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Exploring the Effect of Product Development Time Span on Product Paradigms Through Phones

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This article examines the effects of product development process durations on paradigms through desk phones and smartphones. Product paradigms are launched with radical innovations, being developed further with incremental innovations for optimization. It is argued that the technology and meaning of products change incrementally in the market pull innovations. It is stated that human-centered design studies bring the paradigms to the optimal point. However, the speed of the product development, when determined by the incremental innovations in technology, can have a negative impact on human-centered design studies. In this conceptual framework study, the evolutions of desk phones and smartphones are compared; it is observed that smartphones may not have benefited from human-centered design studies yet. It was concluded that rapid technological developments could shorten the product development processes and human-centered design studies could remain diminished, avoiding the paradigm to reach the optimum level.

Keywords innovation; incremental innovation; product development; human-centered design

1 Introduction

With the improvements through both design and technology, products that perform a certain function may face paradigm shifts in the course of time. Evolution and change of paradigms may be explored through recent models in innovation to understand the effect of the product development process durations on product forms.

Verganti (2009) investigates innovation within two axes; technology and meaning. Technology axis refers to the technical changes in products, being in-line with the prior studies on innovation (Cooper and Press, 1995; Trott, 1998). One major contribution of Verganti's (2009) study is, he appreciates design as an element of innovation; innovations in product meanings are the outcome of the design. Each product development process can be assessed as an innovation, and radical or incremental innovations may appear in the meaning axis, technology axis, or both.

The evolution of a product concept starts with radical innovation and reaches to a certain optimum through incremental innovations (Norman and Verganti, 2014a). Incremental innovations occur through human-centered design; it is also claimed that radical innovations do not emerge as a result of human-centered design (Norman and Verganti, 2014a; Verganti, 2009). Therefore human-centered designs are needed to take a product to its optimum.

In this study, the effect of product development time span on product paradigms is explored through causal narratives of smartphones to argue if shorter product development times lead to underdevelopment in product paradigms. The focus is put on industrial design and the meaning level, and technological innovations and meaning driven innovations are evaluated separately. The aim of this study is to form a conceptual framework to discuss if products that are mostly developed as a result of incremental technological improvement may lack human-centered design efforts to reach an optimum product form, which is more in line with users' natural actions and expectations.

This study aims to discuss the topic on a conceptual level to illustrate the issue and build a ground for upcoming theories on the subject (McGregor, 2017). Conceptual frameworks are valued as they pointing out potential topics that can be explored in depth through an evaluation of existing theories and studies, without presenting new data (Yadav, 2010). The topic is explained further through desk phones and smartphones. They exemplify the effect of rapid incremental technology-push; they are suitable to act as causal narratives, which help to clarify and explain further the topic through one or two cases (McGregor, 2017).

2 Product innovation types and their effects on product paradigms

As mentioned before, recent studies on innovation acknowledge design as an innovation generator. The emergence of a new product paradigm occurs with radical innovations. Here, radical innovations of technology and meaning are evaluated separately, to be followed by incremental innovations of both. As the innovation of meanings refers to minor changes in the form of the product (Verganti, 2009) and incremental technology innovations not necessarily address a change in the product form, incremental innovation of technology is considered as a driving force for new form development.

An earlier example for identification of technology and design-related axes can be seen in the work of Cagan and Vogel (2002); they define 'style' and 'technology' to differentiate product types. They also define ergonomics as another aspect that only appears in breakthrough products that will demonstrate high value in SET (style, ergonomics, technology) factors. Cagan and Vogel's (2002) work can be differentiated as they put more focus on usability and user expectations, while Norman and Verganti (2014a) do not assess user orientation for breakthrough changes. Since the innovations that are not solely user-centered are also in the scope of this study, Verganti's model is considered.

There are four main innovation types that are defined by Verganti (2009). A technology-push innovation constitutes a major change in technology, without a major change in the meaning and use of a product; the transition from CRT TV's to LCD TV's is mentioned as a typical example (Norman and Verganti, 2014a). A technology epiphany is the radical change of both technology and meaning, such as the change in video games by the introduction of MEMS accelerators to trigger exercising concept by Nintendo Wii (Dell'Era et. al., 2010). Lately named as meaning-driven innovation by Norman and Verganti (2014a), the radical change in meaning with minor or no change in technology can be observed in Alessi's Family Follows Fiction product family (Verganti, 2009). Finally, market-pull innovation addresses minor changes in meaning and technology with the human-centered design being the major source of innovation (Norman and Verganti (2014a).

