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Design for Better Comprehension: Investigating the Influence of Product Appearance on Consumers' Comprehension of Really New Products

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RNPs refer to product innovations that integrate advanced technology, which enables consumers to do things that they were previously unable to do. While most existing research focuses on the advertising strategies to facilitate consumers' comprehension of RNPs, this research extends the discussion to investigate the influence of product appearance. Three influential factors of (a) visual complexity, (b) transparency and (c) product metaphor were identified and have been examined accordingly. This research first (1) investigates the influence of visual complexity on consumers' comprehension of product innovations through a controlled experiment, whereby the design principle 'complexity in simplicity' was proposed. The study further (2) investigates the design intentions for adopting transparency in product innovations by conducting interviews with designers in practice. Based on an analogical learning process, (3) the potential and risks of product metaphors influencing consumers' comprehension of RNPs are analysed. The results bridge the theoretical contributions and practical implications, which help designers and managers develop RNPs that are comprehensible for consumers and contribute to the overall success of RNPs.

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DESIGN FOR BETTER COMPREHENSION: INVESTIGATING THE INFLUENCE OF PRODUCT APPEARANCE ON CONSUMERS' COMPREHENSION OF REALLY NEW PRODUCTS

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Design for Better Comprehension: Investigating the Influence of Product Appearance on Consumers' Comprehension of Really New Products

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A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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Certificate of Originality

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Abstract

This doctoral thesis investigates the potential of designing product appearance to facilitate consumers' comprehension of really new products (RNPs). RNPs (also known as discontinuous or radical innovations) refer to product innovations that integrate advanced technology that enables consumers to do things that they were previously unable to do. The success of RNPs ultimately depends on consumers' adoption. Consumers' lack of comprehension threats their adoption of RNPs. To facilitate consumers' comprehension of RNPs, current research mainly focuses on developing the strategies used in advertisements. This thesis extends this line of research by investigating the influence of product appearance.

Chapter 1 introduces several key concepts (i.e., RNPs, consumers' adoption process, consumers' resistance and its consequences and reasons) and highlights the importance of consumers' comprehension. Chapter 2 outlines the relevant literature, including the advertisement strategies to stimulate consumers' adoption of RNPs and the studies on the roles of product appearance in consumers' processing of products. Next, three potential factors were proposed, which can influence consumers' comprehension of RNPs: visual complexity, transparency, and product metaphor. The following chapter investigates each of them.

Chapter 3 investigated the influence of visual complexity on consumers' comprehension of product innovations. Through a controlled experiment, Study 1 revealed that visual complexity can trigger consumers' perceived congruence with RNPs' innovative functionality, which brought fluent processing, leading to enhanced consumers' comprehension of RNPs. To translate this theoretical finding, the design principle 'complexity in simplicity' was proposed, which referred to selectively increasing visual complexity to trigger congruence with product functionality while still keeping overall simplicity. Study 2 conducted experienced designer interviews, resulting in the specific ways to achieve this design principle.

Chapter 4 focused on transparency in product innovations. Study 3 conducted designer interviews to learn the design intentions for using transparency in product innovations. Results revealed the design intention to assist consumers' comprehension when using transparency in product innovations, as well as other intentions, resulting in an overview of design intentions: *facilitate consumers' comprehension*, *enrich visual appeal*, *enrich product experience*, *improve product usability*, and *demonstrate product functionality*. These design intentions were further validated through consumer interviews in Study 4.

Chapter 5 investigated the influence of product metaphors on consumers' comprehension of RNPs. Based on the analogical learning process, the potential and risks of product metaphors on influencing consumers' comprehension of RNPs were analyzed. Through experimental approach, Study 5 demonstrated that product metaphors can improve consumers' comprehension when combined with accompanying textual clues that explained the similarities between the source product and the target RNP. The sole presence of product metaphors lead to reduced consumers' comprehension. To further explore the risks, Study 6 conducted consumer interviews. Results revealed that the risk of solely presenting product metaphors lay in consumers' lack of ability to detect the specific correspondences between sources and target RNPs.

Chapter 6 summarizes the key findings, discusses the theoretical contributions, and outlines the practical implications. The implications can help designers and managers to develop RNPs that are comprehensible for consumers, which further contributes to the overall success of RNPs.

Publications Arising from the Thesis

Cheng, P., Mugge, R. & de Bont, C (2017). *Design for better comprehension: design opportunities on facilitating consumers' comprehension of really new products (RNPs).* In V.Craig, G.Muratovski, & A.Lora (Eds), the proceedings of International Association of Society of Design Research (IASDR) Conference 2017, pp. 236-251

Cheng, P., Mugge, R., & de Bont, C. (2017). *A smart home system is like a "Mother"! --- The effects of product metaphor on consumers' comprehension of really new products (RNPs).* In E. Bohemia, C. de Bont, & L. S. Holm (Eds.), Conference Proceedings of the Design Management Academy (Vol. 4, pp. 1079–1094). London: Design Management Academy. doi: 10.21606/dma.2017.47.

Cheng, P., & Mugge, R. (2016). *Alleviating consumers' negative emotional responses to really new products: the potential of product metaphors.* In Desmet, P.M.A., Fokkinga S.F., Ludden, G.D.S., Cila, N., & Van Zuthem, H. (2016) (Eds.). Celebration & Contemplation: Proceedings of the Tenth International Conference on Design and Emotion, Amsterdam, September 27-30, 2016 (Vol. 1, pp. 600-603). Amsterdam: The Design & Emotion Society.

Cheng, P., & Mugge, R. (2016). *The value of transparency in product innovations.* In P. Lloyd & E. Bohemia, eds., Proceedings of DRS2016: Design + Research + Society - Future-Focused Thinking, Volume 1, pp 215-231. DOI: 10.21606/drs.2016.34.

Cheng, P., & Mugge, R. (2015). *Should product innovations look simple or complex? The effects of visual complexity on consumers' comprehension of product innovations.* In V. Popovic, A.L.Blackler, D.Luh, N.Nithikul, B.Kraal, & Y.Nagai (Eds.), Proceedings of the International Association of Societies of Design Research (IASDR) Conference 2015, pp.365-380.

Cheng,.P,& Mugge, R. (2014) *Preliminary study on the effects of visual complexity on consumer response to product innovations.* In T.Jachna, E.Mclafferty,& S.Tzvetanova Yung (Eds.), the proceedings of ACTION! Doing Design Education DesignEd Asia Conference 2014, pp.308.

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Chapter 1 Introduction

When giving gifts to my family, I like to search for new products. Last year, I bought a Sonicare electronic toothbrush from Philips as a gift for my mom. This electronic toothbrush integrates sonic technology to produce a sonic wave to clean teeth. Together with the traditional brush movement, this toothbrush can clean teeth effectively, remove plaque, provide care for the gums and make teeth whiter. I made the order online and asked that it be delivered to my mom's home. On her birthday, I called her to say happy birthday and to get credit for the brilliant gift of the electronic toothbrush. On the phone, my mom seemed happy about my wishes, but she showed little interest in her newly received gift; she even sounded a little annoyed. She said, *'I appreciate your effort, but the electronic toothbrush is too much. This so-called innovative technology sounds like a stunt. I don't understand why I need it. My manual toothbrush works perfectly for me.'* I tried to persuade her that the toothbrush was useful. I explained how sonic technology worked and its benefits. I also explained how to use the toothbrush, such as how to change between different cleaning modes and how to recharge it. Our talk ended with her promising to try it the next day. However, while visiting my mom during the holidays half a year later, to my surprise, I found the toothbrush on a shelf in the storeroom, still in the package! It seems my mom never comprehended the Sonicare electronic toothbrush.

My mom's difficulty with comprehending an innovative product is not an isolated case. Consumers tend to find it difficult to understand innovative products. This is recognised as an important issue in academic research, and it is the topic of this thesis.

1.1 Defining Really New Products (RNPs)

When a new product with novel elements is introduced to the market, it is termed a 'product innovation' (Chandy & Prabhu, 2011). Product innovations can be categorised into incrementally new products (INPs) and really new products (RNPs) depending on the extent to which the novel elements of the product in question differentiate it from the products currently on the market. INPs (also known as continuous or incremental innovations) are innovations that incorporate new benefits, features or improvements into current products based on current technologies and markets. RNPs (also known as discontinuous or radical innovations) are innovations that integrate advanced technology that has rarely been used in the industry and enables consumers to do things they were previously unable to do (Garcia & Calantone, 2002; Song & Montoya‐Weiss, 1998). The

sonic electronic toothbrush, the gift I gave to my mom, is an example of a RNP: it integrates advanced sonic technology into electronic toothbrushes. The involvement of the sonic technology, which has rarely been used in this product category, provides significant benefits for consumers, such as healthier teeth and gums. In contrast, an INP could comprise a new electronic toothbrush that integrates a more powerful motor to produce faster brush strokes.

Because RNPs are totally different from existing products on the markets, RNPs can establish a totally new product category. However, it is also possible that RNP belong to an existing product category (Goldenberg, Mazursky, & Solomon, 1999; Moreau, Lehmann, & Markman, 2001). The launch of digital tablets (e.g., iPads) is an example to establish a totally new product category of a tablet personal computer. Differently, RNPs can also be categorized into an existing product category. In this case, RNPs can be considered an extension of a current product category, which may result in establishing a sub-category. For example, although Sonic electronic toothbrush integrates totally new technology, it still belongs the product category of the electronic toothbrush. The innovative technology of the Sonic electronic toothbrush is viewed as an extension of current technology used in the electronic toothbrush category. The Sonic electronic toothbrush may in time also become a sub-category of electronic toothbrush.

Developing RNPs is important for companies because the success of those RNPs is crucial for companies' growth and success (Dougherty, 1992; Tellis, Prabhu, & Chandy, 2009). As RNPs provide significant product advantages that may even be patentable, companies can quickly differentiate themselves from other competitors and gain considerable profitability (Calantone, Chan, & Cui, 2006; Danneels & Kleinschmidt, 2001; Kleinschmidt & Cooper, 1991). However, RNP development is often associated with high risks. The failure rate is around 40-90% for new products and even higher for RNPs (Cierpicki, Wright, & Sharp, 2000). It is risky because developing RNPs leads companies into totally new areas where they have little experience to rely on (Kleinschmidt & Cooper, 1991). The high risks also come from consumer reluctance to adopt RNPs (Gourville, 2006).

1.2 Consumers' Resistance to RNPs

The success of RNPs ultimately depends on their adoption by consumers (Hauser, Tellis, & Griffin, 2006). However, although RNPs provide huge benefits, consumers are often resistant to adopting them (Ram & Sheth, 1989). Consumers' resistance to RNPs can

result in the following three situations. First, they may postpone the adoption of the RNPs. Second, they may question the functions and values provided by the RNPs and ultimately reject them. Third, they may oppose the RNPs because they are convinced of their unsuitability and therefore may perform negative word-of-mouth and attack activities.

Consumers' resistance to adopting RNPs threatens the success of those RNPs (Ram & Sheth, 1989) and can result in their rejection or postponement of RNPs that can benefit their lives. In the example of my mom's resistance to the Sonicare electronic toothbrush, she gave up the chance to improve her oral health by using a new toothbrush. In some cases, such resistance can lead to more serious consequences for society. For example, when electric vehicles were launched several years ago, they encountered consumer resistance (Christensen, Wells, & Cipcigan, 2012). Powered by electricity instead of petroleum, electronic vehicles produce reduced carbon emissions, which can significantly benefit the environment. Due to consumer resistance, the diffusion process of the electric vehicles has been slow, burdening the environment and society.

Consumers resist adopting RNPs for different reasons. Rogers (1995) identified five characteristics of RNPs that influenced consumers' adoption: relative advantage, compatibility, trialability, observability and complexity. First, relative advantage refers to 'the degree to which an innovation is perceived as better than the idea it supersedes' (p. 15). The likelihood of consumers' adoption increases with the relative advantages they perceive from a RNP. Second, compatibility refers to 'the degree to which a RNP is perceived as being consistent with the existing values, past experiences, and needs of potential adopters' (p. 15). As RNPs integrate completely new technology, they often require a certain degree of change that differs from current usage patterns, norms, habits and traditions. However, people naturally tend to seek consistency and the status quo instead of trying new behaviours (Gourville, 2005; Sheth & Stellner, 1979). As a result, consumers often feel reluctant to adopt a RNP that is incompatible and requires significant changes. In other words, a RNP with a high degree of compatibility is more likely to be adopted by consumers. Third, trialability refers to 'the degree to which an innovation may be experimented with on a limited basis' (p. 16). If consumers can test an innovation and see what it can do for them, the likelihood of their adoption increases. The trialability of RNPs is positively related to the likelihood of consumers' adoption. Fourth, observability refers to 'the degree to which the results of an innovation are visible to others' (p. 16). As RNPs are totally new, consumers have limited knowledge and

experience with which to evaluate their performance. Thus, if a RNP carries a higher degree of observability, it allows consumers to witness its performance. As a result, consumers are more likely to adopt the RNP. Finally, complexity refers to 'the degree to which an innovation is perceived as difficult to understand and use' (p. 16). The complexity associated with RNPs challenges consumers' comprehension of those RNPs, leading to their resistance (Hoeffler, 2003). When encountering RNPs, consumers must spend considerable cognitive effort to learn them. In contrast to INPs, which consumers can understand relatively easily based on accumulated knowledge and experience, understanding RNPs goes beyond consumers' current knowledge (Gatignon & Robertson, 1985). The integration of really new technology also calls for completely different ways of thinking (Veryzer, 1998). As a result, consumers may not understand how RNPs work or the benefits they can provide (Hoeffler & Herzenstein, 2011).

In addition, RNP adoption is often associated with certain risks (i.e., physical, economic, functional and social risks) (Ram & Sheth, 1989) that influence consumers' adoption of RNPs. Consumers may have concerns about whether the RNPs are harmful (physical risk), whether the prices they pay are worthwhile (economic risk), whether the RNPs can perform well (functional risk) and what their peers will think of them for adopting the RNPs (social risk).

Among these factors that influence consumers' adoption of RNPs, consumers' comprehension of RNPs is a precondition for further adoption (Reinders, Frambach, & Schoormans, 2010). According to consumers' adoption process (Rogers, 1995), gaining comprehension of RNPs is a basis for further considering their potential. If consumers fail to comprehend RNPs, they are unlikely to perceive the provided relative advantages, to understand the changes they must make and to assess the associated risks. It has been argued that consumers go through five stages when adopting a RNP, as shown in Figure 1.1 (Rogers, 1995). The first stage is the knowledge stage. In this stage, a consumer becomes aware of a RNP and has some idea of how it functions. As the consumer has had only limited experience with the RNP up to that point, the comprehension obtained by the consumer at this stage is predominantly a subjective comprehension of the RNP. The consumer may feel that he or she lacks comprehension of the RNP and its novel functions, resulting in feelings of discomfort and confusion about what the innovation entails. In contrast, the consumer may feel confident that he or she understands the RNP and its benefits in detail. After the knowledge stage, the persuasive stage starts, in which the consumer forms a favourable or unfavourable attitude. Next, at the adoption stage,

the consumer refines his or her perceptions and attitudes towards the RNP, resulting in a decision of either adoption or rejection. After the adoption decision, the consumer engages in actual behaviours with the RNP. At the implementation stage, the consumer starts to use and experience the RNP. Finally, at the confirmation stage, the consumer seeks reinforcement for his or her adoption or rejection decision. The consumer can be satisfied with the RNP and continue using it or be disappointed with the RNP and decide to stop using it. The process ends with the consumer either using the RNP or not considering it as a future purchase.

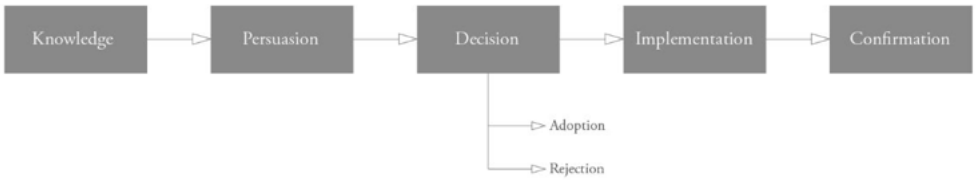


Figure 1.1 The consumer adoption process (Rogers, 1995).

According to the consumer adoption process, consumers carefully consider the potential of RNPs during the persuasion and adoption stages and make adoption decisions afterwards (Rogers, 1995). However, unlike this conventional assumption, recent research has pointed out that consumers' resistance to RNPs does not in fact involve a serious evaluation of the RNPs (Talke & Heidenreich, 2014). In most cases, consumers' initial resistance to a RNP is established early in the knowledge stage. If consumers feel that they lack comprehension of a RNP, the resulting confusion can lead to initial resistance to the RNP. This resistance then leads these consumers to disregard its potential and subsequently reject it. Therefore, for a RNP to be adopted successfully, consumers must believe that they comprehend the RNP during an early stage of their exposure to it, which is mainly dominated by consumers' subjective comprehension.

Consumers' comprehension can be investigated from a subjective and an objective view. The subjective view entails consumers' subjective evaluation towards their processing of the given information. Consumers' self-reporting is often used to measure consumers' subjective comprehension. Differently, the objective comprehension highlights whether and to what degree the defined and specified information has been grasped and extracted by consumers. Consumers' objective comprehension is often measured by examining whether participants can correctly answer specific questions about the product and its

functions (Mick, 1992). As argued earlier in this section, for consumers' adoption, consumers' subjective comprehension plays a more dominant role in the early exposure to RNPs. Therefore, this thesis focuses on consumers' subjective comprehension, which is an effective predictor for consumers' adoption of RNPs (Raju, Lonial, & Mangold, 1995).

1.3 Purpose of this Thesis

Considering the importance of consumers' comprehension for their adoption of RNPs, this thesis aims to investigate the influence of product appearance on consumers' comprehension of RNPs. Product appearance is an initial touchpoint for consumers (Eisenman, 2013; Ulrich, 2007). When encountering RNPs, consumers almost automatically see the appearance of RNPs, and subsequently, process that appearance. Consumers' processing of the appearance of RNPs can significantly influence their comprehension of the RNPs. Specifically, when encountering a RNP, consumers attempt to figure out what it looks like, which product category it belongs to and, if it belongs to no known category, which product it resembles. Consumers can benefit from these comparisons because these allow them to use their current knowledge to learn the RNP, which leads to enhanced comprehension (Rindova & Petkova, 2007). Moreover, when they see the appearance of a RNP, consumers can draw inferences on its functionality (Bloch, 1995; Creusen & Schoormans, 2005). For instance, consumers can infer that a novel-looking product integrates innovative technology (Mugge & Schoormans, 2012a). Such inferences can trigger consumers to form expectations on the functionality of the RNP, which can influence their processing and comprehension.

More importantly, when a RNP is launched on the market, its innovative functionality is generally presented together with its appearance. In other words, the appearance and innovative functionality of a RNP interact with each other to influence consumers' processing of the RNP (Creusen & Schoormans, 2005; Rindova & Petkova, 2007). Research has recognised the potential effect of product appearance on consumers' comprehension of RNPs (Eisenman, 2013; Rindova & Petkova, 2007). However, limited research efforts have been made to investigate this important issue. This thesis aims to fill this gap.

Specifically, among RNPs across different product categories, this thesis focuses on consumer durables. As consumers often encounter or use consumer durables in their daily life, they have basic knowledge and experience with them. Moreover, while encountering consumer durables, consumers often invest considerable time and effort to interpret

product-related information (Creusen & Schoormans, 2005), which makes it possible to investigate consumers' processing and comprehension.

1.4 Practical Relevance

A large number of RNPs are introduced into the market every year. For example, the Consumer Electronic Show (CES) has been organised successfully for over 50 years as the largest platform for companies to introduce next-generation products and technologies. In 2017, more than 4,000 companies have launched their innovative products at CES ("CES by the Numbers," 2017). Moreover, different innovative technologies are emerging, such as robotics, virtual reality (VR), artificial intelligence (AI) and the Internet of technology (IoT). The IoT alone is predicted to drive around 25 billion innovative products that will be launched on the market by 2020 (Gartner, 2013). These numbers indicate the huge demand for RNP development.

Moreover, designers have the freedom to embody many RNPs in different product appearances. The integrated technology in the RNPs does not fundamentally influence product appearance, and thus product appearance is not completely predefined by or dependent on the integrated technology (Rindova & Petkova, 2007). In the example of the IoT, with the technology of sensors and chips, product appearance is not heavily constrained by the adopted technology, which provides designers with the freedom to embody RNPs in different appearances to deliberately facilitate their comprehension. For example, when the first e-book readers were launched on the market, the technology allowed the product to be designed in any shape, yet the product was designed to resemble a physical book to help consumers understand that e-book readers were used for reading (Hekkert & Cila, 2015).

Furthermore, the specific knowledge to effectively support designers to embody RNPs is currently lacking. Due to the differences between INPs and RNPs, designers face different challenges while embodying them. Designers must embody INPs to stand out from competitors (Person, Schoormans, Snelders, & Karjalainen, 2008). Differently, the prominent challenge for embodying RNPs is to communicate those RNPs to the markets, such as to explain what a RNP does, what innovative functionality a RNP integrates, and what benefits a RNP provides (Eisenman, 2013). Due to these different aims, designers' knowledge and expertise on embodying INPs may not translate to the design of RNPs. For example, designers often try to design INPs in novel and attractive ways to draw consumers' attention. Various studies have demonstrated the positive effects of novel

appearances for INPs (e.g., (Hekkert, Snelders, & Wieringen, 2003; Talke, Salomo, Wieringa, & Lutz, 2009). However, research has also demonstrated that a novel appearance actually reduces consumers' appreciation of a RNP because it hinders consumers to retrieve the related knowledge from memory (Mugge & Dahl, 2013). Thus, it is necessary to equip designers with knowledge on how to achieve the difficult design task of embodying RNPs.

1.5 Overview of this Thesis

To address the research goal, this thesis is structured as follows. After this general introduction (Chapter 1), Chapter 2 presents a literature review, including relevant studies considering the stimulation of consumers' adoption of RNPs and concerning the role of product appearance in consumers' processing of products. Next, based on these studies, we propose that product appearance can influence consumers' comprehension of RNPs in three ways (i.e., visual complexity, transparency and product metaphor). Following this, our specific research questions were proposed.

Three empirical studies are presented in Chapters 3-5 that investigate the influences of the three factors of product appearance on consumers' comprehension of RNPs. Chapter 6 integrates the findings from the preceding chapters and discusses the contributions of these findings to design research and practice. Finally, the limitations of the thesis are reflected and possibilities for future research are given.

Chapter 2 Theoretical Background

This chapter provides an overview of the relevant literature. Specifically, several strategies have been developed to facilitate consumers' comprehension and their adoption of RNPs. The relevant strategies (i.e., categorisation, analogical learning, mental simulation and introducing information about RNPs) are introduced in this chapter. Next, the literature related to the different roles of product appearance in influencing consumers' processing of products is reviewed. Based on these insights, we propose three possible ways in which product appearance can influence consumers' comprehension of RNPs: 1) by influencing the congruence between appearance and functionality of the RNP, 2) by directly communicating the innovative functionality of the RNP, and 3) by serving as a visual cue to trigger analogical learning. Finally, the specific research questions are proposed and an overview of the studies are given.

2.1 Strategies Used to Stimulate Consumers' Adoption of RNPs

Different strategies have been developed to promote RNPs and stimulate their adoption by consumers. These strategies are mainly used in advertisements. Some strategies attempt to aid consumers' learning by making use of products or concepts familiar to consumers. For example, the strategy of categorisation facilitates consumers' comprehension of RNPs by relating a RNP to a product category familiar to consumers (Moreau et al., 2001). Analogical learning strategy attempts to help consumers' learning by relating the innovative functionality of a RNP to a product or a concept familiar to consumers (Gregan-Paxton & John, 1997). Other strategies for guiding consumers to imagine the events related to RNPs are developed to help consumers gain experience with RNPs and thus enhance their appreciation; examples of these strategies include mental simulation (Dahl & Hoeffler, 2004; Hoeffler, 2003) and narrative transportation (van den Hende, Dahl, Schoormans, & Snelders, 2012; van der Hende & Schoormans, 2012). In addition, to introduce RNPs to consumers, it is necessary to present information about those RNPs, such as their functions and price. Research has also investigated which types of information about RNPs must be presented and the optimal ways for presenting that information (Talke & Snelders, 2013). This section introduces these strategies.

2.1.1 Categorisation Strategy

By definition, RNPs are truly new, and thus the knowledge stored in consumers' memories is not ideal for explaining them. However, it is still possible to make use of

consumers' stored knowledge of other products and objects to facilitate their learning of RNPs (Hoeffler & Herzenstein, 2011). Categorisation is a learning strategy that makes use of consumers' existing knowledge to learn about a RNP.

Categorisation plays a central role in consumers' learning of new products (Sujan, 1985). It is generally believed that people naturally divide surrounding objects into different categories to process them efficiently and understand them quickly. Due to this tendency, when they encounter a new product, consumers attempt to categorise it into a predefined category. After consumers have categorised the new product successfully, the facts about the product category can be quickly activated and transferred to the new product. Similarly, when a RNP is labelled as a member of an existing product category, the knowledge from the existing product category can be transferred to the RNP, thereby enhancing consumers' comprehension of the RNP (Waldmann, Holyoak, & Fratianne, 1995).

As RNPs are totally different from existing product categories, some cues are necessary to aid consumers' categorisation. These include textual cues, which involve labelling a RNP as a member of an existing product category, and/or visual cues, which involve designing a RNP that looks similar to the prototype of an existing product category. Consumers rely on visual cues to define what a product is and textual cues to learn what a product does (Barton & Komatsu, 1989; Gregan-Paxton, Hoeffler, & Zhao, 2005). For example, when the smartphone was launched, a textual cue was provided by labelling it as a member of the cell phone product category, as made evident by the inclusion of 'phone' in 'smartphone'. In addition to this textual cue, a visual cue was provided by designing the first smartphone (see Figure 2.1a) to make it resemble the traditional cell phone (see Figure 2.1b). Both of these textual and visual cues aimed to help consumers categorise the smartphone into the cell phone product category and, subsequently, to activate and transfer knowledge from the cell phone category to the smartphone. This produced better comprehension and attitudes towards the smartphone.

Figure 2.1a Picture of the first smartphone: IBM Simon, launched in 1994.

Figure 2.1b Picture of a typical cell phone at the time: Motorola 8900X2, launched in 1994.

2.1.2 Analogical Learning Strategy

In addition to assigning a RNP into an existing product (sub)category, RNP can also establish a totally new product category (Hoeffler & Herzenstein, 2011). The recently launched smart home system is such an example, where managers choose to establish a new product category. A smart home system refers to the combination of an information terminal and multiple smart devices connected to that terminal. The smart devices collect various kinds of information about the home, such as its energy consumption, the presence of family members, door locks and entry movement that consumers can access through an app, allowing them to monitor and control their homes from a distance. Due to the innovative functionality provided by the smart home system, the system cannot be readily assigned to an existing product category but should establishe a new one. Then, an analogical learning strategy can be an alternative choice to help consumers learn about a RNP.

Analogical learning refers to the process of relating information from a familiar domain to a novel domain (Gregan-Paxton, Hibbard, Brunel, & Azar, 2002). The familiar domain is termed the source, and the novel domain is termed the target. The knowledge transfer from a source to a target is based on certain similarities between both. A source does not need to be closely related to the RNP. Instead, it shares a strong similarity with the RNP, which triggers effective analogical learning. For example, a smart home system was introduced to the market based on the analogy of a 'mother'. A smart home system is not related to a mother at first glance; however, the functions of a smart home system that

collects information about a home can be compared with the role of a mother who often knows everything about her home.

Analogical learning contains three stages: access, mapping and transfer (Gregan-Paxton & John, 1997). In the access stage, consumers identify a source product or concept. Correspondingly, the knowledge related to the source or concept is activated. Next, in the mapping stage, consumers recognise the similarities between the source and the target RNPs. Consumers establish one-to-one correspondences between the source and the target RNP. Finally, in the transfer stage, the knowledge is transferred from the source domain to the target RNP. In the example of the 'mother' smart home system, in the access stage, consumers first identify the source of the role of a mother at home. Next, in the mapping stage, the consumers should understand the similarities between the smart home system and the role of a mother at home. In the transfer stage, consumers must transfer the knowledge related to the role of a mother at home to the smart home system, which can enhance their comprehension. Research has demonstrated that when describing a RNP based on an analogy in an advertisement, consumers' comprehension of RNPs can be increased (Houssi, Morel, & Hultink, 2009).

Although both the categorisation and analogical learning strategies make use of consumers' existing knowledge to help them comprehend RNPs, the analogical learning strategy is essentially different from the categorisation strategy. Analogical learning only facilitates the transfer based on certain similarities between sources and target RNPs, while categorisation transfers all of the category knowledge to a target RNP (Gregan-Paxton & Moreau, 2003). For example, through an analogical learning strategy, communicating that 'a smart home system is like a mother' suggests that the function of the smart home system, which collects information about a home, is similar to the role of a mother who knows everything about the home. However, other roles such as cooking and caring do not transfer to the smart home system. Consequently, only part of the knowledge is transferred from a source to a target RNP. Differently, through a categorisation strategy, labelling a smartphone as a member of the cell phone product category suggests that the smartphone has the basic characteristics of a cell phone, such as its ability to make phone calls and send and receive text messages. As a result, all of these characteristics of a cell phone will be transferred to a smartphone.

2.1.3 Mental Simulation Strategy and Narrative Transportation Strategy

Mental simulation is another strategy used to stimulate consumers' adoption of RNPs. Different from categorisation and analogical learning, mental simulation does not facilitate knowledge transfer from familiar products or concepts to RNPs. Instead, it helps consumers to imagine detailed scenarios for using RNPs. In advertisements, it is a common strategy to ask consumers to think of specific experiences related to RNPs (e.g., 'picture yourself' and 'just imagine'). Similar to role taking, mental simulation requires consumers to imaginatively put themselves in a situation related to the RNP. Through mental simulation, consumers' relevant personal experiences can be evoked, which can help consumers merge the RNPs with existing usage patterns (Hoeffler, 2003); as a result, consumers have surrogate experiences with the RNPs (Dahl & Hoeffler, 2004). These surrogate experiences can trigger positive feelings and reduce critical thinking (Green & Brock, 2000; Van Laer & De Ruyter, 2010). Research has demonstrated that mental simulation can enhance consumers' preferences for (Hoeffler, 2003), evaluations of (Dahl & Hoeffler, 2004; M. Zhao, Hoeffler, & Dahl, 2009) and comprehension of (Feiereisen, Wong, & Broderick, 2008) RNPs.

Narrative transportation is another strategy used to help consumers to gain vivid experiences with RNPs. Narrative transportation goes beyond mental simulation, as it integrates the attention, imagination and feelings consumers experience while reading narratives. Narrative transportation helps consumers to immerse themselves in a certain situation through telling a story about someone who is using a RNP (van der Hende & Schoormans, 2012). Through reading a story, people can gain the feeling of being transported; they feel lost in the story, engaged with the protagonist and immersed in the events that take place (Green & Brock, 2000; Nell, 1988). As a result, consumers totally immerse themselves in what they read and subsequently form vivid images in their minds and forget the real world around them. The story can be presented with text and a series of static or animated pictures. Studies have demonstrated the positive effects of narrative transportation on consumers' evaluation of RNPs (van den Hende et al., 2012; van der Hende & Schoormans, 2012).

2.1.4 Investigation of Different Types of and Formats for Presenting RNP-Related Information

To introduce RNPs to consumers, it is necessary to present information about RNPs. Studies have investigated the influence of different types of information and different

ways of presenting such information on consumers' evaluations and adoption of RNPs (Talke & O'Connor, 2011; Talke & Snelders, 2013). Specifically, three types of information about a RNP must be presented to consumers: technical information that explains its features and functions, personal/social information about its ability to help one achieve personal/social goals and financial information that deals with the costs of purchasing and maintaining it. This information is necessary because it explains which kinds of innovative functionality a RNP provides, why a consumer finds it necessary and what it costs. Furthermore, results have revealed the optimal way to present the three types of information related to RNPs: it is most effective to convey personal/social information in an abstract way and to convey financial and technical information in a concrete way (Talke & Snelders, 2013). As abstract information is relatively generalised, it allows consumers to select the part that is relevant to them. In contrast, concrete information is descriptive and neutral and leaves less room for further interpretation. Therefore, with abstract personal/social information, it is easier for consumers to imagine how a RNP is relevant to them. With concrete technical and financial information, consumers can find the specific functions and benefits a RNP provides in addition to the exact cost of purchasing the RNP.

2.1.5 Limitations of Current Strategies Used to Stimulate Consumers' Adoption of RNPs

Thus far, this section has provided an overview of the different strategies used to stimulate consumers' adoption of RNPs. Although these strategies have been demonstrated to be effective for facilitating consumers' comprehension and evaluations of RNPs, they exhibit certain limitations. These strategies are often presented in advertisements of RNPs, and they require significant cognitive efforts on the part of consumers to follow the instructions (Feiereisen et al., 2008). For instance, in the mental simulation strategy, consumers must actually think about and imagine the activities related with a RNP, which help consumers gradually develop comprehension of the RNP. Imagining the activities of using the RNP requires significant amount of consumers' efforts (M. Zhao, Hoeffler, & Dahl, 2012).

However, consumers are unlikely to pay attention to advertisements among cluttered information (Pieters, Warlop, & Wedel, 2002) or to process them carefully. Consider the example shown in Figure 2.2. On your way to the office, you pass by a subway station, where many posters hang on the wall of the station, three metres apart from each other.

Among these posters is one promoting an innovative VR glass that creates a vivid 3D experience while playing computer games. On the poster, the key features are listed, a possible scenario for using the VR glass is outlined with text and the words 'Just imagine…' are enlarged. However, on your rush to the office, you seldom look at these posters. Although your attention is drawn to one poster in the series, you are unlikely to read the text on the poster word for word and subsequently follow the instructions to imagine the usage situation. Most likely, you only notice the picture of the new VR glass, but you are unclear about what it can do and how you can benefit from it. Therefore, although these strategies have been demonstrated as effective in experimental settings, their usefulness in real life is questionable because it is not always easy for consumers to notice advertisements, and subsequently, follow their learning strategies.

