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UNDERSTANDING AESTHETIC INNOVATION IN THE CONTEXT OF TECHNOLOGICAL EVOLUTION

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ABSTRACT

The paper theorizes the co-evolution of technology and design by integrating research on the evolution of technology with ideas from sociology, marketing, and psychology that explain the effects of design. Specifically, it applies work arguing that visible design attributes, such as color, shape, or texture allow producers to *explain* what their products do and how best to use them, to *excite* users in a way that generates sales, and to *extend* the basic functionalities of their products by highlighting their symbolic meanings. It then theorizes that the relevance of these three uses varies in the context of technological evolution such that affecting products' design-related attributes is a more central organizational process as product technologies emerge and when they are very mature, suggesting a U-shaped relationship between technological evolution and design. Next, the paper elaborates the moderators of this relationship: the frequency of successive product introductions, the social dynamics affecting consumption, the users' level of technological knowledge, and the volume of discourse attending to design. Thus, the paper offers a holistic theory for understanding the strategic use of design in the context of technological production and as such, advances recent work positioning design as a primary strategic challenge.

Design is an efficient and effective use of technology and materials to create a reliable product. Some aspects of design are not visible—such as the linkages among internal components, however, they affect the tangible form of the product by determining aspects such as size or weight (Clark, 1985). Other aspects of design are visible or otherwise perceptible by the senses: color, shape, texture, sounds emitted, and so on. For example, Alessi, together with the designer Michael Graves, makes a kettle with a bird-shaped spout that chirps as hot air is released. The shape and the sound the kettle emits suggest that the product is a functional kettle useful for boiling water and one which alerts users by producing a sound when the water has boiled. The visible design attributes also trigger emotions, such as joy (Verganti, 2006). And, they elicit various meanings that extend the use of this product beyond the utility of boiling water, in this case, by suggesting that the kettle's owners have the cultural capital and disposable income to appreciate the famous designers.

In this manner, tangible design attributes, which are typically visible, communicate functional as well as aesthetic and symbolic information (Creusen & Schoormans, 2005; Krippendorff, 2006; Norman, 2004; Noble & Kumar, 2010; Rafaeli & Vilnai-Yavetz, 2004; Rindova & Petkova, 2007). Functional information pertains to explaining what a product does and how it should be used. Aesthetic information pertains to the sensory reactions a product triggers, such as affect. And, symbolic information pertains to the meanings and associations users (e.g., relevant stakeholders: consumers, producers, journalists, etc.) attribute to a product beyond its basic utility.

Overall, the communication of information with design, in particular aesthetic and symbolic information, is strategically important because it triggers affect and research has shown that positive affect leads to higher sales (e.g., Bloch, 1995; Gemser & Leenders, 2001; Hertenstein, Platt, & Veryzer, 2005). For this reason, recent work in organizational research emphasized the strategic relevance of product design and suggested that it is a primary challenge for managers in the 21st century (Ravasi & Rindova, 2008; Utterback et al., 2006; Verganti, 2009). This paper advances our understanding of design in the context of competition by integrating insights about the communicative role of tangible design attributes (henceforth: design attributes) into extant organizational theorizing about the evolution of competition.

To clarify, scholars working to understand the drivers of technological change underlying product categories—groupings of products addressing common user needs—view this change as an evolutionary process. Many new technologies emerge and their evolution proceeds in a funnel-like manner in which only certain variations are selected and eventually retained (e.g., Anderson & Tushman, 1990; Utterback & Abernathy, 1975). In working to understand these processes, design has been acknowledged as a product dimension along which firms differentiate and drive marketing initiatives, especially in lieu of more technological avenues for differentiation (e.g., Abernathy & Clark, 1985; Christensen, 1997). In this context, design has been treated as an external layer of a product rather than one tightly linked to core technological concerns and components (e.g., Clark, 1985). Additionally, work on the social construction of technology suggested that a technology's form and physical embodiment are inseparable from its technological features and from the social processes surrounding its evolution (Pinch & Bijker, 1987). These authors sought to explain technological progress as the result of social interaction among the various actors who construct the meanings of technological artifacts according to their interests. As such, the authors focused not on how design operates to generate particular strategic benefits, but on how a particular design manifestation was selected among a larger array of choices, reflecting the interpretations of certain groups and the political relations among them. Consequently, scholars typically view the role of design in a restricted manner that emphasizes its ability to differentiate among products but affords it no importance beyond differentiation in the context of overall technological evolution.

Acknowledging that design is a powerful communicative tool furthers the ideas put forth by scholars of the evolution of technology. Specifically, the paper suggests that design as a tool for explaining what a product does (e.g., Hargadon and Douglas, 2001; Norman, 2004; Talke, Salomo, Wieringa, & Lutz, 2009) is of primary importance as new products emerge and posits that variants which are ultimately selected are those that best explain complex new technologies. As such, design attributes enhance our understanding of the variation and selection processes described by scholars of technological evolution. Additionally, the paper argues that design is a tool for triggering various cognitive and emotional responses (e.g., Bloch, 1995; Rindova & Petkova, 2007; Verganti, 2009) and as such affects the selection and retention processes. Finally, design attributes layer the symbolic facets of products (e.g., Belk, 1988; Bourdieu, 1984; Gottdiener, 1985; McCracken, 1988; Verganti, 2009) and as such also impact retention processes.

To firmly explain these claims, the first part of the paper draws from work about design in sociology and marketing, which suggested that it is a selection of attributes that are perceptible through the senses and that assist in communicating about the product in the three-faceted manner described above. In the following section, it integrates these ideas into our understanding of technological evolution and develops a framework explaining why affecting products' design-related attributes is a more central organizational process as product technologies emerge and when they are very mature, suggesting a U-shaped relationship between technological evolution and design. In the next section, it examines the conditions affecting this basic relationship suggesting that particular technologies and competitive technological settings are more or less receptive to the use of design as a means of communication. As such, the paper outlines a roadmap for a more strategic application of design in competitive contexts. Moreover, it offers a theoretical framework that completes our understanding of the production of technology by emphasizing the aspects in which consumption is not only functional, but also cognitive, emotional, and social.

DESIGN AS COMMUNICATION

Although design is an important concept, it currently lacks agreed upon scholarly definition (c.f. Ravasi & Stigliani, 2012). Luchs and Swan (2011: 338) reviewed and consolidated numerous articles and suggested that design is a tri-faceted product attribute. First, some aspects of design are based on engineering (mechanical, electrical, software, etc.) and are typically not transparent at the level of the final product. These relate to the linkages among internal components and materials. These linkages enable the product to be of functional utility to an end user (Ulrich & Eppinger, 2007). Second, other aspects of design pertain to a product's appearance, such as textures, shapes, colors, materials, ornamentations, and so on. These aspects are visible or otherwise perceptible to the end user. Third, the engineering- and appearance-based aspects work together to generate an integrated product (Utterback et al., 2006).