2.1 Effects of technology-driven radical innovations on product paradigms

As mentioned earlier, technology-driven radical innovations not necessarily have a major effect on product meanings. Technology change in TV's did not immediately result with a meaning change (Norman and Verganti, 2014a); even though new technology enabled a more compact solution with wider screens that can be hanged on walls, TV's were not repurposed for a while. However, physical changes through a technology push innovation may cause alterations in product paradigm, leading to a technology epiphany with the radical change of the product meaning.

In prior studies, the paradigm change is discussed on a communicational and semantic level; introduction of microchips to products that serve for the functions of musical instruments, notebooks,

telephones and such, led to disappearing of communicational cues on these products, leading to a paradigm loss (Bayrakçı, 2004). Unlike designing an electro guitar, designing a synthesizer became a task of covering a black box and creating an interface between the user and the product, without being led with visual cues of mechanical details (Bayrakçı, 2004). The paradigm loss here described as a change in both technology and meaning.

A paradigm shift may also appear with a technology change appearing in products that are considered as black boxes. Nintendo Wii employed MEMS accelerators to change the way the video games are played; formerly players sat through play, but Wii guided them to a new meaning through active involvement in movements required by the game (Verganti, 2011). Although the design problem was still at the black box level, the designs of the control units completely changed as the result of the new meaning.

Radical innovations in material technologies may also lead to new product meanings. Furniture companies are known to have cooperation with material suppliers in an effort to create radically new product meanings (Dell'Era and Verganti, 2007). Also, material suppliers seek for new product meanings themselves in order to trigger alternative product forms in the industry that employ new materials (Verganti and Öberg, 2013).

2.2 Effects of design-driven radical innovations on product paradigms

A meaning driven innovation changes the meaning of the product in a radical way, without a major change in product technology. A typical example is Alessi's Family Follows Fiction series. Even though forms of dancing women, ducks and parrots were introduced to kitchenware (Verganti, 2008), the main user-product interaction and communication followed the prior paradigms. The furniture industry is also widely considered in meaning driven innovation studies; the introduction of innovative forms and styles are considered as radical innovations through design (Dell'Era and Verganti, 2009); however paradigms of furniture and their communications with users rarely changed.

Technology epiphanies combine radical changes in technology and meaning. Sometimes the application of new technology may trigger the innovation. The introduction of mobile communication technology led to the development of mobile phones that did not operate as former mechanical phones, introducing a new paradigm. However, a radical change in meaning can also trigger the employment of technologies that are known before. For instance, Nintendo and the electronics industry, in general, were aware of accelerators; their inclusions to video game consoles were brought about by the change of the product meaning (Verganti, 2009). Likely, smartphones with touchscreens were developed as early as 1992 and marketed in 2000, the first smartphone to be mainly controlled by a touchscreen was Apple's iPhone being introduced in 2007 to change the mobile phone market (Zapata et. al., 2015). The widespread integration of touchscreens to mobile phones may be due to the meaning change, as iPhone redefined mobile phones as customizable products that can even be turned into broadcasting devices with the help of applications.

It can be said that plain meaning driven innovations may not necessarily end up with paradigm shifts. Even though Norman and Verganti (2014b) stress that meaning driven innovations occur through a merger of two different product meanings, this may not affect the product paradigm; an example would be the combination of meanings of toys and kitchenware in Family Follows Fiction, which resulted with products that had familiar mechanisms and communication cues.

2.3 Effects of incremental innovations through human centered design

The human-centered design is claimed to be the driving force behind market pull innovation. Norman and Verganti (2014a) state that incremental innovations bring every radical innovation to its most developed level. Regarding the product paradigms, it can be said that human-centered design helps a paradigm to reach its optimum level.

Norman and Verganti (2014a) evaluate this phenomenon with a hill climbing metaphor. A radical innovation represents a starting point for a product concept; however, it is generally not the most

refined and debugged version. Writers compare the development of a product concept to a hill climbing process; the initial product form is like a lower point on the hill and incremental innovations always search for a higher point on the hill, leading the product to the top. The top of the hill is where the product reaches its optimum level; any further search for another level on the same hill will lessen the quality of the product, but another hill with a higher peak may be searched through another radical innovation (Norman and Verganti, 2014a).

