‘Complexity in simplicity’
the effects of visual complexity on consumers’ comprehension of product innovations

Cheng, Peiyao; Mugge, R.; de Bont, Cees J.P.M.

DOI
10.1504/JDR.2020.118669

Publication date
2020

Document Version
Final published version

Published in
Journal of Design Research (online)

'Complexity in simplicity': the effects of visual complexity on consumers' comprehension of product innovations

Peiyao Cheng*

Faculty of Social Science,
Department of Design,
Harbin Institute of Technology,
Shenzhen, 518000, Guangdong, China
Email: chengpeiyao@hit.edu.cn
*Corresponding author

Ruth Mugge

Faculty of Industrial Design Engineering,
Department of Design, Organisation and Strategy,
Delft University of Technology,
2628 CE Delft, The Netherlands
Email: r.mugge@tudelft.nl

Cees de Bont

School of Design and Creative Arts,
Loughborough University,
Loughborough, LE11 3TU, UK
Email: C.J.De-Bont@lboro.ac.uk

Abstract: Designers are frequently involved in embodying product innovations. It is challenging to embody really new products (RNPs) because consumers often have difficulty comprehending them. This study explores the value of visual complexity for designing RNPs. In study 1, an experiment was conducted ($n = 77$) to test the effects of visual complexity on consumers' comprehension of incrementally new products (INPs) and RNPs. The results revealed different effects for INPs and RNPs. Specifically, a more complex appearance triggers congruence with the functions of a RNP, which facilitates consumers' comprehension. For INPs, no effects for visual complexity were found. Based on the positive effect of visual simplicity on consumers' aesthetic response to product design, the design strategy 'complexity in simplicity' is proposed. In study 2, we asked experienced designers ($n = 6$) to apply this design strategy. Results showed that they can design RNPs using the 'complexity in simplicity' and possible ways to achieve this are explained.

Keywords: congruence; consumer comprehension; design research; product appearance; product innovation; visual complexity.

Reference to this paper should be made as follows: Cheng, P., Mugge, R. and de Bont, C. (2020) ''Complexity in simplicity': the effects of visual complexity on consumers' comprehension of product innovations', *J. Design Research*, Vol. 18, Nos. 5/6, pp.270–293.

Biographical notes: Peiyao Cheng is Assistant Professor in the Design Department in the Faculty of Social Science at Harbin Institute of Technology (Shenzhen), China. Her research focuses on understanding the role of design in influencing consumer response to high-tech products. She has published her works in such journals as *Design Studies*, *International Journal of Design*, *Journal of Engineering Design*, and *International Journal of Research in Marketing*.

Ruth Mugge is a Professor of Design for Sustainable Consumer Behaviour and the Head of the Department Design, Organisation and Strategy at Delft's Faculty of Industrial Design Engineering. Her main research interests are (sustainable) consumer behaviour, product perception, design for behaviour change, and design for the circular economy. She has published on these topics in journals, such as *International Journal of Design*, *Design Studies*, *Journal of Cleaner Production*, and the *Journal of Product Innovation Management*. Furthermore, she serves as an editorial board member for *Journal of Product Innovation Management, Applied Ergonomics*, and *Journal of Design Research*.

Cees de Bont is currently the Dean of the School of Design and Creative Arts at Loughborough University, UK. Previously, he took up the deanship in the Faculty of Industrial Design Engineering of the Delft University of Technology in the Netherlands and the School of Design of the Hong Kong Polytechnic University. His research interests include early concept testing of consumer acceptance, consumer behaviour, innovation adoption, and networked innovation. Among other journals, he has published in *Design Studies*, *Design Issues*, *Journal of Product Innovation Management*, *Journal of Engineering Design*, *She Ji*, and *Journal of Design, Business and Society*.

This paper is a revised and expanded version of a paper entitled 'Should product innovations look simple or complex? The effects of visual complexity on consumers' comprehension of product innovations' presented at *International Association of Society of Design Research (IASDR) 2015 Congress Interplay*, Brisbane, Australia, 2–5 November, 2015.

1 Introduction

Designers are frequently involved in embodying product innovations. A product innovation is a product being introduced to the market with some novel elements (Chandy and Prabhu, 2011). Depending on the extent to which the novel elements of the product in question differentiate it from the existing products in the market, product innovations can be categorised into incrementally new products (INPs) and really new products (RNPs). The difference between INPs and RNPs lies in whether the integrated technology has been frequently used in the industry before. INPs (a.k.a. continuous or incremental innovations) often provide minor improvements through incorporating new features based on existing products, technologies and markets. Differently, through integrating highly innovative technology that has rarely been used in the industry before

(Garcia and Calantone, 2002), RNPs (a.k.a. discontinuous or radical innovations) offer dramatic improvements that enable consumers to do things they were previously unable to do. Consequently, consumers are familiar with INPs because they encounter similar products in daily life frequently. However, due to the incorporation of highly innovative technology, RNPs are totally new to consumers and challenge consumers' comprehension (Dahl and Hoeffler, 2004; Hoeffler, 2003; Lehmann, 1994). RNPs can establish a new product category, but can also belong to an existing category. When first introduced into the market in 1993, the Dyson DC01 vacuum cleaner was an example of a RNP that integrated the innovative dual cyclone technology, which allowed bagless suction. In contrast, an example of an INP is the Hoover vacuum cleaner that integrated an indicator for dust bag changing, which offered an incremental improvement based on traditional technology through adding a new feature.

When embodying INPs and RNPs, designers face different challenges. For INPs that are in the mature stage of the product lifecycle, it becomes difficult to compete on technology and functionality. Thus, the prominent challenge is to differentiate the product from competitors in the market (Person et al., 2008). To support designers, a large number of studies have been conducted to provide knowledge on consumer responses to different appearance attributes, such as novelty (Hekkert et al., 2003; Hung and Chen, 2012; Mugge and Schoormans, 2012), unity (Veryzer and Hutchinson, 1998), harmony (Kumar and Garg, 2010), visual complexity (Creusen et al., 2010) and different product personality characteristics (Mugge, 2011; Mugge et al., 2009).

Differently, for RNPs that are in the early stage of the product lifecycle, the prominent challenge is to communicate RNPs to facilitate consumers' comprehension (Eisenman, 2013). Previous studies have conceptually acknowledged the potential of designing product appearance to facilitate consumers' comprehension of RNPs (Eisenman, 2013; Rindova and Petkova, 2007). This research aims to builds on these studies through investigating the influences of product appearance on consumers' comprehension of RNPs. More specifically, this research focuses on the appearance attribute of visual complexity.

Consumers' difficulty for comprehending RNPs is caused by the highly innovative technology integrated. As demonstrated in previous studies, highly innovative technology can result in significant changes in the marketing and production processes within a company (Abernathy and Clark, 1985), changes in the organisational environment (Tushman and Anderson, 1986) and can result in difficulties for organisations adopting these innovations (Moch and Morse, 1977). In addition, the highly innovative technology integrated in RNPs can have a significant influence on consumers. Specifically, as RNPs are totally different from INPs that consumers encounter in their everyday lives, the highly innovative technology integrated in RNPs is difficult for consumers to comprehend (Hoeffler, 2003). RNPs are characterised with high complexity (Rogers, 1995), which requires a large amount of new knowledge and completely different ways of thinking how to use RNPs (Mukherjee and Hoyer, 2001; Veryzer, 1998).

When first encountering a RNP, consumers need to gain comprehension toward the RNP. Specifically, consumers first become aware of the RNP. Next, consumers gradually develop some idea of how it functions, including how the RNP works, what functions it can offer, and what benefits it can provide. As a result, consumers may either feel that they lack comprehension of the RNP or consumers may feel confident that they understand the RNP and its benefits (Hoeffler and Herzenstein, 2011). At this stage, as consumers have limited experiences with the RNP, consumers' comprehension is

predominantly a subjective comprehension, which refers to consumers' subjective evaluation towards their processing of the target RNP (Mick, 1992). Such subjective comprehension is a precondition for consumers' adoption of RNPs (Reinders et al., 2010). If consumers feel that they lack comprehension of a RNP, the confusion can result in initial resistance to it, which leads to consumers' disregard and even rejection (Talke and Heidenreich, 2014).