The idea of an integrated product suggests that design is a holistic property of the product; one greater than the sum of its particular selections of design attributes. To explain, design attributes are the first point of contact for users and the source of the initial information users have about a product (Ulrich, 2007). These attributes communicate the qualities of a good by hiding or revealing its complexity (Townsend, Montoya, & Calantone, 2011), improving its usability (Norman, 2004), and activating cognitive schemas that allow users to develop emotions towards the product, such as positive affect and approach or negative affect and avoidance, (Bloch, 1995; Creusen & Schoormans, 2005; Rindova & Petkova, 2007) and to interpret its symbolic meanings (Rafaeli & Vilnai-Yavetz, 2004; Verganti, 2009).

More specifically, Ulrich (2007) theorized that several sequential psychological processes operate simultaneously as users understand products by responding to their design attributes. Some are extremely rapid, such as detecting light and motion. Others play out over a second or longer, like those detecting shape, symmetry, gloss, and temperature. Longer psychological processes may evoke symbols from memory culminating with deliberate analytical thought. In this manner, people interacting with a product may form an overall assessment within a fraction of a second, but this assessment may change as they process additional information.

When these assessments lead to positive emotional responses, users form positive assessments of the products' quality (Creusen & Schoormans, 2005). That is, users perceive well-designed, beautiful products as ones that require attentive production processes and costly investments. Firms understand the cognitive links users form (Ulrich, 2007). For example, Asus uses high quality sound components in its notebooks, manufactured by Bang & Olufsen. To create a perceptual link between the sleek design of the laptop and the quality of its sound system, a recent tag line states that it "sounds as good as it looks".

Next, design attributes are at the basis of important cognitive processes of comparison and categorization. Specifically, users understand a product by comparing it to a prototype of a category they already understand and assessing the ways in which it is similar or different (Hargadon & Douglas, 2001; Rindova & Petkova, 2007; Talke et al., 2009). For example, Hargadon and Douglas described how Edison was able to explain what an electric lamp does by designing a form resembling a kerosene lamp and suggesting that the use of the former is akin to that of the latter. Other forms communicate by evoking metaphors. For example, Black and Decker offer a sander shaped like a mouse, with the electricity cord as a tail and grip knobs as eyes to convey the product's functionality for reaching small, tight spots (Noble & Kumar, 2010). In this manner, cognitive processes based on analyses of design attributes enable users to understand products' functionalities.

Additionally, sensory responses toward a product also stem from comparisons and categorizations (Creusen & Schoormans, 2005; Noble & Kumar, 2010). For example, the Apple iMac introduced in 1998 was colorful and thus different from the traditional beige PC makers were using. Users perceived this difference as exciting and Apple's sales soared. Design attributes also allow users to categorize products and product features in a manner that shapes their emotional reaction toward products. For example, the use of rounded shapes and pastel colors in kitchen appliances associates with a "retro" design intended to evoke nostalgia for simpler times. By acquiring and displaying such appliances, consumers can make a statement about their relationship to romantic perceptions of the past (Noble & Kumar, 2010).

Lastly, the processes of comparison and categorization link to the idea of product semantics—the understanding that design attributes act as signifiers that communicate meanings extending beyond their material embodiment (Gottdiener, 1985; Krippendorff, 2006; Verganti, 2009). To explain, users understand and value products at two orders of meaning: a first order, which is related to the immediate functional use of the object, and a second order, which positions products as signifiers for other ideas. For example, Creusen and Schoormans (2005) studied users' evaluations and interpretations of various product designs and found that different design attributes had different effects. More specifically, certain designs, such as rounded versus angular shapes were interpreted as having particular meanings, such as being more contemporary rather than outdated, appearing expensive rather than cheap, or playful rather than businesslike.

These second-order meanings allow consumers to communicate through the products they own. To explain, people use goods to mediate their social space and position themselves relative to others (Bourdieu, 1984; McCracken, 1988; Simmel, 1957[1904]). Consumption choices put forth various details consumers attend to and subsequently, enable consumers to use their possessions as extensions of their self-concepts and as signals about their identities as manifested by these details (cf. Belk, 1988; Solomon, 1983). For example, the purchase and use of luxury items is suggestive of the owners' disposable income, level of education, and social status (Bourdieu, 1984; McCracken, 1988; Veblen, 1953[1899]).

The notion of second-order meanings implies that producers design products with the intention that they carry particular meanings that extend beyond the explicit utility of the product, and in this way extend their potential uses. Gottdiener (1985) gave the example of an automobile—in the context of the first-order of meaning, it is an object used for transportation. In the context of the second-order, it is an object that signals social status. Particular brands of cars convey particular statuses and identifications with particular social groups, and these meanings are generally understood by all users. In this way, the car allows its owner to use it both as a means of transportation and as a means for communicating to others aspects of her identity such as income and taste preferences. Indeed, when producers understand these second-order meanings, they are able to produce them more deliberately and thus generate and satisfy taste markets for their goods (Gottdiener, 1985; Peterson & Anand, 2004).

In sum, work on design suggested that it is a communication process that underlies three important mechanisms. First, design is the language for explaining what products do and how best to use them. Second, design is a language for exciting users by triggering various emotional responses. And third, design is a language for extending the potential uses of products by fostering the generation of various second-order meanings. Together, these mechanisms set the foundation for understanding the conditions influencing firms' use of design in the context of the evolution of technological industries, as explained in the following section. Firms' efforts to affect design attributes in the context of this communication process is henceforth termed aesthetic innovation, as the idea of aesthetics refers to knowing something via sensory perceptions and design attributes convey information that is perceived by the senses.

THE CO-EVOLUTION OF TECHNOLOGICAL AND AESTHETIC INNOVATION

Over the years, scholars have developed insights about the pattern of technological innovation underlying particular product categories. New product-level technologies emerge from radical innovations. These spawn the product market and entail a high level of technological variety (Anderson & Tushman, 1990; Utterback & Abernathy, 1975). At this time, firms attempt to decrease the uncertainty involved with the technology, its uses, and the methods of producing and disseminating it (Tushman & Romanelli, 1985). Eventually, competitors gravitate toward the selection of a "dominant design": technological uncertainty decreases and the technology that underlies the ability of a product to perform becomes common to most competitors, generating fields with high degrees of standardization and commoditization (Utterback & Abernathy, 1975). Subsequently, technological innovation becomes more incremental and process oriented—it is based on relatively minor modifications to the way products fulfil their functional purposes or are manufactured (Utterback, 1994; Utterback & Abernathy, 1975). Such periods are characterized by reduced investments in product innovations. Firms become more efficient and large by concentrating on process innovations, and typically leave more radical product innovations to firms outside of the industry (Jovanovic & MacDonald, 1994; Utterback & Abernathy, 1975). This trajectory suggests that ultimately, technologies near their inherent limits and the costs of refining technological functionalities exceed potential monetary benefits (Klepper, 1996).

