

# A Review of Research on Modeling Design Based on Product Semantics

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## ABSTRACT

The objective is to review the research literature on product semantics and product design both domestically and internationally. The method of article is to systematically review the concepts and application research status of product semantics and product styling with a focus on analyzing more specific semantic forms and features in product design, and summarize and analyze the main research directions of modeling design based on product semantics on the basis of extensive literature research. The results of this review reveal that the information provided by existing products is inconsistent with the functions of the products themselves and the wishes of users, resulting in the difficulty in conveying accurate information due to the logical and scientific nature of product design semantics. The conclusion summarizes various semantic thinking modes in product design, which make the visual form of the product clearer and the design of the shape more in-depth into human psychology. It further points out the direction of research on product semantics and shape design.

*Keywords: Product semantics, Modeling design, Semantic thinking, Product design.*

## 1. INTRODUCTION

Product semantics [1] was a significant revolutionary trend in industrial design in the 1980s. In 1950, the Ulm.Hochschule fur Gestaltung in Germany established the discipline of "Research on the Application of Symbols" to complete its theoretical framework. [2] The "Product Semantics Seminar" organized by the American Industrial Designers Association (IDSA) defines product semantics as a theory that studies the symbolic characteristics of the form of artificial objects in usage contexts and how it can be applied to industrial design [3]. Product semantics is based on semiotic theory, and its emergence is influenced by multiple backgrounds such as philosophy, society, and culture. [4] Currently, schools in the United States, Europe, Japan, India, South Korea, and Taiwan have included product semantics as part of design teaching, organizing academic discussions, and conducting thematic designs on product semantics. In terms of research, it has developed to explore the laws of product semantic cognition from the perspective of cognitive science in psychology, providing new reference basis for product design and teaching research. In countries

such as Japan, research has been developed in depth under the name of "kansei engineering".

This research aims to provide a detailed review of the research on product semantic concepts, features, extensional and connotative semantics, as well as applications in recent years. It aims to summarize various semantic thinking methods and research status in product design, and explore further research issues related to product semantics and product styling.

## 2. OVERVIEW AND FEATURE ANALYSIS OF PRODUCT SEMANTICS

Product semantics originated from semiotic theory [6]. In semiotic theory, it is believed that every individual in society is engaged in verbal and nonverbal communication behaviors anytime and anywhere, and communication between meaning and ideology is constantly ongoing in society. Product design semantics is a specific combination of design and semiotics [7]. Product semantics emphasizes the encoding and decoding of product language, and designers, who are the coders and senders of semantics, play a crucial role in the

entire semantic communication process; Users are the decoders and receivers of semantics, as well as the evaluators of whether semantic communication is smooth or not. Without users, the designer's code loses its meaning. The semantic communication process diagram is shown in "Figure 1". In addition to emphasizing the functional connotation of product symbols, product semantics also need to have an inherent human nature, which emphasizes the cultural, spiritual, and psychological impact of the product on users. These effects endow the product with added value beyond functionality, which is obtained through the aesthetics and experience of the product. Designers need to design

targeted products tailored to different object, cultural, spiritual, and psychological needs. Therefore, design forms need to reflect diversity and meet diverse and diverse human needs. The product form symbol reflects the semantic meaning of the product's functional connotation, economic connotation, and cultural connotation, and is a combination of multiple semantics. Product form symbols not only accurately reflect the function of the product, but also express the cultural connotation of the product, including its social attributes, cultural background, user behavior and aesthetic psychology, as well as a series of emotional symbolic semantics.

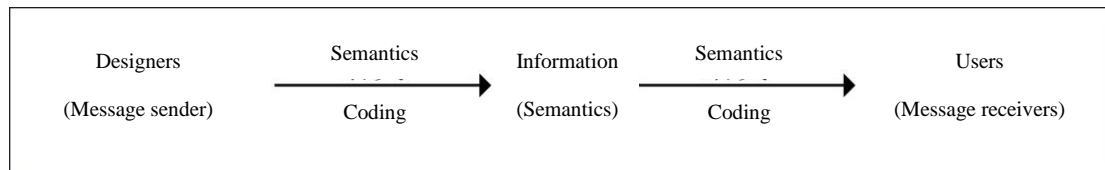


Figure 1 Semantic communication process.

## 2.1 Overview of Product Semantics

Product semantics is the study of the language meaning of products. At the beginning of the birth of product semantics, this discipline was defined as: "Product semantics is the study of the symbolic meaning of the form of artificial objects in the context of use, and is applied to industrial design." [8] The concept of product semantics officially emerged in 1983, proposed by Professor Klaus Krippendorff of the University of Pennsylvania and Professor Reinhart Butter of Ohio State University, and was explicitly proposed at the "Product Semantics Seminar" organized by the Industrial Designers Society of America (IDSA) at the Cranbrook School of Art in the United States, and defined it as: "The so-called product semantics refers to the study of the symbolic characteristics of artificial objects in the usage environment and the application of their knowledge to industrial design [9-10]." Simply put, product semantics is an attempt to indicate through its form what a product is or how it operates [11]. Semantics uses a semiotic cognitive perspective to understand the world [12], and products, as communication media and props of life, can also express rich semantics.

