



## Designing the appearance of environmentally sustainable products



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### ABSTRACT

The study presented in this paper uses a mathematical model to measure the degree in which a product will be perceived as environmentally friendly from its physical attributes. A model based on genetic algorithms and neural networks was developed to predict the judgement of the users about environmental friendliness of different tables. Opinions of real users about a large set of tables were used to train the model. The results of the study suggest that, using this procedure in advanced stages of product design process, designers can determine the set of product's physical attributes that best convey the idea of "environmentally sustainable" to the customer. The analysis of the obtained model allows establishing how different product's attributes influence users' perception. From these results, the utilization of users' affective response models to design the appearance of environmentally sustainable products is discussed.

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### 1. Introduction

Consumer awareness and concern for environmental issues has grown in recent years. The global survey on Corporate Social Responsibility (CSR) conducted in 2012 in Nielsen (2014) revealed that 55% of consumers will pay extra for products and services from companies committed to positive social and environmental impact, and that 52% made at least one purchase in the past six months from one or more socially responsible companies. The same percentage of consumers checks product packaging to ensure sustainable impact. The results of a different survey conducted in 2007 by McKinsey to consumers from the eight world's major economies show that 87% consumers are concerned about the environmental and social impacts of the products they buy (Bonini et al., 2008). These consumers would prefer companies that promote measures for the production of safer and healthier products, consider the impact of their business practices on local communities, ensure the safety and health of their workers and implement policies of environmental sustainability (Gershoff and Frels, 2015; Luchs et al., 2010; Nielsen, 2011). Companies have significant opportunities to differentiate themselves by acting responsibly to improve not only corporate image but also willingness of socially committed consumers to buy their products. Therefore, companies should better

understand consumer expectations and perceptions (Albino et al., 2009; Bonini et al., 2007; Gershoff and Frels, 2015).

The surveys mentioned above show a positive relationship between environmental attitude of consumers and Green Consumer Behavior; yet the market share of environmentally sustainable products is lower than expected when compared to the percentage of customers who claim to be interested in sustainable products (Dupré, 2005; Peattie and Crane, 2005; Rex and Baumann, 2007). The reason may be that consumers do not always know which environmental features characterize a sustainable product (Lin and Huang, 2012), or that many environmentally sustainable products do not meet consumers' expectations due to the gaps that exist between consumers' expectations and their perceptions of those products (Peattie and Crane, 2005; Tseng and Hung, 2013).

Companies apply communication strategies and conventional marketing practices in order to improve acceptance of sustainable products in the market (Delmas and Burbano, 2011; Rex and Baumann, 2007). Other measures consist of analyzing how certain aspects of the sales environment or packaging can influence consumer decision to purchase green products: price presentation (Lee Weisstein et al., 2014), eco-labeling (Atkinson and Rosenthal, 2014), using green color (Pancer et al., 2015), etc. However, companies have paid less attention to product design and appearance.

Previous studies show that environmental sustainability could be communicated to consumers through product's appearance (Hassi and Kumpula, 2009; Hosey, 2012), and that superior product aesthetic design has a positive effect on confidence and choice

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likelihood for sustainable products (Luchs et al., 2012). Even, some authors propose that products appearance can influence their environmental sustainability (Zafarmand et al., 2003). Luchs et al. (2012) suggests that it is especially important for firms interested in marketing sustainable products to develop market-leading product aesthetic design capabilities. However, very little work focuses on how to design the appearance of environmentally sustainable products, and little research on design tools for this objective can be found in the literature on sustainability. Some guidelines for environmentally friendly product's form design are found in Hassi and Kumpula (2009). For example, small products, plainness, natural material appearance, quality appearance or simplicity seem to be attributes related with positive environmental appearance of products. Murto et al. (2014) use a basic design tool (image boards) in shaping the appearance of products in early phases of design to draw conclusions about how consumers infer sustainability from products appearance.

Although these works suppose an important advance, there are more sophisticated design tools to achieve the objective of relating products' attributes with consumers' opinions. Using these tools could be useful to understand the way in which consumers establish relationships between the attributes of products and the environmental sustainability. In product design, the ability of a product to evoke emotions in the observer is becoming increasingly more important, since it has a decisive influence on purchasing decisions (Chuang and Ma, 2001; Creusen and Schoormans, 2005; Desmet, 2003; Holbrook, 1985). In the current market, a great variety of products of the same type can be acquired to sufficiently meet users' needs. Therefore, product's shape, aesthetic features, visual appearance and ability to convey to the user the objectives for which it was designed, are all key to the success or failure of a product (Bloch, 1995; Chuang et al., 2001; Crilly et al., 2004). Additionally, sales platforms such as the Internet limit the user-product relationship to visual interaction, meaning that it is the appearance of a product which defines the image the user has of it (Dahan and Srinivasan, 2000; Vriens et al., 1998).

