"Smart Home System is Like a Mother": *The Potential and Risks of Using Product Metaphors to Influence Consumers' Comprehension of Really New Products*

Peiyao Cheng [1,*], Ruth Mugge [2], and Cees de Bont [3]

[1] *Design Department, Faculty of Social Science, Harbin Institute of Technology (Shenzhen), P.R. China*
[2] *Department of Product Innovation Management, Faculty of Industrial Design Engineering, Delft University of Technology, the Netherlands*
[3] *School of Design and Creative Arts, Loughborough University, United Kingdom*

Driven by innovative technology, really new products (RNPs) incorporate new functions that provide significant benefits for consumers. Consumers, however, often experience difficulty understanding RNPs, which hinders their further adoption. To facilitate consumers' comprehension, the use of product metaphors in RNPs is a promising strategy because it relates a target RNP to a source product/concept familiar to consumers. By using knowledge from the familiar source, consumers could gain better comprehension of the RNP. However, product metaphors can also carry risks that hinder consumers' comprehension of RNPs, such as consumers' misidentification of the source and their inability to use the relevant knowledge to comprehend RNPs. This research investigates the potential and risks of using product metaphors for RNPs through a mixed-methods approach. Specifically, an experiment and in-depth interviews were conducted to examine the effects of product metaphors on consumers' comprehension. Results revealed that consumers encounter difficulty in detecting the similarities between source concepts/products and target RNPs, meaning product metaphors may not necessarily enhance consumers' comprehension. Accompanying a product metaphor with a textual clue can help consumers detect the similarities between source concepts/products and target RNPs, leading to enhanced comprehension. Implications for theory and practice are discussed.

Keywords **–** Analogical Leaning, Consumers' Comprehension, Product Metaphor, Really New Products.

Relevance to Design Practice **–** This research provides important insights into designers' usage of product metaphors in RNPs, including the potential and risks of their use for influencing consumers' comprehension.

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Introduction

Emerging technologies drive a number of innovative products, such as a personal health monitor and a smart home system. Due to the integration of highly advanced technology, these innovative products are referred to as really new products (RNPs), which are also referred to as discontinuous or radical innovations. In contrast to incrementally new products (INPs) that provide improvements based on current functions, RNPs incorporate highly innovative functions that allow consumers to do things that they could never do before (Garcia & Calantone, 2002). An example of a RNP is "SmartThings" by Samsung (see Figure 1), which is a smart home system containing a hub and multiple smart devices connected to it. The smart devices collect various information about the home, such as energy consumption, the presence of family members, door locks, and entry movement that people can access through an app, allowing them to monitor and control their home remotely.

Although RNPs offer significant benefits, consumers often do not readily adopt them (Ram & Sheth, 1989). One of the barriers is that consumers experience difficulty understanding the innovative functions provided by RNPs (Hoeffler, 2003). According to consumers' adoption process, they need to first gain comprehension of RNPs in order to further consider their potential (Rogers, 1995). When encountering an RNP, consumers become aware of it, learn its features and benefits, and thus gain comprehension. Consumers may feel confident because they understand the RNP's features and benefits. At the same time, consumers could also feel confused and uncertain about the RNP's features and benefits. Comprehension, though, is paramount because consumers tend to disregard the RNP's potential if they lack comprehension. In other words, consumers' comprehension of RNPs is a precondition for further adoption (Reinders, Frambach, & Schoormans, 2010). As shown in prior research, consumers' lack of a clear understanding slows down the adoption of smart home systems (Balta-Ozkan, Davidson, Bicket, & Whitmarsh, 2013).

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Corresponding Author: chengpeiyao@hit.edu.cn

Figure 1. "SmartThings" of Samsung.

Thus far, design research has focused on investigating consumers' expectation and usage of high-tech products in daily life. For example, Pettersson (2017) explored consumers' expectations for autonomous cars. Montalván, Shin, Cuéllar, and Lee (2017) investigated how consumers adopt robotics at home. These studies provide effective support for RNPs' development. However, sufficient research efforts have not been made on the investigation of consumers' comprehension, even though comprehension is an important precondition for the adoption of RNPs (Reinders et al., 2010).

Designing product metaphors is a promising way to facilitate consumers' comprehension of RNPs. It is a common design practice that relates a RNP to a familiar product. For example, similar to "SmartThings" (Figure 1), "Mother" is a smart home system that is embodied in the product metaphor of a mother (see Figure 2a). Through relating the smart home system to the role of a mother at home, consumers are expected to comprehend the RNP more easily. In fact, to stimulate consumers' comprehension of RNPs, several marketing strategies have been developed through relating a RNP with a product/concept that is familiar to consumers, such as analogical learning (Gregan-Paxton, Hibbard, Brunel, & Azar, 2002) and product bundling (Reinders et al., 2010). By using the knowledge of the familiar product/concept, consumers can gain comprehension of the RNP.

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

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

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

However, although product metaphors hold the potential to facilitate consumers' comprehension of RNPs, it is questionable whether product metaphors are always effective (Hekkert & Cila, 2015). Specifically, consumers may not be able to build the association between the smart home system and the role of a mother. Moreover, even when consumers successfully build the association, the role of a mother at home is much more inclusive than the functions of a smart home system, which could lead consumers to overestimate the smart home system. These risks can hinder the effective communication of product metaphors for RNPs. Therefore, to help designers use product metaphors more effectively, we need more insight into product metaphors' potential and risks. This research aims to fill this gap.

Product Metaphor

By definition, a product metaphor "intentionally references the physical properties of another entity for specific and expressive purposes" (Hekkert & Cila, 2015, p.199). A product metaphor associates a source with a target product. More specifically, this association between the source and the target can be built on two levels: the conceptual level, where the source and target share the same meanings; and the physical level, where the source and target share physical similarities. Both levels of associations are indispensable for product metaphors (Forceville, Hekkert, & Tan, 2006; Hekkert & Cila, 2015; Van Rompay, 2008). While designing product metaphors, designers first select an appropriate source, which should inherently share conceptual similarities with the target product. Next, based on this conceptual association, designers need to build the physical association through resembling the shape of the source in the appearance of the target product. In the example of "Mother" smart home system, designers selected the role of a mother as the source to highlight the conceptual similarities between a smart home system that collects information about a home and a mother who often knows everything that is happening at home. Next, designers shaped the hub by including human-like features, such as eyes and a mouth (see Figure 2b), in order to encourage anthropomorphism and represent the image of a mother.

