# Conceptualizing Cognitive and Perceptual Processes of Building Product Meaning: Insight from Design, Psychology, and Neuroscience.

Erin Cho

Strategic Design Management, School of Design Strategies, Parsons School of Design, The New School

## Abstract

**Background** To better understand why and how a consumer forms a particular meaning toward a particular property of a product, it is important to look into consumers' internal mental processes involved in perception, cognition, and encoding of product attributes and consumption experiences. This essay discusses how the design and functional properties of a new product would be evaluated, understood, and linked with the existing mental framework to form the meanings of a product.

**Methods** The meaning building mechanism is a complicated process as it involves multiple layers of interactions between consumer perception, cognition, and actions related to product consumption. To obtain a better picture of consumer's meaning forming processes, therefore, this essay integrates literature from not only design but also from the fields of psychology, sociology, ecology and even biology.

**Result** The sensory input obtained from viewing an object can lead to a drastically and qualitatively different consumer experience due to the observer's complex expectations, schema, preference for novelty and surprise, and affective responses. Also, the unique nature of product experience dynamically impacts how a product is viewed in comparison to competitors, even facilitating forgiveness of flaws, as well as increased and enduring customer patronage.

**Conclusions** While designers deal with and often focus on constructing physical and functional properties of a product, it is critical for designers to understand how these properties would be perceived and evaluated by consumers.

**Keywords** Meaning Building, Mental Processes, Perception, Cognition, Prototype, Schema, Emotion

*Citation:* Cho, E. (2015). Conceptualizing Cognitive and Perceptual Processes of Building Product Meaning: Insight from Design, Psychology, and Neuroscience. *Archives of Design Research, 28*(3), 39-47.

http://dx.doi.org/10.15187/adr.2015.08.28.3.39

**Received :** May. 28. 2015 ; **reviewed :** Jun. 16. 2015 ; **Accepted :** Jul. 07. 2015
**pISSN** 1226-8046 **eISSN** 2288-2987

## 1. Introduction

The mantra of the corporate world has been innovation in the past several decades. Successful execution of new product/service development has proven to be the most powerful ammunition to claim and sustain market leadership in many industries all over the world (Cann, 2013). With a rapidly changing business environment and ever more prickly consumer demand, it is no exaggeration to state that a firm's ability to innovate determines its survival and prosperity in the future (Cefis & Marsili, 2006). When thinking about innovation, particularly the innovation that is radically different from what exists, the conventional approach is to frame it in terms of technological advancement. That is, it is using cutting-edge and breakthrough technologies to create novel products or to drastically improve the function of existing products (Garcia & Calantone, 2003). Thus, the core competitive advantage in the race of innovation rests on the firm's technological superiority to its competitors.

Recently, however, design scholars have raised the caution that, while it is unquestionable that technology plays an instrumental role in innovation, it is wrong to equate innovation with technological breakthrough since radical innovation can also be possible by introducing radically different consumption meaning (Verganti, 2009; Norman & Verganti, 2014). In fact, before even thinking about what kinds of new products or new product features to develop, it is critical to first identify what kinds of new experiences we ought to deliver and more importantly, why consumers would find them different and valuable (Cho, 2013).

While studies in the design field have examined how consumers would evaluate new visual and functional features of a product by analyzing observable consumer behaviors, attitudes and intention, and other market data, not much attention has been paid to understanding consumers' internal mental processes involved in such evaluations. To fully understand why and how a consumer forms meaning toward a product, it is necessary to look into the internal mechanism in which varying aspects of product attributes are perceived, understood, and encoded in our mind. This essay addresses this issue.

Specifically, this essay discusses how the visual perception of a product design and the evaluation of product functions would be evaluated, understood, and linked with the existing mental framework to form meanings of product attributes. It is to note that the formation of product meaning is a complicated process involving multiple layers of interactions between perception, cognitions, emotions, and actions related to consumption experiences. To obtain a better picture of a consumer's meaning forming process, therefore, it is useful to turn to the multiple perspectives of psychology and even biology as well as designs.

## 2. Fundamentals of Visual Processing for Product Designs

People's evaluation of product designs begins with the same perceptual and cognitive processing that occurs in the perception of any object. It is thus useful to first understand the internal processes involved in the way an object is perceived in the general context. It is also important to note that the visual experience is not just based on visual features, but is "grounded in sensory perception, extended internally through cognition and language, and modified externally through social and cultural frames" (Pierce, 1991, p. 167). Visual perception is also a multiple-level process. On the sensory level, discrete points of light, shape, and orientation are bound into a whole that can be understood by the brain's visual system. Through perceptual and cognitive processing, these features are grouped and integrated based on preexisting knowledge, environmental context, and the viewer's expectations (Humphreys & Riddoch, 2006).