This pattern of technological innovation corresponds to the growth of firms' markets (Day, 1981). In particular, new technologies are initially treated with caution, and the demand for them grows slowly. However, once many technological questions subside and the dominant design emerges, markets grow rapidly and veer toward saturation (Abernathy & Utterback, 1978). Competition in such mature markets requires firms to maximize their sales by developing new market niches (Abernathy & Clark, 1985). Further, firms develop these markets not by performance improvements, as the rate of technological innovation at this stage is incremental and the technology becomes mature such that significant performance improvements are not likely (Utterback & Abernathy, 1975). Rather, firms develop their markets' by applying design-based changes to the product (Utterback, 1994), changes to the delivery and distribution of the product (Christensen, 1997), or by pursuing specialized market niches (Carroll, 1985).

This evolutionary pattern affects the ways in which aesthetic innovation is beneficial and subsequently determines the extent to which these innovations are central organizational processes. In particular, firms are likely to benefit from aesthetic innovation as new technologies emerge and when they are very mature, as indicated by a low rate of improvement for technological performance and a decline in demand. Thus, there is a U-shaped relationship between the importance of aesthetic innovation and the stages of technological evolution underlying a particular product category, as explained below. Importantly, while acknowledging that among competing firms, some produce only products in a given category while others produce multiple products in multiple categories, the paper discusses the relationship between technology and design in the context of a single product category and the various actors in the field encompassing the production, distribution, and consumption of that category. Figure 1 illustrates the theoretical relationships discussed in the paper. The prominent communication mechanisms are indicated, in their order of relevance, in the context of each relationship.

—Insert Figure 1 about Here—

To begin, as industries emerge around new product-level technologies, firms compete by offering their versions of the new technology and by embodying it in a particular product design. For example, Bijker's (1995) study of the evolution of the bicycle describes the relationships between various bicycling technologies, the physical designs that supported these technologies, and the reasons particular groups of actors and firms supported or opposed these designs. This study showed that as product markets emerge, firms face the challenge of finding the particular material embodiment of their technology. This challenge is critical because firms use design to both explain their technological ideas and to become those whose technological variant is the one the market eventually selects. Thus, firms' decisions at this stage affect how their technology will be understood and received in the market: some designs will succeed while others may become entirely irrelevant forcing their firms to exit the market.

As argued, firms are able to explain radical technological ideas through design. Both the example of Edison and the complex idea of electricity described above (Hargadon & Douglas, 2001) as well as the Dyson vacuum cleaner are good examples of this mechanism. Dyson explained his new vacuuming technology—one that does not require vacuum bags and has improved suction—by embodying it in a radically different design, and by so doing, emphasizing the novelty of his invention as well as assisting users' understanding of it (Talke et al., 2009). Specifically, the design of the Dyson vacuum cleaner is atypical; it is transparent and displays the absence of the bags and the powerful suction system. This design was linked to Dyson's speedy rise to market leadership (Noble & Kumar, 2010).

Furthermore, success in defining the taken-for-granted physical embodiment of the technology sets the industry benchmark to which other firms need to align. In other words, while the setting of the dominant design is typically evaluated using technological criteria, it also manifests as a selection of the preferred physical form of the product among many variants (Bijker, 1995). Firms are motivated to set this benchmark rather than having to spend resources aligning to a benchmark set by a competing firm (c.f., Murmann & Frenken, 2006). Specifically, firms who do not set the standard or who cannot quickly adapt to producing it exit the industry, leaving a larger share of the market to those who remain (Utterback & Suarez, 1993).

Together, both the need to explain the functionality of a new technology and the motivation to set the dominant design suggest that as new product technologies emerge, aesthetic innovation is a central organizational process. Moreover, firms have no way of offering new products and technologies without attending to design-related questions as technologies cannot exist without some physical embodiment. Thus, firms are highly motivated to invest in design, which anchors the left-hand side of the U-shaped curve as illustrated in Figure 2. Additionally, the use of aesthetic innovations to excite users and to extend the potential uses of the product is relevant at this stage of the technology's evolution, albeit to a lesser extent. Specifically, design triggers various sensory responses and can generate second-order meanings. Thus, design can fortify users' affect and ultimately preferences toward the product as well as designate particular social uses and second-order meanings that are relevant for the future demand patterns characterizing the product (Christiansen, Varner, Gasparin, Storm-Nielsen, & Vinther, 2010).

However, the primary purpose of aesthetic innovation at the early stages of a product category's technological evolution is to explain what the product does and how it should be used.

—Insert Figure 2 about Here—

During the next stage in this evolutionary process, product categories settle on a dominant design. This selection marks the market's transition from emergence to growth (Anderson & Tushman, 1990; Utterback & Abernathy, 1975). At this time, both technological and design questions are quieted. As explained, following the emergence of dominant designs, industry firms engage in ramping up production efficiency (Jovanovic & MacDonald, 1994; Klepper, 1996; Utterback & Abernathy, 1975) and are less likely to re-think their design choices. In terms of the U-shaped curve, these periods represent the flat part of the curve in which design has the least importance in terms of organizational processes, as illustrated in figure 2. Anecdotally, Henry Ford's quip that users can have cars "in any color they want so long as it's black" is indicative of firms' preference for efficiency and standardization at the expense of design at this stage.

The importance of design is likely to increase, representing an upswing of the U-shaped curve, as the technology underlying the product matures and overall demand begins to decline. This argument is based on industry dynamics that occur at later stages of the product category lifecycle. As explained, firms' offerings become increasingly standardized and commoditized. Technological progress is incremental and focused on process innovations that affect the ways products are made and distributed rather than on their functionality (Utterback, 1994; Utterback & Abernathy, 1975). Furthermore, the industry structure is altered when large and successful firms consolidate and gain market share at the expense of firms less adept at implementing leaner and more efficient production processes, which exit the industry (Carroll, 1985; Gort & Klepper, 1982). This consolidation further increases the level of product commoditization as it allows firms to reduce their costs and leads to further saturation of the market, and ultimately, to a decline in demand (Abernathy & Utterback, 1978; Day, 1981; Utterback, 1994). Alongside this strategy, firms cultivate market segments that are smaller and more specialized (a strategy that can be pursued by either different firms or divisions of the large firms (Carroll & Swaminathan, 2000)). In addition to these producer-level market dynamics, users also evolve over time in terms of their ability to understand a new technology such that their needs become specialized (Clark, 1985; Rosa, Porac, Runser-Spanjol, & Saxon, 1999).

During these periods, incremental product innovations are the basis for new product offerings. However, the utility users derive from incremental innovations is often difficult to discern ex-ante and in this context, aesthetic innovation is beneficial. Importantly, design is not the only difference among new products and many incremental innovations offer new functional benefits. However, regardless of the potential usefulness of the incremental technological innovation, which may vary by user, aesthetic innovation has the potential to increase users' understanding of and attraction to the new product.

More specifically, design attributes enable firms to explain the extent of the innovation by calling attention to the fact that a new model offers a new or improved functionality, albeit incremental (Rindova & Petkova, 2007). For example, new, lighter materials used to produce suitcases and new technologies affecting the ways in which suitcase wheels turn are incremental, yet extremely useful, innovations. In many cases, these new suitcases are offered with designs that differentiate them from previous models, such as new color schemes and prints. Consequently, users may be drawn to the design attributes only to learn that the technological innovation underlying the new model offers increased utility. To the contrary, design can mask the absence of any meaningful technological change and stimulate sales, as demonstrated in numerous studies on the automobile industry (e.g., Hofer & Riley, 1971; Kwoka, 1993; Menge, 1962; Sherman & Hofer, 1984). In these circumstances, firms use design because they expect it to excite users and increase their affect and approach to products.

