Product Differentiation by Aesthetic and Creative Design: A Psychological and Neural Framework of Design Thinking

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Abstract As firms increasingly use design to successfully differentiate their products from competitors, the concept of design thinking has lately received raised attention among practitioners. Many consider design thinking to fundamentally change the way firms will strive to innovate. Design thinking can be thought of as a methodology for innovation that systematically integrates human, business, and technical factors in problem-forming, problem-solving, and design. As initiatives for design thinking grow significantly, we need to better understand how design thinking helps to foster creativity of designers and product managers and how it supports firms' goal of creating aesthetically appealing products. Despite the relevance of the concept of design thinking, its underlying mechanisms have been poorly understood. The purpose of this chapter is to shed light on the processes of design thinking by integrating extant literature from psychology and neuroscience. In particular, this research focuses on aesthetics and creativity as crucial processes of design thinking. Subsequently, a definition of design thinking is offered, which is accompanied by a psychological and neural framework of design thinking.

1 Introduction

In business environments, where core product attributes have become homogenous across competitors, it is increasingly important for firms to understand how to successfully set their products apart from other market participants by creating additional value for customers (Reimann et al. 2010a, b). Following this line of thought, design has been argued to add a substantial amount of value to core product attributes (Reimann et al. 2010c). In particular, Verganti (2008b) observes

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several firms using design to innovate product meaning and, therefore, increase the emotional and symbolic value of their products. Moreover, Brunner et al. (2009) calls design one of the last great product differentiators for firms to use. As such, the design of products can be seen as a critical component of business competitiveness, to the extent that major firms such as Apple, Procter & Gamble, and Sony have committed themselves to becoming design leaders in their industries (Dunne and Martin 2006). Overall, firms are increasingly devoting to design and engaging design specialists in their innovation processes (Nussbaum et al. 2005).

Despite design becoming a key strategy of differentiation for many firms, its underlying mechanisms remain poorly understood. Particularly, two questions, which are crucial for a better understanding of innovation processes based on design, are in need of answering. First, *what constitutes "good" design from the perspectives of the individual designer?* In trying to answer this question, we will review the extant literature from psychology and neuroscience and argue that good design must be aesthetically appealing to its viewer. Verganti (2008a) posits that "if engineers use technology to make products function, then designers use form to make things beautiful" (p. 23). In line with this argument, our research will provide insights into the affective and cognitive processes at play while experiencing aesthetic design. Second, based on the notion that design is a creative activity (Maldonado 1991), *which methodologies can firms leverage to increase the creativity of their designers and product managers?* Here, the concept of design thinking has emerged as a powerful methodology for integrating human, business, and technical factors in problem-forming, problem-solving, and design (Martin 2009; Plattner et al. 2009). As firms increasingly engage in design thinking, there is a need for a better comprehension of how design thinking helps to foster creativity. While several principles of design thinking are well-established and anchored in a long history of social science research (e.g., the brainstorming literature), other design thinking aspects are unique and novel. Prior research on design thinking, however, has largely been restricted to practitioner-oriented publications. Thus, there is a lack of systematic knowledge of what the design thinking concept has to offer and how it distinguishes itself from other problem solving approaches. Therefore, to arrive at potential answers to the second question, we will integrate literature on creativity from both psychology and neuroscience to shed more light on the mechanisms at play during creative design thinking. As a result, we will define design thinking and present a conceptual framework, derived from the psychological and neural foundations of aesthetics and creativity.

The objective of this research is to establish a model of design thinking by integrating previous psychological and neuroscientific research on aesthetics and creativity. Moreover, providing answers to the aforementioned questions will support firms in their quest for better product design and successful differentiation from competitors.

The remainder of this chapter is organized as follows. Next, we lay out the theoretical background of aesthetics and creativity – two concepts, which we argue are critical for a better understanding of design thinking and, consequently, product differentiation by design. Subsequently, we will define design thinking and derive a conceptual framework of its psychological and neural properties.

2 Aesthetics and Creativity as Design Thinking Mechanisms

In design research, the "first generation" of design theories and methods predominantly leveraged the fields of operations research for its optimization techniques and cybernetics for its systems thinking approaches (Beckman and Barry 2007; Rittel 1972, 1984). However, these purely mechanistic approaches to the design process frustrated followers who were unable to reconcile the methods of the "first generation" with the complexities of real design problems, especially once values of social equity and pluralism were considered (Beckman and Barry 2007). Therefore, the "second generation" of design theories and methods was initiated, focusing on design as a social process (Bucciarelli 1988; Rittel 1972, 1984). Among those design approaches, the increasingly popular concept of design thinking is considered to fundamentally change the way companies nowadays strive to innovate (Nussbaum 2004). Design thinking can be thought of as a methodology for innovation, placing the interaction environment that promotes creative design on the center stage (Plattner et al. 2009).

