Design Concerns of Persuasive Feedback System

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Abstract

Visual feedback is an important approach in persuasive technology. We present four significant design dimensions of persuasive feedback systems. We investigate several previous notable projects and find out the underlying metaphorical structures within them. We analyze the meaning of metaphor in the persuasive feedback design, and examine how metaphor is being used. The results tell us that metaphor analysis plays a useful role in interpreting the creativity of visual design in the persuasive feedback system.

Introduction

Recently, persuasive technology becomes popular. Some designers or engineers use feedback technique to help people change their attitudes or behaviors. These systems use some forms of feedback, such as raw data or a kind of metaphor on digital displays, to connect peoples' behaviors. We term such techniques as *persuasive feeback systems*. We are interested in the feedback of usage via digitial displays. The domain of the target attitudes or behaviors that persuasive feedback systems focus on is quite broad, such as physical activities (Lin et al. 2006) (Consolvo et al. 2008) (Li and Landay 2008), energy conservation behaviors (Holmes 2007) (Dillahunt et al. 2008), transportation habits (Froehlich et al. 2009).

One of the challenges in the persuasive feedback systems is the understanding or comprehension of what users perceive from these systems. Some systems provide users with raw data in digital numerical form. But this often assumes that the users have the ability to understanding and transforming these data into useful information or knowledge. Another potential solution is visual representation approach. The main problem of this approach is that people may misunderstand the connections between the information provided through the system and their own behaviors. They were left to find out what practices or behaviors this figure on the screen relates to (Strengers 2008). Few studies have considered the importance of the visual design and presentation in the persuasive feedback system, except in the energy conservation domain. Froehlich (2009) categorized visual design as one important design dimension in the feedback

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design space. In the author's opinion, the related research is not sufficient thus more research is necessary in the visual design dimension (Froehlich 2009).

Consolvo et al. (2008) said that the persuasive feedback system should offer the individual a choice of metaphors in the awareness display. In their field experiment, participants expect the system to be able to switch to other format of presentation to prevent boredom (Consolvo et al. 2008). Although many themes are suggested by the participants, the appropriateness and effectiveness of these themes are questionable and need further evaluation.

Nakajima et al. (2008) revealed the role of presentation metaphor in the feedback system. They raised an important question: how directly analogous should the measured activity and the presentation metaphor be? They also conducted a minor pretest to examine the users' experience through the use of four presentation metaphors. As a result, the participants prefer the figurative images (Nakajima et al. 2008). However the authors do not present a systematic approach to the interpretation of visual metaphor.

In this paper, we investigate four important design concerns when we consider the visual design of persuasive feedback system. Particularly, we conduct a metaphor analysis of several previous work to provide new insights into the role of metaphor in visual design.

Design Dimensions of Persuasive Feedback Systems

We start with some design strategies from (Consolvo, McDonald, and Landay 2009): Abstract and Reflective, Unobtrusive, Public, Aesthetic. We extend and modify some of these design strategies in order to better fit the practical situations of persuasive feedback system. We present four important design dimensions in the initial design stage. We note that these dimensions are not mutually exclusive thus overlap is possible. The dimensions are:

- ambient
- aesthetic
- emotionally-engaged
- metaphorical

Ambient

The Ambient dimension is the degree to which the system presents data are meant to call attention to a user. This dimension is consistent with the Notification Level (Pousman and Stasko 2006). Most persuasive systems represent information in a way that people consumes little or no awareness. The systems are only available when users need them, thus they do not interrupt users' daily life. Many approaches can achieve this goal. Applying an appropriate artwork-like appearance is one promising approach. The artwork-like appearance not only provides the users aesthetic pleasing but also blends seamlessly into the environment. The Mona Lisa Bookshelf (Nakajima et al. 2008) is an example (See Fighure 1).



Figure 1: The Mona Lisa Bookshelf

Aesthetic

The *Aesthetic* dimension concerns the aesthetics of the system. Designers need to pay attention to the appearance attraction and visual comfort so that the system can sustain interest. Many persuasive projects are installed in public area, these systems are seen not only by a user, but also by colleagues, friends, or family members. Attractive appearance can make people feel good and draw attention.