Moreover, during later stages of the evolutionary cycle, users' expectations about the technology and its ongoing incremental improvement become increasingly taken for granted (Kaplan & Tripsas, 2008; Pinch & Bijker, 1987; Tushman & Romanelli, 1985). Aesthetic innovations enable firms to entice users to replace older product models with newer ones despite offering little technological justification for these new models and to address the issue of users taking for granted incremental technological progress (Kotler & Rath, 1984; Utterback et al., 2006). To explain, by changing and applying frequent changes to products' design attributes, firms seed products with attributes intended to evoke positive affect and subsequently, to excite users and to generate demand for these products (Gemser & Leenders, 2001; Hertenstein et al., 2005). Further, when incremental technological changes are coupled with design changes, users perceive them as improvements to their predecessors and these perceived differences drive their consumption (Abrahamson, 1996; Abrahamson & Eisenman, 2008; Lieberson, 2000).

Additionally, aesthetic innovation enriches the second-order meanings to which users respond. As argued, enriched meanings fuel users' abilities to use products to communicate something about their identities and social statuses, and as such, extend the uses of the product (Bourdieu, 1984; McCracken, 1988). In the context of a mature product category and incremental technological innovation, where firms can no longer drive product change on the basis of technological novelty, the strategic significance of this dynamic becomes more crucial to sales (Carroll & Swaminathan, 2000; Verganti, 2009). Specifically, promoting various second-order meanings that extend the original functionality of the technology enables consumers to express aspects of their identities via their acts of consumption (Belk, 1988; Solomon, 1983). In this case, users' interests in products are often independent of any technological benefits incremental innovations offer. For example, successive models of Apple's iPods and iPads often represent incremental improvements in functionality, such as a different scrolling input interface or a better camera. Additionally, subtle visible differences, such as the width of the product or the color of the casing exist. Consequently, users are able to easily identify which other users have the most current model relative to those that have older models. This creates a "coffee-shop" effect of sorts in which users express something about their identities by self-categorizing into a pecking order based on attributing higher status to users with later models.

Again, the automobile industry is a very intuitive example of the ways in which design attributes excite users and extend the uses of the product. Indeed, competition based on aesthetic innovation is widespread in this industry (Menge, 1962). Scholars have shown that changes to cars' design attributes have a profound effect on sales (Hofer & Riley, 1984; Sherman & Hofer, 1971). Furthermore, Kwoka (1993) demonstrated that changes to cars' design attributes had a stronger impact on sales relative to technological changes, particularly in the case of larger, less efficient vehicles. Taken together, these studies suggested that in the context of a technology that, while evolving, is evolving fairly incrementally, consumers are motivated to purchase new product models that have design attributes that potentially excite them and that effectively convey a sense of progress via novelty in design. Furthermore, these design attributes enable firms to create products that trigger particular second-order meanings that appeal to different users, such as small red cars that are more appealing to users who view their vehicle as a sex symbol relative to large white cars to appeal to users seeking rationality and practicality.

Finally, design attributes allow firms to adapt their core technology to the particular specialized market segments they identify and cultivate. Thus, producers targeting specialized market needs use design to explain how their products differ relative to the extant commodities. For example, Clark (1985: 245) demonstrated that as user-side understanding in the car industry evolved, producers could offer specialized products addressing specialized needs, such as “roadsters”, “touring cars”, or “coupes”. Users understood these cars were different because they had different design attributes.

More recently, scholars suggested that later-stage segmented markets differ not only in terms of users’ needs, but also in terms of the ways products express users’ identities (Carroll & Swaminathan, 2000). Specifically, second-order meanings can structure identity-based market segments (Gottdiener, 1985; Peterson & Anand, 2004). When producers offer users new ways of expressing their identities, they in effect offer users new ways to experience their products, and subsequently, are able to increase their sales (Verganti, 2009). In this context, design, in its capacity to generate second-order meanings, is beneficial.

Taken together, the ideas expressed in the previous paragraphs suggest that aesthetic innovation is an important firm pursuit in the context of incremental technological evolution, marking the upswing of the U-shaped curve illustrated in Figure 2. The arrows under the x-axis demarcate the evolutionary trajectory into three periods and note the underlying communication mechanisms theorized to be important in these times:

P1: A U-shaped relationship exists between the technological evolution of a product category and the extent to which aesthetic innovation is a central organizational process. Aesthetic innovation will be more important as new technologies emerge and when they mature, a first inflection point following the setting of the dominant design, and a second inflection point as demand begins to decline.

MODERATING EFFECTS ON THE RELATIONSHIP BETWEEN TECHNOLOGICAL AND AESTHETIC INNOVATION

The following section identifies various field-level conditions that differentiate among product categories in terms of firms' abilities to use design to explain what the product does and how to use it, to generate positive affect toward the product, or to generate second-order meanings that will enable users to use the product in additional ways. More specifically, the extent to which firms benefit from aesthetic innovation is sensitive to the market dynamics affecting the rate at which firms introduce successive product models and the social context in which consumption takes place. In addition, aesthetic innovations have higher impact in settings with particular user characteristics. Lastly, the behavior of cultural agents impacts the benefits firms draw from aesthetic innovation. The relative effects of the underlying communication mechanisms are illustrated in Figure 1 while Figure 2 offers some illustrations of how these moderators could manifest by presenting examples in which the impact of the underlying communication mechanisms is likely to vary.

Incremental Innovation and Rate of Successive Product Model Introductions

The relationship between technological evolution and aesthetic innovation is affected by the rate of incremental product innovation for a given product category. Different market settings differ in their rate of incremental product innovation. This rate is set by competitive patterns in the market. For example, frequent product introductions (i.e., successive versions of products) often result from renewal cycles that occur in markets in which competition is based on sales strategies that determine the timing of new product introductions, rather than on technological

R&D strategies to determine such introductions. Examples include the car, bicycle, and consumer goods industries, as all these industries need to introduce alluring new products each holiday season, regardless of any technological advances that were achieved throughout the year. Or, frequent product introductions may result from inherent characteristics of the technology that allow for faster rates of innovation (although a full exposition of such inherent characteristics is beyond the scope of this paper).

When frequent introductions are decoupled from significant technological change, the technological differences among successive products are likely to be incremental and often without significant use value (Abernathy & Clark, 1985). As explained above, users may not be able to discern differences among successive models based on incremental technological innovations (Christensen, 1997). Regardless of the extent of functional technological benefits new models offer, producers operating in settings with a higher frequency of successive model introductions are more likely to benefit from aesthetic innovations.