As initiatives for design thinking in industry and academia grow, we need to better understand how the aspects distinguishing design thinking from other problem solving approaches help foster creativity and aesthetically appealing product design. Prior research on design thinking has often been restricted to practitioner-oriented case studies (e.g., Brown 2008), reflecting its early stage. As such, there has been little research aimed at exploring the psychological processes while a person is engaging in creative design thinking or experiencing aesthetically appealing design. Thus, our research aims at providing further insight into the mechanisms that underlie design thinking, while focusing on prior research on aesthetics and creativity. Besides investigating important psychological properties, this research also integrates recent evidence from neuroscience. To isolate relevant mechanisms, we aim at capturing specific affective and cognitive processes involved when people are engaged in design thinking.

2.1 Psychological and Neural Bases of Aesthetics

The word *aesthetics* was coined by Baumgarten (1735), based on the Greek word *aisthēsis* (i.e., perception from the senses, feeling, hearing, and seeing), and subsequently defined as "perfection of sensate cognition" (Osborne 1979). In this section, we review aesthetics research in the context of psychology and neuroscience, focusing on relevant affective and cognitive processes while experiencing aesthetic objects, including product design, artwork, and beautiful faces (e.g., Aharon et al. 2001; Kampe et al. 2001; O'Doherty et al. 2003; Senior 2003; Vartanian and Goel 2004).

2.1.1 Psychology of Aesthetics

Numerous views on aesthetics have developed within psychology research. These perspectives include empirical aesthetics (e.g., Berlyne 1971, 1974; Fechner 1871; Martindale et al. 1990; Seifert 1992), Gestalt theory (e.g., Arnheim 1943; Eysenck 1942), and psychoanalysis (e.g., Hanly 1986; Segal 1952), among others. Within these streams of research, aesthetics and associated terms of aesthetic appreciation, experience, judgment, perception, and preference have been related to arousal (Berlyne 1971, 1974), prototypicality (Martindale 1988; Martindale and Moore 1988; Martindale et al. 1990), and appraisals (Silvia 2005). Recently, Leder et al. (2004) proposed a psychological model of aesthetic experience, comprising of a five-stage process, which includes the perceptual analyses of the object of aesthetic interest, implicit memory integration, explicit classification, cognitive mastering, and evaluation. This process results in aesthetic judgment and aesthetic emotion. While aesthetic judgment (i.e., the cognitive element) is argued to be a result of understanding ambiguity in the object, Leder et al. (2004) further posited that aesthetic emotion (i.e., the affective element) may be seen as an outcome of continuous and satisfactory affective evaluation while processing the five process stages. Moreover, in the tradition of these affective-cognitive models, Hagtvedt et al. (2008) have developed measurement scales for affective and cognitive components perception of aesthetic objects. On the basis of these insights into potentially underlying affective and cognitive mechanisms, we would propose increased affective and cognitive processing for viewers confronted with aesthetic product design.

An effective measure of affective and cognitive processing is reaction time (Bruner and Postman 1947; Sternberg 2004). We expect greater attention and more intense emotional responses (Chatterjee 2004; Leder et al. 2004) and, therefore, longer reaction times, for design that is aesthetic (Reimann et al. 2010c). The notion of longer reaction times in response to aesthetic design may be based on prior research in psychology; for example, Madsen et al. (1993) found longer reaction times in the aesthetic experience to music. As such, aesthetic product designs elicits longer reaction times to arrive at choice than standardized packaging, resulting from increased affect (e.g., increased emotional responses) and cognition (e.g., increased attention) (Reimann et al. 2010c).

2.1.2 Neuroscience of Aesthetics

Recent studies in neuroscience have tried to draw neural frameworks of aesthetics (Chatterjee 2004; Nadal et al. 2008). Chatterjee (2004) developed a conceptual model of visual aesthetics, which was adapted from the cognitive neuroscience of vision. After the viewer is confronted with the visual stimulus, the model proposes a phase of early vision (i.e., a processing of color, luminance, shape, motion and location), followed by a phase of intermediate vision (i.e., grouping of theses features). These phases are coupled with attention and a representational domain (e.g., places or faces) and subsequently followed by an emotional response (i.e., liking versus wanting), and then the decision.

