

Seeing is believing

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Seeing is believing: investigating the influence of transparency on consumers' product perceptions and attitude

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ABSTRACT

Transparency is a design characteristic enabling consumers to see the technical details underneath the product cover to create a unique visual effect. However, involving transparency in product design increases costs; it is thus essential to investigate the effects of transparency to help designers and manufacturers to determine the cost-effect ratio. To address this gap, this study investigates the effects of transparency on consumer attitude and their perceptions of experience and credence attributes (i.e. technological advancement, performance quality, ease of use). Through a controlled experimental design ($N = 126$), this study compared consumer responses between products with transparent and opaque covers in two product categories. The results revealed that products with transparent covers significantly improve consumers' perceptions of technological advancement and performance quality, and attitude in comparison to opaque covers. Results also revealed that the effects of transparency differ between consumers depending on their design acumen. The effects of transparency on consumers' perceptions and attitude are stronger for consumers with high design acumen. The practical implications and theoretical contributions of the study are discussed.

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1. Introduction

While purchasing consumer durables, consumers often pay particular attention to product attributes, such as functionality, performance quality, and usability. They aim to choose products with powerful functionality (Nowlis and Simonson 1996), with superior performance quality (Garvin 1988), and with ease of use (Mack and Sharples 2009). These product attributes can be further divided into search, experience, and credence attributes (Darby and Karni 1973; Ford, Smith, and Swasy 1990; Nelson 1970). Search attributes refer to functional attributes that can be evaluated before purchasing. Experience attributes are the attributes that can only be verified after usage. Credence attributes are those attributes that cannot even be evaluated after intensive usage (Darby and Karni 1973). An example

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of search attributes is the battery power of an electronic toothbrush, which consumers can quickly learn about before purchasing. Ease of use is an experience attribute of an electronic toothbrush. Consumers can only draw a conclusion after some usage of the electronic toothbrush. A credence attribute of an electronic toothbrush is its performance quality in terms of removing plaque. Consumers would hardly judge the consequences even after intensive usage of it. They can only turn to dentists for their professional conclusion.

The experience and credence attributes of products are essential for consumers' purchase decisions because consumers tend to use durables for a long time, and therefore, want to choose products that will give them much value during usage (McMeekin and Tomlinson 1998). Consumers often have difficulties evaluating experience and credence attributes, which demand a degree of experience with the product. However, this experience is often not possible or available at purchase (Thompson and Hamilton 2006). This is particularly true in online purchasing, for consumers have no access to samples or trials, rendering assessment for some attributes impossible to make, especially regarding performance quality and ease of use. Nevertheless, given the importance of experience and credence attributes in influencing consumers' choices, consumers often turn to other accessible cues to draw inferences about these attributes if there is no possibility to assess experience and credence attributes objectively (Berkowitz 1987; Dawar and Parker 1994). Although such subjective perceptions may differ from the objective assessment resulting from actual product usage, these perceptions play an important role in purchase decisions. Consumers need to be subjectively convinced that a product has satisfactory experience and credence attributes before considering buying the product and using it in their daily lives.

Brand is a cue that consumers often use for making inferences about experience and credence attributes. For instance, safety is an attribute for consumers' choice of cars, but consumers are unable to objectively assess a car's safety even after a trial drive because the knowledge required for an objective assessment of safety goes beyond the capability of most consumers. To learn about a car's safety, consumers therefore turn to alternative cues, such as the brand image to draw inferences. As Volvo has built its brand identity on safety, consumers will infer that cars from Volvo are safe. Such a perception of safety in turn influences consumers' purchase decision if they value safety strongly.

Similarly, product appearances can evoke consumers' inferences of product experience and credence attributes (Crilly, Moultrie, and Clarkson 2004; Creusen and Schoormans 2005). Concerning the credence attribute safety, Volvo developed a series of visual elements, such as strong 'shoulder' lines and carved backlights (Karjalainen 2007). When seeing cars with these characteristics, consumers are more likely to perceive them as safe. Extensive studies have acknowledged the role of product appearances for facilitating consumers' inference-making of product experience and credence attributes (Crilly, Moultrie, and Clarkson 2004; Creusen and Schoormans 2005). Specifically, consumers generally draw favourable inferences from attractive product appearances, known as 'what is beautiful is good'. Consumers tend to associate an attractive-looking product with higher quality (Page and Herr 2002; Veryzer and Hutchinson 1998) and better usability (Hassenzahl 2004; Sonderegger and Sauer 2011).

Besides the 'what is beautiful is good' principle, previous studies also found that consumers draw inferences concerning product attributes from other design characteristics of product appearances. Design characteristics refer to the overall visual features that describe

product appearances, such as harmony, novelty, natural, etc. These design characteristics can be used to describe various visual stimuli, including logos, typefaces, packaging design and product appearances (Henderson and Cote 1998; Henderson, Giese, and Cote 2004; Orth and Malkewitz 2008; Mugge, Dahl, and Schoormans 2018). Previous studies demonstrated the effects of various design characteristics on consumers' perception of experience and credence attributes. Specifically, novelty and harmony promote consumers' perception of product performance quality (Mugge and Schoormans 2012a; Mugge, Dahl, and Schoormans 2018). Natural improves consumers' product perception of ease of use (Mugge, Dahl, and Schoormans 2018), while novelty is negatively related to ease of use (Mugge and Schoormans 2012b). Lower length-width ratio of smartphones is also shown to positively influence consumers' perception of ease of use (Seva et al. 2011). Moreover, product appearances can exhibit certain product personality traits, such as friendly, aggressive, and baby-like. Such product personality traits can also evoke consumers' inferences of a product's experience and credence attributes (Mugge 2011; Chowdhury et al. 2014; Karkun, Chowdhury, and Dhar 2018). For instance, with an angular appearance and metallic colour, a product can exhibit a business-like personality, which is associated with a superior performance quality (Mugge 2011).