The multiple-level process can begin on the sensory level ("bottom-up") or on the cognitive level ("top-down"). Bottom-up accounts of visual processing, such as Biederman's (1987) Recognition-by-components theory (RBC), propose that we are able to recognize objects by separating them into discrete units, like cylinders and cones (bottom-up). According to this reductionist theory, these three-dimensional shapes can then be assembled in various arrangements to for a virtually unlimited amount of perceptions that represent objects in the environment. Proponents of Top-down processing, such as Gestalt school of psychology, similarly propose that environmental stimuli are grouped by our perceptual system to create meaningful and interpretable wholes. These theories, however, insist that expectation shapes perception, and that for the environment to be perceived meaningfully, it must be perceived holistically. This top-down proposal is supported by the fact that the raw stimulus information that is gained through the senses (incoming light that stimulates the retinas) is necessary but not sufficient to fully experience reality. The ambiguous sensory input must be enriched by top-down mental processes.

Similarly, Oxman (2002) distinguishes visual perception from visual cognition. Specifically, "perception" is the semantic, temporal low-level visual processing, while "visual cognition" is high-level visual interpretation analogous to the top-down account. Low-level processes are driven by stimulus input and address the question "what is the object?", not "what is the object about?" The latter question is addressed by high-level processes. Visual cognition hinges upon stored information and involves knowledge about the object. Mental imagery ("seeing with the mind's eye") is also an important component of visual process. When input matches such a stored representation, an association is made in memory and one can access associated information.

The goal of a successful designer should be to synthesize functional reductionism as well as "intuitive holism" to communicate product meaning (Dillon and Howe, 2003; Holm, 2006). The focus of an innovation on either reductionism or holism impacts the outcome of the product. We conjecture that meaning building focusing on technological features or attribute-based communication would be elaborated primarily via the reductionist approach, while

meaning and experienced focused products are more likely to be perceived holistically. This distinction between holistic and analytic processing is mirrored in brain organization, with the right cortical hemisphere predominately responsible for perception of global features, and the left hemisphere processing the majority of local dimensions. These two perspectives are then synthesized to create a complex, meaningful perception (Hubner & Volberg, 2005). It is thus to be understood that the process of meaning building is not solely based on either the reductionistic or the holistic approach. It is the mechanism involving both, although the relative significance of each approach would play in consumers' mental processes would vary depending on product characteristics.

In the visual cortex, incoming stimuli are synthesized with memory information distributed throughout the brain. According to Purves (1988), successful interactions with objects strengthen links between input and previous perceptions. Unsuccessful behavioral responses to perceptual assumptions, on the other hand, mute maladaptive associations in the brain. This learning process allows observers to determine function and meaning of objects. Perception of reality is maintained through descriptive representations, cognitive organizations that stand for objects that exist in the environment. Intentions and desires are prescriptive representations that represent goals and aspirations that do not necessarily match the actual state of affairs. Again, this theoretical perspective suggests that perception of meaning is achieved not only through passive sensory input, but also through viewer expectations and mental states.

Every perception is also processed as potential for action. Two neural visual systems work together to comprehend knowledge about function and meaning, as well as behavioral possibilities. The ventral pathway is associated with interpretation of identifying features, and the dorsal pathway analyzing the object's location in space (Grill-Spector et al., 2001; Kourtzi, & Kanwisher, 2001; Spiridon, Fischl, & Kanwisher, 2006). Through these pathways, the visual system accomplishes two tasks: selection and recognition. Selection involves segregation of the complex visual array into separable objects and attributing appropriate physical attributes to these objects (color, texture, etc). Recognition involves processing of an object's enduring meaningful properties. The perceived object must match conceptual information about that object stored in memory for recognition to occur (Jeannerod, 2004).

## 3. Meaning Building of Product Designs as a Function of Cognitive Categorization

*Prototypicality.* Object categorization as well as recognition involves two interacting components: visual processing and cognition. According to computational models, two-dimensional representations of objects are stored in memory and matched to viewed objects (Palmeri & Gauthier, 2004). Cognition contributes to the perceptual categorization of these objects, which are represented in multidimensional psychological space, with similar objects being stored more closely together. These categories are formed through experience based on prototypicality. For example, when viewing a watch, the image is compared to a prototype watch that has been abstracted from experiences with other watches. This exemplar watch

may or may not have been directly experienced, but holds the essential characteristics that make a watch a watch. Perceptually, the prototype includes the basic physical features that define a watch, including a face, hands, and a band to attach to the wrist (Arnheim, 1971). Cognitively, the prototype holds the visual content and/or domain semantics that distinguish watches from other categories of objects. For example, a bracelet is also worn on the wrist, but a watch is used to tell time, which sets it apart from other wrist jewelry.