Designers use product metaphors in their designs for various purposes. Prior research has concluded that designers can hold experiential intentions for using product metaphors, including enriching product experience, triggering rich sensorial and emotional consumer responses (Hekkert & Cila, 2015). Designers

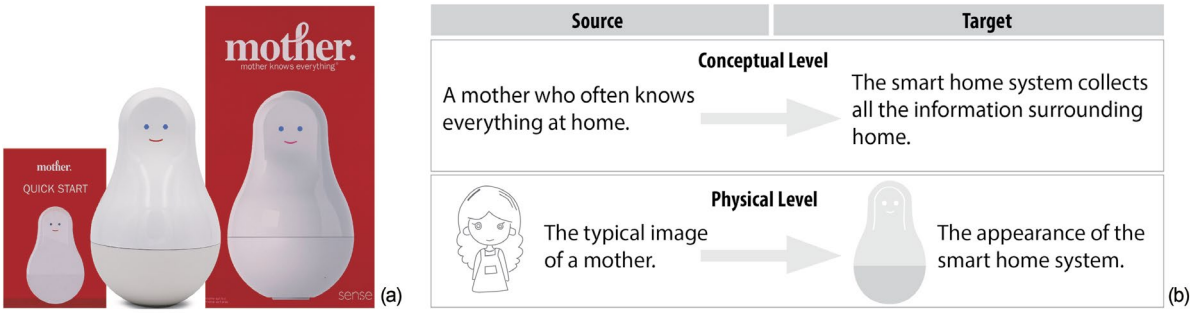

Figure 2. The smart home system: "Mother": (a) the product picture and (b) the two-level associations

can also hold pragmatic intentions for using product metaphors, where designers mainly aim to reduce consumers' cognitive load in recognizing a product and providing instructions for product usage and operation. Due to the different intentions, designers design product metaphors in different ways. To fulfil experiential intentions, designers can create an unexpected association between a source and a target as a catalyst for consumers' cognitive elaboration to discover the intended meanings, leading to a rich experience. For example, to enrich consumers' experience, a humidifier can be embodied in the product metaphor of a whale (see Figure 3a). When seeing it, consumers can recognize the source of a whale and figure out that the humidifier produces an airflow at its top like a whale expelling air through its blowhole, leading to enhanced consumers' appreciation. Differently, with pragmatic intentions, designers tend to focus on straightforward and direct associations between a source and a target, and physically translate the association in a clear and easily recognizable way (Cila, Hekkert, & Visch, 2014a). For example, to facilitate consumers' comprehension of the new product, the first e-book reader was embodied in the product metaphor of a physical book (see Figure 3b).

Product Metaphors in RNPs

When encountering product metaphors in target RNPs, consumers attempt to process and comprehend them. Different theoretical models can be found in the literature on consumer behavior to explain consumers' processing of new targets, such as the analogical learning theory (Gregan-Paxton & John, 1997), which is known as the comparison model in linguistic research (Genter & Wolff, 1997; Miller, 1993); and the categorization theory (Loken & Ward, 1990; Moreau, Lehmann & Markman, 2001), which is known as the categorization model in linguistic research (Glucksberg, 2003; Glucksberg & Keysar, 1990). Several studies compared the differences of how consumers process metaphors through different theoretical models in consumer behavior (Gregan-Paxton & Moreau, 2003) and linguistic research (Bowdle & Gentner, 2005; Jones & Estes, 2006). The analogical learning theory posits that targets are comprehended through aligning the properties of a source with the target and then projecting some of the properties to the target (Gregan-Paxton & John, 1997). The alignment process in the analogical learning theory is selective and based on particular similarities between source and target. The projection process is directional: information flows from source to target (Genter & Wolff, 1997; Miller, 1993). For example, to comprehend the expression that *a PDA is like a secretary*, the similarities between a PDA and a secretary (e.g., that both schedule and structure your appointments) are first identified and a relation is built. Next, the particular properties of the source (e.g., scheduling assistance) that are relevant are projected on the target, whereas others are considered irrelevant (e.g., bringing coffee) (Gregan-Paxton et al., 2002).

In contrast, the categorization model suggests that learning is achieved because the target is considered to be a member of the source category (Loken & Ward, 1990; Glucksberg, 2003;

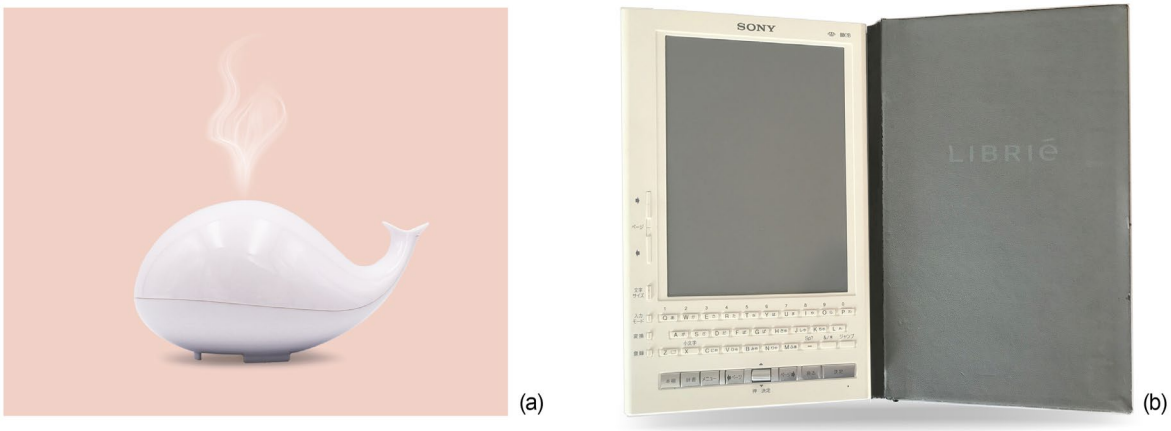

Figure 3. Product examples of product metaphors driven by experiential and pragmatic intention.
(a) a humidifier embodied as the product metaphor of a whale; (b) an e-book reader embodied as the product metaphor of a book.

Glucksberg & Keysar, 1990; Moreau et al., 2001). Following this, all properties of the source are activated and could be applicable for projecting on the target. For example, the expression that a PDA is a diary encourages consumers to see the device as a member of the category diaries and to transfer all properties of this source to it.

As this current research focuses on the pragmatic intention of using product metaphors for facilitating consumers' learning of RNPs, we propose that the projection process is directional and selective: the knowledge is transferred from source to target RNP and only particular similarities between source and target are transferred, whereas others are considered irrelevant. Consequently, the analogical learning process is most appropriate for explaining the effects triggered by product metaphors.

According to analogical learning process, product metaphors can reduce the cognitive load for consumers in understanding the unique and differentiating benefits of RNPs. As a product metaphor already integrates the conceptual association between a RNP and a source, the conceptual association becomes a basis for consumers to link a RNP to a familiar source product/concept. The target RNP physically resembles the source product/concept, which can help consumers to identify a source product/concept (Forbus, Gentner, & Rattermann, 1993). Proceeding with the 'Mother' smart home system example, the conceptual association is built between a smart home system and the role of a mother at home. Through recalling the role of a mother at home, consumers are expected to relate the benefit of the smart home system that collects information about a home. The anthropomorphized design of 'Mother' with the human-like facial features of eyes and a mouth will emphasize the relation to a human and encourage consumers to think of the role of a mother at home. Consequently, it is expected that with the product metaphor of 'mother,' consumers can more easily understand the smart home system.

Although product metaphors carry great potential, risks also exist that they might hinder consumers' comprehension of RNPs. As consumers need to interpret the product metaphor themselves, designers have no complete control of the interpretation process and there are possibilities for consumers' misinterpretation (Hekkert & Cila, 2015). For example, consumers may not be able to identify the source product/concept as designers intended. As a result, different knowledge can be activated, which will not support consumers' learning of the target RNP, leading to consumer confusion.