While prior literature defines incremental innovations basically as small improvements within a product concept (Trott, 1998; Cooper and Press, 1995), Norman and Verganti (2014a) highlight the importance of the subject with emphasizing human-centered design, which helps the product to reach its absolute best version.

It can be said that through human-centered design, the communication between user and product becomes more apparent in products with better fitting usability solutions for product paradigm. The referred phenomenon is studied further through the example of desk phones in the following parts of this study to discuss the subject.

3 Phones: comparing the basic functions in mechanical and electronic phones

In this part, desk phones and smartphones are evaluated through their basic functions to investigate how well their paradigms adapt to users' natural behaviors and expectations.

It is expected for a product paradigm to reach a point where the product and the user act at an optimum communication level, where they are adapted to each other. This optimum communication may not always be dictated by users; Norman (2005) points out that, users have the capacity to adapt to new products. Therefore, he claims that designers should consider the adaptation capacity of a human, and not strictly follow their declared expectations (Norman, 2005). It may be claimed that both users' and products' adaptations should be considered through the evolution of a product, as they both have a potential for evolution to fit each other. Therefore, both users' and products' adaptation capabilities are in the context of this study.

3.1 Evaluation of desk phones

The initial concepts for the desk phones appeared as early as 1876 (Bell, 1876). The device evidently evolved over time to provide a better response to users' needs and basic habits.

Figure 1. Alexander Graham Bell, Experimental Telephone 1876, Museums Victoria.

Bell's initial sketches for telephone illustrated devices with very large cones for mouthpiece and receivers, with communication seemingly being one-sided (Mercer, 2006). Bell developed his model

further to be granted a patent for the product; as it can be expected, in his patent appeal he described the technical infrastructure and affordances such as two-sided communication (Crompton, 2009).

The initial model for the telephone is presented in Figure 1. As it is shown, the device exposes much of its technical details without providing clear data on how to make a call or where to talk. After the initiation of the telephone, the design of the device began to transform; some typical designs emerged, such as Butterstamp in 1878 (which combined receiver and transmitter into one unit), 3-Box in 1882 and Candlestick in 1897 (Mercer, 2006). Figure 2 shows the basic principle for transmitters and receivers for 3-Box and Candlestick phones; users hold the receiver to their ears while they have to place their heads close to the main body of the phone in order to use the transmitter. Figure 2 shows a later example of such a principle; the numbers are placed on the device for making a call.

Figure 2. Wall Telephone - Automatic Residence Set, circa 1920 Museums Victoria.

The well-known desk phone paradigm appeared around 1928; a desk set that united the receiver and transmitter with a handle (Mercer, 2006). The common proportions for this paradigm became popular with the design "300" in 1937 (Mercer, 2006). Recent studies credit the model to George Renwick Lum rather than Henry Dreyfuss, who is acknowledged as a consultant, and his style is stated as being visible in the final product (Flinchum and Meyer, 2017). Dreyfuss is acknowledged for his method of study, which is considered a very early example of ergonomics science and usability, as he measured many people and work with users to find out what they actually did with phones (Mercer, 2006). Even though his actual role in refining the paradigm is discussed as there were similar designs produced by other companies like Ericsson, there is plenty of evidence showing that his ergonomics studies along with other designers played an important role for optimizing the product (Flinchum and Meyer, 2017).

Telephone with buttons has been developed since the 1960s (Flinchum and Meyer, 2017); however, the main ergonomic principles stay pretty much the same when making and ending a call is considered.

A phone call with a classic desk phone paradigm starts with raising the handle. Raising the handle has a direct relation with making a call, as users should bring the receiver close to their mouths and transmitter to their ears in order to make a call. The handle between transmitter and receiver provides a semantic clue about where and how to hold the part. The call is ended with bringing the handle to its resting position on the device. Unlike initial examples of the telephone, the mainstream paradigm is more in line with users' expectations and actions. As the aim of users who bring the headset to their head would be to start a call, the activation of the telephone by raise of the headset is in line with users' purpose. Again, leaving the headset back on the device would only be done at the end of a call; therefore deactivation of the phone also follows the same logic. Here, the opposite of action results in reverse outcome; raising the headset is activation and setting down is deactivation. This kind of logical relation between two actions is named as "natural and consistent mapping"; and keeping the actions in line with users' natural behaviors (like placing the headset to head to make a call) is referred as "mimic normal use" (Ruiz, et. al., 2011).

