The Impact of Unconscious Human Behavior on Sustainable Interaction Design

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Abstract: Sustainability has become a central research issue for interaction design, as emerging interactive products can create serious environmental impacts while products are being used. This research investigates a design method for sustainable interaction. A main concept of the design method is to understand and to apply unconscious human behaviors in design. Products designed with this method are expected to be used unconsciously by users with reduced environmental impacts. A framework of design space matrix is proposed, after understanding the attributes of unconscious human behaviors and the types of interaction behaviors causing environmental impacts. To verify the effect of this approach, a design case developed by this method was tested in user study in terms of sustainability. The proposed framework and the design case can be used as a base of an advanced sustainable interaction design method.

Key words: Sustainable interaction design, unconscious human behaviors, thoughtless act, design for sustainability, interaction design.

1. Introduction

Emerging interactive products create a more serious environmental impact while products are being used than manufactured or disposed. As many electronic products use electricity, resources and fuel, it became very important to consider the way to reduce environmental impacts in the usage phase. In the case of washing machines, we consume detergent, water and electricity rather than the washing machine itself [1].

As the environmental impact is directly influenced by how users interact with the products, sustainable design has become a central research issue in interaction design and recently the research has increased. Research on sustainable interaction largely remains in emphasizing the importance theoretically. The works are motivating sustainability in interaction design [2], suggesting strategies in design process [3] and analyzing existing products [4, 5]. Another approach is to develop various design cases practically and show the effectiveness of sustainable interaction design [6]. Power-aware cord, a power cord which visualizes the flow of electricity, is expected to make people act environmentally friendly by recognizing that the power is on [7]. Becker conducted an experiment to observe users' behavior change while using air conditioner by signaling the conditions of surroundings [8].

These approaches of eco-friendly interaction design are mainly focusing on educating users or making them recognize the need of sustainability. However, as users decide how to interact with product in a very short time, the interaction is highly influenced by users' habitual behaviors and their surroundings. We assume that a proper design can change users' behavior effectively, which are not necessarily emphasizing eco-friendliness in cognitive way. For example, in Jurgen's experiment [9] with the electric kettle, the water consumption was reduced by indicating water level as cups instead of measuring liters. Although they did not let the participants to save waters, people tend to adjust the most efficient water amount naturally.

In this research, we focused on developing a design method for sustainable interaction. The main concept of the design method is to apply unconscious human behaviors in interaction design. Unconscious everyday human behaviors, sometimes referred as thoughtless acts [10], have been used as a source of inspiration for intuitive design [11]. We intend to apply unconscious human behaviors to increase sustainability of interaction. Products designed with this method are expected to be used unconsciously for reducing environmental impact.

In this paper, we present a design method for sustainable interaction using unconscious human behavior and the evaluation of the method. To develop the design framework, we first identified the types of interaction behaviors in terms of sustainability while products are being used. The second step was to identify the attributes of unconscious human behaviors. A framework of design space matrix was then developed with these two elements. Based on the framework, a design case was created to explore exemplary solutions. Finally, a design case was tested by users to evaluate the effect of unconscious behavior on sustainability.

2. Developing Design Method

2.1. Identifying the types of interaction behaviors causing environmental impacts

Eco-friendly behaviors are often classified as 4R, which represents 'reduce, reuse, recycle and recover'. On the other hands, DEFRA explains 13 categories of pro-environmental behaviors in everyday life [12]. It presents guidelines for reducing environmental impacts in various situations. While these classifications are based on the 'activities', this research proposes three patterns in terms of the 'interaction' between users and products.

Behaviors involving a toggle selection

This type causes environmental impacts by performing or not performing an action. Existence of the behaviors decides the eco-friendliness. Example behaviors include switching off electronic products, pulling out a plug from wall outlet, or reusing materials. With these behaviors, users often do not know which action is appropriate, or they have a weak motivation although they know the required action.

Behaviors involving a selection among multiple options

This type causes environmental impacts by selecting one among multiple options. Optimal options vary depending on situations. Example behaviors include separating garbage collection for recycling, turning on a correct light in need, flushing the toilet appropriately, or selecting proper options on washing machines and air conditioners. This type of behaviors takes place quickly, so users tend to be habitual.