Considering the potential and risks of product metaphors for influencing consumers' comprehension of RNPs, it is necessary to empirically investigate the use of product metaphors in RNPs. Specifically, it is beneficial to know 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 can be triggered. It is also important to learn what risks are faced when involving product metaphors in RNPs and how to overcome such risks while using product metaphors in RNPs. This research aims to fill these research gaps.

The investigation of product metaphors on consumers' comprehension of RNPs can provide important contributions to the existing literature. Current research related to product metaphors focuses on how designers use product metaphors in their creative performance (Casakin, 2007), how designers generate product metaphors (Cila, Hekkert, et al., 2014a; Cila, Hekkert, & Visch, 2014b), and consumers' aesthetic appreciation of product metaphors (Cila, Borsboom, & Hekkert, 2014; Lin & Cheng, 2014). This current research can contribute to this line of research by focusing on the context of RNPs. As not all the product metaphors are equally effective, it is beneficial to investigate the effects of using product metaphors in specific contexts (Hekkert & Cila, 2015). More specifically, by investigating the use of product metaphors in RNPs, we tackle pragmatic intentions for using product metaphors, which extends current studies that focus on experiential intentions (Cila, Borsboom, et al., 2014; Lin & Cheng, 2014). Prior research has suggested that product metaphors with pragmatic intentions should focus on the most salient quality of the target product and design product metaphors in a direct and clear way (Cila, Hekkert, et al., 2014a). This implies that the most important and obvious characteristic of the target is selected to create an informative and suitable product metaphor. To illustrate, in the example of an e-book reader, designers focused on the most salient quality of an e-book: that it is intended for reading. Accordingly, designers selected the source of a book to create the product metaphor and designed an e-book reader through closely resembling a typical book (see Figure 3b). However, empirical studies are still lacking. Therefore, this research contributes to the literature on product metaphors by not only providing empirical evidence but also clarifying what potential and risks product metaphors carry for influencing consumers' comprehension of RNPs.

To accomplish this, we conducted two studies through mixed-methods approach. Study 1 aimed at investigating the effects of product metaphors on consumers' comprehension of RNPs. Specifically, we analyzed product metaphors based on three stages of the analogical learning process. We proposed that the positive effects of product metaphors on consumers' comprehension of RNPs can be triggered by presenting them together with textual clues that explain the product metaphors. A controlled experiment was conducted to test the hypothesis. Next, in Study 2, we continued to investigate what risks hinder consumers' comprehension of RNPs through product metaphors alone. Consumer interviews were conducted.

Study 1: *Effect of Product Metaphors on Consumers' Comprehension of RNPs*

This research follows the analogical learning theory to investigate consumers' processing of product metaphors. Analogical learning refers to the process where consumers use familiar knowledge (the source) to learn about a novel domain (the target). This process includes three stages: access, mapping, and transfer (Gregan-Paxton & John, 1997). This section analyses how product metaphors influence each stage of analogical learning.

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). When RNPs are embodied by using product metaphors, the integrated conceptual associations between source and RNP serve as a basis for consumers' access of knowledge in the source domain. The physical similarities can further help consumers to identify the source (Forbus et al., 1993).

However, the successful retrieval of a source by consumers depends on the identification of the correct source, as intended by its designers. If a different source is accessed, a different knowledge base is activated, leading to a failure of the analogical learning process. When the analogical learning strategy is used in advertisements, the source is often clearly stated and explained, such as relating a PDA to a secretary (Houssi, Morel, & Hultink, 2009). Nevertheless, when encountering a product metaphor, consumers need to identify the source by themselves. As suggested in prior research (Black, 1979), the key difference between metaphorical and non-metaphorical statements is that a metaphor may allow for multiple interpretations, which could be untrue and inconclusive. A product metaphor, as a specific type of metaphor, also carries the possibility of multiple interpretations. When encountering a product metaphor, consumers may relate it to multiple sources, which may differ from the one that was intended by designers (Hekkert & Cila, 2015). In the example of the 'Mother' smart home system, 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. As a product metaphor can possibly carry multiple interpretations, it can therefore hinder consumers' accurate access to a specific source domain, resulting in reduced consumers' comprehension of the RNP.

Mapping Stage

After a source domain is successfully activated, the mapping stage follows, where consumers need to identify one-to-one correspondences between sources and target RNPs. Such correspondences are built through either relational mapping or surface mapping. Relational mapping is built on an abstract and conceptual level, while surface mapping is established on a concrete level (Gregan-Paxton & John, 1997). Going back to the example of the PDA, the advertisement statement '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 (e.g., a PDA is like a mobile phone that uses wireless communication, and it has similar attributes to a mobile phone, such as display, keyboard, buttons, etc.; Houssi et al., 2009).

When a product metaphor is used for an RNP, the integrated conceptual association becomes the basis for consumers to build the relational mapping. 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, the knowledge used to understand the target RNP is ready to be transferred from the source domain, which may result in enhanced comprehension.

However, consumers may have difficulties for establishing the correspondences because it requires consumers' detection of the relationships between source domains and target RNPs (Roehm & Sternthal, 2001). Such detection requires consumers' expertise in the source domain (Novick, 1988) and available cognitive resources (Roehm & Sternthal, 2001). As RNPs are completely new, consumers may not know what should be mapped from the source domain. Thus, in order to help consumers' mapping, advertisements often clearly state the intended mapping from the sources to RNPs (Herzenstein & Hoeffler, 2016). In the example '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 map the correspondences between a PDA and a secretary in terms of making appointments and managing documents. However, with product metaphors, consumers need to detect such similarities and build the relational mapping by themselves, which may be difficult.

In addition, another risk that product metaphors carry is that the physical similarities may trigger surface mapping, which is likely to mislead consumers into expecting that RNPs have the features of the sources, while they do not. 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 the 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. For example, 'SSSSSpeaker' is a portable Bluetooth speaker (see Figure 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 functioanlity, the product metaphor used is a foldable cup for traverlers. The relational mapping is built between the portability of a travel cup and the Bluetooth speaker. However, the similar look of the two products is likely to trigger surface mapping as well. Consumers may also expect the speaker to be waterproof, which it is not, leading to confusion.

Figure 4. Product example of Bluetooth speaker 'SSSSSpeaker' in the product metaphor of a travel cup.

Transfer Stage

The transfer stage is considered the result of a successful analogical learning process (Colhoun, Gentner, & Loewenstein, 2008; Herzenstein & Hoeffler, 2016). After mapping one-to-one correspondences between source and target RNP, the relevant knowledge is ready to be used. In the transfer stage, consumers' learning occurs by transferring the relevant knowledge to the target RNP. In other words, if the risks of previous stages can be avoided, the relevant knowledge can be successfully transferred to the target RNP, leading to enhanced consumers' comprehension.

Additional Assistance to Balance Potential and Risks along the Three Stages: *The Presence of Textual Clues*

The use of product metaphor is promising in promoting consumers' analogical learning about RNPs and enhancing consumers' comprehension because it helps to integrate the conceptual association and the physical association facilitates consumers' identification of source domains. However, product metaphors also carry risks, including the following: 1) in the access stage, physical associations integrated in product metaphors may 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; 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.