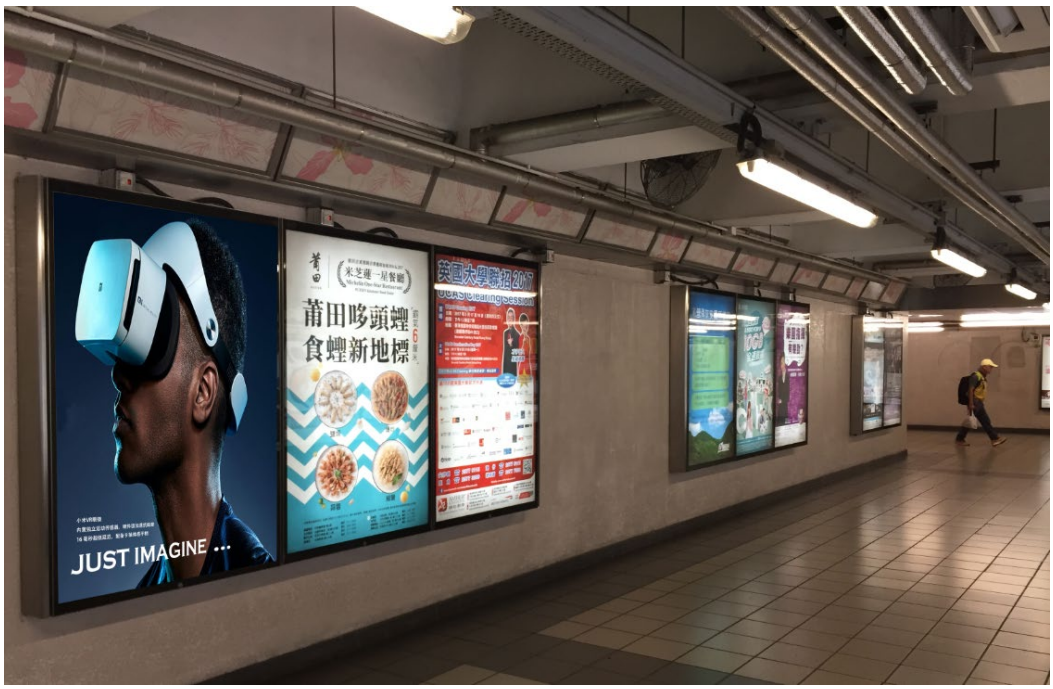


Figure 2.2 Picture of a subway station displaying a series of posters.

2.2 Research Question and Theoretical Contributions

Advertisements are not the only medium for improving consumers' comprehension of RNPs. Product appearance is a direct and indispensable source that consumers encounter while learning about a new product. By looking at a product's appearance, consumers can gain a holistic impression of the product, which directly influences their processing of that product. Consumers can learn what a product is, what it can do and how to use it

(Creusen & Schoormans, 2005; Crilly, Moultrie, & Clarkson, 2004). Similarly, consumers can perceive and process information based on the appearance of a RNP, which can facilitate their comprehension of that RNP. Therefore, to investigate how designers can facilitate consumers' comprehension of RNPs, the general research question in this thesis is proposed as follows.

- How can designers use product appearance to increase consumers' comprehension of RNPs?

An answer to this research question will have important theoretical contributions. First, to facilitate consumers' comprehension of RNPs, studies have mainly focused on developing marketing strategies (Gregan-Paxton, 2001; Hoeffler, 2003; Moreau et al., 2001), while the influence of product appearance remains unexplored. The unawareness of the effect of product appearance may weaken the controls of managers and designers of this important factor, which can be risky for the overall success of RNPs. Thus, this investigation can provide insights on the influence of product appearance on consumers' comprehension of RNPs.

Second, current studies have focused on investigating the influence of product appearance on consumers' processing of INPs (Creusen, Veryzer, & Schoormans, 2010; Mugge, 2011). However, prior research has suggested that product appearance takes on different roles along the different stages in a product's life-cycle (e.g., introduction stage, maturity stage) (Person et al., 2008). In the maturity stage, product appearance can be mainly used for differentiating products. Differently, in the introduction stage, product appearance can be used to communicate the new products to the markets, such as what a new product does, which product category a new product belongs to, and what innovative technology is integrated in a new product (Eisenman, 2013). Thus far, only limited research has investigated the roles that product appearance can play in the product introduction stage. An investigation into the influence of product appearance on consumers' comprehension of RNPs should shed light on the prominent role that product appearance can play in the early stage of a product's life cycle.

Third, previous studies have conceptually discussed the role of product appearance on RNP communication (Eisenman, 2013; Rindova & Petkova, 2007). The potential of using product appearance to facilitate consumers' comprehension of RNPs has been recognized. However, it still remains unclear how product appearance can influence

consumers' comprehension of RNPs and what specific factors in the appearance can trigger it. For instance, it has been proposed that product appearance can facilitate consumers' comprehension of RNPs through analogical learning by resembling the appearance of a product familiar to consumers (Rindova & Petkova, 2007). However, it remains unknown which factors can trigger consumers' analogical learning and whether additional assistance is needed. Therefore, an investigation into the influence of product appearance on consumers' comprehension of RNPs can clarify the underlying mechanisms and the specific factors of product appearance that trigger these mechanisms.

To answer the proposed research question, the following section reviews the literature on how product appearance influences consumers' processing of products.

2.3 The Influence of Product Appearance on Consumers' Processing of Products

To answer the research question, it is necessary to understand how designers influence consumer response through designing product appearance. Crilly et al. (2004) developed a general conceptual framework linking consumers, products, and designers. Product appearance can be considered an instance of communication (Crilly, 2008; Crilly, Good, Matravers, & Clarkson, 2008; Crilly et al., 2004; Mono, 1997). In this communication process, a product can be viewed as a communicative medium to link designers and consumers (see Figure 2.3). While shaping products, designers intend to get consumers to respond to those products, such as by drawing their attention, stimulating their emotions and facilitating their comprehension (Crilly, Moultrie, & Clarkson, 2009). By taking advantage of different factors of product appearance, designers attempt to fulfil their intentions (Crilly, 2011b). These design intentions may not fully translate to the final product designs due to some constraints along the design process (e.g., budget, manufacturing and other stakeholders) (Crilly et al., 2009).

When encountering a product, consumers can form cognitive, affective, and behaviour responses. Cognitive responses result from consumers' evaluation of a product after consumers' processing the information perceived by the senses. Specifically, consumers can form aesthetic impression of a product, learn about its functions (semantic interpretation) and gain perceptions of its social significance (symbolic association) (Crilly et al., 2004). Consumers can also form affective responses, such as generating different emotions, moods and feelings (Desmet, 2004). In addition to the direct interpretations mentioned previously, recent studies have suggested that it is possible for consumers to

infer the design intentions underlying a product design (Crilly, 2008, 2011a, 2011b). In other words, consumers can take a more active role. Consumers may recognise product design as a result of designers' intentional efforts. With this awareness, they may further infer the design intentions, that is, why the product has been designed in this way. Such inferences may not necessarily be the same as the designers' actual intentions, but they can influence consumers' interpretation of products (Da Silva, Crilly, & Hekkert, 2015). As a result, consumers form behavioural responses of approach or avoidance.

Figure 2.3 Basic framework for design as communication (adapted from Crilly et al., 2004).

According to the 'design as communication' framework, designing a successful product appearance largely depends on the extent to which consumer responses correspond to the design intentions (Crilly et al., 2009). However, as designers and consumers inherently perceive the same product designs differently (Blijlevens, Creusen, & Schoormans, 2009; Hsu, Chuang, & Chang, 2000), the effectiveness of communicating messages through a product design is challenged. Therefore, it is necessary to investigate how consumers process product appearance to help designers design product appearance effectively.

In terms of the influence of product appearance on consumers' processing of products, Creusen and Schoormans (2005) identified six roles that product appearance can play in consumers' choice of product. Product appearance can provide aesthetic and symbolic value. It can also draw consumers' attention, communicate ergonomic and functional information about the product and serve as a cue for consumers' categorisation of the product. The following briefly introduces each role of product appearance.

2.3.1 Product Appearance to Provide Aesthetic Value

Product appearance can provide aesthetic value to consumers (Bloch, 1995; Creusen & Schoormans, 2005; Crilly et al., 2004). Consumers can aesthetically appreciate a product by seeing its appearance, which is independent of its functionality (Holbrook, 1980). As a result, when they encounter products with similar prices and functionalities, consumers prefer the product with an aesthetically appealing appearance. To support designers in designing attractive appearances, various studies have investigated the different factors that contribute to attractive appearance, such as novelty (Blijlevens, Carbon, Mugge, & Schoormans, 2012; Hekkert et al., 2003), unity (Veryzer & Hutchinson, 1998), visual complexity (Creusen et al., 2010), harmony (Kumar & Garg, 2010) and the moderating effects of exposure times (Cox & Cox, 2002; Landwehr, Wentzel, & Herrmann, 2013). Furthermore, seven general design styles are recognised across product categories: sportive, tough, geometric, moderate, simple, authentic and elegant. Consumers' appreciation for design styles is also influenced by their age and education level (Snelders, Mugge, & Huinink, 2014).

2.3.2 Product Appearance to Provide Symbolic Value

Product appearance can convey symbolic value. It can trigger a symbolic association (Creusen & Schoormans, 2005; Crilly et al., 2004). Specifically, through product appearance, consumers intend to suggest the kinds of people they are or want to be. Product appearance can thus be a medium for expressing the images that consumers aim to convey to others (Belk, 1988; Landon, 1974; Sirgy, 1982; Solomon, 1983). For example, owning a novel-looking product can suggest that the owner is also innovative. Moreover, product appearance can communicate symbolic meanings. When looking at a product appearance, consumers can relate to different attributes, such as friendly, playful and business-like attributes (Creusen & Schoormans, 2005). The research on product personality has provided insights into the symbolic meanings consumers assign to product appearance. Specifically, product personality refers to a series of personality characteristics consumers use to describe a product, such as friendly, cheerful and tough (Govers & Schoormans, 2005). A 20-item product personality scale has been created and administered to consumers for them to describe products (Mugge, Govers, & Schoormans, 2009).

2.3.3 Product Appearance to Draw Consumers' Attention

In cluttered markets, gaining consumers' attention is the first step in persuading consumers to purchase a product. Product appearance has the ability to draw consumers' attention in physical retail stores. The increase in product size and use of novel colours are more likely to draw consumers' attention (Creusen & Schoormans, 2005). For example, when the Senseo coffee maker was first launched on the market (see Figure 2.4), it was made in blue, making it totally different from other coffee makers at the time. Through the use of this unique colour, consumers' attention was easily drawn to it. Nowadays, an increasing number of products are sold or promoted online. In a similar way, using a novel colour can help make products noticeable to consumers and subsequently prompt consumers to learn more about them.

Figure 2.4 Product picture: the first Senseo coffee maker from Philips.

2.3.4 Product Appearance to Communicate Ergonomic Information

Furthermore, consumers can gain ergonomic information from product appearance. Products are designed for consumers to fulfil certain goals through their usage. Thus, they are often designed to be easy for consumers to operate (March, 1994). However, consumers can only know whether a product is easy to use after actually operating the product. During their first encounters with a product, it is often difficult for consumers to operate it. As a result, consumers use product appearance as an important source for gaining ergonomic information. By looking at a product such as a mixer, consumers can

learn about its weight and stability and the comfort of its handle (Creusen & Schoormans, 2005). For example, as shown in Figure 2.4, the round handle suggests that the mixer is comfortable to use. In addition, consumers can infer usability information from product appearance. For instance, when they look at a novel product, consumers tend to associate it with the advanced technology integrated into it. Consequently, consumers consider the product difficult to use due to the involvement of advanced technology (Mugge & Schoormans, 2012b). Similarly, when they look at a product with a simple appearance (e.g., the mixer in Figure 2.5), consumers tend to associate this with greater ease of use (Creusen et al., 2010).

Figure 2.5 Product picture of a mixer.

2.3.5 Product Appearance to Communicate Functional Information

Similarly, consumers can gain information about a product's functionality through its appearance (Bloch, 1995; Creusen & Schoormans, 2005). Products can differ in the extent to which they fulfil their utilitarian functions, such as the number of provided functional features and effectiveness of the provided utilitarian functions. For example, a hair dryer differs in the temperature (e.g., warm or cold) and amount of airflow produced per second. These differences in functionality can also be communicated through product appearance. Specifically, the functional features a product provides can be directly communicated by making these features visible in the appearance. In the example of a hair dryer (see Figure 2.5a,b), three positions are located near the temperature switch, which communicates that the hair dryer can produce airflow in three different amounts. Similarly, when more controls (e.g., buttons) are shown on a product, the product is perceived to have more

functionalities (Norman, 1988). In addition to the direct communication of functional features, a product's appearance can prompt consumers to make inferences about its functionality (Bloch, 1995; Creusen & Schoormans, 2005; Crilly et al., 2004; Page & Herr, 2002), resulting in a form-function interdependency. Specifically, when looking at a product, consumers tend to infer its functionality from its appearance (Bloch, 1995; Crilly et al., 2004; Jordan, 2002; Mono, 1997; Vihma, 1995). For instance, they tend to perceive a large-sized hair dryer as more powerful, although the size of a product and its effective performance are not objectively related (Creusen & Schoormans, 2005). For example, consumers tend to perceive the hair dryer in Figure 2.6b as performing better than the hair dryer in Figure 2.6a. Likewise, studies have demonstrated that an attractive product is perceived as being of high quality (Page & Herr, 2002; Veryzer & Hutchinson, 1998), while a novel product is perceived as performing better than a common-looking product (Mugge & Schoormans, 2012a) and a business-like product is perceived as providing superior functional performance (Mugge, 2011).

Figure 2.6a Product picture of a small-sized hair dryer

Figure 2.6b Product picture of a large-sized hair dryer

2.3.6 Product Appearance as a Visual Cue for Categorisation

Furthermore, product appearance can be used as a visual cue for categorisation (Bloch, 1995; Creusen & Schoormans, 2005; Veryzer, 1995). By looking at a product appearance, consumers can identify what the product is and to which product category it belongs. Specifically, product appearance can influence the ease with which consumers can categorise the product into a product category. It is easy for consumers to categorise a product with a typical appearance that resembles the prototype of the appropriate product

category (Loken & Ward, 1990). For instance, in the product example shown in Figure 2.7a, consumers can easily recognise the product as a lemon squeezer due to its typical appearance. However, as the product example in Figure 2.7b looks different from a typical lemon squeezer, consumers tend to find it difficult to categorise.

Figure 2.7a Product example of a typical lemon squeezer

Figure 2.7b Product example of a unique lemon squeezer

To summarise, this section provides an overview of the six roles of product appearance in consumers' processing of products, which also apply to consumers' processing of RNPs. Several roles are particularly interesting because they help consumers to comprehend RNPs. To continue this discussion, the next section specifically discusses how product appearance can influence consumers' comprehension of RNPs.

2.4 The Potential Influence of Product Appearance on Consumers' Comprehension of RNPs

Research has discussed the influence of product appearance on consumers' processing of RNPs, such as triggering consumers' aesthetic experience, communicating symbolic associations and communicating how to use a RNP (Eisenman, 2013; Rindova & Petkova, 2007). More importantly, due to the functional and categorisation roles that product appearance can play, product appearance is particularly promising for facilitating consumers' learning and comprehension of RNPs. For example, research has pointed out that the appearance of RNPs serves as a visual cue for triggering consumers' categorisation of those RNPs (Eisenman, 2013; Rindova & Petkova, 2007), which further helps consumers to learn by transferring category knowledge to the RNPs. Studies have

demonstrated that a typical appearance of a RNP can help consumers to identify the category membership of the RNP with more certainty (Goode, Dahl, & Moreau, 2013) and subsequently retrieve the relevant knowledge from the appropriate product category, leading to fewer learning costs and enhanced evaluation of RNPs (Mugge & Dahl, 2013).

In addition to triggering consumers' categorisation of RNPs, product appearance can facilitate consumers' comprehension in other ways. More specifically, this section proposes the following three ways: 1) by influencing consumers' processing of RNPs through congruence between appearance and functionality, 2) by directly communicating the innovative functionality of RNPs, and 3) by serving as a visual cue to trigger analogical learning about RNPs.

2.4.1 Manipulate Visual Complexity to Facilitate Consumers' Comprehension of RNPs through Congruence between Appearance and Functionality

Product appearance can facilitate consumers' comprehension of RNPs through congruence between appearance and functionality. Congruence refers to the extent to which two or more elements within a concept correspond to each other (Van Rompay, De Vries, & Van Venrooij, 2010). Congruence largely depends on consumers' subjective perceptions and thus on the degree to which consumers think that different elements belong together. When consumers perceive different elements as highly corresponding to each other, high congruence results. Conversely, when consumers perceive elements as conflicting with each other, incongruence results. Due to the form-function interdependency, consumers expect congruence between product appearance and functionality. For example, consumers expect congruence between an attractive laptop and superior performance (Page & Herr, 2002). Consumers also expect congruence between a novel appearance and innovative functionality (Mugge & Schoormans, 2012a).

Such congruence can significantly influence consumers' processing of products. High congruence can be processed more easily than incongruence, leading to positive attitudes (Reber, Schwarz, & Winkielman, 2004). For instance, when looking at an attractive laptop, consumers tend to infer that it has greater performance quality (Page & Herr, 2002). When the laptop provides superior performance in line with consumers' initial expectations, a state of congruence is created. With this confirmation of initial expectations, consumers can process the product fluently. Such fluent processing requires less cognitive effort, and thus consumers are expected to have more cognitive efforts to

learn about the innovative functionality of a RNP, which is likely to result in enhanced comprehension.

Visual complexity can trigger congruence between the appearance and function of RNPs. Visual complexity is defined as the level of complexity of a pattern, shape or object (Berlyne, 1971). For products, the level of visual complexity describes the degree of complexity of the product appearance, which is mainly determined by its number of elements (Hung & Chen, 2012). Thus, a visually complex product appearance includes a large number of elements (e.g., lines, colours, materials, finishes) and/or has more details in these elements. Specifically, due to the form-function interdependency, when looking at a visually complex appearance, consumers can naturally relate the complex appearance to complex technologies and functionality (Creusen et al., 2010; Norman, 1988). Furthermore, as complexity is one of the characteristics of a RNP (Rogers, 1995), congruence can be triggered between the visually complex appearance and the functional complexity of the RNP. As a result, we expect that such congruence can influence the fluency of consumers' processing of the RNP, thereby enhancing consumers' comprehension of the RNP.

Contributions and Implications for Investigating Visual Complexity in Product Innovations

This subsection proposes that product appearance can influence consumers' comprehension of RNPs through the congruence between product appearance and functionality. We also propose that visual complexity can trigger the congruence between product appearance and functionality. Therefore, it is necessary to investigate the influence of visual complexity on consumers' comprehension of RNPs.

The investigation of visual complexity will have two theoretical contributions. First, it will demonstrate that changing visual complexity influences consumers' comprehension of RNPs. Several marketing strategies have been demonstrated to assist consumers' comprehension of RNPs (Gregan-Paxton et al., 2002; Reinders et al., 2010). The investigation of visual complexity can contribute to this line of study by designing product appearance to facilitate consumers' comprehension. Second, it will examine the mediating role of congruence between the visually complex appearance and functional complexity of RNPs. Although the congruence between product appearance and functionality has been investigated in other studies (Hoegg & Alba, 2011; Hoegg, Alba, & Dahl, 2010), these studies have mainly focused on the congruence between attractive appearance and

superior performance quality. The investigation of visual complexity contributes to this line of research by examining the factor of visual complexity and its congruence based on complexity in the appearance and the innovative functionality of RNPs.

In addition to the theoretical contributions, the investigation of visual complexity can have practical implications. From a consumer perceptive, simplicity (vs. complexity) has been identified as a product appearance attribute that consumers can perceive and use to form overall impressions of products (Blijlevens et al., 2009). Thus, it is an important factor used to evoke consumers' inferences about products. As consumers rely on simplicity (vs. complexity) to draw inferences about products, the investigation of visual complexity can confirm the usefulness of the results. Furthermore, from a designer's perspective, visual complexity is a design language that designers use frequently while embodying products (Ellis, 1993; Veryzer, 1995). In the market, we can observe RNPs embodied in different levels of visual complexity. For example, to embody rapid air technology that fries food without oil, Philips uses a simple appearance for its Airfryer (see Figure 2.8a) that consists of one regular overall shape with few details. In contrast, the Tefal Actifryer is much more visually complex (see Figure 2.8b). Its cylindrical design is horizontally divided into three parts with three different finishes. The transparent top cover exposes the internal components to consumers. Although both practices can be found in the market, the effect of visual complexity on consumers' comprehension of RNPs remains unclear. Thus, more empirical research on the effects of visual complexity can also provide important insights for practice.

Figure 2.8a Product picture of a Philips Airfryer

Figure 2.8b Product picture of a Tefal Actifryer

2.4.2 Using Transparency to Facilitate Consumers' Comprehension of RNPs through Direct Communication of their Innovative Functionality

Product appearance can directly communicate the innovative functionality of a RNP (Eisenman, 2013). As found in prior research, to encourage with consumers' comprehension, designers often purposely emphasise certain functional components of a product that may otherwise be hidden (Crilly et al., 2009). By emphasising or hiding certain parts, designers actually communicate information by selecting certain information that can assist consumers' comprehension (Crilly, 2011b). Such selection is driven by design intentions that inform consumers how to comprehend or respond to a product. In the example of the lamp from IKEA (see Figure 2.9), several fasteners are exposed in the lamp, which provide information on how the lamp should be (dis)assembled.

Correspondingly, when designing RNPs, designers can also hide or emphasise certain functional components to communicate their innovative functionality and assist with consumers' comprehension. As mentioned in Section 2.1.4, technical information is important for consumers when making adoption decisions (Talke & Snelders, 2013). Such technical information can be communicated through the exposure of certain functional components of RNPs. As a result of the acquired technical information about RNPs, consumers' comprehension of those RNPs can enhance.

Figure 2.9 A picture of a lamp with exposing fastener

In line with this, transparency can be a direct way to expose certain functional components of RNPs and to communicate their innovative functionality. Technically,

transparency is defined as 'having the property of transmitting light'. Depending on how much light can penetrate the surface, transparency can be further measured by four levels: opaque, translucent, transparent and water clear or optical quality (Ashby & Johnson, 2013). Opaque materials completely block out light, while the materials in the remaining three levels allow light to pass through. As a result, consumers can see the situation underneath the transparent materials clearly, whereas they cannot see such a situation underneath opaque materials. Translucent materials allow consumers to see the underlying situation in a blurry way. The optical quality is mainly used for optical instruments (e.g., glasses, microscopes).

Due to this unique characteristic, a transparent cover can expose the functional components underneath product covers, which can assist with consumers' comprehension of RNPs. The Dyson vacuum cleaner (see Figure 2.10) is an example of a product that exposes its functional components to assist with consumers' comprehension of its innovative functionality. The Dyson vacuum cleaner adopts the innovative technology of a dual cyclone suction system that allows for dust collection without bags. To communicate this innovative feature, a transparent cover is used to expose the part of the Dyson vacuum cleaner that collects dust. Through this transparent cover, consumers can see how the airflow collects the dust and how much dust is collected. As a result, without further explanation, consumers gain an understanding of the innovative feature of dust collection without bags. Therefore, the exposure of the functional components of RNPs through transparency offers a promising way to facilitate consumers' comprehension of those RNPs and is worthy of further investigation.

Figure 2.10 Product picture of a Dyson vacuum cleaner.

In addition to facilitating consumers' comprehension of the innovative functionality of RNPs, transparency can influence consumer responses to product innovations in different ways. For instance, the translucent cover used in the Apple iMac G3 (see Figure 2.11)

changed consumers' perceptions of the personal computer. Its translucent cover exposed the hidden technical details that people considered mysterious and longed to know (Coates, 2003), reducing the psychological distance between high-tech products and common consumers. As a result, the image of a personal computer changed from one of a cold office device to one of a friendly and modern household product (Dell'Era, Buganza, Fecchio, & Verganti, 2011). Furthermore, research has produced other fragmented evidence that suggests the different effects transparency can create. Specifically, it has suggested that transparency can be associated with different symbolic meanings (e.g., sexiness, trendiness) (Blijlevens, Mugge, Ye, & Schoormans, 2013; Karana, Barati, Rognoli, & Laan, 2015; Karana, Hekkert, & Kandachar, 2009), demonstrate the effectiveness of products and remind users to clean (Lockton, Harrison, & Stanton, 2010).

Figure 2.11 Product picture of an Apple iMac G3

Contributions and Implications for Investigating Transparency in Product Innovations

This subsection proposes that product appearance can facilitate consumers' comprehension of RNPs by directly communicating their innovative functionality. More specifically, it proposes that using transparency can directly communicate the innovative functionality of RNPs. Therefore, an investigation of transparency in RNPs can contribute to the literature by providing empirical evidence of these effects.

Moreover, transparency is used across product categories, but few studies have focused on investigating transparency in product innovations. Other factors of product appearance such as novelty, visual complexity and unity have received extensive research attention (Creusen et al., 2010; Mugge & Schoormans, 2012a, 2012b; Veryzer & Hutchinson, 1998).

Therefore, an investigation of transparency may contribute to this line of research by exploring the value of an unexplored factor within product appearance.

Furthermore, although fragmented insights into the effects of transparency for product perception have been offered (Blijlevens et al., 2013; Karana et al., 2015; Karana et al., 2009), we still lack an overview of its different possibilities. An investigation of transparency should provide such an overview. This overview would not only equip designers with a way to assist consumers' comprehension of RNPs but also provide designers with the knowledge necessary to make better use of transparency in general.

2.4.3 Design Product Metaphors to Facilitate Consumers' Comprehension of RNPs through Analogical Learning

As explained in Section 2.1.2, analogical learning can facilitate consumers' comprehension of RNPs (Gregan-Paxton et al., 2002). In the learning process, product appearance can serve as a visual cue to trigger analogical learning (Rindova & Petkova, 2007). In the access stage, research has demonstrated that physical similarities between a source and a target can help consumers' identification. By looking at a physical signal, consumers can easily recognise the source and subsequently retrieve knowledge from the source domain (Forbus, Gentner, & Rattermann, 1993). Following this, the appearance of RNPs can help consumers to identify a source domain by resembling the look of the source product or concept. For instance, the analogy of a mother is used to facilitate consumers' comprehension of the smart home system. From a textual standpoint, the smart home system is named 'Mother'. In addition, the information terminal of the smart home system resembles the image of a doll-shaped mother (see Figure 2.11). The physical resemblance is expected to help consumers to access the source domain, that is, the role of the mother at home, and to facilitate the analogical learning process of the smart home system.

Figure 2.12 Product picture of the 'Mother' smart home system.

The concept of the product metaphor is an insightful way to explain why a product appearance is designed based on its resemblance to other entities. The product metaphor is considered to 'intentionally reference the physical properties of another entity' (Hekkert & Cila, 2015). A product metaphor relates a source and a target product physically and conceptually. On the physical level, the product resembles the shape of the source. On the conceptual level, the product and source are associated in terms of certain meanings (Forceville, Hekkert, & Tan, 2006; Hekkert & Cila, 2015; Van Rompay, 2008). Both associations are indispensable for product metaphor. Following this definition, a vacuum cleaner that is shaped like a flower is not a product metaphor if the conceptual association between a vacuum cleaner and a flower is absent. The physical resemblances between a vacuum cleaner and a flower is a juxtaposition, rather than a product metaphor (Hekkert & Cila, 2015).

The two levels of association make product metaphor a promising way to facilitate analogical learning for consumers encountering RNPs. Within a product metaphor, the conceptual association between a RNP and a source is already integrated, which becomes a basis for analogical learning. Physical similarities can help consumers to identify a source domain (Forbus et al., 1993). For example, the 'Mother' smart home system is embodied in the product metaphor of the role of a mother (see Figure 2.12). On the conceptual level, the association is built between a smart home system that collects information about a home and a mother who often knows everything about the home. On the physical level, the design of 'Mother' resembles the shape of a doll, reminding consumers to think of the role of a mother at home. By involving the product metaphor of the mother, consumers are expected to improve their comprehension of the smart home system.

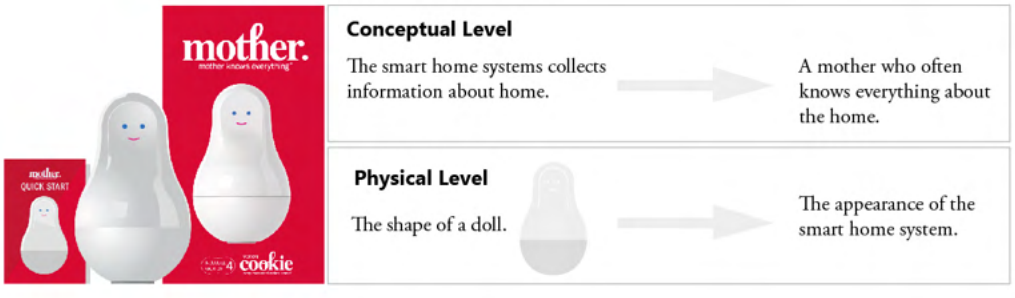


Figure 2.13 Conceptual and physical associations between the source (the role of a mother) and target RNP (smart home system)

Nevertheless, product metaphor can also carry risks that hinder consumers' analogical learning of RNPs. Specifically, in the access stage, a product metaphor may prevent consumers from identifying the source that the designers intended. Compared to verbal metaphors, visual metaphors often allow for multiple interpretations (Black, 1979). In the example of 'Mother', consumers may link the product design to multiple sources, such as a Russian doll, the cartoon character of Barbamama and/or the role of a mother at home. The space for multiple interpretations may hinder consumers from identifying the source precisely, leading to confusion. Next, in the mapping stage, consumers may lack the ability to build one-to-one correspondence between a source and a RNP (Roehm & Sternthal, 2001). In the example of 'Mother', the one-to-one correspondence is built between the role of a mother who often knows everything about her home and the function of a smart home system that collects all the information surrounding a house. To transfer knowledge in the mapping stage, consumers are required to recognize the one-to-one correspondence. In advertisements, one-to-one correspondence is often provided. In terms of the product metaphor, one-to-one correspondence cannot be stated in a product appearance, which also challenges the success of analogical learning about RNPs.

To balance the potential and risks, it can be helpful to provide textual clues that explain the product metaphors. The positive effects of providing such textual clues have been demonstrated in consumers' comprehension of artworks (Leder, Carbon, & Ripsas, 2006) and visual metaphors in ads (Phillipes, 2000), and consumers' appreciation of packaging designs (Van Rompay & Veltkamp, 2014). In the example of the 'Mother' smart home system, the textual clue of 'Mother knows everything' is stated in the product introduction. In this way, the source is activated precisely, and the possibility of misinterpretation is low. Due to the presence of the textual clue stating the similarity between the source and target RNP, the correspondence can be built at the mapping stage. As a result, the presence of textual clues makes use of the potential of the product metaphor while avoiding the risks, which can improve consumers' comprehension of RNPs.

Contributions and Implications for Investigating Product Metaphor in RNPs

This subsection proposes that product appearance can influence consumers' comprehension of RNPs through analogical learning and that designing a product metaphor can influence consumers' analogical learning process.

An investigation of the influence of product metaphors on consumers' comprehension of RNPs will have the following theoretical contributions. First, although studies have suggested that product metaphors can facilitate consumers' comprehension of RNPs (Hekkert & Cila, 2015; Phillipes, 2000), empirical evidence in support of this notion is still lacking. This investigation should fill in this gap.

Second, in addition to demonstrating the potentials of product metaphors, this investigation explores the risks that product metaphors carry along the three stages of analogical learning. We still lack a thorough understanding of the potential and risks of using product metaphors in RNPs. It remains unclear how the product metaphors in RNPs facilitate or hinder consumers' analogical learning about RNPs. Therefore, an investigation of the influence of product metaphors on consumers' comprehension of RNPs should demonstrate not only the potential but also the risks of using product metaphors in RNPs.

Third, to effectively design product metaphors in RNPs, this investigation considers the accompanying role of the textual clue, which can make the best use of potential. The moderating effects of textual clues have been demonstrated in other contexts (Leder et al., 2006; Phillipes, 2000; Van Rompay & Veltkamp, 2014). The investigation should provide empirical evidence for the moderating effects of textual clues in the context of the product metaphor in RNPs. Furthermore, the results of this investigation should provide recommendations for designers in practice. The results can inform designers of the potential and risks that product metaphors carry, and how to make best use of its potential.

2.5 Sub-research Questions and Overview of Studies

This chapter starts with a general research question: *how can designers use product appearance to influence consumers' comprehension of RNPs?* To shed light on this research question, a literature review is conducted to review the current strategies adopted to promote RNPs and the influence of product appearance on consumers' processing. Next, with a specific focus on RNPs, the possible roles played by product appearance are introduced, and the ways in which appearance may influence consumers' comprehension of RNPs are proposed (i.e.,

by triggering congruence between the appearance and functionality of RNPs, by directly communicating the innovative functionality of RNPs, and by triggering analogical learning). To further examine these proposed ways and provide designers with specific factors to trigger them, three factors of product appearance are introduced: visual complexity, transparency and the product metaphor. Therefore, the general research question is divided into three specific research questions.

- How can designers make use of visual complexity to increase consumers' comprehension of RNPs?
- How can designers make use of transparency in product innovations to facilitate consumers' comprehension of RNPs?
- How can designers make use of product metaphors to improve consumers' comprehension of RNPs?

The investigation of these three factors aims to not only examine each proposed mechanism that influences consumers' comprehension of RNPs but also to provide practical knowledge on how designers can make better use of the factors while designing RNPs. Each of the following three chapters focuses on one of these factors.