Behaviors involving an analogue adjustment

This type can minimize environmental impacts by analogue adjustment for an optimum condition. This type frequently occurs in interaction with products which consume energy and resources. Example situations include finding optimal amount of detergent for washing clothes, deciding right quantity of water for bath, or using toilet paper. Careless behaviors bring about redundant energy use.

2.2. Understanding unconscious human behaviors

People often behave unconsciously as a result of external stimuli and environment without their own intention or knowledge. Unconscious behaviors can be explained as automatic process as being effortless, unconscious, and involuntary [13]. A lot of researches looked into the mechanisms of unconsciousness. Although little is known about the types of these behaviors, Suri presents seven patterns with the examples of thoughtless acts in everyday life [10]. This research identifies four attributes of unconscious behavior. This can be also represented in a map with two axes as follows, depending on whether it is individual or social, and whether users had an initial intention or not (Figure 1).

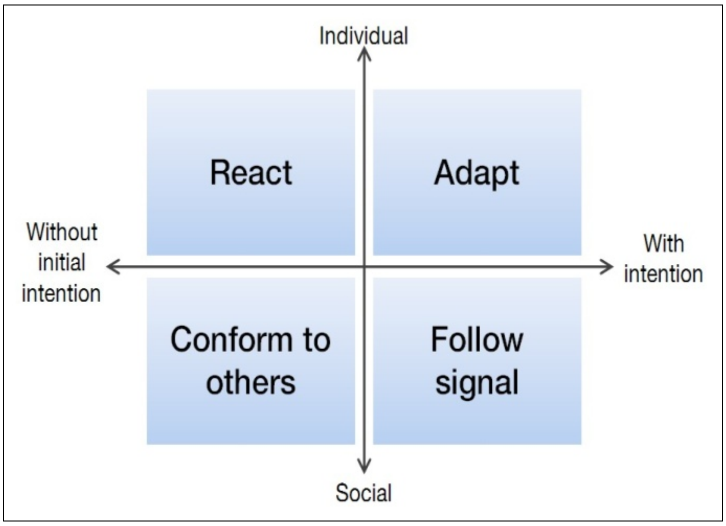

Figure 1. Four attributes of unconscious everyday human behaviors

React

People interact automatically with objects and spaces that they encounter, even without any purpose. Affordance of an object often triggers this attribute [14]. People tend to walk on road lines, or to place a cup in the safe area of a table. This is triggered by the fact that people enjoy making their own orders and desire the orders to be met.

Adapt

Adaptation is related to people's intention. People tend to find opportunities from other objects for a desired condition. People take physical advantages from their surroundings, to achieve their objectives. For example, people usually put their coat on the back of a chair, or use their newspaper as a pot stand.

Conform to others

In social psychology, conformity is the process by which an individual's attributes, beliefs and behaviors are influenced by other people. People unconsciously conform not only to what other people are doing, but also the results of others' behavior.

Follow signal

People respond immediately for the messages that others made. This attribute is similar to 'react' or 'conform to others' attributes, but it has an initial intention. Users turn the volume up by following the signal of a round button and push up by following a sliding button, without thinking or learning.

2.3. Design Framework

With the types of interaction behaviors and the attributes of unconscious human behaviors, a framework was developed for the design method (Table 1). The purpose of framework is to identify design space matrix which designers can systematically develop design solutions for each spaces in the matrix. Design cases can be developed for each type of the interaction behaviors, applying specific attributes of unconscious human behavior.

Table 1. Design framework

	Toggle selection	Selection among multiple options	Analogue adjustment
React			✓
Adapt			
Conform to others			
Follow signal			

3. Measuring the Impact of Unconscious Behavior

3.1. Developing a design case: Curvy-Speedometer

A design case was developed to verify the feasibility of the proposed framework. A driving situation was selected as a design problem. Driving is an important example situation whose environmental impact is largely affected by users' habitual behaviors. Sudden stops, quick starts and over-speeding consume excessive fuel. However, there exists an 'economic speed' according to situations, and we can preserve the amount of fuel if we keep the speed. Therefore, we intended to make users to keep the fuel-efficient speed unconsciously by a design of a car dashboard.

