product is closely related to the way the product is categorized as belonging to a certain kind. For example, people generally assume that turning a light on and off is a standard attribute of products belonging to the kind *light switch*. The more distal effect of a product satisfies a less immediate goal, which is not so closely related to the way the product is typically categorized. In contrast to ordinary light switches, the switch we use as an example has an effect beyond operating the light—it encourages energy conservation. Also, a product can have several effects at any of the levels at which it is influential (however proximal or distal those effects might be). For instance, the water bottle has two effects that are more distal than simply transporting water and that might be considered at a similar level: reducing plastic waste and promoting tap water drinking. In short, products might have different levels of effect and different effects at any level (a similar idea underlies the analysis of artifact aesthetics presented by De Clercq, 2005). Recognizing this multiplicity helps to explain what can be perceived as a maximal effect.

An effect can be perceived to be maximal in different senses. In the sense of *many*, a product can be perceived to have a maximal effect if it has more than one effect at a similar level.¹² The wall clock, like the water bottle, can be perceived to have a maximal effect because it has at least two distal effects: stimulating creativity among prison inmates, and stimulating time appreciation among those who are free from incarceration. In the sense of *big*, a product can be perceived to have a maximal effect simply because it has a distal effect in addition to a proximal one. Just as the light switch does not only operate the light, so the drinking cups do not only contain drinks; they also trigger human interaction and can for that reason be perceived to have a maximal effect.

Although we have described means and effects separately, they are necessarily defined in relation to one another. A particular means is tacitly the means to achieve certain effect, and a particular effect is tacitly

¹² Although the expression *maximal effect* or *maximum effect* grammatically indicates a singular effect, we sometimes use it to refer to a set of effects that a product has at a similar level.

the effect achieved by certain means. Furthermore, within any seemingly simple means–effect relationship lies a chain of means and effects. Consider again the light switch, which allows us to establish a means–effect relationship between *showing a disrupted visual pattern when the light is on* (X), and *encouraging energy conservation* (Z). Note that *stimulating people’s innate need for order* (Y) can be inserted between X and Z. This insertion yields the chain X–Y–Z, in which X is a means to Y, Y is an effect of X and a means to Z, and Z is an effect of Y. Following this line of reasoning, intervening means or effects might be identified for any means–effect pair, resulting in an increasingly long chain of means and effects. MEMM, however, does not describe people’s aesthetic judgment in terms of such a chain. Instead, it focuses on any two of the chain’s elements that are identified (in relation to each other) as the means and the effect (e.g., X and Z, X and Y, or Y and Z). For this reason, we treat our examples in a rather simplified manner, focusing on a particular means–effect pair for analysis while acknowledging that, for any given product, other means–effect pairs also can be identified.

What constitutes minimal and maximal is assessed by establishing a number of relationships, the most obvious of which is the one between a particular means and a particular effect. A given means can be judged to be minimal in relation to a certain effect, and a given effect can be judged to be maximal in relation to a certain means. MEMM allows us to interpret the aesthetic appreciation of a product in this relational sense—that is, as an appreciation of a particular means–effect relationship where the means (product) is minimal and the (product’s) effect is maximal (see Figure 13). The products we use as examples can be judged minimal in relation to their effects, while these effects can be judged maximal in relation to the products. For instance, the drinking cups can be judged minimal in relation to triggering human interaction, while triggering human interaction can be judged maximal in relation to the cups. The wall clock can be judged minimal in relation to both stimulating creativity among prisoners and stimulating time appreciation among those who are free, while these effects can collectively be judged maximal in relation to the clock. Yet MEMM suggests that people’s aesthetic judgment involves an assessment of magnitudes more complex than this.

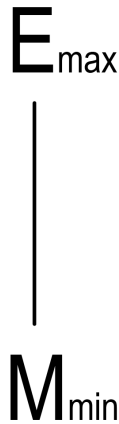


Figure 13. MEMM allows us to interpret the aesthetic appreciation of a product as an appreciation of a particular means-effect relationship, where the means (product) is minimal (Mmin) and the (product's) effect is maximal (Emax) in relation to each other.

THE COMPLEXITY OF THE MEMM JUDGMENT

We have been using the adjectives *minimal* and *maximal* rather than the superlatives suggested by the conventional statement of MEMM: *minimum* (the least) and *maximum* (the most). Grammatically, superlatives express the greatest possible degree of a quality, which is determined by a comparison. For example, if a room has the greatest amount of light in comparison to another (or several others), then it is the lightest. By invoking superlatives, MEMM suggests that the apparently simple judgment of a specific means–effect relationship involves making comparisons with some alternatives in relation to which that particular means and that particular effect can be judged to be *the* minimum and *the* maximum. These alternatives seem to be derived from people's categorizations of artifacts.

People are naturally inclined to make artifact categorizations based on the intentions that designers have to make things that realize certain effects,¹³ whether these effects are proximal (e.g., turning a light on and off) or distal (e.g., encouraging energy conservation). Categories are not stable; they develop with experience and imagination (see Lakoff, 1990).

¹³ The categorization of artifacts according to designers' intentions has been discussed by Barrett et al. (2008). The kind-based categorization has been examined by Bloom (1996), while the function-based categorization has been studied by Matan and Carey (2001).

As people gain knowledge of artifacts and enrich their mental repertoire of artifact possibilities, their categories change, and so *things that turn the light on and off* can eventually include some *things that encourage energy conservation*, and vice versa. Although unstable, these categories provide the grounds to aesthetically judge products in relation to their effects.¹⁴

Based on its proximal effect, our light switch can be compared to all known or imagined light switches (starting with those that simply turn the light on and off) and thus can be found to have the maximum effect. Based on its distal effect, it can be compared to all known or imagined things promoting the conservation of energy (including a media awareness program) and so can be found to be the minimum means to achieve such an effect. A means and an effect can thus be judged to be the minimum and the maximum in relation to a set of alternatives that people consider based on their knowledge of existing and possible artifacts.

A given means can be judged to be the minimum relative to other known or imagined means by which the same (or a similar) effect can be achieved. We mentioned that the light switch can be judged to be the minimum means to encourage energy conservation in comparison to a media awareness program. Analogously, the drinking cups can be judged to be the minimum means to trigger human interaction in comparison to a social networking website. The wall clock can be judged to be the minimum means to stimulate creativity among prisoners and appreciation of time among those who are free, in comparison to a handicrafts workshop where these groups of people get to interact meaningfully. The water bottle can be judged to be the minimum means to reduce plastic waste and promote tap water drinking, in comparison to a government's health policy. MEMM allows us to make the following prediction: For a given effect, if a number of means are assumed as alternatives, the relationship between that effect and what is judged to be the minimum means will be aesthetically preferred (see Figure 14).

¹⁴ Examining how products are judged in terms of alternatives that are based on different categorizations has already led to a better understanding of consumer choice (see Felcher, Malaviya, & McGill, 2001). We believe that this examination can also lead to a better understanding of aesthetic preference.

A given effect can be judged to be the maximum relative to other known or imagined effects that can be achieved through a means of the same (or a similar) kind. Encouraging energy conservation can be judged to be the maximum effect in comparison to operating the light, which might be the only notable effect of a light switch. Triggering human interaction can be similarly judged in comparison to containing drinks, which could be the only effect of a set of drinking cups. Altogether, stimulating creativity and an appreciation of time can be judged to be the maximum effect in comparison to either of these effects separately considered, as well as in relation to giving the time of day, which could be the only effect of a wall clock. Also, reducing plastic waste and promoting tap water drinking can be judged to be the maximum effect in comparison to either of these effects individually considered, as well as in relation to transporting water, which could be the only effect of a water bottle. MEMM allows us to make yet another prediction: For a given means, if a number of effects are assumed as alternatives, the relationship between that means and what is judged to be the maximum effect will be aesthetically preferred (see Figure 15).

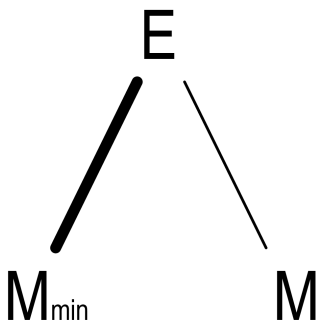


Figure 14. For a given effect, if a number of means (here we only represent two) are assumed as alternatives, the relationship between that effect and what is judged to be the minimum means (M_{\min}) will be aesthetically preferred.

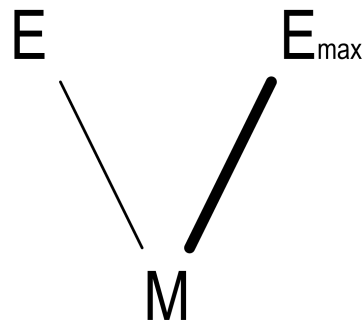


Figure 15. For a given means, if a number of effects (here we only represent two) are assumed as alternatives, the relationship between that means and what is judged to be the maximum effect (E_{\max}) will be aesthetically preferred.

MEMM ultimately suggests that the judgment of any given means–effect relationship is grounded in a set of alternatives assumed for both the means and the effect. Among all possible means–effect relationships established within this set, the one that is judged to be minimum–

maximum will be aesthetically preferred (see Figure 16). The principle thus implies that people’s aesthetic preference for a product emerges from a rather complex process, which involves not only relating the product to its effect, but also comparing means and effects that are assumed as alternatives based on artifact categorizations. We mentioned that these categorizations are developed through experience and imagination. As people gain knowledge of more and more artifacts, they become better able to recall or imagine a richer variety of alternative means and effects with which any given means and effect can be compared.

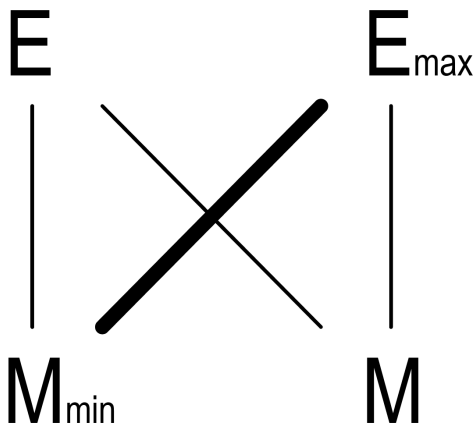


Figure 16. The judgment of any given means-effect relationship is grounded in a set of alternatives assumed for both the means and the effect. Among all possible means-effect relationships established within this set, the one that is judged to be minimum-maximum will be aesthetically preferred.

We related our light switch to an ordinary light switch (because of its proximal effect) and a media awareness program (because of its distal effect). In both cases, we offered arguments explaining why our switch would be aesthetically preferred. But a set of assumed alternatives could grow to include a switch that not only promotes energy conservation, but also teaches children about the importance of such conservation—for instance, a switch shaped like a ghost that reflects and affects human emotions by going from happy to angry as the light is kept on over time, and vice versa when the light is turned off (see Figure 17). Compared with this switch, which seems to have two distal effects rather than just one, our example could be perceived to have the minimum effect and therefore no longer be preferred.



Figure 17. *Tio* (2009) by Tim Holley.

Predicting aesthetic preference is more difficult when comparing our example with other light switches that seem to have no other distal effect than to promote energy conservation—for instance, a switch that turns off the light automatically when people leave the room, one that persuades people to turn off the light by serving as a useful clothes hanger only when the switch is in the off position (see Figure 18), or one that threatens to release a mouse trap on the finger of whoever dares to turn on the light (see Figure 19). The preference for any of these means to promote energy conservation might be explained by determinants of aesthetic appreciation other than MEMM. For example, preference based on unexpectedness or inevitability would depend on the perception of a particular switch as the unanticipated or seemingly only possible way of promoting the conservation of energy. What is clear is that, as the set of alternative means and effects becomes richer, the aesthetic judgment of a particular artifact also becomes more sophisticated.



Figure 18. *Hang Off* (2007) by Scott Amron.



Figure 19. *Switch Me* (2010) by Josselin Zaïgouche.

DISCUSSION OF CHAPTER 3

We have explored the aesthetic judgment of a product as a judgment that involves thinking about the product's effect or purpose. In search of the principles governing people's evaluation of the way a product achieves an effect, we identified MEMM. This principle describes the beauty of a wide range of artifacts, which suggests that it has a universal capacity to explain the aesthetic appeal of the way something is done. It explains the aesthetic judgment of an artifact as the judgment of a means–effect relationship, a relationship that can be aesthetically appreciated for being efficient (i.e., minimum–maximum), but also for being unexpected or inevitable, among other possible qualities. Hence, MEMM not only accounts for the aesthetic appeal of different artifacts, but also provides the grounds for identifying the different factors that explain such appeal.

We have shown how the means–effect relationship can be established between a product and its effect or purpose, and how the product and the effect can be perceived to be (the) minimum and (the) maximum. We have also indicated that the appreciation of the minimum–maximum relationship between a given means and a given effect depends on a set of assumed alternatives for both the means and the effect. On these grounds, we argue that research in design aesthetics should attend to how people evaluate products based on these sets of known or imagined alternatives.¹⁵ We still have much to learn about how people build and use such sets of alternatives, what categorization processes lead them to develop these sets, and to what extent they are aware of making judgments on this basis. Although such questions might well be addressed by a number of different disciplines (including those that employ experimental or scientific methods), the arguments made in this chapter suggest some directions for research in the field of design.

The main goal for future theoretical work seems to be to generate a more precise definition of means and effects in design. We have

¹⁵ We thus agree with Nygaard Folkmann (2013) that research into design aesthetics should attend to the role of possibility (because many possible means can be assumed for an effect, and vice versa), and imagination (because some of these possibilities are only imagined, rather than known by experience).

discussed that a product plays the role of a means insofar as it exploits certain resources to achieve an effect. The resources we highlighted (i.e., sensory properties, working principles, and interactions with people) should be further examined, and other resources could be identified. Our categorization of the effects of products was simply based on the distinction between proximal and distal effects. Future research should further categorize the effects of products. For instance, based on Fokkinga et al. (2014), effects could be classified into experiential (e.g., offering a creative experience to prison inmates), attitudinal (e.g., triggering a collaborative attitude among users of a set of cups), and behavioral (e.g., changing people's behavior in such a way that they conserve energy or reduce plastic waste). A more precise characterization of means and effects in design would provide a basis for studying the qualities that are aesthetically appreciated in them.

We have argued that means and effects can be appreciated for their perceived magnitudes. To better understand what makes a means (the) minimum and an effect (the) maximum in the design context, future research should conceptually relate the defining characteristics of means and effects to such magnitudes. For instance, we might argue that people's effortless interaction with a product plays the most important role in their judgment of the product as the minimum means; or that a behavioral effect can generally be considered to have a greater magnitude than an experiential or attitudinal one because people's behavior has a tangible impact on society.

Since the relationship between means and effects can also be aesthetically characterized by unexpectedness and inevitability, these are qualities worth examining. Based on further review of literature, future research could conceptually define these seemingly incompatible factors and explain how they can jointly contribute to people's appreciation of products (an issue that has already been studied in the field of mathematics; see Cain, 2010). Furthermore, theory could be developed on the possible relationships between these qualities and other determinants of aesthetic appreciation, starting with MEMM.

In addition to theoretical research in the directions mentioned, we suggest conducting complementary experimental studies (as a reference,

see the studies presented and cited by Da Silva et al., 2015 [chap. 2]¹⁶). For example, a study using pairs of products (means) and products' effects as stimulus materials could test aesthetic preference as described in this chapter. The experimental design could consist of the dependent variable aesthetic appreciation, and the independent variables MEMM, unexpectedness, and inevitability. Such a study not only could provide evidence of people's aesthetic appreciation of these qualities in design, but also could reveal if MEMM is a particularly important predictor of such appreciation. The findings would, in turn, suggest new directions for other empirical studies.

To conclude, we want to emphasize how seemingly simple perceptions of product beauty might actually be quite complex. They might involve thinking not only about the product's purpose or effect, but also about a number of alternative products and related effects. A person's assertion that a wall clock or a light switch is beautiful might therefore result from a tacit belief that "another clock would just give me the time of day" or "an awareness program could not make me save energy without my noticing". As researchers in design aesthetics, we must acknowledge and examine such trains of thought. By doing so, we will gain a deeper understanding of the ways in which people experience an increasingly designed world—a world that they increasingly know has been designed for a purpose.

¹⁶From this point on, when citing my own publications, I make an insertion in square brackets to indicate the chapters of this dissertation to which these publications correspond.

CHAPTER 4

*Testing MEMM*¹⁷

The experience of beauty is undeniable, but it is also difficult to unravel. The aesthetic appreciation of physical objects—ranging from art pieces to consumer products—is often explained based on the objects’ appearance, that is, based on aspects such as curvature (Silvia & Barona, 2009; Westerman et al., 2012), unity (Post et al., 2016; Veryzer & Hutchinson, 1998), and symmetry (Jacobsen & Hoefel, 2003; Locher & Nodine, 1989). The aesthetic appreciation of *Gauge*, the flower vase presented in Figure 20, might thus be explained with reference to qualities such as the roundness of its base, the unity of its shape, and its rotational symmetry. Although such use of the term *aesthetic appreciation* can be ambiguous (Koren, 2010), we use it here—just as the word *beauty*—to refer to an appreciation that emerges from perceiving an artifact for its own sake, rather than from evaluating it based on some extrinsic interest. This definition is grounded in the classic understanding of aesthetics (see Goldman, 2001; Kant, 2000 [orig. 1790]).

The prevalence of aesthetic judgments based on appearance does not imply that beauty can only be perceived in visual qualities or form. Many different kinds of thing are aesthetically appreciated even though they do not exhibit any conventional form or where it is not the form that is regarded as beautiful. As examples, we already mentioned literary

¹⁷ This chapter is based on a co-authored article (Da Silva et al., in press).

metaphors (Kaplan & Kris, 1948; Ramachandran & Hirstein, 1999), logical arguments (Walsh, 1979), scientific theories (Orrell, 2012), science experiments (Crease, 2004; Johnson, 2009), chess moves (Margulies, 1977), mathematical demonstrations (Hardy, 1967), and even criminal acts (Black, 1991). We explained that these very different things can all be regarded as artifacts because they realize certain intended effects (Dipert, 1993; Hilpinen, 1992), and that they can all be aesthetically appreciated for how they realize those effects. In this chapter, we empirically examine this kind of aesthetic appreciation, which is conceptually independent from the appreciation of any form that the artifact might possess, and also from the appreciation of the artifact's effect in itself (for instance, when someone talks of “a beautiful murder”; see Black, 1991).



Figure 20. *Gauge* (2012) by Jim Rokos. As the water level drops, the center of gravity rises and the instability of the vase (with flowers) causes it to tilt over.

The intended effect of *Gauge* (Figure 20) is not simply to exhibit flowers, but also—and ultimately—to remind people to water those flowers when needed. Like many other vases, *Gauge* realizes this effect by exploiting the inherent transparency of glass and letting people see the dropping water level. But it does so even more effectively by exploiting the instability intrinsic to its shape (when holding flowers) and the gravitational field, which together cause the vase to tilt as the water level drops. Once people understand this about *Gauge*, either from explicit statements made about the design (Rokos, 2013) or through inference (Crilly, 2011a; 2011b), they are able to appreciate the vase not just for how it looks, but also for how it achieves its purpose. This appreciation is aesthetic because, as we previously argued, it emerges from perceiving

the vase for its own sake, for the way it achieves the effect that it is intended to achieve. This aesthetic appreciation thus arises from having not just any sort of understanding of the artifact (for instance, an insight into its Gestalt, as reported by Muth & Carbon, 2013), but an understanding of the artifact in the light of its designer's intention (as suggested by Hekkert, 2014).

Philosophy on the aesthetics of everyday objects offers some theoretical insights into the type of aesthetic appreciation just described. For instance, Forsey (2013) builds on Kant's notion of dependent beauty to argue that the aesthetic judgment of an artifact is conceptually rich because it involves having knowledge of the artifact's purpose. Parsons and Carlson (2008) also provide philosophical grounds and a conceptualization of functional beauty, that is, a perception of beauty that involves understanding what the function of an artifact is, as well as how the artifact performs this function. Saito (2007) distinguishes an artifact's capacity to function from *the way* in which it functions, arguing—in line with the previous authors—that an artifact can be aesthetically appreciated for *how* it performs a function.

Discourse on the aesthetics of a wide range of artifacts further suggests that the appreciation of the way in which an artifact achieves an intended effect is governed by an essential principle. For example, Hardy (1967) sees beauty in the theorem by which Euclid demonstrates that there are infinite prime numbers through only a couple of statements. Crease (2004) sees it in the experiment by which Eratosthenes measures the large circumference of the Earth with a small shadow. Kaplan and Kris (1948) consider Eliot's metaphor "the shrunken seas" to be beautiful because it allows for multiple and non-exclusory interpretations: a mere state of the tides, a prolonged draught season and death by extension (the connection between ambiguity and aesthetic appreciation has recently been studied by Jakesch & Leder, 2009; 2015; Muth, Hesslinger, & Carbon, 2015). The theorem, the experiment, and the metaphor might be generally taken as examples of cleverness and creativity. But, more specifically, these are instances where cleverness and creativity have been applied to achieve the maximum effect (a proof of infinitude, a measure of immensity, a multiplicity of interpretations) with the minimum means (a few statements, a small shadow, a single verbal expression). The same

can be said about the theories, checkmates, and crimes discussed by Orrell (2012), Margulies (1977), and Black (1991).

The principle of maximum effect for minimum means is thought to govern the aesthetic appreciation of a wide variety of things (as stated by Boselie & Leeuwenberg, 1985). Yet, we lack experimental evidence that an artifact is aesthetically appreciated when perceived as the minimum means to achieve the maximum effect. Our goal is to find such evidence in the context of product design, where MEMM has been identified as a fundamental aesthetic principle (Hekkert, 2006; Hekkert & Leder, 2008), and where it is also referred to as *economy* (Zelanski & Fisher, 1984), *efficiency* (Macnab, 2012), and *Occam's razor* (Lidwell et al., 2010). In this context, a product can be taken as the means by which a designer achieves an intended effect, and it can be appreciated for how efficiently it realizes this effect (even if the effect is considered unpleasant in its own right, as in the cases presented by Savic & Savicic, 2013).

Our investigation builds on two previous pieces of research. The first (Da Silva et al., 2015 [chap. 2]) applied a mixed-methods approach to examining if and how people's appreciation of a product is influenced by their knowledge of the designer's intention. Although this research did not focus on MEMM, it provided interview data suggesting that a product can be appreciated for how it achieves a purpose. The second (Da Silva et al., 2016 [chap. 3]) applied a purely conceptual approach to examining MEMM in the field of product design. It offered a theoretical basis for understanding the aesthetic appreciation of a product through this principle. The second piece of research provided the grounds to prepare the present investigation; for this reason, we will summarize its main points and illustrate them with the *Gauge* example (while acknowledging this example could be interpreted in other ways if other perspectives were being emphasized).