In total, these findings provided effective support for designers and managers for designing product appearances that will trigger desirable perceptions of product attributes. However, there are still many design characteristics that have not received sufficient research attention, and transparency is such a design characteristic. Concerning consumer durables, one study particularly focused on the effects of transparency. Through designer and consumer interviews, the results of the study presented a spectrum of possible benefits that can be brought by using transparency, including a demonstration of product functionality, which is related to product experience and credence attributes (Cheng, Mugge, and de Bont 2018). However, the prior research has an exploratory nature. In addition to the overview of possible effects that transparency can bring, explanatory research is required to validate these effects and reveal under what conditions the effects are significant or stronger. In this way, the exploratory and explanatory research can build on each other to enhance the understanding of consumer responses to transparency in product design. This study aims to contribute to the prior exploratory research by conducting the explanatory research. Specifically, it intends to empirically examine the influence of transparency on consumers' perceptions of experience and credence attributes and attitude. The research also investigates how the effects of transparency vary by consumers' individual differences. Gaining these insights can deepen the understanding of the effects of using transparency in product designs.

2. Transparency in product design

Transparency is a design characteristic that designers can use to embody a product (Ashby and Johnson 2002; Karana, Hekkert, and Kandachar 2009). Transparency refers to the physical property of transmitting light. When transparency is used in product designs, transparency can be further divided into opaque, translucent and transparent based on the amount of light that can go through the surface (Ashby and Johnson 2002). Since opaque materials completely block light, internal technical details are invisible. Transparent materials allow all the light to pass by, while translucent materials enable part of the light to go

through. As a result, consumers can see the internal components underneath transparent product covers clearly and see these details through translucent covers in a blurred way. For example, the transparent cover of Dyson handheld vacuum cleaner allows the consumers to observe how dust is collected (Lockton, Harrison, and Stanton 2010), whereas through translucent cover of the iMac users only have a blurry view of the internal components (Person and Snelders 2010).

Past research demonstrated the influence of transparency on consumers' perception of experience and credence attributes in food packaging (Fernqvist, Olsson, and Spendrup 2015; Simmonds and Spence 2017). As consumers cannot taste the food at the moment of purchasing, they rely on the available cues to make inferences of food experience attributes, such as food freshness, quality and tastiness. Transparent packaging creates the possibility for consumers to see the food inside and further learn about food quality (Fernqvist, Olsson, and Spendrup 2015; Simmonds and Spence 2017). As a result, consumers perceive the food with transparent packaging as fresher and of higher quality than food products with opaque packaging (Simmonds, Woods, and Spence 2018, 2019). These positive perceptions of experience attributes further improve consumers' perception of trustworthiness (Billeter, Zhu, and Inman 2012) and their overall evaluation (Simmonds, Woods, and Spence 2018, 2019).

The findings of transparent packaging research suggest that transparency is also likely to influence consumers' perceptions of experience and credence attributes for consumer durables. However, it remains unclear whether the positive effects of transparency found in packaging design are applicable to durable products because the content exposed through transparency differs. In food packaging, since the food exposed is usually familiar to consumers, transparency mainly facilitates consumers with assessing food qualities and drawing inferences from the visually displayed contents. For instance, while seeing vegetables through a transparent salad packaging, consumers can clearly see the colour of these vegetables and learn about the freshness of the salad. However, for durable products, especially electronics, transparency exposes internal technical components, which are often unfamiliar and complex to most consumers. Given that the exposed parts may play different roles in consumers' decision-making, it is necessary to investigate how transparency influences consumers' perceptions for durable products. The investigation will enrich the understanding of how transparency influences consumers' perceptions in different contexts.

Regarding the effects of transparency in product design, fragmented insights were provided through qualitative research. Although transparency is common in glassware that is easy to break down, it seems such fragile associations may not transfer to consumers' association with transparency in consumer durables. Differently, through transparent covers, consumers can observe the technical details underneath, which could result in positive inferences of experience and credence attributes (Lockton, Harrison, and Stanton 2010). Consumer interviews have also supported the notion consumers' positive perceptions of performance quality for products with transparency (Cheng, Mugge, and de Bont 2018). This study aims to empirically examine the effects of transparency in durable products.

In addition, the study examines whether and how the effects of transparency vary due to one of consumers' individual difference characteristics, design acumen. While transparency provides additional visual information, it also requires consumers to make greater efforts to process such information. Therefore, the influence

of transparency is likely to differ across consumers with different levels of design acumen (Bloch, Brunel, and Arnold 2003; Truong et al. 2014). Moreover, this study focuses on the product category of consumer electronics because consumers are often unable to assess the experience and credence attributes objectively and they rely on other cues, such as product appearances to draw inferences. Companies also heavily invest in developing various product appearances to evoke consumers' perceptions (Person et al. 2008), which makes the product category suitable for this research.

To summarise, this research contributes to the literature in several ways. The study extends previous studies on the role of product appearance for influencing consumers' inferences of product experience and credence attributes (Creusen, Veryzer, and Schoormans 2010; Mugge and Schoormans 2012a, 2012b; Seva et al. 2011) by focusing on the design characteristic of transparency. This study also builds on prior studies on transparency in product design (Cheng, Mugge, and de Bont 2018) by taking an explanatory perspective, which allows for empirically validating the effects of transparency on consumers' perceptions and attitude and exploring the moderating role of design acumen. Next, this study extends previous research on exploring the effects of transparency in food packaging (Simmonds and Spence 2017; Simmonds, Woods, and Spence 2018, 2019) by investigating its effects for durable electronic products.