According to the proposed design framework, the behavior to decide the efficient driving speed can be classified as a type of 'analogue adjustment' interaction behavior. For this behavior, each attribute of unconscious behaviors was used as a source of ideas. As a result, 'curvy-speedometer' was developed, applying the attribute of 'react'. The design space is checked on the framework in Table 1. The main feature of the design is a deformable indicator needle. The needle indicates current speed while at the same time the curvature indicates how far the current speed is from the most fuel-efficient speed. Especially, we call this deformable needle as an 'eco needle'. We also designed to present the fuel-efficient speed area on the dashboard with a different color. It presents different speed area according to the driving situation (Figure 5, right). The driver may unconsciously change the driving speed to make needle straighten due to the bending shape of the eco needle, and the color difference of economic speed area could help additionally to lower the speed.

3.2. Evaluation

An exploratory user study was executed to investigate if the design is helpful for driving at a fuel efficient speed. Firstly, we intended to find out if the eco needle affects to users' driving habit and how they think of the eco needle. Secondly, we wanted to investigate if there is a synergistic effect with another design element which is indicating economic speed area.

3.2.1. Method

Participants

24 graduate students participated in the experiment (12 male and 12 female). The subjects' age ranged from 23 to 34 years old. 20 participants had been driving or had learned to drive, 4 female participants did not have any experience of driving.

Setting up prototype

A driving prototype was developed by a flash simulation and connected to Logitech Momo force feedback wheel. The screen of simulation shows a straight road and a dashboard (Figure 2). Users can rotate the handle to change the direction slightly, but not go out from the road or turn. The simulation is a simple animation for feeling the speed according to their current speed by the moving trees and road lines passing. The whole prototype set was installed in an empty laboratory as shown in figure 3. The simulation was projected on the wall in the front of participants.