In a follow-up study, Nadal et al. (2008) laid empirical results over Chatterjee's (2004) conceptual framework by comparing it to three different neuroimaging studies (i.e., Cela-Conde et al. 2004; Kawabata and Zeki 2004; Vartanian and Goel 2004). Three components of Chatterjee's (2004) model were identified in the data of the reviewed neuroimaging studies: the process of early vision, the emotional response, and the decision.

Early visual processing was found in the *occipital cortex*, the most prominent brain area for vision (Vartanian and Goel 2004). Emotional responses became evident in the representation of reward value and the awareness of the emotional state (Kawabata and Zeki 2004; Vartanian and Goel 2004). Specifically, Nadal et al. (2008) argued that the cortical component of reward value of the aesthetically judged stimuli corresponds to activity in the *medial orbitofrontal cortex*. That is, visual stimuli rated as beautiful were associated with a higher reward value in participants' brains than those rated as ugly (Kawabata and Zeki 2004). Further, the subcortical component of reward value was identified in the *caudate nucleus* by Vartanian and Goel (2004). Nadal et al. (2008) further proposed that increased activation in the *motor cortex* could represent reward magnitude of ugly stimuli or the motor readiness elicited by them (Kawabata and Zeki 2004). Further, the subjective emotional experience associated with aesthetically preferred stimuli was identified in the *anterior cingulate cortex* by Vartanian and Goel (2004) and the decision component of Chatterjee's (2004) framework was identified in Cela-Conde's (2004) work. Yet, Nadal et al. (2008) admitted that it is not possible to determine whether the identified brain activity in the *left dorsolateral prefrontal cortex* reflects decisions based on perceptual information or on information regarding reward value or on both.

In summary, Nadal et al.'s (2008) review of Chatterjee's (2004) model provides a comprehensive overview of potential mechanisms at play while being confronted with aesthetic stimuli. In another empirical neuroimaging study, Jacobsen et al. (2006) showed specific brain activations for aesthetic judgments in comparison to decisions on symmetric objects. As such, while the results of the three former neuroimaging studies refer specifically to neural correlates of judging stimuli as aesthetic versus ugly, Jacobsen et al. (2006) identified neural correlates of judging the beauty of images compared to judging their symmetry, referring to the neural correlates of the judgment process itself.

Although the insights into the visual and decision-making processes in the brain are interesting, the findings on emotional responses seem to be most promising for the present research. These findings suggest that reward (i.e., wanting the aesthetic product) is what may trigger aesthetic preference, judgment, and subsequently decision (Leder et al. 2004; Zeki 1999). In their neural theory of aesthetic experiences, Ramachandran and Hirstein (1999) claimed that experiencing aesthetics is by itself rewarding. This claim is supported by several other empirical neuroimaging studies.

Specifically, Aharon et al. (2001) found that viewing beautiful faces activate the reward circuitry, particularly the *nucleus accumbens*. Additionally, Kampe et al. (2001) identified increased activation in the *ventral striatum* when an attractive faces looks directly at the viewer instead of when eye gaze is directed away, also

indicating that the reward system is engaged. Further, O'Doherty et al. (2003) showed that smiling, beautiful faces produce activation of *medial orbitofrontal cortex*, a brain area which is argued to be involved in representing stimulus-reward value. These findings are in line with the studies reviewed earlier, who also found activation in the *medial orbitofrontal cortex* (Kawabata and Zeki 2004) as well as the *caudate nucleus* (Vartanian and Goel 2004), which is an area of the *striatum*.

In summary, while experiencing aesthetic product design (i.e., after early vision, when emotional responses are elicited), we key areas of the brain's reward system are significantly greater activated for aesthetic design (Reimann et al. 2010c). These brain areas incorporate the *striatum* (which includes the *caudate nucleus* and the *nucleus accumbens*) as well as the *prefrontal cortex*. We expect that increased activation in these areas arises at the point in time when viewer experience (i.e., emotionally respond to) the aesthetic design.

2.2 Psychological and Neural Bases of Creativity

Creativity underlies most of the performance assessments in the design thinking literature (e.g., Brown 2008; Paulus and Brown 2003). But what is a creative idea? The common definition that creativity involves both novelty (i.e., something that is original and unexpected) and usefulness (i.e., something that is appropriate and adaptive regarding the task constraints) (Amabile et al. 1996; Shalley et al. 2004) works for understanding why the *outcome* of a product design process may be judged as creative (Litchfield 2008). This outcome, however, is influenced by a multitude of factors, including available resources to promote product design and opportunities for innovation in the marketplace. Yet, to improve our understanding of how firms can intervene to improve creative *idea generation* of designers, it seems useful to measure creativity at an earlier stage, focusing on factors that can be attributed to the humans involved in the product design process. In the following sections, we will discuss creativity from the perspectives of psychology and neuroscience and focus on the processes while people are being creative.