Next to the scientific contribution, this research topic is also valuable for practice. To stand out in the cluttered markets, companies need to not only invest in improving product experience and credence attributes objectively but also communicate them to consumers successfully (Crilly et al. 2008). Previous studies explored how designers can communicate product performance quality and usability by manipulating various design characteristics (e.g. novelty, visual complexity, natural) (Creusen, Veryzer, and Schoormans 2010; Mugge and Schoormans 2012a, 2012b; Mugge, Dahl, and Schoormans 2018). This research extends this line of research by equipping designers with knowledge on manipulating transparency to communicate product experience and credence attributes in durable products. As using transparency often improves manufacturing costs, insights into the benefits and risks of using transparency can provide designers and managers with rationales for effective decision making.

3. Transparency in product design and consumers' perceptions of experience and credence attributes

For consumer durables, experience and credence attributes mainly refer to the different aspects related to product functionality. These attributes largely relate to or even overlap with each other. In order to capture the main dimensions of experience and credence attributes, prior research has empirically validated these measures and revealed that for consumer durables, the following three experience and credence attributes are important for consumers: performance quality, technological advancement, and ease of use (Mugge, Dahl, and Schoormans 2018). Performance quality mainly deals with the functionality, reliability and quality of products. Technological advancement emphasises the innovativeness of integrated technologies and their relative innovativeness in comparison to competitors. Ease of use captures consumers' subjective evaluation of product usability. In order to examine the influence of transparency on consumers' experience and credence

attributes, this research specifically investigates the relationships between transparency and consumers' perceptions of performance quality, technological advancement, ease of use, and their attitude.

Consumers tend to use product appearances as an important cue to draw inferences of technological advancement because they expect congruence between a product appearance and the integrated technology (Mugge and Schoormans 2012a). Previous studies demonstrated that consumers relate novel product appearances with innovative technology integrated (Mugge and Schoormans 2012a), complex product appearances with complex functionality (Creusen, Veryzer, and Schoormans 2010), and natural appearances with out-of-date technology (Mugge, Dahl, and Schoormans 2018).

In line with the above, transparency is also expected to serve as a cue for consumers' inferences of a product's technological advancement. Through transparency, consumers can see the technical components underneath the product cover, which are often invisible and unevaluable. The exposure of technical components provides more chances for consumers' inference making (Cheng, Mugge, and de Bont 2018). For example, through the transparent cover of the Dyson handheld vacuum cleaner, consumers can clearly see the size and other details of the motor. When the vacuum cleaner starts working, consumers can observe how the airflow is twisted and how much dust is collected. As a result, consumers are likely to believe that the technology adopted therein is effective.

Even though, in some cases, consumers may not be capable of assessing the innovativeness of the adopted technology by merely looking at the technical details, transparency can still prompt consumers' inference-making of technological advancement. For example, for a smartphone with a transparent cover (e.g. Fairphone), chips and sensors are exposed. Most consumers cannot learn or understand the adopted technology by seeing electronic chips and sensors. Still, they tend to believe that the product must adopt highly innovative technology if manufacturers dare to show the technical components inside (Cheng, Mugge, and de Bont 2018). They tend to infer the reasons why manufacturers show the internal components to them. Next, they believe the products must include certain innovativeness as the reason for using transparency. A similar inference-making process has been demonstrated in consumers' perception of transparent food packaging (Simmonds and Spence 2017; Burrows 2013). Therefore, it is hypothesised that transparency will positively influence consumers' perception of technological advancement in product designs.

H1: In comparison to products with opaque covers, products with transparent covers will increase consumers' perception of technological advancement.

If transparency promotes consumers' perception of technological advancement, this designing characteristic can also improve consumers' perception of performance quality. Technological advancement often includes technological improvements, such as new principles, architectures, or components (Gemünden, Salomo, and Krieger 2005). The integration of innovative technologies can bring considerable performance enhancement (Green, Gavin, and Aiman-Smith 1995). Consumers also perceive technological advancement as an indicator of additional benefits provided by the manufacturer (Mukherjee and Hoyer 2001). Consequently, consumers tend to believe that products with technological advancements will perform more effectively and efficiently. Therefore, the following hypothesis is given:

H2: In comparison to products with opaque covers, products with transparent covers will increase consumers' perception of performance quality.

Moreover, a product's technological advancement and product performance quality are essential attributes that determine consumers' attitude towards a product. Consumers evaluate a product more positively when a product integrates advanced technology and provides superior performance quality (Darby and Karni 1973; Ford, Smith, and Swasy 1990; Nelson 1970). Thus, the following hypothesis is given:

H3: In comparison to products with opaque covers, products with transparent covers will increase consumers' attitude.

Furthermore, a significant effect of transparency on ease of use is not expected. Prior research proposed that transparency may improve product usability by providing additional information regarding product operation (Cheng, Mugge, and de Bont 2018). However, for consumer electronics, transparency can hardly communicate any information related to product operation, and thus transparency is unlikely to influence consumers' perception of ease of use.