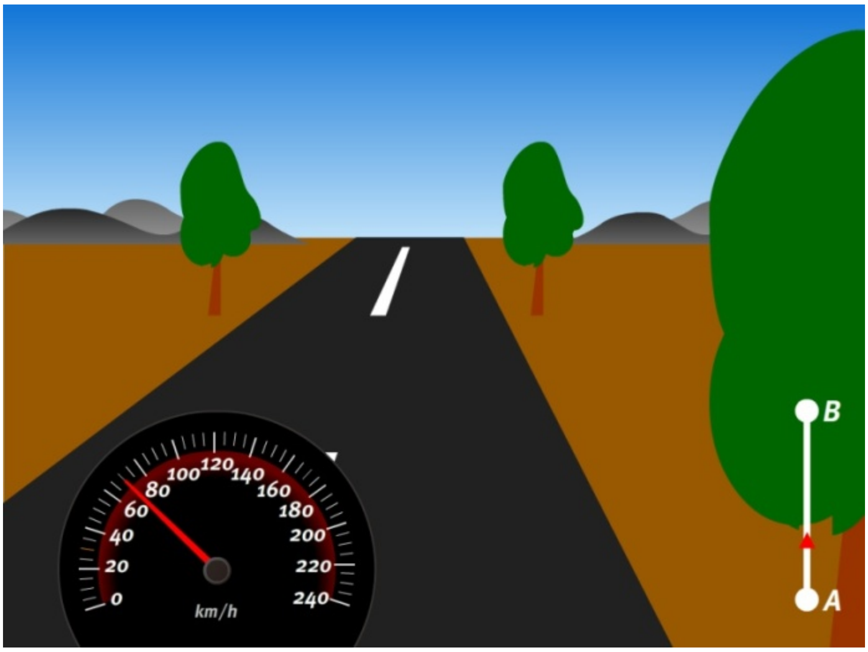

Figure 2. The screenshot of driving simulation

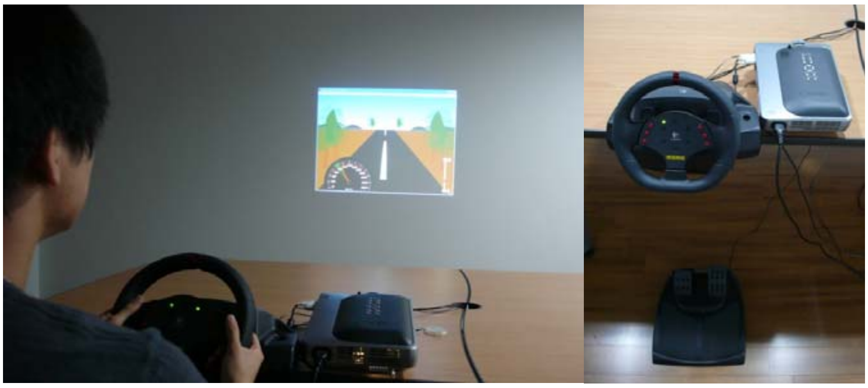

Figure 3. Installation of prototype

User Study Procedure

The user study was divided into three parts, a practice before the experiment, main experiment and a simple paper questionnaire.

Main Experiment

The participants were divided into two groups (6 male and 6 female each); group 1 was tested with normal dashboard without marking the economic speed area (figure 4), and group 2 was tested with the dashboard with economic speed area (figure 5). In the simulation, the dashboard was changed to conduct different tasks for each group. Group 1 had not given any information about the economic speed or the purpose of eco needle, while group 2 was told that the green area implicates the economic speed and they can save fuel if they fit the needle in the area during driving. However, they were not pushed to keep driving in that speed or not asked to consider environmental impact.

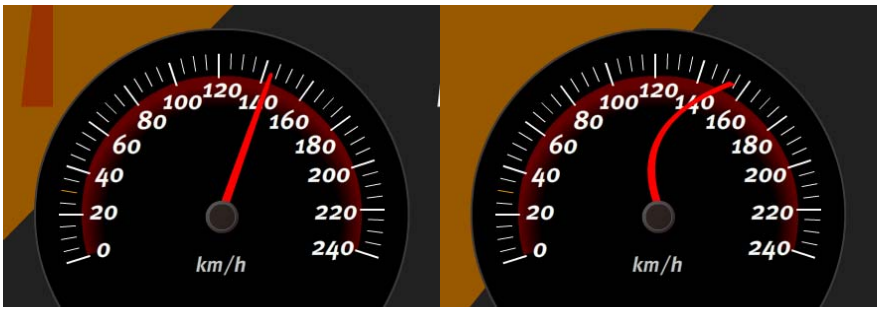

Figure 4. Dashboards without economic speed area for *Group 1*

Figure 5. Dashboards with economic speed area for *Group 2*

The experiment included two tasks; a task using normal needle and another task using eco needle. In each task, users start from a point A and drive about 2km until the point B (Figure 2). Each task took about 2 to 3 minutes. To eliminate the effect of orders between tasks, half the participants were tested with normal needle first, and the rest was with eco needle first.

Independent variables in these tasks are i) two shapes of needle and ii) two dashboards with and without economic speed area, and dependent variable is the average speed of driving. The speed in each time period (1/48 second) was logged by the flash simulation program, and the average speed was analyzed with the data to compare within and between the groups.

Questionnaire

The questionnaire asked; i) general information about participants, ii) evaluating the impression of the eco needle and iii) grading each design in terms of adjusting the economic speed. 8 sentences were presented to examine their impressions about the curvy speedometer, in terms of the correspondence of purpose, visibility and safety, effect on driving, and amusement. Participants were asked to check on 5 point Likert scale, from 1 point as the most negative to 5 point as the most positive. For grading the designs, all the dashboards were explained to participants first, because all participants were tested with only two dashboards out of four different designs. It was also measured by 5 point Likert scale.

3.2.2. Results

Effect by the shapes of needles

There was no statistically significant difference between normal needle and eco needle in both groups. Nevertheless, it is interesting that the results in group 1 and group 2 are contrary to each other. From group 1 (drove with the normal dashboard without marking economic speed area), the average speed was slightly reduced when they use eco needle than when they use normal needle (from 112.33km/h to 108.40km/h). However, in the case of group 2, the speed was increased about 2.5% while using eco needle (Figure 6 left).