Considering the potential and risks of product metaphors, the positive effects of product metaphors on consumers' comprehension of RNPs are more likely to be triggered when consumers receive specific assistance. Textual clues that explain the similarities between sources and target RNPs are likely to promote the positive effects of product metaphors, while avoiding the risks. As the presence of textual clues can state the sources clearly, consumers' identification of the source domain is directed to the one intended by designers, thus avoiding the possibility of other interpretations. 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' relational mapping and helps to avoid surface mapping, making it less likely for consumers to map 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. Among the multiple roles that a mother plays (e.g., knowing everything about the home, cooking and taking care of every family member), what needs to be mapped is also stated clearly: 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 positive effects of providing explanatory information have been demonstrated in consumers' comprehension of artworks (Leder, Carbon, & Ripsas, 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 an RNP, presenting a textual clue to explain the metaphor will enhance consumers' comprehension, compared to when such a textual clue is absent.

Method

To generate suitable stimuli for our main experiment, we conducted two design sessions and two pretests. 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 the participants to design product metaphors based on conceptual associations. Participants were required to integrate the selected concepts in physical forms. The designed product metaphors were validated in pretest 2. The stimuli creation process is explained in Appendix A.

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 possessing the expertise to search for sources (Cila, Hekkert, et al., 2014b).

RNPs were collected from the Consumer Electronic Show (CES), 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://trio.sensorwake.com/), a pan that measures 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 and a stand-alone shortcut button to control various digital devices (https://flic.io/). The briefs provided to participants described the key functions and benefits of the RNPs. The challenge was to think of other products/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, together with two examples of product metaphors. 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 (see Appendix A for the generated conceptual metaphors). 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. The research team reviewed all the generated metaphors and discussed the conceptual associations between the generated source concepts and the target RNPs and the degree to which this would help understanding the functions and benefits of the RNP in the mapping stage of the analogical learning process. Based on this review, the research team concluded that the conceptual metaphors that were mentioned more than one time had the strongest and most insightful conceptual associations between source and target RNPs. As a result, 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 design students (53% male) participated in pretest 1. In total, six conceptual metaphors were tested. Each participant evaluated three generated conceptual metaphors, and they were first presented with descriptions of the RNPs. The order of presentation was randomised. They were told that as the RNPs were highly innovative for consumers, companies aimed to use metaphors to explain them. 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 using 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'. Participants responded to these statements by choosing a number between 1 (strongly disagree) and 7 (strongly agree; α ranged from .77 to .92). Analyses were conducted separately for each generated conceptual product metaphor (see Table 1 for results). Consistent with prior research (Gregan-Paxton et al., 2002), the soundness of the generated conceptual metaphors and target RNPs only reached moderately high scores. It is likely that the high innovativeness of RNPs increased the difficulty of finding products/concepts that are perceived as highly sound. The generated conceptual metaphors with higher ratings for soundness were selected. Consequently, 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.

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 designing consumer durables. 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. It was also emphasized that the created metaphors should allow consumers' recognition of the source products at first sight to encourage a successful access stage in the analogical learning process. With respect to each conceptual metaphor, several sketches were created, resulting in ten sketched product metaphors for four conceptual metaphors. Next, the research team reviewed the created sketches to determine their possibility of bringing about other confounding effects in the experiment. Among the ten product metaphors, we decided to exclude the product metaphors of a flower for the odour alarm clock and the product metaphor scale for the smart pan from the research. While creating the stimuli, we realized that categorization effects may influence the effects for these product categories. As the overall product categories 'clock' and 'pan' are mature, people expect these products to adhere to specific category cues (e.g., a pan has a round metal cooking part and a handle) (Loken & Ward, 1990). As a result, these categorisation effects may confound with the effects of analogical learning process that is triggered by product metaphors. Therefore, the product metaphor of a mint container and a magnifying glass were selected for further stimuli creation.

Subsequently, among the sketches created for the product metaphors of a mint container and a magnifying glass, the research team reviewed them carefully based on the potential for instant recognition of the source (access stage) and the ability to transfer important associations (mapping stage), resulting in the selection

Table 1. Results of pretest 1: Soundness of generated product metaphors and RNPs.

Target RNP	Alarm clock with odour		Smart pan		Oral health monitor	Molecular sensor
Proposed conceptual metaphor	a Flower*	Perfume	Scale*	Thermometer	Mint Container*	Magnifying Glass*
Soundness Mean (SD)	4.56 (1.57)	3.98 (1.30)	3.95 (1.35)	2.87 (1.46)	3.85 (1.62)	4.02 (1.32)

Note: * The selected conceptual metaphors for Design Session 2

of the sketches that closely resembled the source products. Then, the designer was asked to elaborate on the sketches through 3D modeling and rendering as well as to finalize the graphic design. Consequently, the product metaphors of a magnifying glass for the molecular sensor and a mint container for the oral health monitor were created as stimuli for the main study. 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 2).

Pretest 2: Relatedness between Physical Forms and Intended Product Metaphors

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 design students were invited to participate in this study (mean age = 21.87, 56.4% male).

In pretest 2, for both conditions, we measured the relatedness between generated product metaphors and RNPs and the attractiveness of the generated product metaphors. The relatedness was measured to learn the extent to which the generated product metaphors were 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 was measured by a 7-point scale anchored with 'ugly/beautiful'.

Results were analysed separately for each product category. T-tests were conducted with the presence of product metaphors as the independent variable and relatedness and attractiveness 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 (see Table 3), ruling out attractiveness as a confounding effect. 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 2. Results of design session 2: Stimuli for conditions with and without product metaphors for both product categories.

	With product metaphor (Created appearance of RNPs)	Without product metaphor (Original appearance of RNPs)
Oral health monitor		
Molecular sensor		

Table 3. Results of pretest-2: Means(SD) for the relatedness and attractiveness of the stimuli.

		Relatedness*	Attractiveness
Oral health monitor	With product metaphor	5.73 (1.28)	3.25 (1.21)
	Without product metaphor	2.12 (0.72)	3.75 (1.02)
Molecular sensor	With product metaphor	6.53 (0. 81)	4.35 (1.27)
	Without product metaphor	1.82 (0.89)	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.

Participants (114 in total) were collected (mean age = 43.28, 36.9% male) from a consumer panel. Prior research has demonstrated that older adults performed poorly in analogical reasoning processes, which could be triggered by a decline in attention (Viskontas, Morrison, Holyoak, Hummel & Knowlton, 2004). The declining performance caused by age can be confounding with the analogical learning process triggered by product metaphors. Moreover, as previous studies revealed that most cognitive capabilities (e.g., attention, working memory and processing speed) start to decline at the mid-50s (Drag & Bieliauskas, 2010; Schaie, 2012), we invited participants who were younger than 55 years old.

Final Stimuli

The product designs from pretest 2 (product metaphors: present vs. absent) were combined with a 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)." This has been used in previous studies, and it effectively triggered analogical learning (e.g., Herzenstein & Hoeffler, 2016). With these textual clues, the risks carried by product metaphors could be avoided. Moreover, following the example of prior studies, the word 'like' was involved, as the direct use of 'is' can trigger categorisation effects that lead consumers to believe 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. Subsequently, 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 they evaluated two products on several measures. The order of presentation of the two products was randomised. The product description for each product category was provided to participants together with the final stimuli (see Appendix A).

Consumers' comprehension of the RNP was measured by asking participants to indicate to what extent they agreed on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree; α ranged from .888 to .890) with the following four statements (Feiereisen, Wong, & Broderick, 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."