Indeed, several studies suggested that aesthetic innovation is more important in the context of more frequent product introductions. Rubera, Griffith, and Yalcinkaya (2012) studied the mobile phone industry and demonstrated that products with greater emphasis on aesthetic innovation met greater market success when introduced at shorter intervals. In fact, Karjalainen and Snelders (2010) examined an exemplar from this industry, Nokia, a firm that introduces new models annually. They found that Nokia came to consider aesthetic innovation as a core competence of the firm, understanding their competitive dictum to offer new designs very frequently regardless of the extent of technological differences between successive models. Thus, Nokia was able to introduce new products making older ones appear outdated at a fast pace. Lastly, the U.S. auto industry described above also demonstrates similar dynamics. Firms in this industry compete by offering new models and model updates annually, and, as the findings described above demonstrate, aesthetic changes to successive models profoundly impact sales.

These findings have various sociological roots. As explained above, producers are motivated to couple incremental technological changes with design changes because users perceive products with novel designs as better and different regardless of any technological novelty (Abrahamson, 1996; Abrahamson & Eisenman, 2008; Lieberson, 2000). Also, affecting design attributes leads to positive sensory stimulation, which excites users and induces sales (Bloch, 1995; Rindova & Petkova, 2007). Lastly, scholars have associated the possession of later models with higher social status (McCracken, 1988; Simmel, 1957[1904]). Thus, by ascertaining that new models are embodied in new designs, producers following more frequent product introductions are able to induce a sense of technological progress that would justify model replacement and to encourage users to link design attributes to social dynamics such as displays of identity and status, as demonstrated by scholars of the automobile industry cited above.

Taken together, these ideas suggest that to the extent that firms compete in settings requiring them to introduce successive models at a more frequent rate, they will rely on aesthetic innovations to a greater extent. Using aesthetic innovations in such settings allows firms to explain the benefits of as well as to generate excitement about the new models and to establish a balance between these mechanisms such that they can highlight technological benefits when these exist or mask their absence when they do not. Additionally, aesthetic innovations enable firms to extend the uses of the new products by promoting various second-order meanings, such as those users attribute to being the owners of the latest mobile phones or car models. The presence of these meanings can induce consumption without requiring new functional benefits which are likely to be less prominent in these settings. Taken together, these arguments suggest that in periods of incremental product innovation, represented by the right-hand side of the U-shaped curve, firms that introduce successive models at a faster rate are more likely to invest in aesthetic innovation. Graphically, the right-hand side of the curve will reach higher values on the Y-axis at a faster pace relative to market settings in which successive models are introduced at a slower pace. Formally:

P2: the proposed relationship between technological evolution and aesthetic innovation is positively moderated by the rate of successive product model introductions.

Social Context of Consumption

Next, the benefits of aesthetic innovation will be more valuable in contexts that support the appreciation of the second-order meanings design attributes generate. As explained, the second-order meanings evoked by design attributes allow users to express their identities. However, product categories differ in the extent to which they can be easily linked to their users' identities suggesting that the relationship between technological evolution and aesthetic innovation varies according to this parameter.

More specifically, second-order meanings imply that products can also be used as social signals. As argued, design is the foundation for this social communication (Krippendorff, 2006; Verganti, 2009). Like any language, the language of design as a social signal is relevant only in settings in which there are other social actors and more useful in situations in which the intended meanings are commonly understood. In other words, for goods to successfully enable users to position themselves relative to others, two conditions must be fulfilled. First, the product selections of a focal consumer must be witnessed by other consumers who will then make attributions about these selections (McCracken, 1988; Simmel, 1957[1904]; Solomon, 1983; Veblen, 1953[1899]). Second, there needs to be a high level of social agreement about these attributions, otherwise, they diffuse rather than have a communicative impact (Bourdieu, 1984). In this context, Richins (1994) differentiated between the private and public meanings of goods. Goods have private meanings, those that represent users' personal attributions about the product (e.g., I like my red phone because I like the color red) as well as public meanings—attributions that most people share (e.g., red items are sexier). Only goods that have public meanings can be understood as social signals.

The consumption of luxury goods such as a Jaguar sports car or a Rolex watch is an intuitive example of these ideas. The car or watch are visible to others at the time they are in use and they have commonly shared public meanings. As such, other users make similar attributions about the consumption of these products. In this example, attributions may pertain to the focal user's level of disposable income allowing her to spend money on very expensive products or to the level of education she has allowing her to recognize these brands.

Therefore, using aesthetic innovations to generate various second-order meanings is more beneficial to the extent that products can effectively meet both conditions described here: being visibly consumed and also having publically shared second-order meanings. If the first of these conditions is not met, the second is not feasible (Wong, 1997). In other words, users are more likely to use products as social signals that communicate about their identities in the context of goods that are visibly consumed and which have shared public meanings.

In terms of the U-shaped curve, as a new technology emerges, questions about whether its consumption will be visible are relatively straightforward. That is, producers making paint thinners or microchips understand that the consumption of their product will be less visible relative to producers of mobile phones and kitchen appliances. Thus, mobile phone producers understand that aesthetic innovations leading to second-order meanings will be valuable in the context of their potential users and will invest in developing these early on and continue to do so after the emergence of a dominant design. For example, Nokia deliberately generated second-order meanings prompting the use of mobile phones as fashion accessories (Djelic & Ainamo, 2005). As this understanding emerges alongside the technology underlying the product category, the left-hand side of the U-shaped curve will start from higher levels on the Y-axis.

Importantly, firms can only suggest second-order meanings through their selections of design attributes (Ulrich, 2007; Utterback et al., 2006). Overall, these meanings are embedded within the socio-cultural context in which the products are produced and consumed (Blumer, 1969; Bourdieu, 1984; Ulrich, 2007; Verganti, 2009). Therefore, to become fully realized, these meanings must be acknowledged by a broad range of users: consumers, product reviewers, and other firms (Krippendorff, 2006; Verganti, 2009), a point further developed below. Thus, firms are not able to assess ex-ante the extent to which their product categories will have *shared* second-order meanings. At most, they can invest in aesthetic innovations with the intent of generating these meanings in settings they perceive as more receptive to these social dynamics.

As the technology stabilizes and a dominant design emerges, firms are better able to assess whether shared second-order meanings about their products have emerged. In these cases, they are motivated to continually cultivate these meanings as these links have the potential to drive sales and repurchases of new models. Therefore, periods of reduced investments in design will be shorter and the overall curve will be less flat relative to product categories for which there are no shared second-order meanings.

Furthermore, fostering second-order meanings becomes more important after the emergence of the dominant design because the generation of these meanings allows firms to extend the uses of their products and to offset the relatively small technological benefits offered by successive model introductions, as explained above. To the extent that a product category enters this evolutionary stage with established shared meanings, firms will continue to use aesthetic innovation to promote them. In settings in which firms make products that are consumed visibly but which do not yet have shared second order meanings, firms are particularly motivated to invest in design and to generate them. Therefore, the right-hand side of the U-shaped curve will reach higher levels on the Y-axis relative to settings in which firms perceive users as less likely to communicate about their identities through products. Taken as a whole:

P3: the proposed relationship between technological evolution and aesthetic innovation is positively moderated by the likelihood users will develop shared understandings about the product category's second-order meanings.