4. The effects of transparency and the moderating role of design acumen

Consumers' product perception is not only influenced by design characteristics but can also be influenced by individual differences, such as design acumen. Design acumen is an innate characteristic of consumers, and it is defined as a person's 'ability to recognise, categorise, and evaluate product appearances (Bloch, Brunel, and Arnold 2003, p.553). Consumers differ in their ability to process product appearances. Consumers with high design acumen are equipped with rich expertise and a systematic knowledge structure about design, which allows them to develop more sophisticated preferences for design (Csikszentmihalyi and Robinson 1990). In other words, consumers with high design acumen are equipped with greater abilities to process specific design characteristics and draw more inferences, which can overwhelm consumers with low design acumen. Previous studies found that consumers do not favour high novel product appearances because processing high-level novelty goes beyond most consumers' capabilities (Meyers-Levy and Tybout 1989; Hekkert, Snelders, and Van Wieringen 2003). However, another study further revealed that highly novel product appearances are preferred by consumers with high design acumen (Truong et al. 2014).

Similar to novelty, transparency is a design characteristic that requires consumers' processing to form attitude and draw inferences. Transparency exposes internal components of products, which require consumers' more efforts and greater capabilities to process. Consumers with high design acumen are equipped with greater abilities to recognise and process transparency. When encountering a product with a transparent cover, consumers with high design acumen can be more sensitive to it and pay greater attention to it. Then, they will process transparency and draw more inferences of product attributes accordingly. In contrast, consumers with low design acumen, as they lack sensitivity and visual knowledge, may not recognise transparency and draw further inferences. Consequently, compared to consumers with low design acumen, the influence of transparency will be stronger for consumers with high design acumen. The H4 is given as below:

H4: The effects of transparency on consumers' perceptions of technological advancement (a), performance quality (b), and attitude (c) are stronger for consumers with high design acumen than for their low-design acumen counterparts.

Table 1. Experimental design and stimuli.

Within-subject factor	Between-subject factor	
	Transparent condition	Opaque condition
Smartphone		
Electronic toothbrush		

5. Method

5.1. Design and participants

To test the proposed hypotheses, a controlled experiment was conducted. This study used a 2 (transparency level: transparent vs opaque) \times 2 (product categories: smartphone, electronic toothbrush) mixed factorial design, with the transparency level as the between-subject factor, and product category as the within-subject factor (see Table 1 for the experimental design). Participants were randomly assigned into one of two conditions: they were asked to evaluate products either with transparent covers or with opaque covers. Each participant evaluated two products, i.e. a smartphone and an electronic toothbrush. Through Amazon M-Turk, one hundred and twenty-six participants were collected from the United States (mean age = 37.95, SD = 12.56, 53.2% male).

5.2. Stimuli

Two product categories were chosen as stimuli: smartphones and electronic toothbrushes. Both product categories belong to consumer electronic, and they are in the mature stage

of the product life cycle. As a consequence, the experience and credence attributes play an important role in consumers' attitude and purchases of these products. A professional designer created the stimuli. Two different product designs were created by digitally integrating transparent covers that expose the technical details behind the product cover (see Table 1). Specifically, a smartphone with a transparent cover was used as stimulus material in the transparent condition and added an opaque cover to create the stimuli in the opaque condition. For the electronic toothbrush, an existing product was used as the stimulus material for the opaque condition and a transparent cover was added for the transparent condition. Consequently, these created stimuli were presented to consumers as product photographs. Using product photographs as stimuli has been extensively used to investigate consumers' perceptions of product appearances (e.g. Hoegg and Alba 2011; Creusen and Schoormans 2005). It also closely resembles today's online shopping contexts, where consumers draw inferences from product photographs to make further decisions. Thus, it is valid to present product photographs to consumers as stimuli for learning their inferences drawn from transparency in product designs.

5.3. Procedure and measures

Each participant was randomly assigned to one of the two transparency conditions, and they evaluated the two products on several multi-item measures. Prior to the presentation of stimuli and the questionnaire, participants were explained how to answer questions using a 7-point scale. Next, a short product description was created for each product. This description included some technical specifications that matched the typical specifications of these product categories at the time the study was conducted (see Appendix A). The order of presenting the two products was randomised. Then, after carefully observing product pictures and reading product descriptions, participants were asked to answer a series of questions.

Multiple items were used to measure each construct in order to improve reliability. To measure the reliability of the used measures, the Pearson's coefficient of correlation was calculated for the two-item measures and Cronbach's alpha was calculated for measures that included three or more items. In the data analysis, the multiple items were combined by calculating the average score for each respondent. The perceived technological advancement was measured by asking participants to indicate on 7-point Likert scales from 1 (strongly disagree) to 7 (strongly agree) to what extent they agreed with the following two items: 'This product makes use of the latest technology' and 'This product has many advantages in comparison to other products in this product category (Pearson's coefficient of correlation $r_{\text{toothbrush}} = .63$, $r_{\text{smartphone}} = .77$, $p < .01$)' (Mugge, Dahl, and Schoormans 2018). Performance quality was measured with the following four 7-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree; Cronbach's alpha $\alpha_{\text{toothbrush}} = .92$, $\alpha_{\text{smartphone}} = .90$): 'This product is reliable'; 'This product will last a long time'; 'This product functions very well' and 'This product is of high quality' (Mugge, Dahl, and Schoormans 2018). Consumer attitude was measured by 7-point semantic differential scales based on the following four items: 'negative/positive', 'bad/good', 'dislike/like', and 'unfavorable/favorable' (Mugge and Dahl 2013) ($\alpha_{\text{toothbrush}} = .95$, $\alpha_{\text{smartphone}} = .94$). Participants were asked to indicate their response by ticking a choice between two opposite concepts ranging from 1(negative/bad/dislike/unfavourable) to 7 (positive/good/like/favourable).