Relatedness was measured as a manipulation check to learn to what degree the created product metaphors related to the intended sources. The measures were identical to the ones used in pretest 2 (α ranged from .95 to .98). Next, to avoid confounding effects, the attractiveness of the 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, Klink, Fort-Rioche, & Athaide, 2014). Consumer innovativeness was measured by four 7-point Likert scale items from 1 (strongly disagree) to 7 (strongly agree; α = .89) (Manning, Bearden, & Madden, 1995) (see Appendix B for measures). Moreover, consumers' ability to process visual metaphors varies (Van Rompay & Veltkamp, 2014). Consumers who are better at processing metaphors may produce more elaborate thoughts, and thus textual clues may provide less assistance. Consumers' tendency to process product metaphors was measured by eight 7-point Likert scale items from 1 (strongly disagree) to 7 (strongly agree; α = .88) (adapted from Van Rompay & Veltkamp, 2014) (see Appendix B for measures).

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, the presence of textual clues, and product category as independent variables, while the ratings of relatedness were 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

To test H1, 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, with the 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). Across two product categories, when product metaphors were present, participants reported better comprehension when textual clues were present, 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 4). These results support H1.

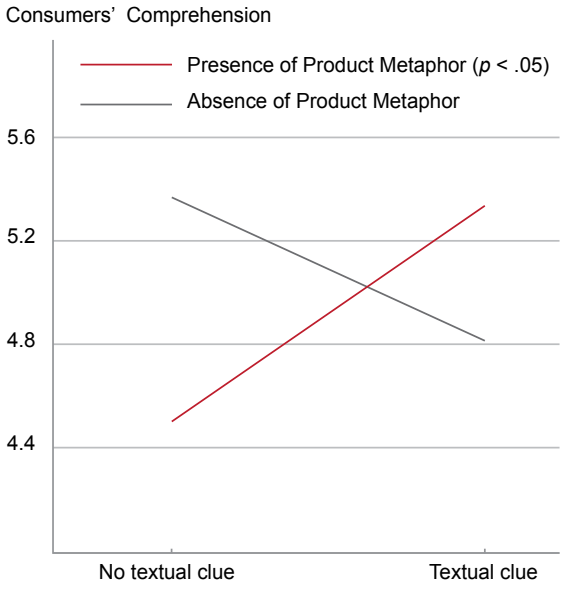

Figure 5. The interaction effect of the presence of textual clues and product metaphors on consumers' comprehension.

Discussion of Study 1

The results of Study 1 support our hypotheses. Study 1 demonstrates that the presence of a product metaphor and accompanying textual clues resulted in greater consumers comprehension of an RNP than when the product metaphor was presented alone. When a textual clue is absent, the sole presence of a product metaphor confuses consumers, leading to reduced consumers comprehension. The results demonstrate that the presence of textual clues can help avoid possible problems with consumer comprehension, while triggering 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.

The necessity of textual clues could be attributed to different reasons, as explained earlier. First, the risk at the access stage is that consumers will misidentify the intended source domain. Although this possibility exists conceptually, it is very unlikely to have been triggered in Study 1 because the stimuli used in Study 1 result from two design sessions and two pretests, which ensured relatedness was well established. The manipulation checks also demonstrated that the stimuli were physically similar to the source products. Second, the risk in the mapping stage lies in consumers' inability to detect the similarities between the source products and target RNPs. Even if the relevant source knowledge is activated, consumers may not be able to build the link between this knowledge and the target RNPs, leading to an unsuccessful analogical learning process. Third, in the mapping stage, as the created product metaphors are highly similar to the source products, consumers may recognize them as source products rather than RNPs. After reading the descriptions of RNPs, consumers may realize that the RNPs actually are not source products. Instead, they are highly innovative products that are in many ways different from the source products. In this situation, if consumers are unable to realize the similarities, they are likely to feel confused concerning the already activated knowledge related to the source products. This can become a burden for consumers, leading to reduced consumers' comprehension. Fourth, another risk that product metaphors carry is the possibility of promoting surface mapping, which hinders consumers' comprehension of RNPs through product metaphors alone. In order to examine whether these risks actually occur when product metaphors are

Table 4. Results of the main study: Adjusted means for consumers' comprehension, relatedness and innovativeness by product category.

		Presenting Product Metaphor		No Product Metaphor	
		With textual clue	No textual clue	With textual clue	No textual clue
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

presented alone, we conducted consumer interviews in Study 2. Combined with the experimental approach in Study 1, the mixed-methods approach provides data triangulation, leading to a rich understanding of product metaphors in RNPs. The mixed-method approach also improves the validity of this investigation.

Furthermore, we acknowledge that in comparison to the condition without the metaphor and textual clue, the presence of product metaphors and textual clues did not lead to significant enhancement of consumers' comprehension of the RNPs. This might be caused by the experimental setting. As we used a professional consumer panel, participants tend to pay more attention and read the product descriptions carefully, resulting in overall greater comprehension levels. Consequently, the positive effect of the product metaphors and textual clues on consumers' comprehension may have become less strong. However, in a real-life setting, consumers are unlikely to pay extensive attention to texts as a result of cluttered information (Pieters, Warlop, & Wedel, 2002). Consumers' attention influences their comprehension of RNPs (Feiereisen et al., 2008). With limited attention to process a RNP, there could be better possibilities for product metaphors to attract consumers' attention and influence their comprehension.

Study 2: *Investigating the Risks of Product Metaphors for Influencing Consumers' Comprehension of RNPs*

Method

Participants and Procedure

Stimuli were selected from those used in Study 1, which were the two RNPs with product metaphors. Thirty-one participants were involved (42% male, average age = 33.84 years old). Participants were randomly given one of the stimuli products and were asked several questions related to it.

The questions included in the consumer interviews were organised in four parts: access, mapping, transfer and an additional stage in which the textual clue was presented (see Table 5 for questions).

In the first part, the main aim was to learn about the influence of product metaphors during the access stage: 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 accomplish this, only the picture of the stimuli product was shown to participants. In the second part, the original functional description of the stimuli product was shown to participants (see Appendix A). After reading the descriptions, they were first asked to rate their comprehension of the stimuli product on the same four measures ($\alpha = 0.85$) as used in Study 1 (Feiereisen et al., 2008). Next, they were asked about the parts they understood and the parts they did not understand and their general opinion of the stimuli product. In the third part, we aimed to learn how participants built one-to-one correspondences, including whether they were able to build correspondences and what correspondences were built. Participants were first asked to evaluate the extent to which the stimuli product was similar to the source product based on the measure of relatedness used in Study 1 ($\alpha = .97$). Next, 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 1 were presented, and the 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. In this way, this part can replicate the results of Study 1 and provide additional insights into how the textual clues helped.

Table 5. Interview questions divided into four parts.

	No.	Questions
Access Stage: Present product pictures only	Q1	Have you seen this product before?
	Q2	What is the product?
	Q3	Could you talk more about this product?
Mapping Stage: Present product pictures and original product descriptions	Q4	To what degree do you think you understand the product functions? (4 items on 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 original product descriptions	Q7	Do you think the product is similar to the source? (3 items on 7-point 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	Q9	To what degree do you think you understand the product functions? (4 items on 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?