## 2.2 Analysis of Product Semantic Features

Product design is aimed at meeting human needs, which is first manifested as meeting people's daily needs, and then to meet the different spiritual

needs of users. Therefore, the product needs to have two symbolic features: the first is the symbol that expresses the product's own function; the second is a symbol that reflects the spiritual needs of users and consumer culture. There is a constantly evolving and changing interactive relationship between products and human needs, and any product is the product of this interactive relationship. It is necessary to know how to accurately integrate product semantics into the design of product form, convey product information, and then use the extension and connotation of product semantics as inspiration to analyze more specific semantic forms and features in product design, and analyze and summarize the respective connotations and design points of functional semantics, symbolic semantics, interesting semantics, and caring semantics based on actual product cases, in order to prepare for better design of meaningful and valuable products. In product form bionic design, full consideration is given to the inherent correlation between the bionic object and the design object. From creativity to modeling semantics, and then to functional semantics, iterative optimization can make form bionic product design more usable, cultural, and emotional [14].

### 2.2.1 Functional Semantics of Products

The functional semantics of a product refer to the functional meanings expressed by its form.

Functional definition is a crucial process for understanding the essence of a product and evaluating its value [15]. Functional semantics mainly answer what a product is and what its purpose is; Indicative semantics answer the question of how to use a product, expressing the functional level of the product through conventional or practical symbols. In biomimetic design, straightforward expression is the direct utilization of natural biological forms and functions, with a focus on creative expression of the original functions of nature. The straightforward expression method utilizes the original functions of natural forms and also uses the impressions of forms in people's minds to express the functional semantics of products [16]. In people's inherent thinking, there is a generally consistent understanding of the functions of various natural forms, which has become the semantic appeal point of product bionic design. Combining product semantics with shape bionic design can enhance the functional and aesthetic connotations of products [17-18].

### 2.2.2 *Symbolic Semantics of Products*

Symbolic semantics reflect a certain spiritual level of the product. Generally speaking, communication between products with certain symbolic meanings and users is not limited to simple functional physiological communication, but emphasizes emotional communication and dialogue between products and people. The traditional concept of "form follows function" is gradually changing, and product design is becoming more user centered, influenced to some extent by fashion, personality, culture, and economic conditions, becoming a symbol. Users often seek resonance in their symbolic reserves, explore symbolic elements, and seek spiritual value satisfaction. Symbolic semantics, as an important aspect of product semantics, greatly enriches modern design culture and expands the modeling language of product design, becoming an important medium for the expression of symbolic semantics in products [19].

### 2.2.3 *Interesting Semantics of Products*

Interesting semantics [20] is the expression of designers' care for people and understanding of life's interests. Interesting semantics products can give people more fun experiences, and are an important way and method to break the monotony, rigidity, dullness, and oppression of products, making people have beautiful memories. The interesting semantics of products are mainly

expressed through playful design symbols. While meeting basic functions, various humorous, cute, and cartoon symbols and design elements are integrated into the design body. Based on human emotional experience, image details are processed to bring surprises to people. Specifically, it can be divided into various semantic features such as liveliness, machine interest, and humor [21]. In addition to being achieved through direct fun forms, materials, and colors, it can also be indirectly achieved through clever modeling design and structure to generate new ways of use. For fun product design, semantics provides an important theoretical foundation and provides multiple design methods in specific designs. With the continuous enrichment and improvement of product semantics, the emotional design of products will also expand to more design fields, bringing more joy to people's lives and better meeting their emotional and spiritual needs [22-23].

### 2.2.4 *Product Care Semantics*

All languages (including all symbolic systems) first appear as a means of communication, and the process of sending and receiving information is the process of information transmission [24]. Product design advocates "people-oriented", and design without humans is isolated and worthless; On the contrary, products embody care for people, especially special groups, while meeting their functions. Care semantics [25] emphasizes the dual care of human physiology and psychology in product design. Through detailed design, the audience can feel the emotional experience of being cared for, which is an important embodiment of product design and people-oriented approach.