What happens if a novel watch, such as a smart watch, is experienced that has a unique defining semantic attribute that does not apply to the exemplar model? Treisman and DeSchepper (1994) proposed a dichotomous conceptualization of object perception that differentiates between familiar prototypes and related, but not matching, novel perceptions. A "visual type" is a stored representation of frequently experienced objects that is used as a standard model for identification and classification, a concept equivalent to the prototype or exemplar model. In contrast, "visual tokens" correspond to occasions of object perception that contain specific properties with no preexisting related type. This difference between "type" and "token" is potentially related to consumers' perception of imitators versus innovators. That is, innovators are likely initially perceived as tokens, allowing them to become the prototype of a newly formed category.

*Schemata*. Our interpretation of products is highly influenced by our preexisting cognitive organization, or schemata. (Sujan & Bettman, 1989) A schema is a cognitive pattern of associations that represents ideas, thoughts, behaviors, aspects of self, social information, and assumptions about the environment. When a viewed object matches a preexisting schema, we are more likely to notice it and confirm our assumptions formed by past experiences. We are unconsciously motivated to reaffirm our existing schemata over changing them to incorporate non-matching instances. In these cases, the new object is assimilated into an existing schema, potentially overgeneralizing the qualities of the object. Our preference for maintaining schematic integrity may result in ignoring stimuli that do not match our expectations, but may also allow for the perception of unanticipated objects to be viewed as "special". When something contradicts a preexisting schema, such as a meaning innovation, it may be encoded as an exception to existing assumptions and thus be interpreted as unique. A new schema may be formed for this non-matching entity through the process of accommodation.

Putting these all together, we can draw the mental processes consumers are likely to follow when encountering a smart watch. First, expectations arise from prior knowledge structures related to experiences with related products and brands. When a meaningfully unique design is encountered, schema incongruity results (Sujan & Bettman, 1989). Perception of novelties can create or violate schema expectations, or both. This violation draws the viewer in, and motivates him to reconcile the incongruity. Schema creation triggers related schemata and opens possibilities of associations not previously existing. When products are complex enough to activate multiple, previously unrelated schema, schema layering results and allows for more engaged processing. Separate, but related, schemata are connected through association networks that are recruited through spreading activation. When one schema is activated, related schemata are recruited according to the level of relevance. For example,

when viewing a smart watch, the nodes related to a regular watch and a smart phone would be activated, and then associated nodes, such as “time”, “wrist”, “band”, “call”, “apps”, would be recruited appropriately based on the observers experiences. Theoretically, this could cause assimilation of a smart watch into the existing watch or a smart phone schema, thus either muting the special features of a smart watch, or imposing the potential for all smart phones to be worn around a wrist. It is also possible that a separate and new schema would be formed for this specific instance of a smart watch, thus representing a smart watch as distinct from other products and more deeply engaging.

The role of schemata on perception is also important to understand why and how consumer perceives one brand a pioneer or a following in the same product category. Sujan and colleagues (1989) empirically explored this relationship, and the results of four studies showed that the degree of difference between alternatives within a category influences the consumer's perception of the brand within that category. If a brand is perceived as strongly different from others in the category, it is sub-typed into a niche position. In other words, a separate schema is created. When a brand is perceived as moderately different, it receives a differentiated position but is maintained within the original category. Sub-typing was found to be associated with better memory for the brand's distinguishing features, increased importance placed on this distinguishing attribute, and less concern with other attributes. This process is related to pioneer's advantage (Carpenter & Nakamoto, 1987), and suggests that successful imitators must also achieve a sub-typed position (likely based on different attribute) to avoid assimilation into the category forged by the innovator. Relatedly, when imitator products are very similar to the innovator, the pioneer preference effect is maximized (Carpenter & Nakamoto, 1987).

## 4. Meaning Building of Product Functions

We identify objects based on more than visual appearance. For instance, two objects that are similar visually (e.g.- calculator & cell phone) are distinguished as different, while two visually different stimuli (e.g.- cell phone & rotary phone) are identified as in the same category (Bar, 2004). Fournier (1991) proposed a model of derivation of meaning from the functional consumption of a product. This theory suggests that products are assigned meaning through belonging to one (or more) of eight categories including objects of utility, objects of action, and objects of appreciation. These categorizations may be thought of as neural activation networks that serve to cognitively group objects by their meaningful attributes. When the preconceived meaning of a product is challenged, neural connections are formed or modified based on this association.

