From respect to change user behaviour.
Research on how to design a next generation of smart home objects from User Experience and Interaction Design

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Abstract:
With the rapid development of IoTs and ICT technologies, smart objects become a rising commodity in our life. Several innovative smart objects and concepts are constantly proposed to the market and to crowd-funding platforms. Most of these products have similar features, with added sensors, actuators, memory capabilities, and they can exchange information with a smart phone, allowing users to control them at a distance and to collect data in everyday life.

There are two typologies of smart objects: traditional products updated by implanted digital technologies; brand new products designed to meet a specific demand. In this paper, we focus on the smart objects for home, such as smart power plugs, smart surveillance systems, smart lamps, etc., and on user behaviours. The user experiences associated to the two typologies are different: the first typology should improve an existing habit, while the second should provide a fresh action. The latter create new behaviours and the paper investigates the correlation between behaviours induced by the innovative products and their success/failure.

The research is mainly based on the analysis of several smart objects proposed on the market and on crowdfunding platforms. The analysis considers usability, interactive modes and the modalities of control. The goal is to extract knowledge on how to design the next generation of "smarter" home objects, i.e. not only intelligent, connected and controllable at a distance, but also requiring acceptable changes in behaviours.

Keywords: Smart object, User behaviour, Design methods, Interaction Design, Design for Experience.
1. The smart home objects

1.1 The smart objects in our life

With the rapid development of IoTs and ICT technologies, smart objects become a rising commodity in our life. Wearable devices, smart home systems, Internet of Things have opened a new smart object field. Several new smart home objects and concepts are constantly proposed to the market and to crowd-funding platforms; products in our life become smart and this appears as an inevitable tendency. In a research report on smart objects, the statistics of global smart objects installed capacity is 78.7 billion in 2015, and it will be raised to 104.2 billion in 2016, the growth rate is 27.3%.

Undeniably, the smart objects are changing our surroundings in different directions, showing their value in social, economic and innovation sense. The consumption patterns of people are changing, lifestyles tend to mobility and smartness in fields such as transportation, communication, entertainment. Connected products created a new industry; they brought new economic growth and are becoming one of the most promising market; connected products are promoting technology diversification and give birth to more innovative thinking pattern. With respect to applications, the value of smart objects is ample, and quite promising to improve life quality and health care services. Until October 2016, the successful offer of smart objects on Kickstarter.com corresponds to 435.62 USD. On the other hand, the success rate of the new products proposed on platforms is only 19.6%. We argue that design methodologies should be improved so to decrease the rate of failures.

1.2 The motivation of this research

As connected products bring several advantages, we should consider that they are here to stay, and that they will modify the infrastructures of our social environments. As they are new, they will evolve in the future, so to be optimized with respect to human needs and with respect to the evolving contexts.

We began our analysis of case studies focusing on the characteristics of the products under test with respect to their implicit requirements of change of behaviour in use. We considered simple smart objects, such as the so called smart drinking cups, i.e. glasses with added electronics capable to
perform functions such as checking and controlling the temperature, analyse the contents (quality and quantity), and so on. For example, “Cup Time” is a smart water cup working with a smart phone so to record drinking habits, and to remind the user to stay hydrated and healthy. It uses capacitive water monitoring technology to measure the precise volume of drunk water. It got 22 million USD funds on the crowdfunding platform, corresponding to the 13585% of the expected money, totally sold 110,000 ones. From the statistics, it could be considered as a successful product, but the feedbacks on the actual performance challenge the user’s existing behaviour, especially the function “remind users to drink”.

"The first day with Cuptime, I tried to make myself drink plenty of water, in order not to waste the value of this 58 USD cup, but also to make my life more technological…. but I think I will not go to the efforts of synchronization, or always pay attention to the phone or the cup whether it reminds me to drink water or not...” (tech.163.com, 2014)

"For most people, you may be too busy and forget to eat, but I very few hear of ‘Too busy and forget to drink.’ And what we usually drink is based on the body needs to drink water; when you feel thirsty, you will naturally pick up the cup of water to drink and you are not likely to regularly drink water, such as in an hour you must drink two glasses of water...” (tech.hexun.com, 2014)

Li Xiaoliang, the CEO of Mecare, the company which produces the Cuptime also said: "... As a cup, it is not perfect, such as carrying, keep warm and so on, are not as good as a traditional cup... ... Drinking water data are worthless. Many users’ feedback, although the smart cup monitors the record drinking water, and cannot play any practical value. Many users would no longer use it after a period of use” (leiphone.com, 2015)

From the retailer feedbacks, Cuptime advanced the concept of healthy living, and it combines sensors and IoT technology to data measurement to make “drinking water” as a more sound activity. But, meanwhile, asking users to drink water in some fixed model is against the habits and will of individuals.