Chapter 3 focuses on investigating the effects of visual complexity on consumers' comprehension of RNPs to address how designers can use visual complexity to increase consumers' comprehension of RNPs. This research question is addressed through two empirical studies. In Study 1, a controlled experiment is designed and conducted to examine the effects of visual complexity on consumers' comprehension of INPs and RNPs. Next, Study 2 is conducted to translate the theoretical findings into design guidelines.

Chapter 4 centres on the use of transparency in product innovations to determine how designers can make use of transparency in product innovations to facilitate consumers' comprehension of RNPs. This research question is addressed by determining what designers intend to convey through transparency in product innovations and how consumers interpret that transparency. Specifically, in Study 3, designer interviews are conducted to determine the intentions designers hold when using transparency, including whether designers intend to use transparency to facilitate consumers' comprehension of RNPs. Moreover, as consumers may not respond to product innovations in the ways intended by designers, design intentions may not be fulfilled. Thus, consumers' interpretations are investigated in Study 4 to validate the findings of Study 3. Specifically,

consumer interviews are conducted to learn about consumers' interpretations of transparency in product innovations. Design intentions and consumers' interpretations of transparency in product innovations are compared to reveal the effectiveness of using transparency in product innovations.

Chapter 5 investigates product metaphor to determine how designers can make use of product metaphors to improve consumers' comprehension of RNPs. In Study 5, a controlled experiment is conducted to investigate the interaction effects of product metaphors and corresponding textual clues on consumers' comprehension of RNPs. The results provide empirical evidence for the effects of product metaphors on consumers' comprehension of RNPs. Next, in Study 6, according to the three stages (i.e., access, mapping, transfer) in the analogical learning process, consumers are interviewed to further determine how product metaphors influence consumers' comprehension of RNPs in each stage.

Chapter 3 'Complexity in Simplicity': the Effects of Visual Complexity on Consumers' Comprehension of Product Innovations

This chapter focuses on investigating the attribute of visual complexity in product innovations to address the following research question: *'How can designers make use of visual complexity to increase consumers' comprehension of RNPs?'* In product innovations, visual complexity describes the degree of complexity of their appearances (Hung & Chen, 2012). A visually complex product appearance includes a large number of elements (e.g., lines, colours, materials, finishes) and/or has more details in these elements. In contrast, a visually simple product appearance includes limited elements and few details in these elements.

Will a visually simple or a visually complex product innovation help consumers' comprehension of RNPs? Both styles can be observed to embody RNPs in the market. For example, Dyson often communicates its innovative products in a complexity style, while Philips is famous for its simplicity style. Simplicity is often appreciated for its high aesthetic value (Creusen et al., 2010) because it is easy to process cognitively (Berlyne, 1971), whereas complexity is likely to be cognitively overwhelming (Noble & Kumar, 2010). Thus, it is possible that a simple-looking product innovation could help consumers' comprehension because more cognitive resources can be used for processing the innovative functionality of RNPs. However, due to form-function interdependency, it is also suggested that consumers perceive product appearance and its functionality as a whole (Hoegg & Alba, 2011). By looking at product appearances, consumers tend to draw inferences on the functionality of the product (Creusen & Schoormans, 2005; Mugge & Schoormans, 2012a, 2012b). Then, the congruence between product appearance and functionality could play a role. As consumers tend to relate visual complexity with product functionality (Creusen et al., 2010), 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, Pruyn, & Tieke, 2009), which positively influences consumers' comprehension.

Therefore, in order to examine which underlying mechanism dominates consumers' processing, a controlled experiment was set up in Study 1. Next, Study 2 was conducted to translate the theoretical finding from Study 1 into practical design guidelines.

3.1 Study 1: the Effects of Visual Complexity on Consumers' Comprehension of Product Innovations

3.1.1 Hypotheses Building

Visual complexity influences consumer response in different ways. For artificial patterns, the relationship between visual complexity and aesthetic appraisal follows an inverted U-curve. A moderate level of visual complexity is preferred because this can trigger interest and bring about acceptable processing difficulty that is within people's capacity (Berlyne, 1971). Neither low nor high visual complexity are preferred because the former makes people feel bored easily, whereas the latter is too difficult to process. Different from artificial patterns, consumer durables are not low in visual complexity. Consequently, it is demonstrated that consumers for whom aesthetics is important prefer an appearance with low visual complexity (Creusen et al., 2010).

In addition to aesthetic preferences, other effects of visual complexity may take place in product appearance. Specifically, although visual complexity is often independent from product functionality from an objective perspective, consumers may still use visual complexity to infer a product's functional attributes (Creusen et al., 2010). Prior research concluded that consumers form different perceptions on product functionality by drawing inferences from product appearances (Bloch, 1995; Creusen & Schoormans, 2005; Crilly et al., 2004; Mugge, 2011). For instance, consumers associate a product with a novel appearance with advanced technology (Mugge & Schoormans, 2012a, 2012b; Rindova & Petkova, 2007). Correspondingly, when encountering products with different visual complexity levels, consumers can also form different perceptions about a product's functional attributes. In this respect, Creusen et al. (2010) demonstrated that visual complexity is related to consumers' perceptions of product functionality and performance quality. Consumers who value product functionality or performance quality prefer a visually complex product appearance over a simple one. Following this, for RNPs we expect a positive effect of visual complexity on consumers' comprehension resulting from the congruence between the visual complexity of the appearance and the really new functions of these innovations.

Congruence plays an important role in consumers' processing of consumer durables. When encountering a consumer durable, consumers need to process information conveyed by the product appearance and information about the product's functions. Consumers naturally expect congruence between product appearance and the functions

of the product (Hoegg & Alba, 2011). For instance, when seeing an unattractive laptop, consumers tend to infer that it performs poorly. When the laptop provides plain 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 judgment easily. Conversely, when the laptop performs superior, incongruence is triggered, which violates consumers' initial expectation. To recognize and resolve the incongruence, consumers need to elaborate on it. Unlike an affective response that can be made quickly (Page & Herr, 2002), such an elaboration is an effortful process that requires ample cognitive efforts (Hoegg et al., 2010). When ample cognitive resources are available, consumers can be motivated to solve the incongruence. As a result, consumers pay greater attention to the product's functional features, leading to enhanced evaluation of these functional features. 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 & 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 really new functions of a RNP. When encountering a complex appearance, consumers may naturally expect that the product contains complex technology (Norman, 1988). As complexity is an attribute of RNPs (Rogers, 1995), which corresponds to consumers' initial expectations, congruence between product appearance and functions is triggered. In contrast, when consumers encounter a simple appearance, the presence of complex technology in the functions of a RNP may trigger incongruence. In line with prior findings on the effects of congruence, we expect that in comparison to incongruence, congruence between product appearance and functions will result in fluent processing.

Furthermore, we expect that the effect of congruence on consumers' comprehension will differ between the different types of product innovations. In the case of RNPs, consumers have difficulty in understanding their functions (Gatignon & Robertson, 1985). Learning and understanding RNPs requires great cognitive efforts from consumers (Olshavsky & Spreng, 1996). As congruence can facilitate consumers' processing (Van Rompay & Pruyn, 2011) and demand fewer cognitive efforts (Hoegg et al., 2010), more cognitive resources can be spent on understanding the really new functions, resulting in enhanced comprehension of the RNP. Conversely, if incongruence between the product appearance and function exists for a RNP, consumers need to spend extra cognitive

efforts to deal with the incongruence, resulting in fewer cognitive efforts to learn and understand the really new functions. Consequently, consumers' comprehension of the RNP will be lower.

However, for INPs we do not expect that visual complexity will influence consumers' comprehension. As consumers are already equipped with sufficient knowledge of INPs due to their daily experience with similar products, comprehending INPs is within consumers' capability. Thus, (in)congruence between product appearance and function will not influence consumers' learning of INPs. The fluent processing triggered by the congruence will not result in better comprehension because consumers already have sufficient comprehension of INPs. Likewise, the incongruence will not hinder consumers' learning of INPs because ample cognitive efforts are available to process the incongruence. Therefore, consumers' comprehension is not likely to differ between simple and complex appearances for INPs. Moreover, INPs are often in the mature phase of the product life cycle, where products differentiate from competitors through different product appearances (Person et al., 2008). Thus, it is likely that consumers are frequently exposed to INPs with diverse product appearances, including INPs with different visual complexity levels. Therefore, we expect that consumers will perceive both simple and complex appearances as congruent to the functions of an INP. Figure 3.1 summarizes the interaction effects of visual complexity and innovation type on consumers' comprehension and the mediating role of congruence level. 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 level of visual complexity does not influence consumers' comprehension (H1b).

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

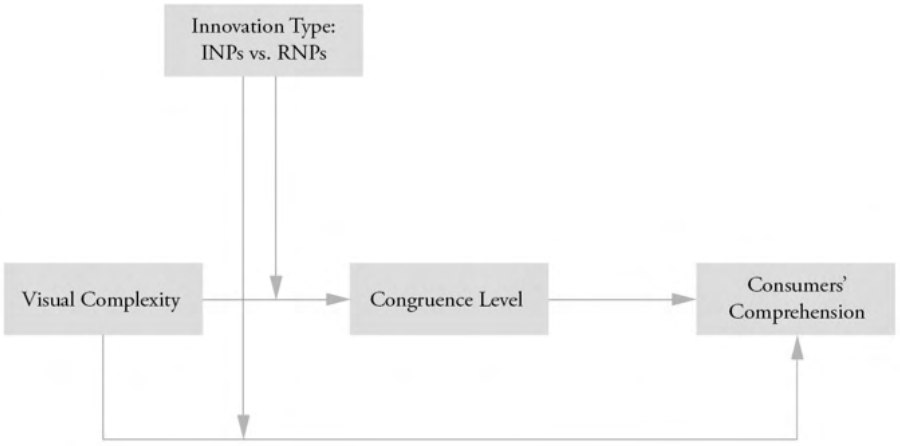


Figure 3.1 The interaction effect of visual complexity and innovation type on consumers' perceived congruence level and consumers' comprehension: the moderating role of innovation type and the mediating role of congruence level

3.1.2 Method

To test the hypotheses, we conducted one main study and two pretests. In pretest 1, textual descriptions of new products were tested to create INPs and RNPs. Different product appearances were tested in pretest 2 to ensure that there were differences in visual complexity, while preventing any confounding effects. In the main study, the textual descriptions of INPs and RNPs were combined with either simple or complex product appearances, resulting in four different conditions. To improve the study's generalizability, stimuli were created for: irons, electric kettles, and hairdryers. These three categories were selected because they are common consumer durables. Thus, all participants have basic knowledge of these products. Moreover, the relative diverse styles of these product categories make it feasible to create different levels of visual complexity, while minimizing confounding effects.

Pretest 1: INPs versus RNPs

To manipulate INPs and RNPs, textual descriptions were created for each product category based on the theory on mutability (Moreau et al., 2001; Mugge & Dahl, 2013). Mutability refers to the conceptual transformability of features in a certain category. The degree of mutability depends on the variability of a certain feature used in the product category and the number of other features that rely on this feature (Love & Sloman, 1995). 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 this core feature, such as a

water tank to store water and vent holes to produce steam. By changing such an immutable feature (e.g., heated steam in an iron is replaced by ultrasound waves), the product will deviate strongly from other products in this category. Consumers' perception of the discontinuity increases and the innovation is perceived to be a RNP. Therefore, textual descriptions of RNPs were created by changing immutable features into significantly different features that were rarely used in the corresponding product categories at the time the study took place. Changing the immutable features was done based on existing innovations and concepts that were found online. The technological feasibility of the created textual descriptions was confirmed by an engineer with a PhD degree. For the INPs, the texts described a new product for which the immutable features did not change, but which does incorporate new features (e.g., a more powerful heating element that produces steam continuously). We followed prior research while writing the texts (Hoeffler, 2003; Mugge & Dahl, 2013). 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).

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 within-subject factor. Twenty-five participants were asked to rate the textual description of one innovation for each product category. To measure the innovativeness of the stimuli, participants were asked to respond to the following 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 .80 to .86). As intended, a main effect was found for innovation type, $F(1, 23)=14.21$, $p<.05$. Across three product categories, participants assigned to rate RNPs perceived the product as more innovative than participants who rated INPs (see Table 3.1).

Table 3.1. Results of pretest 1: means for the innovativeness of the INPs and RNPs by product category.

	INP	**RNP**

Iron*	3.47	4.85
Electric kettle*	3.03	4.54
Hairdryer*	2.78	4.54

Note: *Consumers' ratings of innovativeness were significant across three product categories.

Pretest 2: Simple versus Complex Product Appearances

For the manipulation of the visual complexity of the product appearances, five product appearances were created for each product category. We included one simple appearance and four visually complex appearances in the pretest for each category to manipulate visual complexity while preventing any confounding effects. It is possible that a change in visual complexity will also change the product appearance in terms of attractiveness, typicality/novelty or functionality. To ascertain that the demonstrated effects were evoked by visual complexity, rather than such confounding effects, we aimed to prevent confounding effects by selecting stimuli in pretest 2 that differed significantly in visual complexity level but did not significantly differ in terms of attractiveness, typicality and functionality level. All product appearances were created by a trained designer with a MSc in Industrial Design. First, the designer created a simple appearance for each product category based on the typical appearance of this category, while reducing the visual complexity of all elements as much as possible. Subsequently, based on the simple appearances, more elements (e.g., lines, textures, coverings) and details were included to increase the visual complexity level, while minimizing potential confounding effects. Existing products were reviewed and used as examples to keep the created stimuli realistic and typical. Figure 3.2 demonstrates how the stimuli were created for the category hairdryers. Existing hairdryers made use of lines, coverings consisting of different materials, and specific detailing to make the product appearance more complex (see Figure 3.2a). We simulated these effects in our stimuli (see Figure 3.2b). Specifically, we increased visual complexity level by adding decorative elements that did not communicate functionality, in order to prevent the possible enhancement of comprehension facilitated by the communication of functionality. Thus, hairdryer 2 was more complex than hairdryer 1 by adding three coverings. Hairdryer 3 was even more 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 hairdryer1. All elements and details were

carefully arranged to keep the harmony and attractiveness of the created product appearances similar.

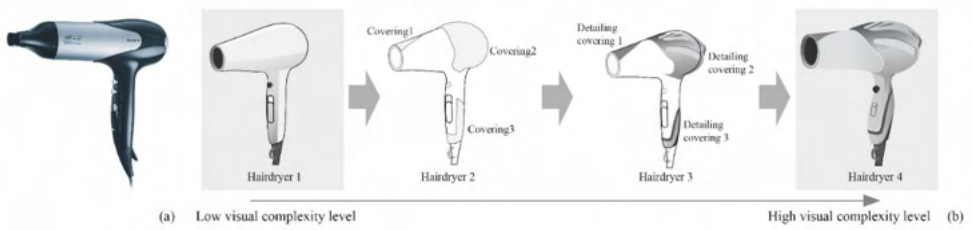


Figure 3.2 Example of stimuli creation process in the product category of hairdryer: (a) example of an existing hairdryer in the market; (b) the process of increasing visual complexity level of a hairdryer

All product appearances were designed as 3D visualizations, which were standardized in size, color and buttons (Mugge & Dahl, 2013; Veryzer & Hutchinson, 1998). The 3D visualizations were made in black and white to prevent confounding effects of color (Grossman & Wisenblit, 1999).

Next, 60 participants (40% male, mean age = 21.87) evaluated the product appearances. All participants had a design background, which made them sensitive to visual differences. A 5 (visual complexity level: simple vs. complex product appearance) ×3 (product category: iron, electric kettle, and hairdryer) mixed design was used, with visual complexity level as between-subject factor and product category as 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 level was measured with two 7-point scale items anchored by: "simple/complicated" and "not complex/complex" (Pearson's r's ranging from .53 to .63) (Cox & Cox, 2002). To prevent confounding effects, attractiveness, typicality, and functionality were also measured. Attractiveness of the product appearances was measured using the two items: "unattractive/attractive" and "ugly/beautiful" (Pearson's r's ranging from .72 to .89). Typicality was measured by the three 7-point scale items (Veryzer & 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 .84 to .91). As a visually complex product may trigger the expectation of increased functionalities (Creusen et al., 2010; Norman, 1988), functionality was assessed to check for such a confounding effect by three 7-point scale items (Cox & Cox, 2002) anchored by:

"not useful/useful," "not functional/functional," and "not practical/practical" (α's ranging from .71 to .89).

Analyses were conducted separately for each product category. One-way ANOVAs were conducted with visual complexity level as the independent variable, and the ratings on visual complexity, attractiveness, functionality, 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<.05), electric kettle (F (4, 55) =3.37, p<.05), and hairdryer (F (4, 55) =5.53, p<.05). Subsequently, participants' ratings on attractiveness, typicality, and functionality were analyzed. Based on these results, two product appearances were selected for each product category that demonstrated the largest difference on visual complexity but did not significantly differ with respect to typicality, attractiveness, and functionality (see Table 3.2). LSD post hoc tests were conducted and confirmed the significant differences on selected stimuli in terms of visual complexity among the three product categories. Results also revealed that no significant differences between selected stimuli were found on the control variables for all product categories, minimizing the risk of potential confounding effects. The selected stimuli can be found in Appendix B.

Table 3.2. Results of pretest 2: means for visual complexity, typicality, attractiveness, and functionality by product category

		Low visual complexity group	High visual complexity group
Iron	Visual Complexity*	2.73	4.21
	Typicality	5.88	5.19
	Attractiveness	3.91	3.57
	Functionality	5.67	5.62
Electric kettle	Visual Complexity*	2.73	4.42
	Typicality	5.79	4.92
	Attractiveness	3.36	3.27
	Functionality	5.70	5.51
Hairdryer	Visual Complexity*	2.27	3.45
	Typicality	5.70	5.37
	Attractiveness	3.95	4.10

Functionality	5.39	5.70

Note: *Consumers' ratings were significant between low and high visual complexity group.

Main Study

Design and Participants

The main study had a 2 (innovation type: INPs vs. RNPs) ×2 (visual complexity level: simple vs. complex product appearance) ×3 (product category: iron, electric kettle, and hairdryer) mixed design, with innovation type and visual complexity level as between-subject factors and product category as within-subject factor. Seventy-seven participants (42.9% male, mean age = 41.00) were collected from a consumer panel, which was affiliated with a Dutch university. This research panel is representative of the general population in Netherlands in terms of gender and age. We selected this research panel because it was developed for academic purposes. Participants below 55 years old were selected, because younger people generally have less difficulty accepting new products (Loudon & Bitta, 1993).

Procedure and Measurements

The textual descriptions in pretest 1 and the visualizations of pretest 2 were combined to create the stimuli used in the main study. This resulted in four conditions for each product category. Each participant was assigned to one of the four conditions and was 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 .78 to .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 level between the product function and appearance, we used the following 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 .83 to .92). As congruence largely depends on consumers' subjective perceptions, we used self-reports to measure the congruence level that participants' perceived. To validate the success of the manipulations, we included measures of innovativeness (α's ranging from .79 to .84) and visual complexity level of product appearance (Pearson's r's ranging from .74 to .83). These measures 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 .80 to .94). Typicality of product appearance was measured by rating one 7-point scale item "bad/good example of the product category." Consumer innovativeness and the design acumen dimension of the Centrality of Visual Product Aesthetics (Bloch, Brunel, & Arnold, 2003) were included, as these constructs were shown to influence participants' responses to product innovations (Truong, Klink, Fort-Rioche, & Athaide, 2014). Consumer innovativeness was measured by four 7-point Likert scale items (Manning, Bearden, & Madden, 1995): "I often seek out information about new products and brands," "I like to go to places where I would be exposed to information about new products and brands," "I like magazines that introduce new brands," and "I take advantage of the first available opportunity to find out about new and different products," ranging from 1 (strongly disagree) to 7 (strongly agree; α = .82). Following Truong et al. (2014), design acumen was measured by two 7-point Likert scale items: "Being able to see subtle differences in product designs is one skill that I have developed over time" and "I see things in a product's design that other people tend to pass over," ranging from 1 (strongly disagree) to 7 (strongly agree; Pearson's r =.75).

3.1.3 Results

Manipulation Checks

To test whether the manipulation of innovation type was successful, a 2×2×3 mixed ANOVA was conducted with innovation type, visual complexity level, and product category as independent variables, and ratings of innovativeness as the dependent variable. The results confirmed the success of the manipulation of innovativeness, $F(1, 73)=79.43$,

p<.01. Across three product categories, participants rated RNPs as being significantly more innovative than INPs (see Table 3.3). Furthermore, analyses on the three product categories were conducted separately. For all three 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. As intended, the results showed a significant difference between the simple and complex product appearances at the level of visual complexity (F(1, 73)=7.25, p<.01) (see Table 3.3). Across the product categories, participants assigned to the complex condition evaluated the product appearance as significantly more complex than participants in the simple condition. Furthermore, separate analyses on the three product categories were conducted. For all product categories, the product appearances in the complex conditions were judged to be more complex than the product appearances 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). In addition, no significant differences were found between simple and complex appearances in terms of attractiveness (F(1, 73)=3.09, p>.08) and typicality (F(1, 73)<1), which provided further evidence for the successful manipulation of our stimuli.

Test of Hypotheses

H1: Effects of visual complexity on consumers' comprehension

H1 states that a more complex product appearance will increase consumers' comprehension of RNPs. To test this hypothesis, a 2×2×3 mixed ANCOVA was conducted with innovation type, visual complexity, and product category as independent variables, consumers' comprehension as dependent variable, and age, gender, consumer innovativeness, and design acumen as covariates. Results showed a significant interaction effect between innovation type and visual complexity level on consumers' comprehension (F(1, 69)=7.12, p<.05). Across three product categories, participants reported greater comprehension of the RNP when the RNP had a product appearance that was visually more complex (F(1, 30)=5.18, p<.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>.10; M_{simple}=5.61, $M_{complex}$=5.07; see Figure 3.3a). No effect was found for product category and no other interaction effects were found, suggesting generalizability

of the findings. These results provide support for H1. In addition, the pattern of means was explored for the three product categories separately and the means for the variable of consumers' comprehension were all in the predicted direction: all participants reported better comprehension of the RNP when it was embodied in a more complex appearance compared to a RNP with a simple appearance. In contrast, for INPs, the differences of means for consumers' comprehension between the complex and simple appearance conditions did not reach statistical significance, suggesting that a complex (vs. simple) product appearance did not help participants to gain better comprehension of INPs. Table 3.3 provides an overview of the results of the main study.

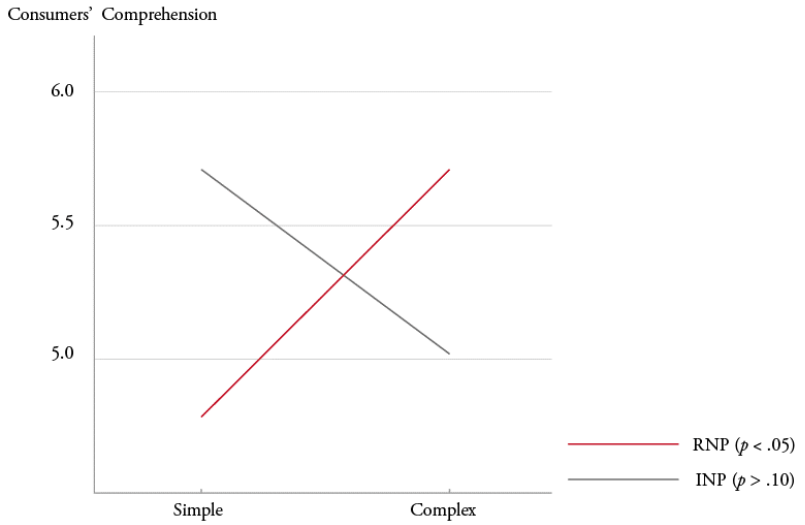


Figure 3.3a The interaction effects of visual complexity and innovation type on consumers' comprehension

H2: Mediation role of congruence for RNPs

In H2, we hypothesized that the effect of visual complexity on comprehension is mediated by congruence between the product appearance and the really new function of RNPs. We firstly examined whether participants perceived congruence between the visually complex product appearance and the really new function of RNPs by conducting a 2×2×3 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 level (F (1, 69)=5.68, p<.05). This effect was qualified by an interaction effect between innovation type and visual complexity level (F (1, 69)=4.07, p<.05). Across three product categories, participants reported a higher score on

congruence when the RNP had a product appearance that was visually complex than when it was simple (F (1, 30)=10.52, p<.01; M_{simple}=3.74, $M_{complex}$=4.92, see Figure 3.3b). However, for INPs, visual complexity had no impact on the congruence level (F (1, 35)<1, p>.10; M_{simple}=4.60, $M_{complex}$=4.68). No effect was found for 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 the variable of congruence were all in the predicted direction: all participants reported a higher score on congruence when the RNP is embodied with a more complex appearance compared to a RNP with a simple appearance (see Table 3.3). In contrast, no congruence effects were found for INPs.

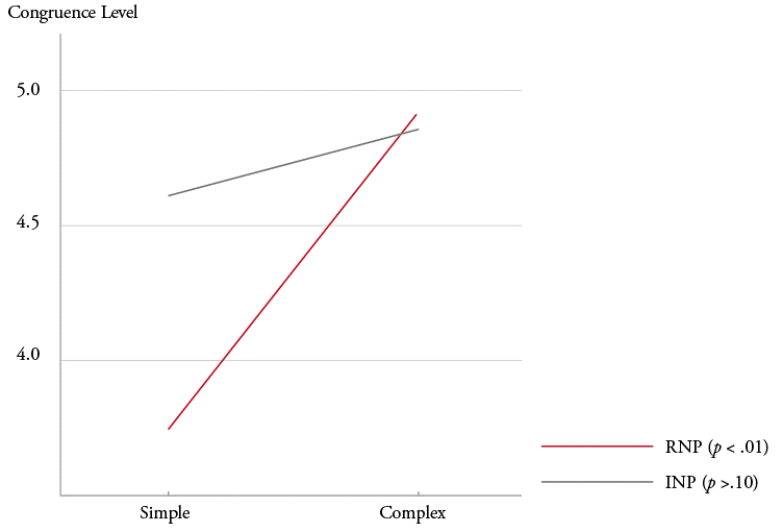


Figure 3.3b The interaction effects of visual complexity and innovation type on congruence level

Table 3.3. Results of main study: adjusted means (including covariates) for comprehension, congruence level, visual complexity, and innovativeness by product category

		INP			RNP		
Visual Complexity Level		**Low**	**vs.**	**High**	**Low**	**vs.**	**High**
Iron	Comprehension	5.37	vs.	4.36	4.37	vs.	5.16*
	Congruence	4.59	vs.	4.47	3.79	vs.	4.94*
	Visual complexity	2.36	vs.	3.19*	2.52	vs.	2.84
	Innovativeness	3.16	vs.	2.87	5.00	vs.	5.19
Electric kettle	Comprehension	5.98	vs.	5.63	4.97	vs.	5.72*
	Congruence	4.37	vs.	4.56	3.43	vs.	4.74*
	Visual complexity	2.09	vs.	2.82	2.31	vs.	3.51*
	Innovativeness	2.61	vs.	2.76	4.45	vs.	4.13
Hairdryer	Comprehension	5.75	vs.	5.09	5.08	vs.	5.57*

Congruence	4.83	vs.	5.00	4.00	vs.	5.09*
Visual complexity	1.77	vs.	2.45*	2.57	vs.	3.33
Innovativeness	2.06	vs.	2.32	4.12	vs.	4.80

Note: * The comparison between means is significant ($p<.05$)

To test whether the effect of visual complexity on consumers' comprehension of RNPs is due to differences in the congruence between the product appearance and the functions, a mediation analysis was conducted by following the methodology proposed by Preacher and Hayes (2004) (MODMED; model 8). Participants' ratings were first standardized. 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. To demonstrate support for congruence as a mediator of the relationship between visual complexity and consumers' comprehension of RNPs, the 95% confidence interval associated with the point estimate of the indirect effect of visual complexity on consumers' comprehension must not include zero (Preacher & Hayes, 2004; X. Zhao, Lynch, & Chen, 2010). This point estimate represents the product of the regression coefficients (a.k.a the indirect effect) calculated when visual complexity predicts congruence and when congruence predicts consumers' comprehension of RNPs.

The bootstrap analysis 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 .07 to 1.12, for the point of estimate of 0.26, without including zero. More importantly, 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, .15 to 1.11). However, for INPs, the mediation through congruence was not significant (B = 0.34, 95% CI, -.25 to .36). In support of H2, these results suggest that increasing visual complexity positively influences consumers' comprehension of RNPs, and congruence between product appearance and the product's functions serves as a mediator for this effect of visual complexity.

3.1.4 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. Although the results demonstrate that more visually complex RNPs facilitate consumers' comprehension than visually simple ones, the findings should not be considered as a choice between simple or complex appearances. Consequently, we propose that complexity and simplicity are not necessarily mutually exclusive design strategies. Instead, designers can make use of the benefits of both complexity and simplicity when designing RNPs. Specifically, designers can use complexity to trigger the perceived congruence and improve consumers' comprehension. Moreover, designers can simultaneously use simplicity to create attractive appearances (Lockwood, 2015). To make optimal use of both complexity and simplicity in product appearances of RNPs, we propose the design principle 'complexity in simplicity', which refers to increasing the visual complexity level in certain parts to trigger congruence with product functionality while still keeping the overall 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 will 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. The resulting product appearance will have both simple and complex elements, which we refer to as 'complexity in simplicity'.

While creating stimuli, we attempted to follow the design principle 'complexity in simplicity'. Specifically, we performed extensive pretests to increase visual complexity while preventing significant differences on attractiveness. Consequently, our stimuli only conveyed moderate complexity, and the overall shape of the stimuli still conveyed a sense of simplicity. Nevertheless, some limitations exist concerning the stimuli creation process of study 1. We manipulated visual complexity by adding decorative details and elements that did not directly communicate information related to the product functionality. The choice of 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. We expect that the positive effect of visual complexity on consumers' comprehension will be even larger if the included elements communicated

information related to the functionality of the RNP.

Therefore, to show how to achieve the design principle 'complexity in simplicity', Study 2 was conducted. Study 2 fulfills two aims. First, it investigates whether experienced designers can use this principle to design RNPs. Second, Study 2 will demonstrate how they designed these appearances to provide more insights in the design principle 'complexity in simplicity' and how it can be applied in practice.

3.2 Study 2: the Design Principle of 'Complexity in Simplicity'

3.2.1 Method

Participants

To show how designers can make use of the findings from Study 1, we invited six experienced product designers (5-25 years of design experience) to design RNPs. These participants differed in cultural background, including Chinese, French and Italian. We selected participants with different cultural background to avoid the influence of culture. Due to their extensive design experience, these designers were able to design in different styles and explain possible ways to achieve certain styles.

Procedure

We used the product descriptions in Study 1 as design briefs. Participants were explained the concepts of the RNPs and the findings from Study 1. Several product examples were shown to familiarize them with simplicity and complexity styles in product designs. They were also explained that although visual complex RNPs facilitate consumers' comprehension, an extremely complex design can be less attractive. They were asked to combine complexity and simplicity, and to design two RNPs in the design principle of 'complexity in simplicity'. They were allowed to draw the sketches physically or digitally within 20 minutes. After finishing the designs, a short interview followed. Participants were asked to explain their designs, their opinions on the design principle of 'complexity in simplicity', and the possible ways to achieve it.

3.2.2 Results and Discussion

All participants completed the design tasks. In general, the generated designs achieved 'complexity in simplicity'. As shown in Figure 3.4, the created designs followed the simplicity style in terms of overall appearance, and included complexity on certain

elements. During the interviews, designers explained that increasing the visual complexity was an effective way to communicate the innovative functionality of RNPs. By increasing visual complexity, designers could highlight the innovative functionality. This may not have an actual functional purpose, but it does emphasize and elucidate the new and differentiating features, which can contribute to people's comprehension of RNPs. For example, in Figure 3.4a, the designer made the two sensors of the hairdryer 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 3.4b), and by including an array of LED on the surface of the electric kettle to indicate UV rays (see Figure 3.4c). Designers also explained that the overall shape should have a sense of simplicity to be aesthetically pleasing.

Figure 3.4 Examples of designs created in Study 2

In terms of simplicity and complexity, designers explained that both were different ways of communication, but not necessarily mutually exclusive. Instead, simplicity and complexity should be combined while designing to selectively communicate information related to product functionality and technology, in order to 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 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, overall product appearances should be simple and coherent, which make the products aesthetically pleasing. Second, to increase visual complexity, designers can add some elements and more details on certain parts to communicate the functionality of the

products (see Figure 3.4). Designers can add LEDs, parts, layers and lines to highlight the innovative functionality. Furthermore, designers can also use different colors and materials to create contrasts within the products. Third, designers highlighted that when increasing the number of elements, these elements should share some similarities to create rhythm and harmony among them, which contributes to the overall simplicity. A large number of elements that share no relationships can make the product appearance less attractive.

Designers mentioned that using transparent or translucent materials can achieve 'complexity in simplicity' effectively. The exposure of technical details underneath the product's surface increases the visual complexity level and communicates additional information concerning the product functionality, which could facilitate consumers' comprehension, while maintaining the overall simplicity (e.g., Tefal Actifryer in Figure 2.10b).

These findings explain how designers can achieve 'complexity in simplicity'. When reviewing existing products in markets, we could easily find products that followed these principles as well. Figure 3.5 shows three examples of vacuum cleaners with different levels of visual complexity. In comparison to product A, the visual complexity level is increased in product B by implementing more elements, such as additional lines on the surface, more color variations, more details on the wheel and a transparent surface on the top. In product C, the visual complexity level is further increased by adding a handle on the top and including a larger transparent surface that exposes the internal components. The inclusion of these additional elements (e.g., lines, handle, transparency) increases visual complexity effectively. It should be noted that the different elements shared some similarities so that rhythm is created and overall simplicity is maintained. For example, the additional lines in product B are in parallel with the product parting lines. In product C, the handle was arranged in parallel with the surface. In practice, designers need to carefully consider which elements and details need to be included and how to create rhythm among these elements in order to create 'complexity in simplicity', and thereby facilitate consumers' comprehension, while keeping the product attractive.