This justifies the efforts carried out by many authors (Chen and Yan, 2008; Chen et al., 2006, 2002; Diego-Mas and Alcaide-Marzal, 2016; Han et al., 2000; Hasdoğan, 1996; Lai et al., 2006, 2005; Lin et al., 2007; Park and Han, 2004; Tsai et al., 2006; Yang and Shieh, 2010) to provide mathematical models which match the attributes of a product to the consumers' affective responses (hereinafter CAR models). These models can be used to estimate how a user will assess a product in the early stages of the design process. Product's design can then be adapted to evoke the desired emotional response prior to its launch.

Han and Hong (2003) contends that the user's affective response is based on a cause-effect relationship with the attributes of the product. In other words, certain product attributes lead to a certain user response. This is a basic assumption for the development of a CAR model, given that the model can be created by systematically analyzing the relationship between the users' responses and products' attributes (Yang and Shieh, 2010). Nevertheless, establishing such relationships is not easy given that there are several fundamental problems that must be solved. One problem is that the mental process carried out by the user from the time he receives the information regarding the product until the time he makes a judgment on it, is in practice, unknown. Other problems relate to how to codify the inputs and outputs of the models or to determining the mathematical technique whose use is most appropriate for obtaining the model. However, the fundamental problem relating to the development of CAR models stems from the variety of different users' opinions regarding a single product. Generally, the models are based on the premise that there is a cause and effect relationship between the attributes of the product and the user's

response. Nevertheless, these relationships vary from one user to the next since their opinions are not based entirely on the attributes of the object. Individual and external conditioning factors such as personal taste, cultural environment, level of education, and personal motivations and aims will all lead the perception of each user to vary (Allenby and Ginter, 1995; Engel et al., 1995; Hoch et al., 1995). In the case of a model developed to predict if a product is perceived as environmental friendly, the personal environmental attitudes of consumers could be considered important external conditioning factors.

Diego-Mas and Alcaide-Marzal (2016) proposes a procedure to develop single users' affective responses models (SUAR models) that address some of the problems in CAR models' development. In the present paper, a SUAR model is developed to predict if a product will be perceived as environmentally friendly based only on its physical attributes. There were several objectives in this work. One of them was to introduce this kind of design tools in environmentally-friendly product design. These models have been proved to be useful for predicting user's impulse to purchase or judgements related to essential functionalities of the product. However, environmental friendliness of a product is a more specific judgement, and the relationships between product attributes and users' perception could be harder to find. If this main objective is achieved, a secondary objective will be to provide insights on the process by which consumers infer beliefs about environmental sustainability from the appearance of products. To do this, the relationships between inputs and outputs of the obtained model will be analyzed. Finally, previous aforementioned studies address the appearance of products in terms of seeking inspiration and locating guiding principles for the continuation of a development process. Our work focuses on more advanced stages of the product design process, when designers are dealing with different product options, and could take advantage of these tools to select the most appropriate set of product's attributes to transmit environmental friendliness.

Section 2 in this paper will be devoted to an overview of SUAR models. Section 3 will show a case study in which a SUAR model is developed to predict if users perceive a product as environmental friendly based on its attributes. Results will be shown in Section 4 and will be discussed in Section 5.

## 2. Overview of SUAR models

The development of CAR models stems from supposing that the user's affective response is based on a cause-effect relationship with the attributes of the product. However, the fundamental problem relating to the development of these models is the variety of different users' opinions regarding a single product due to individual and external conditioning factors. Taking the above into account, a SUAR model approach develops several CAR models for several single users. These individual models do not suffer from the dispersion of users' opinions and it is supposed that they will be more accurate. The disadvantage is that these models would only be valid for one user. However, although the perceptual relationships to be modeled are different for different users, if the opinions of a group of users regarding a selected sample of products are similar enough, it can be concluded that their perception processes and specific conditioning factors are similar. Consequently, by grouping users based on the similarity of their judgments, a mathematical model can be generated for a user representative of each one of those groups. With a certain margin of error, these models would be valid for all users included in their cluster. The mean market response could be determined weighting the response from each model by the relative size of the cluster containing the user from which the model was obtained. Several

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