2.2.1 Psychology of Creativity

In psychology, the subject matter of creativity did not substantially develop until after Guilford's (1950) call for more research on this topic (Simonton 2000). Since then, a number of theories have been proposed, including social, developmental, cognitive, and biological perspectives (e.g., Amabile 1983; Eysenck 1993; Martindale 1995, 1999).

Simonton (2000) summarizes that most research progress has been made in four areas of creativity: first, the cognitive processes involved in the creative act; second, the distinctive individual characteristics of the creative person; third, the development and manifestation of creativity across the life span; and fourth, the social

surroundings that are associated with creativity. In particular, the *cognitive processes* related to creativity span from the process of insight (e.g., Sternberg and Davidson 1995) to the creative cognition approach (i.e., creativity as a combination of ordinary cognitive processes; e.g., Ward et al. 1997). Moreover, relevant *individual characteristics* of creativity have been said to include intelligence (e.g., Gardner 1993) and personality traits such as being independent, nonconformist, or unconventional (e.g., Dellas and Gaier 1970; Martindale 1989; Simonton 1999). Yet another topic of research on creativity is its *developmental dimension*. Here, research has investigated acquisition and actualization of creative potential, suggesting, for example, that exceptional creativity does not at all times emerge from creatively nurturing environments (e.g., Eisenstadt 1978). Finally, after earlier research on creativity focused mainly on the cognitive, individual, and developmental perspective (i.e., creativity was viewed as a process taking place in the mind of a single individual, e.g., see Simonton 2000), research became interested in the *social impact* on creativity (e.g., Amabile 1983). For example, prior research investigated the interpersonal environment of creativity, especially how reward or surveillance impact a person that is engaging in a creative task (Amabile 1996), or how brainstorming improves the level of creativity of an outcome (Osborn 1957).

In summary, psychological research offers a broad spectrum of insight into the cognitive, individual, developmental, and social aspects of creativity. Especially, research findings on the cognitive and social aspects of creativity seem to be valuable to the study of design thinking. For example, based on the notion that creativity is a combination of specific cognitive processes that interact (Ward et al. 1997), we propose that design thinking also recruits a unique set of interacting mechanisms. For example, these processes include attention pertaining to the design problem as well as acquisition and integration of memory, leading to a new, creative design idea.

2.2.2 Neuroscience of Creativity

The subject of creativity has recently also been approached with neuroscientific methodology. A topical literature review by Fink et al. (2007) reveals that electroencephalography (EEG) – a technique that allows the recording of electrical activity in the brain's cortex – is the most commonly used method for the study of creative thinking. Besides other methods, functional magnetic resonance imaging (fMRI) comes second to EEG in the number of existing creativity studies (Fink et al. 2007). FMRI measures changes in blood flow in the brain, which is highly correlated with brain activity (Logothetis and Wandell 2004). Compared to EEG, fMRI reveals brain activity not only in the cortex but also in subcortical brain areas (i.e., regions related to affective responses). Experimental designs in prior studies comprise a range of facets of creativity, including mentally composing a drawing (Bhattacharya and Petsche 2005), generating creative stories by using given words (Howard-Jones et al. 2005), and creating uses for real objects (Folley and Park 2005), among others.

In particular, prior neuroscientific research indicates that creativity is related to several regions in the brain. For example, Folley and Park (2005) report that

their divergent thinking task (i.e., creating uses for real objects) is associated with activation in the prefrontal cortex (PFC) in both hemispheres of the brain. Furthermore, in a fMRI experiment, Jung-Beeman et al. (2004) found increased activity in the anterior superior temporal gyrus for creative insight (i.e., an "Aha!" moment) relative to noninsight solutions. Moreover, Howard-Jones et al. (2005) report activation increases in the right medial frontal gyrus as well as the cingulate gyrus for creative versus uncreative stories.

In summary, extant neuroscientific research suggests that multiple regions of the brain are involved. While it is too early to make conclusions of the unique neural network that lies beneath creativity, prior research using neuroimaging methodology such as fMRI indicate that affect and cognition play an important role in the process of creativity.