Figure 3.5 Examples of product designs with different levels of visual complexity: increasing level of visual complexity from (a) to (c)

These insights are also important for design managers. When developing design briefs, design managers often state specific design principles, such as the simplicity design principle, to encourage designers to create appearances that are considered attractive by the target group. However, our findings suggest that design managers should first consider the type of product innovation. If the newly developed product is a RNP, design managers can also consider to include visual complexity on certain elements to facilitate congruence between appearance and functions and thereby increase consumers' comprehension of RNPs.

3.3 General Discussion

This chapter investigates visual complexity in designing RNPs through two studies. In Study 1, we proposed and tested the different effects of visual complexity on consumers' comprehension of INPs and RNPs, and the mediating role of congruence between appearance and functionality. Results of Study 1 supported our hypotheses. Specifically, the findings of Study 1 provide support for an interaction effect between visual complexity and innovation type, indicating the different effects of visual complexity on consumers' comprehension of INPs and RNPs. When encountering a RNP with a visually complex appearance, consumers perceive congruence between the really new functions of the product innovation and its complex appearance. This congruence results in more fluent processing, which facilitates consumers' comprehension because it leaves more cognitive resources available for understanding the really new functions of the RNP. For INPs, consumers do not experience difficulty in comprehending the products, because they gain sufficient knowledge by encountering similar products in daily lives. Thus, congruence and visual complexity will not influence consumers' comprehension of INPs.

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 keep the overall simplicity. Accordingly, we propose the design principle 'complexity in simplicity' to designers and design managers as an effective principle to create RNPs that are aesthetically attractive and perceived as more comprehensible. The findings of Study 2 showed that it was possible for designers to design RNPs following the design principle of 'complexity in simplicity'. More importantly, designers increased visual complexity not only by adding decorative elements but by including specific elements that communicated the innovative functionality of the RNP. By emphasizing and elucidating the unique and differentiating features of a RNP via visual complexity, visual complexity can directly contribute to consumers' comprehension as well as indirectly through congruence. Overall simplicity can be maintained by creating rhythm among the different elements.

The results of this chapter contribute to our understanding of the value of visual complexity in different ways. First, through an experimental approach in Study 1, the value of visual complexity for improving consumers' comprehension of RNPs is demonstrated. Different from the traditional notion that visual complexity can be cognitively overwhelming (Noble & Kumar, 2010), our results reveal that visual complexity does not burden consumers' processing of RNPs because consumers process product appearance and functionality as whole. In other words, the congruence between appearance and functionality plays a more important role in consumers' processing of RNPs.

Study 1 also contributes to our understanding on congruence between product appearance and a product's functions as the underlying mechanism for facilitating consumers' comprehension. The effects of (in)congruence between appearance and functions have received limited research attention thus far. The few studies exploring such (in)congruence have focused on examining the effects of (in)congruence between attractiveness of appearances and the superiority of the product's functions (Hoegg & Alba, 2011; Hoegg et al., 2010). Our study contributes by examining congruence between the visual complexity of the product appearance and the complexity of the really new functions of a RNP, and further demonstrates the effects of congruence on consumers' comprehension of RNPs.

Furthermore, Study 2 makes a methodological contribution on how to translate the theoretical findings into a design principle through interviewing designers. A number of studies have been conducted to investigate effects of various factors on consumer

response (e.g., Creusen et al., 2010; Mugge & Schoormans, 2012a; 2012b; Mugge & Dahl, 2013). These studies concluded with the effects of certain factors (e.g., visual complexity, novelty) on consumers' responses (e.g., consumers' perception of product performance, usability, overall evaluation). These studies resulted in effective design principle for guiding designers in practice. However, it is still unknown how designers respond to these design strategies and how designers make use of them. As these design strategies are generated for supporting designers, it is important to know designers' insights on them. Understanding designers' insights can help us to further validate the usefulness of proposed design strategies. Furthermore, through learning how designers make use of design strategies, we can specify the concrete ways to achieve them, which are particularly helpful for junior designers and design students. In this chapter, Study 2 contributes to this line of research by interviewing experienced designers. Through the designer interviews, the usefulness of design principle 'complexity in simplicity' is further validated. The concrete ways to achieve this design principle are also specified.

Limitation and Future research

In this chapter, we explore the value of visual complexity and demonstrate the congruence between a visually complex appearance and the innovative functionality of RNPs. The results suggest that while designing, designers can consider manipulating certain appearance attributes to trigger congruity between product appearance and the innovative functionality of RNPs. Thus far, visual complexity has been demonstrated to be congruent with the innovative functionality of RNPs. Additional appearance attributes could exist as well, such as the used materials, certain colors, and contrasts among different parts within the product appearance. For example, the innovative hair dryer from Dyson integrates the air multiplier technology to provide powerful and stable airflow, sensors to measure the temperature of the hair and a microprocessor to give suggestions on the optimal temperature. It allows for a fast hair drying without damaging the hair. The product design uses a geometric appearance and metallic surfaces, to convey a high-tech feeling, which together creates an expectation of a highly innovative functionality provided by the product (see Figure 3.6). Future research can investigate the different appearance attributes that are congruent with innovative functionality of RNPs.

Figure 3.6 Product example of Dyson hairdryer

A limitation of this chapter is that we focused on RNPs that belonged to a specific category. Thus, a prototype of the product category is already established. To avoid the influence of typicality, we controlled the typicality of all the stimuli. As a result, our results apply for the cases where a product category prototype is already established and increasing visual complexity can thus be helpful. Future research can investigate the joint effects of novelty and visual complexity, to uncover the influence of increasing both factors on consumers' comprehension of RNPs. Furthermore, future research can investigate the effects of visual complexity on RNPs that do not belong to a specific category.

Chapter 4 Transparency in Product Innovations: Investigating Design Intentions and Consumers' Interpretations

This chapter focuses on investigating the attribute of transparency in product innovations to address the following research question: *'How can designers make use of transparency in product innovations to facilitate consumers' comprehension of RNPs?'* The unique characteristic of transparency lies in creating additional communicative possibilities. Compared to other factors of product appearances, transparency reveals additional information on the parts situated under the product covers. While designing their products, designers intend to convey different information by highlighting or hiding certain parts (Crilly, 2011b). Accordingly, using transparency can be a direct way to highlight the internal components of a product. Depending on the context (e.g., product category, stage in product life cycle, which parts are exposed), revealing additional information can trigger different consumer responses.

When transparency is used in RNPs, the innovative functionality can be exposed. Directly exposing the innovative functionality may lead to consumers' enhanced comprehension of a RNP. As illustrated in Section 2.4.2, to introduce the innovative functionality of dual-cyclone technology, the Dyson vacuum cleaner uses a transparent body to expose the internal space where the airflow twists and sucks dust. When encountering this vacuum cleaner, consumers can see through the transparent body and notice the internal space, which is likely to help consumers' comprehension of the innovative functionality of this vacuum cleaner.

In addition to communicating the innovative functionality of RNPs, transparency can create other possibilities. One of the most famous examples concerning the use of transparency in product innovations is the launch of the Apple iMac G3 in 1998. With its glossy translucent appearance, the Apple iMac G3 created a distinct style (Person & Snelders, 2010) by exposing technical details hidden underneath the product cover. At that time, people felt that Silicon Valley technologies were mysterious. The transparent cover of the Apple iMac G3 thus enabled people to see technical details they wished to discover under the product cover (Coates, 2003). As a result, consumers faced a completely new experience: they considered the Apple iMac G3 not as a cold office device but as a friendly and modern household product (Dell'Era et al., 2011).

To date, there has been a research gap in the study of transparency in product innovations. In the context of RNPs, it remains unknown whether the involvement of transparency

can explain an innovative functionality and subsequently enhance consumers' comprehension, and if so whether this communication of innovative functionality through transparency differs across product categories. For which product categories can the usage of transparency effectively enhance consumers' comprehension of RNPs? In addition to using transparency to explain the innovative functionality of RNPs, the other possibilities that transparency can create in product innovations remain unexplored. Current studies pay limited attention to the specific investigation of transparency. Several studies focusing on materials and design intentions provide fragmented insights into transparency. Karana et al. (2009) found that as one kind of material property, transparency is related to the symbolic meanings of sexiness. Lockton et al. (2010) suggested that transparency can draw consumers' attention to and influence their perception of product effectiveness. Although these studies shed light on the possible effects of transparency, there is a need for an overview of its many possibilities.

Therefore, the present investigation of transparency helps to fulfil the following goals: 1) investigate how transparency is used to communicate the innovative functionality of RNPs and whether it can enhance consumers' comprehension of RNPs and 2) generate an overview of the different possibilities of transparency in product innovations. The investigation of transparency combines both research goals by giving an overview of the different possibilities of transparency. With this overview, it is easy to learn whether and how transparency can be used to enhance consumers' comprehension of RNPs. Two studies are conducted in this chapter. Study 3 aims to explore designers' intentions for using transparency in product innovations, including whether and how designers make use of transparency to facilitate consumers' comprehension of RNPs. Study 4 attempts to validate the findings of Study 3 by examining how consumers interpret transparency in product innovations.

4.1 Transparency in Product Innovations Considering the Design as Communication Framework

To gain an overview of the different possibilities created by transparency, it can be insightful to explore what designers intend to convey through transparency. Prior research concluded that designers have different intentions while designing product appearances, such as facilitating consumers' comprehension of product functionalities, assisting consumers' classification of product categories and triggering consumers' emotional responses (Crilly et al., 2009). Designers may hold different intentions that may differ in

prominence. To fulfil their intention(s), designers use different attributes (e.g., shape, material, colour). In other words, the use of different attributes in product appearances can be seen as a medium for realising design intentions. Following this, using transparency in product innovations can be considered a medium for achieving certain design intentions. Thus, exploring underlying design intentions can help us to obtain an overview of the different possibilities of transparency.

However, to obtain this overview, it is insufficient to simply investigate design intentions to use transparency in product innovations, as these intentions may not be fulfilled. Original design intentions aim at triggering certain consumer responses (Crilly et al., 2009). Yet, consumers may not respond to product innovations in the ways intended by designers (Crilly et al., 2008). Specifically, although designers may intend to use transparency in RNPs to help consumers' comprehension, the enhancement of that comprehension depends on whether consumers notice the internal components exposed by transparency, process them and subsequently comprehend them.

Studies have empirically compared design intentions and consumers' interpretations in different contexts. Their results have revealed that design intentions are not necessarily fulfilled. For example, in the context of package designs, designers were asked to design packages with the intention of expressing certain tastes. Consumers were then asked to relate tastes and packages (Smets & Overbeeke, 1995). The results revealed that consumers could link 75% of the package designs with the corresponding tastes as intended by designers. In the context of product innovations, designers were asked to design products with certain characteristics and create corresponding mood boards reflecting these characteristics for each product. Next, consumers were asked to connect products and corresponding mood boards. The results showed that consumers were able to relate products and mood boards in the way intended by designers for only one out of five products (Ahmed & Boelskifte, 2006). The difficulty in fulfilling design intentions can result from differences between designers and consumers (Blijlevens et al., 2009; Hsu et al., 2000). When encountering the same product appearances, designers and consumers form different perceptions: designers detect more differences in product appearances and use more concrete words to describe their perceptions than consumers do.

Therefore, due to the possible differences between design intentions and consumers' interpretations, it is interesting to explore consumers' interpretations of transparency in product innovations. This exploration can validate design intentions to use transparency, resulting in an overview of the effective uses of transparency in product innovations. Two

studies were conducted. In Study 3, experienced designers were interviewed to discuss the underlying design intentions when using transparency in selected product innovations. Product promotion materials were also analysed to validate the findings of the design interviews. Subsequently, in Study 4, consumer interviews were conducted to explore how consumers interpreted transparency in product innovations. The data collected from the consumer interviews were analysed by comparing different design intentions. In this way, the overview of the possibilities created by transparency could be validated and help us learn whether and how designers intend to use transparency to facilitate consumers' comprehension of RNPs.

4.2 Study 3: Design Intentions to Use Transparency in Product Innovations

Design intentions can be learned by asking designers and through marketing materials, including product descriptions, advertisements and product manuals (Da Silva et al., 2015). To learn about the underlying design intentions to use transparency in product innovations, we collected information from both sources. First, to gain a comprehensive overview covering the different possibilities created by transparency, a large set of diverse product examples was collected. Due to the large number of collected product examples, it was difficult to directly interview each designer about his/her actual design intentions. Hence, we decided to interview experienced designers about the design intentions that they anticipated based on the product appearance. Although the identified design intentions were anticipated rather than actual, they were representative of actual intentions. Indeed, experienced designers were able to identify the underlying design intentions for different products due to their expertise in inferring the underlying design intentions for other products developed through practice. Furthermore, to validate the anticipated design intentions found from designer interviews, additional analyses were conducted by collecting and analysing product descriptions from marketing materials that were related to the actual design intentions. Throughout this chapter, the expression 'design intention(s)' refers to anticipated design intention(s).

4.2.1 Method

Participants

In-depth interviews were conducted with six experienced industrial designers. Participants were collected through personal contacts. Seven potential candidates were contacted and six of them took part in this study. One participant did not join the study due to schedule incompatibility. These participants were contacted because of their practical experience

and the excellent quality of their design works. They had designed products for many years, mainly focusing on designing consumer durables (see Table 4.1 for details), such as consumer electronics, automotive, furniture and medical devices. Moreover, they had won international design prize(s) (e.g., RedDot, iF) for their design work(s). Therefore, they were qualified to identify the different design intentions in product innovations. Due to their expertise, they were equipped with the knowledge to explain how and why transparency was used to fulfil certain intentions. Furthermore, the participants had different cultural background, including Chinese, Korean, Mexican, Indian, and Lebanese. At the moment when the study was conducted, they based in Hong Kong. The diversity in cultural background guaranteed the generalizability of results.

Table 4.1. Detailed information of participants in Study 3.

	Work Experience	**Expertise**	**Clients/Employers**
Participant 1	19 yrs	Consumer electronics, Automotive.	General Motors, Ford Motor, Philips Design, TCL and Tonly Electronics, etc.
Participant 2	23 yrs	Furniture, household products.	Siemens, Cassina, etc.
Participant 3	27 yrs	Consumer electronics, household products, furniture.	Philips, HP, Alessi, Huawei, Suzuki, Samsung, etc.
Participant 4	18 yrs	Furniture, household products, medical devices, consumer electronics.	Mercedes-Benz, Hansen, Grohe, etc.
Participant 5	13 yrs	Furniture, transportation, household products, consumer electronics.	Coolpad, ZTE, etc.
Participant 6	12 yrs	Consumer electronics, household products, medical devices.	Electrolux, Philips, Shell, etc.

Stimuli

Stimuli materials were collected from the product categories of consumer durables. We first collected products and concepts that were partly or fully made of transparent or translucent materials. As a result, more than 100 products and concepts were collected through an extensive Internet search using the keywords 'transparency', 'transparent', 'transparent products', 'translucent' and 'translucent products'. To ensure coverage of the full range of possible intentions to use transparency, we selected products and concepts from different product categories, such as kitchen appliances, furniture and consumer electronics. To obtain a practical number of stimuli materials for the designer interviews, we excluded some products and concepts that were very similar in appearance and where transparency was used for similar products and parts. For each product category, we selected the most well-known products or brands. Consequently, 32 products were included as final stimuli. These products covered different categories and differed in their levels of innovativeness. Stimuli were presented as A5 size cards in portrait orientation, with the product picture(s) in colour and the name of the product category. The picture(s) of the products were standardised in size (11 by 12.5 centimetres) and in resolution (300 dots per inch [dpi]). The brand logo was digitally removed. If a product example was very innovative and potentially unfamiliar to participants, key features were listed. Appendix C presents the stimuli used in this study.

Procedure

Participants were invited to the laboratory individually. When they arrived, they were first informed about the aim and procedure of the interview and asked permission to record and photograph. Next, the interviews started with the following warm-up question: *'When designing, when would you consider using transparent materials in product innovation?'* With further probing questions, participants were encouraged to talk about the various purposes and intentions to use transparency. Subsequently, participants were asked to perform a categorisation task. They were asked to classify the 32 stimuli into different groups based on design intentions to use transparency. Stimuli were presented in a random order. Participants were asked to think aloud while categorising. Specifically, they were told the following: *'All of these examples involve transparent/opaque materials. Based on your understanding, what do you think designers intend to express by using transparent/opaque materials in these examples? Could you categorise them based on different intentions?'* They were free to choose the numbers of groups and stimuli in each group (Handel & Imai, 1972). The goal of this categorisation task was to sort the

stimuli into different groups according to mutual similarities and differences considering the intention to use transparency in stimuli products. As the usage of transparency in product innovations can result from a combination of multiple design intentions (Crilly et al., 2009), a categorisation task can help participants distinguish the underlying design intentions and determine the prominence of each design intention. While completing the categorisation, the participants were asked to label each category with an explicit name that illustrated the design intention. They were also required to explain the name and to clarify why certain stimuli belonged to the same group. For each group, they were asked to explain the following: *'Why are the transparent materials used here? What intentions do the designers want to express?'* The final categorisations were photographed. After the categorisation task, the participants were asked to cite other interesting examples that used transparency in product innovations driven by design intentions that were not mentioned here. No other product examples were mentioned, and all of the participants indicated that the selected examples were sufficient to cover the various design intentions to use transparency in product innovations. Interviews lasted between 45 and 115 minutes.

Data Processing

All of the interviews were fully transcribed. Content analysis was conducted using the Atlas.it software. Due to the explorative purpose of this study, data were processed inductively. The interviews were coded for patterns and themes in the data directly (Thomas, 2006). This coding process was conducted interview by interview, which resulted in approximately 80 codes initially. The codes that were not directly related to our research goals were removed from further analyses. For instance, the code 'personal choice' was removed from further analyses because it was not directly related to specific design intention for triggering certain consumer responses. Then, the remaining codes were further compared and codes with similar meanings were merged. For instance, the codes 'fresh' and 'clean' were merged into the code 'symbolic meanings', which encompassed different meanings symbolically related to a product (e.g., expensive, playful, friendly; Creusen & Schoormans, 2005). Moreover, codes that shared the same meanings were grouped into a single theme. Finally, this process resulted in 11 codes distributed over five themes that were directly related to design intentions to use transparency in product innovations. The point of saturation was reached after the third interview and coding the remaining interviews did not reveal any significant new themes. The coding was checked by two researchers who were unaware of the research goals of the study. Table 4.10 presents an overview of the final codes and themes.

4.2.2 Results

In general, the interviews ran smoothly. Regarding the categorisation task, participants had a few difficulties. For some of the examples, participants mentioned that they were uncertain about the underlying design intentions to use transparency. They considered them designers' personal choices or decisions made due to manufacturing availability. After some revisions and adjustments, participants were satisfied with the final categorisation. In terms of designers' opinions on transparency, participants clearly expressed their opinions on stimuli products. Participants mentioned that transparency was an attribute they used while designing product innovations. They also mentioned that the most prominent characteristic of transparency was the opportunity to see through the back of the product into its internal components. Participants especially highlighted that because using transparency increased manufacturing costs, there were often strong motivations to choose transparency.

The results of the categorisation task did not highly correspond. As participants were asked to categorise stimuli freely, they created various categorisations based on different rationales and used different wordings to label each category. For example, one participant categorised stimuli based on the degree of necessity of transparency (see Figure 4.1a). Thus, he labelled his three categories 'transparency was necessary', 'transparency was partly necessary' and 'transparency was not necessary'. In contrast, another participant made his categorisation based on aesthetic intention or functional intention (see Figure 4.1b). The stimuli products were classified into six groups with six labels (e.g., artist statement, physical operation). Some of the products were placed into two groups (e.g., No. 15), as the participant thought that the use of transparency was driven by two main intentions. Due to the different rationales used by the participants, the results of the categorisation task were not directly used for the analyses. Instead, the categorisation task was used as a tool to push participants to think reflectively and clarify their opinions. However, the insights provided during the categorisation task corresponded highly. The data analyses were mainly based on the participants' thoughts expressed during the categorisation task and the rationale for their categorisation.

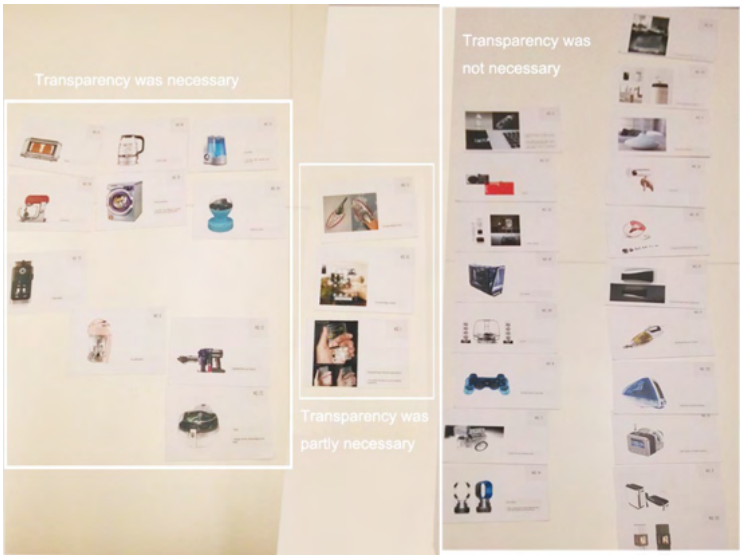


Figure 4.1a. Example of categorisation task made by one participant

Figure 4.1b. Example of categorisation task made by one participant

Five themes emerged from the content analysis: *facilitate consumers' comprehension, enrich visual appeal, enrich product experience, improve product usability* and *demonstrate product functionality*. The five themes were directly related to the different intentions of designers to use transparency in product innovations. The design intention '*facilitate consumers' comprehension'* was closely related to the main aim of this investigation: whether and how designers use transparency to communicate the innovative functionality of RNPs and further enhance consumers' comprehension. Furthermore, the five design intentions provided an overview of the use of transparency in product innovations. These intentions are explained in detail below.

Facilitate Consumers' Comprehension

The theme *'facilitate consumers' comprehension'* emerged from the data analysis. Participants mentioned that using transparency in product innovations was one way to facilitate consumers' comprehension of innovative functionality. Most of the participants (i.e., P2, P3, P4, P5, P6) mentioned that the involvement of transparency in product innovations could show the working process of the products, which can help consumers comprehend the innovative technology adopted in the products. One participant mentioned the following: *'When we are using transparent materials, the product itself will give us some idea of the function of the product we are talking about (P3)'*. Specifically, participants explained this design intention through product examples, such as the Dyson Vacuum Cleaner (No. 12) (see Figure 4.2a), '*By looking at this area, you know what is happening inside… The dust is collected here… We can say that to some extent, by seeing it, users can understand (P4)*', and the Tefal ActiFryer (No. 22) (see Figure 4.2b), *'Here, people can see what is going [on] inside, how it cooks… It helps people understand'*. In short, consumers may gain a better understanding of the products because they see the immediate results of the innovative technology, which helps them to grasp its benefits and features. In the example of the Dyson vacuum cleaner, consumers can directly see how the dust is sucked into the container and how both the airflow and dust twist inside it, which help them to understand the benefits of this innovative technology. In the example of the Tefal Actifyrer, consumers can see how the food gradually changes. In this situation, consumers cannot see how the innovative technology works, but they can see its results, which also helps them to comprehend its benefits. One participant mentioned the following: *'It also depends on the type of technology. Sometimes, if they use radiation, people cannot see it. Actually, hot air is a kind of radiation. But we see the immediate feedback, the result'*.

Figure 4.2a. Product example: Dyson vacuum cleaner (No. 12)

Figure 4.2b. Product example: Tefal ActiFryer (No. 22)

Participants further explained that the enhancement of consumers' comprehension could be triggered by seeing how the integrated technology worked. Specifically, to facilitate consumers' comprehension, rather than showing static content, the exposed

parts should communicate the dynamic working process of the innovative technology integrated in the RNPs. One participant mentioned the following: *'People can see what happens inside… Not just to see the content inside. People can see what is happening when it works'.* In the example of Dyson vacuum cleaner, the transparent cover indeed exposed the dynamic working process of its integrated technology. Through the transparent cover, consumers can observe how airflow twisted and how dusts gradually accumulated, which assist consumers' comprehension. Differently, although a transparent cover was also involved in the example of the humidifier (see Figure 4.3), consumers' comprehension is not likely to be enhanced because the transparency cover exposed the static content of water level changing.

Figure 4.3 Product example: humidifier (No. 13)

In addition, the enhancement of consumers' comprehension of RNPs may differ across product categories. For some product categories whose working process is comprehensible for consumers, participants considered that showing the working process could be helpful (e.g., Dyson vacuum cleaner, Tefal ActiFryer). By seeing the dynamic working process, consumers can learn how the innovative technology works, which may lead to enhanced comprehension. However, if the working process itself is incomprehensible for consumers, seeing the working process is not likely to assist consumers' comprehension of RNPs. For example, for consumer electronics (e.g., digital camera, classic PC), showing the working process may not be helpful for consumers' comprehension, as they may not understand how the integrated chips and sensors work. As a result, during the interviews, for the design intention '*facilitate consumers' comprehension'*, participants mentioned examples like the Dyson vacuum cleaner, Tefal ActiFryer and soy milk maker, but rarely mentioned the digital camera and the personal computer chassis.

Furthermore, the design intention '*facilitate consumers' comprehension*' was more prominent for RNPs with integrated innovative technology. Participants considered

the intention to use transparency together with the integrated functionality of a product innovation. As innovative technologies could challenge consumers' comprehension, participants highlighted the necessity of exposing the working process to assist consumers' comprehension of RNPs. In contrast, for product innovations that did not involve innovative technologies (e.g., INPs), although the working process could be exposed through transparency, participants considered that the choice of transparency was driven by different intentions, such as *'influence consumers' experience'* and *'improve product usability'* (see following sessions for detailed explanations of these design intentions). For example, one participant mentioned the following: *'This (Dyson vacuum cleaner, No. 12) is also showing its working process. But this is different from another example of vacuum cleaner (No. 11. See Figure 4.4) because this (No. 12) is a new technology. It demonstrates the technological process. This is more about how the internal filter works'.*

Figure 4.4 Product example: vacuum cleaner (No. 11)

Enrich Visual Appeal

Transparency can be used to enrich the appeal of a product innovation. By visual appeal, we mean the various visual factors related to the appearance of a product innovation, including the aesthetics and symbolic role of that appearance (Creusen & Schoormans, 2005). Designers often manipulate different factors to create aesthetically pleasing product appearances and convey different symbolic meanings. Correspondingly, participants mentioned using transparency to design aesthetically pleasing appearances and convey different symbolic meanings. Specifically, four different ways of using transparency to '*enrich visual appeal* ' were identified: create special visual effects, convey different symbolic meanings, improve visual complexity, and introduce a novel visual style.

First, transparency can create different special visual effects for product innovations. The physical property of letting light pass through surfaces is naturally shared by

water, ice, diamond and crystal, which create special visual effects. Thus, when transparency is used in product innovation, it copies these special effects of nature, which the participants considered as special visual effects, such as the effects of ice cubes and ocean-like creatures. Second, transparency can be used to convey certain symbolic meanings of products. As concluded by Creusen and Schoormans (2005), a product appearance can convey certain symbolic meanings by looking cheerful, friendly or playful. Participants mentioned the following symbolic meanings conveyed through transparency: clean, fresh, openness and light. Third, participants mentioned that transparency could improve the visual complexity of product appearances. As demonstrated in prior research, moderately improving the visual complexity of product appearances can make a product appearance aesthetically appealing (Berlyne, 1971). The use of transparency in product appearances can improve their visual complexity by creating contrasts between different parts and allowing internal parts to be visible. Fourth, transparency can create a novel look when it is rarely used in a product category. Designing product appearances that deviate from typical appearances in a product category can make a product look new. Thus, when transparency is rarely used in a product category, using transparency can create a novel-looking product innovation. The codes and corresponding quotes can be found in Table 4.2.

Table 4.2. Codes and quotes for the design intention *'enrich visual appeal'* by using transparency in product innovations

Code: Create special visual effects (mentioned by P1, P2, P3, P5, P6)
Corresponding quote: *'I have to say that if you have an image of the ice cube light, it directly mimics ice by using a transparent, very thick material, it looks like a box inside an ice cube (P5)'. (See Figure 4.5a)*
Code: Convey different symbolic meanings (mentioned by P1, P2, P3, P5, P6)
Corresponding quote: *'Imagine, if this part uses the same material as this part… then it would be heavier and look heavy for a portable handheld device. (I think designers added a transparent material) to make the product lighter (P1)'. (See Figure 4.5b)*
Code: Improve visual complexity (mentioned by P2, P3, P4)
Corresponding quote: *'This one uses transparency to break the monolithic look. Because if it is monolithic without any transparency, it is entirely white. It may not look good… To break [the] monolithic look… they used some transparent material to make it beautiful (P4)'. (See Figure 4.5c)*
Code: Introduce a novel visual style (mentioned by P2, P3)
Corresponding quote: *'I think it just looks cool… I think the intention is just to create it…*

because you have never seen a speaker that is completely transparent before. So it just looks cool. Especially at that time, because nobody has seen that before (P2)'. (See Figure 4.5d)

Figure 4.5a Product example: portable speaker (No. 9)

Figure 4.5b Product example: hairdryer (No. 31)

Figure 4.5c Product example: oil diffuser (No. 4)

Figure 4.5d Product example: sound (No. 30)

Enrich Product Experience

Another design intention to use transparency was '*enrich product experience*'. By using the term 'product experience', we refer to the consumers' subjective experience resulting from their interaction with a product (Hekkert & Schifferstein, 2008). Consumers' product experience is determined at the same time by the product, the consumer and the interaction between both. Following this, transparency can influence the product experience by influencing the product and influencing the interaction between product and consumer. Specifically, transparency can '*enrich product experience*' in three ways: it can enrich consumers' sensorial experience by appreciating the process, enrich consumers' sensorial experience by appreciating the inside and project an engaging experience. The quotes for this design intention can be found in Table 4.3.

Consumers' sensorial experience is an important source for the overall product experience (Desmet & Hekkert, 2007). How a product looks contributes to consumers' sensorial experience of the product. When transparency is involved in a

product innovation, the internal parts of a product innovation are exposed, which allows consumers to appreciate the process. For some product innovations, especially for kitchen appliances, observing how food is cooking can be pleasant, such as seeing how bread browns (No. 21) and how coffee drips drop by drop (No. 25). Compared with opaque exteriors, transparency creates the opportunity for consumers to observe and appreciate the process, which contributes to their sensorial experience. Furthermore, for some product innovations that are used for certain purposes, the usage of transparency can create one more channel of sensorial experience by offering an appreciation of the inside. For example, a transparent cover exposes the fire inside a stove. When consumers see it, they can feel warm. In other words, in addition to feeling warm in terms of physical temperature, seeing the fire makes consumers feel warm psychologically. In this way, transparency enriches consumers' experience of the stove by exposing the fire inside.

In addition, transparency can create a more engaging experience for consumers. The psychological distance between consumers and product innovations can decrease when they see a product's internal components. When consumers can see the internal components inside a product innovation, they may feel more involved. In this study, the participants mentioned that exposing internal components in a product innovation intended to make the product-consumer interaction more engaging, which further led to a rich product experience. One participant offered the following explanation: *'The product stands between a user and a client… If you want to erase the barrier, if you want the person to see inside… then you use transparent materials. Users can become more involved, or at least more informed if nothing else, about the product itself. Transparency is more inviting (P6)'*. The increased engaged experience created by transparency is also related to sensorial experience and improved product usability. However, as Desmet and Hekkert (2007) suggested, sensorial experience is an important part in product experience and product usability is considered a source of product experience. Therefore, we separated 'project an engaging product experience' as an independent code to highlight the ultimate results of involving transparency in product innovations.