MEMM suggests that a means-effect relationship can be established between a product (the means) and the effect that the product is intended to have, and that this relationship is aesthetically appreciated when the product is judged to be the minimum means and its effect is judged to be the maximum effect. Any purpose that a designer aims at achieving through a product can be considered the intended effect of the

product; this includes ordinary practical functions as well as human-centered effects (like those described by Crilly et al., 2009; Fokkinga et al., 2014). For *Gauge*, we have identified reminding people to water the flowers (in addition to displaying flowers) as the effect. Also, any resource that a product exploits to achieve a given effect characterizes the product as a means; this includes the product's properties, the mechanisms by which it works and the interactions it establishes with people. For *Gauge*, we have identified the instability of the vase and the gravitational field as salient resources.

The effect of a product can be judged maximal when it exceeds a merely practical function, while the product can be judged minimal as a means when it exploits resources that are inherent or already available—in particular, simple properties or mechanisms and intuitive or effortless interactions—to achieve a given effect. The product and its effect can be judged to be the minimum and the maximum based on artifact categories such as flower vase, which people develop intuitively (see Barrett et al., 2008; Bloom, 1996; Matan & Carey, 2001) through experience and imagination (see Lakoff, 1990). A given effect can be judged to be the maximum relative to other known or imagined effects achievable by artifacts in the same category (or similar categories). Reminding people to water the flowers (in addition to displaying flowers) can thus be judged the maximum effect relative to just displaying flowers, which can be taken as the most immediate function of a flower vase. Similarly, a given means can be judged to be the minimum relative to other known or imagined means by which the same (or a similar) effect can be achieved. *Gauge* can therefore be judged the minimum means relative to, for example, a regular flower pot fitted with a sensor that assesses a plant's needs and sends notifications to the plant's owner through a smartphone application (see “Parrot: Flower power”, 2012). In sum, MEMM implies that people's aesthetic appreciation of the relationship between a means and an effect is grounded in a set of assumed alternatives in comparison to which the means is perceived to be the minimum and the effect the maximum (Figure 21).

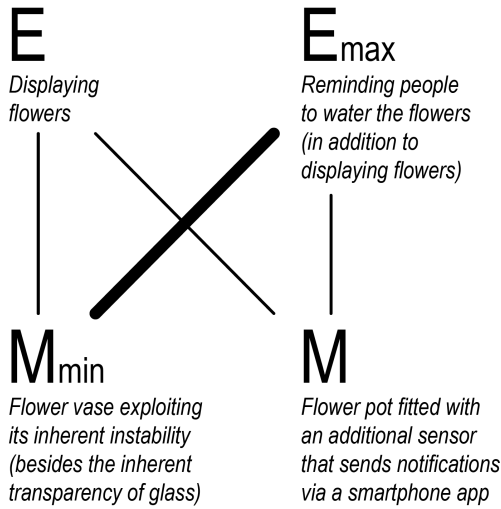


Figure 21. Aesthetic appreciation according to MEMM. Of a number of different effects and means (here we only represent two of each), people aesthetically prefer the maximum effect (E_{max}) that results from the minimum means (M_{min}).

In the previous chapter, we acknowledged that the aesthetic appreciation of a means-effect relationship might be explained by factors other than MEMM. The literature providing illustrations of this principle also suggests unexpectedness and inevitability as alternatives, which makes us question the relationship among these three factors. Unexpectedness involves perceiving the means as an unanticipated or unpredicted way of attaining the effect, or the effect as being surprising or unforeseen given the means. Inevitability involves perceiving the means as a predetermined or unequivocal way of attaining the effect, or the effect as being unavoidable or necessary given the means. Both factors are thought to describe the beauty of mathematical demonstrations and architecture (Hardy, 1967; Parsons & Carlson, 2008); unexpectedness also explains the beauty of ballet leaps and rhymes (Boselie & Leeuwenberg, 1985; Poe, 1846); and inevitability that of music and scientific theories too (Howard, 1923; Orrell, 2012). The literature further suggests that these factors are not mutually exclusive. On the one hand, something inevitable is not necessarily obvious and can very well be unexpected or surprising (Howard, 1923). On the other hand, something unexpected is not necessarily arbitrary or optional and thus can still be inevitable, the result of necessity (Cain, 2010). While the relationship between these two factors has been discussed, their relationship with MEMM remains uncertain.

To complement our non-experimental findings regarding MEMM (Da Silva et al., 2015 [chap. 2]; 2016 [chap. 3]) and thus deepen the understanding of this principle, we conducted two studies. In Study 3, we tested the hypothesis that the aesthetic appreciation of a product would be positively affected by the perception of the product as the minimum means achieving the maximum effect, while controlling for the influence of unexpectedness and inevitability. For this study, we selected a range of products that naturally varied in their effects and the resources they used as means. Encouraged by the results of this first study, we conducted Study 4 to find further evidence of the principle of MEMM while controlling for the influence of visual appearance by employing a more controlled experimental design.

STUDY 3

METHOD

Participants. Sixty students from Delft University of Technology took part in this study in return for 10 Euros each. There were 43 males and 17 females, with an average age of 23.53 years ($SD = 2.72$). To prevent results being affected by specialized design knowledge, students from the faculties of Industrial Design and Architecture were not included.








Design. This study used a within-subject experimental design and employed a questionnaire for data collection. In the questionnaire, products were rated on four 7-point scales corresponding to the dependent variable aesthetic appreciation, and the three independent variables MEMM, unexpectedness, and inevitability.

Materials. Existing consumer products were used as stimulus materials. We represented the products with full-color photographs and written statements describing their intended effects (the real purposes for which they were designed), as well as the resources (properties, mechanisms, or interactions) that they employed as means to achieve these effects; the texts also indicated the categories to which the products belonged. For instance, one of the products preselected as stimulus was the *Gauge* flower vase. We represented this product with the image shown in Figure 20 and the following text: “This flower vase exploits the laws of

physics to tilt as it runs out of water to remind people to water the flowers”. We used these texts in an attempt to control for the various inferences that the participants might make about means and effects based on the product images, as well as for the different categorizations on which they would spontaneously base their MEMM judgments. Also, to prevent the participants from making comparisons among the stimuli, we made sure that the products used in the study belonged to different categories.

To make a final selection of 15 products that represented a range of variation in MEMM, we submitted a total of 25 products to a pretest. We conducted this pretest with two professional designers, considering that their professional experience qualified them as experts in the assessment of consumer products and the means-effect relationships that they represent. The designers were asked if they agreed or disagreed with the following four items regarding each product: (1) “this [product (e.g., *flower vase*)] uses unnecessary means for its purpose” (phrased to avoid double negative, answer reversed for analysis); (2) “this [product and effect (e.g., *flower vase reminds people to water the flowers*)] in an efficient way”; (3) “this [product] does more than [products from the same category (e.g., *flower vases*)] normally do”; and (4) “compared with other [products from the same category], this one has an additional purpose”. We assigned one point to each agreement and calculated sum scores for each product, with the highest possible score being 8 (four agreements by two designers). We took sum scores of between 0 to 2, 3 to 5, and 6 to 8 points as corresponding indicators of low, medium, and high degrees of MEMM. On a first round, 15 products were pretested with the expectation that five of them would be rated as low, five as medium, and five as high in MEMM. Only 10 products were rated according to this prediction and thus selected as stimuli (they represented high and medium degrees of MEMM only). On a second round, 10 more products were pretested with the expectation that at least five of them would be rated as low in MEMM. Only four were rated accordingly, so we completed our final selection of 15 products with one that obtained a sum rating of 3. The final selection of products is presented in Table 3.

Table 3. Stimulus materials used in Study 3.

Product	Image	Text
Backpack (by Enerplex)		This <i>backpack</i> is fitted with thin solar panels to power portable electronic appliances.
Ceiling lamp (by Ikea)		This <i>ceiling lamp</i> uses an electric bulb and an aluminum shade to <i>light up a room</i> .
Bathroom tap (by Tavistock)		This <i>bathroom tap</i> controls a valve mixing cold and hot water in order to <i>wash people's hands</i> .
Door handle (by The Agency of Design)		This <i>door handle</i> dispenses hand sanitizer when pulled, so as to <i>promote hygiene in hospitals</i> .
Flower vase (by Jim Rokos)		This <i>flower vase</i> exploits the laws of physics to tilt as it runs out of water to <i>remind people to water the flowers</i> .
Light switch (by Leviton)		This <i>light switch</i> uses a motion sensor to turn off the light when there is no one around, so as to <i>save energy</i> .
Mountain bike (by The House of Solid Gold)		This <i>mountain bike</i> has heavy-duty wheels and a frame covered in 24-carat gold to <i>enable off-road cycling</i> .

Mug (by
Heraldic
Pottery)



This *mug*, with both body and handle made of glazed ceramic, enables people to *drink warm coffee*.

Office chair
(by Zuo)



This *office chair* uses two metallic rods to connect five cylindrical cushions so as to *provide back support*.

Toaster (by
Kalorik)



This *toaster* requires the user to press buttons, turn dials and push down levers in order to *toast bread*.

Umbrella (by
Senz)



This *umbrella* is shaped asymmetrically, exploiting the laws of aerodynamics to *withstand strong winds*.

USB stick (by
Star
Enterprises)



This *USB stick* uses flash memory covered with a metallic case and pieces of leather in order to *store data*.

Vacuum cleaner (by
West Point)



This *vacuum cleaner* uses an electrically-powered air pump to *suck up dust from different surfaces*.

Washing machine (by
Ventus)



This *washing machine* requires the user to fill it with water and pump a pedal continuously so as to *wash clothes*.

Watch (by
Muji)



This *watch* uses a battery-powered mechanism to move a set of hands and thus *give the time of day*.

Four scales were prepared for this study, each comprising a number of items on which the participants would rate the products from 1 (*disagree*) to 7 (*agree*). The scale measuring the dependent variable aesthetic appreciation was based on an existing scale (developed by Blijlevens et al., 2014). To reduce the likelihood that the participants gave aesthetic ratings mainly based on the products' visual appearance, we rephrased the items of this scale so as to explicitly require the participants to take the products' effects into account. The items were phrased as follows: (1) "given that it is designed to [effect], this is a beautiful [product]"; (2) "taking into account its purpose, this is an attractive [product]"; and (3) "I like to look at this [product] knowing what it is for".

For each of the three independent variables, we developed a scale based on the theory that a product can be judged relative to a fixed effect or purpose, and that an effect can be judged relative to a fixed product or product category (as explained by Da Silva et al., 2016 [chap. 3]). Half of the items of each scale accounted for each of these possibilities. The MEMM scale comprised the four items already used in the pretest. The unexpectedness scale included the following two items: (1) "I would expect a [product] to [effect]" (phrased to avoid negative, score reversed for analysis); and (2) "for a [product], this has a surprising purpose". The inevitability scale comprised the following two items: (1) "because of the way it is designed, this [product] will certainly [effect]"; and (2) "[effect] is an unavoidable outcome of using this [product]". (The fragments of the stimulus texts inserted between brackets in the scale items are italicized in Table 3.)

Procedure. The study was conducted in groups of up to four participants in a private well-lit meeting room of the Faculty of Industrial Design Engineering at Delft University of Technology. After being taken through a standard procedure to establish their informed consent, each participant sat in front of a 17 by 29 cm computer screen and completed the questionnaire in silence. The questionnaire was introduced as part of a research project on general product perception so as to prevent results being affected by the participants' awareness of the aesthetic focus of the study. As we already explained, the products were presented through images and texts; the images were displayed at a uniform 5 cm high and ranged between 3 and 8 cm in width according to their shape. The

application that was used to develop the questionnaire presented one product at a time and required the participants to rate each product before presenting the next. It also required them to rate all the products on all the scale items to avoid having missing values in the data collected. The order of presentation of both products and scale items was randomized between participants to prevent order effects. It took approximately 30 minutes for the participants to complete the questionnaire.

RESULTS

In preparation for the statistical analyses, we reversed the ratings for the first items of both the MEMM and the unexpectedness scales, which had been phrased to avoid possibly confusing (double) negatives. We then submitted the four scales to a reliability test (Cronbach's alpha). The internal consistency was good for aesthetic appreciation ($\alpha = .78$), MEMM ($\alpha = .70$), and unexpectedness ($\alpha = .78$), and relatively poor—but still acceptable—for inevitability ($\alpha = .54$). Next, we calculated ratings for aesthetic appreciation, MEMM, unexpectedness, and inevitability by averaging the ratings each participant gave to each product on the items of each scale. We conducted our main analysis with the ratings thus obtained.

To examine if aesthetic appreciation was influenced by MEMM, unexpectedness, and inevitability, we conducted a stepwise multiple regression analysis. At step one of the analysis, we only introduced MEMM as independent variable to test the hypothesis that the aesthetic appreciation of a product would be positively affected by the perception of the product as the minimum means achieving the maximum effect. The results supported our hypothesis, indicating that a significant proportion of the variance in aesthetic appreciation was explained by MEMM ($\beta = .54$, $p < .001$); $R^2 = .30$, $F(1,898) = 381.97$, $p < .001$. MEMM had, as expected, a positive influence on aesthetic appreciation. The more a product was perceived to comply with MEMM, the more it was aesthetically appreciated. This linear relationship is illustrated in Figure 22.

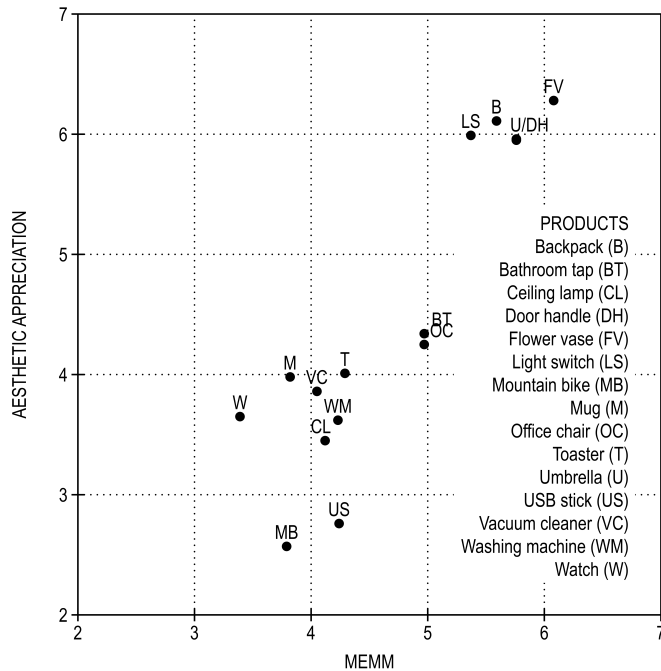


Figure 22. Relationship between mean aesthetic-appreciation and MEMM ratings of the products (Study 3).

At step two of the analysis, we added unexpectedness and inevitability as independent variables to examine if the aesthetic appreciation of a product would also be influenced by the perception of the product as an unexpected or inevitable means to achieve an effect, or as a means achieving an unexpected or inevitable effect. The results indicated that a significant proportion of the variance in aesthetic appreciation was explained not just by MEMM ($\beta = .45, p < .001$), but also by unexpectedness ($\beta = .09, p = .003$), and inevitability ($\beta = .06, p = .044$); $R^2 = .31, F(3, 896) = 131.85, p < .001$. Similarly to MEMM, unexpectedness and inevitability had a positive influence on aesthetic appreciation. But, as compared to MEMM, these variables explained a much smaller proportion of the variance in aesthetic appreciation.

The explanatory power of MEMM slightly decreased when we included unexpectedness and inevitability as independent variables in the previously reported regression analysis. This suggested that MEMM shared a fraction of its explanatory power with them. To explore the relationship of MEMM with unexpectedness and inevitability, we

conducted additional regression analyses. For these analyses, we averaged the ratings of the MEMM scale items 1 and 2, on the one hand, and 3 and 4, on the other, and took them as measures of minimum means and maximum effect respectively. We treated the ratings of the unexpectedness scale items 1 and 2 as measures of unexpected means and unexpected effect correspondingly. We also treated the ratings of the inevitability scale items 1 and 2 as measures of inevitable means and inevitable effect correspondingly. In the rest of our analyses, we tested the measures thus identified as predictors of aesthetic appreciation.

To explore the relationships among minimum means, maximum effect, unexpected means, unexpected effect, inevitable means, and inevitable effect as predictors of aesthetic appreciation, we initially conducted a stepwise multiple regression analysis. At step one of the analysis, we only introduced minimum means and maximum effect as predictors. The results indicated that a significant proportion of the variance in aesthetic appreciation was explained by both minimum means ($\beta = .20, p < .001$) and maximum effect ($\beta = .31, p < .001$); $R^2 = .31$; $F(2,897) = 196.41, p < .001$. At step two of the analysis, we added unexpected means, unexpected effect, inevitable means, and inevitable effect as predictors. The results indicated that a significant proportion of the variance in aesthetic appreciation was explained not just by minimum means ($\beta = .16, p < .001$) and maximum effect ($\beta = .24, p < .001$), but also by inevitable means ($\beta = .09, p = .004$) and unexpected effect ($\beta = .11, p = .001$); $R^2 = .32$; $F(6,893) = 69.96, p < .001$. They also showed that the explanatory power of both minimum means and maximum effect slightly decreased when inevitable means and unexpected effect were introduced in the regression analysis. By conducting a series of stepwise regressions where we controlled for each predictor at a time, we found that the explanatory power of minimum means decreased with the introduction of inevitable means, and the explanatory power of maximum effect decreased with the introduction of unexpected effect. We will discuss this finding in the following section.

DISCUSSION

Study 3 provided evidence that the aesthetic appreciation of a product is partially governed by the principle of MEMM. In support of our

hypothesis, it showed that the aesthetic appreciation of a product is positively affected by the perception of the product as the minimum means achieving the maximum effect. For the way these concepts were operationalized, this implies that a product is aesthetically appreciated when it achieves more than other products from its category by making an efficient use of resources such as properties, mechanisms, and interactions. Of the stimuli tested, the flower vase received the highest aesthetic-appreciation and MEMM ratings. Just like a normal glass vase, it displays flowers and allows the water level to be seen, but it additionally reminds people to water the flowers by exploiting the inherent instability of its shape rather than by using supplementary, external resources.

Study 3 also indicated that unexpectedness and inevitability influence aesthetic appreciation positively, although to a much smaller extent than MEMM. Our findings further suggested that there is a relationship between these two factors and MEMM; in particular, a relationship between an unexpected effect and the maximum effect, on the one hand, and an inevitable means and the minimum means, on the other. We interpret this finding as follows: An effect might be perceived to be the maximum when it exceeds the effect that is normally expected from a product of a given category, hence, when it is unexpected; also, a means might be perceived to be the minimum when it uses only those resources that cannot be avoided in the search for a certain effect, hence, when it is inevitable.

In Study 3, we used a set of existing products that naturally varied in the effects they were intended to achieve and the resources they exploited as means, which contributed to the ecological validity of our findings. Although we thus demonstrated that MEMM positively affects the aesthetic appreciation of a product, it cannot be ruled out that the visual appearance of the products we used as stimuli played a confounding role. We mentioned the effects of these products in the scale items measuring aesthetic appreciation in an attempt to prevent participants from rating the products aesthetically mainly based on visual appearance. But this adaptation of the scale might have also biased the aesthetic-appreciation ratings.

To put the principle of MEMM to a more rigorous test, which would allow us to control for the influence of visual appearance experimentally without requiring any adaptation of the aesthetic-appreciation scale, we conducted a second study. In Study 4, we aimed at keeping the visual appearance of a product constant while varying the means-effect relationship that the product represented. Since Study 3 revealed that unexpectedness and inevitability only had a minor influence on aesthetic appreciation, we did not include these factors in Study 4.

STUDY 4

METHOD

Participants. Ninety students from Delft University of Technology took part in this study in return for five Euros each. There were 75 males and 15 females, with an average age of 24.06 years ($SD = 2.35$). To prevent results being affected by specialized design knowledge, students from the faculties of Industrial Design and Architecture were not included.

Design. This study used a between-subject experimental design and employed a questionnaire for data collection. In the questionnaire, products were rated on two 7-point scales corresponding to the dependent variable aesthetic appreciation and the independent variable MEMM. The experimental design entailed manipulating stimulus materials to create two conditions: low MEMM and high MEMM.

Materials. With the aim of creating low-MEMM and high-MEMM conditions, we first selected a subset of the products used as stimuli in Study 3. This selection was based on the mean MEMM ratings calculated for the products with data from that study (where the average MEMM rating was 4.45, $SD = 1.27$). Five products had ratings above one standard deviation from the mean. We selected these products and those five with the lowest ratings (two of which were below one standard deviation from the mean). In Table 4, we present our selection of 10 products along with the mean MEMM ratings they obtained in Study 3.

Table 4. Subset of products selected as stimulus materials for Study 4.

Product	MEMM ratings obtained in Study 3	
	Highest	Lowest
Backpack	6.11	
Ceiling lamp		3.45
Door handle	5.95	
Flower vase	6.28	
Light switch	5.99	
Mountain bike		2.57
Umbrella	5.96	
USB stick		2.76
Washing machine		3.62
Watch		3.65

Again, we represented the selected products with images and texts. To keep visual appearance constant, we represented each product with a single image, which was taken from Study 3. To vary the means-effect relationship each product represented and thus create the low-MEMM and high-MEMM conditions, we paired the product image with different texts. For this, we took the 10 texts already used in Study 3 and additionally developed new ones. We developed the new texts with attention to product attributes that could be directly perceived or imagined based on the images, regardless of whether these attributes really described the products or not. Like the old texts, the new ones referred to each product instance (e.g., *This*) as a member of a product category (e.g., *flower vase*), so the same practical functions associated with that category (e.g., displaying flowers) could be assumed in both conditions. They also indicated the intended effects of the products and the resources the products used as means, so the same kind of information would be provided in both conditions. For the five products with the lowest MEMM ratings in Study 3, the new texts aimed at triggering the perception of a “high-MEMM” relationship. For the products with the highest MEMM ratings in Study 3, they aimed at triggering the perception of a “low-MEMM” relationship. For instance, a new description of the flower vase stimulus read as follows: “This flower vase is made of heavy glass, but can be inclined towards the sink tap so

as to facilitate the process of watering flowers”. We generated a total of 30 new texts, three for each of the 10 selected products.