This four-item scale has been extensively used in previous research (e.g. Spangenberg, Grohmann, and Sprott 2005; Eckler and Bolls 2011), which provides convincing support for its validity.

In addition, consistent with Truong et al. (2014), design acumen was measured using two items of the design acumen construct from the Centrality of Visual Product Aesthetics (CVPA) scale (Bloch et al. 2003), which has been extensively used for measuring consumers' individual differences in processing visual stimuli (e.g. Becker et al. 2011; Giese et al. 2014). Participants were asked to indicate to what degree they agreed with the following two items: 'Being able to see subtle differences in product designs is one skill that I have developed over time' and 'I see things in a product's design that other people tend to pass over' from 1 (strongly disagree) to 7 (strongly agree; $r = .83, p < .01$).

To measure the success of the created stimuli, participants were asked to respond to what extent they can see the internal technical details exposed through transparency using the following question: 'What do you think of the visibility of the technical details?' based on a 7-point scale from 1 (totally invisible) to 7 (totally visible). This question served as a manipulation check. To avoid confounding effects, the attractiveness of product appearances was measured by two 7-point scale items: 'ugly/beautiful' and 'unattractive/attractive' ($r_{\text{toothbrush}} = .82, r_{\text{smartphone}} = .84, p < .01$).

6. Results

6.1. Manipulation check

To check the success of the transparency manipulation in our stimuli, a 2×2 repeated ANOVA was conducted with transparency and product category as independent variables, and the visibility of the technical details as the dependent variable. The results confirmed the success of the created stimuli ($F(1, 124) = 4.88, p < 0.05$; $Mean_{\text{transparency}} = 4.96$ vs. $Mean_{\text{opaque}} = 4.43$). For both product categories, consumers reported significantly higher scores on the measure of the visibility of the technical details when the transparent covers were used in comparison to when the opaque covers were used.

6.2. The main effects of transparency on consumer attitude and perception of experience and credence attributes

In order to test the hypotheses, a series of 2×2 repeated ANCOVAs were conducted with transparency and product categories as independent variables, with consumers' attitude, and their perceptions of technological advancement, and performance quality as dependent variables. Consumers' age and gender were included as covariates as previous studies suggested that these factors can influence consumers' product perceptions (Creusen and Schoormans 2005; Creusen 2010). Appendix B presented a comparison of the effects of transparency by either including or excluding the covariates of age and gender. The main effects of transparency are stronger when controlling for the differences in age and gender. Age and gender are well-known factors that can influence people's attitudes and responses to product design (Creusen 2010; Snelders, Mugge, and Huinink 2014). For example, younger people tend to prefer sportive designs more than older groups. By including age and gender as covariates, these possible effects are controlled for and it is possible to test the effects of transparency more accurately.

As expected, across two product categories, participants who were presented with products with transparency reported higher ratings on technological advancements than those participants in the condition of opaque covers ($F(1, 121) = 9.43, p < 0.01$; $Mean_{transparency} = 5.21$ vs $Mean_{opaque} = 4.54$). Similarly, participants in the transparent condition also perceived the products to have more superior performance quality than participants in the opaque condition ($F(1, 121) = 5.05, p < 0.05$; $Mean_{transparency} = 5.28$ vs $Mean_{opaque} = 4.87$). For consumer attitude, a similar effect was detected. Participants who were presented products with transparent covers evaluated the products more positively than those who were presented products with opaque covers ($F(1, 121) = 4.61, p < 0.05$; $Mean_{transparency} = 5.73$ vs $Mean_{opaque} = 5.36$). The above results were similar for both product categories. No significant effects of the product category or interaction effects between product category and transparency were detected ($p > .05$). These results provided support for H1-H3.

6.3. The moderating role of design acumen on the effects of transparency

Based on the design acumen scale, results revealed that participants varied in their ability of processing product appearances ($Mean = 4.51, SD = 1.62$). As design acumen is a continuous variable, the previous research strongly recommended using regression analyses to test the moderating effect rather than dichotomising. The statistical power of dichotomising can be low, and dichotomising could possibly cause misleading interpretations (Fitzsimons 2008; Irwin and McClelland 2001). Therefore, moderated regression analyses were conducted to test the moderating effect of design acumen on the relationship between transparency and consumers' attitude. Specifically, transparency was firstly coded as a dummy variable (1 = transparent; 0 = opaque), and consumers' design acumen was standardised. Next, transparency and design acumen were included as independent variables. Finally, the interaction between transparency and design acumen was also entered as an independent variable. The dependent variables included consumers' perceptions of technological advancement, performance quality and attitude. In order to account for the within-subject of product category, a random effect model was used by general linear mixed model (GLMM). The mixed effects model allows for examining the differences between groups without aggregating over product categories or participants (Baayen, Davidson, and Bates 2008; Judd, Westfall, and Kenny 2012). Product categories were considered cross random effects. Participants' ratings of technological advancement, performance quality, and attitude were used as dependent variables.

The GLMM analyses with technological advancement, performance quality, and attitude as dependent variables were significant (see Table 2). As hypothesised, significant interaction effects between transparency and design acumen were found for technological advancement ($b = .38, p < .05$), performance quality ($b = .42, p < .05$) and attitude ($b = .34, p < .05$). These findings suggest that the effects of transparency on technological advancement, performance quality and attitude differ significantly depending on consumers' design acumen.

To further explore these interactions, the slopes of consumers' design acumen in the GLMM were examined at both levels of transparency (Fitzsimons 2008; Irwin and McClelland 2001). Specifically, the effects of design acumen on technological advancement,

Table 2. Moderated GLMM analysis for transparency (dummy) and design acumen on consumers’ perceptions of technological advancement, performance quality, and consumer attitude.