Table 4.3. Codes and quotes for the design intention *'enrich product experience'*

Code: Enrich consumers' sensorial experience by appreciating the process (mentioned by P1, P3, P5)
Corresponding quote: *'Some designers like to highlight the process… For instance, the coffee dripper—in the old days we didn't see its internal parts and even the working process of coffee machines, it was like a black box. Ultimately, the goal of this range product is for you to enjoy the process (P3)'. (See Figure 4.6a)*
Code: Enrich consumers' sensorial experience by appreciating the inside content (mentioned by P3, P5, P6)
Corresponding quote: *'They show the nature of the product itself. You know some products related to power, to air, to greenness, to warmth, the relations need to be seen… These are more about the meaning of the products themselves (P5)'. (See Figure 4.6b)*
Code: Project an engaging product experience (mentioned by P1, P3, P5, P6)
Corresponding quote: *'The product interacts more with users, in a much deeper way in a sense. Like this (toaster), if it does not look like this, you put the bread in, press the button and you get it out. But this one gives you immediate feedback; they improve your user experience (P3)'. (See Figure 4.6c)*

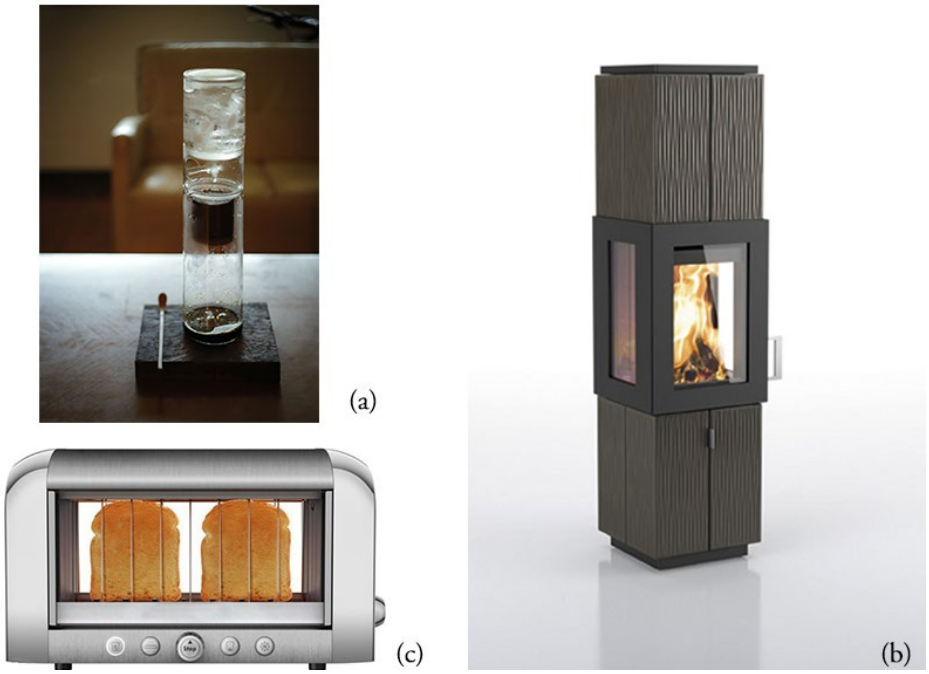


Figure 4.6a Product Example: coffee dripper (No.25)

Figure 4.6b Product Example: stove (No.20)

Figure 4.6c Product Example: toaster (No.21)

'Improve product usability' was identified as another design intention to use transparency in product innovations. Product usability is determined by the effectiveness and efficiency of a product to achieve a goal and by consumers' satisfaction with using the product to achieve a goal (Jordan, 1998). When transparency is used in product innovations, it can communicate information related to the product operation, which can contribute to the efficiency of using a product and to consumers' satisfaction. Specifically, transparency can communicate three types of information: 1) *communication of the product's operation mode*, 2) *communication of immediate feedback regarding the product's operation* and 3) *communication of the outcome of the product's operation*. By communicating these three types of information, participants expected the products to be more usable and interactive. Regarding the communication of the product's operation mode, the underlying design intention was to inform consumers about whether the product was working and whether the product was working normally. Another design intention was to communicate immediate feedback regarding the product's operation, including how much of the task was completed, and to provide suggestions on how to further operate the product. Furthermore, once a product innovation completed its work, transparency could be used to communicate the outcome of the product operation, such as the amount of dust collected by the vacuum cleaner (No. 11) and the amount of coffee made by the coffee maker (No. 29) (see Table 4.4 for codes and corresponding quotes).

Figure 4.7a Product example: washing machine (No. 18)

Figure 4.7b Product concept example: iron (No. 5)

Table 4.4. Codes and quotes for the design intention *'improve product usability'*

Code: Communicate operative information (mentioned by P1, P3, P4, P5, P6)
Corresponding quote: *'It tells you that "I am working, I am implementing the process" (P4)'. (See Figure 4.7a)*

Code: Provide immediate feedback (mentioned by P1, P2, P3, P4, P5, P6)
Corresponding quote: *'You get information. When you iron, you may get some wrinkles. If you iron again, it makes it even worse. With this product, you can improve the ironing process. You have better control over the whole process (P5)'. (See Figure 4.7b)*
Code: Show operative outcomes (mentioned by P1, P2, P3, P5)
Corresponding quote: *'We need users to see through what is being operated… Transparency has a single function, showing the result of the operation (P3)'. (See Figure 4.4)*

Demonstrate Product Functionality

Furthermore, participants indicated that transparency could be used to *'demonstrate product functionality'* by showing the effectiveness of the adopted technology. As transparent parts generally expose internal components to consumers, companies need to devote additional effort and money to the design of internal components to make them look organised and attractive to consumers. As a result, participants considered these products as high-end products. Thus, exposing internal components by using transparency became a way for companies to demonstrate their technological abilities. One participant mentioned the following: *'This is their strategy [to show the internal structure]… All of the vacuum cleaner manufacturers would like people to see it, because it is expensive. If you want people to look inside, it means that the internal components need to look beautiful'.*

Specifically, two kinds of product functionality demonstrations were identified (see Table 4.5). When the adopted technology was very innovative (e.g., RNPs), transparency was used to highlight the innovative technology and thereby communicate the product's powerful functionality. When the technology was a common one (e.g., INPs), using transparency improved the novelty of the product appearance and indicated that some improvements had been made to this product. As consumers tend to relate a novel-looking product innovation to an integrated innovative technology (Mugge & Schoormans, 2012a), consumers may perceive a product using transparency as an innovative technology. However, when transparency is widely used in a product category, consumers may relate the usage of transparency to neither novelty nor integrated innovative technology.

Table 4.5 Codes and quotes for the design intention *'demonstrate product functionality'*

Code: Demonstrate innovative technology (mentioned by P1, P2, P3, P4, P5, P6)
Corresponding quote: *'Ultraviolet light to kill bacteria, especially bacteria in the water. Can you*

see the ultraviolet light? Some new technology has been applied… The product highlights this new technology (No. 14; P5)'. (See Figure 4.8a)
Code: Demonstrate updated version of current technology (mentioned by P4, P5)
Corresponding quote: *'[They] try to show some novelty. They try to show their technology, but actually transparency doesn't really have a functionality here (P5)'. (See Figure 4.8b)*

Figure 4.8a. Product example: Dyson humidifier (No. 14)

Figure 4.8b. Product example: wireless game controller (No. 8)

4.2.3 Additional Analyses of Design Intentions through Marketing Materials

In Study 3, design intentions were collected through interviews with experienced designers. Although these designers had the expertise to explain underlying design intentions, these design intentions remained anticipated rather than actual. Aware of the possible differences between anticipated and actual design intentions, we conducted additional analyses to explore the actual design intentions of actual designers, to validate the findings of the interviews with experienced designers.

We collected this information from the official websites of these products. For 16 (of 32) product innovations, information related to actual design intentions to use transparency was collected, but little information was collected for the others. Based on the collected descriptions, content analysis was conducted to identify and analyse the actual design intentions to use transparency. As a result, several actual design

intentions were identified. The results were checked by one researcher who was unaware of the research goal. The results showed that the actual design intentions corresponded to the design intentions anticipated in Study 3. Appendix D provides a table summarising the identified design intentions and their correspondence to design intentions found in the designer interviews.

4.2.4 Discussion of Study 3

Through interviews with experienced designers in Study 3, two research aims are fulfilled. In terms of facilitating consumers' comprehension of RNPs, the results show that designers intend to use transparency to communicate innovative functionalities. Designers highlighted that the exposed parts through transparency should communicate the dynamic working process of the integrated technology in order to assist consumers' comprehension of RNPs. This intention is more prominent in RNPs with integrated innovative technology that consumers have difficulty comprehending. For INPs that are comprehensible for consumers, transparency is prominently used to fulfil other intentions. Moreover, the intention of facilitating consumers' comprehension is more relevant for RNPs whose working process is comprehensible for consumers. Consequently, for some product categories whose working process is comprehensible for consumers (e.g., kitchen appliances, household appliances), the usage of transparency can facilitate consumers' comprehension. In contrast, for product categories whose working process is incomprehensible for consumers (e.g., consumer electronics), designers do not consider that transparency helps consumers' comprehension, as sensors and chips are incomprehensible to most consumers.

Furthermore, regarding the overview of the different design intentions for using transparency in product innovations, five different design intentions are identified: *facilitate consumers' comprehension, enrich visual appeal, enrich product experience, improve product usability* and *demonstrate product functionality*. For each design intention, each code specifies concrete ways to achieve the design intention. This overview can inform designers of the different possibilities created by transparency. Although five design intentions are identified, they are not necessarily mutually exclusive. In fact, while designing, designers may have different design intentions that are interrelated and overlapping (Crilly et al., 2009). Similarly, designers may have different intentions while using transparency, but these intentions may differ from one another in terms of prominence. While one prominent design intention is used, other design intentions can also be covered. For instance, in the example of the Tefal ActiFryer (No. 22), while driven by the design intention *'facilitate consumers' comprehension'*, the transparent

lid is used to reveal the working process of the product. The transparent lid also simultaneously communicates information about product operation, which is related to the design intention *'improve product usability'*.

A designer's prominent design intention is often influenced by the product category. For kitchen appliances (e.g., No. 28, kitchen machine), the design intention *'improve product usability'* may be more prominent, as consumers need to know the immediate situation of the food to cook conveniently. However, for some products (e.g., No. 24, coffee dripper), the design intention *'enrich consumers' experience'* may be more important, as the meanings of these products are not only limited to satisfying certain practical purposes (e.g., having a cup of coffee to drink), but also lie in enjoying the experience of making coffee. For furniture (i.e. No. 17, 20, 32), the prominent design intention is to *'enrich visual appeal'*, as furniture is often selected based on high aesthetic value. Other intentions mentioned include *'enrich product experience'* and *'improve product usability'*.

4.3 Study 4: Consumers' Interpretations of Transparency in Product Innovations

Study 3 demonstrates that designers use transparency while designing RNPs to facilitate consumers' comprehension. The results of Study 3 also generate an overview of the different possibilities created by transparency in product innovations. However, as demonstrated in previous studies (Ahmed & Boelskifte, 2006; Hsu et al., 2000), design intentions may not be fulfilled due to differences between consumers and designers. While interpreting transparency in a product innovation, consumers may not process it the way designers intended, resulting in differences between design intentions and consumers' interpretations. Therefore, it is necessary to investigate consumers' interpretations to validate the findings of Study 3. In Study 4, we aimed to investigate how consumers interpreted transparency in product innovations and uncover whether they interpreted product innovations as intended by designers.

4.3.1 Method

Participants

In-depth interviews were conducted with consumers in a big city in China. Thirteen consumers were recruited (six male participants, ranging in age from 25 to 52 with a mean age of 34). None of the participants had a product-design-related background. All the collected participants were Chinese. This group of participants were recruited due to the convenient accessibility. Chinese is native language for both the author and the participants, which guaranteed the diversity and accuracy of collected information

during interviews. These participants were collected through personal contacts. First, they were informed that the interview was being conducted for academic research purposes and that its aim was to determine their opinions on consumer durables. Next, they were asked whether they were interested in participating and an appointment was made. All of the contacted participants joined the interviews. They received a gift for their participation.

Stimuli

To make the interview feasible for the participants, 16 product examples were selected as stimuli materials in Study 4 (see Appendix C). These stimuli were selected from the 32 stimuli used in Study 3. Based on the experienced designers' responses in Study 3, some product examples were excluded because the usage of transparency was considered a personal choice of designers or was initiated due to manufacturing possibilities, rather than driven by clear and strong design intentions. To cover different design intentions, the most typical product examples representing each design intention were selected. The selected product examples covered different product categories.

Procedure

Participants were invited to an enclosed and quiet environment. They were first informed about the aim and procedure of the interview. Next, they were asked permission to record and photograph. The interview was conducted in two parts. In the first part, participants were presented with 16 product examples one by one and were asked to talk about their general opinions and feelings towards these products. These product examples were presented in a random order. In the second part, participants were asked about their opinions and feelings towards these products one more time, with a specific focus on the transparent parts. Table 4.6 presents the interview questions and objectives of each question.

During the consumer interviews, we aimed at uncover how consumers interpreted transparency in product innovations, including whether they comprehended RNPs better and whether the other design intentions that were found in Study 3 were fulfilled. We did not directly check design intentions by directly asking whether consumers felt this way. Instead, we encouraged consumers to express their own opinions. Next, consumers' opinions were compared with design intentions. To do so, five questions were planned to encourage consumers to talk more about transparency. These questions were asked in a sequence of prompts from relatively open questions to concrete questions.

Table 4.6 Interview questions for consumer interviews in Study 4

Part 1	
Q1	*How do you feel about this product in general?*
Aim of Q1	Familiarise participants with the stimuli products. The product functions can be explained in detail, when necessary.
Q2	*What do you think about the design of this product?*
Aim of Q2	Encourage participants to focus on product innovation.
Part 2	
Q3	*How do you feel about the transparent parts in this product?*
Aim of Q3	Lead participants to focus on the transparent parts. Learn how participants interpret transparency.
Q4	*Why do you have such feelings?* *Probe: Could you think of several pros and cons of involving transparent parts in this product?*
Aim of Q4	Trigger consumers to talk more about transparent parts.
Aim of probe	Encourage participants to search for reasons why transparency contributes to their specific feelings.
Q5	*Why do you think designers use a transparent part here?*
Aim of Q5	Push participants to deduce why transparent parts are used in certain products.

4.3.2 Data Analysis

The interviews ran smoothly and lasted between 40 and 81 minutes. The 13 consumer interviews were fully transcribed and analysed using Atlas.it. Consumers' opinions related to the overall evaluation of the product examples were excluded from analysis, as the specific focus of this research was to understand their interpretations of transparency.

Study 4 sought to explore how consumers interpreted transparency in product innovations and whether design intentions were fulfilled. Thus, to assess the fulfilment of design intentions, the results from Study 3 were used as a coding framework to analyse the data from Study 4. Specifically, the 11 codes and five themes were used as coding schemes for data analyses in Study 4. Consumer' opinions on

transparency was firstly categorised as 1 of 11 codes. If certain quotes could not be classified into existing codes, new codes were added.

The coding scheme was checked for reliability using Cohen's kappa coefficient. Specifically, consumers' transcripts were analysed. Then, another researcher was invited to analyse the data adopting the same coding scheme. This researcher was not aware of the research goals. Consumers' quotes and coding scheme were first presented to the research. The description of each code and examples of consumers' quotes that fell into each code were also provided. Second, the results of the categorisation were compared with the categorisation made by the author, with a kappa coefficient of 0.92, suggesting a high inter-coder reliability.

4.3.3 Results and Discussion

In terms of consumers' interpretations of transparency, consumers' quotes were categorised in the coding scheme. For the code *'demonstrate updated version of technology'*, no consumer quotes could be assigned. As with the results from Study 3, the following session reports the correspondences between consumers' interpretations and design intentions for each theme.

Corresponding to 'Facilitate Consumers' Comprehension'

Consistent with the design intention *'facilitate consumers' comprehension'*, participants confirmed that they gained a better comprehension by seeing the product's working process through the transparent cover (see Figure 4.6b): *'It [No. 22] helps me understand the function, to some degree. It is very intuitive… If [a] salesman introduces this product to me, I understand it as soon as I see it'*. This finding indicates that participants were able to notice the additional information conveyed through transparency and to subsequently process the information.

Regarding how transparency helped their comprehension, the participants mentioned several reasons. First, they explained that seeing how the product worked was direct and intuitive, which helped them comprehend a RNP. For example, one participant said, *'Because the ActiFryer is new, someone may be confused about how to use air to fry food. Transparency can allow people to directly see how it fries food from raw to cooked using air (P4)'*. Second, participants showed curiosity for the integrated innovative technology in RNPs. Consumers' curiosity was satisfied by seeing what was going on underneath the transparent covers of product innovations. One participant expressed the following: *'The transparent cover allows you to see internal components… People are curious, they want to know what is inside (P10)'*. Third, participants showed some concern about the innovative

technology. They were concerned about safety. By seeing the internal components through the transparent cover, the participants felt relieved. As a result, they believed that the RNP was reliable. One participant offered the following explanation:

'The transparent cover makes me feel relieved. Because it is a fryer that uses a new technology… If it uses [an] opaque cover, as frying requires a very high temperature, I am worried that it will explode. I am not sure whether it is safe or not. By using [a] transparent [cover], I feel it is safe, I feel relieved'.

As with the design intention *'facilitate consumers' comprehension'*, the product examples that participants reported to understand better mainly focused on RNPs, such as the Tefal Actifryer, soy milk maker, coffee dripper and Dyson vacuum cleaner. For consumer electronics (e.g., wireless camera, No. 24), participants did not report a better comprehension. Instead, they felt it was disorganised; as one participant mentioned, *'It is messy inside (P13)'*.

Corresponding to 'Enrich Visual Appeal'

Corresponding to the design intention *'enrich visual appeal'*, participants expressed that transparency in product innovations could trigger special visual effects. Specifically, participants mentioned several effects, such as looking like an ice cube, an ocean or a crystal. With respect to symbolic meanings, participants associated transparency with different meanings, such as quiet, fresh, clean and light. Participants also mentioned that transparency was beautiful in general. Furthermore, participants expressed that for some product innovations, the involvement of transparency was novel and unique. Table 4.7 presents the consumer quotes and frequency.

In Study 3, designers intended to use transparency to *'improve visual complexity'* and make product appearances aesthetically appealing. In this study, the results revealed that participants felt that transparency was beautiful, but they could not clarify an underlying reason. The designers' expertise enabled them to explain specific ways to make products look aesthetically appealing. Ordinary consumers may not be equipped with the necessary background knowledge. Nevertheless, as consumers mentioned transparency was beautiful, the goal of designers was still fulfilled. Therefore, we considered the fulfilment of the design intention.

Table 4.7 Consumer quotes corresponding to each code for the design intention *'enrich product appeal'*

Code: Create special visual effects (mentioned by P1, P2, P4, P5, P7, P12, P13)
Corresponding quote: *'This product makes me think of an ice cube. Making a speaker look*

like an ice cube is cool (P2)'. (Mini speaker)
Code: Convey different symbolic meanings (mentioned by P1, P2, P3, P4, P5, P6, P7, P9, P10, P11, P12, P13)
Corresponding quote: *'This transparent part makes me feel that the product is not that heavy (P1)'. (Hair dryer)*
Code: Improve visual complexity (mentioned by P1, P2, P3, P6, P7, P9, P10, P11, P12, P13)
Corresponding quote: *'I feel that transparent things are pretty (P1)'. (No. 10)*
Code: Introduce a novel visual style (mentioned by P1, P3, P5, P6, P7, P11, P12)
Corresponding quote: *'This one is different from other [kettles]. Others are made from ceramics or metal… (P1)'. (Kettle, No. 19)*

Corresponding to 'Enrich Product Experience'

Corresponding to the design intention '*enrich product experience*', the participants reported their experiences with transparency in product innovations. Participants mentioned that transparency created an engaging product experience. They mentioned that the distance between the product and themselves decreased. As one participant expressed, *'The transparency makes me feel closer to the product. I even feel that the product is easier to use (P2)'*. Moreover, participants reported that transparency allowed them to observe and enjoy the process of using certain products (e.g., kettle, coffee dripper, fryer, soy milk maker). Participants also reported that transparency created a visual channel for their sensorial experience, such as seeing ice in the ice-coffee dripper and seeing fire in the stove. Table 4.8 presents concrete quotes and frequency.

Table 4.8 Consumer quotes corresponding to each code for the design intention *'enrich product experience'*

Code: Project an engaging product experience (mentioned by P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12)
Corresponding quote: *'It [ordinary coffee maker] feels like a black box. I only know I should put coffee beans or [a] capsule inside and coffee will come out automatically… This coffee maker makes me see the whole process very clearly… I have a strong feeling of engagement (P2)'. (No. 25, coffee dripper)*
Code: Enrich consumers' sensorial experience by appreciating the process

(mentioned by P1, P2, P4, P5, P10, P14)
Corresponding quote: *'I feel this shows the process of making coffee, to see how coffee is made… It is very enjoyable (P7)'. (No. 25, coffee dripper)*
Code: Enrich consumers' sensorial experience by appreciating the inside content (mentioned by P2, P4, P5, P6, P7, P9, P10, P11)
Corresponding quote: *'Through the transparent cover, we can directly see the fire in the stove. It feels warm. As a stove is used for heating… in a sense, seeing the fire inside feels warm (P4)'. (Stove)*

Corresponding to 'Improve Product Usability'

Regarding the design intention *'improve product usability'*, the participants responded in the way designers expected. Participants mentioned that transparency allowed them to see the immediate situation, the outcomes of the product operation and the operative mode of the products (see Table 4.9 for consumers' quotes).

Table 4.9 Consumer quotes corresponding to each code for the design intention *'improve product usability'*

Code: Provide immediate feedback (mentioned by P1, P2, P6, P7, P8, P9, P10, P11, P12, P13)
Corresponding quote: *'The transparent one is good… If soy milk is too heavy, you can immediately turn it off. You can always observe the immediate situation inside (See Figure 4.9) (P7)'.*
Code: Communicate operative mode (mentioned by P2, P6, P8)
Corresponding quote: *'Many washing machine doors are transparent. You can see how it washes, whether it is spinning, whether it performs well. This is reminding information. For instance, if I press the on-button but it does not start working, then I know it is broken or something is wrong (P2)'.*
Code: Show the outcomes of using product (mentioned by P1, P2, P4, P5, P6, P7, P9, P10, P11, P12, P13)
Corresponding quote: *'It sucks dust into the box. How much dust is collected can be seen*

easily (P4)'.

Figure 4.9 Product example: soy milk maker (No. 6)

Corresponding to 'Demonstrate Product Functionality'

Corresponding to the design intention *'demonstrate product functionality'*, the participants reported that products with transparency performed better. Consumers inferred the improved performance according to two reasons. First, the exposure of internal components allowed consumers to assess the quality of the products, as mentioned in the case of the soy milk maker (No. 6) (see Figure 4.9): *'Look at this circle: there is one more layer under it, so the heating effect must be better. This layer looks solid and heavy, so this must be [a] medium or even a better soy milk maker'.*

Then, consumers' interpretation of effective product functionality resulted from their inferences from design intentions, as expressed by one participant: *'Using transparency in [a] new product suggests that their technological ability is one step forward, because they [manufacturers/designers] dare show new things to you'.* This participant considered the usage of transparency as a result of the designer's intentional choice. Subsequently, participants actively deduced why designers made such a choice. They concluded that if companies/designers dared to expose internal parts, the product performance must be innovative and effective.

Furthermore, consumers' quotes were assigned to the code *'demonstrate innovative technology'*. No quotes were categorised in the code *'demonstrate updated version of current*

technology'. This was caused by consumers' limited knowledge of integrated technology in product innovations. They were not able to evaluate whether the integrated technology was an innovative technology or merely an updated version of a current technology.

4.4 General Discussion

This chapter aims to investigate the use of transparency in product innovations. The two specific research goals are 1) to examine how to use transparency to communicate the innovative functionality of RNPs and 2) to provide an overview of possibilities created by transparency in product innovations. Two studies are conducted to achieve these research goals. Designer interviews in Study 3 provide an overview of possibilities intended by designers. However, to prevent possible differences between designers and consumers, this overview is further validated through customer interviews in Study 4.

The design intention *'facilitate consumers' comprehension'* emerges among the various design intentions to use transparency in product innovations, which indicates that designers consider using transparency to communicate products' innovative functionalities and facilitate consumers' comprehension of RNPs. Designers also highlight that what is exposed through transparency should directly show the dynamic working process of an innovative technology and/or show the immediate results of an innovative technology. Through seeing how innovative technology works and/or observing the immediate results of innovative technology, consumers can gain comprehension of the innovative technology. Moreover, the exposed working process should be comprehensible for consumers. For some RNPs, showing the working process may help consumers' comprehension, as consumers can get clues by seeing the working process. In contrast, for other RNPs that are driven by sensors and chips (e.g., consumer electronics), showing the working process confuses consumers, for whom the working process is incomprehensible.

Furthermore, as intended by designers, consumers mention that they comprehend RNPs better when transparency is involved to show the working process of innovative technology. Consumers mention several reasons for this improved comprehension, such as seeing the working process intuitively and directly, satisfying their curiosity by seeing the working process and alleviating their concerns by seeing the working process.

In addition to the design intention *facilitate consumers' comprehension*, other design

intentions are found. Thus, this research results in an overview of possibilities created by transparency in product innovations: *facilitate consumers' comprehension, enrich visual appeal, enrich product experience, improve product usability,* and *demonstrate product functionality*. These design intentions are further validated by consumer interviews. This overview of design intentions explains the different uses created by transparency. Within each design intention, the specific codes also explain the concrete ways to achieve these intentions (see Table 4.10).

Table 4.10 The overview of design intentions to use transparency in product innovations

Design Intentions	**Specific Codes**
Facilitate consumers' comprehension	
Enrich visual appeal	
	Create special visual effects
	Convey different symbolic meanings
	Improve visual complexity
	Introduce a novel style
Enrich product experience	
	Project an engaging product experience
	Enrich consumers' sensorial experience by appreciating the process
	Enrich consumers' sensorial experience by appreciating the inside content
Improve product usability	
	Communicate operative mode
	Communicate immediate feedback
	Show outcomes of product performance
Demonstrate product functionality	
	Demonstrate updated version of current technology
	Demonstrate innovative technology

Theoretical Contributions

This research provides several theoretical contributions. First, it contributes to current studies investigating the usage of transparency to facilitate consumers' comprehension of RNPs. Research has conceptually suggested that product appearance can directly communicate the innovative functionality of RNPs (Eisenman, 2013). Product appearance can serve as a medium to convey information by highlighting or hiding

different parts of the products (Crilly, 2011b). This investigation contributes to these studies by specifying how transparency can communicate the innovative functionality and further enhance consumers' comprehension of RNPs.

Second, this study contributes to the current research by providing an overview of the possibilities created by transparency. Several studies have paid attention to various factors used by designers in product appearances, such as visual complexity (Creusen et al., 2010), novelty (Hekkert et al., 2003), and different product personality (Mugge, 2011). Nevertheless, transparency is one factor often used by designers that remains unexplored. This study fills this research gap by exploring the usage of transparency in product innovations, resulting in an overview of the possibilities.

Third, this study makes a methodological contribution by examining transparency in a distinct way. When investigating a factor of product appearance, studies have considered a specific factor and isolated it from design intentions (Creusen et al., 2010; Hekkert et al., 2003; Mugge, 2011). Moreover, these studies have investigated consumer responses to this objective factor. Their results have informed designers about how consumers respond to the objective factor. In contrast, to investigate transparency, this research takes into account both design intentions and consumers' interpretations. Rather than studying the perceptions and experiences promoted by transparency directly, this research first investigates the 'messages' intended by designers. It then validates design intentions involving transparency through consumers' interpretations. The results of this investigation offer more actionable, practical and direct information to designers (Crilly, 2011b).

Practical Implications

The results of this research can serve designers in practice in different ways. They inform designers in the process of designing RNPs that the use of transparency can communicate an innovative functionality, which can enhance consumers' comprehension of RNPs. Specifically, while using transparency in RNPs, designers need to carefully determine which parts should be exposed. As results demonstrate that consumers' enhanced comprehension is triggered by seeing the dynamic working process of RNPs, designers need to use transparency on the parts that reveal that working process, which should enable consumers to directly observe how the integrated technology works. For example, in the Tefal Actifryer, the transparent lid exposes the space where the food is fried by the airflow. Through the lid, consumers can see how the food is fried, from raw to cooked. When seeing this process, consumers subjectively understand how the innovative functionality works to fry food.

However, showing the working process through transparency may enhance consumers' comprehension of product innovations whose working process is comprehensible for consumers. For consumer electronics whose working process is incomprehensible for consumers, the exposure of internal components often confuses consumers.

The findings of this research should also help designers decide how to use transparency in product innovations. Associated with current toolkits for material selections (Karana et al., 2015), this overview can help designers determine whether and how to use transparency in product innovations. The codes for each intention provide information by specifying concrete ways to achieve each design intention. These insights can especially help junior designers and design students to find concrete ways to fulfil certain design intentions. These results can also help designers to better explain their choice of transparency to other stakeholders in product development teams. Designers can better articulate their intention(s) when using transparency and the prominence of different intentions.

Limitations and Future Research

There are different opportunities for future research to strengthen the findings of this research, which demonstrate that transparency helps to communicate innovative functionality and facilitate consumers' comprehension of RNPs. Consumers suggest several reasons for their enhanced understanding, such as seeing the working process directly, satisfying their curiosity by seeing the working process and alleviating their concerns about an innovative technology by seeing the working process. Although these reasons explain how transparency enhances consumers' comprehension of RNPs, they are based on different underlying mechanisms. For example, consumers' comprehension can be enhanced by seeing the working process due to information processing. Seeing the working process provides information about an innovative technology, leading to enhanced comprehension. Conversely, consumers also mention that satisfying their curiosity is one reason for their enhanced comprehension. Consumers may be curious about an innovative technology. Satisfying their curiosity by seeing the working process can generate extra pleasure, leading to enhanced comprehension. Future research may continue to investigate the underlying mechanisms through which transparency enhances consumers' comprehension of RNPs. Understanding which way(s) or combination(s) of ways trigger consumers' comprehension of RNPs can help designers to make use of transparency more effectively.

Moreover, this research uses product pictures as stimuli to investigate the influence of transparency on consumers' subjective comprehension. For future research, it may be interesting to use real products during the consumer interviews, which would allow consumers to operate the RNPs themselves. While the consumers operate the products, more information may be communicated through transparency. Specifically, instead of imagining the motion based on product pictures, consumers may actually see how things move underneath the product covers. In this way, results may reveal not only the influence of transparency on consumers' comprehension, but also how consumers learn to use RNPs. Using RNPs for the first time may challenge consumers, as they may not have relevant experiences. Thus, future research may investigate how transparency influences consumers' first usage of RNPs.

Furthermore, an overview of the possibilities created by transparency was generated through designer interviews in Study 3. To validate this overview, consumers' interpretations were analysed using the overview generated in Study 3 as the coding framework for Study 4. In other words, the validation was conducted at an overview level, rather than a product level. While analysing consumers' interpretations in Study 4, we compared consumers' opinions with the design intentions found in Study 3 and classified them into the design intentions. However, as this study aimed at generating an overview of transparency uses, we did not compare consumers' interpretations and design intentions for each stimuli product. Future research may conduct the comparison at the product level to provide evidence on the precise correspondence between design intentions and consumers' interpretations.

Chapter 5 Investigating the Influence of Product Metaphors on Consumers' Comprehension of RNPs

This chapter aims to investigating the influence of using product metaphors in RNPs on consumers' comprehension. A product metaphor connects two entities (Hekkert & Cila, 2015): a source (what a product/concept is normally used for) and a target (what is transferred into another product/concept). Product metaphors associate sources and targets physically and conceptually. On the conceptual level, the source and target share similar meanings. On the physical level, the physical aspect of the target resembles the source. When a product metaphor is used to embody a RNP, it links a source product or concept with the target RNP. In this way, when encountering RNPs with product metaphors, consumers are likely to recognise the source product or concept and to subsequently use the knowledge related to the source product to learn about the target RNP. In this process, the analogical learning process is likely to be triggered, which may lead to enhanced consumer comprehension of RNPs (Gregan-Paxton & John, 1997).

Prior research conceptually recognises the possibility of designing product metaphors to facilitate consumers' comprehension of RNPs (Hekkert & Cila, 2015). As outlined in section 2.4.3, product metaphors carry both potential and risks when influencing consumers' comprehension of RNPs. However, such potentials and risks remain conceptual. Specifically, it is still unknown whether consumers' comprehension of RNPs can be improved through the use of product metaphors, and if so, under what conditions the positive effects of product metaphors are triggered. It also remains unclear what risks are faced when involving product metaphors in RNPs and how to overcome such risks while using product metaphors in RNPs. Accordingly, it is necessary to empirically investigate the usage of product metaphors in RNPs. Our understanding may be enhanced by investigating how product metaphors influence consumers' comprehension of RNPs and the conditions in which the positive effects of product metaphors are triggered. This knowledge can help designers to make use of product metaphors in RNPs more effectively.

To do so, two studies are reported in this chapter. Through a controlled experiment, Study 5 demonstrates the interaction effects of the presence of product metaphors and textual clues on consumers' comprehension of RNPs. Next, through consumer interviews, Study 6 investigates how product metaphors influence consumers' comprehension of RNPs based on the three stages of analogical learning.

5.1 Study 5: Investigating the Potentials of Product Metaphor for Enhancing Consumers' Comprehension of RNPs

5.1.1 Hypothesis Building

Previous studies investigate the usage of visual metaphors in advertisements. These studies find multiple benefits of using visual metaphors, such as improving responses to advertisements (McQuarrie & Mick, 1996, 1999), triggering extensive ad processing (Toncar & Munch, 2001) and improving consumers' comprehension of advertisements (Phillipes, 2000). Consumers' cognitive elaboration triggers the positive effects of visual metaphors. As visual metaphors connect two different entities, consumers first need to understand how the two entities are related, which requires extra cognitive efforts. If consumers successfully identify the similarities between the two entities, the cognitive elaboration leads to enhanced consumers' appreciation. In contrast, the failure to recognise the similarities shared by both entities result in consumers' frustration. Consequently, consumers favour visual metaphors that require a moderate level of cognitive elaboration. Neither a straightforward nor a complicated visual metaphor is appreciated as the former is too easy to process while the latter goes beyond consumers' processing ability (Phillipes, 2000; Van Rompay & Veltkamp, 2014).

Product metaphors can be used to fulfil different purposes. While designing product metaphors, designers can opt for an experiential intention to trigger rich and meaningful product experiences, but also a pragmatic intention to provide clues for consumers' identification and product operation (Hekkert & Cila, 2015). When a product metaphor is driven by an experiential intention, such as visual metaphors, consumers' appreciation of a product metaphor depends on cognitive elaboration (Cila, Borsboom, & Hekkert, 2014). Thus, consumers appreciate product metaphors that are both identifiable and subtle, in which the source is identifiable but subtly hints at the similarities shared between source and target. Consumers need to identify how the source is related to the target product. If consumers successfully manage the task, their appreciation greatly improves. Therefore, designers often use the non-salient quality of a source to create a sophisticated and interesting product experience (Cila, Hekkert, & Visch, 2014a). For example, the humidifier involves the product metaphor of a whale (see Figure 5.1a). When seeing it, consumers can easily recognise a whale as the source product. Next, they need to understand that the humidifier produces an airflow at its top like a whale expelling air through its blowhole. If consumers successfully acknowledge this relation, they may gain enhanced appreciation.