It can be inferred that the desk phone designs started with initial examples that emphasize mechanical details on the product form. Later on, telephones were designed which communicate better with users through more natural and logical actions for operation. Studies on the history of desk phones suggest that human-centered design activities and ergonomics studies that were applied may have helped the phone paradigm to reach an optimal level.

3.2 Evaluation of smartphones

As mentioned before, the touchscreen smartphone concept goes back to the beginning of the '90s, and the IBM Simon is widely acknowledged as the first smartphone that has been marketed, which is developed in 1992 and launched in 1993 (Buisson and Silberzahn, 2010; Gupta and Prinzinger, 2013). Today's smartphone paradigm is based on Apple's iPhone, which was launched in 1997, as it's claimed to be imitated by its competitors (Buisson and Silberzahn, 2010). However, it's claimed that a dominant design hasn't emerged immediately, regarding the software and infrastructure (Cecere et. al, 2015).

Modern smartphone design is dominated by a screen, where the graphics for applications that are operated in the phone also appear. Since the screen is the basic interaction area, the communication of the smartphone with the user through a screen is often discussed as a design problem. Most of the time, visual references from tangible correspondences of applications are included in the visual design, leading to criticisms about skeuomorphism (Page, 2014). In order to make interaction less screen oriented and more physical on smartphones, some studies tested touch-less gesture controls (Lu et. al., 2013), which are widely used in industries such as household, security, fitness, education and so (Gavrilova et. al., 2018, Khan, 2018).

The studies for the usability of smartphones are important on many levels. As expected, it's claimed that using the controls that are suggested by users is important (Rauch, 2011), as users' usability perception affects their attitude towards smartphones (Shin, 2012). It may be difficult for designers to apply standard usability principles, as there are many operating platforms for smart devices that should be considered (Rauch, 2011; De Luca and Lindqvist, 2015). The software interface of a smartphone is considered as the main medium for constructing meaning, being the core element for usability (Folkmann, 2012). The studies about the usability of basic functions focus on software commands and search for their physical equivalents. Studies show that to build a more inclusive design, especially regarding the visually impaired people, physical references are needed as users find it hard to spot the command areas on the screen (Mi et. al., 2014).

Since this paper focuses on the basic functions of a phone, answering and ending a phone call in a smartphone is evaluated.

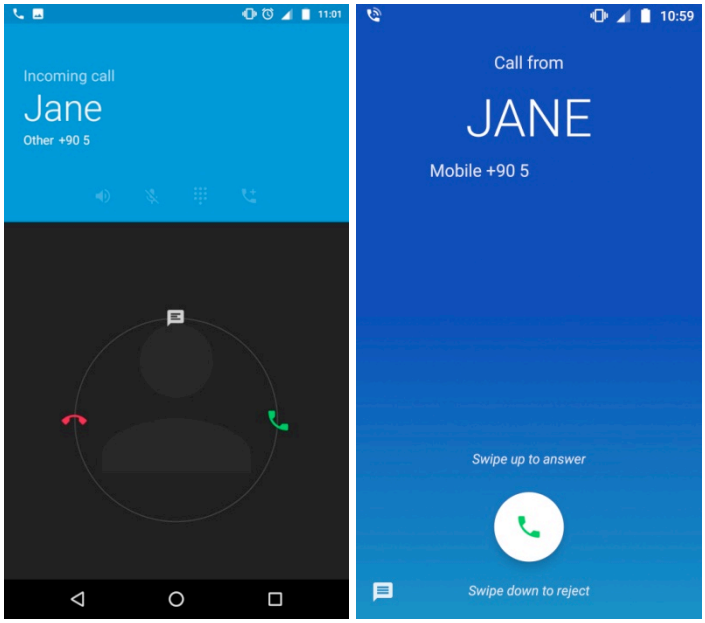

Figure 3. Answering a call in the last two versions of the Android operating system (Screenshots by author).