	Technological advancement		Performance quality		Consumer attitude	
	Standardised β -estimate	<i>p</i> -value	Standardised β -estimate	<i>p</i> -value	Standardised β -estimate	<i>p</i> -value
Intercept	4.584	.000	4.917	.000	5.382	.000
Transparency (dummy)	.601	.000	.303	.035	.277	.052
Design acumen (z-score)	.129	.260	.108	.266	.0081	.396
Transparency \times design acumen (z-score)	.374	.029	.416	.004	.344	.017
Model	$F(3,248) = 10.57, p < .01$		$F(3,248) = 10.38, p < .01$		$F(3,248) = 7.24, p < .01$	

performance quality, and attitude were examined in the GLMM when the dummy variable of transparency was set to 0. When the products included transparent covers, the slope of design acumen was significant and positive for technological advancement perception ($b = .50, p < .01$), performance quality perception ($b = .52, p < .01$), and attitude ($b = .43, p < .01$), suggesting that high design acumen consumers evaluated the products more positively than consumers with low design acumen. When the products included opaque covers, the slope of design acumen was not significant for technological advancement ($b = .13, ns$), performance quality ($b = .11, ns$), and attitude ($b = .08, ns$), suggesting that no differences between high design acumen and low design acumen consumers were found.

Furthermore, spotlight analyses for consumers with high design acumen (one standard deviation above mean) showed significant and positive effects of transparency on technological advancement ($b = .97, p < .01$), performance quality ($b = .72, p < .01$), and attitude ($b = .62, p < .05$) (see Table 3). These results indicated that consumers with high design acumen evaluated the products with transparent covers more positively than products with opaque covers. Next, the spotlight analysis for consumers with low design acumen (one standard deviation below mean) was conducted. As expected, no significant results were detected for the effects of transparency on technological advancement ($b = .23, ns$), performance quality ($b = -.011, ns$), and consumer attitude ($b = -.068, ns$) (see Table 4). These findings suggest that for consumers with low design acumen, transparency does not have a significant influence on attitude and perceptions. Therefore, these

Table 3. Spotlight analysis for consumers with high design acumen (one standard deviation above mean).

	Technological advancement		Performance quality		Attitude	
	Standardised β -estimate	<i>p</i> -value	Standardised β -estimate	<i>p</i> -value	Standardised β -estimate	<i>p</i> -value
Transparency (dummy)	0.974	.000	.719	.000	.621	.002
Design acumen (z-score)	0.129	.260	.108	.266	.081	.396
Transparency \times design acumen (z-score)	0.374	.029	.416	.004	.344	.017

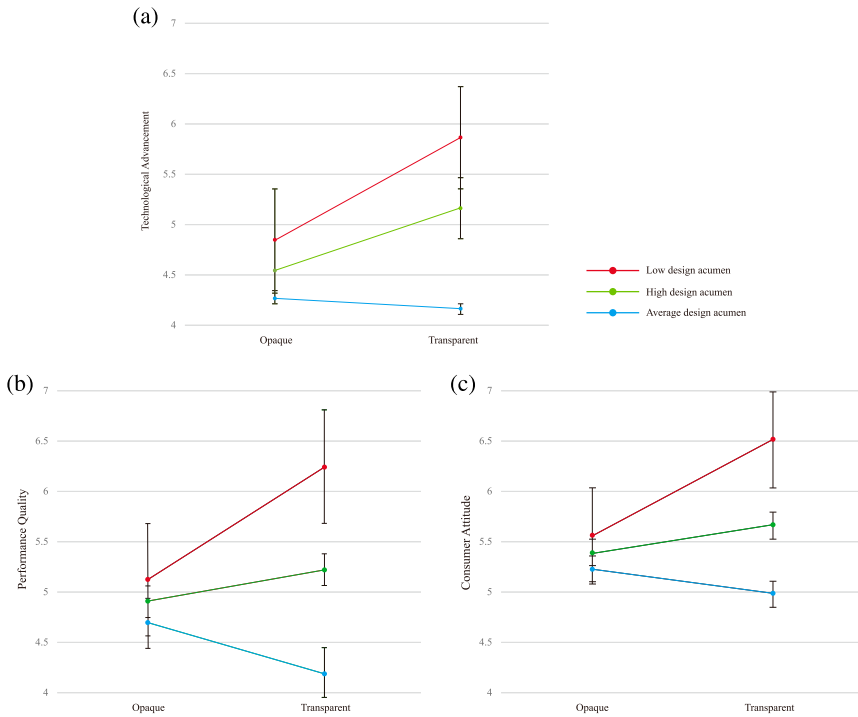


Figure 1. Moderating effects of design acumen on technological advancement (a), performance quality (b), and attitude (c).

Table 4. Spotlight analysis for consumers with low design acumen (one standard deviation below mean).

	Technological advancement			Performance quality		Attitude	
	Standardised β	-estimate	p-value	Standardised β -estimate	p-value	Standardised β -estimate	p-value
Transparency (dummy)	.227		.349	-.0113	.581	-.068	.739
Design acumen (z-score)	.129		.260	.108	.266	.081	.396
Transparency \times design acumen (z-score)	.374		.029	.416	.004	.344	.017

findings support H4 that transparency has a stronger influence on perceptions and attitude for consumers with high design acumen. These results, visualised in Figure 1, show the effects of transparency on consumers with a mean level of design acumen, low design acumen, and high design acumen. Figure 1 demonstrates that consumers with high design acumen and general design acumen exhibit improvements in product perceptions and attitude towards products with transparency. In contrast, consumers with low design acumen showed no significant changes concerning their perceptions and attitude between products with opaque and transparent covers.