Many approaches can achieve visual appealing. One promising approach is to mirror famous artworks produced by a specific artist. The above-mentioned instance, the Mona Lisa Bookshelf, is such a case. The imitations of artworks are suitable in common/shared space like the office through everyday life. The art-like systems not only appeal to people's senses or emotions but also achieve the persuasive goal. Following this strategy, for example, we can replace the fish in Fish'n'Steps (Lin et al. 2006) with the fish in the "Fish Magic", the famous artist Paul Klee's painting. Figure 2 shows the appearance of the virtual fish in Fish'n'Steps system.

Emotionally-engaged

The *Emotionally-engaged* dimension concerns the emotional connection to the system. If the users are emotionally engaged in the persuasive system, they are motivated to change behavior. Some approaches to emotional engagement are introduced in the previous work. Dillahunt et al. (2008) used a virtual polar bear as a motivator for energy conservation. See Figure 3.

They asked participants to read a story about environmental change, particularly describing the impact of climate

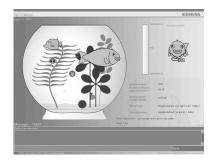


Figure 2: The screenshot of the Fish'n'Steps application

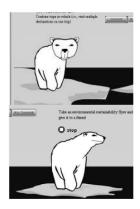


Figure 3: Virtual polar bear

change on the habitat of polar bears. They also asked the participants to write about environmental responsibility and to name the polar bear on their device. This process builds a close relationship between the participant and the virtual pet. The participants will know that their behaviors influence the existence of *their* virtual pet.

Fish'n'Steps (Lin et al. 2006) also applies the virtual pet approach to provide the participants' incentives to encourage physical activity.

Metaphorical

Metaphor is a basic and important phenomenon that occurs throughout the whole range of language activity. In cognitive linguistics, it refers to the understanding of one idea, or conceptual domain, in terms of another. In computer science field, metaphor is a popular approach to user interface design (Barr et al. 2005) (Fishkin 2004).

Lakoff and Johnson (1980) argued that metaphor is a kind of thinking or conceptualization, not limited to language. They revealed that metaphor is pervasive in everyday life, not just in language but in thought and action. They presented the *conceptual metaphor* that is defined as understanding one conceptual domain in terms of another. A conceptual metaphor consists of two conceptual domains: source domain and target domain. The source domain is the concept area from which the metaphor is drawn. The target domain is the concept area to which the metaphor is applied.

Metonymy is also an important kind of figurative language (Kövecses 2002). Metonymy uses one entity to refer to another that is related to it. We can use metonymic concepts to improve the persuasive power of our system.

We collect several previous projects and the corresponding metaphors in Table 1 and discuss some important work in the following.

The most popular strategy in the metaphorical dimension is using SCALE schema, which is one kind of image schemas in cognitive linguistics. An image schema is a dynamic abstract pattern that structure our bodily experiences and can be manifested in rich images, perceptions, and events (Johnson 1987). Johnson (1987) has listed many important image schemas, such as CONTAINER, BALANCE, NEAR-FAR, SCALE and so on. The SCALE schema is basic to the quantitative aspect of our experience and structures our concept of AMOUNT. For example, the metaphor MORE IS UP is based on this schema. This is because in our experience, when we add more of a substance to a pile or container, the level rises. The SCALE schema is also basic to the qualitative aspect of our experience. In our experience, objects and events seem to have certain degrees of intensity. For instance, One light is brighter than another, one blue is deeper than another, and one pain is more intense than another (Johnson 1987). In sum, the SCALE schema can serve as a basis for extension to nonimagistic domains, such as numbers, properties, relations, geometric structures,

The persuasive feedback system is inherently appropriate for SCALE schema. This is because the system tracks the target user behaviors through sensor detection or user self-reporting. Most data of the behavior tracking are transformed into digital or numerical form so that computer system can process and store them. Therefore it is this quantitative amount and qualitative degree or intensity of data that make the SCALE-schematic strategy easily connect the target behavior tracking and the visual representation.

The related projects that apply SCALE-schematic strategy include the virtual tree of (Ko, Hung, and hua Chu 2007), (Holmes 2007), and (Chiu et al. 2009), the virtual aquarium of (Nakajima et al. 2008), the virtual garden of (Consolvo et al. 2008), the virtual apple tree and the Arctic ecosystem of (Froehlich et al. 2009), and the virtual island of (Shiraishi et al. 2009). Note that the above list is by no means exhaustive. We discuss most of them in the following.