Users' Level of Specialized Technological Knowledge

Different users benefit to a greater or lesser extent from aesthetic innovations. As argued, users rely on cues embedded in design attributes to understand the potential benefits of a product (Norman, 2004) and they are responsive to the stimuli embedded in these attributes (Bloch, 1995). Lay users lack specialized technological backgrounds that allow them to ask probing technological questions about the extent to which the underlying technology, in terms of linkages among components and mechanisms, holds promise. Instead, they associate design attributes with firm-level effort, expense, and attention to detail and extrapolate inferences about technological quality from these attributes (Ulrich, 2007). Because lay users think in these ways, they are particularly responsive to firms' use of aesthetic innovations.

Additionally, in absence of a technological toolkit, lay users think of products in terms of aesthetic fit and ask themselves how various products work together with other products they own to generate some inter-product harmony and communicate a consistent identity (Creusen &

Schoormans, 2005; McCracken, 1988; Solomon, 1983). For example, Creusen and Schoormans conducted a study in which they asked participants to explain how they determine their evaluations of and responses to products. These researchers found that a common way for respondents to assess products they were shown was to explain how their designs fit together with the designs of other goods they owned. Thus, this study suggested that users, in absence of solid technological knowledge, search for the design attributes of products they encounter and extrapolate from them various second-order meanings they then use in a broader process of linking objects to their identities as a means of expressing themselves.

Lastly, lay users are more likely to engage in comparisons among and purchases of integrated technological products, such as personal computers, relative to specialized users who are often buyers and evaluators of components that make up these integrated products, such as microchips. Overall, technological products are comprised of several nested subsystems connected with linking mechanisms (Tushman & Murmann, 1998). As explained above, design is a concept that pertains to the synthesis of form and function in products, and as such is more relevant to integrated products rather than to subsystems and linking mechanisms. Specialized users are more likely to be engaged in evaluations and purchases that pertain to various subsystems and linking mechanisms. Their evaluation of products is based on technological concerns that often do not pertain to the integrated product. Thus, specialized users are less responsive to the use of design to explain the underlying technology and less responsive to the sensory ways in which design attributes are exciting or evoke second-order meanings.

Taken together, users with high levels of specialized technological knowledge are less likely to respond to aesthetic innovations relative to lay users. Therefore, producers of integrated products targeted at lay users are more likely to invest in aesthetic innovation. This suggests a different U-shaped pattern for different product categories in the context of the intended user of the product. Specifically, the left hand side of the U-shaped curve will be higher for product categories targeting lay users, as the impact of aesthetic innovation in the context of explaining a new technology and generating affect toward it will be high. Also, the right hand side of the curve will be higher as well, as users are likely to respond to the excite and extend mechanisms of aesthetic innovations, as well as to the continued use of design to explain different functionalities of various incremental innovations and market segmentation efforts of firms. On the other hand, for products targeting specialized users with high technological knowledge, the U-shaped curve is flatter, as the benefits of aesthetic innovation are less pronounced in these settings. Therefore:

P4: the proposed relationship between technological evolution and aesthetic innovation is negatively moderated by the targeted user's level of technological knowledge.

Volume of Discourse about Design

Cultural agents, such as journalists, product reviewers, advertisers, and financial analysts use discourse—the written and spoken texts about the industry, its firms, their products, and their users—to expound the strategies of the firm. This discourse shapes users' perceptions of firms' offerings and shapes the institutional environment in which firms operate (Barthes, 1983; Kennedy, 2008; Lounsbury & Rao, 2004). This discourse also affects the relationship between technological evolution and aesthetic innovation.

In particular, journalists, as a subset of cultural agents, are drawn to design. Journalists tend to have generalist rather than specialist knowledge and work under time constraints (Gitlin, 1980). Consequently, they often favor readily available and easily digestible information at the expense of thorough analyses of complexity (Hayward, Rindova, & Pollock, 2004). In addition, journalists are governed by the need to write in a manner that caters to the interests of their audiences so that their publications will sell. This need further dictates a preference towards simplicity, as most audiences also have generalist rather than specialist knowledge (Hayward et al., 2004). And, it supports writing and content that is more sensationalist, surprising, and distinctive (c.f. Rindova, Pollock, & Hayward, 2006). It follows that journalists are interested in exciting their audiences, and as such, may prefer to write about design attributes as these are more exciting and require less specialized knowledge both on the part of journalists and their audiences.

By writing about design attributes, journalists propel the mechanisms that make aesthetic innovation a beneficial strategy. First, journalists explicitly link design and function, for example, by writing about how the shape of a flash drive ensures that it can only be inserted in the correct direction. Second, journalists suggest to users that they should attend to and appreciate the excitement and sensory stimulations emanating from design attributes. For example, journalists have exalted the virtues of the sleek design of the new Asus Zenbook using words and phrases positioning the item as a sexy, fashionable accessory, and by so doing, suggesting to users that they should evaluate the machine along these criteria. Third, journalists interpret the second-order meanings design attributes suggest and establish shared understandings about these meanings. At the heart of this interpretation is a comparative process by which cultural agents understand the characteristics of various objects by examining the extent to which they adhere to the constraints of the categories to which they belong and the social dynamics shaping these categories (Barthes, 1983; Griswold, 1987; Wijnberg, 2004; Zuckerman, 1999). For example, the first Apple iMac introduced in 1998 did not adhere to the category constraint of producing beige PCs. In the context of Apple's brand development strategy of positioning itself as "different", agents interpreted this break from the category constraint as consistent with the identity of the firm and embraced the product and the return of Steve Jobs to the helm of the firm. Their interpretations shaped the shared understanding of the colored machine as a positive strategic initiative.

Importantly, in the context of these institutional processes, the volume of discourse is more important than its content. A large body of discourse has the ability to capture the attention of users regardless of its content (Pollock & Rindova, 2003). As more cultural agents actively attend to design attributes and aesthetic innovation (by highlighting the ways in which they can extend users' identities, for example), the attention these attributes garner will increase. As a result, firms become more cognizant of the benefits of such innovative processes and view them as more central to competition in their markets (Ocasio, 1997).

Furthermore, large volumes of discourse underlie isomorphic institutional processes. Specifically, firms that receive a lot of coverage from various cultural agents are more salient and subsequently, more influential (Rindova et al., 2006). The choices these firms make are more likely to be imitated, as other firms associate their choices with normative and rational behaviors, and processes of mimetic isomorphism emerge (DiMaggio & Powell, 1983). Thus, to the extent that salient firms compete with aesthetic innovation, they will foster greater attention to design.

Taken together, the arguments presented suggest that in market settings in which cultural agents produce higher volumes of discourse attending to design attributes, the relationship between technological evolution and aesthetic innovation will be more pronounced. Put differently, the mechanisms underlying the usefulness of aesthetic innovations will have greater impact when supported by field-level discourse. Discourse producing agents explain the links between design attributes and the functionalities they suggest. And, discourse articulates to users why the products should excite them and what second-order meanings they evoke. Additionally, journalists' inherent attraction to design attributes fosters a cycle of viewing products as exciting sources of sensory stimulation. Firms are motivated to foster this style of writing as it can ultimately enhance their sales, and they do so by offering stimulating design attributes. Finally, as high volumes of discourse about design establish aesthetic innovation as a legitimate competitive practice, more firms are likely to engage in it. In terms of the U-shaped curve, greater volumes of discourse manifest in higher values of the Y-axis on both sides of the curve.