In the interaction with a smart object, the user experience depends on several factors, such as physical design, material quality, usability, service technology, interfaces, and so on. Usability can be
defined in an ample sense, as an instance: “Usability is usually considered the ability of the user to use the thing to carry out a task successfully, whereas user experience takes a broader view, looking at the individual’s entire interaction with the thing, as well as the thoughts, feelings, and perceptions that result from that interaction” (Albert, 2013, p.4). Even a simple object, such as a smart cup, is a totally new product, requiring people to learn how to use it and to change habits.

We argue that, as a part of the usability test, we should investigate and predict the amount and directions of change in habits with respects to user’s traditional behaviour. The direction of change will affect the acceptance of the user to the smart object, and it will determine its success or failure. Therefore, this research focuses on the investigation and prediction of change as a part of the design process sorting out “smarter” products with respect to the final experience.

2. Smart home objects and user behaviours

2.1 From respect to change user behaviours and habits

In the human civilization history, products appear as a solution to people’s needs; in time, humans had formed their own behaviour and habits depending on the availability of tools that they learned to use, and on the constraints of the environment. A habit is a routine of behaviour that is repeated regularly and tends to occur as an automatism. It is connected to the needs, and it is formed by a long-term experience and training. Currently, the use of smart phones has become a typical habit in daily life, gradually grown by using the phone, day by day, and progressively learning new functionalities. Now, for most users, the loss of a personal phone is source of stress and frustration. Similarly, the change of user’s habit induced by any device needs time and progressive adaptation. For several people, it will be a challenge to modify a behaviour abruptly to use a new product. But in recent years, this challenge has been often associated to smart objects.

The “abruptness” and “friction” associated to the change depend on several factors: the familiarity of users with technologies, the motivation toward the functions, the context of use, the quality of the communication presenting the product and so on. It also depends on the social environment. As an instance, several users began using smart phones because they wanted to stay in touch with other people using it; then, it became an indispensable necessity of life. Despite a smart phone is relatively a complex smart object, users are willing to spend time to learn how to use it, since its functions are more valuable than the cost of learning, and, by frequent operations, using smart phones has become a normal behaviour.

Meanwhile, the evolution of habits associated to phones, from traditional to smart ones, has been also a long-term process, going from wired to wireless, from physical buttons to the touch-screens, from push to multi-gesture; every change was subversive, but never unacceptable for users, and it was usually presented as an addition to the existing useful features; the main function is still to make a call, allowing users to feel everything is in line with their basic senses, and then rely on technology to create a better experience. The rate and speed of change define the process of change, that can be respectful or not toward the human need of continuity.

Another typical example of object for smart home is the smart plug. The smart plug uses IoT technology to allow remote control. The “K Mini” smart plug produced by Ikonke made a record in a China crowdfunding platform on 2015, (the retail price is 7 USD for each), and it finish its crowdfunding collection in 46 days, involving 34 million people to support the project, so getting the amount of 3.5 million USD. It obtained the largest public participation and the highest funding in China. The smart plug does not interfere with the traditional behaviour in using the plug, and,
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through the smart phone remote control, it breaks the time and space constraints of the physical turn on/off the electrical equipment.

Figure 3. Smart plug, ikonke, 2015

Figure 4. using behaviour of smart plug
2.2 From “adding intelligence” on traditional objects to creating new smart home products

After our research, there are two typologies of smart home objects. The first includes traditional products updated by implanted digital technologies, such as smart plugs and smart thermostats. As “traditional product”, in this research, we mean those products that, without electronics, have been used for decades by people; the second instead, collects brand new products designed to meet a specific demand or invented as an application of a technological solution. Both are meant to allow users a tighter control on objects and environments through applications, to satisfy user needs and to provide a better lifestyle and wellbeing.

From the perspective of user experience, the two typologies are different: the first one should improve an existing habit, while the second should provide a new action. In our opinion, in the design of a new object, the designer should understand in depth the user habits and reasons way so to provide effective functions.

![Diagram of user, traditional object, technology, and smart object](image)

*Figure 5. Using traditional object and smart object, using smart object will be more convenient.*

Japanese IT industry venture capital firm SoftBank produced concepts of a set of smart home objects in 2016; these products serve for the elders who are living in rural place, far away from their children and grandchildren, and the elders are not familiar with Internet and high-tech products. The innovation team designed solutions that connect the ordinary life products (such TV and traditional phones) with the modern seamless devices, so networking people and generations differing for technology skills, culture and habits.

One of these products is the Smart Dial Phone. In the presentation, Grandma receives a phone call, and on the TV screen the children's images appear while the audio conversation, on Grandma side,
From respect to change user behaviour. Research on how to design next generation of smart home object from User Experience and Interaction Design takes place through the phone. Traditional devices are used to provide connection with digital applications such as Skype or Facetime.