Figure 5.1a Example of the product metaphor whale used for an experiential intention

Figure 5.1b Example of the product metaphor horn driven by a pragmatic intention

In contrast, when product metaphors are used with a pragmatic intention, designers often focus on the salient qualities of target products to make the product metaphors clear and recognisable for consumers (Cila, Hekkert, et al., 2014a). In other words, a straightforward product metaphor is better to fulfil a pragmatic intention, because it provides clear clues for consumers' identification on how to use a product. For example, the iPhone speaker involves the product metaphor of a horn (see Figure 5.1b). The usage of a horn intends to inform consumers that this product is used to play music and improve the sound of an iPhone. Thus, it involves the most salient quality of a horn, that of increasing volume. Therefore, when encountering the product, consumers can easily identify that this product is a music player for iPhones used to increase volume.

Furthermore, when product metaphors are used to embody RNPs, they may help consumers to learn and understand the unique and differentiating benefits of RNPs. The intention to facilitate consumers' learning of RNPs relates to a pragmatic intention because it seeks to inform consumers about the benefits of RNPs. Specifically, when a product metaphor is used in a RNP, it serves as a basis for facilitating consumers' learning about RNPs. In this process referred to as analogical learning, product metaphors help consumers retrieve existing knowledge and use it to understand RNPs. Current studies mainly focus on investigating how designers generate product metaphors (Cila, Hekkert, et al., 2014a; Cila, Hekkert, & Visch, 2014b) and on how product metaphors influence consumers' emotional responses (Lin & Cheng, 2014). However, limited research investigates the usage of product metaphors in RNPs. To explore how product metaphors influence consumers' comprehension of RNPs, the following section analyses how product metaphors influence each stage of analogical learning (i.e. access, mapping and transfer).

Access Stage

In the access stage, consumers are required to identify the source product or concept, which should subsequently activate the corresponding knowledge in the source domain (Gregan-Paxton & John, 1997). Associations between source and RNP are essentially integrated when RNPs are embodied through product metaphors (Hekkert & Cila, 2015). Specifically, for a RNP using a product metaphor, the appearance of the RNP physically resembles the source, which can help consumers identify the source domain. Prior research demonstrates that physical similarities between source and target can help consumers' identification. By looking at the physical signal, consumers can retrieve the source from their memory and then map and transfer the relevant knowledge (Forbus et al., 1993). Therefore, the physical association integrated in a product metaphor can further facilitate consumers' retrieval of sources in the access stage. In the example of the 'Mother' smart home system, when seeing the doll-shaped information terminal, consumers may think of the role of a mother at home (see Figure 5.2). This may activate the knowledge of the different roles of a mother at home, such as taking care of family members, her familiarity with home situations, etc. This knowledge can help consumers comprehend the innovative functionality of this smart home system.

Figure 5.2 Illustration of a product metaphor that triggers consumers' access to sources: the 'Mother' smart home system

However, the successful retrieval of a source by consumers depends on the identification of the correct source, as intended by its designers. In contrast, if a different source is accessed, a different knowledge base is activated, which will lead to consumers' confusion over the mapping of similarities and their failure to transfer the relevant knowledge. When analogical learning strategy is used in advertisements, the source is often clearly stated, such as assimilating a PDA to a secretary (Houssi et al., 2009). Conversely, when encountering a product metaphor, consumers need to identify the source by themselves. In this process, consumers may not identify the

source of RNPs as intended by designers, which thus hinders the analogical learning process. Specifically, as one kind of visual metaphor, a product metaphor allows for multiple interpretations (Black, 1979). When seeing a product metaphor, consumers may relate it to different sources, thereby thwarting consumers' precise identification of the source. In the example of 'Mother', consumers may link the product metaphor to multiple sources, such as a Russian doll, the cartoon character Barbamama and/or the role of a mother at home (see Figure 5.3). Consequently, when product metaphors allow for multiple interpretations, they can hinder consumers' accurate access to a specific source domain, resulting in reduced consumers' comprehension of RNPs.

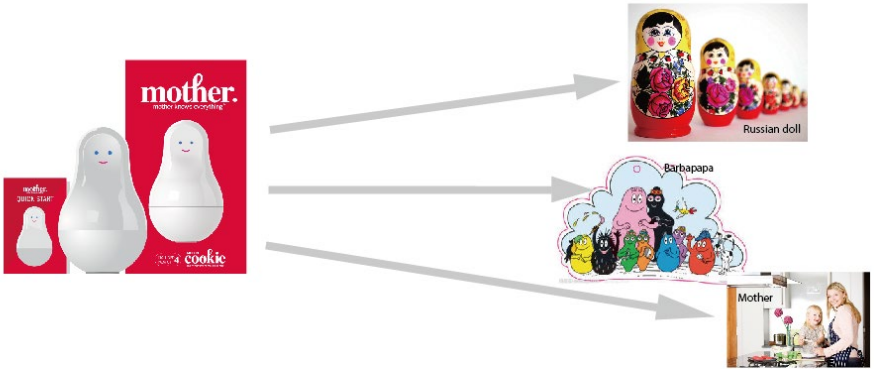


Figure 5.3 Illustration of the multiple interpretations of the 'Mother' smart home system

Mapping Stage

After a source domain is successfully activated, the mapping stage follows, in which consumers need to align the source and target RNP. Specifically, consumers are required to identify one-to-one correspondences between sources and target RNPs (Gregan-Paxton & John, 1997). Such correspondences are built through either relational mapping or surface mapping. Relational mapping can be built on a more abstract and conceptual level than surface mapping, which often establishes correspondences on a more concrete and surface level. Going back to the example of the PDA, the analogy 'a PDA is like a secretary' is an example of relational mapping. The correspondence is established between the role of a secretary who manages appointments, books and documents and the functions of a PDA. In contrast, 'a PDA is like a mobile phone' is an example of surface mapping. In this analogy, the mapping is established on a more concrete level (e.g., a PDA is like a mobile phone that uses wireless communication, it has similar attributes to a mobile phone, such as display, keyboard, buttons, etc.; Houssi et al., 2009). Relational mapping has more explanatory power for consumers' learning about RNPs, thus it is often used to introduce

high-tech products (Gregan-Paxton & John, 1997).

In line with the above discussion, when a product metaphor is used in a RNP, the integrated conceptual association serves as the basis for consumers to build the relational mapping. During the design process, designers already integrate the conceptual association in product metaphors (Cila, Hekkert, et al., 2014b). In the example of the 'Mother' smart home system, the conceptual association is built between the role of a mother who often knows everything about the home and the benefit of a smart home system that collects all of the information about the home. If consumers manage to identify the relational mapping between the source and target RNP successfully, the knowledge used to understand the target RNP is ready to be transferred from the source domain, which may result in enhanced comprehension.

However, during the mapping process, consumers may have difficulties building the relational mapping. Consumers may not be able to recognise the similarities between source and target RNP. Prior studies demonstrate that the establishment of correspondences depends on the consumers' ability to detect the relationships between source domains and target RNPs and on the available cognitive resources for consumers' detection and mapping (Roehm & Sternthal, 2001). Specifically, consumers with expertise in the source domain are more likely to build the relational mapping, compared with consumers who are novices in the source domain (Novick, 1988). For novice consumers, it may thus be useful to inform them of the correct mapping, from sources to RNPs (Herzenstein & Hoeffler, 2016). In advertisements, to facilitate relational mapping, the information can be stated clearly. In the analogy 'a PDA is like a secretary', the additional explanation 'a PDA is like a secretary who helps manage appointments and documents' can be provided. In this way, consumers can learn that a PDA is similar to a secretary in terms of making appointments and managing documents. However, with product metaphors, consumers need to detect similarities and build the relational mapping by themselves, which may be difficult.

In addition, another risk that product metaphors can carry is that the physical similarities may trigger the mapping on a surface level, which is likely to mislead consumers into expecting that RNPs have the features of the sources, while they do not. As stated in previous studies, when the mapping is primarily built on a surface level, consumers may expect targets to have many features of the sources (Gregan-Paxton & John, 1997). In the example of 'a PDA is like a mobile phone', consumers may expect that the PDA can achieve wireless communication and that it also has similar display, keyboard and buttons (Houssi, Morel, & Hultink, 2005). Following this, for RNPs with product metaphors that physically resemble the source

products, the physical similarities are likely to trigger consumers' surface mapping. The surface mapping may lead consumers to expect RNPs to have some features of the sources, which they may not. For example, 'SSSSSpeaker' is a portable Bluetooth speaker (see Figure 5.4). Its innovative functions include its ability to connect with a smartphone to play music outdoors and its ability to be folded. To communicate its innovative functionality, the product metaphor invokes a foldable cup for travellers. The relational mapping is built between the portability of a travel cup and the Bluetooth speaker. The similar look of the two products is likely to trigger surface mapping. As a result, consumers may also expect the speaker to be waterproof, which it is not. Therefore, consumers' expectations are likely to be disappointed, leading to confusion.

Figure 5.4 Product example of Bluetooth Speaker 'SSSSSpeaker' in the product metaphor of a travel cup

Transfer Stage

After mapping one-to-one correspondences between sources and target RNPs, the relevant knowledge is ready to be used. In the transfer stage, consumers' learning occurs by transferring the relevant knowledge to the target RNPs, leading to consumers' enhanced comprehension. Previous studies usually consider the transfer of knowledge as the result of a successful analogical learning process and use it as an important dependent measure (Colhoun, Gentner, & Loewenstein, 2008; Herzenstein & Hoeffler, 2016). Therefore, if the risks of previous stages can be avoided, the relevant knowledge should be activated and lead to the successful transfer of knowledge.

The Moderating Role of Textual Clues

The previous section analyses how product metaphors influence consumers' analogical learning about RNPs. Specifically, the physical association integrated in

product metaphors can help consumers' identification of source products. The conceptual association integrated in product metaphors is the basis for consumers to build the relational mapping between sources and target RNPs. These physical and conceptual associations make product metaphors promising tools to facilitate consumers' analogical learning and enhance their comprehension of RNPs. However, product metaphors also carry risks, which hinder consumers' analogical learning. These risks include the following: 1) in the access stage, physical associations integrated in product metaphors allow for multiple consumers' interpretations, 2) in the mapping stage, consumers may lack the ability to build the relational mapping between source products/concepts and target RNPs integrated in conceptual associations, and 3) in the mapping stage, physical associations integrated in product metaphors may trigger consumers' surface mapping, which may prompt consumers to expect RNPs to have other unrelated features of the source products/concepts.

The positive effects of product metaphors on consumers' comprehension of RNPs are likely to be triggered with certain assistances. Textual clues that explain the similarities between sources and target RNPs are likely to promote the positive effects of product metaphors. The presence of textual clues can state the sources clearly, thereby avoiding the risks of multiple interpretations. By providing a textual clue to explain a product metaphor, consumers' identification of the source domain is directed to the one intended by designers, thus avoiding the possibility of interpreting it in different ways. Moreover, the textual clue can explain one-to-one correspondences between source products/concepts and target RNPs, thus overcoming the consumers' lack of ability to detect similarities. Finally, explaining one-to-one correspondences also promotes consumers' mapping at a relational level, thus avoiding surface mapping. As a result, it is unlikely for consumers to map other, unrelated features of the source to the target RNP. In the example of the 'Mother smart home system, the textual clue of 'Mother knows everything' is stated in the product introduction. In this way, 'the role of a mother' as the source is stated clearly. What needs to be mapped is also stated clearly. Among the multiple roles that a mother plays (e.g., knowing everything about the home, cooking and taking care of every family member), this statement clarifies that only the role of knowing everything about the home is related to the smart home system, while other roles are irrelevant. As the textual clue promotes relational mapping, consumers' surface mapping is discouraged. The possibility for misinterpretation is largely avoided.

The positive effects of providing explanatory information have been demonstrated in consumers' comprehension of artworks (Leder et al., 2006), visual metaphors in ads

(Phillipes, 2000) and consumers' appreciation of packaging designs (Van Rompay & Veltkamp, 2014). Therefore, we expect that the positive effects of product metaphors on consumers' comprehension of RNPs can be triggered with the help of textual clues. H1 is formulated as follows:

H1: When a product metaphor is used in a RNP, the presence of a textual clue moderates the enhancement of consumers' comprehension. Specifically, when a product metaphor is used in a RNP, the presence of a textual clue can enhance consumers' comprehension, compared with the absence of a textual clue. When a textual clue is absent, the involvement of a product metaphor in a RNP reduces consumers' comprehension, compared with the absence of a product metaphor in a RNP.

5.1.2 Method

An experimental study was conducted to test the hypothesis. To generate appropriate stimuli for this research, we conducted two design sessions and two pretests to generate and select suitable product metaphors for the main study. The stimuli generation was conducted on two levels: generating conceptual associations and physical associations of product metaphors for several RNPs. In design session 1, participants were asked to generate metaphors on a conceptual level. Participants were invited to propose products/concepts that shared conceptual similarities with the target RNPs. Next, pretest 1 tested the soundness of the proposed conceptual metaphors and RNPs. Design session 2 was conducted to ask participants to design product metaphors based on conceptual associations. They were required to integrate the selected concepts in physical forms. The designed product metaphors were validated in pretest 2.

Stimuli Creation

Design Session 1

Twelve participants were invited to generate metaphors at the conceptual level. These participants were Master's candidates who studied design-related subjects, thus they possessed the expertise to search for sources (Cila, Hekkert, et al., 2014b).

RNPs were collected from the Consumer Electronic Show (CES) 2016, which is a famous platform for launching innovative products. Among these innovative products,

we selected RNPs that targeted the mass market and challenged consumers' learning. Six RNPs were selected: an alarm clock that wakes people up using odour (https://sensorwake.com/sensorwake), a pan that measures the calories (https://smartypans.io/#), an oral health monitor (www.breathometer.com), a molecular sensor that detects the composition of objects (https://www.consumerphysics.com/), an activity tracking sensor for running (www.run-rockets.com) and a stand-alone shortcut button to control various digital devices (https://flic.io/). In the briefs provided to participants, the key functions and benefits of the RNPs were described. The challenge was to think of other products or concepts that could help consumers understand the innovative functions of these products. Explanations on the concept of product metaphors, RNPs, conceptual associations and physical associations within product metaphors were given. Two examples of existing product metaphors were also provided. Each participant was asked to think of metaphors for three of the six RNPs. For each RNP, participants were first asked to generate as many metaphors as possible at the conceptual level and to select one to finalise in sketching. As a result, two or three product metaphors were generated for each RNP. Among the six RNPs, the same conceptual metaphors were mentioned several times by participants for four RNPs, but no consistent conceptual metaphors were generated for the two other RNPs (activity tracking sensor for running and stand-alone shortcut button), suggesting that no prominent association was found. We selected the four RNPs with the consistent conceptual metaphors for the next tests.

Pretest 1: Soundness of the Generated Conceptual Metaphors

Pretest 1 was conducted to test whether the generated metaphors were considered sound to explain the innovative functions of the RNPs. Soundness refers to the extent to which both source and target share deep underlying relational similarities (Gentner, Rattermann, & Forbus, 1993). A sound metaphor shares a strong relationship, which is more likely to prompt consumers' successful identification and comprehension.

Forty students (53% male) participated in pretest 1. In total, six conceptual metaphors were tested. Each participant evaluated three generated conceptual metaphors. The order of presentation was randomised. Participants were first presented with descriptions of the RNPs. They were told that as these RNPs are highly innovative for consumers, companies aimed to make use of metaphors to explain these RNPs.

Therefore, their task was to evaluate whether the generated conceptual metaphors properly explained the RNPs. Next, following Gentner et al. (1993), the soundness between the generated conceptual metaphors and target RNPs was measured by the following three statements: 'the generated conceptual metaphor matches very well with the RNP', 'the generated conceptual metaphor shares essential similarities with the RNP' and 'the generated conceptual metaphor is strongly associated with the RNP', from 1 (strongly disagree) to 7 (strongly agree; α ranged from .77 to .92). In addition, the soundness in terms of experience was measured by asking participants to answer the following question: 'to what extent is the usage experience of the RNP similar to experiencing the generated conceptual metaphor?', from 1 (not similar at all) to 7 (very much similar). Analyses were conducted separately for each generated conceptual product metaphor (see Table 5.1 for results). The soundness of the generated conceptual metaphors and target RNPs did not reach a very high score because the RNPs were completely new, which increased the difficulty of finding products/concepts perceived as highly sound. The generated conceptual metaphors with higher ratings for soundness and soundness in terms of experience were selected. As a result, the following conceptual metaphors were selected: the conceptual metaphor of a flower for the alarm clock with odour, a scale for the smart pan with calorie measurement, a mint container for the oral health monitor and a magnifying glass for the molecular sensor.

Table 5.1 Results of pretest 1: soundness of generated product metaphors and RNPs

	Soundness	Soundness in terms of experience
	Mean (SD)	Mean (SD)
Target RNP: alarm clock with odour		
The conceptual metaphor of a Flower*	4.56 (1.57)	4.00 (1.80)
The conceptual metaphor of Perfume	3.98 (1.30)	3.05 (1.76)
Target RNP: smart pan with calorie measurement		
The conceptual metaphor of a Scale*	3.95 (1.35)	3.40 (1.39)
The conceptual metaphor of a Thermometer	2.87 (1.46)	2.45 (1.64)
Target RNP: oral health monitor		
The conceptual metaphor of a Mint Container*	3.85 (1.62)	3.75 (1.74)
Target RNP: molecular sensor		
The conceptual metaphor of a Magnifying Glass*	4.02 (1.32)	3.90 (1.37)

Note: * The selected conceptual metaphors for Design Session 2

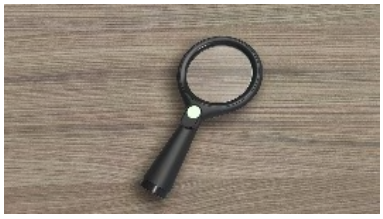
Design Session 2

The aim of design session 2 was to integrate the conceptual associations into physical forms. One professional designer was invited to design the product metaphors. The designer held a Master's degree in industrial design and had several years of experience in product design. The descriptions of the four RNPs were provided, accompanied with the generated conceptual metaphors. It was highlighted that the generated conceptual metaphors were aimed to aid consumers' learning about the corresponding RNPs and that the task was to integrate the conceptual metaphors in tangible product designs. Four product metaphors were first generated in the form of sketches. Among these four product metaphors, the product metaphors of a flower for the odour alarm clock and a scale for the smart pan were excluded from the research as the overall product categories 'clock' and 'pan' are mature. Therefore, the categorisation effects are likely to confound with the effects of product metaphors. For example, if the product metaphor of a flower is used, the odour alarm clock should have the shape of a flower. However, the product category alarm clock already triggers a clear prototype in consumers' mind that differs from a flower. As a result, when seeing the shape of a flower, consumers may be puzzled about this shape as it is different from their idea of a typical alarm clock. This puzzlement may complicate the analogical learning process that is triggered by the presence of product metaphors, thereby challenging the validity of the experiment.

Consequently, the product metaphors of a magnifying glass for the molecular sensor and a mint container for the oral health monitor were selected for subsequent 3D modelling and rendering for the usage of final stimuli. For the condition of RNPs without product metaphors, the original product appearances were used as stimuli. The brand information was digitally removed. For both conditions, the colour and details of the product appearances were made as similar as possible. The pictures of RNPs were presented with the same background, size and perspectives for both conditions (see Table 5.2).

Table 5.2. Results of design session 2: stimuli for conditions with and without product metaphors for both product categories

	With product metaphor	Without product metaphor

Oral health monitor		
Molecular sensor		

Pretest 2: Relatedness between Physical Forms and Intended Product Metaphors

The aim of design session 2 was to integrate the generated conceptual metaphors in product metaphors physically. Pretest 2 was conducted to test to what degree consumers were able to relate the physical forms to the intended conceptual metaphors for the two target RNPs. Specifically, a 2 (product metaphor: present vs. absent) × 2 (product category: oral health monitor vs. molecular sensor) mixed experiment was conducted, with the presence of product metaphors as between-subject factor and product category as within-subject factor. Each participant was assigned to one of the two conditions and evaluated two products. The order of the products was counterbalanced. Forty participants were involved (mean age = 21.87, 56.4% male).

In pretest 2, for both conditions, we measured the relatedness between generated product metaphors and RNPs, the novelty and the attractiveness of generated product metaphors. The relatedness was measured considering the space for interpretation and the strength of relatedness. By measuring the space for interpretation, we aimed to learn whether the generated product metaphors allowed for multiple interpretations. We attempted to learn whether consumers could identify the intended sources when seeing the product metaphors. The space for interpretation was measured by the following open questions: 'after seeing the picture of the product, what comes to your mind immediately? Could you relate it to any familiar things (e.g., a familiar product, animal, plant or person)? Please write your answers below'. Next, the strength of relatedness was measured, to learn the extent to which the generated product metaphors were strongly associated with the intended sources. Participants were asked

to respond to three statements: 'by seeing the picture of this product, I can confidently draw the conclusion that this design is related to a mint container/magnifying glass', 'by seeing the picture of this product, I am able to relate it to a mint container/magnifying glass' and 'after seeing the picture of this product, a mint container/magnifying glass immediately comes to mind' on a 7-point scale from strongly disagree to strongly agree (αs ranging from .71 to .91). In addition, to avoid confounding effects, attractiveness and novelty were measured. Attractiveness was measured by a 7-point scale anchored with 'ugly/beautiful' and novelty was measured with 'common/novel'.

Results were analysed separately for each product category. For the molecular sensor, in the open questions, 18 out of the 20 participants mentioned a magnifying glass in the product metaphor condition. For the oral health monitor, 17 out of the 20 participants mentioned a mint container in the product metaphor condition. The results suggested that the spaces for multiple interpretations enabled by created stimuli were very limited. Most consumers were not very likely to relate the RNPs to different source products. In addition, t-tests were conducted with the presence of product metaphors as the independent variable and relatedness, attractiveness and novelty as the dependent variables. Results revealed that participants' ratings differed significantly on relatedness for the molecular sensor ($t(38)= 17.45$, $p<0.001$) and the oral health monitor ($t(38)=11.029$, $p<.001$). No significant differences were detected in terms of attractiveness and novelty (see Table 5.3). These results suggested that compared to stimuli without product metaphors, stimuli with product metaphors were closely related to the source products as intended, which was the basis for successful analogical learning.

Table 5.3. Results of pretest-2

	Relatedness*	**Novelty**	**Attractiveness**
	Mean (SD)	Mean (SD)	Mean (SD)
Oral health monitor			
With product metaphor	5.73 (1.28)	3.05 (1.05)	3.25 (1.21)
Without product metaphor	2.12 (0.72)	2.95 (1.10)	3.75 (1.02)
Molecular sensor			
With product metaphor	6.53 (0. 81)	3.50 (1.43)	4.35 (1.27)
Without product metaphor	1.82 (0.89)	3.40 (1.60)	4.40 (1.43)

Note: * Across two product categories, the comparison between the presence and absence of product metaphor is significant ($p < .05$)

Main Study

Design and Participants

The main study used a 2 (product metaphor: present vs. absent) ×2 (textual clue: present vs. absent) ×2 (product category: oral health monitor vs. molecular sensor) mixed experimental design, with the presence of product metaphor and the textual clue as between-subject factors and product category as within-subject factor.

One-hundred-and-fourteen participants were collected (mean age = 43.28, 36.9% male) from a consumer panel. The consumer panel was afflicted with a Dutch university and was mainly used for academic purposes. The panel is representative of general population in Netherlands. This consumer panel was selected due to the focus on academic research and convenient accessibility. People who were younger than 55 years old were invited to participate in this study, as older people might have difficulty accepting new products (Loudon & Bitta, 1993).

Final Stimuli

The product designs from pretest 2 (product metaphors: present vs. absent) were combined with the textual clue (present vs. absent) to create the final stimuli for the main study. The textual clues intended to state the sources clearly and to clarify the similarities between the sources and target RNPs. To do so, the textual clues were created in the following way: '(The RNP) is like (source product) that provides (similarities shared by source product and target RNP)', which has been used in previous studies and effectively triggered analogical learning (e.g., Herzenstein & Hoeffler, 2016). With these textual clues, the risks carried by product metaphors could be avoided. Indeed, the sources were clearly stated to prevent multiple interpretations in the access stage, the similarities were clearly explained to facilitate the relational mapping from source products to target RNPs in the mapping stage and the possibilities for surface mapping were also largely limited by clearly emphasising shared similarities.

Moreover, following prior studies the word 'like' was involved, as the direct use of 'is' can trigger the categorisation effects that lead consumers to consider that the RNP belongs to the product category (Gregan-Paxton & Moreau, 2003). By involving 'like', consumers are unlikely to consider the RNP as a member of the product category.

Instead, they tend to understand that the RNP shares similarities with the source product. In this way, analogical learning can be triggered. Consequently, the textual clues were created for two stimuli: 'it is like a mint container that helps freshen your breath' and 'it is like a magnifying glass that detects detailed information'.

Procedure and Measurements

Each participant was assigned to one of the four conditions and evaluated two products on several measures. The order of presentation of the two products was randomised. A short product description for each product category (see Appendix E) was provided to participants together with the final stimuli. The short product descriptions were identical across the four conditions.

Consumers' comprehension of the RNP was measured by asking participants to indicate to what extent they agreed with the following four statements (Feiereisen et al., 2008): 'After looking at the picture of the product and reading the description, I found the product difficult to understand/easy to understand', 'After looking at the picture of the product and reading the description, I found the product confusing/straightforward', 'After looking at the picture of the product and reading the description, I completely understand the various features of this new product' and 'I understand what the main benefits of this product' on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree; α ranged from .888 to .890).

To check successfulness of created stimuli, relatedness was measured to learn to what degree the created product metaphors related to the intended sources. The measures were identical with the ones used in pretest 2. Participants were asked to indicate to what extent they agree with the following three statements on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree; α ranged from .95 to .98): 'By seeing the picture of this product, I can confidently draw the conclusion that this design is related to a mint container/magnifying glass', 'By seeing the picture of this product, I am able to relate it to a mint container/magnifying glass' and 'After seeing the picture of this product, a mint container/magnifying glass immediately comes to mind. ' Next, to avoid confounding effects, the attractiveness of product appearances was measured by two 7-point scale items: 'ugly/beautiful' and 'unattractive/attractive' (Pearson's r ranged from .69 to .73).

In addition, consumer innovativeness was measured as it can influence consumer responses to RNPs (Truong et al., 2014). Consumer innovativeness was measured by four 7-point Likert scale items from 1 (strongly disagree) to 7 (strongly agree; α = .89) (Manning et al., 1995): 'I often seek out information about new products and brands',

'I like to visit places where I can be exposed to information about new products and brands', 'I like magazines that introduce new brands', and 'I take advantage of the first available opportunity to find out about new and different products'.

Consumers' tendency for processing metaphors was also measured, as consumers' ability and tendency to process visual metaphors vary (Van Rompay & Veltkamp, 2014). Consumers' tendency to process visual metaphors can influence the effects of textual clues. Consumers who are better at processing metaphors tend to produce more elaborate thoughts about why a product is designed a certain way, thus textual clues provide less assistance. Conversely, for consumers who are less inclined to process metaphors, textual clues may have a bigger influence. Moreover, consumers' tendency to process product metaphors was measured by the following seven 7-point Likert scale items from 1 (strongly disagree) to 7 (strongly agree; $\alpha = .88$) (adapted from Van Rompay & Veltkamp, 2014): 'I tend to look for meanings behind a product appearance', 'An atypical appearance makes me question the reasons behind the shape of the product, 'A product appearance activates all kinds of associations', 'The thoughts activated by a product appearance give me a good impression of the product itself', 'Understanding the idea behind a product appearance makes me happy', 'I find pleasure in discovering the underlying idea of a product appearance' and 'It is unpleasant to not know why a product has a specific appearance'.

5.1.3 Results

Manipulation Check

To test the success of the manipulation of product metaphors, a 2×2×2 mixed ANOVA was conducted with the presence of product metaphors, presence of textual clues and product category as independent variables and the ratings of relatedness as the dependent variable. The results confirmed the success of the created stimuli (F (1, 110) = 646.14, $p < .01$; $M_{\text{with product metaphor}} = 6.26$, $M_{\text{without product metaphor}} = 1.98$). For both product categories, compared with when a product metaphor was absent, participants reported significantly higher scores on the measure of relatedness when a product metaphor was present. No effects were found for the presence of a textual clue and the interaction between a textual clue and product metaphor ($p > .10$).

Test of Hypotheses

H1: Effects of the presence of product metaphors and textual clues on consumers' comprehension of RNPs

To test hypothesis 1, a 2×2×2 mixed ANOVA was conducted with the presence of

product metaphors, the presence of textual clues and product categories as independent variables and consumers' comprehension as the dependent variable. Consumer innovativeness, consumers' tendency to process metaphors, gender and age were initially included as covariates, but they were not included in further analyses as the results did not prove significant. No main effects of the presence of product metaphors and textual clues were detected (p >.10). A significant interaction effect was found between the presence of product metaphors and textual clues on consumers' comprehension (F (1,110) = 11.67, p < .05) (see Figure 5.5). Across two product categories, when product metaphors were present, participants reported better comprehension when textual clues were provided, in comparison with the absence of textual clues (F (1, 52) = 7.33, p < .05; $M_{\text{with textual clue}}$ = 5.34, $M_{\text{without textual clue}}$ = 4.51). When textual clues were present, participants reported better comprehension when product metaphors were provided, compared with the absence of product metaphors (F (1, 56) = 4.04, p < .05; $M_{\text{with product metaphor}}$ = 5.34, $M_{\text{without product metaphor}}$ = 4.81). When textual clues were absent, the presence of product metaphors resulted in a significant decrease in consumers' comprehension (F (1, 54) = 7.67, p < .05; $M_{\text{with product metaphor}}$ = 4.51, $M_{\text{without product metaphor}}$ = 5.37), which suggested that the sole presence of product metaphors confused consumers. For both product categories, the pattern of means was analysed separately. The means for the variable consumers' comprehension followed the expected direction (see Table 5.4). These results support H1.

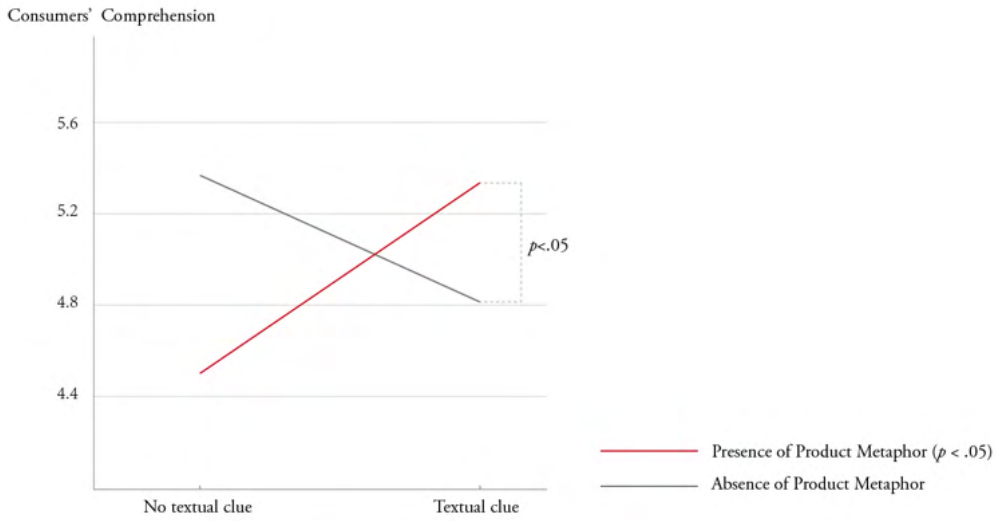


Figure 5.5 The interaction effect of the presence of textual clues and product metaphors on consumers' comprehension

Table 5.4. Results of the main study: adjusted means for consumers' comprehension,

relatedness and innovativeness by product category.

Presenting	Product metaphor & textual clue	Product metaphor only	Textual only	None
Oral health monitor				
Consumers' comprehension	5.44	5.10	5.08	5.62
Relatedness	6.22	5.94	2.72	2.33
Innovativeness	5.58	5.44	5.39	5.28
Molecular sensor				
Consumers' comprehension	5.25	3.92	4.54	5.11
Relatedness	6.42	6.46	1.51	1.33
Innovativeness	5.51	5.36	5.51	5.59

5.1.4 Discussion of Study 5

By analysing the influence of product metaphors on the three stages of consumers' analogical learning, we explore the potentials and risks of influencing consumers' comprehension of product metaphors. To best use their potential and avoid risks, we propose that the positive effects of product metaphors on consumers' comprehension of RNPs need to be triggered by accompanying them with textual clues. The results of Study 5 support our hypotheses. Study 5 demonstrate that the presence of product metaphors and accompanying textual clues together improved consumers' comprehension of RNPs, compared with providing product metaphors alone. When the textual clue is absent, the sole presence of a product metaphor confuse consumers, leading to reduced consumer comprehension. These results fill the research gap by providing empirical evidence for the influence of product metaphors on consumers' comprehension of RNPs.

The necessity of textual clues could be attributed to different reasons. In the hypothesis building section, the risks of product metaphors are identified. Study 5 demonstrate that the presence of textual clues could overcome the listed risks and trigger the positive effects of product metaphors on consumers' comprehension. However, it remains unclear which risks hinder consumers' comprehension of RNPs when product metaphors are presented alone.

Specifically, at the access stage it is possible that product metaphors hinder consumers'

identification of source domains, which further reduces their comprehension of RNPs. Although this possibility conceptually exists, it is very unlikely to have been triggered in Study 5. Indeed, the stimuli used in Study 5 result from two design sessions and two pretests; therefore, the relatedness was well established. In other words, for most people the possibility of identifying the sample products as belonging to other source products/concepts are largely avoided by the pretests. The manipulation checks also ensure that the stimuli are physically similar to the source products. In other words, the reduced consumer comprehension is unlikely to result from the multiple interpretations enabled by product metaphors.