To make a final selection of 10 texts that would serve as alternative descriptions of the products, we pretested the 30 new texts against the 10 old ones. We conducted this pretest with 12 professional designers, considering again that their professional experience qualified them as experts in the assessment of the means-effect relationships that consumer products represent. In this pretest, each designer rated a single set of 10 texts presented with the corresponding product images using the 7-point MEMM scale from Study 3. Since the new texts did not necessarily describe the products’ real attributes, we also asked the designers to rate these texts from 1 (*disagree*) to 7 (*agree*) on the following three items: (1) “the explanation makes sense”, (2) “it is possible that this [product] was designed to work as described in the explanation”, and (3) “it is possible that this [product] was designed to [effect]”. We considered these three items as joint indicators of plausibility. For both the old and the new texts, we calculated mean MEMM scores; for the new texts, we also calculated mean plausibility scores.




Based on the results of the pretest, we selected 10 new texts following two criteria. First, their plausibility scores had to be above average ($M = 4.63$, $SD = 1.07$). Second, if the new text was required to trigger the perception of a high-MEMM relationship, then its MEMM score had to be higher than that of the old text describing the same product; if it was required to trigger the perception of a low-MEMM relationship, then its MEMM score had to be lower than that of the old text describing the same product. Table 5 presents the mean MEMM scores the old texts obtained in the pretest, as well as the mean MEMM and plausibility scores of the new texts selected as stimuli.

Table 5. Pretest scores of the stimulus materials selected for Study 4.

Product	MEMM		Plausibility New text
	Old text	New text	
Backpack	5.08	2.17	5.11
Ceiling lamp	3.25	5.75	6.67
Door handle	6.42	2.92	4.89
Flower vase	5.83	4.17	5.44
Light switch	6.17	4.25	4.67
Mountain bike	1.75	5.42	5.67
Umbrella	5.83	5.08	6.00
USB stick	2.42	4.58	5.00
Washing machine	3.67	6.08	6.11
Watch	3.58	5.33	5.78

Our final selection of stimulus materials, including the two sets of texts that allowed for the creation of the high-MEMM and low-MEMM conditions, is presented in Table 6.

Table 6. Stimulus materials used in Study 4.

Product	Image	Text in high-MEMM condition	Text in low-MEMM condition
Backpack (by Enerplex)		This <i>backpack</i> is fitted with thin solar panels to <i>power portable electronic appliances</i> .	This <i>backpack</i> is made of heavy-duty textiles and reinforced with an aluminum structure so as to <i>carry school textbooks and utensils</i> .
Ceiling lamp (by Ikea)		This <i>ceiling lamp</i> uses an occupancy sensor to turn off the light when there is no one in the room, so as to <i>reduce electricity usage</i> .	This <i>ceiling lamp</i> uses an electric bulb and an aluminum shade to <i>light up a room</i> .
Door handle (by The Agency of Design)		This <i>door handle</i> dispenses hand sanitizer when pulled, so as to <i>promote hygiene in hospitals</i> .	This <i>door handle</i> requires people to insert an identification card into a narrow slot and hold it there for five seconds so as to <i>open the door</i> .

Flower vase
(by Jim
Rokos)



This *flower vase* exploits the laws of physics to tilt as it runs out of water to *remind people to water the flowers*.

This *flower vase* is made of heavy glass, but can be inclined towards the sink tap so as to *facilitate the process of watering flowers*.

Light switch
(by Leviton)



This *light switch* uses a motion sensor to turn off the light when there is no one around, so as to *save energy*.

This *light switch* requires the user to turn a dial 360 degrees to *change the intensity of light*.

Mountain bike
(by The
House of
Solid Gold)



This *mountain bike* uses energy generated by pedaling to *charge devices like smartphones and music players*.

This *mountain bike* has heavy-duty wheels and a frame covered in 24-carat gold to *enable off-road cycling*.

Umbrella (by
Senz)



This *umbrella* is shaped asymmetrically, exploiting the laws of aerodynamics to *withstand strong winds*.

This *umbrella* uses a hydraulic pump and fine oils to *activate an opening mechanism*.

USB stick (by
Star
Enterprises)



This *USB stick* has a flexible surface that inflates and deflates to *indicate how much data is currently being stored*.

This *USB stick* uses flash memory covered with a metallic case and pieces of leather in order to *store data*.

Washing
machine (by
Ventus)



This *washing machine* uses a simple human-powered mechanism to *enable people to do laundry in rural areas*.

This *washing machine* requires the user to fill it with water and pump a pedal continuously so as to *wash clothes*.

Watch (by
Muji)



This *watch* employs GPS signals to set the time automatically and thus *give the correct time of day anywhere in the world*.

This *watch* uses a battery-powered mechanism to move a set of hands and thus *give the time of day*.

Two scales were used in this study, each comprising a number of items on which the participants would rate the products from 1 (*disagree*) to 7 (*agree*). The scale measuring the dependent variable aesthetic appreciation in Study 3 was brought back to its original form (as presented by

Blijlevens et al., 2014) for Study 4. This means that the scale items did not explicitly establish a relationship between the product being judged and its effect. Instead, the items read as follows: (1) “this is a beautiful [product]”, (2) “this is an attractive [product]”, and (3) “I like to look at this [product]”. As we mentioned earlier, we had adapted the scale items for Study 3 to reduce the likelihood that the participants mainly based their aesthetic ratings on the products’ visual appearance. The experimental design of Study 4 provided a strong control for the influence of visual appearance and therefore did not require any such adaptation of the scale. The scale used to measure the independent variable MEMM was exactly the same as in Study 3. (The fragments of the stimulus texts inserted between brackets in the scale items are italicized in Table 6.)

Procedure. Study 4 was conducted similarly to Study 3. The participants completed a questionnaire presenting each product through the corresponding image and a text describing either a low-MEMM or a high-MEMM relationship. No participant was shown the same product (image) twice, as one description of the product could affect the rating of the product when shown with the alternative description. Also, no participant was provided with a combination of both low-MEMM and high-MEMM texts. The low-MEMM texts mentioned the most immediate practical functions of the products as effects, that is, effects that could easily be inferred from how the products were explicitly categorized. By contrast, the high-MEMM texts revealed effects additional to those functions, more maximal effects that would be more difficult to infer because they were not so closely related to the way the products were explicitly categorized. If we provided the same participant with high-MEMM and low-MEMM texts, the high-MEMM texts could prompt inferences of additional (more maximal) effects in the low-MEMM condition, which would suggest that the low-MEMM products were high-MEMM instead. To avoid this, we randomly allocated each participant to either the low-MEMM or the high-MEMM condition while balancing gender between the conditions. It took approximately 30 minutes for the participants to complete the questionnaire.

RESULTS

In preparation for the statistical analyses, we reversed the ratings for the first item of the MEMM scale, which had been phrased so as to avoid a possibly confusing double negative. We then calculated ratings for both aesthetic appreciation and MEMM by averaging the ratings each participant gave to each product on the items of each scale. We conducted all our analyses with the ratings thus obtained.

To first validate our stimulus manipulation, we performed an independent-samples *t*-test to compare MEMM ratings in high-MEMM and low-MEMM conditions. This test revealed that the ratings were significantly higher in the high-MEMM condition ($M = 5.33, SD = 1.27$) than in the low-MEMM condition ($M = 3.90, SD = 1.61$); $t(851.57) = -14.83, p < .001$. In line with the pretest we had conducted, this confirmed that our stimulus manipulation was successful. Altogether, the products selected as stimuli were perceived as the minimum means achieving the maximum effects in the high-MEMM condition more so than in the low-MEMM condition. The effect size for this analysis ($d = .97$) was found to exceed Cohen's (1998) convention for a large effect ($d = .80$).

To check the stimulus manipulation at the product level, we conducted a total of 10 independent-samples *t*-tests to compare the MEMM ratings of each product in high-MEMM and low-MEMM conditions. The results of these tests are presented in Table 7. They showed that the ratings of all products were significantly higher in the high-MEMM condition than in the low-MEMM condition, except in the case of the light switch stimulus (for which the difference was not significant). Based on this finding, we omitted the ratings of this product stimulus from the rest of our analyses.

To again test the hypothesis that the aesthetic appreciation of a product would be positively affected by the perception of the product as the minimum means achieving the maximum effect, we conducted an independent-samples *t*-test to compare aesthetic-appreciation ratings in high-MEMM and low-MEMM conditions. These results also supported our hypothesis, showing that the ratings were significantly higher in the high-MEMM condition ($M = 4.80, SD = 1.46$) than in the low-MEMM

condition ($M = 4.35$, $SD = 1.73$); $t(785.64) = -4.10$, $p < .001$. They provided further evidence that a product is more aesthetically appreciated the more it is perceived to comply with MEMM. The effect size for this analysis ($d = .28$) was found to exceed Cohen's (1998) convention for a small effect ($d = .20$).

Table 7. MEMM ratings of the products in high-MEMM and low-MEMM conditions obtained in Study 4.

Product	High MEMM		Low MEMM		Difference			Effect size
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>	<i>d</i>
Backpack	5.86	.74	3.71	1.46	-8.80	65.00	< .001	1.85
Ceiling lamp	5.84	.90	4.04	1.26	-7.76	88.00	< .001	1.64
Door handle	5.57	1.12	4.89	1.38	-2.56	88.00	.012	.54
Flower vase	5.55	1.01	4.94	1.23	-2.57	88.00	.012	.54
Light switch	5.78	.83	5.57	1.37	-.91	72.24	.367	.19
Mountain bike	5.59	1.29	2.42	1.27	-11.76	88.00	< .001	2.48
Umbrella	5.61	.95	3.92	1.44	-6.56	76.23	< .001	1.39
USB stick	3.86	1.71	2.46	.98	-4.77	69.95	< .001	1.00
Washing machine	4.70	1.09	3.61	1.46	-4.02	81.43	< .001	.85
Watch	4.97	1.30	3.42	1.02	-6.29	83.07	< .001	1.33

To further examine the influence of MEMM on aesthetic appreciation, we conducted a simple regression analysis entering MEMM ratings (from both low-MEMM and high-MEMM conditions) as predictors of aesthetic-appreciation ratings (from both low-MEMM and high-MEMM conditions). In line with our previous findings, this analysis indicated that a significant proportion of the variance in aesthetic appreciation was explained by MEMM ($\beta = .43$, $p < .001$); $R^2 = .18$, $F(1,808) = 180.83$, $p < .001$. The results confirmed that the more a product is perceived to comply with MEMM, the more it is aesthetically appreciated. This linear relationship is illustrated in Figure 23.

Finally, to examine the influence of MEMM on aesthetic appreciation at the product level, we conducted a total of nine independent-samples *t*-tests to compare the aesthetic-appreciation ratings of each product in high-MEMM and low-MEMM conditions. The results of these tests are presented in Table 8. They showed that aesthetic appreciation was

generally higher in the high-MEMM condition than in the low-MEMM condition, but that it only differed significantly for four of the nine tested products. We will reflect on this finding in the coming section.

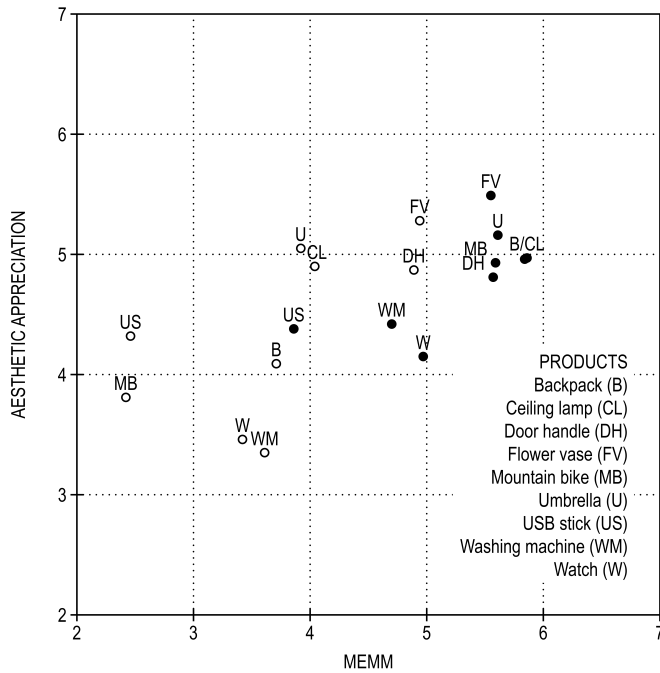


Figure 23. Relationship between mean aesthetic-appreciation and MEMM ratings of the products in high-MEMM (dots) and low-MEMM (circles) conditions (Study 4).

Table 8. Aesthetic-appreciation ratings of the products in high-MEMM and low-MEMM conditions obtained in Study 4.

Product	High MEMM		Low MEMM		Difference			Effect size
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>df</i>	<i>p</i>	<i>d</i>
Backpack	4.97	1.23	4.09	1.37	-3.21	88.00	.002	.66
Ceiling lamp	4.96	1.03	4.90	1.51	-.24	77.76	.808	.05
Door handle	4.81	1.40	4.87	1.63	.19	88.00	.854	.04
Flower vase	5.49	1.31	5.28	1.41	-.72	88.00	.471	.15
Mountain bike	4.93	1.61	3.81	2.07	-2.88	82.85	.005	.60
Umbrella	5.16	1.33	5.05	1.47	-.35	88.00	.726	.08
USB stick	4.38	1.73	4.32	1.79	-.16	88.00	.873	.03
Washing machine	4.42	1.37	3.35	1.65	-3.37	88.00	.001	.71
Watch	4.15	1.59	3.46	1.44	-2.15	87.07	.034	.45

DISCUSSION

Study 4 provided further evidence that the aesthetic appreciation of a product is partially governed by the principle of MEMM. In line with Study 3, it showed that the perception of a product as the minimum means achieving the maximum effect has a positive influence on the aesthetic appreciation of the product. Unlike Study 3, Study 4 involved a manipulation of stimulus materials, which did not exactly reflect the world of existing products, but increased the internal validity of our findings. This manipulation allowed us to experimentally assess the influence of MEMM independently of visual appearance.

Study 4 revealed that a product can be aesthetically appreciated based on MEMM irrespective of how it looks. This suggests that, when comparing two similar looking products, people would aesthetically prefer the one that they perceive to better comply with MEMM. For example, they would prefer the vase that reminds them to water the flowers by exploiting the instability intrinsic to its shape over the pot that accomplishes the same effect by using a sensor and a smartphone app, even if these artifacts looked alike. This is not to deny that MEMM and visual appearance can jointly contribute to the aesthetic appreciation of a product. The resources that a product uses to achieve an effect might be visible and pleasing to look at (e.g., the shape of the flower vase); and, if not visible (e.g., the vase's center of gravity), they might be inferred from visual appearance.

Although MEMM positively influenced the aesthetic appreciation of the products used as stimuli in Study 4, it only had a significant effect on the aesthetic appreciation of four of them. Two of these products had the biggest difference in MEMM ratings between conditions, which indicates that their low-MEMM and high-MEMM written descriptions triggered very contrasting perceptions of each of them. All the descriptions mentioned the effects of the products as well as the resources the products exploited as means, but they did not systematically vary in the kind of information they provided about means and effects. Hence, it remains to be seen how specific qualities of the means and the effect influence the aesthetic appreciation of an artifact.

DISCUSSION OF CHAPTER 4

Theory and discourse suggest that the aesthetic appreciation of an artifact depends, to some extent, on the perception that the artifact achieves the maximum effect through the minimum means. In this chapter, we sought experimental evidence of the principle of MEMM in the context of product design. In Study 3, we tested the hypothesis that the aesthetic appreciation of a product would be positively affected by the perception of the product as the minimum means achieving the maximum effect. We confirmed this hypothesis and also found that MEMM is related to two other factors, namely unexpectedness and inevitability. In Study 4, we used a more controlled experimental design to again test the principle of MEMM. We demonstrated that a product can be aesthetically appreciated as the minimum means to achieve the maximum effect irrespective of its visual appearance. In particular, our findings indicate that the aesthetic appreciation of a product partially depends on the perception that the product achieves more than other products from its category by making an efficient use of resources.

To better understand MEMM in the context of consumer products and other artifacts, further research is required. Our operationalization of MEMM and stimulus manipulation might serve as a basis for this. Although we conceptually distinguished some of the resources a product can use as a means (properties, mechanisms, interactions) and some of the effects it can have (immediate practical functions and additional effects), these distinctions are rather broad and were not taken into account to manipulate stimuli in a systematic manner. Because of this, we cannot make any claims as to how specific aspects of means and effects affect aesthetic appreciation. Future studies could adopt an exploratory approach to research (for instance, by using interviews and questionnaires with open-ended prompts) to identify more specific aspects of means and effects and, more importantly, the qualities that make a means minimal and an effect maximal. Once identified, these qualities could be systematically manipulated in experimental stimuli to test the principle of MEMM in a more controlled manner. Future studies should further take into account the participants' level of design literacy. Although we avoided having students in design and architecture as participants to prevent results being affected by specialized design

knowledge, it could be argued that our participants did not represent a completely naïve population insofar as they were all students in technical fields and therefore had formally acquired some knowledge of the way artifacts work. It remains to be seen whether our findings can be extended to a population with no technical background. Researchers should not overlook, however, that participants with a design background might contribute to unraveling MEMM in a way that other participants might not. For example, giving designers the task of (re)designing artifacts based on this principle could clarify how the notions of the minimum means and the maximum effect translate into design practice.

Research into the principle of MEMM can enhance the practice and teaching of artifact development in a number of areas, including design and the arts. In design, aesthetics often connotes the most superficial layer of a product, a merely decorative layer, clearly distinct from functionality. In the arts, aesthetics is a fundamental concern, but an aesthetically appealing art piece is not usually described in terms of an efficient means-effect relationship. Learning about MEMM involves acknowledging that aesthetics and functionality are not mutually exclusive. If design practitioners and educators focus on the development of products that do more than performing practical tasks, that is, products that influence people's relationship with their environment and one another, they might achieve not just efficiency, but beauty also. Initiatives such as design for sustainability, design for well-being, and design for behavioral change are taking a step in this direction. If artists and art critics become aware that a creative work can be aesthetically appreciated as the minimum means to convey an intended message or feeling, regardless of what this message or feeling is, they might gain a useful criterion to guide creative processes and assess works of art. This is particularly relevant for conceptual art, where the art object is not intended to be attractive in itself, but as a means to convey the artist's idea. Professionals such as marketers, advertisers, and curators, who are responsible for presenting artifacts to different audiences, might also benefit from understanding MEMM. The principle could help them identify invisible aspects of an artifact that are aesthetically appreciated and thus deserve to be communicated. To the everyday users of products and regular museum visitors, knowledge of

MEMM will provide some awareness of the reason they might like certain artifacts, an insight into their perceptions of beauty in efficiency.

CHAPTER 5

*Designing for MEMM*¹⁸

Among the major spheres of human experience, along with morality and sexuality, there is beauty (Pinker, 2002). The aesthetic component of people's experience of a designed product or, more generally, any artifact is not to be underestimated. Beauty equals a gratification of the senses and thereby contributes to the overall pleasurable experience of an artifact (Desmet & Hekkert, 2007; Hekkert, 2006). Moreover, an artifact's aesthetic appeal can improve perceived usability and user performance (Moshagen, Musch, & Göritz, 2009; Sonderegger & Sauer, 2010; Tractinsky, Katz, & Ikar, 2000); it can promote credibility, trust, and loyalty (Cyr, Head, & Ivanov, 2006; Li & Yeh, 2010; Robins & Holmes, 2008); it can affect perceived quality and value (Cai & Xu, 2011; De Klerk & Lubbe, 2008; Wang, Hernández, & Minor, 2010); it can influence the evaluation of the artifact even more than price, performance, and brand (Reimann, Zaichkowsky, Neuhaus, Bender, & Weber, 2010; Yamamoto & Lambert, 1994); and so it can play a prominent role in consumer purchase intention and choice (Creusen & Schoormans, 2005; Vieira, 2010). Because of all this, designers and other professionals engaged in product development can benefit from knowing how to enhance an artifact's aesthetic appeal.

¹⁸ This chapter is based on a co-authored article in preparation.

Many strategies are already known by which designers can enhance the aesthetic appeal of an artifact. For example, the manipulation of color, light, texture, line, shape, space, and movement, among other sensory elements; the application of organizational rules such as those that promote perceptual grouping (e.g., the Gestalt laws of similarity, continuity, and closure), a sense of balance (e.g., translation, reflection, and rotation symmetry), a “good” proportion (e.g., the golden ratio, the waist-to-hip ratio, and the rule of thirds); and, more specifically, the application of the principle of unity in variety, which promotes a maximization of both order and complexity (this principle is further described by Hekkert, 2006; Hekkert & Leder, 2008; the other rules and manipulations are explained by Fiore, 2010; Lidwell et al., 2010; Macnab, 2012). An artifact’s attractiveness can certainly be enhanced in these ways (for instance, regarding symmetry, see the evidence provided by Bauerly & Liu, 2008; Tuch, Bargas-Avila, & Opwis, 2010; regarding unity in variety, see the evidence provided by Cupchik, Spiegel, & Shereck, 1996; Post et al., 2016). These traditional design interventions, however, focus on the artifact’s formal organization or appearance. This is an important source of aesthetic pleasure, but not the only one.

It has been argued that people judge an artifact aesthetically not only on the basis of its form, but also on the basis of its *raison d’être*, the reason why the artifact is designed the way it is designed (Hekkert, 2014)—which people can learn about explicitly or by inference (see Crilly, 2011a; 2011b). By now, we have empirical evidence that the appreciation of an artifact is affected by knowledge of the intention that the artifact was designed with (Da Silva et al., 2015 [chap. 2]). But it is still unclear how designers can enhance the aesthetic appeal of an artifact by taking into account the artifact’s purpose or intended effect. Existing literature does not provide an answer to this issue and in this sense fails to assist design practice in the development of aesthetically pleasing artifacts. Such assistance is particularly relevant in times when design initiatives are defined by the effects that they aim at achieving, as in the cases of design for sustainability, design for subjective well-being, and design for behavioral change (these initiatives have been examined by, for instance, Chick & Micklethwaite, 2011; Desmet & Pohlmeier, 2013; Tromp et al., 2011). The literature, nonetheless, does provide us with a basis to address the question of how designers can enhance the aesthetic appeal

of an artifact by considering the artifact as the means to achieve an intended effect.¹⁹

First, research in design aesthetics indicates that an artifact can be aesthetically appreciated based on the principle of maximum effect for minimum means (Da Silva et al., 2016 [chap. 3]; in press [chap. 4]; Hekkert, 2006). MEMM has been discussed in the context of product design (Hekkert & Leder, 2008) and product service-systems (Post, Da Silva, & Hekkert, 2015), but it is also relevant to fields as different as digital design and food design because it can guide the development of efficient and therefore attractive solutions of any kind. Second, design methods such as Vision in Product Design (Hekkert & Van Dijk, 2011) and Design with Intent (Lockton, Harrison, & Stanton, 2010a; 2010b) show how design practice can aim at achieving any of many possible effects defined at different levels of specificity (e.g., triggering socially responsible behaviour being more general than prompting a particular action to avoid city pollution), and how each of these effects can be attained through any of many possible means (e.g., a product, a product service-system). Third, studies on design fixation generally indicate that providing designers with verbal or visual information about the way a problem can be solved affects their own development of solutions in various ways (for a review of these studies, see Vasconcelos & Crilly, 2016). This general finding suggests that showing designers an example of how the same effect can be achieved through different—more or less varied—means will have an influence on their development of means for a given effect. Building on this body of literature, we address our research question (how can designers enhance the aesthetic appeal of an artifact...?) by providing designers with explicit information about MEMM and observing how they manipulate the artifact (means) and its effect when undertaking a design task.