Ko et al.(2007) presented persuasive project, called Mug-Tree, that encourage people to drink water regularly and to keep a good water-drinking habit. Figure 4 shows the overview of the mug and its display. In this system, the act of caring and watering a virtual tree maps a similar act of caring for one's own body through regular water drinking (Ko, Hung, and hua Chu 2007). According to SCALE schema, if one does not drink enough water, the virtual tree will turn from beautiful green full of leaves to withered bare branches.

Chiu et al.(2009) presented a similar water-drinking reminder system, called Playful Bottle. It supports multi-user social persuasion (Chiu et al. 2009). See Figure 5. They also used SCALE schema in the visual representation.

Consolvo et al.(2008) presented UbiFit mobile system to



Figure 4: The Mug-Tree



Figure 5: On the left is a screenshot of the Playful Bottle. On the right is the five-level sequence of withering trees

encourage individuals to self-monitor their physical activities (Consolvo et al. 2008). They also applied SCALE schema in the visual representation. Each flower in the virtual garden represents an physical activity behavior and different types of butterflies represent the goal-attainment status. See Figure 6.

Froehlich et al.(2009) applied SCALE schema in their UbiGreen system. See Figure 8 and Figure 7. Both the tree and the Arctic ecosystem indicate green transportation activity. In the tree interface, leaves, blossoms, and eventually apples are added to the tree after each green transportation activity is carried out. In the Arctic ecosystem interface, at the start of the week, a polar bear is shown on an iceberg. As green transportation actions are taken over the week, the iceberg grows and the ecosystem also improves progressively.

HeatSink (Arroyo, Bonanni, and Selker 2005) illuminates the stream of water red when it is hot and blue when it is cold. See Figure 9. This metaphorical relationship within is motivated by a WHOLE AND PART type of metonymy (Kövecses 2002). Due to Kövecses's opinion, properties can be seen as parts of a category. We find that both the target domain"hot/cold water" and the source domain"red/blue color" are subcategories of "objects or things with high/low temperature". Therefore the HeatSink uses the metaphor where both the target and the source are subcategories of a higher, more inclusive category.

We can apply metaphor based on WHOLE AND PART metonymy to redesign the case of the Mona Lisa Bookshelf (Nakajima et al. 2008). We may choose the mementos of great ecologists, foresters, or environmentalists such as Henry David Thoreau, John Muir or Aldo Leopold, instead of Mona Lisa painting. When we look at the mementos, we are not just looking at them alone. We will probably think of the work related to the great man, such as his environmental observations and thoughts, his role in history, etc. Thus this kind of design can affect both user's thought and action.

Table 1: Collection of previous work

Authors	Metaphor	Target Behavior	Presentation Medium
Arroyo et al. 2005	Color	Water-Using Activity	Water
Lin et al. 2006	Virtual Fish	Physical Activity	Electronic Display
Ko et al. 2007	Virtual Tree	Water-drinking Behavior	Electronic Display
Holmes 2007	Virtual Tree	Electricity Conservation	Electronic Display
Nakajima et al. 2008	MONA LISA painting, Virtual Aquarium	Bookshelf-organizing Behavior, Reading, Tooth-	Electronic Display
		brushing	
Dillahunt et al. 2008	Virtual Polar Bear	Environmentally Responsible Behavior	Electronic Display
Consolvo et al. 2008	Virtual Garden	Physical Activity (Cardio, Resistance Training,	Mobile Display
		Flexibility, Walking)	
Li and Landay 2008	Virtual Aquarium	Physical Activity	Tablet PC Display
Froehlich et al. 2009	Virtual Apple Tree and Virtual Arctic Ecosystem	Transportation Habit	Mobile Display
Shiraishi et al. 2009	Virtual Land	CO2-reducing Behavior	Electronic Display
Chiu et al. 2009	Virtual Tree	Water-drinking Behavior	Electronic Display



Figure 6: Top: the garden at the beginning of the week; Medium: after one cardio workout; Bottom: a garden with workout variety