To facilitate consumers' comprehension of RNPs, several effective marketing strategies have been developed, such as product bundling (Reinders et al., 2010) and analogical learning via advertisements (Gregan-Paxton et al., 2002). In design research, designing product appearance to facilitate consumers' comprehension of RNPs has not yet received adequate research attention. Thus far, prior research has demonstrated that a typical-looking RNP helps consumers to retrieve knowledge from the relevant product category and reduce the anticipated learning costs (Mugge and Dahl, 2013). In comparison to the studies on investigating consumer response to product appearance of INPs, studies on RNPs are limited.

Investigating the influence of product appearance on consumers' comprehension is important because designers intend to help consumers to comprehend a product through its appearance (Crilly et al., 2009). For many RNPs, the integrated technology does not fundamentally influence their appearances, and product appearances are not predefined by the integrated technology (Rindova and Petkova, 2007). Then, designers can embody RNPs in various appearances and thereby deliberately influence consumers' comprehension. For example, the first e-books were designed to resemble physical books, thereby communicating to consumers that e-books are used for reading. However, the effect of product appearance goes beyond mere categorisation. There are many appearance attributes still unexplored, which have the potential to facilitate consumers' comprehension. Specifically, this research focuses on the potential of the appearance attribute of visual complexity for influencing consumers' comprehension of product innovations.

2 Literature review: visual complexity and visual simplicity in product innovations

Visual complexity is defined as the level of complexity of a pattern, shape, or object (Berlyne, 1971). In this sense, visual complexity differs from the term complexity that is frequently used to describe the number of functional features included in a product (Thompson et al., 2015). In other words, complexity relates to product functionality, while visual complexity focuses on product appearance. For products, visual complexity describes how complex the appearance is, which is mainly determined by the number of elements the product appearance entails (Hung and Chen, 2012). Thus, high visual complexity refers to a product appearance that includes a large number of elements (e.g., lines, colours, materials, finishes) and has many details in these elements, while low visual complexity, or visual simplicity, refers to a product appearance that contains minimal elements.

Visual complexity is worthwhile to investigate because it is one of the design languages that designers frequently use while embodying product innovations (Ellis, 1993; Veryzer, 1995). In the market, we can observe product innovations embodied in different visual complexity levels. For example, to embody rapid air technology that fries

food without oil, Philips uses a simple appearance for its Airfryer (see Figure 1(a)) that consists of one regular overall shape with few details. In contrast, the Tefal Actifryer is much more visually complex (see Figure 1(b)). Its cylindrical design is horizontally divided into three parts with three different finishes. The transparent top cover exposes the internal components to consumers. However, it is unknown how different visual complexity levels influence consumers' comprehension of product innovations. Moreover, visual simplicity (vs. visual complexity) has been identified as one of the appearance attributes that consumers can perceive and use to form an overall impression of products (Blijlevens et al., 2009). Specifically, consumers tend to relate visual complexity with product functionality (Creusen et al., 2010). As a result, consumers may perceive congruence between the visual complexity of the product appearance and the innovative functionality of RNPs. Such congruence can trigger fluent processing (Van Rompay et al., 2009), which positively influences consumers' comprehension.

Figure 1 Examples of RNPs with different visual complexity levels: (a) Philips AirFryer (simple appearance) and (b) Tefal ActiFryer (complex appearance) (see online version for colours)

In order to examine the influence of visual complexity on consumers' comprehension of product innovations, a controlled experiment was set up in Study 1. Next, Study 2 explores how to apply these findings by interviewing designers. These findings can provide designers with knowledge on how to increase consumers' comprehension through changing visual complexity.

3 Hypothesis development: visual complexity and consumer comprehension of product innovations

Visual complexity influences consumer response in different ways. First, visual complexity influences consumers' aesthetic preferences. Traditionally, Gestalt psychologists believed that a high degree of ordering and thus low visual complexity leads to aesthetic preference (Muller, 2001). Prior research has empirically supported that visual simplicity (low visual complexity) enhances consumers' aesthetic preferences (Creusen et al., 2010; Snelders et al., 2014) because it is easy to process cognitively (Berlyne, 1971). In addition to aesthetic preference, visual complexity can influence consumers' evaluation of product functionality. Although visual complexity is often

independent of product functionality from an objective perspective, consumers may still use visual complexity to infer a product's functional attributes. Consumers thus form different perceptions on product functionality by drawing inferences from product appearances (Bloch, 1995; Creusen and Schoormans, 2005). Specifically, Creusen et al. (2010) demonstrated that consumers who value product functionality prefer a complex product appearance over a simple one because they infer enhanced functionality from this appearance. Correspondingly, for RNPs, we expect that consumers perceive congruence between a complex appearance and the innovative functionality of RNPs.

Congruence refers to the extent to which two or more elements correspond to each other (Van Rompay et al., 2010). The congruence largely depends on consumers' subjective perceptions and thus on to what degree consumers think different elements belong together. When consumers perceive different elements as highly corresponding to each other, high congruence is triggered. Conversely, when consumers perceive elements as conflicting with each other, incongruence is evoked.

Consumers can perceive congruence in various contexts, such as between a new product and the associated product category: to what extent a new product is perceived to be congruent with the associated product category (Goldenberg et al., 2003; Meyers-Levy and Tybout, 1988; Noseworthy and Trudel, 2011), between colour and product category: to what extent the colour of a product is perceived to be congruent/appropriate for the product category (Bottomley and Doyle, 2006), between a brand's emotional benefits and the emotions associated with product usage: to what extent the emotional benefits promised by a brand are congruent with the product usage provided by the brand (Ruth, 2001), and between a product's attribute and a brand image of the product: to what extent the function provided by the product attribute is congruent with the image promised by the brand (Brown and Carpenter, 2000).

Furthermore, previous studies have demonstrated a congruence effect for packaging design and product design. Consumers can experience congruence regarding symbolic meanings between textual and visual elements of a product package (Van Rompay et al., 2009), and between shape and typeface of a package (Van Rompay and Pruyn, 2011). Furthermore, consumers can perceive congruence between product appearance and product functionality. By looking at product appearance, consumers tend to infer product functionality. When the product provides the functionality corresponding to consumers' inferences, a high level of congruence is triggered. For example, by encountering a novel-looking product, consumers expect the product to have novel functionality (Mugge and Schoormans, 2012). When the product provides novel functionality, the experienced congruence can significantly influence consumers' processing of products.

To gain comprehension of a product innovation, consumers engage in information searching and processing. Consumers need to process information conveyed by the product appearance and information about the product's new functions. In this process, (in)congruence plays a significant role in influencing consumers' processing. In comparison to incongruence, high congruence can be processed more easily, leading to positive attitudes (Reber et al., 2004). Consumers naturally expect congruence between product appearance and the product functionality (Hoegg and Alba, 2011). For instance, when seeing an attractive laptop, consumers tend to infer that it has greater performance quality (Page and Herr, 2002). When the laptop provides superior performance in line with consumers' initial expectation, a state of congruence is created. With this confirmation of initial expectations, consumers can process the product fluently and form a judgement easily. Conversely, in the case of incongruence, consumers need to elaborate

on it to recognise and resolve the incongruence, which requires ample cognitive efforts (Hoegg et al., 2010). When ample cognitive resources are available, consumers can be motivated to solve the incongruence. However, when cognitive resources are limited, consumers may not be motivated to solve the incongruence, leading to less fluent processing of the product.

Following the effects of (in)congruence between (un)attractive product appearance and superior functions (Hoegg and Alba, 2011; Hoegg et al., 2010), this study proposes that congruence can also be triggered by the visual complexity of the appearance and the complexity of the functionality of a RNP. When encountering a complex appearance, consumers may naturally expect that the product innovation contains complex technology. As complexity is an attribute of RNPs, which corresponds to consumers' initial expectation, congruence between product appearance and functionality is triggered. Such congruence can facilitate consumers' processing (Van Rompay and Pruyn, 2011) and demand fewer cognitive efforts (Hoegg et al., 2010). As learning and understanding RNPs requires great cognitive efforts from consumers, more cognitive resources can be spent on understanding the really new functions, resulting in enhanced comprehension of the RNPs. Conversely, when consumers encounter a simple appearance, the presence of complex technology in a RNP may trigger incongruence. Then, consumers need to spend extra cognitive efforts to deal with the incongruence, resulting in fewer cognitive efforts to learn the really new functions. Consequently, consumers will have less comprehension of the RNP.