The principle of MEMM can explain the aesthetic appreciation of an artifact even when the artifact is not particularly attractive for its appearance. Take the example of *Keymoment* (Figure 24). Besides serving as a key holder, it promotes physical activity and reduces air pollution by simply going out of balance when the heavy car key is taken, thereby

¹⁹ In this case, I use the word *artifact* instead of *product* to emphasize that I am referring to any of the many possible outcomes of a design process.

dropping the bike key as a suggestion to stay active and protect the environment (see Laschke, 2014). We interpret this design as achieving a maximal effect, that is, an effect beneficial to people and the environment on a global scale (promoting physical activity and reducing air pollution) through minimal means, that is, through resources that are already available (the weight of the keys and the usual physical interaction with a key holder). Thus interpreted, *Keymoment* can be aesthetically appreciated with grounds in MEMM. For design practice, this principle implies that an artifact can be developed as a means to achieve any of many possible effects and that an effect can be achieved through any of many possible means. Most importantly, it suggests that it is worth pursuing the maximum possible effect through the minimum possible means. These general considerations about MEMM underlie the research here reported (where we sometimes use the terms *minimal* and *maximal* rather than *minimum* and *maximum* to be grammatically correct).

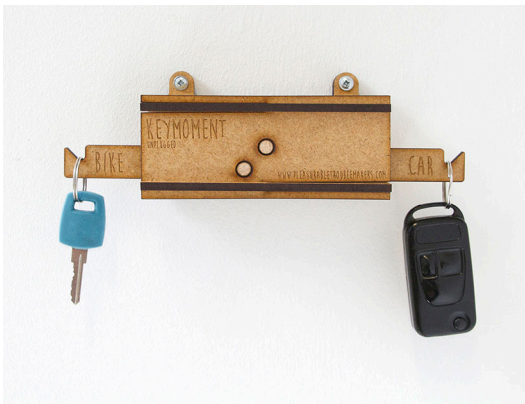


Figure 24. *Keymoment*, unplugged version (2014) by Matthias Laschke and Marc Hassenzahl. A movie illustrating the product in use is available at www.pleasurabletroublemakers.com/keymoment-1.

To find out how designers can enhance an artifact's aesthetic appeal by considering the artifact as the means to achieve an intended effect, we conducted three studies. Study 5 examined how both effects and means can be manipulated based on MEMM. Study 6 focused on how means can be minimized for a pre-established effect. Study 7 further tested the hypothesis that designers develop more aesthetically appealing artifacts when they consider a relatively broad set of alternative means to achieve an effect. We conducted our studies using a mixed-methods approach to research, particularly a sequential exploratory design (as described by Creswell, 2009). For the first two studies we employed an inductive

approach to theory building (Thomas, 2006) supported by thematic analysis of the data (Braun & Clarke, 2006), while for the third we employed statistical methods for data analysis.

We had to make choices regarding the variables that define designers, the tasks that they undertake and the artifacts that result from these tasks. We understand design(ing) as the activity by which a human agent (or group of agents) creates something intentionally. Design is thus defined by the intentional quality of this activity rather than by the specific qualities of the thing that results from it. In this sense, design encompasses the development of very different artifacts (e.g., a pair of stilettos, a public service), which result from very different tasks (e.g., stylizing feet, providing health care), which in turn are undertaken by people—designers—with very different skills (e.g., a fashion designer, a service designer). As participants taking the role of designers, we used master students who had acquired basic design knowledge at a bachelor’s level of education and who, for this reason, could help us identify basic design manipulations, that is, manipulations applicable to a variety of design areas and therefore relevant to design practice in general. We gave these participants tasks that explicitly focused on MEMM, but that were open enough so as to stimulate the (re)design of a variety of artifacts, including a wide range of products and services.

STUDY 5

METHOD

Participants. Eighty students from the Faculty of Industrial Design Engineering at Delft University of Technology participated in this study voluntarily.

Design. The study used a qualitative approach to research and was performed in the form of an individual assignment. The assignment consisted of open questions, which provided the opportunity to obtain unanticipated answers and thus explore unanticipated themes (see Fowler, 2009).

Materials. The materials used in this study were selected by the participants. Each participant was asked to choose an existing product merely based on their personal preference. The product could be physical or virtual, static or dynamic, and it could be connected to a service and integrated into a system. The participants' selection included, for example: an activity tracker, a bike-sharing system, a car, a drawing tablet, a fire extinguisher, a game console, a hand-held food blender, a kettle, a laptop, a lemon squeezer, an online payment app, a photo-sharing website, a record player, a sewing machine, a smartphone, a supermarket scanner, a vending coffee machine, a watch, a wake-up light, and a web browser.

Procedure. The participants were given an assignment that read as follows:

Designers develop products to achieve a variety of effects (for instance, to perform practical functions or to influence people's experiences, attitudes and behaviors in some way). This is why products and all the resources they make use of (for instance, the properties they have and the interactions they elicit) can be seen as means to achieve intended effects.

People appreciate a product aesthetically when they see it as a minimal means to achieve a maximal effect. This appreciation is governed by the principle of maximum effect for minimum means. Based on this principle, you will evaluate and suggest changes to the design of an existing product of your choice. Choose a product and answer the following questions:

(Q1) What is the intended effect of the product? Suggest a more maximal effect a product such as this could aim for (an alternative to the originally intended effect). Explain why the alternative effect is more maximal than the originally intended one.

(Q2) What resources are used by the product to achieve the intended effect? Suggest a more minimal way (means) to achieve the intended effect (an alternative to the existing product). Explain why the alternative means is more minimal than the existing product.

The participants were given a week to complete the assignment in written form. They submitted the assignments as typed documents in digital media, so there was no need for transcription.

RESULTS

The text of the participants' answers was submitted to thematic analysis using a general inductive approach, with a focus on the participants' explicit statements. The analysis involved: getting familiar with the data,

examining the entire data set in search for potential themes, reviewing the themes and refining the specific aspects of each of them, defining and labeling the main themes, and integrating the themes into this report.

Five themes were derived from answers to Q1, and five more from answers to Q2. The themes derived from answers to Q1 indicate general qualities of the maximum effect, while those derived from answers to Q2 indicate general qualities of the minimum means. These are the qualities that the participants aimed at to make the originally intended effect of the product more maximal or the product, as a means, more minimal.

The maximum effect was described as (a) *additional*, (b) *beyond practical*, (c) *relevant*, (d) *wide reaching*, or (e) *long lasting* relative to the product's originally intended effect (no hierarchy is implied in the order in which these qualities are mentioned).

(a) *Additional*. The maximum effect supplements a more basic effect or function that is already being achieved or performed. For example, a supermarket scanner has the fundamental function of informing people of an item's price. In addition, it could provide them with nutritional information about the item or even suggestions on how to use the item to prepare a meal. In comparison to just revealing a price, providing nutritional facts or guidelines for cooking (in addition to revealing the price) is a more maximal effect for the supermarket scanner.

(b) *Beyond practical*. The maximum effect influences people's lives in a non-instrumental way. It affects their experiences, attitudes, or behaviors and therefore can have implications for well-being, society, and the environment. For instance, a backpack assists people practically by helping them carry their belongings. But it could further show that it is made with recycled materials and ultimately stimulate sustainability. Relative to carrying personal belongings, promoting eco-friendly attitudes and behaviors among people is a more maximal effect for the backpack.

(c) *Relevant*. The maximum effect contributes to solving an important issue or to helping those people who are most in need. For example, a transport platform such as the railways helps people get from one point to the other on a regular basis, whether this is to go to work or to visit sites for recreation. But in the case of a global emergency in which large groups of people are forced to flee their homes in search for political asylum, the railways could offer transport to refugee centers. The railways would thus have a more maximal effect given the severity and urgency of the problem addressed.

(d) *Wide reaching*. The maximum effect affects many aspects of a person's life or the lives of many people. For instance, a lamp can mimic the way sunlight gradually increases at dawn to wake up people more naturally and thus help them get started with their morning routines. But the lamp could further mimic the dusk when it is time to go to bed and thereby help people relax and fall asleep. The effect of the lamp becomes more maximal as the lamp facilitates more routines for one person. Also, it becomes more maximal as the lamp facilitates these routines for more people.

(e) *Long lasting*. The maximum effect remains for a relatively long period of time. For example, a coffee machine has the immediate effect of providing people with a cup of coffee. In a work environment, the machine can further provide co-workers with an opportunity to talk to each other and get to know each other better. In the long term, the machine could contribute to creating a friendly and relaxed atmosphere at work. In comparison to the short-term effect of providing people with a cup of coffee, the latter and longer-lasting effect is more maximal for the machine.

Table 9 presents some of the participants' statements from which these five themes (and examples) were derived. More statements are provided for theme (b) *beyond practical* to represent the various aspects (experiential, attitudinal, behavioral) and implications (for well-being, society, and the environment) that this theme comprises. The connection of these statements with each of such aspects and implications is evident in the statements themselves.

Table 9. Themes derived from Study 5 representing qualities of the maximum effect.

Theme	Example of the statements from which the theme was derived
Additional	<p>Pressing the button should have a bigger effect than just showing the price and name of the [grocery] product. When pressing the button, a recipe with a suggestion for the next product to buy could pop up on the screen. [In] This way, the customer could not only see the price, but also follow the suggestions. (Participant 37, supermarket scanner.)</p>
	<p>If the red housing would be transparent the [insides] are shown and thereby people are challenged to solve the puzzle of the extinguisher's function. This facilitates a learning experience before and after use and keeps the extinguishing effect in case of fire. The extinguisher keeps its typical shape and purpose, but with a novel application of material and color an alternative effect is realized. (Participant 44, fire extinguisher.)</p>
Beyond practical	<p>A more maximal effect for the speaker can for example be "make you enjoy the music", "let you dance to the music", "let you see the music" or "get a feeling for the music". All these more maximal effects will improve the experience of the music. (Participant 28, speakers.)</p>
	<p>The current intended effect of the product is to store the user's personal things [...]. In order to be more sustainable and at the same time waterproof, the backpack could be made from decommissioned sails. In that way, not only the backpack would be an upcycled product, but the attitude of the user would change too, because he/she will be more encouraged to care about the environment. (Participant 17, backpack.)</p>
	<p>To achieve a more maximal effect, the scanner could also increase awareness of our online spending behavior. (Participant 55, bank card reader.)</p>
	<p>A more maximal effect that could be aimed for is to stimulate the shopper to buy more healthy food. [...] By buying more vegetables and less snacks, the individual will become healthier and will have an increased feeling of well-being. (Participant 47, grocery bag.)</p>
<p>The product could aim for triggering human interaction. The original effect only focuses on the user's individual feeling. My intended one broadens the effect to a social relationship. (Participant 45, smart lamp speaker.)</p>	
<p>The personal computer can take the role of a housekeeper, especially in the resource aspect. Thus, to fill a vacancy of carbon emission supervision in individual houses and also help people be aware of the resources they use in daily life. (Participant 34, laptop.)</p>	
Relevant	<p>A more maximal effect would be getting people to feel safe. For example, by making the car part of a product-service system to get refugees to a place where they feel safe. Compared to just transporting people, the effect of the car is now helping people who are in danger. The effect has become therefore more maximal than the originally intended one. (Participant 39, car.)</p>
	<p>The maximal effect this bag could be aiming for is that it could use the different patterns to help travellers with a language barrier ask for help (get directions to scenic spots, toilets, etc.), especially the disabled who have speaking problems. (Participant 10, tote bag.)</p>

	The intended effect of the product is waking you up more naturally. The more maximum effect would be helping you get the best night rest. This is a more maximum effect since it not only affects the waking up, but also the going to bed. (Participant 54, wake-up light.)
Wide reaching	The camera is intended to be used mostly by beginners who want to take quality pictures. An alternative to reach a more maximal effect is to make the product also suitable for intermediate and advanced photographers who want a more compact camera [...] This is a more maximal effect since the product can be used by a wide[r] range of photographers. (Participant 20, photo camera.)

	The coffee machine could provide the customer with renewed energy, with relief from stress and with inspiration to go on studying. This effect will last for a longer period of time than just providing the customer with a coffee. (Participant 60, vending coffee machine.)
Long lasting	The originally intended effect unfortunately lasts for a time because at some point the product will gain marks of wear and tear, usually the undesirable kind like cracks and scratches. What if wood that ages over time was used as the material instead of glass that shatters? This would not only serve as an aesthetical improvement over time as the texture of the organic warm material underneath is revealed, but also change the way we look at smartphones as they age. (Participant 15, smartphone.)

The minimum means was described as (a) *simple*, (b) *direct*, (c) *fast*, (d) *easy*, or (e) *inexpensive* relative to the existing product (again, no hierarchy is implied in the order in which these qualities are mentioned).

(a) *Simple*. The minimum means has few physical or virtual elements like buttons and icons, it comprises few functions and it requires few actions. For instance, a sewing machine can create many different stitches, each of which involves a specific function (and button) and requires the user to take specific measures (regarding fabric, thread, etc.) Some stitches are very similar to others and thus redundant. The machine becomes more minimal when its functions—and related buttons—are reduced, and when it engages the user—with less functions to consider—in a simpler interaction.

(b) *Direct*. The minimum means operates through a process or interaction consisting of few phases, stages or steps. For instance, a bike-sharing system currently requires the user to contact an employee who then scans the user's identification card and thereby registers the loan of the bike. Alternatively, a scanner could be integrated into the bike, so that the user could register the loan without the mediation of another

person. This would make the interaction with the system more direct and consequently minimize the system as a means.

(c) *Fast*. The minimum means achieves the effect in a relatively short period of time, which is closely related to the fact that it operates through a process involving a few steps or actions. For example, a photo printer normally requires people to, on the one hand, feed it with paper, and, on the other, press a button to start the printing job. But the printer could use the paper feed as a cue for starting the job, thereby removing the need for pressing a button and reducing the time required for printing. The quicker the printer manages to print, the more minimal it becomes.

(d) *Easy*. The minimum means requires people to have little skill or make little effort, whether physical or cognitive, during use or interaction. For instance, a payment terminal traditionally requires people to insert or swipe their bankcard within a narrow slot. Alternatively, it can make use of wireless technology to read the card at a short distance. Although placing the card in the slot is not very difficult, just bringing it close to the terminal is even easier. The easier the interaction with the terminal is, the more minimal the terminal becomes.

(e) *Inexpensive*. The minimum means operates by exploiting only a few resources, resources that are already available or resources that do not cost much. For example, a car normally uses fuel to run, which can be quite expensive. Moreover, the car's combustion of fuel causes polluting CO₂ emissions and thus reduces the amount of available fresh air. In this sense, the use of fuel is also expensive environmentally. Clearly, by comparison, a bicycle is a more minimal means of transportation.

Table 10 presents some of the participants' statements from which these five themes (and examples) were derived.

Table 10. Themes derived from Study 5 representing qualities of the minimum means.

Theme	Example of the statements from which the theme was derived
Simple	There is a total of twenty-three buttons on it to achieve functions that are quite similar, so I would propose to get rid of most of them and combine them in one simple interface. However, it's arguable if those functions are even necessary to fulfill the effect, so we could get rid of them altogether. (Participant 56, sewing machine.)
	To achieve the intended effect, users need to adjust both music and light. The methods could be tapping the surface, connecting the product with a phone or pressing the buttons directly on the product. My suggestion for a minimal way is to make the product elicit the interaction requiring just one kind of action. (Participant 45, smart lamp speaker.)
Direct	An employee now has to scan the bike, and the customer has to wait in line for the bike to be scanned. In the redesign, the bike itself contains the scanner, meaning it can be unlocked by the public transport card and simultaneously register the use of the bike on the card. This creates a more direct interaction, making it a more minimal means. (Participant 38, bike-sharing system.)
	The process of downloading images can be optimized by reducing the steps of the current process to a hand gesture. (Participant 13, photo camera.)
Fast	It would make sense if the action of sliding the paper into the printer would start the print job [...] The time delay is [thereby] removed. (Participant 50, photo printer.)
	With this redesign, you do not have to brew the coffee in a percolator, but brew it already in a small espresso cup. The process [of brewing the coffee] is quicker. (Participant 66, mocha pot.)
Easy	The payment process can be made easier by making it unnecessary to connect the bankcard and the terminal at a close distance. When the terminal is able to recognize a bankcard is near, the user will be able to identify himself at the terminal by pin code or fingerprint. The process will be even more easy. (Participant 61, payment terminal.)
	The main screen offers to go into five main menu sections [...] Yet there are way more than five elements visible on this page. The top of the page for example is covered by two large elements which seem to be aimed more at graphically decorating the page than achieving the intended effect. [...] The redesign attempts to minimize the perceptible load on the user. (Participant 31, phone account management app.)
Inexpensive	A car normally uses fuel to get from A to B. This is polluting the environment and exhausting the planet. A more minimum way would be for example using magnetic fields as energy source for transportation because it is less exhausting for the planet. (Participant 39, car.)
	The washing process consumes electricity, water and also the soap. [...] The alternative means is more minimal because it fits the cleaning process into the after-use of the towels. It avoids another cycle of actions specially for cleaning and saves resources consumed for maintenance. (Participant 11, bath towel.)

DISCUSSION

Study 5 suggested how designers can enhance the aesthetic appeal of an artifact by manipulating both the artifact as a means and the effect the artifact has. They can maximize the artifact's effect by making it additional, beyond practical, relevant, wide reaching, or long lasting. For example, they can add an extra effect to the basic function of a product so as to affect people experientially (thus creating an additional and beyond-practical effect). They can minimize the artifact as a means by making it simple, direct, fast, easy, or inexpensive. For example, they can remove all redundant features of a product and enable an effortless interaction with it (thus creating a simple and easy means).

The findings of this study are based on the redesign of a variety of existing products (or product-service systems), which suggests that the aforementioned qualities could serve as aesthetic criteria for the development of a wide range of artifacts. This also implies, however, that our findings carry the limitation of being grounded in the redesign of existing products, which is quite restricting for designers. Further information on potential design strategies could be found by examining artifacts explicitly designed as means to achieve a certain effect. For instance, evaluating a set of different design concepts developed to achieve the same effect could provide a deeper insight into how a means can be minimized. Study 5 indicated that a means can be minimized based on five qualities, but also suggested that these qualities refer to different dimensions of an artifact (e.g., direct and easy were linked to the interaction the artifact allows for). We conducted Study 6 to further explore the minimization of means, but this time for a fixed effect.

STUDY 6

METHOD

Participants. Two students from the Faculty of Industrial Design Engineering at Delft University of Technology were given two design briefs, which they undertook voluntarily. Their work was then evaluated by twenty students from the same Faculty, who were paid 10 Euros each

in return for their evaluations. From now on, we refer to the first two participants as *the designers* and to the other twenty as *the evaluators*.

Design. The study used a qualitative approach to research and was performed in two stages. Two sets of design concepts were initially developed based on two different briefs. The two sets were then assessed in writing by filling a semi-structured printed form.

Materials. The materials used in this study were developed to gain a deeper insight into how designers can enhance the aesthetic appeal of an artifact by minimizing the artifact as a means. They were developed based on two design briefs conceived with a common idea: the same effect can be achieved through different means. Both briefs instructed the designers to develop various means to achieve an effect of their choice. But for Brief A these means were to be developed within the domain of product design, while for Brief B they were to be developed across design domains. We tried to ensure diversity of designs by, on the one hand, letting the designers freely choose the effect they were designing for and, on the other hand, instructing one of them to develop means within a single design domain and the other one to develop them in several domains.

For both briefs, the means were developed as design concepts represented with sketches and written descriptions. The sketches were drawn by hand to a similar level of detail within each set of concepts. The descriptions were prepared in collaboration with the research team so as to ensure that the texts were of similar length and provided the same kind of information: a general description of the concept (“this is...”) and the particular way in which it achieved the designer’s intended effect (“it [achieves the effect] by...”). The resulting sets of concepts A and B will be presented in the results section.

Procedure. The designers developed the sets of concepts independently and in their own time, over a period of approximately six weeks. Both of them submitted the sketches and texts describing their concepts as digital files, so there was no need for digitization or transcription.

The rest of the study was conducted in the studios of the Faculty of Industrial Design Engineering at Delft University of Technology. After

being introduced to the study, the evaluators were given either set of concepts on cards measuring 10 by 14 cm. The evaluation task was presented with the following text:


Designs are developed to achieve a variety of effects (for instance, to perform practical functions or to influence people’s experiences, attitudes, and behaviors in some way). This is why designs and all the resources they make use of (for instance, certain properties or interactions) can be seen as means to achieve intended effects. People appreciate a design aesthetically when they see it as a minimal means to achieve a maximal effect. This appreciation is governed by the principle of maximum effect for minimum means.





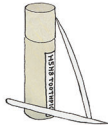

The evaluators were first asked to rank the concepts according to how they achieved the corresponding effect, from the minimum means to the maximum means. They were then asked to write an answer to the question “what criteria did you use to rank the seven concepts?” They were required to summarize each criterion by using the format “the more/less [quality or description (e.g., simple)], the more minimal the concept is”. They were given an hour to complete the task. Their written answers were then transcribed for analysis.

RESULTS

The designer undertaking Brief A proposed ways to “make the most of (sanitized) culled-chicken materials” (a non-specific intended effect). As alternative means, this designer developed a set of seven concepts identified as jewelry, lamp, lampshade, stool, tableware, toothpicks, and urn. This set of concepts (Set A), which is further described in the designer’s master thesis (Van Spronsen, 2015), is presented in Table 11.



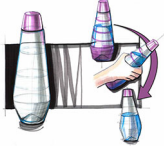
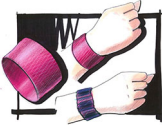



Table 11. Set A of concepts developed and evaluated in Study 6.

Concept	Sketch	Description
Jewelry		This is a set of jewelry in which items are shaped similarly to sick body cells. It makes the most of chicken materials by covering bits of chicken meat in transparent epoxy.