Next, at the mapping stage, it is possible that consumers are unable to detect the similarities between the source products and target RNPs, which may have hindered consumers' analogical learning of RNPs when seeing product metaphors alone.

In addition, product metaphors might carry the risk of promoting surface mapping. Specifically, through seeing product metaphors, consumers may expect the RNPs to have the features of the source products. After reading the functional descriptions provided, consumers may have found that the RNPs do not have the expected features, which could lead to consumers' confusion and result in reduced consumers' comprehension. Yet, the experimental approach does not allow for investigating this risk. Therefore, to further understand what hinders consumers' comprehension of RNPs with product metaphors alone, it is necessary to investigate each risk discussed above. To do so, consumer interviews are conducted in Study 6 by using a subset of the stimuli from Study 5.

5.2 Study 6: Investigating the Risks of Product Metaphors on Consumers' Comprehension of RNPs

5.2.1 Method

Design and Participants

Stimuli were selected from those used in Study 5. Specifically, only two RNPs with product metaphors were used as stimuli in this study. Thirty-one participants were involved (42% male, average age = 33.84 years old). The participants were selected from a city in China. This group of participants was collected due to the convenient accessibility. Participants were randomly given one of the stimuli products and were asked several questions related to the stimuli product.

Procedure

The questions included in the consumer interviews were organised in four parts: access stage, mapping stage, transfer stage and an additional stage in which the textual clue was presented. Specifically, in the access stage, only a picture of the stimuli product was presented, to learn whether the intended domain was accessed and what specific domain knowledge was activated. In the mapping and transfer stage, both picture and the basic functional description of the stimuli product (without the textual clue) were presented, to learn whether the activated knowledge was transferred to comprehend the stimuli product, and if so, what knowledge was transferred. In addition to the three stages of the analogical learning process, an additional stage was tested in which the textual clue of Study 5 was added to the stimuli, to learn how textual clues might assist consumers' comprehension of RNPs. The questions can be found in Table 5.5.

In the first part, the main aim was to learn about the influence of product metaphors during the access stage: whether the presence of product metaphors could help consumers' identification of the source domains, whether participants' identification was the same as that intended by the designer and what knowledge in the source domain was activated. In this way, we could learn whether product metaphors might carry the risks of enabling multiple interpretations. To fulfil this aim, only the picture of the stimuli product was shown to participants. After seeing the picture of the stimuli product, they were asked whether they knew this product before, and if so, what the product was. They were also asked to talk more about the product.

Table 5.5 Interview questions divided into four parts

Access Stage: Present product pictures only	
No.	Questions
Q1.	Have you seen this product before?
Q2.	What is the product?
Q3.	Could you talk more about this product?
Map Stage: Present product pictures and product descriptions	
No.	Questions
Q4.	To what degree do you think you understand the product functions? (7-point scale)
Q5.	Which parts do you understand? Which parts don't you understand?
Q6.	What do you think of this product in general?
Transfer Stage: Present product pictures and product descriptions	
No.	Questions

Q7.	Do you think the product is similar to the source? 7-point Likert scale
Q8.	Could you explain in what ways the product is similar to the source?
Additional Stage: Present textual clue, product pictures and product descriptions	
No.	Questions
Q9.	To what degree do you think you understand the product functions? (7-point scale)
Q10.	Does the presence of a textual clue help you comprehend the RNP? If so, how?
Q11.	Did you identify these similarities before? Why?

In the second part, the actual functional description of the stimuli product was shown to participants. After reading the descriptions, they were first asked to rate their comprehension of the stimuli product on the same measures as used in Study 5. Specifically, participants were asked to indicate to what extent they agreed with the following four statements (Feiereisen et al., 2008): 'After looking at the picture of the product and reading the description, I found the product difficult to understand/easy to understand', 'After looking at the picture of the product and reading the description, I found the product confusing/straightforward', 'After looking at the picture of the product and reading the description, I completely understand the various features of this new product' and 'I understand what the main benefits of this product are', on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree; α = 0.85). Second, they were asked about the parts they understood and the parts they did not understand and their general opinion of the stimuli product. In this way, we could gain more insights into consumers' difficulty to comprehend RNPs.

In the third part, we aimed to learn how participants built one-to-one correspondences, including whether they were able to build correspondences in terms of both attributes and relations and what correspondences were built. Participants were first asked to evaluate the extent to which the stimuli product was similar to the source product. The measure was the same as in Study 5. Specifically, participants were asked to indicate to what degree they agreed with the following statements: 'By seeing the picture of this product, I can confidently draw the conclusion that this design is related to a mint container/magnifying glass', 'By seeing the picture of this product, I am able to relate it to a mint container/magnifying glass' and 'After seeing the picture of this product, a mint container/magnifying glass immediately comes to mind', on a 7-point scale from strongly disagree to strongly agree (α = .97). Second, they were asked in what ways the products were similar to each other.

Finally, in the fourth part, the same textual clues used in Study 5 were presented: 'The molecular sensor is like a magnifying glass that detects detailed information/The oral health monitor is like a mint container that helps freshen your breath'. Next, participants were asked to evaluate their comprehension one more time based on the same measures. Subsequently, participants were asked how the presence of the textual clue influenced their comprehension of the RNP. They were also asked whether they realised the similarities mentioned in the textual clue before reading the clue. If not, they were asked what hindered their recognition of these similarities. Although the results of Study 5 already demonstrated the positive effects of textual clues on consumers' comprehension, this part aimed first to replicate the results of Study 5 and second to provide additional insights into how the textual clues helped.

5.2.2 Results

All of the consumer interviews were fully transcribed. The content analyses were conducted with the Atlas.ti software. A thematic analysis was conducted on the open questions of the interviews (Braun & Clarke, 2006). The analysis was conducted from an inductive approach (Thomas, 2006), with an interest in understanding what risks product metaphors might carry in each stage and how the presence of textual clues helped consumers' comprehension of RNPs. Both prevalence of responses and content of responses were reported. The following section reports the findings based on the four parts of the consumer interviews.

Access Stage

In terms of identification of the source products (in response to Q1 and Q2), all of the participants recognised the source products correctly, suggesting that participants were able to identify the source products as intended by the designer. While discussing their thoughts on the source products (in response to Q3), participants mentioned the functions of the source products, participants' experiences with the source products and their perceptions of the source products.

Specifically, for the participants who were presented with the molecular sensor, all participants mentioned that it was a magnifying glass. In terms of the functions of a magnifying glass, participants mentioned that it can focus light and project a larger image of objects. Participants also mentioned their experiences with a magnifying glass, including using a magnifying glass to set a paper on fire and using it to read very small words. In addition, participants mentioned their perceptions of a magnifying glass, such as a professor uses it for investigation, a detective uses it to look for tiny

clues and an elderly person uses it to read the newspaper. These results indicated that participants were able to recognise the source product and that the corresponding knowledge was activated, as one participant explained the following:

'Physically, a magnifying glass is able to focus light. During my childhood, I used it to heat and set (something) on fire. For example, if there was an insect, I used a magnifying glass to focus the sunlight on it for a while and set it on fire. Another function is to enlarge things. For example, it is common to see an elderly person hold a magnifying glass while reading the newspaper and move the magnifying glass line by line. These are experiences in my life. Maybe there are other ways to use it, such as a telescope or something…'

Similarly, for the participants who were presented with the oral health monitor, all participants mentioned that it was a mint container. Participants mentioned the main functions of a mint, including maintaining oral health and helping have fresh breath, as mentioned by one participant: *'I feel mints are something that everyone uses, something indispensable… It has its own function, mainly remedy bad breath'.* In addition, participants mentioned that mints could help refresh minds. Participants also explained their own experiences with mints, such as eating mints after meals, eating mints while driving to freshen one's breath and sharing mints with colleagues.

These results indicated that product metaphors could facilitate consumers' access to source products. Consumers could identify the source products in the way that the designer intended. In other words, the risk of enabling multiple interpretations carried by product metaphors was avoided by carefully designing product metaphors. Once the source product was correctly recognised, the relevant knowledge in the source domain was retrieved. The activated knowledge included functions and perceptions of the source products and consumers' experiences with the source products.

Mapping Stage

At the mapping stage, participants were shown the actual functional description of two stimuli products. Participants first rated their comprehension of the stimuli products (Mean = 5.82, SD = 0.89). After rating, they were asked to explain which parts they understood and which parts they did not understand. Specifically, participants explained that they were able to understand the functions and benefits of the stimuli products, but they were confused about how the products could fulfil the functions technically, as explained by one participant for the stimuli product the oral health monitor:

'In terms of function, I feel that I know what it is used for after reading the product description. But in terms of technical stuff, I don't understand how it measures bacteria, how it works, how it changes

my oral environment and how it collects and analyses data…'

Furthermore, participants mentioned that they did not understand how the RNPs could benefit them. For example, for the molecular sensor, one participant stated: *'I feel that this product is too far from me. It is too different from my life, so it is hard to understand. (I cannot imagine) if I used it in my life, what it would be like…'*

While answering the questions in this part, participants seldom mentioned the source products. Only three participants clearly mentioned that the stimuli products were extensions of the source products. In terms of the molecular sensor, one participant declared:

'At the beginning, I considered it as a magnifying glass… it looks like a magnifying glass and it also feels like a magnifying glass because the function is similar to a magnifying glass. Just like a cell phone, the relationship between a smartphone and a cell phone. Based on a cell phone, a smartphone has new functions. With a cell phone, you can only make phone calls. With a smart phone, you can also send text messages, watch video online and chat online. A smartphone is more powerful. Similarly, I don't only imagine it as a magnifying glass, it is better (has more functions)'.

Likewise, regarding the oral health monitor, one participant mentioned: *'Because I eat mints every day, I know their functions very well. So this product somehow has the same function as mints'*. Most participants did not mention anything related to the source products, which suggested that participants had difficulty linking the target RNPs to the source products.

We did not find any evidence of participants' misinterpretations of the target RNPs. Participants did not expect the target RNPs to have the same characteristics as the source products. In contrast, participants clearly understood that the target RNPs were different products, as one participant explained for the oral health monitor: *'although they are similar looking, their functions are totally different. One helps you solve problem, the other one helps you detect problems. Their functions are different'*.

Transfer Stage

In terms of similarities between source products and stimuli products (in response to Q7), participants considered the stimuli RNPs as highly similar to the source products (Mean = 6.46, SD = 0.66). Regarding the explanation of this similarity (in response to Q8), most participants mentioned that the stimuli product was similar to the source product in terms of appearance. Only 5 of the 31 participants mentioned that the stimuli product and source product were similar to each other on both appearance and function levels. For example, for the oral health monitor, one participant mentioned:

'Functionally, they are related to oral health, like personal belongings. Basically, (they are) the same. But one is for detecting, another one is for refreshing'. For the molecular sensor, one participant explained:

'A magnifying glass enlarges the size of objects, which allows people to see it more clearly. But it refers to enlarging things physically to allow your eyes to see clearly. This product (the molecular sensor) also "enlarges" things, but it allows people to see its composition. Thus, its function is enlarging, but it enlarges on a higher level'.

These results suggested that most participants were not able to detect the conceptual similarities between RNPs and source products themselves. Participants were able to identify the physical similarities between source products and target RNPs. However, most participants were unable to build the relational mapping. In the access stage, we found that the relevant knowledge was already activated, such as the functions of the source products. However, participants were still unable to map them with the target RNPs.

Additional Stage of Presenting the Textual Clue

After the textual clues were presented to participants, they were asked to report their comprehension one more time (Mean = 6.44, SD = 0.72). A paired sample t-test was conducted to compare this comprehension with the one in the mapping stage, where textual clues were not present. Results revealed that the second rating is significantly higher than the comprehension that participants reported in the first rating ($t(30) = -3.62$, $p < .05$; $\text{Mean}_{\text{mapping stage}} = 5.82$ vs. $\text{Mean}_{\text{additional stage}} = 6.44$). This result supported the findings of Study 5, which demonstrated that the presence of textual clues significantly improved participants' comprehension of RNPs with product metaphors.

Regarding the influence of presenting textual clues (in response to Q10), around 71% of participants claimed that the presence of a textual clue helped them comprehend the RNPs. Specifically, participants further explained the reasons: the presence of textual clues 1) helped them relate to familiar products, 2) prompted them to compare similarities and differences between the RNPs and the source products and 3) simplified the functions of the RNPs. These results further explained why textual clues were necessary. The explanation regarding the similarities between the source products and the RNPs could help consumers' relational mapping. For example, participants mentioned that the textual clue allowed them to relate the RNPs to familiar products, which helped them learn about the RNPs:

'This one equals the other. They share some similarities. A magnifying glass is used to enlarge (things) because it is easier to recognise. This one directly presents the data inside. I think both are presenting

the inside content in a better way'.

Participants also mentioned that the presence of the textual clue promoted similarities and differences between RNPs and source products. For instance, one participant mentioned for the molecular sensor:

'To speak frankly, a magnifying glass allows seeing detailed things on the surface. This molecular one allows seeing internal and essential things. We use a magnifying glass to look at small details on the surface, but this one is used to look inside'.

Furthermore, participants mentioned that the presence of the textual clue simplified the functions of RNPs, for instance for the molecular sensor, one declared: *'It simplifies things. At the beginning, learning about it was complex. I saw a magnifying glass and learnt its functions. Later, (with the textual clue), it became easier'.*

5.2.3 Discussion of Study 6

Through consumer interviews, Study 6 revealed how product metaphors influence the three stages of consumers' analogical learning of RNPs. Specifically, in the access stage, product metaphors could help consumers' identification of the source products and the activation of knowledge in the source domains. However, in the mapping stage, consumers had difficulty detecting the relational similarities between the source products and the RNPs, which hindered the knowledge transfer. The presence of textual clues that explained the similarities between the source products and the RNPs could help consumers. After introducing the textual clue, consumers' comprehension was improved significantly compared to the comprehension they previously reported.

These results provided additional insights into the findings of Study 5. The results of Study 6 further supported the findings that it was necessary to present textual clues to facilitate consumers' comprehension of RNPs. Furthermore, Study 5 found that the sole presence of product metaphors reduced consumers' comprehension of RNPs. The results of Study 6 revealed that the reduced comprehension was caused by consumers' lack of ability to detect the similarities between the source products and the target RNPs. Consumers' lack of ability was supported by prior research that demonstrated that the mapping depended on consumers' own ability to detect similarities and on consumers' cognitive resources (Roehm & Sternthal, 2001). To help consumers' mapping, it was helpful to present related information to explain relationships between sources and target RNPs. The difficulty that consumers had in mapping determined the amount of information required to explain similarities (Herzenstein & Hoeffler, 2016). Specifically, when consumers had greater difficulty in

mapping, a detailed explanation was necessary to facilitate their mapping. Otherwise, presenting a moderate amount of information that explained the similarities between sources and targets was sufficient.

Moreover, in Study 6, the results revealed that only 16% of participants detected the similarities between source products and RNPs by themselves without the help of textual clues. This finding suggested that it was necessary to present textual clues, as most people were unable to detect similarities by themselves. Conversely, it also suggested that a small group of people were able to build the mapping by themselves. Previous studies suggested that consumers had different skill levels to process metaphors (Van Rompay & Veltkamp, 2014). Thus, for the group of people who had a higher ability to process metaphors, the textual clue could be absent. Future research may further investigate individual differences between consumers.

5.3 General Discussion

This chapter reports two studies on the use of product metaphors in RNPs. Through an experimental approach, Study 5 provides empirical evidence on the effects of product metaphors for enhancing consumers' comprehension of RNPs. Specifically, Study 5 finds that the presence of both a product metaphor and a textual clue can lead to enhanced consumers' comprehension of RNPs, but the sole presence of product metaphor confuses consumers. Study 6 continues this investigation through consumers' interviews, to reveal the influence of product metaphors in each stage of analogical learning. The results of Study 6 show that product metaphors can help consumers access source domains and activate the corresponding knowledge. In the mapping stage, consumers have difficulty mapping the corresponding knowledge between sources and target RNPs. To help consumers' mapping, the presence of textual clues that explain the similarities between source products and target RNPs is helpful and significantly enhances consumers' comprehension of RNPs.

In addition, these findings contribute to previous research on product metaphors by providing empirical evidence. Although it is generally believed that product metaphors facilitate consumers' comprehension of RNPs (Hekkert & Cila, 2015), no support was offered concerning the idea that designers can make effective use of product metaphors for this purpose. The results of these two studies provide evidence for the general notion. Moreover, the two studies demonstrate that the positive effects of product metaphors can only be triggered by the combined presence of textual clues and product metaphors. The sole presence of product metaphors is insufficient and can even reduce consumers' comprehension.

Compared to previous studies on product metaphors, this investigation expands into an unexplored area by using product metaphors to facilitate consumers' comprehension of RNPs. Previous studies classify the intention of using product metaphors in an experimental intention and a pragmatic intention (Cila, Hekkert, et al., 2014a; Hekkert & Cila, 2015). In contrast, this investigation focuses on how product metaphors influence consumers' learning about the unique benefits of RNPs, which is a specific type of pragmatic intention. This investigation demonstrates that product metaphors can be used to assist consumers' comprehension of RNPs. Based on the analogical learning process, this research investigates how product metaphors influence each stage of the analogical learning process, including what potential and risks product metaphors carry. Through these two studies, this investigation demonstrates the effects of product metaphors on consumers' comprehension of RNPs.

The effects of product metaphors on consumers' comprehension of RNPs apply to RNPs that do not belong to any existing product category. When RNPs belong to an existing product category, the categorisation effect can be triggered, which influences consumers' analogical learning process. In the two studies, we aimed at examining the effects of product metaphors for triggering analogy-based knowledge transfer in RNPs. Thus, we selected RNPs that did not belong to any existing product category, to prevent potential confounding effects resulting from category-based knowledge transfer. Future research may examine the effects of product metaphors on consumers' comprehension of RNPs that belong to a mature product category.

Specifically, it may be possible that both category-based and analogy-based knowledge transfer are triggered, which together contribute to consumers' learning. In the example of the odour alarm clock, when embodied through the product metaphor of a flower, it is possible that the category 'flower' is activated. Thus, consumers may associate it with 'releasing odour'. Through reading the product descriptions, consumers learn that the product is an innovative clock, which may activate the knowledge of the product category 'clock'. Prior studies demonstrated that consumers can draw inferences on RNPs from multiple categories (Gregan-Paxton et al., 2005). It is possible that the knowledge from both categories of 'flower' and 'clock' is used to learn about the innovative functionality of the RNP, leading to enhanced comprehension. However, it is also possible that the presence of a product metaphor triggers the analogy-based knowledge transfer but hinders the category-based knowledge transfer. Following the example of the odour alarm clock, the 'flower' product metaphor may facilitate consumers' retrieval of the characteristic 'a flower has

a smell', but it may hinder consumers' recognition of the product as an alarm clock. The shape of a flower conflicts with the prototype of an alarm clock, thus consumers may not recognise it as a clock, resulting in reduced comprehension. Therefore, future research may investigate the effects of using product metaphors in RNPs that belong to mature product categories.

Our findings can provide valuable practical support for designers and design managers. For designers, this research informs them about the potential and risks of designing RNPs with product metaphors. Although positive interaction effects of product metaphors and textual clues on consumers' comprehension of RNPs are found, designers should interpret the results of this study carefully. The positive effects were based on strong soundness and relatedness between product metaphors and target RNPs. Thus, while designing, designers may need to carefully select sources and precisely integrate them in physical forms. The sources should be strongly related to the target RNPs in terms of benefits provided, but also align with the target RNPs in terms of experience. Additionally, the product metaphors should be easily recognisable for consumers.

Moreover, because textual clues are necessary to trigger positive effects, product metaphors may not need to be as straightforward as the stimuli used in both studies. As demonstrated in prior studies (Cila, Borsboom, et al., 2014), an identifiable but subtle product metaphor contributes to consumers' aesthetic preference. In this research, to investigate the risks of product metaphors, the created stimuli closely resembled the source products. In practice, as textual clues will be provided together with product metaphors to help consumers' identification, product metaphors can be designed in a more subtle way and be more aesthetically pleasing. Going back to the two examples of the aiia Bluetooth speaker and the 'Mother' smart home system, the product metaphor of the travel cup is used in the aiia speaker in a straightforward manner: the colour, shape and materials are identical to a travel cup. Conversely, the metaphor of a mother is integrated in the 'Mother' smart home system in a subtle manner: the information terminal is designed in a doll-shape, which intends to match with the name 'Mother'. The involvement of subtle product metaphors can bring extra benefits, such as triggering consumers' emotional responses (Lin & Cheng, 2014) and contributing to vivid brand perceptions (Ang & Lim, 2006). With the help of textual clues, consumers' comprehension of RNPs can also be enhanced.

Furthermore, for design managers, the results of this study suggest that the positive effects of product metaphors on consumers' comprehension can be triggered by accompanying product appearances with textual clues. If design managers decide to

embody RNPs by using product metaphors, they need to collaborate with marketing managers to make sure that the marketing materials state the sources clearly. Otherwise, the sole presence of product metaphors will lead to confusion and a decrease in consumers' comprehension.

Chapter 6 General Discussion

This doctoral thesis investigates the influence of product appearance on consumers' comprehension of RNPs. Nowadays, different innovative technologies emerge, such as Internet of Things, virtual reality, artificial intelligence, and robotics. These innovative technologies increase the number of RNPs that are launched in the market. Although these RNPs can provide significant benefits for consumers, the risk for failure is high (Cierpicki et al., 2000). One reason for the high risk of RNPs is consumers' resistance due to a lack of comprehension (Gourville, 2006; Reinders et al., 2010; Talke & Heidenreich, 2014). As designers are responsible for embodying these RNPs, designers need specific knowledge on how to design RNPs to facilitate consumers' comprehension. The results of this doctoral thesis can provide designers with knowledge on how to achieve the task of embodying RNPs.

To facilitate consumers' comprehension of RNPs, current research mainly focuses on developing strategies that can be used in advertisements (Gregan-Paxton, 2001; Reinders et al., 2010; van den Hende et al., 2012; M. Zhao et al., 2012). This thesis extends this line of research by investigating the influence of product appearance on consumers' comprehension of RNPs, which has not received sufficient research attention thus far. As the product appearance is generally presented together with the innovative functionality of a RNP, consumers almost automatically see product appearance while processing the RNP. In other words, product appearance and product functionality interact with each other and influence consumers' processing (Rindova & Petkova, 2007), and subsequently, consumers' comprehension of a RNP.

Specifically, this thesis focuses on consumers' subjective comprehension of benefits and features provided by RNPs. Such subjective comprehension results from consumers' processing of the RNP during their first encounters. The subjective comprehension is a precondition for further consumers' adoption of RNPs (Reinders et al., 2010). If consumers fail to comprehend the RNP, they are unlikely to further consider and adopt it. Consumers' subjective comprehension is thus an effective predictor for consumers' adoption decision (Raju et al., 1995). Through six studies, this thesis demonstrates the influence of product appearance on consumers' comprehension of RNPs. Through using different factors within product appearance

(i.e., visual complexity, transparency, product metaphor), designers can encourage consumers' comprehension of RNPs and further facilitate the consumers' adoption of RNPs.

This chapter summarizes the key findings of this research. Then, it describes the theoretical contributions and practical implications are given. Finally, the limitations of this research and suggestions for future research are discussed.

6.1 Summary of Key Findings

This thesis starts with a general introduction in Chapter 1, where the key concepts were introduced, including RNPs, consumers' resistance to RNPs. The consequences and reasons of consumers' resistance were outlined. Among the factors that influence consumers' adoption of RNPs, consumers' comprehension is a precondition for consumers' adoption of RNPs, which was recognized as the research focus of this thesis. Consequently, the general research question was proposed: *how can designers use product appearance to increase consumers' comprehension of RNPs?*

To address this research question, Chapter 2 reviewed the relevant literature, including studies concerning the stimulation of consumers' adoption of RNPs, categorization (Waldmann et al., 1995), analogical learning (Gregan-Paxton & John, 1997), mental simulation (Hoeffler, 2003), narrative transportation (van der Hende & Schoormans, 2012), the presence of RNP-related information (Talke & Snelders, 2013), and the role of product appearance in consumers' processing of products (Creusen & Schoormans, 2005; Crilly et al., 2004). Based on these insights, three factors were proposed that can influence consumers' comprehension of RNPs through three ways: 1) change visual complexity to influence congruence between the product appearance and the innovative functionality of RNPs, 2) use transparency to directly communicate the innovative functionality of RNPs, and 3) use product metaphors to facilitate consumers' analogical learning of RNPs. Next, Chapter 3, Chapter 4 and Chapter 5 investigated each factor respectively (see table 6.1 for an overview of studies in each chapter).

Table 6.1 Overview of chapters based on topics, research questions and studies

Chapter	Topic	Sub-research question	Studies
Chapter 3	Visual complexity	How can designers make use of visual complexity to increase consumers' comprehension of RNPs?	Study 1: Experimental study to investigate the effects of visual complexity on consumers' comprehension of product innovations Study 2: Designer interviews to translate the theoretical findings into design principle 'complexity in simplicity'
Chapter 4	Transparency	How can designers make use of transparency in product innovations to facilitate consumers' comprehension of RNPs?	Study 3: Designer interviews to explore an overview of possibilities created by transparency, including whether and how designers intend to use transparency to facilitate consumers' comprehension of RNPs Study 4: Consumer interviews to validate the findings from study 3.
Chapter 5	Product metaphor	How can designers make use of product metaphors to improve consumers' comprehension of RNPs?	Study 5: Experimental study on the effects of product metaphors on consumers' comprehension of RNPs, and its interaction effects with textual clues. Study 6: Consumer interviews to uncover the risks of product metaphors that hinder consumers' learning for RNPs through product metaphors alone.

In Chapter 3, the influence of visual complexity on consumers' comprehension of product innovations was investigated. Through a controlled experiment, Study 1 demonstrated that visual complexity can trigger consumers' perceived congruence with the innovative functionality of RNPs. The congruence brought a fluent processing, leading to enhanced consumers' comprehension of RNPs. This finding demonstrated the positive effect of visual complexity on consumers' comprehension of RNPs. However, a high visual complexity can lead to low consumers' aesthetic preference. Aesthetically, consumers favored simplicity. Therefore, designers should make use of both complexity and simplicity while designing RNPs. Thus, the design principle 'complexity in simplicity' was proposed, which referred to increasing visual complexity in certain parts to trigger congruence with product functionality while still keeping the overall simplicity in the product appearance. In this way, the appearance of RNPs can facilitate consumers' comprehension while also being aesthetically pleasing. To gain insights on this design principle 'complexity in simplicity', experienced designer interviews were conducted in Study 2. Results showed that designers considered this to be an effective principle to design RNPs. Furthermore, the ways to achieve this design principle were specified: 1) to create a simple and coherent overall appearance, 2) to increase visual complexity through communicating innovative functionality, such as by adding elements and more details on certain parts, and 3) to create rhythm and harmony among these elements through creating similarities among them.

Chapter 4 investigated the usage of transparency to directly communicate the functionality of product innovations, in order to facilitate consumers' comprehension. In Study 3, designer interviews were conducted to learn the underlying design intentions for using transparency in product innovations. Results revealed that designers considered that using transparency was an effective way to facilitate consumers' comprehension of RNPs. Designers highlighted that the exposed parts should communicate the dynamic working process of the integrated technology, which allows consumers to observe the immediate changes. Designers also mentioned that the exposed parts should be comprehensible for consumers. For example, for RNPs whose working process is comprehensible for consumers (e.g., kitchen appliances, vacuum cleaners), using transparency can be helpful for consumers. In contrast, for RNPs whose working process is incomprehensible for consumers (e.g., consumer electronics), using transparency may not be helpful due to the fact that the internal components are incomprehensible for consumers. Furthermore, results revealed other design intentions for using transparency in product innovations. In total, an overview of possibilities created by transparency in product innovations was

identified: *facilitate consumers' comprehension, enrich visual appeal, enrich product experience, improve product usability,* and *demonstrate product functionality*. In addition, as consumers may not respond to product innovations in the ways intended by designers, consumer interviews were conducted in Study 4 to validate the findings of Study 3. Corresponding to the design intention of facilitate consumers' comprehension, it was found that consumers reported better comprehension of RNPs that involved transparency. For the other design intentions related to using transparency in product innovations, consumers' interpretations of transparency in product innovations corresponded to the identified design intentions.

Based on the analogical learning process (i.e., access, mapping, transfer), Chapter 5 focused on investigating the influence of product metaphor on consumers' comprehension of RNPs. First, the potential and risks that product metaphor carried in influencing consumers' comprehension of RNPs were analyzed. Product metaphor has the potential to facilitate consumers' analogical learning because it integrates the conceptual and physical associations between sources (the products/concepts that consumers are familiar with) and target RNPs (the innovative products that consumers do not know beforehand). Product metaphor can also hinder consumers' analogical learning because 1) it allows for multiple interpretations in the access stage, 2) consumers lack the ability to recognize the similarities between the source and target RNPs in the mapping stage, and 3) product metaphor may mislead consumers to expect RNPs to carry other features of the sources. Next, to make best use of the potential of product metaphor and avoid its risks, Study 5 demonstrated that product metaphor can improve consumers' comprehension when an accompanying textual clue is also presented that explains the similarities between the source product and target RNP. The sole presence of product metaphor confuses consumers, resulting in reduced consumers' comprehension. To further understand what risks hinder consumers' learning of RNPs through product metaphor, Study 6 was conducted through consumer interviews. Results revealed that consumers are able to recognize the source products and access the knowledge in the source domain. The risk of solely presenting product metaphor lies in consumers' lack of ability to recognize the conceptual similarities between sources and target RNPs. Consumers have difficulty detecting how the target RNPs are similar to the sources, which hinders the knowledge transfer. Furthermore, because source products and target RNPs are often far away from each other, the physical resemblance is not likely to trigger consumers' surface mapping. In other words, consumers are not likely to expect the RNPs to carry the same features as source products.

Overall, these findings demonstrate that product appearance can significantly

influence consumers' comprehension of RNPs. More specifically, through manipulating visual complexity, transparency, and product metaphor, designers can facilitate consumers' processing fluency, consumers' learning of the innovative functionality, and consumers' analogical learning, which can enhance consumers' comprehension of RNPs.

6.2 Theoretical Contributions

This thesis has important theoretical contributions. As stated in Section 2.2, the main contribution of this thesis lies in the investigation of the influence of product appearance on consumers' comprehension of RNPs. We built on theories from two areas, including literature on strategies for promoting RNPs used in advertisements and the literature concerning the role of product appearance in consumers' processing. Based on the review of the current strategies, the limitations were discussed and the importance of designing product appearance to facilitate consumers' comprehension of RNPs was highlighted. More specifically, this investigation makes the following theoretical contributions:

First, this thesis contributes to the current research by exploring the role of product appearance in the early stage of the product life cycle. Prior research has concluded that product appearance plays a more important role in the maturity stage of the product life cycle (Person et al., 2008). In the maturity stage, as it becomes difficult for products to compete in terms of technology and functionality, product appearance is used as a strategic tool to differentiate products in order to satisfy the tastes from different consumer segments and to slow down the speed of declining sales. However, the role of product appearance largely remains unexplored in the early stage of the product life cycle. In the introduction stages, companies tend to spend fewer resources on designing product appearance (Levitt, 1965; Person et al., 2008). Companies often design product appearances similar to other products in the product category to reduce the risk for consumers' trying out a new product (Person et al., 2008), and reduce the cognitive efforts to learn a new product (Mugge & Dahl, 2013). Regarding the role that the product appearance plays in the introduction stage, past research has conceptually discussed that product appearance may be important for consumers' comprehension of RNPs (Eisenman, 2013; Rindova & Petkova, 2007). However, whether and how product appearance can facilitate consumers' comprehension of RNPs remains unexplored. What factors within product appearance will influence consumers' comprehension of RNPs and which underlying mechanisms trigger this remain unclear. Therefore, the results of this research project demonstrate the role of product appearance in the early stage of the product life cycle. Rather than

differentiating products in the maturity stage, product appearance can facilitate consumers' comprehension of RNPs in the introduction stage, which further contributes to the success of RNPs.

Second, this research project contributes by revealing three ways (i.e., congruence between product appearance and product functionality, direct communication of product functionality, analogical learning) that influence consumers' processing of products. Prior studies related to the influence of product appearance on consumer responses have focused on investigating the effects of product appearance on various consumer responses, including consumers' aesthetic preferences (Hekkert et al., 2003; Hung & Chen, 2012), consumers' perception of product performance (Creusen et al., 2010; Mugge & Schoormans, 2012a, 2012b), and consumers' perception of environmental friendliness (Lee, Jung, & Chu, 2015) . Limited research efforts have focused on investigating the influence of product appearance on consumers' comprehension. This research project extends this line of research by investigating the influence of product appearance on consumers' comprehension of RNPs. More specifically, literature related to consumers' processing mainly focused on the categorization role of product appearance, such as investigating the influence of typicality of product appearance on consumers' ease of categorizing a new product (Loken & Ward, 1990) and consumers' cognitive efforts for learning a new product (Mugge & Dahl, 2013). This research project extends these studies by demonstrating that product appearance can also influence consumers' processing of new products by other routes than categorization. Specifically, this thesis demonstrates that product appearance cannot only be used as a visual cue for influencing consumers' categorization of a product innovation, but also influence consumers' processing fluency, communicate the innovative functionality, and serve as a visual cue for triggering consumers' analogical learning.

The influence of congruence has been demonstrated in consumers' processing of packages (Van Rompay & Pruyn, 2011) and webpages (Van Rompay et al., 2010). This research project (Study 1) contributes to these studies by demonstrating the influence of congruence between product appearance and product functionality on consumers' processing of RNPs. Similarly, previous studies conceptually illustrated the potential of product appearance to communicate the innovative functionality of RNPs (Eisenman, 2013) and trigger consumers' analogical learning of RNPs (Hekkert & Cila, 2015). However, few research efforts have empirically investigated them and explored under what conditions these ways can assist consumers' comprehension. This research project contributes to these studies by demonstrating that transparency can directly communicate the innovative functionality of RNPs (Study 3&4) and that

product metaphors can trigger consumers' analogical learning (Study 5&6). Furthermore, this research project uncovers the conditions under which product appearance can facilitate consumers' comprehension of RNPs (i.e., when transparency shows working processes that are comprehensible for consumers, when the product metaphor is presented together with textual clues that explain the shared similarities between source and target RNPs).