![Figure 6. Work principle of Smart Dial Phone, SoftBank, 2016](image)

Another example is the SNS Newspaper. The contents of this newspaper are uploaded on Facebook or other social networks by the grandmother’s grandson, but are received printed on paper, in a layout format of a newspaper.
This smart home set includes other four products and, in the whole, they provide an optimal example of solution designed respecting user behaviours and habits. The presentation is quite convincing since the storytelling focuses on the needs of the elders, and it presents a way to make them join the smart world while they can maintain old habits, such as using dial phone to making a call and getting information by reading on printed paper.

On the other hand, in some cases, the success of a smart object is due to its capability to respond to new demands of people in these days, thus creating new markets and filling. For instance, this is the case of the smart baby milk machine.

It is a milk making machine for parents of their babies, coming with an application connecting it to a smart phone; it works as a built-in system, making milk from powder automatically with appropriate quantity, volume and temperature based on the babies’ physiological data inputted by parents. Furthermore, the application can analyse the behaviours, recording feeding times and the baby’s weight growing data, also providing assistance by pediatricians in a 24H online service. This smart product met the needs of new parents who have no experience of feeding infants. It got 54 million USD funds on the crowdfunding platform, corresponding to the at 650% of the expected amount.
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This is an example of a new smart object meeting an existing need with no precedent solution. It makes the new parents feel safe on feeding babies; it generates multiple modes by data collection and analysis. Parents just need to follow the instructions that are similar to those of a coffee machine. The use of the milk machine reduces cognitive efforts and practical tasks; the product is easy to use and it shapes new habits in a short time.

Figure 9. Traditional milk making behaviours and using smart milk making machine behaviours

2.3 Factors related to behaviour in the use of smart home objects

In the study of cases, we aim to investigate all the main factors influencing the user experience, and the connections between different factors, also considering priorities in the definition of values, including different perspectives, reasons and possibilities. As usual, in product design we consider the target user, the product semantic, the actions/activities, the context and the environment as main factors.
In this research, the environment is the home; the users are in accordance with the traditional family structure including children, parents, maybe grandparents; the context and actions are related to the specific activities at home. The objects under analysis weren’t evaluated with respect to other social models of domestic communities for the sake of simplicity.

In the following, we report some examples of case studies we analysed.

1. **Amazon Dash**. It is an ordering service based on a proprietary device for ordering goods over the Internet; it includes 3 components: the Amazon Dash scanning device, used to inventory consumer goods in the house; the Amazon Dash Button, a small tray-like consumer electronic device that can be placed wherever in the house and programmed so to order a consumer good; the Amazon Dash Replenishment Service, that allow manufacturers to add a physical button or auto-detection capability to their appliances so to reorder supplies from Amazon when necessary.

Amazon Dash performs automatic supplement of goods without changing behaviours in the house; on the other hand, it subverts the online shopping process making an essential revolution to this respect; furthermore, it reduces the effort of shopping and the economical costs, saving time and
mental energy to write the list. It simplify complex actions, switching from off-line to on-line, from select on the web to push one button. Meanwhile, Dash considers the context of users: the user can choose scan barcode or voice input to order the merchandise; if you lost the package of the merchandise with the barcode, you can use voice inputs; if you want more accurate ordering, you can scan a barcode to have a better choice. Dash Button simplifies the process of action to the extreme, reducing it to the push of one button. Almost zero is the cost for to form this habit.

![Diagram of Amazon Dash and Dash Button](image)

**Figure 12. Amazon Dash and Dash Button**

2. **MEMO bird**, smart mini printer. It is a small thermal printer, an evolution of the traditional devices, new not only for the size, but also for the scenarios of use: it acts as a physical recorder, printing out information such as a good recipe, a coupon, or other fragments of information that, coming from the phone, are “buried” and hidden in the mass of digital data. It is an emotional little machine, conveying important emotions through paper, and transforming the phone’s messages into tangible objects, so making them real and reliable. It can be used to provide interactive entertainment or playful color mapping games; it can be used to learn/remember words and symbols of another culture, (as an instance, when you are travelling in a country using different symbols and language). The product achieved its crowdfunding goal on several different platforms in China, the most successful one got 10 million USD, 623% of the expected funds.

It is also a good example of design thinking pattern. It fully concerns the user’s habits and scenarios of using this product and it explores the potential needs. It allows users to print out the content directly subscribed on the Internet. After the user experience, the materialized information is quite valuable; it is easy for users to pay more attention to understand the information printed on paper, and the device can also generate further actions of users. It just like a note posted on the refrigerator, to allow relatives to know that there is some food in the fridge for lunch. We consider the MEMO bird as an interesting example of thinking pattern in design: easy to use and simple to
understand in its functionalities. In our analysis, users understand the potentials of this product by using it. The little printer finds a new “reason way” in each different context (a bar, a restaurant, an office, a place where short information must be at hand, ...). “It comes out of interviews that it is easier to pay attention and to understand the information when they are insulated and printed on a material support,” as it said on the crowdfunding platform (demohour.com, 2015). The device enables users to invent creative ways of use and new business applications beyond the obvious ones.