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 inductively (Thomas, 2006), with an interest aimed at understanding what risks product metaphors might carry in each stage. The following section reports consumer responses, including both prevalence and content, based on the four parts of the consumer interviews. The results outline can be found in Appendix D.

Access Stage

In terms of identification of the source products (in response to Q1 and Q2), all of the participants recognised the intended 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 participants who were presented with the molecular sensor embodied by the product metaphor of a magnifying glass, participants mentioned the functions of a magnifying glass (focusing light and projecting a larger image of objects); their experiences with a magnifying glass (setting a paper on fire and using it to read very small words); and their perceptions of a magnifying glass (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). 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. It is common to see an elderly person hold a magnifying glass while reading the newspaper and move the magnifying glass line by line.

Similarly, for the participants who were presented with the oral health monitor with metaphor of mints, participants mentioned the functions of maintaining oral health, and that it can help to have fresh breath and refresh one's mind. 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 indicate that consumers can identify the source products in the way that the designer intended. In other words, for the stimuli products, the risk of enabling other interpretations as a result of the product metaphors was avoided by carefully designing the product metaphors. Once the source product was correctly recognised, the relevant knowledge in the source domain was retrieved.

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). Next, they were asked about their comprehension of the stimuli products. Specifically, participants were confused about how the products could technically fulfil the functions, as explained by one participant concerning the oral health monitor: "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 did not understand how the stimuli products 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".

At this stage, most participants did not mention anything related to the source products. Only three participants (10%) clearly mentioned that the stimuli products were extensions of the source products. In terms of the molecular sensor, one participant declared: "It looks like a magnifying glass and it also feels like a magnifying glass because the function is similar to 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".

We did not find any evidence of participants' surface mapping. 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 [a] problem, the other one helps you [to] detect problems. Their functions are different". As illustrated, the results indicate that the physical resemblance did not promote surface mapping between the source products and target RNPs.

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 similarity (in response to Q8), most participants mentioned the appearance similarity. Only five participants (16%) mentioned both appearance and function similarities. For example, one participant explained the molecular sensor as follows:

> 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 suggest that most participants were unable to build the relational mapping between RNPs and source products themselves although the relevant knowledge was already activated in the access stage.

Additional Stage of Presenting the Textual Clue

In this part, participants were presented with the textual clues. The textual clues used were identical to the ones used in Study 1: "It is like a mint container that helps freshen your breath" and

"It is like a magnifying glass that detects detailed information." After reading the textual clues, participants were asked to report their comprehension one more time based on the same measures (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 a significant improvement ($t(30) = -3.62$, $p < .05$; $\text{Mean}_{\text{mapping stage}} = 5.82$ vs. $\text{Mean}_{\text{additional stage}} = 6.44$), indicating that the presence of textual clues significantly improved participants' comprehension of RNPs with product metaphors. This result provided additional support to the findings of Study 1.

Regarding the influence of presenting textual clues (in response to Q10), participants claimed that the presence of a textual clue helped them comprehend the RNPs. They also claimed that they did not realize the similarities beforehand. Specifically, participants further explained that the presence of textual clues helped them relate the RNPs to the familiar source products and prompted them to compare similarities and differences between the RNPs and the source products. In other words, the explanation regarding the similarities between the source products and the RNPs could help consumers' relational mapping, as mentioned by one participant 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.

Participants also 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".

Discussion of Study 2

Through consumer interviews, Study 2 revealed how product metaphors influence the three stages of consumers' analogical learning of RNPs. Specifically, in the access stage, product metaphors can help consumers' identification of the source products and the activation of knowledge in the source domains. However, in the mapping stage, consumers experienced 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 can help consumers, resulting in enhanced comprehension.

The results of Study 2 further support the findings that it is necessary to present textual clues to facilitate consumers' comprehension of RNPs. The results reveal that the sole presence of product metaphors may even reduce consumers' comprehension because consumers' lack the ability to detect the similarities between the source products and the target RNPs. This is 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). As RNPs are totally new, consumers can lack the ability to detect similarities. Then, it is helpful to present related information to explain relationships between sources and target RNPs.

General Discussion

This research includes two studies on the use of product metaphors in RNPs. Through an experimental approach, Study 1 provides empirical evidence for the effect of product metaphors on consumers' comprehension of RNPs. Specifically, product metaphors result in greater consumer comprehension when accompanying textual clues are present than when product metaphors and textual clues are presented separately. Study 2 continues this investigation through consumer interviews to reveal the risks that product metaphors carry on influencing consumer comprehension of RNPs. The results of Study 2 show that product metaphors can help consumers access source domains and activate the corresponding knowledge. But consumers have difficulty mapping the corresponding knowledge between sources and target RNPs, which is a challenge for product metaphors alone to overcome. Thus, it is beneficial to combine a product metaphor with a textual clue that explains the similarities between source products and target RNPs, which significantly enhances consumers' comprehension of RNPs.

These findings contribute to prior research on product metaphors in several ways. First, previous studies on product metaphors mainly focused on experiential intentions (Cila, Hekkert, et al., 2014a; Hekkert & Cila, 2015). This investigation expands these studies by investigating the use of product metaphors in an unexplored context: product metaphors in RNPs to influence consumers' comprehension, which is a specific type of pragmatic intention. Building on the analogical learning process, this research reveals the potential and risks of product metaphors for influencing consumers' comprehension of RNPs.

Second, this research provides empirical evidence to the general notion that product metaphors facilitate consumer comprehension of RNPs (Hekkert & Cila, 2015). This research clarifies that the positive effects of product metaphors can only be triggered when an accompanying textual clue is provided that explains the similarities between the sources and target RNPs. The sole presence of product metaphors is insufficient, which can even reduce consumer comprehension. This research also reveals that the problem of presenting product metaphors alone lies in the consumers' lack of ability to map the one-to-one correspondences between sources and target RNPs, which is difficult to overcome solely via the design of product metaphors.

Third, this research extends the literature stream on marketing strategies for facilitating consumers' comprehension of RNPs (Gregan-Paxton & John, 1997; Reinders et al., 2010) by demonstrating the value of product appearance. Although several studies have demonstrated that product appearance influences consumer adoption of RNPs (Mugge & Dahl, 2013; Cheng, Mugge, & De Bont, 2018), this research contributes by investigating the specific influence of product metaphors.

Practical Implications

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 by using product metaphors. Although positive effects from the interaction of product metaphors and textual clues on consumers' comprehension of RNPs are found, designers should interpret the results carefully. The positive effects were based on a high degree of soundness and relatedness between the product metaphors and the target RNPs. Thus, while designing, designers need to carefully select sources and 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.

As textual clues are necessary to positively influence consumers' comprehension, product metaphors may not need to be as obvious as the stimuli used in both studies. As demonstrated in the prior study (Cila, Borsboom, et al., 2014), an identifiable but subtle product metaphor contributes to consumers' aesthetic preference. Going back to the two examples of the Bluetooth speaker 'SSSSSpeaker' (see Figure 4) and the 'Mother' smart home system (see Figure 2), the product metaphor of the travel cup is used for the 'SSSSSpeaker' Bluetooth 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 hub is designed in an anthropomorphized shape with eyes and a mouth, which intends to match the source of 'Mother'.