For INPs, we do not expect that visual complexity will influence consumers' comprehension. As consumers are equipped with sufficient knowledge of INPs due to their daily experiences with similar products, they are capable of comprehending INPs. Moreover, INPs are often in the mature phase of the product lifecycle, where products differentiate from competitors through different appearances (Person et al., 2008). Thus, it is likely that consumers are frequently exposed to INPs with various appearances, including simple and complex ones. Therefore, we expect that consumers will perceive both simple and complex appearances as congruent to the functions of an INP. Correspondingly, the following hypotheses are proposed:

H1: Visual complexity moderates the relationship between innovation type and consumers' comprehension. Specifically, for a RNP, a more complex appearance will increase consumers' comprehension (H1a). For an INP, the visual complexity does not influence consumers' comprehension (H1b).

H2: For a RNP, the congruence between product appearance and function mediates the relationship between the visual complexity and consumers' comprehension.

4 Study 1

4.1 Research method

To test the hypotheses, we conducted one main study and two pretests. Pretest 1 tested textual descriptions for INPs and RNPs. Pretest 2 tested product appearances to ensure differences in visual complexity while preventing any confounding effects. These results were combined to create four different conditions for the main study. To enhance generalisability, stimuli were created for: irons, electric kettles, and hairdryers. We

selected these product categories because they are common consumer durables in the markets, which makes it feasible to create different levels of visual complexity and ensures that consumers have some basic knowledge.

4.1.1 Pretest 1: INPs vs. RNPs

To manipulate INPs and RNPs, textual descriptions were created by changing the immutable feature in each product category (Moreau et al., 2001). An immutable feature refers to a core feature of the product category that cannot be replaced and that other features heavily rely on it. When the immutable feature is changed, the product will deviate strongly from other products in this category. Consequently, consumers' perception of the discontinuity increases and comprehension of such a RNP is challenging. For instance, for an iron, heated steam is an immutable feature, because it is used widely in the product category and other features are designed based on it, such as a water tank and vent holes to produce steam. By changing the heated steam into ultrasound waves, a RNP is created. Textual descriptions of RNPs were created by changing immutable features into significantly different ones that were rarely used in the corresponding product categories at the time the study took place. An engineer with a PhD confirmed the technological feasibility of the created textual descriptions. For the INPs, the texts described a new product with new features for which the immutable features did not change (e.g., an iron with a more powerful heating element that produces steam continuously). Similarly, INPs were created for an electrical kettle and a hairdryer with higher wattages, while RNPs were created for an electrical kettle with UV ray to kill bacteria and a hairdryer with a sensor to measure hair dryness to produce air in different temperatures accordingly. The general description of the product was listed first, followed by the key functional feature and benefits and three identical general functional attributes. The wording and length of the texts were kept as similar as possible (see Appendix A for an example of the textual description for a hairdryer).

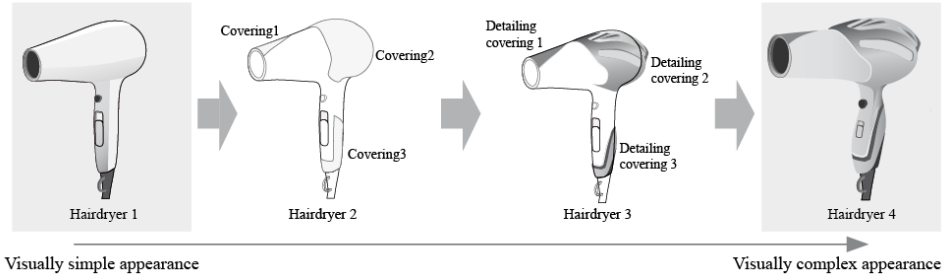
To check this manipulation, a 2 (innovation type: INP vs. RNP) ×3 (product category: iron, electric kettle, and hairdryer) mixed design was used, with innovation type as between-subject factor and product category as a within-subject factor. Twenty-five participants were asked to rate the textual description for each product category. To measure the innovativeness of the stimuli, participants were asked to respond to the three-item measure (Moreau et al., 2001): (1) How different is this product from other products in this product category you currently know about? (1 = 'not at all different' to 7 = 'very different'); (2) How innovative do you perceive this product to be? (1 = 'not very innovative' to 7 = 'very innovative'); and (3) To what extent would this product change the way you would use this type of product? (1 = 'not at all' to 7 = 'very much') (α's ranging from 0.80 to 0.86). The main effect was found for innovation type, $F(1, 23) = 14.21$, $p < 0.05$. Across three product categories, participants assigned to rate RNPs perceived the product as more innovative than participants who rated INPs.

4.1.2 Pretest 2: simple vs. complex product appearances

For the manipulation of the visual complexity of the product appearances, five product appearances were created for each product category. A change in visual complexity in product appearance is possible to bring changes in attractiveness and typicality/novelty. To ascertain that the demonstrated effects were evoked by visual complexity, rather than

such confounding effects, we selected stimuli in pretest 2 that differed significantly in visual complexity but did not differ in attractiveness and typicality. Based on participants' ratings, we first selected the stimuli whose ratings of visual complexity significantly differed. Next, among the selected stimuli, we compared the ratings on attractiveness and typicality. The stimuli that differed significantly on attractiveness and typicality were excluded. All product appearances were created by a trained designer with an MSc in Industrial Design. First, the designer created a simple appearance for each product category based on the typical appearance of this category. Subsequently, based on the simple appearances, more elements (e.g., lines, textures, coverings) and details were included to increase the visual complexity, while minimising potential confounding effects. Existing products were reviewed and used as examples to keep the created stimuli realistic. Existing hairdryers use lines, coverings consisting of different materials, and specific detailing to make the product appearance more visually complex. We simulated these effects in our stimuli (see Figure 2). Thus, hairdryer 2 is more visually complex than hairdryer 1 by adding three coverings. Hairdryer 3 is even more visually complex due to the creation of details on the coverings. Consequently, based on hairdryer 3, hairdryer 4 was created and used as stimuli, together with hairdryer 1. All product appearances were designed as 3D visualisations, which were standardised in size, buttons, and black and white colours to prevent confounding effects.

Figure 2 Example of stimuli creation process for a hairdryer: the process of increasing visual complexity of a hairdryer



Next, 60 participants (40% male, mean age = 21.87) evaluated the product appearances. A 5 (visual complexity: simple vs. complex product appearance) ×3 (product category: iron, electric kettle, and hairdryer) mixed design was used, with visual complexity as between-subject factor and product category as a within-subject factor (See Appendix B). Each participant was randomly assigned to one of the five conditions and rated one product appearance for each of the three product categories on various measures. Visual complexity was measured with two 7-point scale items anchored by: 'simple/complicated' and 'not complex/complex' (Pearson's *r's* ranging from 0.53 to 0.63). To prevent confounding effects, attractiveness and typicality were measured. Attractiveness of the product appearances was measured by two items: 'unattractive/attractive' and 'ugly/beautiful' (Pearson's *r's* ranging from 0.72 to 0.89). Typicality was measured by three 7-point scale items (Veryzer and Hutchinson, 1998) anchored by 'bad/good example of the product category', 'not very/very typical for the product category', and 'unusual/usual' (α's ranging from 0.84 to 0.91).

Analyses were conducted separately for each product category. One-way ANOVAs were conducted with visual complexity as the independent variable, and the ratings on visual complexity, attractiveness, and typicality as dependent variables. Results revealed that participants' ratings of visual complexity of product appearances significantly differed among the stimuli for all three product categories: iron ($F(4, 55) = 3.49$, $p < 0.05$), electric kettle ($F(4, 55) = 3.37$, $p < 0.05$), and hairdryer ($F(4, 55) = 5.53$, $p < 0.05$). Subsequently, participants' ratings on attractiveness and typicality were analysed. Based on these results, two product appearances were selected for each product category that demonstrated the largest difference in visual complexity but did not significantly differ concerning typicality and attractiveness (see Appendix B).