Lamp		<p>This is a pendant lamp revealing a pattern of feathers when the light is turned on. It makes the most of chicken materials by casting see-through resin together with chicken feathers that have been shredded.</p>
Lampshade		<p>This is a lampshade with a relatively typical shape. It makes the most of chicken materials by displaying pieces of chicken leather that have been tanned in different tones and pasted together with glue.</p>
Stool		<p>This is a stool recalling the ancient use of chicken feathers as pillow fillers. It makes the most of chicken materials by exhibiting a cushion-like shape cast in clear resin with colored feathers on top of four wooden legs.</p>
Tableware		<p>This is a set of tableware that might provide some "food for thought". It makes the most of chicken materials by being formed by hand using grounded chicken bone as clay, which is fired at high temperature.</p>
Toothpicks		<p>These are toothpicks that can be reused because of how strong and flexible they are. They make the most of chicken material by exploiting the natural properties of chicken bones, which only require filing and polishing.</p>
Um		<p>This is an urn symbolizing how the death of chicken can be turned into life. It makes the most of chicken material by being 3D-printed with chicken bone ash and further containing ashes that can be used as soil fertilizers.</p>

The designer undertaking Brief B chose to “stimulate people to drink more water” (intended effect). As alternative means, this designer developed seven concepts identified as app, bite, bottle, bracelet, installation, poster, and service, in the corresponding domains of digital-, food-, product-, fashion-, interior-, graphic-, and service design. This set of concepts (Set B) is presented in Table 12.

Table 12. Set B of concepts developed and evaluated in Study 6.

Concept	Sketch	Description
App		This is an application for smart devices that “dehydrates” the icons on the main screen after a predefined lapse of time. It stimulates people to drink more water by metaphorically showing the effects of dehydration.
Bite		This is a healthy bite with an outer shell of flavored jelly and water filling. It stimulates people to drink more water by disguising it as a more tempting thing to eat.
Bottle		This is a drinking bottle that changes from translucent to colored when not moved regularly. It stimulates people to take the bottle and then drink more water by creating an inviting perceptual stimulus.
Bracelet		This is a bracelet made with a smart textile that senses skin moisture and wrinkles when the moisture level is low. It stimulates people to drink more water by physically showing the consequences of dehydration.
Installation		This is a waterfall-like interior installation from where drinkable water can be poured. It stimulates people to drink more water by creating an appealing visual and auditory sensation while facilitating water pouring.
Poster		This is a poster using a motivational message to highlight the benefits of water consumption. It stimulates people to drink more water by providing explicit arguments for this behavior.
Service		This is an opt-out service that provides people with a personal bottle and numerous refill stations within their work environment. It stimulates people to drink more water by creating optimal conditions in the workplace.

As mentioned in the procedure section, the evaluators assessed these sets of concepts on how minimal they were as means to achieve the corresponding effect. Transcripts of these assessments were submitted to thematic analysis using a general inductive approach, with a focus on the evaluators' explicit statements. We conducted this analysis following the same steps as in Study 5.

In answers to the question “what criteria did you use to rank the seven concepts?”, we identified the same five themes derived from Q2 in Study 5, which indicate qualities of the minimum means: (a) *simple*, (b) *direct*, (c) *fast*, (d) *easy*, and (e) *inexpensive*. We also derived another theme representing an additional quality of the minimum means, i.e., (f) *seamless*. We further refined our analysis by deriving three subthemes. These subthemes represent dimensions of an artifact to which the six aforementioned qualities apply: *conceptualization*, *production*, and *interaction*. In describing the themes, we emphasize how each relates to the subthemes. Not all six themes are characterized by all three subthemes. This is to say not all the six qualities of the minimum means apply to all three dimensions of an artifact.

(a) *Simple*. The minimum means can be described by a simple conceptualization, production, or interaction. Simple conceptualization implies that the means is conceived to have as few components as possible, devoid of any redundant element, whether physical or virtual. Simple production implies that it can be manufactured through a single or few methods, or through methods that are not very complex or sophisticated. Simple interaction implies that it requires few physical actions or an uncomplicated mental process from people.

(b) *Direct*. The minimum means can be described by a direct conceptualization, production, or interaction. Direct conceptualization implies that the means is conceived as an immediate way to achieve an effect, or as a direct solution to a problem, which does not require the intervention of an external mechanism or agent. Direct production implies that it can be manufactured through a process that involves relatively few steps or phases, hence, that the production of the means is relatively immediate. Direct interaction implies that people only need to take a few physical or mental steps to engage with the means.

(c) *Fast*. The minimum means can be described by a fast production or interaction. Fast production denotes that the means can be manufactured in a relatively short period of time; for instance, due to automatized processes or new technologies. Fast interaction denotes that it only requires people to invest a small amount of time to make sense of it or use it.

(d) *Easy*. The minimum means can be described by an easy production or interaction. Easy production denotes that the means can be manufactured without much difficulty; for instance, without materials that are hard to find or process. Easy interaction denotes that it does not demand much physical or mental effort from people and that is therefore easy to operate or understand.

(e) *Inexpensive*. The minimum means can be described by an inexpensive production, that is, by a production that does not cost much because it requires relatively few resources or because it requires resources that are relatively cheap or are already available. These resources include, for example, materials, technologies, and workforce.

(f) *Seamless*. The minimum means can be described by a seamless interaction, that is, by an interaction that is well integrated into people's existing routines, as opposed to an interaction that interferes with their daily practices. For instance, a minimal way to make people drink more water could be to strategically place water stations in their work environment. The stations would stimulate a seamless interaction if they are placed along the corridors that people walk through the most, or in the areas where they spend most of their working hours, rather than just in pantries and cafeterias.

Table 13 presents some of the evaluators' statements from which the themes and subthemes were derived. In this table, we identify the evaluators with a letter-number combination. Letters A and B indicate the set of concepts they were given to assess and numbers from 1 to 10 distinguish the evaluators assessing each set of concepts.

Table 13. Themes and subthemes derived from Study 6 representing qualities of the minimum means and the dimensions to which they apply.

Theme	Subtheme	Example of the statements from which the theme and subtheme were derived
Simple	Conceptualization	The solution should have a minimal amount of components—The less components, the more minimal the concept is. (Evaluator B2.)
	Production	The less manufacturing methods, the more minimal the concept is. (Evaluator A2.)
	Interaction	The more simple to use, the more minimal the concept is. (Evaluator B4.)
Direct	Conceptualization	The solution can be in the product itself (water bottle, jelly bites) or outside of the product (bracelet, poster, app)—The closer the solution is related to the problem, the more minimal the concept is. (Evaluator B3.)
	Production	If the product can be made in fewer steps, I would think it [is] more minimal—The less [manufacturing] steps, the more minimal the concept is. (Evaluator A10.)
	Interaction	The less other distracting actions are needed to finish or accomplish something, the more minimal the concept is. (Evaluator B9.)
Fast	Production	How much time would it take to make?—The less time needed, the more minimal the concept is. (Evaluator A4.)
	Interaction	It doesn't take long to understand how the [more minimal] concept works. (Evaluator B2.)
Easy	Production	A poster can be easily printed—The less difficult to make, the more minimal the concept is. (Evaluator B8.)
	Interaction	The more easily the product can be understood or used, the more minimal the concept is. (Evaluator A1.)
Inexpensive	Production	A concept appears minimal to me if it requires less materials or work power in its development or fabrication, especially fabrication—The less resources [are required] in building it, the more minimal the concept is. (Evaluator B6.)
Seamless	Interaction	People shouldn't have to make changes in their "normal routine" [for the concept]—The more integrated into [people's] normal life, the more minimal the concept is. (Evaluator B3.)

The selection of statements presented in Table 13 further represents two distinct general patterns in the evaluations of the two sets concepts. Set A was predominantly evaluated based on considerations about production, while Set B was evaluated based on considerations about conceptualization and interaction too. We will discuss this finding in the next section.

DISCUSSION

Study 6 expanded on the findings of Study 5 showing how designers can enhance the aesthetic appeal of an artifact by manipulating the artifact as a means. It first confirmed that designers can minimize an artifact as a means by making it simple, direct, fast, easy, or inexpensive, and added seamless to this list of qualities. It also revealed that these qualities refer to different dimensions of the artifact: conceptualization, production, and interaction. This implies that an artifact can be minimized through a simple or direct conceptualization; through a simple, direct, fast, easy, or inexpensive production; and through a simple, direct, fast, easy, or seamless interaction. Altogether, the findings of Studies 5 and 6 suggest a set of qualities that designers can aim at when defining an intended effect and developing an artifact as the means to achieve it; more specifically, they suggest what aspects of an artifact can be manipulated based on these qualities. Figure 25 summarizes these findings.

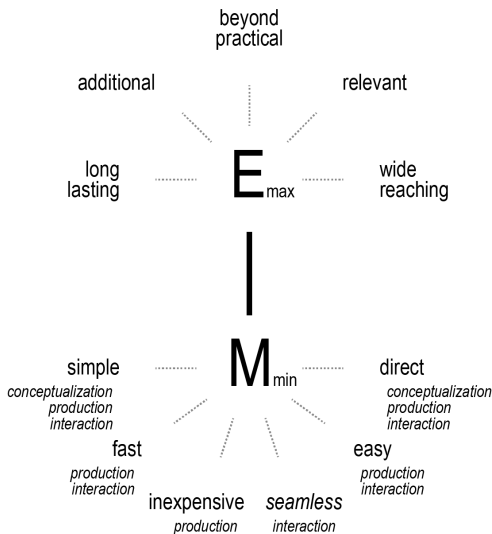


Figure 25. Summary of the findings of Study 5 (regular font) and Study 6 (italicized font). These studies reveal the qualities of the effect and the means that the principle of MEMM relates, i.e., the maximum effect (E_{max}) and the minimum means (M_{min}).

Two different sets of concepts were developed and evaluated in Study 6, each with a single effect in mind. The concepts in Set A were all developed within the domain of product design, while those in Set B were developed in seven different design domains (digital-, food-, product-, fashion-, interior-, graphic-, and service design). The concepts in Set A were mainly evaluated based on their production, while the concepts in Set B were evaluated based on conceptualization and interaction too. Based on the range of design domains it covered and the range of dimensions on which it was evaluated, Set B represents a wider collection of means than Set A. Hence, these sets of concepts not only show that designers can pursue the same effect through many different means, but also that they can think of these possible means in relatively narrow (as in Set A) or broad (as in Set B) ways. In other words, designers can consider more or less limited sets of alternative solutions for a given problem. In light of this, we wondered if the outcome of a design task would be more or less aesthetically appealing depending on whether designers consider a “broad” or a “narrow” collection of alternative means to achieve a given effect. In comparison with a narrow set, a broad set of means seems more likely to include what people would judge to be the minimum means and thus—according to MEMM—the most appealing one. On this basis, we hypothesized that designers develop more aesthetically appealing artifacts (more minimal artifacts) when they consider a relatively broad set of alternative means to achieve an effect. A way to test this hypothesis is to prepare designers for the same task so as to stimulate them to think of design solutions in more or less limited manners. For example, prior to being given the task, one group of designers could be shown Set A of concepts (in what can be referred to as a “narrow-priming” condition) and another group of designers could be shown Set B of concepts (in what can be referred to as a “broad-priming” condition). This is what we did in Study 7.

STUDY 7

METHOD

Participants. The twenty students who served as the evaluators in Study 6 took the role of *the designers* in this study in return for 15 Euros. Their work was evaluated by thirty-three educators from the Faculty of

Industrial Design Engineering at Delft University of Technology, who participated in this study voluntarily. We refer to these educators as *the evaluators* from now on.

Design. The study used a quantitative approach to research and was conducted in two stages. Two sets of design ideas were initially developed based on the same design brief, but under two different priming conditions: narrow priming and broad priming. These sets were then assessed on two 7-point scales measuring the variables minimum means and aesthetic appeal.²⁰

Materials. Considering the hypothesis we aimed at testing, we asked the evaluators of Study 6, who had assessed concepts from either Set A (narrow priming) or Set B (broad priming), to take the role of designers and develop the materials for Study 7. These materials were generated based on a brief that instructed the designers to each develop the minimum means to achieve an effect pre-established by the research team. By fixing the effect, we tried to ensure the comparability of means necessary for their evaluation; by asking the designers to work independently, we tried to ensure some diversity among these means.

The means were developed as ideas represented with sketches and written descriptions. The sketches were drawn by hand and the descriptions were written using a format provided by the research team, so that they would offer the same kind of information: a general description of the idea (“this is...”) and the particular way in which it achieved the specified effect (“it [achieves the effect] by...”). The resulting sets of ideas A (narrow priming) and B (broad priming) will be presented in the results section.

Procedure. The designers generated their ideas in the studios of the Faculty of Industrial Design Engineering at Delft University of Technology. Having been provided with general information about MEMM in Study 6, they were instructed to design a minimal way to “integrate refugees into European society”. This pre-established effect is

²⁰ These variables and the corresponding scales are related to those from Studies 3 and 4. Minimum means represents a specific aspect of what we labeled *MEMM* in Studies 3 and 4, while aesthetic appeal can be taken as the equivalent of what we identified as *aesthetic appreciation* in those studies.

in line with the effects that contemporary designers aim at achieving to ultimately improve the world (see, for example, the ideas presented by Van Lier & Nolan, 2015). The designers developed their ideas based on the information they found from Internet searches and the following text (of which the first two paragraphs were adapted from BBC, 2015):

Europe is experiencing one of the most significant influxes of migrants and refugees in its history. Pushed by civil war and terrorism, and pulled by the promise of a better life, hundreds of thousands of people have fled the Middle East and Africa, risking their lives along the way.

Under EU rule, refugees are required to claim asylum at arrival. Asylum seekers have the right to food, first aid and shelter in a reception center, and are supposed to be granted the right to work within nine months of arrival.

Keeping in mind the principle of maximum effect for minimum means, your task is to design a minimal way to integrate refugees into European society.

The designers were given one and a half hour to develop their ideas, and they were supervised to make sure they worked individually. They submitted the sketches and written descriptions on paper. These materials were then digitized and transcribed to conduct the rest of the study.

The rest of the study was conducted as an online questionnaire with the evaluators, who completed the questionnaire in their own time. The questionnaire first explained the intended effect of the ideas and then displayed the sketches at a uniform 12 cm high and 17 cm wide, together with the written descriptions. It required the evaluators to rate each idea from 1 (*fully disagree*) to 7 (*fully agree*) on the following items: “this idea is an efficient way to integrate refugees into European society”; “this idea uses unnecessary means to integrate refugees into European society” (phrased to avoid double negative, rating inverted for analysis); “this is a beautiful idea”; and “this is an attractive idea”. We took the first two items as joint indicators of minimum means (based on Da Silva et al., 2016 [chap. 3]), and the last two as joint indicators of aesthetic appeal (based on Blijlevens et al., 2014). The order of presentation of both ideas and scale items was randomized between the evaluators to prevent order effects. It took them approximately 20 minutes to complete the questionnaire.

RESULTS

The designers in the narrow-priming condition generated a total of 10 ideas (Set A), as did those in the broad-priming condition (Set B). These sets of ideas are presented in Tables 14 and 15 respectively. In these tables, we identify the ideas with a letter-number combination. Letters A and B indicate the conditions the ideas were generated in, while numbers 1 to 10 distinguish the designers working in each condition. This coding will be used for their identification in the remaining analyses.




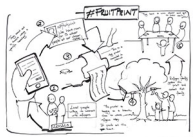
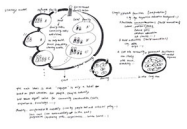
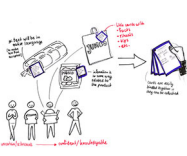


Table 14. Set A of ideas generated and evaluated in Study 7.

Idea	Sketch	Description
A1		<p>This is an exchange exhibition held in the local neighborhood and by the local community. It contributes to integrating refugees into European society by building a face-to-face connection for them to share their personal experiences as well as for local Europeans to share living goods and supplies; by exchanging stories and supplies, people understand and trust each other more.</p>
A2		<p>This is a tent for holding a second-hand market for refugees. It contributes to integrating refugees into European society by helping them get the stuff they need, being a medium to communicate with locals and conveying the feeling of the local atmosphere.</p>
A3		<p>This is a simple and common wearable product. It contributes to integrating refugees into European society by asking European people to help teach the language and also by explaining a little of the refugees' situation so as to create a topic a conversation and trigger another citizen to help out.</p>
A4		<p>This is a puzzle game to teach English to refugees: If they match the right tiles, the word is spoken and becomes visible; this also helps against boredom at the refugee center. It contributes to integrating refugees into European society by teaching them the local language, or a well-known language, so they can communicate with locals, find a job and feel part of the community.</p>
A5		<p>This is a service design that brings European society and refugees together. It contributes to integrating refugees into European society by letting them learn habits and language and by creating mutual appreciation and respect.</p>

A6		<p>This is a service that matches people and brings them together. It contributes to integrating refugees into European society by helping them find someone that can help them with anything: finding the right store to buy something, learning the language, or finding a sports team to play with.</p>
A7		<p>This is a service-system solution covering the overall refugees' journey from arrival into the EU to full integration. It contributes to integrating refugees into European society by involving the refugees themselves in the refugee emergency management, but aiming at job finding and language and culture learning as the ultimate target.</p>
A8		<p>This is a temporary module that provides shelter and basic amenities for nine months or until the refugees find employment. It contributes to integrating refugees into European society by providing the essentials required to sustain life and an opportunity to secure the refugees' future.</p>
A9		<p>This is an internet helping system, a simple platform. It contributes to integrating refugees into European society by stimulating them to engage in EU society and making EU people and refugees more knowledgeable about each other.</p>
A10		<p>This is a story-sharing machine placed in public areas such as train stations and markets. It contributes to integrating refugees into European society by creating a channel for them to share some things of their own.</p>

Table 15. Set B of ideas generated and evaluated in Study 7.

Idea	Sketch	Description
B1		<p>This is an official EU online information support service-system where refugees advertise themselves to the labor market, seek for legal documentation procedures, and look for the help they need. It contributes to integrating refugees into European society by allocating them into matchable categories according to the labor openings across EU countries, hence planning their own applications.</p>
B2		<p>This is a set of cards with different symbols and pictures, ranging from simple to complex, from funny to more serious topics. It contributes to integrating refugees into European society by creating a setting in which both refugees and Europeans can comment on what a certain picture means to them and then come to understand the other person or culture in a more profound way.</p>

- B3  This is a smartphone app to connect refugees with residents by means of a service exchange: Refugees can help residents in exchange for help from residents. It contributes to integrating refugees into European society by stimulating them to make friends and learn about a different culture while feeling comfortable and accepted.
- B4  This is an app for a mobile device that crosses the barrier between refugees and EU citizens by connecting them for just a brief period of time. It contributes to integrating refugees into European society by teaching them more about their new environment, helping them with everyday problems and getting them in contact with European citizens.
- B5  This is a card that shows the motivation of the refugee to integrate. It contributes to integrating refugees into European society by triggering empathy among Europeans and ultimately facilitating job opportunities for the refugees.
- B6  This is a tiny printing device connected to the Internet; locals can send out tweets that will be printed by the device close to where the refugees stay. It contributes to integrating refugees into European society by connecting them with locals without requiring them to have a smart device.
- B7  This is a service design to assist refugee families in starting their lives in an unfamiliar country more comfortably. It contributes to integrating refugees into European society by using the human source (community source) which is already there, but not active or motivated enough yet.
- B8  This is a graphic addition to the food packages and other supplies distributed among refugees, explaining certain rituals, activities or values of the European country they are in and how they relate to their culture. It contributes to integrating refugees into European society by teaching them about the country's culture so that they feel more at ease.
- B9  This is a social project that offers refugees a public stage to share their thoughts. It contributes to integrating refugees into European society by creating a chance for them to share their values and character with the Europeans, so as to crack any misunderstanding and facilitate the communication between the two groups.
- B10  This is an app that teaches refugees the language of the country where they will be staying. It contributes to integrating refugees into European society by enabling them to start learning as soon as possible, without waiting for the official integration lessons, thus facilitating life in their new environment.

As mentioned in the procedure section, the evaluators rated each of these ideas from 1 to 7 on four items, of which two were taken as a joint measure of minimum means, and the other two as a joint measure of aesthetic appeal. We averaged the scores of the items measuring minimum means, on the one hand, and aesthetic appeal, on the other, and analyzed the data thus obtained statistically.

To assess the effects of priming (narrow priming and broad priming) and minimum means on aesthetic appeal, we conducted a regression analysis. Since each evaluator rated the entire set of ideas, the ratings obtained from an individual evaluator were not independent of one another. Also, each idea was rated by the entire group of evaluators, so the ratings given to an individual idea were not independent of one another either. Our data were therefore nested at both the level of the evaluators and the level of the ideas. To account for this, we conducted a multilevel linear analysis (West, Welch, & Galecki, 2014), which had a cross-classified design with random intercepts at both levels (evaluators and ideas). In that way, it was formally accounted for by the model that individual evaluators and individual ideas might deviate from the general rating pattern. Such deviations were irrelevant in view of our hypothesis, which required us to focus on the general effects (or fixed effects) of priming and minimum means, independently of the peculiarities of individual evaluators or ideas. Our statistical procedure therefore led to a more accurate estimation of the effects we were interested in.

The multilevel linear analysis revealed that priming had no significant effect on aesthetic appeal. Contrary to our hypothesis, the ideas generated in the broad-priming condition were not judged to be more aesthetically appealing than those generated in the narrow-priming condition. Minimum means, however, did have a significant positive effect on aesthetic appeal ($b = .70$, $SE = .04$, $p < .001$). In line with the principle of MEMM, the more minimal an idea was perceived to be, the more appealing it was judged to be as well. (The interaction between priming and minimum means was not significant.) In sum, this analysis provided no evidence that the designers primed with a relatively wide range of means generated more aesthetically appealing ideas. But it did indicate that, irrespective of the means they were primed with, those

designers that employed the more minimal means generated the more aesthetically appealing ideas.

To offer a more complete report on the relationship between minimum means and aesthetic appeal, we calculated mean ratings for the whole data set (minimum means: $M = 4.01$, $SD = 1.54$; aesthetic appeal: $M = 3.51$, $SD = 1.62$) and for each of the ideas. We present the mean ratings of the ideas in Table 16 and illustrate their linear relationship in Figure 26.

Table 16. Ratings of the ideas generated in Study 7.