## 3. ANALYZING PRODUCT DESIGN FROM A SEMANTIC PERSPECTIVE

Communication between people is through language, while communication between products and people is through product semantics. Just as great poets use language to express an emotion and depict an artistic conception. As a medium of communication and a tool for daily life, products can express different forms of semantics, which can be divided into extensional semantics and connotative semantics according to hierarchy [26]. The former refers to the definite, explicit, or common sense semantics that a product possesses, which are directly expressed in the product context as "explicit" relationships. By using product design

as a means, people can quickly understand "what product this is", "what is used for", "how to operate" and other issues through appearance design [27]. Connotative semantics, mainly including psychological and physiological reactions such as feelings, senses, and emotions, are the symbolic values of the psychological, social, and cultural aspects displayed in the product's usage context. It is a person's perceptual perception of a product, a "latent" relationship that cannot be directly expressed in the product context, and is contained in metaphors or metaphors of the product form. In fact, in specific design practice, more attention is paid to the refinement of the semantic meaning "what is specific" and "what semantic features are possessed" that the product needs to express.

### 3.1 Externally Extended Semantics and Connotative Semantics

Usually, visual information transmission is the most intuitive, and the primary visual information

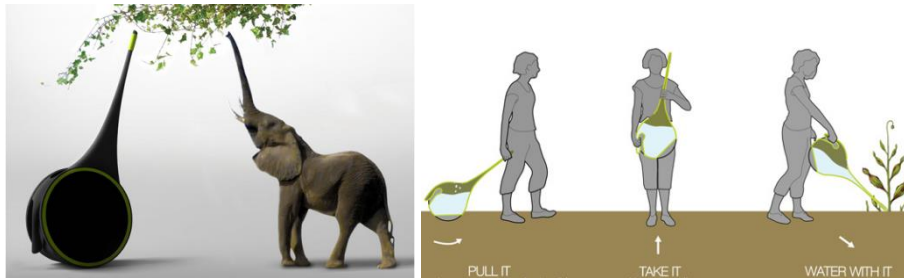


Figure 2 Design of a Long Nosed Sprinkler.

The scope of connotative semantics [31-32] is extremely broad and requires the premise of extensional semantics, which are closely related. Connotative semantics refer to the symbolic values conveyed by a product in its usage context, including psychological, social, and cultural aspects. The design of daily necessities has its unique connotation, and symbolic function is an important factor that cannot be ignored. The function of a watch is to time, which precisely explains the indicative function of product semantics. The "Rolex" watch shown in "Figure 3" symbolizes status, while the "Swatch" watch shown in "Figure 4" symbolizes love. There are countless examples of such products, whether they are indicative or symbolic functions, they are undoubtedly the perfect interpretation of the connotation of daily necessities.

transmission lies in the appearance and form of the product, so it is the first reference element for consumers to choose [28]. A good application of product extensional semantic design can effectively match the knowledge in the user's mind with the external knowledge conveyed by the product, improving the usability of the product. Designer Diane Dupire's Long Nosed Sprinkler Pot U-CAN biomimetic object is selected from the elephant's long nose. From a morphological perspective, the personalized features of the elephant's long nose are applied to the design of the spray pot spout, with a unique shape and beautiful form. The product extension semantics of the long nosed watering can design are "what" (the watering tool) and "how to do" (holding the pot body, the long nose of the spout can spray water, and grasping the long nose can easily drag it), which can naturally convey the product extension semantics. The handle and overall design of the pot meet the user's human body size requirements, reflecting the comfortable and convenient human-machine characteristics [29-30], as shown in "Figure 2".



Figure 3 "Rolex" watch.



Figure 4 "Swatch" watch.

### 3.2 *The Signifier and Signified of Product Semantics*

The relationship between semantics and semiotics is very complex, and for product design, it is generally based on the theory of "signifier-signified" to explore product design [33]. The signifier and signified are language creation terms proposed by linguist Saussure [34] to express the properties of language symbols. The signifier mainly refers to the sound and image of language, while the signified refers to the concept of things reflected in language. In product design, the language of product design reflects the signifier of product extensional semantics, while the way the

product is used and the symbolic meaning it possesses constitute the signifier of product intensional semantics. The design of Adidas Men's Perfume and Dior My Lady Perfume is shown in "Figure 5". From the perspective of morphological and semantic elements, straight lines represent male masculinity, while curved shapes represent female femininity. In addition, the bottle shape of Dior Zhenmei perfume comes from the neck characteristics of Karen girls at the northern border of Thailand and Myanmar, as well as the physical characteristics of the copper collar. This design goes beyond its referential significance and is more relevant to the artistic background.



Adidas Men's Perfume



Dior My Lady Perfume

Figure 5 Perfume bottle design.