7. General discussion

This research has uncovered the benefits of using transparency in product designs through a factorial experiment. The results show that in comparison to opaque covers, using transparent covers in product designs can significantly improve consumers' perceptions of technological advancement and performance quality, which further leads to enhanced consumer attitude. This research further reveals that the effects of transparency are moderated by consumers' design acumen. The positive effects of transparency are stronger for consumers with high design acumen than for consumers with low design acumen.

As product experience and credence attributes are highly important for consumers' purchase decisions, improvements of the perceptions of these attributes can enhance the competitiveness of a product in the market. Designers thus need to understand how to design product appearances to evoke consumers' perception of experience and credence attributes. To equip designers with these knowledge, past research has explored the relationships between various design characteristics (e.g. novelty, product personality traits, harmony, etc.) and consumers' perceptions of product experience and credence attributes (Mugge and Schoormans 2012a, 2012b; Creusen, Veryzer, and Schoormans 2010). This research builds on these studies by demonstrating the effects of transparency. Prior research has acknowledged the potential of investigating transparency in product designs and presented the overview of possible influences of using transparency (Cheng, Mugge, and de Bont 2018). This study further adds on it by empirically validating the positive effects of transparency on consumers' perception of technological advancement and performance quality, as well as consumer attitude.

More importantly, this research further reveals how the effects of transparency vary depending on individual differences. Consistent with the general notion that consumers' processing of product appearance differs between individuals (Bloch, Brunel, and Arnold 2003), this study shows that consumers' processing of transparency is influenced by design acumen. In line with previous studies (Truong et al. 2014; Becker et al. 2011), the present study finds that consumers with high design acumen have greater capabilities to process product appearances with transparency. As a result, transparency exerts stronger influences on consumers with high design acumen than consumers with low design acumen.

Furthermore, this study extends past research on transparency in packaging design to durable electronic products (Simmonds and Spence 2017; Simmonds, Woods, and Spence 2018, 2019). The results show a similar effect of transparency for product designs as for packaging design: seeing the inside contents can have a positive influence on consumers' product perception of experience and credence attributes. A possible explanation for these effects may be that seeing the internal content may facilitate consumers' imagery. For food packaging, transparency is shown to facilitate consumers' imagery of food freshness and tastiness (Simmonds, Woods, and Spence 2018). For product designs, seeing the technical components through transparency may trigger consumers to imagine how the innovative technology is implemented, resulting in more positive perceptions and attitude.

7.1. Limitations and future research

Although this study is carefully designed and conducted, it carries several limitations, which can be interesting opportunities for future research. The first limitation lies in the creation

of stimuli. A transparent window was used in this research while creating the stimuli, but there can be many alternative ways to include transparency in product appearances. Rather than including a transparent window, designers can use transparency to embody the whole product, such as the SoundSticks from Harman Kardon. The increasing size of transparency allows consumers to see all the internal components, which may even strengthen consumers' positive perception of experience and credence attributes found in this research. Moreover, this research used product photographs as stimuli presented to consumers. Although it is a valid way and extensively used in current consumer research (e.g. Creusen and Schoormans 2005; Hoegg and Alba 2011), there can be other ways to present stimuli, such as showing participants real products in physical shops. By seeing and interacting products physically, consumers could gain additional information, such as the materials, textures, and finishing of the internal components, which could further facilitate their inference-making of product experience and credence attributes. Future research can validate our findings using real products as stimuli.

Second, this study recruited 126 participants from the U.S via MTurk, a commonly used panel of which the reliability has been confirmed (Buhrmester, Kwang, and Gosling 2016). Although this sample size is sufficient to guarantee the validity of this factorial experiment, the sample collected via MTurk may have restrictions in terms of cultural and educational background. Thus, it would be interesting to use different samples to replicate the effects of transparency in future research. It is possible that consumers coming from cultures that value simplicity (e.g. Japanese) feel reluctant to products with transparency because transparency makes the product look more complex.

Third, to measure design acumen, this research used a self-reported scale, which has been developed and used extensively in past research (Truong et al. 2014; Becker et al. 2011; Giese et al. 2014). A self-reported scale captures consumers' self-reflection of their own capability of processing visual stimuli, which may differ from others or more objective evaluations. It may be interesting for future research to explore whether it is possible to measure design acumen in other, more objective manners, such as by using a quiz on visual language knowledge.

Fourth, this research focuses on consumer electronics that use ambiguous electronic technology as the product stimuli. For such consumer electronics, the exposure of internal components does not communicate any detailed information regarding the product operation, other than the fact that the product uses electronics to operate. However, for other product categories (e.g. kitchen appliances), transparency may reveal additional information related to the product operation. As a result, transparency can possibly bring additional benefits (Cheng, Mugge, and de Bont 2018; Lockton, Harrison, and Stanton 2010). For example, for kitchen appliances, consumers can observe how the food is prepared through a transparent cover, which can improve product usability and can enrich consumers' food-making experiences. Therefore, future research can explore how transparency influences consumers' perception of product experience and credence attributes in other product categories to provide a comprehensive understanding of the effects of transparency.