In Figure 3, two different answering tasks can be seen. The one on the left is from the previous version of Android, while the one on the right is the recent version. The finger move to answer a call has changed to sliding the finger to the up from sliding the finger to the right. Both of these movements are versions of the original sliding move from the IOS system, and both of them are commands that belong to the software paradigm; they have no relation to actual moves of a user who answers a phone.

To make smartphones more usable for visually impaired, studies were done to understand the more easy-to-remember and natural moves for basic phone tasks. Two of these studies derive similar solutions from users to answer a phone; users find it natural to bring the smartphone to the ear for answering a call (Dim and Ren, 2014).

There are also gesture controls that are assigned to smartphones by operating systems. Two examples are shown in Figure 4 and Figure 5.

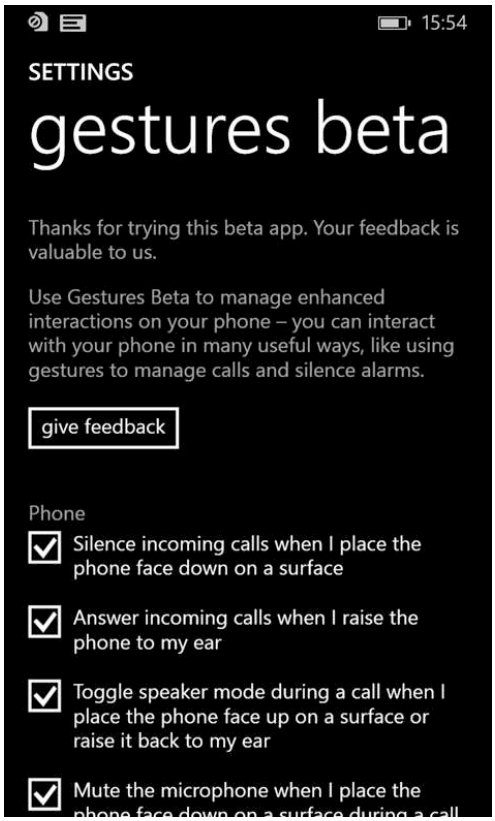

Figure 4. Screenshot of Gestures Beta (Microsoft Mobile).

Figure 4 shows options in Gestures Beta, an additional application by Microsoft Mobile for Nokia Lumia smartphones, while Figure 5 shows Moto Actions that provide gesture controls for Motorola smartphones. As can be seen from the figures, the same gesture of putting the phone face down can serve for two different actions; eliminating the environment voices when listening to the caller through the speaker in Lumia phones, and eliminating sound notifications during standby mode in Motorola phones. Picking up a ringing phone silences the ringtone in Motorola smartphones, which can be considered as “mimic normal use” as a ringtone is not necessary when someone is paying attention to a ringing phone. Raising a ringing phone to ear results with answering the phone in Gestures Beta, and this move is in line with the user expectations that are detected in the studies (Ruiz et. al., 2011; Dim and Ren, 2014). Putting a phone face up to a surface during a call puts it in the speaker mode in Gestures Beta while raising it back to ear mutes the speaker; both of these actions can also be evaluated as mimicking normal use.

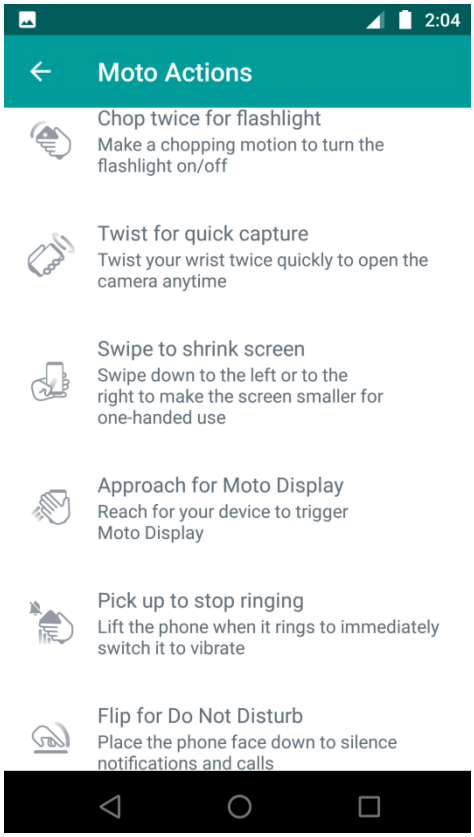

Figure 5. Screenshot of Moto Actions (Screenshots by author).