4.2 Main study

4.2.1 Design and participants

To test the hypotheses, the main study had a 2 (innovation type: INPs vs. RNPs) ×2 (visual complexity: simple vs. complex product appearance) ×3 (product category: iron, electric kettle, and hairdryer) mixed design, with innovation type and visual complexity as between-subject factors and product category as a within-subject factor. Consequently, the combination of the two independent variables innovation type and visual complexity resulted in four conditions: (1) INPs with a simple appearance, (2) INPs with a complex appearance, (3) RNPs with a simple appearance, and (4) RNPs with a complex appearance. Moreover, these conditions were created for three product categories to improve generalisability.

Seventy-seven participants (42.9% male, mean age = 41.00) from a consumer panel participated in our experiment. Participants below 55 years old were selected because younger people generally have less difficulty accepting new products (Loudon and Bitta, 1993).

4.2.2 Procedure and measurements

To create the final stimuli, the results of pretest 1 and pretest 2 were combined. The textual descriptions of INPs and RNPs for each of the three product categories (pretest 1) were combined with the complex and simple appearances (pretest 2). Each participant was assigned to one of the four conditions and asked to evaluate three product categories on several measures. The order of presenting the products was counterbalanced.

Participants' comprehension of product innovations was measured by asking participants to indicate to what degree they agreed with the following two statements (Reinders et al., 2010): "After looking at the picture of the product and reading the description, I have a very solid understanding of how this product works" and "After looking at the picture of the product and reading the description, I completely understand the various features of this new product" from 1 (strongly disagree) to 7 (strongly agree; Pearson's r's ranging from 0.78 to 0.88). Such self-reporting measurements are considered a feasible measurement of consumers' comprehension and an effective predictor of decision outcomes (Raju et al., 1995). To measure the congruence between the product function and appearance, we used the three statements (adapted from Fleck and Quester (2007)): "The product appearance of this product is well matched with the functions," "In my opinion, the function of this product is very well communicated

through this product appearance," and "The product appearance and the functions of this product go well together" from 1 (strongly disagree) to 7 (strongly agree; α's ranging from 0.83 to 0.92). To check the manipulation, we included measures of innovativeness (α's ranging from 0.79 to 0.84) and visual complexity (Pearson's r's ranging from 0.74 to 0.83), which were identical to those used in the pretests.

To avoid potential confounding effects, attractiveness and typicality of product appearances were measured. Attractiveness of product appearance was assessed by two 7-point scale items: 'ugly/beautiful' and 'unattractive/attractive' (Pearson's r's ranging from 0.80 to 0.94). Typicality of product appearance was measured by rating one 7-point scale item "bad/good example of the product category." As individual differences were shown to influence participants' responses to product innovations (Truong et al., 2014), consumer innovativeness (Manning et al., 1995) and the design acumen dimension of the Centrality of Visual Product Aesthetics (Bloch et al., 2003) were included.

4.3 Results

4.3.1 Manipulation checks

To check the manipulation of innovation type, a 2 × 2 × 3 mixed ANOVA was conducted with innovation type, visual complexity, and product category as independent variables, and ratings of innovativeness as the dependent variable. Across three product categories, participants rated RNPs as being significantly more innovative than INPs, $F(1, 73) = 79.43$, $p < 0.01$ (see Table 1). Furthermore, analyses of the three product categories were conducted separately. For all product categories, RNPs were evaluated to be significantly more innovative than INPs, confirming the success of the innovation type manipulations. No effects were found for visual complexity and the interaction between visual complexity and innovation type ($p>.50$).

Next, a 2 × 2 × 3 mixed ANOVA was performed with ratings of visual complexity as the dependent variable. The results showed a significant difference between the simple and complex product appearances at the ratings on visual complexity ($F(1, 73) = 7.25$, $p < 0.01$) (see Table 1). Across the product categories, participants who were assigned to the complex condition reported higher scores on visual complexity for product appearances than the participants in the simple condition. Furthermore, separate analyses on the three product categories were conducted, and results revealed that the product appearances in the complex conditions were judged to be more complex than the ones in the simple conditions. No effects were found for the type of innovation and the interaction between type of innovation and visual complexity ($p>.20$). No significant differences were found between simple and complex appearances regarding attractiveness ($F(1, 73) = 3.09$, $p>.08$) and typicality ($F(1, 73)<1$), which confirmed the success of the stimuli manipulation.

4.3.2 Test of hypotheses

H1: Effects of visual complexity on consumers' comprehension

To test H1 that a more complex product appearance will increase consumers' comprehension of RNPs, a 2 × 2 × 3 mixed ANCOVA was conducted with innovation type, visual complexity, and product category as independent variables, consumers' comprehension as the dependent variable, and age, gender, consumer innovativeness, and

design acumen as covariates. Results showed a significant interaction effect between innovation type and visual complexity on consumers' comprehension ($F(1, 69) = 7.12$, $p < 0.05$). Across three product categories, participants reported greater comprehension of the RNP when the RNP had a more visually complex appearance ($F(1, 30) = 5.18$, $p < 0.05$; $M_{simple} = 4.75$, $M_{complex} = 5.61$). For INPs, no significant difference was found between the two visual complexity conditions ($F(1, 35) = 2.47$, $p > 0.10$; $M_{simple} = 5.61$, $M_{complex} = 5.07$; see Figure 3(a)). No effect was found for the product category, and no other interaction effects were found, suggesting generalisability of the findings. These results support H1. Furthermore, the pattern of means was explored for the three product categories separately, and the means for consumers' comprehension were all in the predicted direction: all participants reported better comprehension of the RNP when it was embodied in a complex appearance compared to a simple appearance. Conversely, for INPs, the differences of means for consumers' comprehension between the complex and simple appearance conditions did not reach statistical significance, suggesting that visual complexity did not help participants' comprehension of INPs (see Table 1 for an overview of results).

H2: Mediation role of congruence for RNPs

H2 states that the effect of visual complexity on comprehension is mediated by congruence between the product appearance and the really new function of RNPs. We first examined whether participants perceived congruence between the complex product appearance and the really new function of RNPs by conducting a $2 \times 2 \times 3$ mixed ANCOVA, with visual complexity and innovation type as independent variables, congruence as the dependent variable, and age, gender, consumer innovativeness, and design acumen as covariates. Results revealed a significant main effect of visual complexity on congruence ($F(1, 69) = 5.68$, $p < 0.05$). This effect was qualified by an interaction effect between innovation type and visual complexity ($F(1, 69) = 4.07$, $p < 0.05$). Across three product categories, participants reported a higher score on congruence when the RNP was visually complex than when it was visually simple ($F(1, 30) = 10.52$, $p < 0.01$; $M_{simple} = 3.74$, $M_{complex} = 4.92$, see Figure 3(b)). However, for INPs, visual complexity did not affect congruence ($F(1, 35)<1$, $p > 0.10$; $M_{simple} = 4.60$, $M_{complex} = 4.68$). No effect for the product category and no other interaction effects were found. Furthermore, the pattern of means was explored for the three product categories separately, and the means for congruence were in the predicted direction: all participants reported a higher score on congruence when the RNP was embodied with a complex appearance compared to a RNP with a simple appearance (see Table 1). In contrast, no congruence effects were found for INPs.

To test whether the effect of visual complexity on consumers' comprehension of RNPs is due to differences in congruence, a mediation analysis was conducted by following the methodology proposed by Preacher and Hayes (2004) (MODMED; model 8). Participants' ratings were first standardised. Next, the ratings of consumers' comprehension and congruence were averaged across three product categories. In the bootstrap analysis, a visual complexity dummy variable was included as an independent variable, an innovation type dummy variable as a moderator, and consumers' comprehension as a dependent variable; age, gender, consumer innovativeness, and design acumen were included as covariates. Results revealed that the interaction effects of visual complexity and innovation types on consumers' comprehension were mediated by congruence as the 95% confidence interval (CI) ranged from 0.07 to 1.12, for the point

of estimate of 0.26, without including zero (Preacher and Hayes, 2004; Zhao et al., 2010). We further examined the indirect effects for both innovation types separately to assess support for moderated mediation. For RNPs, the mediation through congruence was significant ($B = 0.49$, 95% CI, 0.15 to 1.11). However, for INPs, the mediation through congruence was not significant ($B = 0.34$, 95% CI, –0.25 to 0.36). These results supported H2, suggesting that visual complexity positively influences consumers' comprehension of RNPs, and congruence between product appearance and the product's functions mediates this effect.