In addition, greater volumes of discourse about design suggest a narrower flat part of the curve. As argued above, immediately following the emergence of the dominant design, aesthetic innovation is likely to become less central to firms' processes because they focus on increasing their efficiency and require less technological explaining. However, high volumes of design discourse generate excitement about the concept of design and call attention to these product attributes. Thus, while in post-dominant design settings interest may shift away from design attributes, on-going attention from cultural agents mitigates this shift. Subsequently, in these settings, periods of reduced investments in design are likely to be shorter relative to similar periods in fields where attention to design is not supported by high levels of discourse. Thus:

> P5: the proposed relationship between technological evolution and aesthetic innovation is positively moderated by the volume of discourse about design**.**

DISCUSSION

This paper's contribution lies in explaining the co-evolution of technology and design. It highlights three mechanisms through which the development of design attributes benefits technological product categories. Namely, design attributes are useful for explaining to users what a new technological product does and how it should be used. This mechanism is particularly useful as new technologies emerge and when firms introduce products targeting particular market segments. Design attributes also excite users by generating sensory reactions and attachments to products. This mechanism fosters emotional connections to the product at any point along the evolutionary technological cycle. However, it is particularly useful in the context of ongoing incremental innovation, as it has the potential to generate excitement toward products that offer few functional benefits, and consequently, increase the sales of these products. Lastly, design attributes extend the potential functionalities of a technological item by generating second-order meanings. These meanings create symbolic uses for products that extend their functional uses. While these meanings may emerge as the technology is introduced, this mechanism is particularly useful in post-dominant design settings when it enhances users' attachments to products that offer few additional functional benefits or when it links specialized product offerings to distinct user identities. The paper also theorizes particular conditions that would enhance the manifestation of these mechanisms: the rate of successive product introductions, the social context in which consumption occurs, the users' characteristics, and the volume of discourse calling attention to design.

Taken broadly, the paper posits that design is an inseparable facet of any technological product and works to couch recent work on the importance of products' design attributes within the broader base of organizational knowledge about how technology evolves. Specifically, it integrates several areas of research to offer a holistic theory of aesthetic innovation. The paper extends ideas about technological evolution (e.g., Anderson & Tushman, 1990; Utterback, 1994; Utterback & Abernathy, 1975) using insights from psychology and marketing that explain why users respond to designs (e.g., Belk, 1988; Bloch, 1995; Kotler & Rath, 1984; Rindova & Petkova, 2007; Solomon, 1983; Ulrich, 2007) as well as to sociological perspectives that explain how goods have second-order meanings that allow users to express themselves in a social context (e.g., Bourdieu, 1984; Gottdiener, 1985; Krippendorff, 2006; Lieberson, 2000). In this manner, the paper acknowledges consumption in a way that is not fully acknowledged in extant theorizing about technological cycles and one which enriches our ability to analyze processes of retention.

Furthermore, the paper broadens the frameworks put forth by scholars of technological evolution by explaining that design is an important aspect of product innovation at key stages of the evolutionary cycle. In this sense, it serves strategic functions that extend beyond differentiation and may take precedence in eras typically associated with process innovations. More specifically, the paper elaborates the treatment of design-related aspects of product innovation by explaining that design enables firms to give form to new technological ideas, a form critical to communicating with various users and to competing in the market.

Additionally, this treatment further enhances our understanding of the dominant design in that it explains that the variation selected is not only an assemblage of technological components, but also a selection of a particular embodiment of this assemblage. This embodiment comes to signify the product as users associate it with what the “product looks like”. As such, the paper suggests that the dominant design is a concept broader than a field-level agreement about a configuration of particular technological components that enable market progress through processes of standardization. It suggests that the dominant design is also a dominant aesthetic manifestation that affects the institutionalization of the technology by cementing a variant that has a taken-for-granted physical form. Understanding the dominant design as a dominant aesthetic manifestation further extends our understanding of the institutional processes surrounding the evolutionary cycle as well as our understanding of the underlying mechanisms that affect the selection of particular variants. Namely, and as future work may explore more fully, variants selected are more likely to be those that better explain what the new technology does and how it should be used as well as appeal to users’ senses.

Moreover, the paper contributes to recent work enriching our understanding of the strategic role of design (e.g., Abrahamson, 2011; Cillo & Verona, 2008; Dell'Era & Verganti, 2010; Djelic & Ainamo, 2005; Ravasi & Lojacono, 2005; Ravasi & Rindova, 2008; Rindova, Dalpiaz, & Ravasi, 2011; Rindova & Petkova, 2007; Talke et al., 2009; Verona & Ravasi, 2003; Walsh, 1996). It is particularly in line with recent investigations examining the extent to which established ideas about technological evolution apply to non-technological contexts. For example, Cappetta, Cillo, and Ponti's (2006) work linking patterns of variation, selection, and retention of aesthetic styles to concepts about these patterns in the context of technological evolution in the fashion industry and Dell'Era and Verganti' s (2007) investigation of imitation and innovation dynamics in the context of products' design attributes in the furniture industry. Additionally, by specifying the interactions among firms, users, and cultural agents, this paper adds to Verganti' s (2009) work suggesting that aesthetic innovation occurs in the context of a large network of agents who examine and shape changes in society, culture, and technology.

Theoretical Extensions

The ideas discussed in this paper offer a rich foundation for future research. In particular, more fine grained distinctions could be made to better qualify and empirically test the competitive dynamics presented. One direction is examining the potential interactions among the moderators proposed above. For example, lay users are more likely to engage in the visible consumption of products with broadly shared meanings and social consumption dynamics are likely to be enhanced when supported by higher volumes of discourse elaborating products' second-order meanings. A second direction is to tease out the extent to which recursive iterations affect the relationships outlined in this paper. For example, journalists may be more likely to notice aesthetic innovations in settings in which key firms offer prominent aesthetic innovations.

In such cases, the behavior of these key firms fosters the design discourse that comes to support attempts at aesthetic innovation made by competing firms.

Another promising direction for future work is to further qualify the effect of the technological limitations endogenously imposed by a particular product category. More specifically, technology and the intended functionality of the product place stronger or weaker limitations on the possibilities for aesthetic innovation. For example, tires must be round and most likely black as they will not perform their intended function having a different shape and their use will turn them black regardless of their initial color. On the other hand, mobile phones should be relatively small. But, there are no apparent limitations on their required shape or color, as these design parameters do not interact with their intended function. Future work could explore the implications of these endogenous differences.