Idea	Minimum means		Aesthetic appeal	
	M	SD	M	SD
A1	4.26	1.40	3.67	1.61
A2	3.30	1.64	2.86	1.43
A3	3.44	1.81	2.79	1.67
A4	4.06	1.51	3.95	1.72
A5	4.91	1.28	4.27	1.78
A6	4.92	1.18	4.12	1.43
A7	4.95	1.19	4.15	1.49
A8	4.02	1.20	3.39	1.56
A9	3.73	1.24	2.98	1.47
A10	2.42	1.36	2.50	1.36
B1	4.74	1.36	3.80	1.58
B2	4.18	1.48	4.09	1.66
B3	4.50	1.46	3.64	1.48
B4	4.32	1.39	3.73	1.40
B5	3.48	1.56	2.58	1.48
B6	3.15	1.37	2.95	1.49
B7	4.30	1.32	3.52	1.68
B8	4.03	1.50	3.73	1.45
B9	3.95	1.45	3.53	1.73
B10	4.45	1.56	3.89	1.40

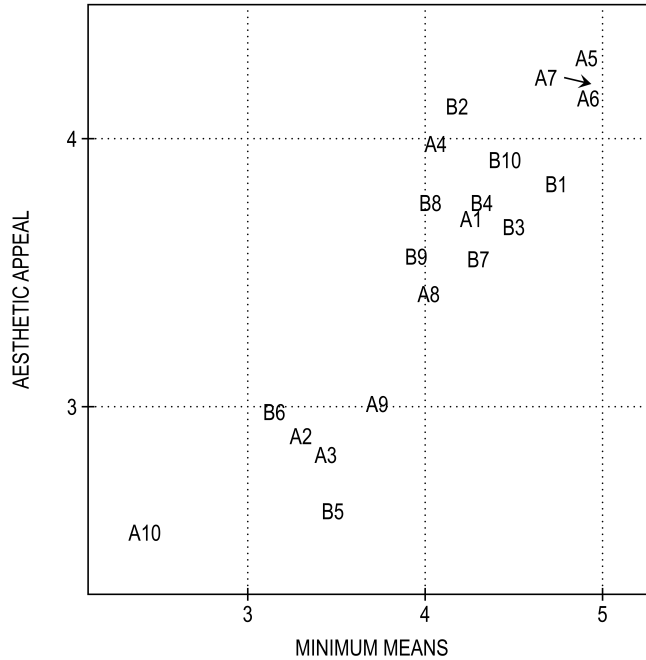


Figure 26. Relationship between average aesthetic-appeal and minimum-means ratings of the ideas (Study 7). (Higher minimum-means ratings represent more minimal ideas.)

DISCUSSION

Study 7 tested the hypothesis that designers develop more aesthetically appealing artifacts (more minimal artifacts) when they consider a relatively broad set of alternative means to achieve an effect. We found no support for this hypothesis. The designers in the broad-priming condition did not come up with more minimal or more aesthetically appealing design ideas than those in the narrow-priming condition. The study, however, provided evidence that the aesthetic appeal of an artifact partially depends on how minimal the artifact is judged to be: the more minimal, the more appealing it is perceived to be. This lends empirical support for the principle of MEMM, in line with the findings of previous research (Da Silva et al., 2016 [chap. 3]).

The results of Study 6 indicate we primed the designers in Study 7 with the right stimulus materials. As compared to the materials used for narrow priming, those used for broad priming were developed in a variety of design domains (rather than just product design); moreover,

they represented a variety of means manipulations as they involved manipulations of conceptualization, production, and interaction (rather than just production). Hence, our selection of stimuli does not seem to explain why we did not find support for our hypothesis. Instead, our results might be explained by the difficulty of the brief we gave the designers and the limited time they had to work on this brief. Integrating refugees into European society is a complex design task, which requires much more than one hour and a half to be fully developed. Irrespective of the stimuli they were primed with, the designers might have not even been able to make full sense of the effect they were asked to achieve, let alone to develop a minimal means to achieve it. Providing designers with a simpler brief and more time to work on it might thus contribute to further understand how they can design aesthetically appealing means for a given effect.

DISCUSSION OF CHAPTER 5

Based on the principle of MEMM, we investigated how designers can enhance an artifact's aesthetic appeal by considering the artifact as the means to achieve an intended effect. Study 5 examined how an effect can be maximized and a means minimized, while Study 6 focused on the minimization of the means for a fixed effect. Altogether, the results of Studies 5 and 6 suggested that designers can enhance the aesthetic appeal of an artifact by making the artifact's effect additional, beyond practical, relevant, wide reaching, or long lasting, as well as by making the artifact itself (means) simple, direct, fast, easy, inexpensive, or seamless with regards to its conceptualization, production, or interaction. Study 7 tested the hypothesis that designers develop more aesthetically appealing artifacts when they consider a relatively broad set of alternative means to achieve an effect. The study did not provide support for this hypothesis. Nonetheless, it provided evidence that the more minimal a means is judged to be, the more aesthetically appealing it is perceived to be as well. This adds to the evidence presented in the previous chapter that the aesthetic appreciation of an artifact partially depends on MEMM.

Our findings should be interpreted considering the way designers, design tasks and (designed) artifacts were represented in our studies. As we previously mentioned, design(ing) can be defined based on the

intentional quality of human agency, rather than by the specific qualities of the artifact that is created through this agency. This means that many different things can play the role of an artifact, but also that very different tasks can be considered design tasks, and that people with very different abilities can be considered designers. In Studies 5 to 7, design students played the role of the designers. We believe their non-specialized design knowledge helped us identify a set of basic manipulations, applicable to various design fields. Other, more specific ways to enhance aesthetic appeal might be identified by studying how professional designers apply MEMM in specific fields (e.g., car designers might reveal manipulations specific to automotive design). We gave our participants tasks that explicitly focused on MEMM and required no more than a visual and written proposal for the (re)design of artifacts. While these tasks provided the opportunity to address our research question, they differ from actual design tasks where designers are not only or mainly driven by aesthetic concerns, and where they have to take into account the various consequences their actions can have in reality. Hence, the manipulations we identified should not be applied to real-life scenarios without considering their non-aesthetic ramifications (e.g., enhancing services aesthetically by dismissing employees from their jobs has serious social implications). Finally, with the aim of drawing conclusions relevant to a wide range of design domains, we used a wide range of artifacts as stimulus materials. None of our sets of materials should be taken as a complete representation of a particular design domain (e.g., the concepts in Set A, Study 6, were developed within the domain of product design, but they only represent a fraction of possible designed products—a very peculiar fraction, involving the use of culled-chicken materials). For this reason, we cannot draw domain-specific conclusions from our studies. Yet, we see how our findings can support two distinct kinds of design practice.

Thinking about design practice in terms of means and effects is not uncommon, although these notions often shape the understanding of design practice only implicitly. This practice is frequently defined based on either the means that it uses (e.g., product design, service design, digital design) or the effect that it aims at achieving (e.g., design for sustainability, design for well-being, design for behavioral change). The means are relatively fixed for the means-based practice, as are the effects

for the effect-based practice. For instance, a diversity of applications can be developed within the realm of digital design, but they all are *digital* applications; a variety of transformations can be pursued in the domain of design for behavioral change, but they all are *behavioral* transformations. The means-based practice might benefit from aiming at the maximum effects it can attain through its particular means, while the effect-based practice might benefit from developing the minimum possible means to attain its desired effect. Our findings provide a basis to support design practice in either way. With grounds in the findings of Studies 5 and 6, future research could expand on the maximization of the effect achievable through a specific design means (e.g., a physical product, a service), as well as on the minimization of the means by which a specific effect (e.g., sustainability, subjective well-being) can be achieved. It could expand on the finding of Study 6 that a means can be minimized on different dimensions (conceptualization, production, or interaction), and explore whether the maximization of an effect also involves distinct dimensions or aspects. Through further research we might ultimately find out that the aesthetic appeal of an artifact is particularly related to some of these qualities and dimensions.

The sets of concepts and ideas generated and evaluated in Studies 6 and 7 illustrate how designers can pursue the same effect through more or less different means. As we mentioned earlier, it could be argued that when designers consider a relatively broad set of means to achieve an effect, they are more likely to design more minimal and aesthetically appealing artifacts. Study 7, however, provided no evidence that designers undertaking a brief in a broad-priming condition designed more minimal or more aesthetically appealing artifacts than those undertaking the same brief in a narrow-priming condition. We discussed that our results might be explained by both the difficulty of the brief we gave the designers and the little time they had to undertake it. Our hypothesis could thus be retested by conducting a more rigorous study, which would involve pretesting how much effort and time a particular brief requires from designers. More generally, the line of reasoning underlying Study 7 raises a research question relevant to design education: how can designers be stimulated to explore a broad range of means when trying to accomplish a given effect? In relation to this, it might be argued that educational programs on means-based design areas

such as product design or architecture restrict the exploration of means (for example, to the domain of products or buildings) and could therefore be substituted by programs on effect-based design areas such as design for subjective well-being or design for behavioral change (where the means are completely undefined). For design aesthetics, the unanswered question remains: does a broad consideration of means for a given effect contribute to the development of more minimal and more aesthetically appealing artifacts? In addressing questions such as this, future studies will further reveal what it takes to enhance an artifact's aesthetic appeal by designing for the maximum effect with the minimum means.

CHAPTER 6

Reflecting on findings and further research

Paul Valéry is quoted saying “a poem is never finished, only abandoned”. The same could be said about any dissertation. Although the beauty of efficiency in design is not entirely explained by the research presented in the previous chapters, it is time to reflect on the implications of my findings and the ways in which these findings might be expanded or challenged with further research. Before doing so, I will recapitulate.

In Chapter 1, I explained how a variety of human creations and performances can be understood as artifacts or designed things because, regardless of their particularities, they are intended to achieve certain effects. The perception of beauty in these things is fundamentally different from the perception of beauty in natural things precisely because people are intuitively inclined to consider the intention underlying human creations and performances, and this consideration—as philosophical and evolutionary theory on aesthetics indicates—allows for a special kind of aesthetic appreciation. I focused on examining this kind of appreciation in the context of product design, where it involves evaluating how a product (as a means) achieves its intended effect, and identified MEMM as a principle that could possibly account for this appreciation.

In Chapter 2, I investigated if people's general appreciation of a product is affected by their knowledge of the product's intended effect or the designer's intention and, if so, in what way. I conducted two studies using a mixed-methods approach to research. Study 1 provided experimental evidence that intention knowledge influences product appreciation. Study 2 explained this finding with interview data, revealing that intention knowledge affects product appreciation in at least three ways: it influences the perception of the product, it enables an evaluation of the intention (intended effect), and it also enables an evaluation of the product as a means to fulfill the intention (intended effect). I interpreted the latter evaluation to be aesthetic with grounds in literature describing the aesthetic appreciation of a product based on MEMM.

In Chapter 3, I analyzed MEMM conceptually. Not only does the principle explain the aesthetic appreciation of many different artifacts besides products, but also offers a basis for identifying the different factors that explain such appreciation (for instance, unexpectedness and inevitability). In "The basics of the MEMM judgment", I explained how a means–effect relationship can be established between a product and its intended effect, and how the product and the effect can be judged to be (the) minimum and (the) maximum. In "The complexity of the MEMM judgment", I explained that the appreciation of the minimum–maximum relationship between a given means and a given effect depends on a set of assumed alternatives for both the means and the effect. In sum, I developed a theoretical framework for MEMM.

In Chapter 4, and through experiments, I tested the hypothesis that people's aesthetic appreciation of a product is positively affected by their perception of the product as the minimum means achieving the maximum effect. Study 3 provided support for this hypothesis and also revealed that MEMM is partially related to two other factors: unexpectedness and inevitability. Concerned that the visual appearance of the product stimuli might have played a confounding role in this study, I conducted another one using a more controlled experimental design. Study 4 also provided evidence of MEMM. Together, Studies 3 and 4 indicated that a product is aesthetically appreciated when it achieves more than other products from the same category by making an

efficient use of resources such as properties, mechanisms, and interactions.

Finally, in Chapter 5, I explored how designers can enhance the aesthetic appeal of a product by considering the product as the means to achieve an intended effect. Using a mixed-methods approach to research, I conducted three studies where I provided designers with information about MEMM and observed how they manipulated the product (means) and its effect when undertaking a design task. Studies 5 and 6 suggested that the aesthetic appeal of a product can be enhanced by making the product's effect additional, beyond practical, relevant, wide reaching, or long lasting, and by making the product itself simple, direct, fast, easy, inexpensive, or seamless with regards to its conceptualization, production, or interaction. In Study 7, I tested the hypothesis that designers develop more aesthetically appealing products (and artifacts in general) when they consider a relatively broad set of alternative means to achieve an effect. The study did not offer support for this hypothesis, but it provided further experimental evidence of MEMM.

IMPLICATIONS OF FINDINGS

The most immediate implications of my findings concern design research, design practice, design education, the marketing of products and services, and the everyday experience of products and services. In this section, I will discuss these implications. At the end of this chapter, I will further reflect on how my research is also relevant to fields dealing with artifacts other than products and services.

IMPLICATIONS FOR DESIGN RESEARCH

I found that knowledge of a designer's intention can affect the perception of a product and further trigger an evaluation of the product as an embodiment of this intention (or intended effect). As suggested by Crilly (2011a), intention knowledge can therefore affect non-aesthetic aspects of product experience, such as meaning attribution and emotion (I adopt the framework of product experience offered by Desmet & Hekkert, 2007). For instance, the discovery that the chair in Figure 27 has been customized to prevent bags from being stolen in public spaces

might explain why people would attribute (the meaning of) safety to this seemingly ordinary chair, while the guess that the lighter in Figure 28 is meant to raise awareness of the health risks of smoking might explain why someone would have positive emotions towards this disturbing (digital) object. Knowledge that the chair is intended to prevent crime might also affect people's behavior around the chair (e.g., someone might want to prove that it cannot prevent bags from being stolen), while knowledge that the lighter was actually conceived as a "critical interpretation of commodity culture" (McConnell, 2011, <http://www.coroflot.com/JacksonMcConnell/Critical-Design>) might stop people from having an emotional response to the lighter and rather make them examine the designer's critical intention in an intellectual way. With this in mind, I believe that research on product experience generally considered can benefit from taking into account people's knowledge of intended effects. As the previous examples suggest, this concerns research in a variety of areas, including design against crime, social design, critical design, and design for emotion.



Figure 27. *Stop Thief!* (2000) by Lorraine Gamman, Jackie Piper and Marcus Willcocks (Design Against Crime Research Initiative, Central Saint Martins College of Art and Design).



Figure 28. Untitled digital design (2011) by Jackson McConnell.

With regards to design aesthetics, this dissertation suggests a line of research that focuses on the appreciation of an artifact as the means to achieve an intended effect. Following this line of research involves taking into consideration a number of factors (some of which I have

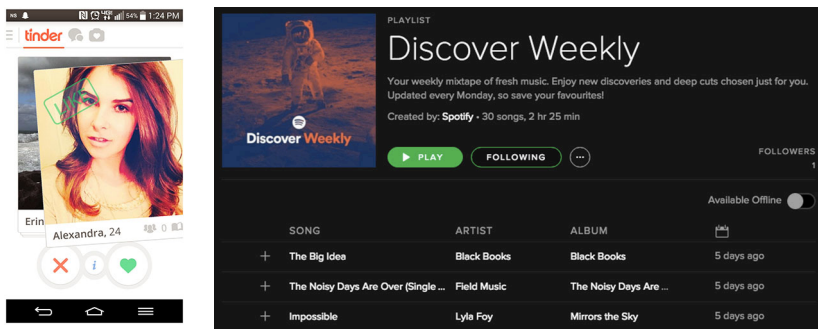
mentioned elsewhere; see Da Silva, Crilly, & Hekkert, 2014). They include: (a) the conceptual definition of the means and the effect; (b) the experimental representation of the means and the effect; (c) the ability that people might have to judge and report on the means-effect relationship depending on their expertise; (d) the principles describing the appreciation of a means-effect relationship and their operationalization; (e) the assumed alternatives for both the means and the effect at the basis of such appreciation; (f) the methods and tools available to examine such appreciation; and (g) the specific research questions to be addressed. Since the role of the means can be taken by a physical product, but also, for instance, by a virtual product or a service, this line of research can be explored in the field of product design as well as in fields such as digital design and service design.

IMPLICATIONS FOR DESIGN PRACTICE

I have suggested that designing fundamentally involves defining a desired effect and developing an artifact of any kind as the means to achieve it. My findings indicate that it is worthwhile designing for the maximum effect with the minimum means, not just for the sake of efficiency, but in the interests of beauty also. Design practices for which the effect is relatively fixed (e.g., design for sustainability, design for well-being, design for behavioral change) might benefit from developing the minimum possible means by which this effect can be attained, while design practices for which the means is relatively fixed (e.g., product design, service design, digital design) might benefit from aiming at the maximum possible effect attainable through this means. MEMM-derived design strategies can help develop appealing artifacts in any case.

My research indicates that the appeal of an artifact depends not only on how the artifact looks or feels, but also on how it interacts with people and what effect it achieves. Hence, contrary to the idea that it is mainly physical products that can be beautifully designed insofar as they allow for manipulations of appearance, also virtual products and services can be beautifully designed based on manipulations of interaction and effect. In exploring this issue, I found that a smartphone application can be aesthetically appreciated for enabling people to reach a major goal through an intuitive touch interface; for example, *Tinder*—a location-

based dating app—can be appreciated because it allows strangers to get in touch through a hand gesture, and ultimately because “by a single swipe to the right you, in theory, can find the love of your life” (as stated by a study participant; see Post et al., 2015, p. 1726). Similarly, a service can be aesthetically appreciated when it offers a lot to users without disrupting their lives, but rather being integrated with their personal routines. *Spotify*—a digital music service—can be taken as an example of this. It gives access to millions of songs via streaming, that is, without reducing the users’ capacity to store data in their devices. Moreover, this service helps users find (new) songs they might like by automatically generating and regularly updating a playlist based on their listening history (see Figures 29 and 30).



Figures 29 and 30. Screenshots showing the interfaces of *Tinder* (left), where a simple swipe can turn into a date with an attractive stranger, and *Spotify* (right), where an automatically-generated playlist introduces users to songs they are likely to enjoy.

IMPLICATIONS FOR DESIGN EDUCATION

In lectures and manuals on product development, a sharp distinction is frequently drawn between form and function. The aesthetic appeal of a product is associated with the product’s formal features (e.g., color, shape, texture) and thereby dissociated from the product’s intended function or effect. Yet, my findings indicate that a product’s aesthetic appeal partially depends on the perception that the product achieves the maximum effect with the minimum means, that it functions efficiently. This challenges the view that aesthetics and functionality are independent. Considering my findings, design educators might reflect on the value of teaching how beauty and efficiency might intertwine in the development and experience of a product or any other artifact.

Another issue concerning design education is derived from my means-effect distinction of design practices. These practices are often defined by either the effects that they pursue or the means that they use to achieve these effects. It seems that educational programs in design are predominantly—although implicitly—defined by the means that students are trained to develop. Examples include master’s programs in product design, service design, graphic design, fashion design, and food design, where the means are relatively fixed (as means of the kind *product*, *service*, *graphics*, *clothes*, and *food*), but the effects are not specified at all. Institutions offering such programs might benefit from pondering the advantages and challenges of shaping design education in this way. By focusing on a particular kind of means, students might develop a better capacity to analyze and manipulate the qualities specific to this kind, as well as a better capacity to analyze and manipulate the effects that can be immediately achieved through these qualities. But they might also need to be stimulated to explore unfamiliar design solutions and goals; for instance, by learning a design strategy that requires them to first think about the effect that they would like to achieve and only then, considering the requirements of this effect, determine the properties of the means by which this effect will be realized. Such a strategy is provided by Hekkert and Van Dijk (2011).

IMPLICATIONS CONCERNING THE MARKETING OF PRODUCTS AND SERVICES

Just like researchers, designers, and educators, marketers can interpret a product or service as the means to achieve an intended effect. Marketing a product or service thus implies communicating both the effect that the product or service is intended to achieve as well as how the product or service operates as a means to achieve this effect. In this sense, marketers should be able to identify and convey the qualities that potential consumers are likely to appreciate in both the product or service and its intended effect. Based on my findings, these are the qualities for which the product or service can be perceived to be minimal and its effect maximal. Some of these qualities might be immediately observable or easy to infer, but some others might not (e.g., how lasting the effect of a product is or how easy the interaction with a service is). Marketers might want to take this into account when deciding what

qualities are worth communicating more emphatically or explicitly, as well as when choosing among possible advertising channels. For instance, the less obvious qualities for which a product or service appeals might be explained in more detail through a TV commercial than through a billboard.

An advertisement or commercial can also be considered the means to attain a certain effect. Its appeal can thus be explained, at least partially, by the principle of MEMM. This implies that marketers should not just aim at promoting the MEMM-derived qualities of a product or service, but at promoting them through an advertisement that exhibits these qualities itself. A MEMM-based advertisement would not describe product or service features that are self-evident and it would use forms of communication that are immediately, effortlessly graspable; for instance, a slogan or tagline, as contrasted to a lengthy voice-over or text, or a striking image, as contrasted to a sequence of frames. Nike's catchy "Just Do It", as well as the printed adverts for Sanzer hand sanitizer and FedEx shipping services, illustrate this kind of advertisement. In the advert for Sanzer (Figure 31), the keys of a payphone are replaced by filthy fingertips, in an image that evokes the frequent, yet unnoticed, passing of bacteria from person to person and, ultimately, the need for hand sanitization. In the advert for FedEx (Figure 32), a parcel makes its way across the map of The Americas as a person hands it to their neighbor, in an image that suggests how quick and safe the shipping of a parcel can be thanks to these services.

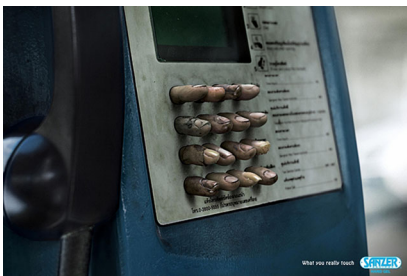


Figure 31. Printed advert for Sanzer hand sanitizer by Chuo Senko.



Figure 32. Printed advert for FedEx shipping services by DDB Brazil.

IMPLICATIONS CONCERNING THE EVERYDAY EXPERIENCE OF PRODUCTS AND SERVICES

By developing knowledge that supports the design of aesthetically appealing artifacts, this dissertation might eventually contribute to providing more pleasant product and service experiences to those people taking the role of users or consumers in everyday life (not excluding researchers, designers, educators, or marketers). More immediately, however, this dissertation can provide these people with some understanding of the principle of MEMM, that is, with some awareness of the reason why they might like a particular product or service. This involves realizing that an apparently simple perception of appeal, expressed by an equally simple statement such as “I like this product” or “what a nice service!”, might actually result from a complex judgment that involves relating the product or service to its intended effect, and further comparing both the product or service and its effect with a number of alternatives that are either known or merely imagined. By gaining awareness of their own aesthetic judgments, people might also gain awareness of the reason why they are inclined to consume or use certain products and services rather than others. So, just as my findings offer some guidance on how to promote products and services, they also offer some grounds to make more knowledgeable consumer choices.