3. **SONY MESH.** MESH is a tool that let users explore the smart world using everyday objects. You can attach a MESH tag to any physical object, connecting it to various devices and Internet applications on the MESH app. Its use does not require any training or programming expertise, and you can simply drag and drop to connect the icons on the MESH app. With this set of the tags, it is possible to transform any traditional product into a smart one, depending on user’s needs. It maximizes user’s participation, and it inspires user’s creativity.
3 The next generation of smart objects

3.1 The value of smart objects for home

The smart objects for home are just at the beginning of their fast development era. On the other hand, as designers, we should contribute to design successful objects, capable to encounter user needs and the approval in the market. Design methodologies should support the ability to predict the acceptance, reduce the costs of the design process and of time waste. We believe that a first step toward this goal consists in the preliminary evaluation of the consequences of the design choices in terms of impact on user behaviours. Our study on the success/failure dynamics on crowdfunding platforms together with some analysis we performed on the experience related to the use of commercial products encourage us in our conviction.

Several smart products appear as useful and fascinating at a first sight, but they show, during actual use, constraints and requirements that make user refuse them. Other products cannot communicate immediately a robust application of use, but reveal themselves as suitable with respect to personal goals in specific contexts. In the design of new smart object, we should better consider the different factors of the user experience so to learn how to predict their suitability in the early phases of the design process. Indeed, we should focus on the evolution in time of the perceived value, trying to understand if it can rise in a straight-line.

3.2 Design method and strategy issues for a next generation of smart objects

In the design of a smart product, we must consider the interaction of five factors: user, product, activity, context and environment. In our approach, the environment is the physical space and the surrounding condition, while the context is the specific situation depending on motivations, abilities, culture, social constraints and so on. A preliminary research, apt to understand the trend of the acceptance of a product, should work on all the five factors and on their reciprocal interactions. The suitability of a product can be evaluated in terms of a balance between the efforts required by its use (i.e. the economical and cognitive efforts, the practical constraints induced by the use of the product, ...) and the advantages in terms of problems solutions and reduction of the efforts with respect to an activity in a specific context. This approach could appear as mechanistic, but the investigation of the user experience in a vast sense could reduce the risks of design failures.

Furthermore, the amount of required change in habits and in material organization is another factor that should be predicted and evaluated in the design of smart objects. As an instance, we can refer...
to the SoftBank’s example: with seniors that have been using the dial phone for decades, the most efficient way to make them learn how to use a digital service is to design a solution that reduces the amount of change through a suitable project of the physical characteristics of the new products and of the interaction modes in digital interfaces.

Mapping the human behaviours of existing activities and recording the actions of the users during the whole process are tasks that can prepare the investigation of potential behaviours and acceptance. They could help designers to observe the physical and mental activities, and to frame the logical and experiential processes. Before we design a new object for a new function, we must think about the reasons and necessity for each action involved in its use, and evaluate the efforts required with respect to ergonomics and psychological principles, so to optimize the paths of behaviours.

About the strategy, our results can be summarized into three points:

- **Grafting.** We consider as an important design principle to consider the needs of conceptual and practical continuity in the design of a new product. As discussed before, when a smart object corresponds to a new demand, it requires users to learn the new behaviour and to form a new habit, and the amount of these efforts should be carefully investigated. New products could conveniently be developed as a modification or as a translation of existing solutions, such as it happened for the milk making machine that employs the same fundamental principles and interfaces of a coffee machine, already familiar to users.

- **Simplification.** Talking of simplification, we refer to the simplification of the experience more than to the one of the product itself. This means, in most cases, design for subtraction: reduce whatever is not necessary or that can unnecessarily affect the user habit. At the same time, we should not only simplify the using process, but also the operating mode in the whole, included the applications on smart phone that usually support the control of the smart products. Again, it means to reduce the need of controlling the object through the digital interface, so to allow, instead, the direct control through the physical interface of the product itself.

- **Optionality.** It means that smart products should be flexible with respect to different modes of use, and to different requirements of the contexts and needs. This is what happens with Amazon Dash, that offers options of functions, and with MEMO bird, suitable for different activities, from entertainment to study. Optionality means enabling the user to invent applications of the product and make the product compatible with different habits. As an extension, let users free to create her/his own smart object coherent with their own habits and favour, like MESH of Sony.

On this line we are researching, so to give a contribution to the development of design methodologies capable to support the efficiency and effectiveness of the project process.

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