This research demonstrates a joint effect of both product metaphors and textual clues on consumers' comprehension of RNPs. When a product metaphor is used, the combined presence of a textual clue significantly increases consumers' comprehension. Similarly, with respect to the use of a textual clue, the presence of a product metaphor enhances consumers' comprehension in comparison to when a product metaphor is absent. Thus, design managers should collaborate intensely with marketing managers to successfully stimulate consumers' comprehension. Even though our results suggest that a combination of a product metaphor and a textual clue provides the best effects for enhancing consumers' comprehension and delivering a coherent experience, some situations may limit the possibilities of one of these cues. For example, in some cases, consumers may be unlikely to read and interpret the textual cue, due to which product metaphors have more potential for enhancing consumers' comprehension. In other situations, the metaphor may be difficult to visualize in the product appearance without resulting into ambiguity, due to which textual clues play more prominent roles for highlighting metaphorical associations than product metaphors (e.g., "Mother" smart home system, see figure 2). Thus, design mangers and marketing managers should carefully consider the potential of textual clues and product metaphors in explaining the metaphorical associations. Nowadays, thanks to the multiple e-channels and media, companies can explain product metaphors in different ways. Specifically, product metaphors can be explained through textual clues via printed advertisements, product packages, or product appearance, but also through different visualizations, such as videos and animations. It is particularly interesting to use interactive media (e.g., VR, AR) to explain product metaphors more vividly, which not only contributes to consumers' comprehension but will also deliver a rich experience.

Limitations & Future Research

There are several directions for future research, however several limitations became evident while creating stimuli. First, for the generation of conceptual metaphors as a source for the RNPs, we invited Master students with a Bachelor degree in design. We believe that this level of education makes these participants proficient enough to imagine suitable conceptual metaphors. However, as design expertise increases the ability of generating sound metaphors (Cila, Hekkert, et al., 2014a), it would be interesting for future research to replicate our findings with stimuli created by designers with extensive expertise in practice.

Second, while selecting stimuli for the main study, we selected RNPs that do not belong to any existing product category in order to prevent confounding effects. Future research can investigate the effects of using product metaphors in RNPs that belong to mature product categories, for which a typical exemplar exists. When RNPs are embodied in product metaphors that deviate from the typical exemplar in the product category, consumers may not recognize it as a member from the product category. As a result, the category-based knowledge will not be activated, which may hinder consumers' access of the category knowledge. For example, in the case 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 consumer recognition of the product as an alarm clock because the shape of a flower conflicts with the typical exemplar of an alarm clock.

Third, in this research, the created stimuli closely resembled the sources of the intended product metaphor. The stimuli were designed like that to facilitate consumers' identification of sources in the access stage. However, it may have prevented consumer recognition of the fact that the product was in fact not a typical exemplar of the source, but a RNP with innovative functions. For example, the molecular sensor closely resembled the source of a magnifying glass but only the white button demonstrated that it had additional functions and was actually an RNP. Future research can investigate the possibilities for designing product metaphors by resembling sources as well as providing more visual clues for consumers' categorization of the target RNP. As consumers can draw inferences from multiple categories (Gregan-Paxton, Hoeffler, & Zhao, 2005), they are likely to relate the source and learn its general category membership at the same time when encountering the product metaphor, which could be interesting for future research.

Fourth, this research focuses on product metaphors that associate a source and target through the appearance, but we realize that these associations can be established via multiple modes, such as interaction, sound, and smell (Hekkert & Cila, 2015). Associations evoked via multiple modes could not only facilitate consumers'

comprehension of RNPs but also inform consumers about the usage of RNPs and enrich consumers' experience. It would be interesting for future research to explore the value of using multiple modes for the generation of product metaphors in RNPs.

Fifth, this research focuses on analogical learning theory to project particular properties of the source to the new target. For future research, it would be interesting to investigate other ways in which different inputs can create new meaning when evaluating products. For example, in linguistics, conceptual blending theory has been proposed as a way to construct meaning from two inputs that partially match (Fauconnier & Turner, 2003). Blending consists in partially matching these two inputs and projecting parts of both inputs into a new blended output. For example, the linguistic blend "dolphin-safe" takes parts of the input "dolphin" and part of the input "safe" to create a new output, which suggests that measures were taken to avoid harming dolphins during the harvesting of tuna. Corresponding to such linguistic blending, it is likely that designers can also make use of two different inputs and create product designs that are based on both, thereby evoking a new blended meaning.

Finally, we realize that our results did not reveal significant improvements in consumers' comprehension of RNPs between the presence of product metaphors and textual clues and the condition in which both were absent. We believe that this is due to the experimental setting. In a real-life setting, consumers are often too distracted to carefully read product descriptions, resulting in lower comprehension when only a product description is provided. In addition, there are more benefits of using product metaphors in RNPs. For example, by using product metaphors, designers can relate the RNPs to products/concepts that consumers are familiar with, which can help to ease the anxiety triggered by the technology (Mick & Fournier, 1998) and can thus improve consumers' attitudes towards RNPs. Product metaphors can also promote enhanced appreciation when interacting with the product (Lin & Cheng, 2014), which could contribute to consumers' adoption of RNPs. Furthermore, the use of product metaphors can contribute to brand vividness and excitement (Ang & Lim, 2006). Following this, the use of product metaphors could also influence brand image and even consumers' perceived innovativeness of a brand.

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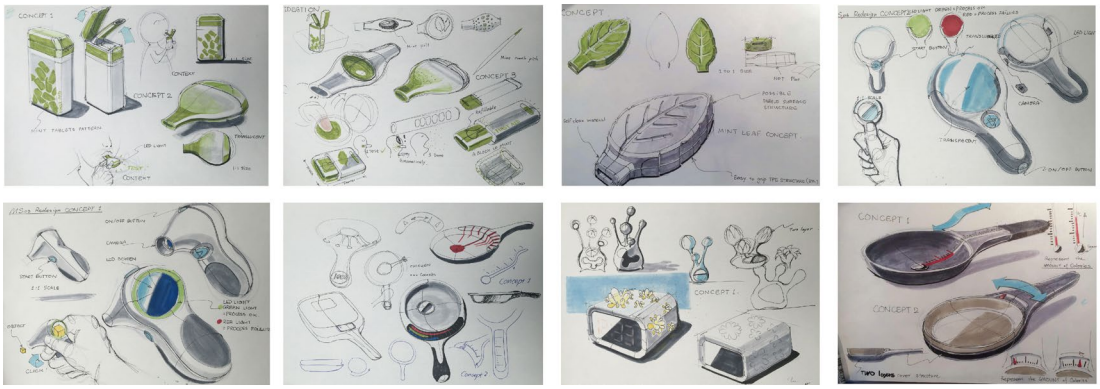
Appendix

Appendix A. Stimuli creation process.