Third, this thesis contributes to the discussion on the relationship between "form and function." Traditionally, there is a widespread notion of "form follows function" (Sullivan, 1896), which indicates that the final appearance of a product can be logically determined by the functions that the product must provide. Different from this notion, it is believed that although a product's functions may provide constraints to its appearance, the appearance can never be objectively defined by its functions. Thus, to a certain degree, designers can decide how a product should look, based on what consumers responses that designers intend to trigger (Crilly et al., 2009). In other words, product appearance and function interact with each other. Thus, while designing, designers or a product development team "should address both form and function as integrated – and interdependent – elements of product design (Luchs & Swan, 2011; p.336)." Following this, previous research has highlighted the necessity for investigating consumer responses to the interaction between product form and function (Luchs & Swan, 2011; Rindova & Petkova, 2007). The investigation on consumers' adoption of innovation is a relevant area (Bloch, 2011), which can shed light on the interaction between product appearance and function. This thesis fills this gap by focusing on the relationships between three factors within product appearance (i.e., visual complexity, transparency, product metaphor) and innovative product functionality; and further investigating how these factors together with the innovative product functionality influence consumers' comprehension. Results demonstrate that product appearance influences consumers' processing of products with common functionality and products with innovative functionality differently, which also suggests that different product appearances should be designed to embody products with innovative functionality, such as RNPs.

Finally, this thesis also has methodological contributions through involving designers and consumers during the investigation of each factor, which makes the results more actionable. To investigate the influence of product appearance on consumer responses, previous studies often solely focus on how consumers process and respond to product appearance (Blijlevens et al., 2009; Lee et al., 2015; Mugge & Dahl, 2013), or investigating how designers generate new designs (Cila, Hekkert, et al., 2014a, 2014b). Results of these studies deepen our understanding either of how consumers process

product appearance or how designers generate new designs. However, in order to provide recommendations for designers in practice, the knowledge from both perspectives are necessary. It is necessary to understand how consumers process product appearance. It is also crucial to learn how these knowledge can effectively support designers. In this thesis, across the three main investigations, both designers and consumers were involved. When the investigation started from the consumers' perspective (Study 1, Study 5), designers are involved to make use of the findings (Study 2) or generate product appearances for consumers' evaluations (Study 5). When the investigation started from the designers' perspective (Study 3), consumers are involved to validate designers' opinions (Study 4). In this way, the investigation remains a balance between theoretically revealing the effects of product appearance on consumers' processing and practically generating guidelines that are valuable for design practice. Consequently, results will not only inform designers on how consumers process product appearance of RNPs; but will also provide recommendations for designers on how to make use of this knowledge while designing RNPs. Example are the ways to achieve 'complexity in simplicity' (Study 2), the overview of possibilities that transparency can trigger (Study 3), and the recommendations for designing product metaphors in RNPs (Study 5 & 6).

6.3 Practical Implications

This investigation can provide practical implications in several ways. First, it provides implications for designers in their daily practice to embody RNPs. Second, it can support designers in communicating their designs with product development teams. Third, the results also help NPD managers while developing RNPs.

Implications for Designers

Designers often rely on their intuitive judgements and 'educated guesses' to design products, which can carry the risk that designers are not representative of the target consumers. To overcome this risk, investigating consumer responses to product appearance can support designers (Crilly et al., 2004). Results of this research project can provide such supports for designers so that they can embody the RNPs effectively. According to previous research findings, consumers often have difficulty comprehending the innovative functionality of RNPs (Hoeffler, 2003). This thesis specifically generates knowledge on how to design the appearance of RNPs to facilitate consumers' comprehension. As comprehension results from consumers' cognitive processing of product appearance, which is difficult to speculate by consumers themselves, results of this research project provide valuable support for

designers to understand how consumers process the appearance of RNPs.

This research project focuses on RNPs but the implications of results are not only limited to designing RNPs. The results can also be applicable to some INPs that consumers' find difficult to comprehend. Specifically, the adopted technology is not the sole factor that influences consumers' difficulty for comprehending a product innovation. Whether consumers have been exposed to similar products before also influences their comprehension (Garcia & Calantone, 2002). Therefore, even though a product innovation is an INP in one market, where consumers are familiar with it, it can be totally new to consumers in another market, due to which consumers may encounter difficulty in understanding it. For example, nowadays, the Nespresso coffee maker is an INP in European markets because consumers are very familiar with it. In contrast, for Chinese consumers, it can be a RNP. As most of Chinese consumers do not have the habit of making coffee at home, the coffee maker is already new to them. The Nespresso coffee maker is even more innovative due to its involvement of capsules. In other words, for a product innovation, the level of difficulty that consumers can encounter largely depends on the target consumers. Therefore, before designing, designers need to assess how difficult it will be for consumers to comprehend a product innovation. If consumers encounter difficulty, designers can consider using the results in this thesis to facilitate consumers' comprehension.

This research project demonstrates three factors (i.e., visual complexity, transparency, and product metaphor) that influence consumers' comprehension of RNPs. Designers can make use of these factors to facilitate consumers' comprehension of RNPs. While designing, designers need to consider when to use which factor because each of them triggers a different underlying mechanism. The choice for using a specific factor depends on the product category and the characteristics of RNPs. These considerations when used in conjunction with research findings from this thesis, can deepen designers' understanding on the influences of product appearance on consumers' comprehension of RNPs, which can provide insights for designers' practice. Below, these findings are translated into several recommendations for designing appearances of RNPs.

- **Decide the category membership of a RNP**

While designing, designers need to firstly determine the category membership. This decision can be made together with managers. As stated in past research, a RNP is often associated with the freedom to be categorized into an existing (sub)product category or to establish a new product category (Hoeffler & Herzenstein, 2011).

The decision of category membership depends on whether there is existing category

knowledge available for learning a RNP. If the knowledge required for comprehending a RNP shares similarities with the knowledge in an existing product category, designers and managers can consider assigning the RNP into the existing product category. Thus, the category knowledge can be used for comprehending the RNP. Furthermore, to highlight the innovative features of a RNP, managers and designers can consider establishing a sub-product category. For example, the first smart phone was assigned into the product category of mobile phone because it is used for making phone calls. To highlight the innovative feature of smart phone, the sub-category of 'smart phone' is established. In this way, the category knowledge of mobile phone can be used for comprehending a smart phone. The word 'smart' also suggests the differences between a smart phone and a traditional mobile phone.

Differently, for some RNPs (e.g., smart home system), if there is no well-established product category knowledge available, designers can consider establishing a totally new product category for the RNP. In this case, to facilitate consumers' comprehension, although no category knowledge is available, designers can think of whether there are existing concepts/products that are similar to the RNP. If so, designers can make use of the knowledge related to the existing concepts/products through analogical learning. Designers can design product metaphors to facilitate the analogical learning process. In this process, designers need to make sure that the RNP has no clear categorization membership. In this way, analogical learning can be triggered and it will not be confounded with categorization effects.

- **Appearance of RNPs should be congruent with consumers' perception of a RNP (Chapter 3)**

While designing, designers should make sure that the inferences consumers gained from the appearance of RNPs match with consumers' perception of the innovative functionality of RNPs. As consumers process RNPs as a whole, the congruence between product appearance and product functionality influences processing fluency, which further influences consumers' comprehension of RNPs. Designers can thus design product appearance to trigger the congruence between product appearance and product functionality of RNPs.

Consumers can form various perceptions related with RNPs. Designers need to firstly understand consumers' perceptions related to a RNP. Next, designers should attempt to design the RNP in the way that is congruent with consumers' perception. Designers also need to ensure the created appearances of RNPs are aesthetically attractive. For example, consumers often relate RNPs with complexity because they consider the integrated innovative technology highly complicated. Therefore,

improving visual complexity is one way to trigger congruence with the innovative functionality of RNPs. To improve visual complexity, designers can highlight the innovative functionality of RNPs, create contrasts, and use different colours and finishing. Yet, it is also important to make sure the product appearance is aesthetically attractive. Thus, the overall simplicity should be maintained. Designers can create the overall shape in simple and coherent way. The elements within the product appearance should share some similarities to keep the overall simplicity.

- **Be bold to show the innovative technology adopted in a RNP, as long as it is comprehensible for target consumers (Chapter 4)**

To facilitate consumers' comprehension of RNPs, designers can directly communicate the adopted innovative technology. Designers can show the working process of the adopted innovative technology. When seeing it, consumers can gain clues for the innovative technology, which helps them comprehend the RNP. In Dyson vacuum cleaner, a transparent cover is used to show how the innovative technology works, which helps consumers' comprehension. While showing working process, designers need to show the dynamic working process of integrated technology of RNPs. The exposure of static internal components is not likely to assist consumers' comprehension. Designer should also ensure that the exposed working process is comprehensible for target consumers. Seeing how a vacuum cleaner works is comprehensible for consumers, while seeing how a digital camera works is likely to confuse consumers. Moreover, designers can show the immediate results of the innovative technology of a RNP. Through observing the immediate results, consumers can learn the results of the adopted technology in the RNP and feel its effectiveness, which assists their comprehension of the RNP. In the example of Telfal ActiFry, consumers can see through the transparent cover and observe the immediate changes of food inside, which contribute to consumers' comprehension of the innovative technology integrated.

Using transparency is one way to show working process. Designers need to carefully consider whether the working process is comprehensible for consumers or not, in order to decide whether to expose the working process or not. If working process is comprehensible, designers can expose the working process. Designer should make sure the exposed parts communicate dynamic working process of innovative technology. Designers can also try to show the immediate results of innovative technology, in order to facilitate consumers' comprehension.

- **Give an opportunity for "existing products/concepts" (Chapter 5)**

When RNPs establish a new product category, designers can still make use of consumers' existing knowledge to stimulate their comprehension of RNPs. Designers can search for source products from these "existing products/concepts" that share

strong similarities with target RNPs. The selected source products should share strong underlying similarities with target RNPs. The functions or characteristics of source products/concepts should strongly align with target RNPs.

As RNPs are completely new, searching for existing products/concepts may be difficult. Designers can consider products from distant product categories. Designers can also think of animals or persons. While searching for inspirations, designers need to explore the essential functions/benefits/characteristics of these sources. The most salient functions/benefits/characteristics of sources need to be powerful to explain the benefits of target RNPs. Moreover, designers should notice that the selected sources should not conflict with target RNPs, and they should not relate with negative associations.

Furthermore, while designing product metaphors, designers also need to ensure that the appearances of RNPs physically resemble the source products/concepts. Thus, consumers can identify the source products/concepts, and further activate the related knowledge to learn RNPs.

- **Remember to give clear clues on the shared similarities (Chapter 5)**

While using product metaphors, designers need to remember to explain the shared similarities between source products and target RNPs. Consumers often have difficulty for identifying similarities between the source products and target RNPs. Therefore, it is necessary to explain such similarities. To explain such similarities, designers can use different ways, such as presenting them textually in printed advertisements and packages, explaining them verbally in radio/television advertisements, and printing them textually on the product appearance of RNPs.

Implications for Communication in Product Development Team

In a product development team, designers are not the only ones who determine product appearances. Other stakeholders can also influence the appearances of RNPs, which may alter the appearances that designers originally designed. In this situation, designers need to communicate with other stakeholders, in order to convince or compromise with them (Crilly et al., 2009). Design works are essentially difficult to measure and speculate the underlying rationales. Designers and stakeholders have different knowledge backgrounds, which makes it even more difficult for designers to self-explain and further convince others. In this process, designers often need to refer to materials or competitors to explain the rationales underlying their design works and the expected effects of the design works (Crilly et al., 2004).

Results of this investigation can provide support for designers' communication with

other stakeholders in the product development teams. Results of six studies explain the consequences of using certain factors in the appearance of RNPs and clarify the underlying reasons that lead to these consequences. For example, as improving visual complexity and using transparency in product innovations can increase manufacturing costs, designers may encounter more difficulty in convincing other stakeholders. In this situation, in order to better communicate with other stakeholders, designers need to explain the rationale and consequences of increasing visual complexity and using transparency.

Implications for NPD Managers

In order to facilitate consumers' comprehension of RNPs, several strategies have been developed to help managers promote RNPs effectively in advertisements, such as analogical learning strategy and mental simulation strategy (Feiereisen et al., 2008; Gregan-Paxton & John, 1997; Reinders et al., 2010). Although advertisement is an important channel that managers can use, results of this research project demonstrate the influence of the product appearance on consumers' comprehension of RNPs. Thus, managers should be aware that product appearance can also fulfil the aim of enhancing consumers' comprehension of RNPs. During RNP development, managers can include the consideration for enhancing the consumers' comprehension of RNPs in design briefs and stimulate designers to fulfil it.

Moreover, in advertisements of RNPs, as the pictures of RNPs are often presented, managers can make use of product appearance together with advertisements to facilitate consumers' comprehension of RNPs. The joint effects of product appearance and advertisements can even enhance consumers' comprehension of RNPs. For example, the air humidifier from Dyson adopts the innovative technology of an air multiplier, which amplifies airflow and produces a long-range stream of airflow. To promote the RNP, the product picture is presented in its promotion material (see figure 6.1a). The 'complexity in simplicity' style is adopted in its appearance. The overall appearance is simple and coherent. The visual complexity is improved by three parts horizontally arranged and using a transparent cover to expose the internal components in the middle part. In this way, based on research findings from study 1, consumers can perceive congruence between its complex appearance and its innovative functionality. Moreover, in the introduction materials of its adopted technology, a more detailed illustration is presented (see Figure 6.1b), which shows highly complex components inside the product. In this way, when seeing this illustration, consumers can also perceive congruence, which can bring fluent processing and enhanced comprehension. Overall, both the appearance of the air

humidifier and its promotion materials include visual complexity, which triggers consumers' perceived congruence, leading to enhanced comprehension.

Figure 6.1a Product picture of Air Purifier from Dyson.

Figure 6.1b Promotion material for Air Purifier from Dyson.

The usage of transparency in the appearance of RNPs can also be used together with advertisements. Transparency can assist consumers' comprehension of RNPs through displaying the working process. By seeing how a product works, consumers can gain direct and intuitive comprehension of RNPs. In addition to using transparency in RNPs, such a working process can also be revealed through illustrations in product promotions, which can assist consumers' comprehension. The Dyson vacuum cleaner is an example that uses transparent cover to show the working process and provides visual clues in advertisements (see figure 6.2). In this way, consumers can gain better comprehension.

Figure 6.2 Promotion material for vacuum cleaner from Dyson.

Furthermore, product metaphors can be used together with analogical learning strategies in advertisements. For example, MegNeo is an AR intelligent device for children, which allows children to capture images and some natural objects. Then, rich

media related to the images or objects will be presented on top of it. The appearance of this product involves the product metaphor of a magnifying glass (see Figure 6.3), which can assist consumers' comprehension of this AR device. In the promotion materials, the innovative function is introduced with an analogy to the function of a magnifying glass: just look and you know everything. The analogy of a magnifying glass used in this RNP is coincidently the same as the stimuli used in study 5 and 6. The analogy in promotion materials, and the product metaphor together can enhance consumers' comprehension towards this RNP.

Figure 6.3a Product picture of MagNeo AR device

Figure 6.3b Promotion material of MagNeo AR device

6.4 Limitations and Future Research

Although the studies reported in this thesis were carefully conducted, there are still some limitations. First, the stimuli used across six studies were a combination of pictures of product innovations and textual descriptions that explained the innovative functionality of RNPs. The combination of product pictures and functional descriptions was also used as stimuli in previous studies to study consumer responses to product innovations (Dahl & Hoeffler, 2004; Mugge & Dahl, 2013). To study consumer responses to product appearance, product pictures are often used as stimuli as well (Creusen et al., 2010; Mugge, 2011). Thus, using product pictures and textual descriptions are valid and an effective way to investigate consumers' comprehension and product appearance. At the present time, with the widespread of online shopping, the presence of product pictures and textual descriptions also resembles the way that consumers encounter RNPs online. However, consumers can encounter RNPs in different occasions, such as learning RNPs through videos on social media websites and through retail stores. For example, when consumers encounter a RNP in a retail

store, the actual product is physically presented, and most likely, a salesman is around to introduce the product. Perhaps, consumers are allowed to try out the RNP. In this situation, product appearance can play a different role. As salesmen can introduce the innovative functionality, consumers can spend more effort on observing the appearance of the RNP. While trying out the RNP, consumers can gain more information from it, such as through seeing the flashing lighting on its appearance, hearing the sound during product operation, and the interaction between the RNP and consumers. These information will influence consumers' comprehension of the innovative the innovative functionality provided by RNPs. Therefore, future research can use physical products as stimuli to investigate how it influences consumers' comprehension of RNPs. Results can provide knowledge for designers not only on how to design appearance to facilitate consumers' comprehension of RNPs, but also how to make use of lighting, sound, and interaction to influence consumers' comprehension of RNPs.

Second, across different studies in this research, participants were collected from Netherlands or China. The sampling strategy resulted from a combination of convenience and purposive consideration. First, the participants were recruited because their response can help us reach the research goals. Specifically, while conducting experimental studies (i.e., Study 1, Study 5), we collected Dutch people from a consumer panel, which was experienced in collecting data for experimental studies. While conducting consumer interviews (i.e., Study 4, Study 6), we recruited Chinese consumers from a city in China because their response can help use learn consumers' interpretations. For the designer interviews (i.e., Study 2, Study 3), experienced designers were collected from personal contacts due to their expertise. Moreover, these participants were collected due to the convenient accessibility. After confirmation of the suitability for the research goals, we selected these participants because they were easy to access. However, we are aware that consumers' cultural background influences their comprehension of certain product innovations. For example, coffee maker is a common product for Western people, but it can be a RNP for Chinese people because Chinese people do not have the coffee culture. Therefore, it would be interesting for future research to replicate the findings in the thesis with different groups of participants, such as different cultural background and geographic locations. Second, this research focuses on RNPs whose appearances are largely independent from the integrated technology. As a consequence, all RNPs provided ample freedom concerning the possible product appearances. However, in some situations, the appearance of a RNP can be influenced or even shaped by the technological innovation. In this case, designers may have less freedom to embody

RNPs. An example is the air humidifier from Dyson (see Figure 6.1a), which integrates the air multiplier technology. This innovative technology requires overall the shape in a circle, in order to create a powerful stream of airflow from different directions. Although its appearance is heavily constrained by the adopted technology, we believe there is still sufficient space for designers to embody it and try to facilitate consumers' comprehension. For example, the overall appearance is simple. The product is divided into three parts. This product also involves transparency and different finishing and colors, which improve visual complexity. In this way, when seeing it, consumers are likely to infer innovative functionality associated with this product, which can trigger processing influencing and result in enhanced comprehension. Nevertheless, it would be interesting for future research to validate whether the findings in this research project can be applicable in situations where RNPs' appearances are largely determined by its adopted technology.

Third, this research mainly considered technological driven innovation. However, technological innovation is not the only innovation strategy used by companies nowadays, another innovation strategy can be design-driven innovation. Different from technological-driven innovation, design-driven innovation proposes new meanings for products (Verganti, 2009). New meanings are often concerned with emotional and symbolic aspects of a product innovation (Rampino, 2011). Similar to technological-driven innovation, design-driven innovation also involves a radical change to the meaning of a product. As a result, it also requires time for consumers to comprehend and appreciate it. In this situation, perhaps, consumers may also lack comprehension of the new proposed meaning. As the product innovation proposes totally new meanings which go beyond consumers' existing experience and knowledge, consumers can encounter difficulties in comprehending the new meanings. Muji CD player is an example resulting from design-driven innovation. This CD player reinterprets the meaning of a CD player from a cold electronic product into a device that creates an intensive music experience. To do so, this CD player allows consumers to turn it on through pulling the string just like controlling a fan, which aims to create the experience of music flowing out just like air flowing. To comprehend this radically different meaning, consumers need to have experience with controlling a traditional fan and comprehend the proposed meaning of music coming out from air, which can be difficult. Future research needs to be conducted to reveal why consumers may face difficulty comprehending new meanings and the ways to assist their comprehension.

Figure 6.4 Product picture of Muji CD player

Fourth, while investigating consumers' comprehension, this thesis focused on consumers' subjective comprehension during first encounters because it has been demonstrated as an important predictor for consumers' further adoption decisions (Raju et al., 1995). Another dimension of consumers' comprehension is consumers' objective comprehension, which measures how precisely consumers understand the given information (Mick, 1992). During consumer' adoption of RNPs, the prominence of consumers' subjective comprehension and objective comprehension can be different. In the five stages of the consumers' adoption process (knowledge, persuasion, adoption, confirmation, and implementation), consumers' subjective comprehension plays a prominent role in the knowledge stage because it determines whether consumers comprehend the main benefits and functionality of RNPs and whether they will further consider it. Consumers' objective comprehension can be more crucial in the confirmation and implementation stage. In these stages, consumers start to operate a RNP. They need to comprehend how to operate a RNP, how to deal with it when the RNP does not work normally, and how to constantly benefit from it. The lack of objective comprehension can lead to failure in the consumers' confirmation and implementation of a RNP, which may lead to consumers' rejection of the RNP. Thus, future research can focus on investigating consumers' objective comprehension.

Fifth, this research project focuses on investigating the influence of product appearance on consumers' comprehension of RNPs. To conduct this research, the investigation was specified into three factors: visual complexity, transparency and product metaphor. The investigation was conducted separately for each factor. However, among these three factors, there can be interaction effects. For example, the

involvement of transparency can enhance visual complexity of appearance of RNPs. As found in Study 2 and Study 3, involving transparency can improve visual complexity. These interaction effects among these factors were not investigated in this thesis, which can be interesting for future research.

Finally, to facilitate consumers' comprehension of RNPs through product appearance, the three factors investigated in this thesis are not exhaustive. There could be additional factors that remain unexplored, which carry the potential to facilitate consumers' comprehension of RNPs. For example, in addition to visual complexity there can be other factors that can be congruent with the innovative functionality of RNPs, such as certain personality trait, angular or round shapes, and certain materials. Future research can continue exploring other factors within product appearance. Moreover, product appearance cannot only influence consumers' comprehension of RNPs, but also influence other factors of consumers' adoption of RNPs, such as consumers' emotional responses towards RNPs (Wood & Moreau, 2006), observability of RNPs (Rogers, 1995), and the perceived risks that consumers associate with RNPs (Ram & Sheth, 1989). Thus, future research can investigate how product appearance influences consumers' emotional response towards RNPs, observability of RNPs, and consumers' perceived risks. Together with findings from this thesis, results can make a significant contribution to the development of successful RNPs.

Appendices

Appendix A: Textual Descriptions of INPs and RNPs Used as Stimuli in Study 1

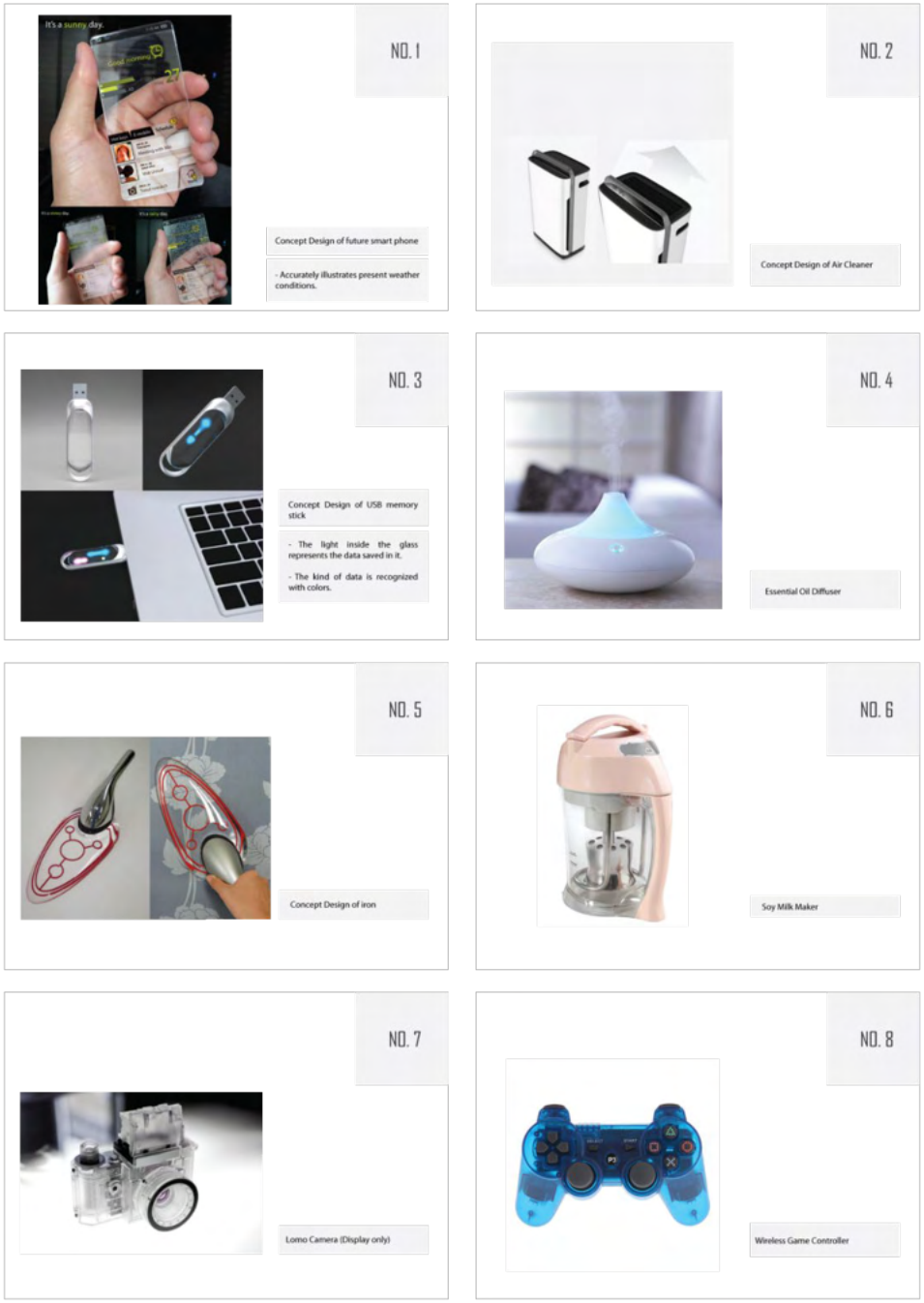
	Incrementally New Product (INP)	Really New Product (RNP)
Iron	JC-X3 is a new iron. This iron has a more powerful heating element to produce steam continuously. This will allow the iron to moisten the fabric evenly, and to remove the wrinkles in clothes faster. Furthermore, the iron has three different levels for producing steam and weighs 0.50 kg.	JC-X3 is a new iron. This iron produces ultrasound waves rather than steam to iron clothes. This will allow the iron to remove the wrinkles in clothes with little pressure. Furthermore, the iron has three different levels for producing ultrasound waves and weighs 0.50 kg.
Electric Kettle	The KL-T3 is a new electric kettle. This kettle incorporates a heating element with a higher wattage. This will allow the kettle to heat water in a much shorter time. Furthermore, the kettle has a safety system against short circuit and boil-dry, and it can contain 1.6 L water.	The KL-T3 is a new electric kettle. This kettle incorporates an advanced technology that can produce UV rays. This will allow the kettle to purify water while heating water. Furthermore, the kettle has a safety system against short circuit and boil-dry, and it can contain 1.6 L water.
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.

Appendix B: Product Appearances Used as Stimuli in Study 1

	Simple appearance (Used in main study& pretest 2)	Complex appearance (Used in main study & pretest 2)	Complex appearance (Used in pretest 2)	Complex appearance (Used in pretest 2)	Complex appearance (Used in pretest 2)
Iron					
Electric Kettle					
Hairdryer					

Appendix C: Stimuli Used in Study 3 and Study 4

All the presented stimuli were used in study 1. The following stimuli were used in study 2: 4, 6, 9, 10, 11, 12, 13, 16, 18, 19, 20, 22, 24, 25, 31, 32.



NO. 9

Mini Digital Portable Speaker

NO. 10

PC chassis

NO. 11

Handheld Vacuum Cleaner

NO. 12

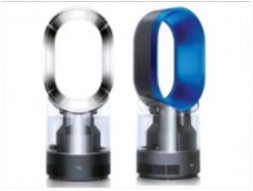
Handheld Vacuum Cleaner

NO. 13

Humidifier

- Provides 96% bacteria free warm mist

NO. 14



Humidifier

- Uses ultrasonic to humidify the air
- Use ultraviolet to kill bacteria

NO. 15

Concept Design of Tablet

NO. 16

Concept Design of TV

NO. 17

Concept Design of Air Conditioner

NO. 18

Washing Machine

- Provides very efficient washing by adoping duel rotating drum.

NO. 19

Electric Kettle

NO. 20

Stove

NO. 21

Toaster

NO. 22

Fryer

- Adopts ActiFry Technology to fry food

NO. 23

Personal computer displayer

NO. 24

Wireless camera

NO. 25

Coffee dripper

NO. 26

Power bank & Air purifier

NO. 27

Radio

NO. 28

Stand Mixer

NO. 29

Coffee Maker

NO. 30

Sound

NO. 31

Hair Dryer

NO. 32

Living Colors Generation Lamp

Appendix D: Table Comparing Actual Design Intentions and Anticipated Design Intentions Identified in Study 3

Anticipated Design Intentions found in Study 3	Actual Design Intentions	Product Examples	Selected product descriptions related with design intentions of using transparency
Convey different symbolic meanings	Communicate Freshness	No.4. Essential oil diffuser	Dew brings the freshness … into your everyday life.
Convey different symbolic meanings	Communicate compactness	No.9. NiZHi TT-028: mini digital portable speaker	Elegant and stylish in appearance, compact and portable. With unique transparent acrylic design and colorful lighting function, making it more fascinating!
Convey different symbolic meanings	Clean and freshness.	No.17. Electrolux Green AC: concept design of air conditioner	The louvers were made in transparent and frosted plastic which gives the impression of clean and fresh air.
Convey different symbolic meanings Enrich consumers' sensorial experience by appreciating the process	Cleanness. Watch water boil.	No.19. Breville Crystal Clear: electrical kettle	A clean taste starts with clean water. How do you ensure a more pure boil? With the natural purity of glass -- easy to see, easy to clean. So simply elegant, you may want to watch water boil.
Convey different symbolic meanings	Simple	No.25. Biduhaev cold brew system coffee dripper	This is an extreme simple product.
Convey different symbolic meanings	Minimalistic. Reveal inside components.	No.27. Lexon Flow FM radio	The main goal in creating Flow was to design a minimalistic radio, limiting the design to the strict minimum. The idea was to offer the user the possibility to discover and understand the industrial design of the object by allowing, with the transparent casing, to see inside and see the composing elements
Introduce a novel visual style	Novel style	No.15. Concept design of tablet	Sometimes, however, once comes across our desks that catches our eye.
Introduce a novel visual style	Distinct visual style	No.23. Apple Mac G3: personal computer displayer	It's hard to beat Apple when it comes to recognisable products and the 1998 iMac is no exception. This all-in-one monitor and

			computer has the same visual impact today as it did then.
Create special visual effects	High aesthetic value	No.30. Harman Kardon SoundSticks III	Improving on its famous sibling's pop-culture appeal, the SoundSticks III system is all that and much more.
Project an engaging product experience	Enrich product experience	No.2. Concept design of air cleaner	A very iconic transparent screen to show the lighting and information. Intuitive experience.
Project an engaging product experience	Enrich product experience	No.3. Concept design of USB memory stick	It would be more fun if the lights can move in the glass when you shake it.
Project an engaging product experience	Satisfy consumers' curiosity	No.7.Konstruktor transparent collector's edition Lomo camera (display only)	Konstruktor Transparent Collector's Edition lets you discover the magic inside.
Enrich consumers' sensorial experience by appreciating the inside content	Reveal view of fire	No.20. Hase Asmara stove	Hase Asmara woodstove offers beautiful view of the fire from 3 sides and with its high slim shape a leading design.
Provide immediate feedback	Communicate immediate information.	No.21.Magimix vision toaster	The worlds first see-through toaster. For toast, just the way you like it. Visual control, easy to use, long-life quartz elements, double insulated.
Demonstrate innovative technology	Demonstrate technology	No.10. In Win TOU aluminium frame PC chassis	When illuminated from the inside with your system on, the tòu's mirror coating becomes transparent, showing off your internal hardware and hopefully reassuring your $800 purchase.
Demonstrate innovative technology	Demonstrate technology	No.16.Concept design of television	As the first of its kind, the Loewe Invisio introduces technical innovation, combining conventional LCD and the latest TOLED display technology.

Appendix E. Product Descriptions Used in Study 5 and Study 6

Product category of XT02 (oral health monitor)
XT02 is a portable device to improve the oral healthcare by monitoring breath quality and hydration levels. XT02 draws a sample of air from the mouth and analyzes this sample by measuring the organic compounds released by various bacteria. Subsequently, XT02 reports the state of the oral and breath health to the smartphone app within seconds. Furthermore, XT02 tracks the changes of breath quality and hydration levels in time, and provides personalized guidance on cleaning routine and diet. XT02 is small and easy to carry.
Product category of MS03 (molecular sensor)
MS03 is a molecular sensor that enables people to examine objects for their chemical composition and identification. MS03 projects a light source to illuminate the object at 2cm from the object. By measuring the interaction between the light and the molecular vibrations of the object, MS03 can detect the composition of the object and provide results on the smartphone app within seconds. Furthermore, MS03 can detect compositions for all kinds of things, such as objects, food, medicine, etc. MS03 is small and easy to carry.

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