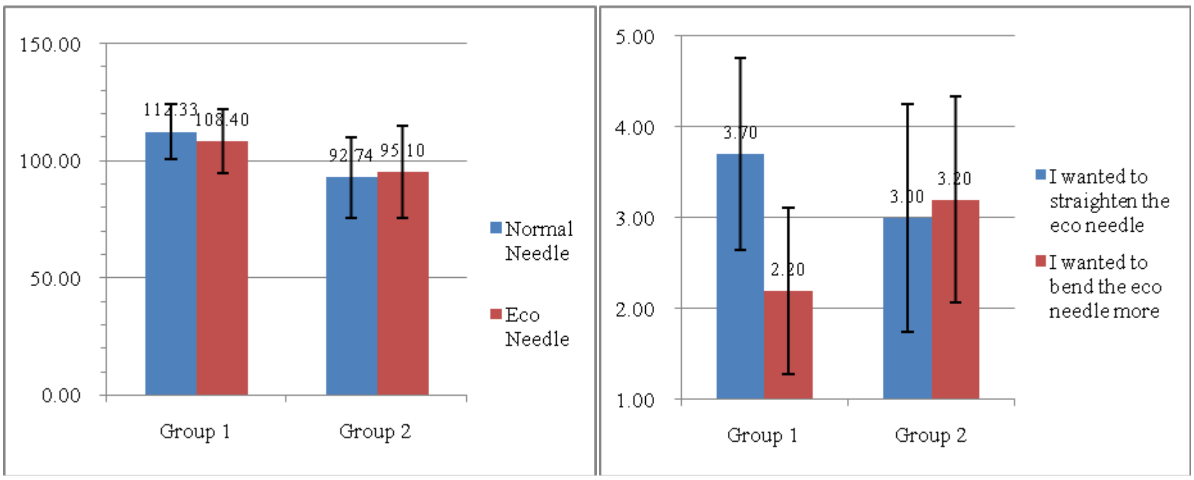

Figure 6. Average speed affected by shapes of needles (left) and impression from eco needle (right)

Although the results of experiment are not statistically significant, it is corresponding with the users' impression about eco needle from the questionnaire (Figure 6 right). For the two opposite sentences, group 1 answered that they wanted to make the eco needle straight rather than to make it bent more (p=0.000, N=12). However, group 2 did not show any significant difference (p=0.501, N=12), and slightly more agreed to feel like bending it.

Effects of marking economic speed area

When the dashboard presents the economic speed area, the average speed was more reduced than the dashboard without economic speed area (Figure 7). While using normal needle, the average speed was significantly reduced when the economic area was presented. It was reduced 17.4% from 112.33km/h to 92.74km/h (p=0.004, N=24). In the case of eco needle, the speed was lowered about 12.3% from 108.40km/h to 95.10km/h, but the difference is not statistically significant (p=0.067, N=24).

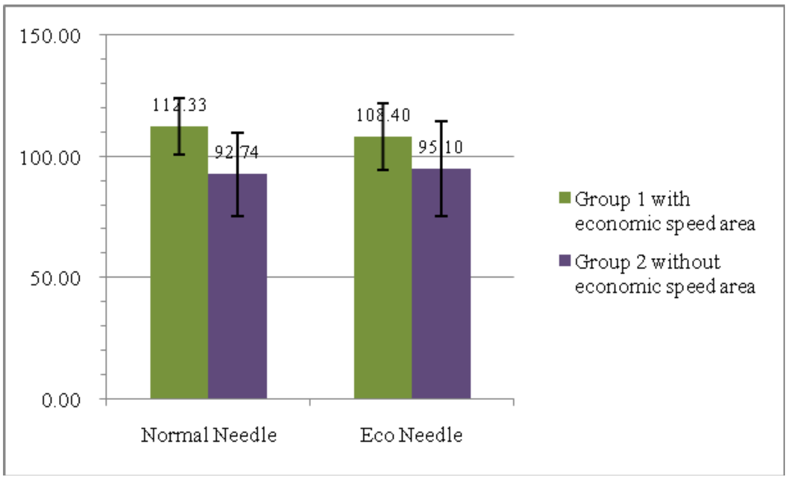

Figure 7. Average speed affected by economic speed area

The most efficient design for adjusting economic speed

In average, participants answered that they think the most efficient design for keeping economic speed is the speedometer with both eco needle and economic speed area (Figure 8 left). Clearly, participants think that presenting economic speed area was effective in both needles. However, there are some differences between the answers from group 1 and group 2 (Figure 8 right). While group 1 considered that the eco needle was distinctively more effective than normal needle in the normal dashboard (p=0.000, N=12), group 2 did not think the eco needle made difference. The difference between two needles was also not statistically significant in the dashboard with markings of the economic speed area (p=0.664, N=12).