SUGGESTIONS FOR FURTHER RESEARCH

When discussing the implications of my findings for design research, I listed seven factors concerning the study of people’s aesthetic appreciation of an artifact (means) in light of the artifact’s intended effect. Considering each of these factors, I will reflect on the research I conducted and provide some suggestions for its continuation. Although this continuation can most obviously take place in the field of product (or service) design, it can also take place in fields such as the arts. I will reflect on this issue at the end of this chapter.

(a) *The conceptual definition of the means and the effect.* I interpreted the means to be a designed product and the effect to be (what people perceive as) the designer’s intended effect. I further considered that, as a means, the product exploits resources such as properties, mechanisms, and

interactions; and that it can have an effect or several effects at more proximal or distal levels. But I did not categorize the means or the effect (e.g., contrasting physical and virtual products, experiential and behavioral effects), nor did I examine how they admit more general or specific categorizations (e.g., contrasting between a coffee machine and a vending coffee machine, an effect on attitude and an effect on social attitude). A more precise conceptualization of the means and the effect in the context of design would contribute to further investigating the qualities for which they are appreciated.

(b) *The experimental representation of the means and the effect.* In the studies I conducted, I represented the means and the effect by using a combination of image and text describing the product and its intended effect. In this way, I controlled for the influence of the many interactions participants could have with an actual product (rather than an image), as well as for the influence of the many inferences they could make about the product's effect (if not explicit). While this improved the validity of my findings, it also prevented me from learning what happens to the appreciation of a product when the effect that people infer directly from the product does not match the effect that the product is explicitly said to have, or when this explicitly stated effect does not match the effect that the product has in reality. These are issues worth exploring because product experiences are often mediated by adverts and other sources of explicit information.

(c) *The ability that people might have to judge and report on the means-effect relationship depending on their expertise.* Considering that people with a certain level of design literacy would be better able to judge a product in relation to its intended effect as well as to report on this judgment, I conducted some of my studies and pretests with design students and professionals. To avoid the influence of specialized design knowledge, I conducted some other studies with students in technical fields excluding design and architecture. It might be argued that, due to this technical background, the last group of participants also had some formal knowledge of the way artifacts are developed and how they work, and therefore did not represent a population of non-experts. Hence, further research is required to see if my findings can be extended to a

population with no technical background or, more generally, to a population that has no specialized knowledge of how artifacts work.

(d) *The principles describing the appreciation of a means-effect relationship and their operationalization.* This dissertation focused on the principle of maximum effect for minimum means and therefore required a certain operationalization of it. The scale I developed for MEMM measures the perception that a product achieves more than other products from the same category (the maximum effect) by making an efficient use of resources (the minimum means). Yet, the principle could be operationalized in a different or more nuanced way (e.g., considering that the maximum effect might encompass several distal effects). Moreover, other factors could be examined as predictors of aesthetic appreciation understood in means-effect terms. I briefly studied unexpectedness and inevitability, but also factors such as novelty and typicality could be studied in these terms (e.g., a product can be judged to be a novel means to achieve a typical effect, and an effect can be judged to be novel for a typical product or product category).

(e) *The assumed alternatives for both the means and the effect at the basis of the appreciation of a means-effect relationship.* From the conceptual examination of MEMM, I concluded that the aesthetic appreciation of a particular means-effect relationship is based on a set of known or imagined means and effects that people see as alternatives with grounds in artifact categorizations. But I did not explore this matter empirically. Keeping this set of alternatives in mind, I argued that designers can aim at achieving many alternative effects and that, for each of these effects, they can develop many alternative means—the more means they consider, the more able they might be to develop a minimal and appealing one. But I did not find experimental evidence of this. Further research is required to understand people's consideration of alternative means and effects, as well as the influence that this consideration might have on their aesthetic judgments and design processes.

(f) *The methods and tools available to examine the appreciation of a means-effect relationship.* In my investigation, I used explanatory and exploratory mixed-methods research designs, as well as purely conceptual and purely experimental approaches. In this sense, my dissertation offers a basis for

further researching the aesthetic appreciation of a means-effect relationship with any of these approaches. For example, when testing the principle of MEMM experimentally, I successfully manipulated stimulus materials to create a high-MEMM and a low-MEMM condition. Building on this manipulation, more systematic ones could be performed (e.g., consistently varying specific aspects of a product and its intended effect) so as to test people's aesthetic appreciation of a means-effect relationship in a more controlled manner, whether according to MEMM or another factor.

(g) *The specific research questions to be addressed.* A number of questions that are still unanswered or could be answered more comprehensively can be derived from the previous paragraphs. For instance, how can the means and the effect be (further) characterized in the context of design or in the context of a particular design domain (e.g., service design)? What specific qualities of the means and the effect thus characterized are aesthetically appreciated? What principles other than MEMM (or factors other than unexpectedness or inevitability) explain the appreciation of a means-effect relationship? What alternative means and effects do people consider when judging or designing an artifact? And how does this consideration influence their perception of beauty or their capacity to develop an appealing artifact?

There is one unresolved issue that I would like to reflect on. In Chapter 1, I introduced Hekkert's (2014) Unified Model of Aesthetics (UMA), which accounts for the aesthetic appreciation of a product based on two primary human needs: the need for safety and the need for accomplishment. The model explains people's aesthetic preference on three levels: perceptual, as a balance between unity and variety; cognitive, as a balance between typicality and novelty; and social, as a balance between connectedness and autonomy. The model also aims at accounting for the kind of aesthetic appreciation that results from thinking about the intention of the product's designer, but does not specify how this kind of appreciation relates to the aforementioned levels,²¹ or what kind of balance it involves. Although not in relation to

²¹ Berghman, Cila, and Hekkert (2014) have taken a first step to clarify this issue by testing the effects of both intention knowledge and (perceived) unity in variety on the aesthetic appreciation of a product.

intention knowledge, Hekkert (2006) himself has argued that MEMM is a mother principle, of a different order than the principles governing product appreciation on the perceptual, cognitive, and social levels. Based on this idea and building on my findings, further research could be conducted so as to explain the role that MEMM plays in the overall aesthetic appreciation of a product as described by UMA. In other words, how can UMA be expanded to include MEMM? It might be that the need for safety (for what is undemanding or requires a small investment of resources) explains the appreciation of the minimum means, while the need for accomplishment (for what allows people to broaden their experiences and develop their capacities) explains the appreciation of the maximum effect. UMA might thus be expanded in the way illustrated in Figure 33.

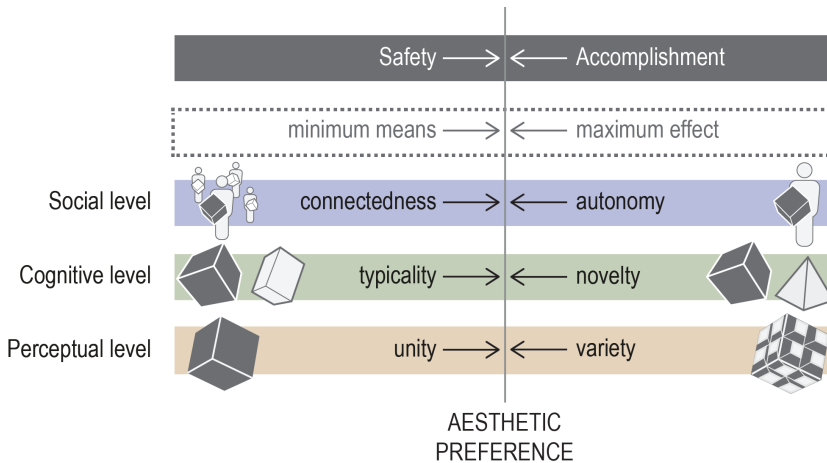


Figure 33. Possible expansion of Hekkert's UMA. The expansion (dotted line) occurs on a distinct level, where the aesthetic preference for a product results from perceiving a balance between the minimum means and the maximum effect.

FINAL THOUGHTS: FROM HOLLOW BRICKS TO PARMESAN RISOTTO

So far, I have focused on the implications and further development of my research within the fields of product and service design. However, considering that MEMM can describe the appreciation of many other artifacts besides products and services, the points I have made and the

questions I have raised can be extrapolated to other fields of knowledge and practice. To illustrate this, I will take the arts as an example and consider specific instances of architecture, cinema, conceptual art, and gastronomy. Like a product and a service, a building, a film, a conceptual piece of art, and a dish are designed things in the sense that they are intentionally created. They can all be developed, experienced, and researched with grounds in a means-effect relationship and, more specifically, with grounds in MEMM. In the following paragraphs, I will briefly describe some personal perceptions of beauty only to suggest such extrapolation of the principle.

As an undergraduate student, I attended the Central University of Venezuela. The institution was founded in 1721, but its current campus was developed as a major project in the mid 1900s, a period of national prosperity due to the oil boom. The campus shows a strong influence of functionalism and Le Corbusier's efficient urban planning, but it is also characterized by an integration of architecture with nature and the arts. It exhibits sculptures by Alexander Calder, stained-glass windows by Fernand Léger, and murals by Victor Vasarely, among other eye-catching works of art. Yet, something that I found—and still find—particularly stunning are the hollow concrete bricks that let the outside air and the natural light come into the hallways, and that further transform the tropical sun glare into a subtle, moving pattern of reflections and shadows (Figure 34). Thanks to these bricks, many of the campus hallways need no additional ventilation, artificial light only at night, and are a spectacle to walk through.



Figure 34.
Hallways of the
Central University
of Venezuela.
University City of
Caracas (1940-
1960) by Carlos
Raúl Villanueva.

Long before I moved to Finland in 2007, I became obsessed with Nordic cinema. I was fascinated by Bergman’s beautifully-shot movies, but also by *The Idiots*. This film depicts a group of young adults who try to get rid of their inhibitions by behaving as if they were physically and mentally disabled (see Figure 35). I found this film difficult to watch, but I cannot deny the impact it had on me. It made me think of why certain behaviors are socially accepted or perceived as normal, while others are not. In fact, it made me wonder why I personally felt so uncomfortable witnessing the deliberate conduct of its characters; it destabilized my own notion of what is normal and acceptable. The film’s impact on me contrasts with the way it was made, that is, in compliance with the manifesto of the filmmaking movement known as Dogma 95. The manifesto requires the camera to be hand-held and forbids the post-production of sound and image, as well as the use of any kind of technical trick to enhance a film’s appearance.



Figure 35. Still frame from *The Idiots* (1998) by Lars von Trier.

Last year, I paid my first visit to the Stedelijk Museum Amsterdam, a museum for modern and contemporary art. Having seen canvases painted with excrement and a number of unimpressive conceptual pieces, I thought I would not be astonished by anything shown in the museum. But I was proved wrong the minute I entered a room where there was nothing—absolutely nothing—to see, except for the security guards doing their job. At least, that is what it seemed like. The guards, though, started to sing the line “this is so contemporary” repeatedly and to dance around me erratically. I found the situation (see Figure 36)

funny, but also very clever. It gave voice to a sort of artistic self-awareness of how ironic—and certainly contemporary—it is for a museum to exhibit works of art that are fundamentally invisible or intangible in the sense that they are fundamentally conceptual. This voice required no art object for me to hear it; the guards already working at the museum sufficed.



Figure 36. *This Is So Contemporary* (2004) by Tino Sehgal, as presented in the Stedelijk Museum Amsterdam in 2015. (Photo by Somers, n.d.)

The last aesthetic experience I will describe occurred a few hours ago, as I sat at the table to have a Michelin-star risotto—so to speak (Figure 37). This is the risotto that Massimo Bottura conceived after a series of earthquakes hit the north of Italy in 2012. The earthquakes caused thousands of wheels of Parmesan cheese to fall from the shelves where they were stored and crash to the ground. To promote the use of this cheese, which was hard to sell and ran the risk of being discarded, Bottura came up with a recipe that anyone could prepare at home. In contrast to a traditional risotto recipe, this one does not require a base of onion or garlic, nor does it require the rice to be cooked in meat or vegetable broth. Instead, the rice is cooked in an infusion of Parmesan and then integrated with a cream that is also extracted from the cheese. A pinch of pepper is added at the end. As several ingredients of the traditional recipe are removed, the Parmesan’s flavor becomes more intense and takes the central role in the dish. This central role is emphasized by how the risotto is served: “The white monochrome plate leaves behind any distractions to focus on the purity and intensity of the Parmigiano Reggiano” (Bottura, 2014, p. 118).



Figure 37. *Risotto Cacio e Pepe* (2012) by Massimo Bottura, as prepared by my husband for a Sunday lunch in the spring of 2016.

MEMM does not necessarily come to my mind when I am enjoying a meal, and countless times I walk out of a museum, movie theater, or building without reflecting on the reason why I like a particular work of art, film, or architectural detail. Yet, whether I analyze them or not, experiences such as the ones I just described can have a profound effect on me. There is still a long way to go to fully understand such experiences, but as we go through this way—as researchers, designers, educators, marketers, or consumers—we are reminded that the effort is worthy. We are touched by the beauty of efficiency in design.

REFERENCES

- Barrett, H. C., Laurence, S., & Margolis, E. (2008). Artifacts and original intent: A cross-cultural perspective on the design stance. *Journal of Cognition and Culture*, 8(1), 1–22.
- Bauerly, M., & Liu, Y. (2008). Effects of symmetry and number of compositional elements on interface and design aesthetics. *International Journal of Human-Computer Interaction*, 24(3), 275–287.
- BBC. (2015). Why is EU struggling with migrants and asylum? Retrieved November 2015, from <http://www.bbc.com/news/world-europe-24583286>.
- Berghman, M., Cila, N., & Hekkert, P. (2014). The combined effect of perceptual and conceptual dimensions on product design aesthetics. In A. Kozbelt (Ed.), *Proceedings of LAEA 2014* (pp. 89–94). New York: Hunter College of the City of New York.
- Berlyne, D. E. (1971). *Aesthetics and psychobiology*. New York: Appleton-Century-Crofts.

- Bernstein, S. (1999). Goethe's architectonic *Bildung* and buildings in classical Weimar. *Modern Language Notes*, 114(5), 1014–1036.
- Best, D. (1974). The aesthetic in sport. *British Journal of Aesthetics*, 14(3), 197–213.
- Black, J. (1991). *The aesthetics of murder: A study in romantic literature and contemporary culture*. Baltimore: John Hopkins University Press.
- Blijlevens, J., & Hekkert, P. (2014). Influence of social connectedness and autonomy on aesthetic pleasure for product designs. In A. Kozbelt (Ed.), *Proceedings of LAEA 2014* (pp. 95–99). New York: Hunter College of the City of New York.
- Blijlevens, J., Thurgood, C., Hekkert, P., Leder, H., & Whitfield, A. (2014). The development of a reliable and valid scale to measure aesthetic pleasure in design. In A. Kozbelt (Ed.), *Proceedings of LAEA 2014* (pp. 100–106). New York: Hunter College of the City of New York.
- Bloom, P. (1996). Intention, history, and artifact concepts. *Cognition*, 60(1), 1–29.
- Bloom, P. (2000). *How children learn the meanings of words*. Cambridge: Massachusetts Institute of Technology Press.
- Bloom, P. (2011). *How pleasure works: Why we like what we like*. London: Vintage.
- Bordens, K. S. (2010). Contextual information, artistic style and the perception of art. *Empirical Studies of the Arts*, 28(1), 111–130.
- Boselie, F., & Leeuwenberg, E. (1985). Birkhoff revisited: Beauty as a function of effect and means. *The American Journal of Psychology*, 98(1), 1–39.
- Bottura, M. (2014). *Never trust a skinny Italian chef*. New York: Phaidon.

- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101.
- Breakwell, G. M. (2006). Interviewing methods. In G. M. Breakwell, C. Fife-Schaw, & J. A. Smith (Eds.), *Research methods in psychology* (3rd ed., pp. 232–253). London: Sage.
- Broms, L. (2011). *Sustainable interactions: Studies in the design of energy awareness artefacts* [Licentiate thesis]. Linköping University, Linköping.
- Cai, S., & Xu, Y. (2011). Designing not just for pleasure: Effects of web site aesthetics on consumer shopping value. *International Journal of Electronic Commerce*, 15(4), 159–188.
- Cain, A. J. (2010). *Deus ex machina* and the aesthetics of proof. *The Mathematical Intelligencer*, 32(3), 7–11.
- Chick, A., & Micklethwaite, P. (2011). *Design for sustainable change: How design and designers can drive the sustainability agenda*. Lausanne: AVA Publishing.
- Cohen, J. (1998). *Statistical power analysis for the behavioral sciences* (2nd ed.). New York: Lawrence Erlbaum.
- Crease, R. P. (2004). *The prism and the pendulum: The ten most beautiful experiments in science*. New York: Random House.
- Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). London: Sage.
- Creusen, M. E. H., & Schoormans, J. P. L. (2005). The different roles of product appearance in consumer choice. *Journal of Product Innovation Management*, 22(1), 63–81.
- Crilly, N. (2011a). Do users know what designers are up to? Product experience and the inference of persuasive intentions. *International Journal of Design*, 5(3), 1–15.
- Crilly, N. (2011b). The design stance in user-system interaction. *Design Issues*, 27(4), 16–29.

- Crilly, N. (2013). Function propagation through nested systems. *Design Studies*, 34(2), 216–242.
- Crilly, N., Good, D., Matravers, D., & Clarkson, P. J. (2008). Design as communication: Exploring the validity and utility of relating intention to interpretation. *Design Studies*, 29(5), 425–457.
- Crilly, N., Moultrie, J., & Clarkson, P. J. (2009). Shaping things: Intended consumer response and the other determinants of product form. *Design Studies*, 30(3), 224–254.
- Cupchik, G. C., Shereck, L., & Spiegel, S. (1994). The effects of textual information on artistic communication. *Visual Arts Research*, 20, 62–78.
- Cupchik, G. C., Spiegel, S., & Shereck, L. (1996). Unity in the diversity of aesthetic response. *Visual Arts Research*, 22(1), 1–10.
- Cyr, D., Head, M., & Ivanov, A. (2006). Design aesthetics leading to loyalty in mobile commerce. *Information & Management*, 43(8), 950–963.
- Da Silva, O., Crilly, N., & Hekkert, P. (2014). Intentions and the aesthetics of artifacts. In A. Kozbelt (Ed.), *Proceedings of LAEA 2014* (pp. 148–152). New York: Hunter College of the City of New York.
- Da Silva, O., Crilly, N., & Hekkert, P. (2015). How people's appreciation of products is affected by their knowledge of the designers' intentions. *International Journal of Design*, 9(2), 21–33.
- Da Silva, O., Crilly, N., & Hekkert, P. (2016). Maximum effect for minimum means: The aesthetics of efficiency. *Design Issues*, 32(1), 41–51.
- Da Silva, O., Crilly, N., & Hekkert, P. (in press). Beauty in efficiency: An experimental enquiry into the principle of maximum effect for minimum means. *Empirical Studies of the Arts*.

- De Clercq, R. (2005). The aesthetic peculiarity of multifunctional artefacts. *The British Journal of Aesthetics*, 45(4), 412–425.
- De Klerk, H. M., & Lubbe, S. (2008). Female consumers' evaluation of apparel quality: Exploring the importance of aesthetics. *Journal of Fashion Marketing and Management*, 12(1), 36–50.
- Dennett, D. C. (1989). *The intentional stance*. Cambridge: Massachusetts Institute of Technology Press.
- Desmet, P., & Hekkert, P. (2007). Framework of product experience. *International Journal of Design*, 1(1), 57–66.
- Desmet, P., & Pohlmeier, A. E. (2013). Positive design: An introduction to design for subjective well-being. *International Journal of Design*, 7(3), 5–19.
- Dipert, R. R. (1993). *Artifacts, art works, and agency*. Philadelphia: Temple University Press.
- Dopper: The bottle is the message. (2010). Retrieved January 2016, from <https://dopper.com/nl>.
- Dutton, D. (2010). A Darwinian theory of beauty [Video file]. Retrieved March 2016, from http://www.ted.com/talks/denis_dutton_a_darwinian_theory_of_beauty.
- Etcoff, N. (2000). *Survival of the prettiest: The science of beauty*. New York: Anchor Books.
- Faraday, M. (2011). *The chemical history of a candle*. Oxford: Oxford University Press.
- Felcher, E. M., Malaviya, P., & McGill, A. L. (2001). The role of taxonomic and goal-derived product categorization in, within, and across category judgments. *Psychology & Marketing*, 18(8), 865–887.
- Ferrari, S. (2013). Personal communication. Delft.

- Fiore, A. M. (2010). *Understanding aesthetics for the merchandising and design professional* (2nd ed.). New York: Fairchild Books.
- Fokkinga, S., Hekkert, P., Desmet, P., & Özcan, E. (2014). From product to effect: Towards a human-centered model of product impact. In K. Niedderer & Y.-K. Lim (Eds.), *Proceedings of DRS 2014* (pp. 71–83). Umeå: Umeå Institute of Design.
- Forsey, J. (2013). *The aesthetics of design*. Oxford: Oxford University Press.
- Fowler, F. J. J. (2009). *Survey research methods* (4 ed.). London: Sage.
- Gibbs, R. W., Kushner, J. M., & Mills, W. R. (1991). Authorial intentions and metaphor comprehension. *Journal of Psycholinguistic Research*, 20(1), 11–30.
- Goldman, A. (2001). The aesthetic. In B. Gaut & D. McIver Lopes (Eds.), *The Routledge companion to aesthetics* (pp. 181–192). London: Routledge.
- Gutman, J. (1982). A means-end chain model based on consumer categorization processes. *The Journal of Marketing*, 46(2), 60–72.
- Guyer, P. (2002). Beauty and utility in eighteenth-century aesthetics. *Eighteenth-Century Studies*, 35(3), 439–453.
- Hardy, G. H. (1967). *A mathematician's apology*. Cambridge: Cambridge University Press.
- Hawley-Dolan, A., & Young, L. (2013). Whose mind matters more: the agent or the artist? An investigation of ethical and aesthetic evaluations. *PLoS ONE*, 8(9), e70759.
- Hekkert, P. (2006). Design aesthetics: Principles of pleasure in design. *Psychology Science*, 48(2), 157–172.