3 A Definition and Framework of Design Thinking

Prior research considers design thinking as a methodology for innovation that systematically integrates human, business, and technical factors in problem-forming, problem-solving, and design (Plattner et al. 2009). This chapter focuses on the human factor by considering aesthetics and creativity as crucial dimensions of design thinking. In line with previous research on aesthetics and creativity, we propose that creative design thinking comprises of increased affect and cognition. In particular, design thinking may require increased attention, memory acquisition, and learning, followed by an aesthetically appealing design as an outcome, which in turn results in increased attention (e.g., slower reaction times while viewing it) as well as an emotional response (e.g., wanting). Specifically component of the emotional response to the aesthetically appealing design is linked to the reward system in the brain (Reimann et al. 2010c). Besides these individual-level factors of creative design thinking and its consequence – an aesthetically appealing design – a number of social-level factors are at the core of the design thinking concept and, therefore, may distinguish design thinking from other problem solving approaches. Drawing from the fragmented business literature on design thinking and related concepts, four factors can be highlighted as being central characteristics of design thinking in product design.

Inspiration Before Ideation According to Brown (2008), product development projects following a design thinking approach pass through three broad phases: inspiration (i.e., motivating the search for solutions), ideation (i.e., generating and developing ideas), and finally implementation (i.e., bringing the product to the market). In this process, it is considered fundamental that inspiration precedes ideation.

User-Centricity Design thinking is a methodology that imbues the full spectrum of innovation activities with a user-centered design ethos (Brown 2008; Gerber 2006). As such, innovation activities are driven by focusing on what people want and need

in their lives and what they like or dislike about the way particular products are made, packaged, marketed, sold, and supported.

Prototyping Design thinking is heavily dependent upon socially constructed, physical objects (Brereton and McGarry 2000). With a rudimentary prototype in hand, product designers have a more precise idea about what the ultimate design should accomplish. Prototypes also help to learn about the strengths and weaknesses of the idea and to identify new directions that product improvements might take.

Avoiding Criticism Social interaction in exploring the intersection of different points of view is at the heart of the design thinking approach (Gerber 2006). Embracing concepts from brainstorming research (Osborn 1957), design thinking involves a commitment of participants and facilitators to discouraging criticism in product development interaction (Litchfield 2008; Sutton and Hargadon 1996). Deferring adverse judgments has been argued to fundamentally help improve creativity in idea generation processes (Paulus and Brown 2003).

In summary, design thinking consists of specific individual-level and social-level factors that determine the design outcome and its level of aesthetic appeal. Figure 1 illustrates the framework of design thinking. Based on this framework, we offer the following definition of design thinking:

> Design thinking is a creative, individual-level process influenced by social-level factors (that is, high inspiration by others, high user-centricity, high prototyping, and low criticism by other), which includes attention, memory, and learning and leads to an aesthetically appealing object.

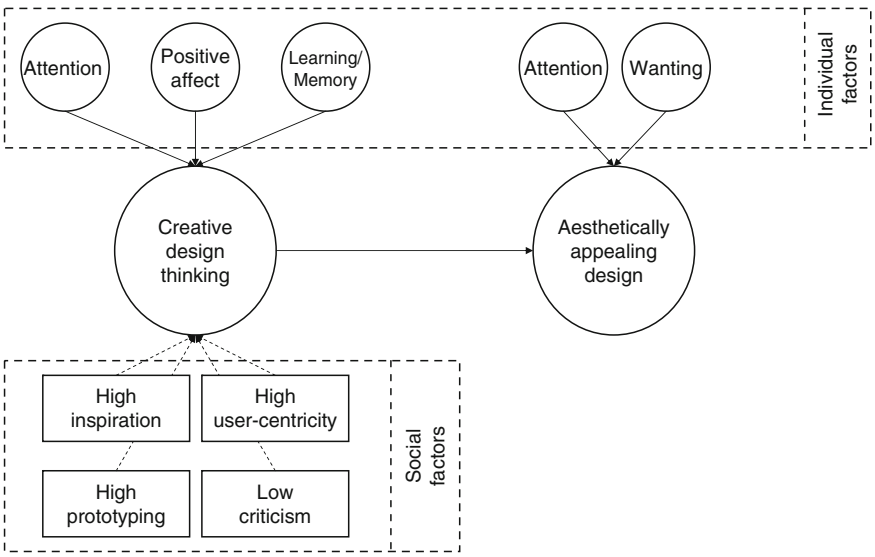

Fig. 1 Framework of design thinking

4 Conclusion

The prospect for research on the psychological and neural bases of design thinking is promising. Adapting ideas from the extant literature on aesthetics and creativity may help guide the testing of hypotheses about the affective and cognitive aspects of design thinking, leading to a better understanding of differentiation by design. The purpose of this chapter is to shed light on aesthetics and creativity, two important processes at play during design thinking. Our conceptual framework now underscores the need for empirical research in seeking to understand the mechanisms underlying design thinking and aesthetically appealing designs. We hope that further studies will conduct experimental work both in the field as well as in controlled settings, using psychometric, behavioral, and neuroimaging methodology.

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