Ending a call with gestures can be more complicated in smartphones, as removing the phone from the ear is necessary for completing dialing tasks within some phone calls, such as speaking with customer services. This is due to the fact that the dialing area is not separated from the receiver and transmitter as it is in the desk phones. Some users suggest taking the phone from the ear and facing it down to end a call, claiming that it mimics a desk phone; this type of analogies are labelled as “real-world metaphors” (Ruiz et. al., 2011). In Dim and Rem (2014) study, visually impaired users suggested putting the phone on any surface after removing it from the ear. Even though this preference may interfere with a hands-free phone call, the suggested gesture is in line with “mimic normal use” behavior.

To sum up, it can be said that current smartphones operate pretty much similar to the prior solutions. The smartphone paradigm reached its dominant physical appearance through Apple iPhone; with the dominant use of touchscreen technology, there was a radical innovation that can be named as a technology epiphany. However, the upcoming incremental innovations did not bring many different solutions to usability. Regarding the basic phone functions, answering and ending a phone call is mainly done through software interfaces in smartphones and this tendency is in-line with the original smartphone solution that dictates today's paradigm. However, some more natural gesture alternatives, which are in line with user expectations, have been provided for answering a call through additional applications. One of these provided solutions is in line with the "mimic normal use" gesture type. Ending a phone call with a gesture is more complicated regarding the call tasks that require dialing numbers, but users suggest "real-world metaphor" gestures to overcome the issue.

4 Comparing the basic functions in mechanical and electronic phones to evaluate the effect of product development durations

The evolution of desk phones and smartphones are slightly different when triggers for innovation are considered.

The desk phones' mechanical and electrical design has not changed much after the initiation of first examples for the paradigm around the 1930's; however, infrastructure and production improvements had some effect on the product (Mercer, 2006). On the other hand, smartphones are affected by the improvements in electronic equipment, such as disc drives, which are considered as "fruit flies" of the business world as their lifecycle is quite short (Christiensen, 1997). This results with shorter life cycles for smartphones as mentioned by studies that focus on sustainability (Ylä-Mella et. al. 2015; Cox et. al., 2013). Companies that compete in the consumer electronics industry by developing incremental innovations declare that usability researches are not frequently conducted because of the short life cycles (Eroğlu, 2019). Also, it is reported that very basic usability problems happen to occur in consumer electronics products, as declared by their users (Kim and Christiaans, 2016). Short life cycles and lack of usability in consumer electronics may address a lack of human-centered design studies in smartphones.

Since desk phones took advantage of usability and ergonomics studies when finalizing the product paradigm, their adaption to users' needs and natural behaviors when making a call can be linked to the slower change in the technology. A slower change in technology enabled a more evident emphasis in product design within market pull innovation, resulting in a better application of human-centered design. On the other hand, smartphones as we know today has not faced a breakthrough change in technology that affected the paradigm; however, they evolved through many incremental changes that were pushed by technology upgrade, leading to shorter life cycles for the products (Arthur, 2002, Entner, 2011).

Even though later models of desk phones and smartphones can be both considered as market pull innovations, the effect of human-centered design differs in the two paradigms. Norman and Verganti (2014a) place human-centered design at the hearth of market pull innovation, but it may be discussed that technology-driven incremental innovations sometimes may hamper human-centered design efforts. At this point, it may be helpful to discuss if constant incremental developments in the technologies have a technology push innovation effect, even though they are not radical innovations. However, the faster abandonment of the phones for up-to-date products suggests that users also demand technology updates such as longer battery life, better screen, more internal memory and such (Entner, 2011; Cox et. al., 2013).

It may be investigated if frequent technology driven incremental innovations hamper usability analysis to avoid the product paradigm to reach its optimum level. As mentioned before, a product paradigm first appears through radical innovations, which needs more developments in order to eliminate problems in the original design (Norman and Verganti, 2014a). However, the lack of time in product development may avoid the foundation of better solutions for a design problem. The cognitive effect behind this phenomenon can be better understood through the literature on design fixation.