- Hekkert, P. (2014). Aesthetic responses to design: A battle of impulses. In T. Smith & P. Tinio (Eds.), *The Cambridge handbook of the psychology of aesthetics and the arts* (pp. 277–299). Cambridge: Cambridge University Press.
- Hekkert, P., & Leder, H. (2008). Product aesthetics. In H. N. Schifferstein & P. Hekkert (Eds.), *Product experience* (pp. 259–285). Amsterdam: Elsevier.
- Hekkert, P., & Van Dijk, M. (2011). *Vision in product design: A guidebook for innovators*. Amsterdam: BIS Publishers.
- Hekkert, P., Snelders, D., & Van Wieringen, P. C. (2003). Most advanced, yet acceptable: Typicality and novelty as joint predictors of aesthetic preference in industrial design. *British Journal of Psychology*, *94*(1), 111–124.
- Hilpinen, R. (1992). On artifacts and works of art. *Theoria*, *58*(1), 58–82.
- Howard, J. T. (1923). Inevitability as a criterion of art. *The Musical Quarterly*, *9*(3), 303–313.
- Hume, D. (2000). *A treatise of human nature*. Oxford: Oxford University Press.
- Iseminger, G. (Ed.). (1992). *Intention & interpretation*. Philadelphia: Temple University Press.
- Jacobsen, T., & Hoefel, L. (2003). Descriptive and evaluative judgment processes: Behavioral and electrophysiological indices of processing symmetry and aesthetics. *Cognitive Affective & Behavioral Neuroscience*, *3*(4), 289–299.
- Jakesch, M., & Leder, H. (2009). Finding meaning in art: Preferred levels of ambiguity in art appreciation. *The Quarterly Journal of Experimental Psychology*, *62*(11), 2105–2112.
- Jakesch, M., & Leder, H. (2015). The qualitative side of complexity: Testing effects of ambiguity on complexity judgments. *Psychology of Aesthetics, Creativity, and the Arts*, *9*(3), 200–205.

- Johnson, G. (2009). *The ten most beautiful experiments*. New York: Vintage Books.
- Jordan, P. W. (2000). *Designing pleasurable products: An introduction to the new human factors*. London: Taylor & Francis.
- Jucker, J.-L., Barrett, J. L., & Wlodarski, R. (2014). “I just don’t get it”: Perceived artists’ intentions affect art evaluations. *Empirical Studies of the Arts*, 32(2), 149–182.
- Kant, I. (2000). *Critique of the power of judgment*. Cambridge: Cambridge University Press.
- Kaplan, A., & Kris, E. (1948). Esthetic ambiguity. *Philosophy and Phenomenological Research*, 8(3), 415–435.
- Kelemen, D., & Carey, S. (2007). The essence of artifacts: Developing the design stance. In E. Margolis & S. Laurence (Eds.), *Creations of the mind: Theories of artifacts and their representation* (pp. 212–230). Oxford: Oxford University Press.
- Koren, L. (2010). *Which “aesthetics” do you mean? Ten definitions*. Point Reyes, California: Imperfect Publishing.
- Kumar, R. (2005). *Research methodology: A step-by-step guide for beginners* (2nd ed.). London: Sage.
- Lakoff, G. (1990). *Women, fire, and dangerous things: What categories reveal about the mind*. Chicago: University of Chicago Press.
- Laschke, M. (2014). Keymoment (unplugged). Retrieved January 2016, from <http://www.pleasurabletroublemakers.com/#/keymoment-1>.
- Leder, H., Carbon, C. C., & Ripsas, A. L. (2006). Entitling art: Influence of title information on understanding and appreciation of paintings. *Acta Psychologica*, 121(2), 176–198.

- Lenz, E., Diefenbach, S., & Hassenzahl, M. (2014). Aesthetics of interaction: A literature synthesis. In T. Olsson & E. Hvannberg (Eds.), *Proceedings of NordiCHI 2014* (pp. 628–637). Helsinki: Aalto University.
- Li, Y.-M., & Yeh, Y.-S. (2010). Increasing trust in mobile commerce through design aesthetics. *Computers in Human Behavior*, *26*(4), 673–684.
- Lidwell, W., Holden, K., & Butler, J. (2010). *Universal principles of design: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design*. Beverly: Rockport.
- Livingston, P. (2007). *Art and intention: A philosophical study*. Oxford: Oxford University Press.
- Locher, P., & Nodine, C. (1989). The perceptual value of symmetry. *Computers & Mathematics with Applications*, *17*(4-6), 475–484.
- Lockton, D., Harrison, D., & Stanton, N. A. (2010a). *Design with intent: 101 patterns for influencing behaviour through design*. Windsor: Equifine.
- Lockton, D., Harrison, D., & Stanton, N. A. (2010b). The design with intent method: A design tool for influencing user behaviour. *Applied Ergonomics*, *41*(3), 382–392.
- Macnab, M. (2012). *Design by nature: Using universal forms and principles in design*. Berkeley: New Riders.
- Mallaband, P. (2002). Understanding Kant's distinction between free and dependent beauty. *The Philosophical Quarterly*, *52*(206), 66–81.
- Margulies, S. (1977). Principles of beauty. *Psychological Reports*, *41*, 3–11.
- Matan, A., & Carey, S. (2001). Developmental changes within the core of artifact concepts. *Cognition*, *78*(1), 1–26.

- McConnell, J. (2011). Critical design. Retrieved March 2016, from <http://www.coroflot.com/JacksonMcConnell/Critical-Design>.
- Miller, G. (2001). *The mating mind*. New York: Anchor Books.
- Millis, K. (2001). Making meaning brings pleasure: The influence of titles on aesthetic experiences. *Emotion*, 1(3), 320–329.
- Moshagen, M., Musch, J., & Göritz, A. S. (2009). A blessing, not a curse: Experimental evidence for beneficial effects of visual aesthetics on performance. *Ergonomics*, 52(10), 1311–1320.
- Muth, C., & Carbon, C. C. (2013). The aesthetic aha: On the pleasure of having insights into Gestalt. *Acta Psychologica*, 144(1), 25–30.
- Muth, C., Hesslinger, V. M., & Carbon, C. C. (2015). The appeal of challenge in the perception of art: How ambiguity, solvability of ambiguity, and the opportunity for insight affect appreciation. *Psychology of Aesthetics, Creativity, and the Arts*, 9(3), 206–216.
- Niedderer, K. (2007). Designing mindful interaction: The category of performative object. *Design Issues*, 23(1), 3–17.
- Nygaard Folkmann, M. (2013). *The aesthetics of imagination in design*. Cambridge: Massachusetts Institute of Technology Press.
- Orians, G. H., & Heerwagen, J. H. (1992). Evolved responses to landscapes. In J. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind* (pp. 555–579). Oxford: Oxford University Press.
- Orrell, D. (2012). *Truth or beauty: Science and the quest for order*. New Haven: Yale University Press.
- Parrot: Flower power. (2012). Retrieved January 2016, from <http://www.parrot.com/nl/producten/flower-power>.

- Parsons, G., & Carlson, A. (2008). *Functional beauty*. Oxford: Oxford University Press.
- Parsons, M. J. (1987). *How we understand art: A cognitive developmental account of aesthetic experience*. Cambridge: Cambridge University Press.
- Pfaff, K. L., & Gibbs, R. W., Jr. (1997). Authorial intentions in understanding satirical texts. *Poetics*, 25(1), 45–70.
- Pinker, S. (2002). *The blank slate: The modern denial of human nature*. London: Penguin Books.
- Poe, E. A. (1846). Marginalia. *Graham's Magazine*, 28(2), 116–118.
- Post, R., Blijlevens, J., & Hekkert, P. (2016). “To preserve unity while almost allowing for chaos”: Testing the aesthetic principle of unity-in-variety in product design. *Acta Psychologica*, 163(1), 142–152.
- Post, R., Da Silva, O., & Hekkert, P. (2015). The beauty in product-service systems. In V. Popovic, A. Blackler, D.-B. Luh, N. Nimkulrat, B. Kraal, & Y. Nagai (Eds.), *Proceedings of LASDR 2015* (pp. 1717–1730). Brisbane: Queensland University of Technology.
- Preissler, M. A., & Bloom, P. (2008). Two-year-olds use artist intention to understand drawings. *Cognition*, 106(1), 512–518.
- Ramachandran, V. S., & Hirstein, W. (1999). The science of art. *Journal of Consciousness Studies*, 6(6-7), 15–51.
- Reimann, M., Zaichkowsky, J., Neuhaus, C., Bender, T., & Weber, B. (2010). Aesthetic package design: A behavioral, neural, and psychological investigation. *Journal of Consumer Psychology*, 20(4), 431–441.
- Robins, D., & Holmes, J. (2008). Aesthetics and credibility in web site design. *Information Processing & Management*, 44(1), 386–399.

- Rokos, J. (2013). Gauge. Retrieved January 2016, from http://www.jimrokos.com/gauge_story.html.
- Russell, P. A. (2003). Effort after meaning and the hedonic value of paintings. *British Journal of Psychology*, *94*(1), 99–110.
- Saito, Y. (2007). *Everyday aesthetics*. Oxford: Oxford University Press.
- Savic, S., & Savicic, G. (Eds.). (2013). *Unpleasant design*. Belgrade: G.L.O.R.I.A.
- Shah, J., Higgins, T., & Friedman, R. S. (1998). Performance incentives and means: How regulatory focus influences goal attainment. *Journal of Personality and Social Psychology*, *74*(2), 285–293.
- Silvia, P. J., & Barona, C. M. (2009). Do people prefer curved objects? Angularity, expertise, and aesthetic preference. *Empirical Studies of the Arts*, *27*(1), 25–42.
- Smith, A. (2002). *The theory of moral sentiments*. Cambridge: Cambridge University Press.
- Somers, T. (n.d.). *200% The Lengths to Which Artists Go*. Retrieved April 2016, from <http://200-percent.com/tino-seghal-at-stedelijk-museum-412>.
- Sonderegger, A., & Sauer, J. (2010). The influence of design aesthetics in usability testing: Effects on user performance and perceived usability. *Applied Ergonomics*, *41*(3), 403–410.
- Specht, S. M. (2010). Artists' statements can influence perceptions of artwork. *Empirical Studies of the Arts*, *28*(2), 193–206.
- Stolnitz, J. (1969). The aesthetic attitude. In J. Hospers (Ed.), *Introductory readings in aesthetics* (pp. 17–27). New York: The Free Press.
- Sullivan, L. H. (1979). *Kindergarten chats and other writings*. New York: Dover.

- Tatarkiewicz, W. (1980). *A history of six ideas: An essay in aesthetics*. The Hague: Martinus Nijhoff.
- Temme, J. E. V. (1992). Amount and kind of information in museums: Its effects on visitors satisfaction and appreciation of art. *Visual Arts Research*, 28–36.
- Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation*, 27(2), 237–246.
- Thornhill, R. (2003). Darwinian aesthetics inform traditional aesthetics. In E. Voland & K. Grammer (Eds.), *Evolutionary aesthetics* (pp. 9–35). New York: Springer.
- Törrönen, J. (2002). Semiotic theory on qualitative interviewing using stimulus texts. *Qualitative Research*, 2(3), 343–362.
- Tractinsky, N., Katz, A. S., & Ikar, D. (2000). What is beautiful is usable. *Interacting with Computers*.
- Tromp, N., Hekkert, P., & Verbeek, P.-P. (2011). Design for socially responsible behavior: A classification of influence based on intended user experience. *Design Issues*, 27(3), 3–19.
- Tuch, A. N., Bargas-Avila, J. A., & Opwis, K. (2010). Symmetry and aesthetics in website design: It's a man's business. *Computers in Human Behavior*, 26(6), 1831–1837.
- Van Lier, B., & Nolan, B. (Eds.). (2015). *31 Brilliant ideas for a better world: Celebrating 5 years of What Design Can Do!* Amsterdam: n.p.
- Van Spronsen, E. (2015). *H5N8: Designing aesthetically pleasing products with contaminated chicken material* [Master thesis]. Delft University of Technology, Delft.
- Vasconcelos, L. A., & Crilly, N. (2016). Inspiration and fixation: Questions, methods, findings, and challenges. *Design Studies*, 42, 1–32.

- Vermaas, P. E., Carrara, M., Borgo, S., & Garbacz, P. (2013). The design stance and its artefacts. *Synthese*, 190(6), 1131–1152.
- Veryzer, R. W., & Hutchinson, J. W. (1998). The influence of unity and prototypicality on aesthetic responses to new product designs. *Journal of Consumer Research*, 24, 374–394.
- Vieira, V. A. (2010). Visual aesthetics in store environment and its moderating role on consumer intention. *Journal of Consumer Behaviour*, 9(5), 364–380.
- Walsh, D. (1979). Occam's razor. *American Philosophical Quarterly*, 16(3), 1–4.
- Wang, Y. J., Hernández, M. D., & Minor, M. S. (2010). Web aesthetics effects on perceived online service quality and satisfaction in an e-tail environment: The moderating role of purchase task. *Journal of Business Research*, 63(9-10), 935–942.
- West, B. T., Welch, K. B., & Galecki, A. T. (2014). *Linear mixed models: A practical guide using statistical software* (2nd ed.). Boca Raton: CRS Press.
- Westerman, S. J., Gardner, P. H., Sutherland, E. J., White, T., Jordan, K., Watts, D., & Wells, S. (2012). Product design: Preference for rounded versus angular design elements. *Psychology & Marketing*, 29(8), 595–605.
- Wicks, R. (1997). Dependent beauty as the appreciation of teleological style. *The Journal of Aesthetics and Art Criticism*, 55(4), 387–400.
- Yamamoto, M., & Lambert, D. R. (1994). The impact of product aesthetics on the evaluation of industrial products. *Journal of Product Innovation Management*, 11(4), 309–324.
- Zelanski, P., & Fisher, M. P. (1984). *Design: Principles and problems*. New York: CBS College Publishing.

ACKNOWLEDGMENTS

I am grateful to my supervisors and co-authors Paul Hekkert and Nathan Crilly for trusting me with the responsibility of undertaking this research project and guiding me along the way, while keeping the way interesting and exciting. Whether we discussed science or life, our talks were filled with insights and laughter. Paul, this project was born from your dream of a Unified Model of Aesthetics (UMA) and your ability to persuade The Netherlands Organization for Scientific Research that this was a dream worth pursuing (this research was supported by the MAGW VICI grant number 453-10-004). Nathan, these pages could have not been written without your prompt, detailed, and constructive comments to my countless drafts. Countless thanks go to you.

I am grateful to my fellow UMA-researchers from Delft University of Technology: Janneke Blijlevens, Michaël Berghman, Nazli Cila, and Ruben Post. I thank you for the support you gave me through the years, whether it was in the form of statistical advice or coffee sharing. Working with you, I sensed and cherished the true spirit of collaboration. I am lucky to call you my friends. Ruben, I am particularly thankful that I got to share this whole process with you, from beginning to end, like a perfect playlist. I am also grateful to Simón Jiménez Jaramillo, our dedicated research assistant and my one and only paronymph. Simón, your being there has been precious to me. I hope you know that. Thanks also go to Shivani Tyagi and Clementine

Thurgood, fellow UMA-researchers from Swinburne University of Technology. It was a pleasure to welcome you in Delft and meet you in Istanbul, Tokyo, and New York.

I am grateful to the stimulating group of people that surrounded me in the Faculty of Industrial Design Engineering at Delft University of Technology, in particular to the members of the Design Aesthetics section and the Studiolab. Special thanks go to Deger Ozkaramanli, Elif Özcan Vieira, Anna Pohlmeier, Jay Yoon, Steven Fokkinga, Nynke Tromp, Valentijn Visch, Natalia Romero Herrera, Juan Jiménez García, Fenne van Doorn, Patrizia D’Olivo, Lyè Goto, Reinier Jansen, and Niko Vegt. Thanks to Daphne van der Does, Amanda Klumpers-Nieuwpoort, Denise Keislair, and Charleyne van Zijl, ever helpful at the Secretariat. Thanks to Sylvia Pont, my mentor from the Graduate School. Thanks to Charlotte Vanhoutte and Emilie van Spronsen, whom I came to know as master students. I learned a lot from you both.

I am grateful that I had the opportunity of developing part of my research as an academic visitor at the University of Cambridge, kindly hosted by Nathan Crilly. I treasure the time I spent in a place haunted by Newton, Darwin, and so many other brilliant spirits. Thanks to Jackie Searle, head housekeeper at Clare College; Jenny Ridgeon, research office administrator at the Department of Engineering; and the members of the Engineering Design Centre with whom I had the chance of discussing my work. Special thanks go to fellow doctoral researchers Wei-Ying Chou, Jimena Gómez Lues, and Emilene Zitkus, with whom I shared lunch and wonderful talks. Emilene, thanks for speaking to me in Portuguese, for wearing that bright-red sweater against the Department’s pale-blue walls. You were the perfect antidote to homesickness.

I am grateful to professors Derek Matravers and Nicholas Humphrey from the University of Cambridge, Allan Whitfield from Swinburne University of Technology, Helmut Leder from the University of Vienna, Marc Hassenzahl from the Folkwang University of Arts, Lin-Lin Chen from the National Taiwan University of Science and Technology, Gerald Cupchik from the University of Toronto Scarborough, Mads Nygaard Folkmann from the University of Southern Denmark, as well as to Matthijs van Dijk and Jeroen van Erp from Delft University of

Technology. Thank you for taking the time to discuss my research at different stages. Special thanks go to professor Yuriko Saito from the Rhode Island School of Design, professor Rolf Reber from the University of Oslo, and doctor Pieter Vermaas from Delft University of Technology, whose thoughtful remarks helped me refine the final version of this dissertation.

I am grateful to editors Lin-Lin Chen, Yaliang Chuang, and Carolyn Barnes from the *International Journal of Design*, Dennis Doordan and Gail Papay from *Design Issues*, Oshin Vartanian from *Empirical Studies of the Arts*, and to the anonymous reviewers whose feedback helped me improve the quality of my work. I would like to thank designers Jinhyun Jeon, Crispin Jones, Yan Lu, Loove Broms, Karin Ehrnberger, Kristina Niedderer, Sara Ferrari, Tim Holley, Scott Amron, Josselin Zaïgouche, Jim Rokos, and Matthias Laschke for providing me with images of their designs to illustrate my research. I would also like to thank everyone who participated in my studies for nothing else than the sake of science.

I am grateful to the friends who kept me company while I was working on my research: Janneke de Rijk, Gabriel Millán, Martha Castillo, Oswaldo Maccio, Carolina Gómez de Llarena, Gabriela Kizer, Kim Tiala, María Angélica García, Crista Snel, Stefanie Kooijman, Jaap Kokorian, and especially Pim van der Male, Dirk Gooren, and Humberto Ortiz. Pim, thank you for being such a great listener, for taking my mind off work and making me discuss music and grammar instead. Dirk, thank you for introducing me to all things designerly and engaging with my black humor in otherwise dull commutes, for sticking around no matter what. Humberto, thank you for teaching me about beauty when I was your student at the Central University of Venezuela. I would have never gotten this far had you not expelled me from Plato's Republic.

I would have never completed or even applied for this project without the unconditional support of my family, which includes the most fantastic in-laws. Grazie, Luisa, I am talking about you. Dear parents, the desire to make you proud keeps on pushing me forward. Dad, thank you for sharing with me your love for beautifully-designed things. Mom, I cannot thank you enough for helping me out as I prepared for my

doctoral defense. Marianne—the best friend I could ask for, you made me take my running shoes to conferences and convinced me I could run 21 kilometers without much training. Dearest JR—the best cook I will ever know, you encouraged me to make time for poetry and convinced me I could write a whole book of poems alongside this dissertation. You two make me do impossible things. I simply could not do without you.

I submitted the full draft of this dissertation after having my first contractions at three a.m. My beloved baby boy was born 27 hours later. Lucas, when you are old enough to read, I hope it is Jules Verne or *Frankenstein* keeping you busy. But, if you ever find yourself looking through these pages, you should know that I owe you big time. I owe you for pushing me beyond my limits. I owe you for putting things into perspective. I owe you for I knew nothing until you came into this world.

ABOUT THE AUTHOR

Odette da Silva (Caracas, 1978) holds a bachelor's degree in arts (Central University of Venezuela, 2002) and a master's degree in philosophy (Simón Bolívar University, 2007), both earned with Highest Honors. She lectured philosophical aesthetics in her native country (Central University of Venezuela, 2002-07) and Latin American art in Finland (Åbo Akademi University, 2008-09) before starting her doctoral research in design aesthetics at Delft University of Technology (2012).

Odette developed part of her doctoral research as an academic visitor at the University of Cambridge (2013). She has presented her studies in conferences such as the Congress of the International Association of Empirical Aesthetics, where she was given the Robert Francès Award for the Most Outstanding Student Research Contribution (2014). Her research has been published by the *International Journal of Design* (2015), *Design Issues* (2016), and *Empirical Studies of the Arts* (in press).

Odette is also the author of *En Busca del Lenguaje Originario* (2011), a dissertation on the philosophy of language of Friedrich Nietzsche, and three books of poetry: *Escandinavia y Otros Destinos* (2006), *Contra el Viento del Norte* (2016), and *Poemas Bajos / Nether Poems* (in press). As a poet, she has been awarded the Monte Ávila Prize for Unpublished Authors (2006), and received Honorable Mention in the Eugenio Montejo Poetry Contest (2011).

AUTHOR'S PUBLICATIONS RELATED TO THIS DISSERTATION

- Da Silva, O., Crilly, N., & Hekkert, P. (2013). Aesthetic appreciation of products: The effect of ideas underlying design. In K. Sugiyama (Ed.), *Proceedings of LASDR 2013* (Vol. 2, pp. 2558–2566). Tokyo: Shibaura Institute of Technology.
- Da Silva, O., Crilly, N., & Hekkert, P. (2014). Can a light switch be beautiful? Aesthetic appreciation of products as means. In K. Niedderer & Y.-K. Lim (Eds.), *Proceedings of DRS 2014* (pp. 1691–1692). Umeå: Umeå Institute of Design.
- Da Silva, O., Crilly, N., & Hekkert, P. (2014). Intentions and the aesthetics of artifacts. In A. Kozbelt (Ed.), *Proceedings of LAEA 2014* (pp. 148–152). New York: Hunter College of the City of New York.
- Da Silva, O., Crilly, N., & Hekkert, P. (2015). How people's appreciation of products is affected by their knowledge of the designers' intentions. *International Journal of Design*, 9(2), 21–33.
- Da Silva, O., Crilly, N., & Hekkert, P. (2016). Maximum effect for minimum means: The aesthetics of efficiency. *Design Issues*, 32(1), 41–51.
- Da Silva, O., Crilly, N., & Hekkert, P. (in press). Beauty in efficiency: An experimental enquiry into the principle of maximum effect for minimum means. *Empirical Studies of the Arts*.
- Post, R., Da Silva, O., & Hekkert, P. (2015). The beauty in product-service systems. In V. Popovic, A. Blackler, D.-B. Luh, N. Nimkulrat, B. Kraal, & Y. Nagai (Eds.), *Proceedings of LASDR 2015* (pp. 1717–1730). Brisbane: Queensland University of Technology.