Fifth, this research focuses on the influences of transparency on consumers' perception of experience and credence attributes. In addition to these perceptions, transparency can trigger other benefits. Through transparency, consumers can observe the situations of internal product components, which allows consumers to detect problems more quickly

and repair products timely. As found in the prior research, the changes in product appearances can remind consumers how long they have used a product and trigger consumers to take product care activities (Ackermann, Mugge, and Schoormans 2018). Consequently, consumers may postpone product replacement plans and use the products for a longer time. Furthermore, seeing the internal parts through a transparent cover, consumers may also realise how many components a product requires, reminding them that the resources are scarce and limited. As a result, consumers may realise more environmental concerns of replacing products too often and thus be willing to postpone their replacement plan, contributing to a sustainable society. Future research can explore how transparency influences consumers' product care activities and their replacement.

7.2. Practical implications

Considering the benefits of using transparency for improving consumers' perceptions and attitude, designers may intend to use transparency in product designs. Implementing transparency in the product design requires engineers' additional efforts and increased manufacturing costs. Thus, it is essential for designers to learn what benefits transparency can bring in order to make effective decisions. This research offers some guidelines. While designing, designers should carefully consider what perceptions they intend to trigger and decide whether using transparency can fulfil their intentions. Using transparency can be an effective strategy when designers intend to communicate technological advancements and superior performance quality. If designers intend to prompt consumers' perception of ease of use, transparency may not be optimal.

Designers should also consider whether transparency is suitable for a specific product category. Depending on what contents a transparency cover exposes in a product, the effects of transparency may differ from product categories. This research suggests that transparency is suitable for consumer electronics. But for some product categories (e.g. waste bins, luggage), transparency may be less suitable because transparency in waste bins exposes unpleasant contents and transparency in luggage triggers concerns on privacy. Even if transparency is suitable for a product category, designers still need to consider how to use transparency to effectively trigger the intended perceptions optimally. Designers can use transparency selectively through exposing certain parts that can facilitate consumers' perceptions while hiding the parts that are less likely to influence consumers' perception. For example, aiming to trigger consumers' perceptions of technological advancement for consumer electronics, it may be more interesting for designers to expose chips and sensors than the battery because consumers will more easily relate advanced technology with electronic chips than with the battery.

Furthermore, while including transparency in product designs, designers not only need to design the outer product appearances but also the internal contents that are exposed through transparency. Specifically, underneath product covers, there are often a number of technical components, especially for consumer electronics. These technical components can look numerous and chaotic, leading to unattractive product appearances. To arrange the technical components in an aesthetically pleasing way, the aesthetic principle 'unity in variety' can be helpful. This principle suggests that unity among various components can create aesthetically pleasing appearances (Post, Blijlevens, and Hekkert 2016). Thus, designers need to collaborate with engineers to balance unity and variety. Designers can try to

create similarities among these components, such as colourising different components into the same colour and arrange similar-looking components together.

In addition, as using transparency can make a product design look more novel, it is important to further explore the effects of transparency together with the possible effects of novelty. Previous research concluded that consumers do not prefer highly novel-looking products because processing high novelty goes beyond consumers' processing capability (Hekkert, Snelders, and Van Wieringen 2003; Schoormans and Robben 1997). To create stimuli for this study, transparent windows were added to products with typical appearances. The current results showed that consumers are able to process transparency and draw positive evaluations. However, when product appearances already include novelty (e.g. asymmetry, atypicality), using transparency may not be an optimal choice because too many novel elements may go beyond consumers' processing capability. Therefore, designers need to carefully assess the overall novelty of product appearances before considering whether involving transparency in product design would exceed consumers' processing capability.

This research also provides guidelines for selecting the proper consumer segment for using transparency. To promote products with transparency, it can be particularly effective for companies to target consumers with a medium to high level of design acumen. Companies can specifically target channels that high design acumen people often attend, such as design-related websites, or via visual artists or designers in social media. High design acumen consumers serve as 'design experts' in their peers. The investments in this group of consumers can even facilitate the diffusion of new products in general, which contributes to product success in markets.

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Appendices

Appendix A. Stimuli used in this study

Product category of electronic toothbrush:

The TB-E9 is a new electronic toothbrush. This electronic toothbrush integrates a new motor to clean teeth effectively and efficiently. It provides two brushing modes: clean and white. Moreover, this electronic toothbrush is rechargeable through a travel charger.

Product category of smartphone:

The HD-M8 is a new smartphone. This smartphone has 6 inches edge-to-edge screen design. It incorporates 8MP front camera and 12MP rear camera to allow you to capture photos. Moreover, this smartphone has a 2500 mAh battery.

Appendix B. The comparison of repeated ANOVA results between including covariates (Table 5) and excluding (Table 6) the covariates of age and gender

Table A1. Results of repeated ANOVA with transparency as IV, age and gender as covariates, product evaluation, technical advancement, and performance quality as DVs.

	Technological advancement		Performance quality		Consumer attitude	
	<i>F</i> value	<i>p</i> -value	<i>F</i> value	<i>p</i> -value	<i>F</i> value	<i>p</i> -value
Intercept	127.923	.000	187.346	.000	210.082	.000
Transparency	9.43	.003	5.052	.026	4.61	.034
Age	.000	.986	1.068	.303	5.65	.019
Gender	.163	.687	1.565	.213	.917	.340

Table A2. Results of repeated ANOVA with transparency as IV, product evaluation, technical advancement, and performance quality as DVs.

	Technological advancement		Performance quality		Consumer attitude	
	<i>F</i> value	<i>p</i> -value	<i>F</i> value	<i>p</i> -value	<i>F</i> value	<i>p</i> -value
Intercept	2144.364	.000	3189.22	.000	4076.12	.000
Transparency	9.55	.002	3.99	.048	3.13	.080