4. Discussion

Although there are some differences by participants' individual personality, the curvy needle can be said that makes people unconsciously react to the shape. While some participants answered that the curvy needle does not give any emotional effect to straighten or to bend, other participants said that it made them very uncomfortable and that they wanted to straighten it. When only the curvy needle was applied into the dashboard, users were

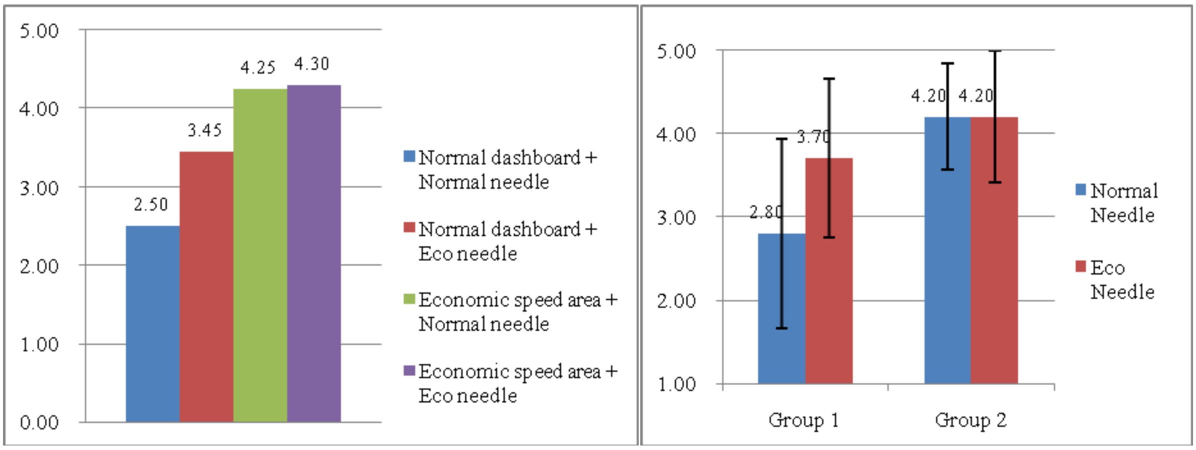

Figure 8. The most efficient design for economic driving; in general (left) and by groups (right)

likely to straighten it more than to bend it and eventually this helps them lower their speed. The dashboard indicating the economic speed area by color helps users more effectively lower their speed. We can assume that this design cognitively affects to the users to fit in the area, because the function was explained before the test of group 2. However, when the two elements were applied together, the effect did not get better. Users could feel that the design is complex and may not catch the meaning immediately. Therefore, we can conclude that the elements should be combined carefully for designing the dashboard for the sustainable interaction.

This concept can be easily installed in a car as an interactive deformation graphic with an electric display, but the safety issue should also be considered before implementing. As the solution affects unconsciously to human, we cannot ignore that there could be differences in between cultures or generations. If more diverse experiments were conducted, the results could be more reliable. The most important factor is that there could be more issues in the real driving situation, as the experiment was held in the laboratory. We expect that the impact could be increased, because people tend to consider their money consumption when they drive their own car.

5. Conclusion

Through this research, we suggested the design method applying unconscious human behaviors for sustainable interaction and verified the impact of the design created by this method. The results of the experiment and questionnaire show the possibility of inducing users to interact sustainably in an unconscious way. The framework and design cases provide a theoretical base for eco-friendly interaction design methods that can be practical in both industry and academia. The results of this work can be used as a design method to change users' behaviors for sustainability. The proposed framework can also be used as a systematic and an analytic tool for evaluation. A general guideline for each type of interaction behavior can be further developed considering all attributes of unconscious human behavior.

In future work, the suggested design should be tested in the real driving situation in terms of fuel-efficiency as well as safety. The elements in the framework should be verified carefully and many design cases should be developed to support the framework. After investigating many examples in design spaces of the framework, a general design guideline could be further developed. Finally, a structural evaluation method for environmental impact adopting this method could be developed as an analyzing tool for existing products and new design ideas.

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