Figure 3 The interaction effects of visual complexity and innovation type on: (a) consumers' comprehension and (b) congruence (see online version for colours)

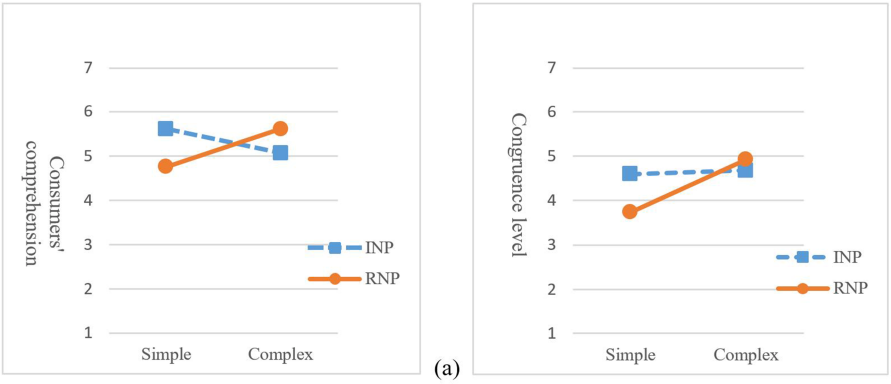


Table 1 Results of main study: means for comprehension*, congruence*, visual complexity, and innovativeness by product category

		INP		*RNP*	
		Simple	*Complex*	*Simple*	*Complex*
Iron	Comprehension	5.37	4.36	4.37	5.16
	Congruence	4.59	4.47	3.79	4.94
	Visual complexity	2.36	3.19	2.52	2.84
	Innovativeness	3.16	2.87	5.00	5.19
Electric kettle	Comprehension	5.98	5.63	4.97	5.72
	Congruence	4.37	4.56	3.43	4.74
	Visual complexity	2.09	2.82	2.31	3.51
	Innovativeness	2.61	2.76	4.45	4.13
Hairdryer	Comprehension	5.75	5.09	5.08	5.57
	Congruence	4.83	5.00	4.00	5.09
	Visual complexity	1.77	2.45	2.57	3.33
	Innovativeness	2.06	2.32	4.12	4.80

*Means are adjusted for including covariates.

4.4 Discussion of study 1

The findings of study 1 support the hypotheses that consumers perceive congruence between a complex appearance and the innovative functionality of RNPs, which triggers fluent processing and leads to enhanced comprehension of RNPs. Through the controlled experiment, the results demonstrate that more visually complex RNPs result in enhanced consumers' comprehension in comparison to visually simple RNPs.

Although the results of Study 1 support our hypothesis, there are several limitations. First, the created stimuli only reached moderate visual complexity levels. While designing the stimuli, we realised that high visual complexity also brings changes on novelty and is likely to trigger categorisation effects. If consumers cannot easily recognise to which category the innovation belongs, this may result in confusion (Loken and Ward, 1990; Meyers-Levy and Tybout, 1988; Schoormans and Robben, 1997) for both INPs and RNPs. To prevent confounding effects triggered by the extensively studied categorisation effect and focus specifically on the effect of congruence, we conducted several pretests to select stimuli that only differed on visual complexity and did not differ significantly on novelty and attractiveness.

Second, visual complexity was created by adding decorative elements. We manipulated visual complexity by adding decorative details and elements that did not directly communicate information related to the product functionality. The choice for including decorative elements was made because it allowed us to focus solely on the effect of visual complexity and congruence while ruling out confounding effects, for example, initiated by actual changes in the product's functionality. In practice, designers often jointly change these factors.

Third, the findings remain conceptual. Although we demonstrated the positive influence of visual complexity of consumers' comprehension of RNPs, how to increase visual complexity can differ from the stimuli creation process in Study 1. In fact, we believe it would be fruitful for designers to increase visual complexity by communicating the associated innovative functionality, which can further enhance consumers' comprehension. In other words, the findings of Study 1 are relatively conceptual and it would be worthwhile to further explore how these can be implemented to serve design practice.

5 Study 2

Study 2 aims to translate the theoretical findings from Study 1 into practical design guidelines. Following prior research that has asked designers to interpret and make use of research findings (Fokkinga and Desmet, 2013; Pedgley et al., 2018), we have interviewed designers to elucidate the results of Study 1.

In order to translate the theoretical findings into practical guidelines, the findings of Study 1 should be interpreted more carefully. Specifically, it can be challenging to design RNPs with highly complex appearances as such appearances are often perceived as aesthetically unattractive (Berlyne, 1971; Creusen et al., 2010). Moreover, according to the findings of Study 1, a highly simple appearance triggers incongruence with the functionality of a RNP, which hinders consumers' comprehension of the RNP. Thus, we propose that designers should make use of the benefits of both visual complexity and visual simplicity when designing RNPs. Specifically, designers can use visual complexity

to trigger the perceived congruence and improve consumers' comprehension. Furthermore, designers can simultaneously use visual simplicity to create attractive appearances (Lockwood, 2015). To make optimal use of both visual complexity and visual simplicity in product appearances of RNPs, we propose the design strategy 'complexity in simplicity', which refers to the simultaneous implementation of both visual complexity and visual simplicity in the product appearance. More specifically, this implies that designers, first of all, establish visual simplicity by keeping the overall shape basic, following a minimalistic design, which can trigger positive aesthetic responses. Subsequently, visual complexity can be designed in certain elements of the product appearance to trigger congruence with the complex technology in RNPs and facilitate consumers' comprehension. Study 2 was conducted to show how to achieve 'complexity in simplicity'. We interviewed experienced designers to investigate whether they can use this strategy to design RNPs; and if so, how they would design the RNPs, to provide more insights into 'complexity in simplicity.'

5.1 Research method

5.1.1 Participants

To show how designers can create 'complexity in simplicity', we invited six experienced product designers (5-25 years of design experience) to design RNPs. Due to their extensive design experience, these designers were able to design in different styles and explain possible ways to achieve specific styles.

5.1.2 Procedure

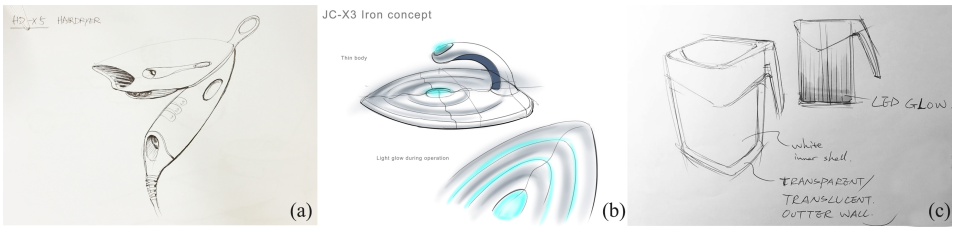
We used the product descriptions in study 1 as design briefs. Participants were presented with the concepts of the RNPs, the findings from study 1, product examples in visually complex and visually simple design styles, and the 'complexity in simplicity' design strategy. They were asked to design two RNPs in 'complexity in simplicity'. After finishing the designs, a short interview followed. Participants were asked to explain their designs, their opinions concerning the design strategy 'complexity in simplicity', and the possible ways to achieve it.