The polar bear examples in (Dillahunt et al. 2008) and (Froehlich et al. 2009) are another applications of metaphors. See Figure 3 and Figure 7 respectively. Note that the virtual polar bears play a different role in (Dillahunt et al. 2008) and (Froehlich et al. 2009). Dillahunt et al. (2008) used the virtual polar bear as a pet for the user just like the Tamagotchis. Users who formed emotional attachment to the virtual polar bear were found more concerned about the environment, and committed to more environmentally responsible actions than users who did not form bonds. UbiGreen (Froehlich et al. 2009) contains the virtual Arctic ecosystem that reflects the green transportation habits. UbiGreen does not emphasize the emotional attachment to the virtual polar bear, especially the relationship between the pet

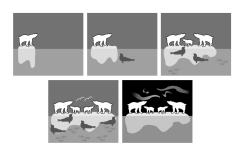


Figure 7: A sample of images from the Arctic ecosystem progress



Figure 8: A sample of images from the virtual tree progress

and the owner.

Although the polar bear visuals in (Dillahunt et al. 2008) and (Froehlich et al. 2009) are treated in different way, they have similar metaphorical meanings. Polar bears are the most famous Arctic species that are threatened by extinction due to global warming. Therefore when we use polar bears as the interface visuals, we form the following chain of conceptualization:

People's choices or behaviors affect the environment, especially the greenhouse gas emissions; The increase of greenhouse gas leads to the global warming. The global warming affects the habitat of polar bears. Thus human's behaviors will push polar bears toward extinction.

We put this polar bear of visual design as the EFFECT

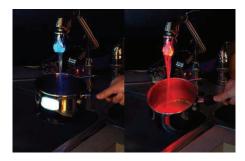


Figure 9: The HeatSink project

FOR CAUSE metonymy (Kövecses 2002): the change of polar bear's habitat is the effect, human's behavior is the cause. Thus this effect forms the virtual polar bear metaphor through a metonymic process.

The EFFECT FOR CAUSE metonymy is also used in the persuasive system presented by Shiraishi et al.(2009). This system, called EcoIsland, persuades individuals and families to change their everyday lifestyle patterns to reduce carbon emissions (Shiraishi et al. 2009). Figure 10 illustrates the main screen of EcoIsland. When users watch the sea level rising (the EFFECT), they would reflect that their behaviors (the CAUSE) result in this situation.



Figure 10: The EcoIsland

Another metaphor method used in Fish'n'Steps (Lin et al. 2006) is the anthropomorphic form of the virtual fish. The virtual fish has facial expressions to show its emotions. The designers gave human qualities to nonhuman entities. This anthropomorphic approach is similar to *personification*, an ontological metaphor most used in linguistics (Lakoff and Johnson 1980). This anthropomorphism makes it easier to understand the situation that the virtual fish lives in, but to what degree does it influence the persuasive power is unknown.

Conclusion

We present four design dimensions of persuasive feedback system. More variety of visual presentation is necessary for successful persuasive feedback system. It is significant for developers to consider these four dimensions when they design persuasive feedback systems. In particular, we argue that metaphor plays a major role in the visual design of persuasive feedback system.

It is possible to think of all the four design concerns when

engineers or developers build a persuasive feedback system. The 7000 oaks and counting in (Holmes 2007) is such a system that explicitly considers our four design dimensions. Figure 11 is a sample of animated clips. Because this project is a public art, the designer emphasizes the tree imagery and colorful background in the animation such that this art can attract human interest. This is related to the Ambient dimension and Aesthetic dimension. The virtual tree in the project is the oak tree, that is state tree of Illinois and national tree of the United States of American. This choice of virtual tree strengthens the emotional engagement, that is the main point in our Emotionally-engaged dimension. In the Metaphorical dimension, the designer also use SCALE schema in the visual representation: the AMOUNT of tree numbers decreases if more energy is consumed. He replaces trees with energy consuming appliances like hairdryers, coffeepots, and cars in an aesthetic way.

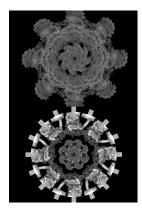


Figure 11: Top: Fully green. Bottom: more energy consumed; energy consuming appliances like hairdryers and coffeepots replace trees.

In the future, we plan to investigate the finding of suitable metaphors for persuasive feedback and the formalization of persuasive metaphor analysis. We also plan to find out the potential of image schemas in aid of persuasive feedback research.

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