Studies on design fixation suggest that designers seem to repeat a solution for a design problem, if they are exposed to it prior to the problem-solving process (Jansson and Smith, 1991. It is also stated that expertise in an area may increase fixation tendency (Purcell and Gero, 1996; Björklund, 2013) and industrial designers tend to get fixated on product forms (Cheng et. al., 2014). Within domain analogies are formerly defined solutions to a design problem; they create a possibility of problem fixation through semantic analogies (Moreno et. al., 2014). There are studies which suggest designers are affected by existent solutions that are presented; many of them have a tendency to fixate on visual examples rather than verbal explanations, even though the visual examples are inaccurate (LeFevre and Dixon, 1986; Smith et. al., 1993; Chrysikou and Weisberg, 2005; Christiaans and Van Andel, 1993). In order to diminish the fixation effect, several strategies are suggested. Some studies suggest “forgetting” the problem by staying away for a while, which may decrease the fixation occurrence (Kohn and Smith, 2009; Smith et. al, 2011). It is claimed that context change, therefore staying away from factors that cause fixation is an effective method to avoid fixation (Smith and Linsey, 2011). Moreno et. al. (2015) also state that having breaks or dealing with other tasks that are

irrelevant to the original problem may lead to disconnection and separation to avoid getting fixated on exemplary solutions.

When desk phones and smartphones are compared regarding the improvements in usability, it can be claimed that shorter life cycles may keep the product paradigm away from reaching its optimal level. As the product development process become shorter, designers may have fewer opportunities to conduct human-centered design studies and they may get more fixated to original solutions that had formed in software design. Also, the shorter product development times may hamper their chance to stay away from the design problem in order to create better or more original solutions, keeping themselves from getting fixated to prior solutions.

5 Discussions

Literature suggests that new product concepts come out as a result of radical innovations, and they reach their optimal level through human-centered design studies that occur in incremental innovation processes. However, frequent incremental technological improvements can shorten the product life cycle, resulting in diminished human-centered design practices. Although incremental improvements in technology can be considered market-pull or even human centered in a way, human centered design activities that concentrate on product meaning can have a significant effect on optimization of the product paradigm.

When the cases of desk phones and smartphones are compared, it can be seen that desk phones favored from ergonomics studies and usability researches. After the mainstream paradigm appeared in 1928, ergonomics studies were conducted within the next 10 years to optimize the paradigm. The final form of the paradigm fits users' natural movements when they make a phone call. On the other hand, the current smartphone paradigm faced many incremental improvements on the technological level, however, it lacked usability improvements. Smartphones did not face major form changes unlike the desk phone did within the first 10 years after initiation in 1876, nor did they reach their optimal ergonomics and usability level as the desk phones did through 1928-1937. The first 10 years of smartphones may be considered as a fine-tuning period; however, this would mean that incremental technological improvements should slow down at some level.

The incremental innovations in smartphone technology may or may not slow down in the near future. Independently from upcoming developments, it can be said that technology-driven incremental innovations' effect on market pull innovations should be discussed regarding the design input. The current state of smartphone paradigm suggests that shorter product life cycle and product development periods may hamper human-centered design studies. This may keep the product paradigm from reaching its optimal level, as the human-product interaction and communication can still be needed to refine. Therefore, in the market pull innovations, where both technology and meaning evolve incrementally, attention may be given to the speed of technological improvements to understanding the progress of usability of the product and evolution of the paradigm to its optimal level. In Verganti's (2009) model, incremental innovation in both meaning and technology results with the human-centered design. However, in the case of smartphones, the actual designs today do not fit with the preferences declared by users in several studies (Dim and Ren, 2014; Ruiz et al., 2011), and the uses of the devices are not clear. Therefore, it may be worth investigating if incremental innovations that are mainly driven by technology can be linked strictly with the human-centered design.

This study is limited to the evaluation of product development duration's effect on product paradigm through the literature on innovation regarding the optimization of product contexts, and the main aim of this paper is to initiate a discussion on the subject. The issue can be explored further with more examples to understand the effect of technological improvements' speed on product life cycles and specifically human-centered design, to understand the dynamics behind the optimization of a product paradigm.

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Figure 5. Author’s screenshot

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