5.1.3 Results and discussion

All participants completed the design tasks. The generated designs achieved 'complexity in simplicity' (see Figure 4). The created designs followed the visual simplicity style in their overall appearance and included visual complexity in certain elements. During the interviews, designers explained that increasing visual complexity was an effective way to communicate the innovative functionality of RNPs because it enabled them to highlight the innovative functionality. This opinion further built on the research finding of congruence between innovation functionality and visually complex appearance in Study 1. This view has also been supported by previous studies on congruence between product functionality and appearance (Hoegg and Alba, 2011; Hoegg et al., 2010; Mugge and Schoormans, 2012). In fact, improving visual complexity may not have an actual functional purpose, but it does emphasise and elucidate the new features, which can contribute to people's comprehension of RNPs. For example, in Figure 4(a), the designer made the two sensors of the hairdryer visually complex, because these sensors were the

innovative parts of the RNP. Similarly, designers improved the visual complexity by designing the iron plate in the shape of water waves to communicate ultrasound waves (see Figure 4(b)), and by including an array of LED on the surface of the electric kettle to indicate UV rays (see Figure 4(c)). Designers also explained that the overall shape should have visual simplicity to be aesthetically pleasing.

Figure 4 Examples of designs created in study 2: (a) a hair dryer, (b) electronic iron and (c) electronic kettle (see online version for colours)



As for simplicity and complexity, designers explained that both were different communication strategies that are not necessarily mutually exclusive. This corresponded to the notion that visual simplicity is required to bring order to visual complexity (Shelley, 2015). Thus, visual simplicity and visual complexity should be combined to selectively communicate information related to product functionality and technology and thereby facilitate consumers' comprehension. As one designer mentioned:

> "When designers want to make something simple, they have to digest a lot of complexity and select these parts that consumers can understand, and these parts consumers don't want to understand, and those parts consumers would like or [are] curious to know. That is sort of different parts of information you need to design into the product."

Furthermore, designers suggested possible ways to achieve 'complexity in simplicity'. First, designers proposed that the overall appearance should be simple and coherent to make the product aesthetically pleasing, which followed the research findings of the positive effect of visual simplicity on consumers' aesthetic preferences (Creusen et al., 2010; Snelders et al., 2014). Second, corresponding to the literature (Hung and Chen, 2012), designers suggested that visual complexity can be increased by adding more elements and details. The interview results revealed specific ways to enhance visual complexity in RNPs, such as including LEDs, parts, layers, and lines, to highlight and communicate the innovative functionality of the product (see Figure 4). Furthermore, designers can use different colours and materials to create contrasts in the appearance. Third, designers highlighted that when increasing the number of elements, these elements should share some similarities to create rhythm and harmony, contributing to the overall simplicity.

Moreover, designers mentioned that using transparent or translucent materials is another way to achieve 'complexity in simplicity'. This finding is supported by prior research on transparency (Cheng et al., 2018). Exposing technical details underneath the product's surface increases the visual complexity and communicates additional information concerning the product functionality, which can facilitate consumers' comprehension while maintaining the overall simplicity.

6 General discussion

Considering the critical role of RNPs for many companies, it is crucial to equip designers and design managers with knowledge on how to use product appearance to influence consumers' comprehension positively. Specifically, the findings of study 1 reveal that visual complexity can increase consumers' subjective comprehension of RNPs. When encountering a RNP with a complex appearance, consumers perceive congruence between the really new functions and its complex appearance. This congruence brings about more fluent processing, which facilitates consumers' comprehension because it leaves more cognitive resources available for understanding the really new functions of the RNP. Consumers do not experience difficulty in comprehending INPs, so congruence and visual complexity will not influence consumers' comprehension of these innovations. These findings suggest that designers can consider increasing visual complexity while designing RNPs to facilitate consumers' comprehension. However, to create an attractive appearance, it is also important to preserve overall simplicity. Accordingly, we propose 'complexity in simplicity' to designers and design managers as an effective strategy to create RNPs that are aesthetically attractive and perceived as more comprehensible. The findings of study 2 show that designers can design RNPs by following 'complexity in simplicity'. Moreover, designers increased visual complexity not only by adding decorative elements but by communicating the innovative functionality of the RNP. By emphasising and elucidating the unique features of a RNP via visual complexity, visual complexity can directly facilitate consumers' comprehension as well as indirectly through congruence. Overall simplicity can be maintained by making a coherent overall shape and creating rhythm among the different elements.

This research contributes to the literature in the following ways. First, this research contributes to the studies investigating consumer response to product appearance by specifically focusing on RNPs that are in the introduction stage of the product lifecycle. In the marketing and innovation literature, a number of studies have investigated product innovations (Rogers, 1995) and concluded that the challenge in the introduction stage lies in facilitating consumers' comprehension (Hoeffler, 2003; Hoeffler and Herzenstein, 2011). Marketing research has also conceptually recognised the value of product appearance for influencing consumer response to products that are in the introduction stage (Eisenman, 2013; Rindova and Petkova, 2007). However, not sufficient research efforts have been paid on investigating the effects of specific product appearance characteristics, such as visual complexity. Prior studies investigating the role of product appearance in consumer response have focused on products that are in the growth and maturity stages of the product lifecycle (Person et al., 2008). In these studies, the functionality of stimuli products is familiar to consumers and thus comprehension is not a major concern (e.g., Blijlevens et al., 2009; Creusen et al., 2010; Hekkert et al., 2003; Hung and Chen, 2012). The present research fills in this knowledge gap by demonstrating the prominent role of product appearance for facilitating consumers' comprehension of RNPs.

Second, we found that the enhancement of comprehension is mediated by the congruence that consumers perceive between the really new functions and complex appearances of RNPs. Thus far, current studies that investigated congruence effects have focused on the congruence between a new product and the associated product category (Goldenberg et al., 2003; Meyers-Levy and Tybout, 1988; Noseworthy and Trudel, 2011). The effects of (in)congruence between appearance and functions have received

limited research attention, and focus has only been on (in)congruence between the attractiveness of appearances and the superiority of the product's functions (Hoegg and Alba, 2011; Hoegg et al., 2010). Our findings uncover that consumers can perceive (in)congruence in an additional way: between a complex product appearance and the product's innovative functionality.

Third, this research provides suggestions for translating the theoretical findings into practical guidelines. Specifically, we propose 'complexity in simplicity' to balance the visual complexity and visual simplicity style in order to use the benefits of both. Moreover, in line with previous studies that translate theoretical findings into design guidelines through involving designers (Fokkinga and Desmet, 2013; Pedgley et al., 2018), this research invited experienced designers to make use of research findings to generate design guidelines. As a result, possible ways to achieve 'complexity in simplicity' were given: by creating visual simplicity in the overall appearance, by including visual complexity in the innovative elements and by creating similarities among the different elements. We acknowledge that in practice, designers should also take into account the specific context of the RNP when deciding for the most preferred level of complexity. Specifically, specific brands may be associated with more visual simplicity than others. In order to preserve brand recognition, this may limit the possibilities to use greater levels of visual complexity in the appearance.

6.1 Future research and limitations

Although this research demonstrates the value of visual complexity, there are several limitations, which could be interesting for future research. First, to distinguish a high-end product from a more basic product, designers in practice often attempt to increase visual complexity in the design of high-end products. Based on our research findings, we expect that the congruence effect between appearance and functionality provides a rationale for this decision. As consumers perceive congruence between a visually complex appearance and innovative functionality, they are also likely to perceive congruence between a visually complex appearance and a high-end product. It would be interesting for future research to investigate the relationship between visual complexity and the price of products within a product line to shed lights on these effects.

Second, although this research focuses on the choice between visual simplicity and visual complexity and demonstrated the positive effect of visual complexity on consumers' comprehension of RNPs, the choice between visual simplicity and visual complexity should be made by considering other contextual factors, such as market situations and brand identity. For example, when the market is filled with products with a simplicity style, enhancing visual complexity to embody RNPs can also be desirable because it brings consumers' attention and signals the innovativeness. Similarly, designers should consider the brand image in order to decide the desirable visual complexity levels.

Third, our research focused on RNPs that belonged to a specific category and of which the appearance is largely independent of the integrated technology. Consequently, all RNPs provided ample freedom concerning the possible appearances. Our findings suggest that for such RNPs visual complexity contributes to consumers' comprehension. However, while evaluating the stimuli and the created drawings in study 2, it is apparent that all appearances are recognisable as belonging to the specific category and are thus relatively typical. In some situations, the appearance of a RNP can be influenced or even

shaped by the technological innovation. Then, the product appearance can deviate from the prototype or even establish a new (sub)category. More research is needed to understand the role of visual complexity for these RNPs.