Activity	Results
Design Session 1	Research Goal: Generate conceptual metaphors that can facilitate consumers' comprehension of target RNPs Conceptual metaphors generated for six RNPs: 1. An alarm clock that wakes people up using odour: Flower (2 times), perfume bottle (2 times), projector, Nespresso machine, capsule, bubble wrap, pill, honey cell, teacup. 2. A pan that measures calories: Thermometer (2 times), scale (2 times), magnifying glass, CPU, radar, palette. 3. An oral health monitor: Mint container (3 times), a drop of water, thermometer, breathalyzer, mouth, pacifier. 4. A molecular sensor that detects the composition of objects: Magnifying glass (3 times), microscope, 3D scanner, security scanner, robot, dog. 5. An activity tracking sensor for running: Shoe pad, shoe laces, sticker, bondi, icon of electricity, fire. 6. A stand-alone shortcut button to control various digital devices: Dust plug, small tablet, iPod, magic cube, dice, octopus, starfish. Among these conceptual metaphors, the six conceptual metaphors presented in bold were selected for pretest 1. *Selection criteria: the soundness between the conceptual metaphors and target RNPs.*
Pretest 1	Research Goal: evaluate the soundness of the generated conceptual metaphors in Design Session1 and select the sound ones for Design Session 2. *Selection criteria: conceptual metaphors with relatively high scores on soundness* Four conceptual metaphors were selected based on the results of Pretest 1. Another two conceptual metaphors were not selected due to the relatively low scores on soundness.
Design Session 2	Research Goal: generate product metaphors on a physical level based on the selected conceptual metaphors. 1. Ten product metaphors designed for four RNPs, in the form of sketch.  *Selection criteria: product metaphors that closely resembled the source products.* 2. Two product metaphors designed for two RNPs, in the form of 3D model and rendering.
Pretest 2	Research Goal: evaluate the relatedness of the created product metaphors Two final stimuli and two original products are used for pretest 2.

Appendix B. Product descriptions used in Study 1 and Study 2.

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.
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.

Appendix C. Measures used in Study 1.

Consumer innovativeness measure	'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'
	'I take advantage of the first available opportunity to find out about new and different products'
Consumer visual metaphor processing measure	'I tend to look for meanings behind a product appearance'
	'An atypical appearance makes me question the reasons behind the shape of the product'
	'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'
	'It is unpleasant to not know why a product has a specific appearance'

Appendix D. Results outline of Study 2.

Theme	Code	Consumers' quotes
Access Stage (Q3)		
Q3: Could you talk more on this product (source product)?		
Functions of magnifying glass	Enlarge (11)	When you cannot see something clearly, you use a magnifying glass to enlarge things.
	Focus Light (4)	Physically, a magnifying glass can focus light. When you put it under sunshine, it can fire things.
Perception of a magnifying glass	For elderly (4)	Sometimes, you can see elderly people use a magnifying glass to read the newspaper. They use it line by line to go through the newspaper.
	For investigation (3)	A magnifying glass can be more useful for researchers. If they need to observe something they cannot see by eyes directly, researchers need to use magnifying glass.
	Detective (1)	Magnifying glass also feels like a stage prop. A detective always holds a magnifying glass.
Functions of mint container	Keep fresh breath	After meals, I often have one or two. Then I feel my breath becomes fresh.
	Refresh minds	I often want mints when I feel sleepy … It can help me refresh.
Perception of a mint container (25)	Have mints after meal	After meal with garlic, I really need mints.
	Have mints while drive	The most necessary situation for having mints is during driving. It can refresh your mind.
Mapping Stage (Q5 & Q6)		
Comprehensive parts	General understanding of functions (10)	I feel I generally understand its main function: measure the breath quality. (oral health monitor) I feel I can only generally understand this product. I am not familiar with this area. (molecular sensor)
	Similar to existing products (7)	It is similar to the detector for drunk driving. Policemen ask drivers to blow and the detector can tell the amount of alcohol. (oral health monitor) Similar to heart rate and blood pressure monitors, they are connected with a smart phone. This one measures different things. (oral health monitor)
	Extension of the source products (3)	It looks like a magnifying glass and it also feels like a magnifying glass because the function is similar to a magnifying glass … it is better (has more functions). (molecular sensor) Because I eat mints every day, I know their functions very well. So this product somehow has the same function as mints. (oral health monitor)
	Technology sounds feasible (3)	From my own experience, when my health condition changes, there will be changes in mouth breath. So I believe it is feasible. (oral health monitor) The light projects on the object. Then it measures the interaction between the light and the molecular vibration of the object. I learned physics before, it sounds feasible. (molecular sensor)
	Necessary in life (3)	For example, after you wash fruits or vegetables, you can use it to know whether it is clean, whether there are still pesticide left on them. (molecular sensor) I feel it is necessary. The bacteria in mouth can be bad for the teeth. Many people around me have problems with their teeth. So I think this is good (oral health monitor)

Appendix D. Results outline of Study 2 (continued).

Theme	Code	Consumers' quotes
Incomprehensive parts	Feasibility of technology (11)	It detects the composition through measuring the interaction between the light and the molecular vibration of the object. I get this general principle. But I feel confused on how it exactly works. (molecular sensor) I don't understand how it measures bacteria, how it works, how it changes my oral environment and how it collects and analyses data… (oral health monitor)
	Benefits (6)	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) how I would use it in my life, what it would be like. (molecular sensor) After it presents me with data, could it tell what kinds of diseases or problems I have? … The purpose is not clear to me. What medicines should I take to solve these problems? (oral health monitor)
	Limited experience with source products/ smart phone (2)	I never heard about these cells or bacteria. Maybe for guys, they are more often to have mints after smoking and drinking alcohol. We girls are not very familiar with them. (oral health monitor)
	Safety (1)	Another part I feel confused is the safety. Whether it is safe? Whether it has potential risks? (oral health monitor)
Opinions towards stimuli products	Useful (16)	Mints can only work for a short time … But this one can give you advice on oral health, eating habits. I feel it is very practical. (oral health monitor) I think it is useful. For many products, it (the package) tells you their composition. Through using this one to measure, we can know whether the provided composition is true. (molecular sensor)
	Concerns on practicality (10)	Although it tells me the object composition, how should I interpret it? (molecular sensor) I feel this product is not very necessary. If I can solve it with a mint, why do I need this product? (oral health monitor)
	Additional concerns: size, price, product performance (4)	I haven't seen the tangible product. What is the size? Whether it is easy to carry? (molecular sensor) Whether it can function as it states? I am not sure. What about the price? (oral health monitor)
Transfer Stage (Q8)		
Similarities between source and target RNPs	Look similar (27)	The appearance looks similar. When I saw the picture, I believe it is mints, or products similar to it. (oral health monitor) My first impression is a magnifying glass. It looks like a magnifying glass a lot. (molecular sensor)
	Similar functions (5)	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. (molecular sensor) The functions are also related with oral health. They are similar. One [oral health monitor] functions through sensors' detection, while the other one [mints] make your breath fresh. (oral health monitor)
Additional Stage (Q10)		
Reasons why textual clue can aid in learning (22)	Compare similarities and contrasts between RNPs and source products (13)	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. (molecular sensor) Mints help you in a simple and straightforward way. But this one helps in a long-term way. (oral health monitor)
	Relate to familiar products (12)	I understand mints very well. I use it very often. It feels like… you use the functions of mints…then you feel this product is similar to mints in a certain way. The similarities help my understanding. (oral health monitor) Magnifying glass is common to see. Its function is similar to a magnifying glass. A magnifying glass enlarges objects, this one can see the composition. It feels similar, logically. (molecular sensor)
	Simplify the functions of RNPs (3)	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. (molecular sensor)