Furthermore, the expected benefits of aesthetic innovation may affect firm-level search for solutions to these endogenous limitations. For example, producers desire to make consumer electronics small and portable so that they can be used in many settings and not tethered to an outlet. However, batteries that last longer are typically relatively large. Additionally, some of these products, such as laptops, heat up when used and need to have cooling mechanisms. Thus, making changes to the size, shape, or types of materials used for casing a technology require novel technological solutions. When firms decide to engage in aesthetic innovation, they realize the relationship between these endogenous parameters and the range of aesthetic innovations they can offer. Thus, to fully engage in aesthetic innovation, firms will direct some of their technological search toward increasing this potential range. Because firms' pursuit of aesthetic innovation affects other firms studying their strategic choices, firms not only shape the direction of their particular technological search, but also shape this process for their competitors.

Also, future work should expound the levers of inter-firm variance with regards to pursuing aesthetic innovation. Very generally, firms' strategic choices are a function of their particular, path dependent courses (Nelson & Winter, 1982).That is, the firms' founder, the competitive setting at founding, the background of the top management team, and intra-firm politics are all sources of inter-firm variance (e.g., Hambrick & Mason, 1984; Stinchcombe, 1965; Weber, Thomas, & Rao, 2009). In addition to these general levers, inter-firm variance is a function of firm-specific experience with producing design attributes and interpreting second-order meanings (Ravasi & Rindova, 2008; Ravasi, Rindova, & Dalpiaz, 2012). Thus, firms that engage in aesthetic innovation in the context of more product categories will become more experienced than those who engage in aesthetic innovation in the context of fewer categories, and this difference in experience would generate variance among firms.

Next, inter-firm variance is likely to emerge as firms make particular choices regarding the ways they pursue aesthetic innovation. More specifically, some firms' will offer designs that are radically different and become known for their abilities to do so (e.g., Dell'Era & Verganti, 2007; Gemser & Wijnberg, 2001). Other firms will imitate innovators' choices rather than re-interpret them. An intuitive example is the difference between Apple, a radical innovator in the context of personal computers, and Dell, a firm who recently began engaging in aesthetic innovation by offering laptops with various colors.

Furthermore, the timing of firms' entry would affect inter-firm variance. In this context, firms that enter a market at high points of the U-shaped curve described above will invest more heavily in aesthetic innovation and subsequently develop higher resource commitments and more elaborate capabilities in this area. Additionally, the time of entry could affect the types of capabilities firms develop as different uses for aesthetic innovations are relevant at different stages of technological evolution. In particular, firms entering a market during periods of radical technological innovation need to use aesthetic innovation to explain their new technology, requiring them to envision a material embodiment of abstract ideas. However, firms entering a market during periods of incremental technological innovation would need to use aesthetic innovation to induce product replacement, leading them to focus on the ways in which design excites and increases affect toward the product.

Examining these levers of inter-firm variance will shed light on broader agency dynamics, both within the firm and its larger ecosystem. In particular, periods of more intense aesthetic innovation are likely to favor competitors adept at innovating along aesthetic parameters and within these firms, to favor employees with relevant skills, as demonstrated by the prominence of Apple and of its chief designer, Jonathan Ive. In the broader ecosystem, these periods increase the influence of independent design firms and of cultural agents that affect users' appreciation of aesthetic innovation. Furthermore, users are important agents as well because they are also producers of second-order meanings (e.g., Bijker, Hughes, & Pinch 1987; Bogers & West, 2012; Peterson & Anand, 2004). As such, their influence is likely to vary in the context of different product categories and in response to different firm initiatives. For example, Faulkner and Runde (2009) demonstrated that particular user groups developed meanings and uses for turntables that were very different from the original intentions of their producers and that these new meanings and uses, in turn, affected firms technological new product development processes.

Finally, the theoretical arguments proposed in this paper need to be empirically tested. Aesthetic innovation can be operationalized, for example, by measuring spending on design. This measure could be obtained by surveying firms or examining the budgets for design and various aspects of marketing as well as tracking the types of design-related positions that rise to prominence, the salaries of design-related employees, or the emphasis placed on design in the firm generated discourse, such as press releases and interviews. The propositions need to be tested using historical and longitudinal cross-industry studies. Thus, empirical studies should use a comparative selection of cases that exhibit various gradients of the different causal constructs.

CONCLUSIONS

As this paper shows, integrating insights about technological evolution and design advances our understanding of competition. Moreover, when producers of technology engage in aesthetic innovation, they do so with the expectation that users will value the sensory stimulations and second-order meanings their products offer. By innovating in a way that fosters these stimulations and meanings, they are encouraging users to respond to them, and consequently, broadening the range of technological objects that are appreciated for their sensory appeal as well as for their second-order meanings. This broadening, in turn, gradually enlarges the set of objects that although fundamentally technological, have an important design component that affects their use (Abrahamson, 2011). Furthermore, because strategic choices are often imitated by competitors and set off isomorphic processes, firms' pursuit of aesthetic innovation increases the overall attention to design in their industries and in others. This idea explains why aesthetic innovation is becoming a key managerial challenge (e.g., Ravasi & Rindova, 2008; Utterback et al., 2006; Verganti, 2009). The mechanisms exposed in this paper enable firms to address this challenge accurately.

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FIGURE 1

Theoretical Model of Aesthetic Innovation

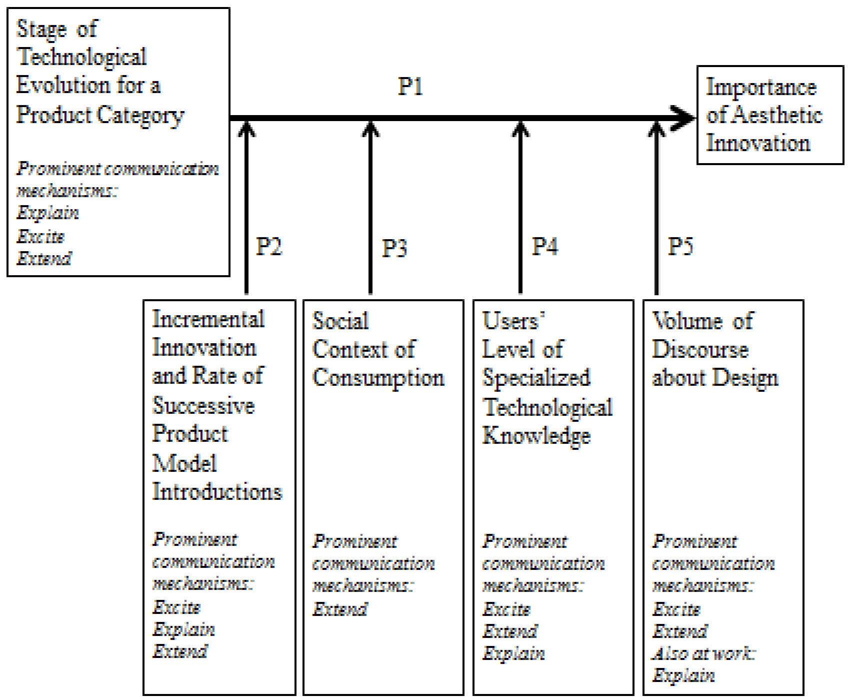

FIGURE 2

Illustration of the Moderating Effects on the Relationship between Technological Evolution of a Product Category and Aesthetic Innovation