Fourth, in this research we focused on investigating visual complexity on RNPs, which is a specific type of product innovations. In this research, although we distinguish INPs and RNPs, it does not suggest that innovations only fall into the two categories. In fact, prior research concludes that product innovativeness is a spectrum and identifies radical innovation in addition to really new innovations and incremental innovations (Garcia and Calantone, 2002). In comparison to RNPs, radical innovations include even higher level of innovativeness. The technology integrated in RNPs is new to the industry, such as Dyson DC01 that uses dual cyclone technology in vacuum cleaner industry for the first time. However, the technology incorporated in radical innovations is completely new to the world, such as the introduction of the internet and steam engine. Future research could investigate whether our findings can also be applicable to radical innovations.

Finally, this research focused on consumers' first encounters with a RNP and on their initial subjective comprehension (Raju et al., 1995), which is an effective predictor for consumers' evaluation and adoption of RNPs. Consumers' subjective comprehension measures the extent to which consumers comprehend the innovative functionality provided by the RNP. For future research, it would be interesting also to investigate consumers' objective comprehension, which can influence consumers' usage experiences of RNPs. Especially, there is evidence suggesting that consumers' attitudes towards visually complex stimuli will improve with multiple exposures (Cox and Cox, 2002). Thus, it would be beneficial for future research to investigate the effects of visual complexity on consumer responses to RNPs over multiple exposures, which will uncover whether consumers' subjective as well as objective comprehension will further increase with multiple exposures and whether it will improve consumers' overall attitudes and adoption decision.

References

Abernathy, W.J. and Clark, K.B. (1985) 'Innovation: mapping the winds of creative destruction', *Research Policy*, Vol. 14, No. 1, pp.3–22.

Berlyne, D.E. (1971) *Aesthetics and Psychobiology*, Appleton-Century-Crofts, New York.

Blijlevens, J., Creusen, M.E. and Schoormans, J.P. (2009) 'How consumers perceive product appearance; the identification of three product appearance attributes', *International Journal of Design*, Vol. 3, No. 3, pp.27–35.

Bloch, P.H. (1995) 'Seeking the ideal form: product design and consumer response', *The Journal of Marketing*, pp.16–29.

Bloch, P.H., Brunel, F.F. and Arnold, T.J. (2003) 'Individual differences in the centrality of visual product aesthetics: concept and measurement', *Journal of Consumer Research*, Vol. 29, No. 4, pp.551–565.

Bottomley, P.A. and Doyle, J.R. (2006) 'The interactive effects of colors and products on perceptions of brand logo appropriateness', *Marketing Theory*, Vol. 6, No. 1, pp.63–83.

Brown, C.L. and Carpenter, G.S. (2000) 'Why is the trivial important? A reasons-based account for the effects of trivial attributes on choice', *Journal of Consumer Research*, Vol. 26, No. 4, pp.372–385.

Chandy, R.K. and Prabhu, J.C. (2011) 'Innovation typologies', *Wiley International Encyclopedia of Marketing*, p.5.

Cheng, P., Mugge, R. and de Bont, C. (2018) 'Transparency in product design: investigating design intentions and consumers' interpretations', *Journal of Engineering Design*, Vol. 29, No. 10, pp.539–568.

Cox, D. and Cox, A.D. (2002) 'Beyond first impressions: the effects of repeated exposure on consumer liking of visually complex and simple product designs', *Journal of the Academy of Marketing Science*, Vol. 30, No. 2, pp.119–130.

Creusen, M.E.H. and Schoormans, J.P. (2005) 'The different roles of product appearance in consumer choice*', *Journal of Product Innovation Management*, Vol. 22, No. 1, pp.63–81.

Creusen, M.E.H., Veryzer, R.W. and Schoormans, J.P. (2010) 'Product value importance and consumer preference for visual complexity and symmetry', *European Journal of Marketing*, Vol. 44, Nos. 9–10, pp.1437–1452.

Crilly, N., Moultrie, J. and Clarkson, P.J. (2009) 'Shaping things: intended consumer response and the other determinants of product form', *Design Studies*, Vol. 30, No. 3, pp.224–254.

Dahl, D.W. and Hoeffler, S. (2004) 'Visualizing the self: exploring the potential benefits and drawbacks for new product evaluation', *Journal of Product Innovation Management*, Vol. 21, No. 4, pp.259–267.

Eisenman, M. (2013) 'Understanding aesthetic innovation in the context of technological evolution', *Academy of Management Review*, Vol. 38, No. 3, pp.332–351.

Ellis, S.R. (1993) *A Psychometric Investigation of a Scale for the Evaluation of the Aesthetic Element in Consumer Durable Goods*, Unpublished Dissertation, University of arizona. Tucson, AZ.

Fleck, N.D. and Quester, P. (2007) 'Birds of a feather flock together… definition, role and measure of congruence: an application to sponsorship', *Psychology and Marketing*, Vol. 24, No. 11, pp.975–1000.

Fokkinga, S. and Desmet, P.M.A. (2013) 'Ten ways to design for disgust, sadness, and other enjoyments: a design approach to enrich product experiences with negative emotions', *International Journal of Design*, Vol. 7, No. 1, pp.19–36.

Garcia, R. and Calantone, R. (2002) 'A critical look at technological innovation typology and innovativeness terminology: a literature review', *Journal of Product Innovation Management*, Vol. 19, No. 2, pp.110–132.

Goldenberg, J., Horowitz, R., Levav, A. and Mazursky, D. (2003) 'Finding your innovation sweet spot', *Harvard Business Review*, Vol. 81, No. 3, pp.120–129.

Gregan-Paxton, J., Hibbard, J.D., Brunel, F.F. and Azar, P. (2002) 'So that's what that is': Examining the impact of analogy on consumers' knowledge development for really new products', *Psychology and Marketing*, Vol. 19, No. 6, pp.533–550.

Hekkert, P., Snelders, D. and Wieringen, P. (2003) 'Most advanced, yet acceptable': typicality and novelty as joint predictors of aesthetic preference in industrial design', *British Journal of Psychology*, Vol. 94, No. 1, pp.111–124.

Hoeffler, S. (2003) 'Measuring preferences for really new products', *Journal of Marketing Research*, Vol. 40, No. 4, pp.406–420.

Hoeffler, S. and Herzenstein, M. (2011) 'Optimal marketing for really new products: Using a consumer perspective to improve communications', in Posavac, S.S. (Ed.): *Cracking the Code: Leveraging Consumer Psychology to Drive Profitability*, M. E. Sharpe, Armonk, NY, pp.21–44.

Hoegg, J., Alba, J.W. and Dahl, D.W. (2010) 'The good, the bad, and the ugly: influence of aesthetics on product feature judgments', *Journal of Consumer Psychology*, Vol. 20, No. 4, pp.419–430.

Hoegg, J. and Alba, J.W. (2011) 'Seeing is believing (too much, pp.the influence of product form on perceptions of functional performance', *Journal of Product Innovation Management*, Vol. 28, No. 3, pp.346–359.

Hung, W-K. and Chen, L-L. (2012) 'Effects of novelty and its dimensions on aesthetic preference in product design', *International Journal of Design*, Vol. 6, No. 2, pp.81–90.

Kumar, M. and Garg, N. (2010) 'Aesthetic principles and cognitive emotion appraisals: how much of the beauty lies in the eye of the beholder?', *Journal of Consumer Psychology*, Vol. 20, No. 4, pp.485–494.

Lehmann, D.R. (1994) 'Characteristics of 'Really' new products', *Paper presented at the Marketing Science Institute Conference*, Boston.

Lockwood, T. (2015) *5 Trends Spotted at the Olympics of Product Design*, Retrieved 21 August, 2015 from http://www.fastcodesign.com/3045492/5-global-trends-spotted-at-the-olympics-of-product-design#3

Loken, B. and Ward, J. (1990) 'Alternative approaches to understanding the determinants of typicality', *Journal of Consumer Research*, Vol. 17, No. 2, pp.111–126.

Loudon, D.L. and Bitta, A.J.D. (1993) *Consumer Behavior: Concepts and Applications*, McGraw-Hill, New York.