The discussions above are supported by the findings from biology and neuroscience as well. The brain area associated with processing of meaning is known to include parahippocampus (Bar 2004). This area receives input from poly-sensory areas including visual-spatial, auditory, motor, and tactile centers. Increased activation in this area occurs when perceived meaning is incongruent with expectations, indicating that semantically unique stimuli call

of increased attention to that object. This brain area is also involved in the flexible activation of appropriate categorical associations depending on the object's context. For example, a hairdryer presented in the context of a salon might also activate image based representations of a brush, mirror, stylist, while in the context of an appliance store, other appliance representations (blender, toaster) may be activated (Bar, 2004).

Product meaning is also understood through consideration of the product functions in relation to ourselves and our environments. Building on Gibson's (1977) notion of affordances, Norman asserts (1998) that "design aspects of objects suggest to the user how the product should be interpreted in function and meaning." That is, objects have affordances (what they can be used for), constraints (limitations of use), and mappings (directions for use) (Norman, 1988). All three dimensions are based on not only actual but also perceived properties, and should be viewed as dependent on culture, prior knowledge and expectations of the observer (Humphreys & Riddoch, 2007; Soegarrd, 2010). This notion has been explored and supported through empirical research. Specifically for example, in neuroscience research, affordance can be linked to sensorimotor representations, or neural networks responsible for coordinated motor sequences during interactions with objects (Kagan, 2002). By measuring neuronal activity in monkeys during their interactions with objects, Asaad and colleagues (2000) found that primates have a specific profile of brain activity associated with each mode of object use, even when the physical motions are exactly the same (as cited in Kagan, 2002).

## 5. The Role of Emotion in Lasting Meaning Building

Another critical component of meaning building is emotion. Due to the visceral nature of emotional experiences, memories for affect-charged events are preserved for a longer time than those that were emotionally neutral (Kagan, 2002). In design, "beauty, fun and pleasure all work together to produce enjoyment, a state of positive affect" (Norman, 2004, p. 103). In the field of positive psychology, researchers and theorists explore how positive emotions facilitate learning and psychological wellbeing. For example, the experience of joy has been found to reduce stress, increase exploratory behavior and thus broadening knowledge (Fredrickson & Joiner, 2002). Design can facilitate positive emotions through meaningful aesthetics (Krippendorff, 1969). For example, the colorful and complex arrangement of the iWatch interface serves a purpose beyond functions, and become something to enjoy looking at or a piece to show off. According to Norman (2004), objects can induce pleasure in one or more of the following ways: through visceral, sensory stimulation (physio-pleasure), by stimulating social engagement (socio-pleasure), through enrichment of psychological states (psycho-pleasure), and through induction of mindful appreciation and reflection (ideo-pleasure). When products induce positive affect in these ways, initial surprise experienced by meaningful innovation can be extended over repeated use.

It is also interesting to note that when products evoke a strong affective response, analysis of unemotional related product information in reduced (Baumgartner, Sujan, & Bettman, 1992). This impact on information processing has implications for why consumers may forgive

shortcomings of innovative products, especially if initial experiences with these products are emotionally charged. When these autobiographical memories are later evoked by repeated experiences with the product, non-affect laden aspects of the product information are again likely disregarded.

In sum, this essay discusses fundamental cognitive processes involved in meaning building related to a product experience. While designers mainly deal with and focus on constructing physical and functional properties of a product, understanding how these properties would be perceived and evaluated by consumers is critical. Given that meaning building is a complicated process, multiple perspectives from design, psychology, and biology can contribute to obtaining a more holistic picture of this mechanism. As illustrated, the sensory input obtained from viewing an object can lead to a drastically and qualitatively different consumer experience due to the observer's complex expectations, schema, preference for novelty and surprise, and affective responses. The unique nature of product experience dynamically impacts how a product is viewed in comparison to competitors, even facilitating forgiveness of flaws, as well as increased and enduring customer patronage. The meaningful direction for the future study would be to empirically test several propositions made by the current study through neuroscience methodologies. For example, examining whether and how neural correlates activated for top-down/bottom-up processes would differ for technology/attribute driven innovations versus innovations focusing more on holistic consumption experience. In addition, we note that product meaning is also affected by the context in which a product is acquired and used. Although the current study focuses on mapping the product characteristics to consumers' perceptive and cognitive mechanisms, the immediate extension of this study is to investigate the mental processes involving the effect of contexts on the meaning of product consumption.

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