## 4. RESEARCH STATUS OF PRODUCT SEMANTICS AND PRODUCT STYLING

At present, research on product semantics and product styling mainly focuses on functional semantics, symbolic semantics, interesting semantics, caring semantics, extensional semantics, connotative semantics, as well as the signifier and signified of products. Li Shujiang et al. [36] analyzed the shape features of yachts and extracted shape feature lines, combined them according to line types, summarized the types of shape lines, evaluated their morphological semantics, and determined the control points of shape feature lines. By changing the design parameters of feature lines to output different schemes, they have verified that the mapping from feature elements to shape images is quantifiable and adjustable. Cao Guozhong et al. [37] used symbolic association for the semantic meaning of "switch" and applied it to the design practice of seasoning bottles. Chen Xu [38] summarized the design principles and laws of product semantics, using fire extinguisher design as

an example to not only meet the needs of emergency rescue, but also enable deeper application of product semantics. Oujing [39] combined semantics with the characteristics of CNC machine tools and constructs a complex product semantic cognition and transformation model based on the Krippendorff product semantic framework. Han Shengzhu [40] summarized the design factors and principles that affect self-service terminals through research and analysis of semantic and semiotic theories, as well as the impact of human cognition on semantic communication. Yu Jiyue [41] proposed a modeling design method and process for hierarchical semantic feature analysis. By constructing the semantic space of service robots, the mapping relationship between perceptual semantics and modeling design elements has been obtained, and the feasibility of the product semantics based modeling design method and process for service robot products has been verified. Zhu Wei et al. [42] proposed a product design method that combines product semantics with biomimetic design techniques, inspired by the phenomenon of cicada sloughing in nature. Liang

Qi et al. [43] studied the classification of design cues from the perspectives of visual and semantic features, discussed the role of design cues in brand recognition, and constructed a brand design clue system based on a certain automotive brand, observing its application in design oriented design.

At present, most designers often rely on their own experience when carrying out cultural and creative design. However, designers' understanding of culture is often implicit and difficult to detect and express. Therefore, characterizing implicit knowledge in explicit form has become a key to design research [44-45]. Design is different from art. It is a combination of sensibility and rationality, a creative activity with a purpose, direction, and plan. Jin Yinglei et al. [46] used relevant theories of extenics to transform implicit knowledge into elements that can be expressed and evaluated rationally. Throughout the analysis process, based on graphical thinking, they focused on convergent evaluation of the graphical semantics of features, integrating cultural features with product design in the form of semantic symbols to achieve the goal of cultural creative design. Zhang Xiaoyan [47] used product semantics to analyze and redesign the surface decorative patterns of Han Dynasty lacquerware. Qin Zhen et al. [48] used extension theory to extract and select the semantic elements of Dong brocade patterns, and completed product design. Ding Ning et al. [49] proposed a method for constructing a semantic quantification model of ethnic patterns for product design. Zhao Hao et al. [50] analyzed the correlation between samples and perceptual semantics through semantic difference method, providing new ideas for product semantics research from the perspective of active aging.

It can be seen that product semantics plays an increasingly important role in product modeling design, not only in the fields of daily necessities, industrial products, and cultural and creative product design, but also provides the theoretical basis for design in other design related fields with its broad content.

## 5. CONCLUSION

This research focuses on reviewing the research achievements in product semantics and product modeling design, and summarizes the application of product semantics. Literature research has found that due to the formal factors (such as shape, color, etc.) bestowed on products by designers, long-term human experience has been accumulated, which directly affects emotional changes and is

accompanied by rich associations and imagination. However, in many cases, the designers' intentions cannot be correctly understood by the user, resulting in incorrect identification and operation, making the product and the users' inner emotions unable to reach consistency and resonance.

The emergence of product semantics is a significant change in the history of design thinking. It relies on the theoretical framework of semiotics and has been continuously developed in the research of scholars and designers from various countries. Although it is no longer a hot topic of design trends, it is still widely applied in various fields of industrial design. Its research scope has also expanded from cognitive fields such as psychology and cognitive science to methodological fields such as product design and development and human-machine interface design. The continuous development of society, the further refinement of consumption levels, and the increasing spiritual demand for products have put forward new requirements and tasks for product design. However, the products that permeate users' lives often make them feel confused, seemingly difficult to understand or operate, and difficult to use. Therefore, how to use product semantics and design symbols to create products that meet the personalized needs of modern humans has become the historical mission of industrial designers.

The semantic purpose of the product is to imply operation and use to the user, and establish the symbolic meaning of the product to meet the spiritual needs of users and the symbol of consumer culture at the same time. Through in-depth research on product semantics, designers can help reveal or imply the internal structure of the product through the design of its external visual form, making the product function clear, making the human-machine interface easy to understand, and conveying more product context and connotation to users with a clearer visual image and more symbolic form design. Therefore, future research should pay attention to the following points: Before designers design, they should first have a deep understanding of the semantic implications of various aspects that need to be reflected in the product shape, so that the designed product shape can be targeted and easy for users to understand the function and usage of the product through the language of the product shape.

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