Manning, K.C., Bearden, W.O. and Madden, T.J. (1995) 'Consumer innovativeness and the adoption process', *Journal of Consumer Psychology*, Vol. 4, No. 4, pp.329–345.

Meyers-Levy, J. and Tybout, A.M. (1988) 'Schema congruity as a basis for product evaluation', *Journal of Consumer Research*, Vol. 16, No. 1, pp.39–54.

Mick, D.G. (1992) 'Levels of subjective comprehension in advertising processing and their relations to ad perceptions, attitudes, and memory', *Journal of Consumer Research*, Vol. 18, No. 4, pp.411–424.

Moch, M.K. and Morse, E.V. (1977) 'Size, centralization and organizational adoption of innovations', *American Sociological Review*, pp.716–725.

Moreau, C.P., Lehmann, D.R. and Markman, A.B. (2001) 'Entrenched knowledge structures and consumer response to new products', *Journal of Marketing Research*, Vol. 38, No. 1, pp.14–29.

Mugge, R. (2011) 'The effect of a business-like personality on the perceived performance quality of products', *International Journal of Design*, Vol. 5, No. 3, pp.67–76.

Mugge, R. and Dahl, D.W. (2013) 'Seeking the ideal level of design newness: consumer response to radical and incremental product design', *Journal of Product Innovation Management*, Vol. 30, pp.34–47.

Mugge, R. and Schoormans, J.P. (2012) 'Newer is better! the influence of a novel appearance on the perceived performance quality of products', *Journal of Engineering Design*, Vol. 23, No. 6, pp.469–484.

Mugge, R., Govers, P.C. and Schoormans, J. (2009) 'The development and testing of a product personality scale', *Design Studies*, Vol. 30, No. 3, pp.287–302.

Mukherjee, A. and Hoyer, W.D. (2001) 'The effect of novel attributes on product evaluation', *Journal of Consumer Research*, Vol. 28, No. 3, pp.462–472.

Muller, W. (2001) *Order and Meaning in Design*, Boom Koninklijke Uitgevers.

Noseworthy, T.J. and Trudel, R. (2011) 'Looks interesting, but what does it do? evaluation of incongruent product form depends on positioning', *Journal of Marketing Research*, Vol. 48, No. 6, pp.1008–1019.

Page, C. and Herr, P.M. (2002) 'An investigation of the processes by which product design and brand strength interact to determine initial affect and quality judgments', *Journal of Consumer Psychology*, Vol. 12, No. 2, pp.133–147.

Pedgley, O., Şener, B., Lilley, D. and Bridgens, B. (2018) 'Embracing material surface imperfections in product design', *International Journal of Design*, Vol. 12, No. 3, pp.21–33.

Person, O., Schoormans, J., Snelders, D. and Karjalainen, T-M. (2008) 'Should new products look similar or different? the influence of the market environment on strategic product styling', *Design Studies*, Vol. 29, No. 1, pp.30–48.

Preacher, K.J. and Hayes, A.F. (2004) 'SPSS and SAS procedures for estimating indirect effects in simple mediation models', *Behavior Research Methods*, *Instruments*, *and Computers*, Vol. 36, No. 4, pp.717–731.

Raju, P.S., Lonial, S.C. and Mangold, W.G. (1995) 'Differential effects of subjective knowledge, objective knowledge, and usage experience on decision making: an exploratory investigation', *Journal of Consumer Psychology*, Vol. 4, No. 2, pp.153–180.

Reber, R., Schwarz, N. and Winkielman, P. (2004) 'Processing fluency and aesthetic pleasure: is beauty in the perceiver's processing experience? *Personality and Social Psychology Review*, Vol. 8, No. 4, pp.364–382.

Reinders, M.J., Frambach, R.T. and Schoormans, J.P. (2010) 'Using product bundling to facilitate the adoption process of radical innovations', *Journal of Product Innovation Management*, Vol. 27, No. 7, pp.1127–1140.

Rindova, V.P. and Petkova, A.P. (2007) 'When is a new thing a good thing? technological change, product form design, and perceptions of value for product innovations', *Organization Science*, Vol. 18, No. 2, pp.217–232.

Rogers (1995) *Diffusion of Innovations*, 4th ed., The Free Press, New York.

Ruth, J.A. (2001) 'Promoting a brand's emotion benefits: the influence of emotion categorization processes on consumer evaluations', *Journal of Consumer Psychology*, Vol. 11, No. 2, pp.99–113.

Schoormans, J.P. and Robben, H.S. (1997) 'The effect of new package design on product attention, categorization and evaluation', *Journal of Economic Psychology*, Vol. 18, Nos. 2–3, pp.271–287.

Shelley, C. (2015) 'The nature of simplicity in apple design', *The Design Journal*, Vol. 18, No. 3, pp.439–456.

Snelders, D., Mugge, R. and Huinink, M. (2014) Using social distinctions in taste for analysing design styles across product categories', *International Journal of Design*, Vol. 8, No. 3, pp.23–34.

Talke, K. and Heidenreich, S. (2014) 'How to overcome pro-change bias: incorporating passive and active innovation resistance in innovation decision models', *Journal of Product Innovation Management*, Vol. 31, No. 5, pp.894–907.

Thompson, D.V., Hamilton, R.W. and Rust, R.T. (2015) 'Feature fatigue: when product capabilities become too much of a good thing', *Journal of Marketing Research*, Vol. 42, No. 4, pp.431–442.

Truong, Y., Klink, R.R., Fort-Rioche, L. and Athaide, G.A. (2014) 'Consumer response to product form in technology-based industries', *Journal of Product Innovation Management*, Vol. 31, No. 4, pp.867–876.

Tushman, M.L. and Anderson, P. (1986) 'Technological discontinuities and organizational environments', *Administrative Science Quarterly*, pp.439–465.

Van Rompay, T. and Pruyn, A.T. (2011) 'When visual product features speak the same language: effects of shape-typeface congruence on brand perception and price expectations*', *Journal of Product Innovation Management*, Vol. 28, No. 4, pp.599–610.

Van Rompay, T., De Vries, P.W. and Van Venrooij, X.G. (2010) 'More than words: on the importance of picture–text congruence in the online environment', *Journal of Interactive Marketing*, Vol. 24, No. 1, pp.22–30.

Van Rompay, T., Pruyn, A. and Tieke, P. (2009) 'Symbolic meaning integration in design and its influence on product and brand evaluation', *International Journal of Design*, Vol. 3, No. 2, pp.19–26.

Veryzer, R.W. (1995) 'The place of product design and aesthetics in consumer research', *Advances in Consumer Research*, Vol. 22, pp.641–641.

Veryzer, R.W. (1998) 'Discontinuous innovation and the new product development process', *Journal of Product Innovation Management*, Vol. 15, No. 4, pp.304–321.

Veryzer, R.W. and Hutchinson, J.W. (1998) 'The influence of unity and prototypicality on aesthetic responses to new product designs', *Journal of Consumer Research*, Vol. 24, No. 4, pp.374–385.

Zhao, X., Lynch, J.G. and Chen, Q. (2010) 'Reconsidering Baron and Kenny: myths and truths about mediation analysis', *Journal of Consumer Research*, Vol. 37, No. 2, pp.197–206.

Appendix A: Textual descriptions of INPs and RNPs used as stimuli

	INPs	*RNPs*
Hairdryer	The HD-X5 is a new hairdryer. This hairdryer incorporates a new engine with a higher wattage that provides more power. This will allow the hairdryer to produce more heat and to dry the hair faster. Furthermore, the hairdryer has three different speeds, comes with an add-on diffuser, and weighs 0.90 kg	The HD-X5 is a new hairdryer. This hairdryer incorporates a new sensor that measures the dryness of the hair. This will allow the hairdryer to automatically adjust the temperature of the air accordingly. Furthermore, the hairdryer has three different air speeds, comes with an add-on diffuser, and weighs 0.90 kg

Other stimuli can be requested from the first author.

Appendix B: Product appearances used as stimuli

	Iron	*Electric Kettle*	*Hairdryer*
Simple appearance			
Complex appearance			
			

Appendix B: Product appearances used as stimuli (continued)

	Iron	*Electric Kettle*	*Hairdryer*
			
			

Products in top two rows are used in main study.