Principles and Skills of Product Design to Promote Green Behavior

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Abstract: Promoting green behavior through product design is a simple way to reduce human impact on the environment. Based on Design for Sustainable Behavior and Behavior Theory, this study aims to propose design principles and techniques to effectively promote green behavior, and take household appliances as the empirical object of research, and introduce Analytical Hierarchy Process to overcome the problem in multi-criteria decision making of choosing the best design principles and skills under limited resources. The empirical results show that “Design for Green Behavior of Perceived Behavioral Control” is the key to promote energy-saving behavior of household appliances. Relevant designers can consider the weight value of the research results, and effectively design products to promote green behavior.

1. Introduction
The use stage is the key link that affects the green effect. It is not necessary to produce the required green results if we focus on other product life cycle stages. How to design products or services to curb or change unsustainable behavior has become a research focus. In recent years, high energy efficiency appliances are encouraged. However, there is obvious rebound effect in daily electricity consumption behavior (improving the energy efficiency of equipment will increase the consumption capacity, leading to the phenomenon that the energy consumption does not decrease but rises instead). The use of high energy efficiency appliances will not reverse the negative impact on the environment (Wang et al., 2014). For example, the standby power consumption of daily household appliances in Taiwan region is 139.065 billion kwh, which is equivalent to 811 tons of carbon dioxide emissions (Lu et al., 2011). If the user behavior can be changed and the plug of standby household appliances can be pulled out at any time, the unnecessary energy waste can be greatly reduced with a little effort. Sustainable design focuses on the impact of the whole product life cycle on the environment. However, designers usually ignore the potential of product use stage for energy saving (Lopes et al., 2012).

Design for Sustainable Behavior (DfSB) is a product design method that considers human behavior, reduces rebound effect, and reduces environmental impact in the use phase. It can be used as a green bridge between the intention behavior gap of designer and user behavior (Lilley, 2009; Lockton et al., 2010). The design of the product itself will affect the user’s willingness to implement green behavior. In the past, green product designers who focused on reducing the impact of production on the environment have realized that human behavior is often a major factor in confusing green design intentions. DfSB has been widely used in various research fields to promote green behavior, such as energy usage (Chiu et al., 2020), human-computer interaction (Irizar-Arrieta et al., 2020), prevention of marine litter (Portman et al., 2019). However, product use behavior involves its own intention and is the result of the interaction of psychological factors inside and outside the individual (Lockton et al., 2010).
Without considering the psychological factors and behavior patterns that affect users, it is obviously a difficult task to guide, maintain or change unsustainable behaviors (Lilley, 2009).

In order to encourage green behaviors that are beneficial to the environment, researchers have developed various methods to reduce the negative impact of individuals on the environment. For example, Hines et al. (1987) used modern statistical methods to conduct meta-analysis on the psychological variables of green behavior and predict the results, pointing out that green behavior depends on personal intention and situational factors. This method urges more researchers to analyze green behavior from the psychological point of view. Among them, the theory of planned behavior (TPB) (Ajzen, 1991) has been widely used in the study of green behaviors such as DfSB (Chiu et al., 2020), e-waste recycling behavior (Abouelmaged, 2021) and energy-saving appliances (Wang et al., 2019). TPB believes that Behavior (B) is mainly determined by intention (I), while intention is controlled by attitude toward the behavior (ATB), subjective norm (SN) and perceived behavioral control (PBC). After comprehensive consideration and judgment of the above-mentioned influencing factors (rational thinking), the individual can decide whether to take action. In addition, studies have shown that personal emotions also significantly affect the willingness to engage in sustainable behavior (Onwezen et al., 2013). “Emotional” refers to the positive and negative emotional reactions of an individual to a specific behavior. Different emotional reactions of an individual to a specific behavior will lead to different evaluations of the behavioral intention (Perugini & bagozzi, 2001). It is pointed out that guilt (a regretful environmental behavior), anger (a disgusting environmental behavior), pride (a proud environmental behavior) and other positive and negative emotions on sustainable behavior significantly affect behavior, which can be specifically used to predict and promote sustainable behavior (Harth et al., 2013).

Green behavior refers to the behavior that has the least damage or is beneficial to the environment, which involves the interaction between personal psychology and environment. Understanding the internal and external psychological factors that affect behavior will help to promote green behavior. If designers want to promote green behavior through products, they should first understand the internal and external psychological factors that affect users to engage in green behavior, and then propose corresponding design rules for these factors, so as to effectively reduce the barriers to engage in green behavior and encourage and promote the willingness to engage in green behavior. This study aims to propose design principles and techniques to effectively promote green behavior based on DfSB and behavior theory, so as to facilitate relevant designers’ consideration in product planning stage.

2. Methods

According to the purpose of this study, the corresponding research framework is proposed, as shown in Fig.1. The framework of this study begins with the review of the relevant literature on DfSB and behavior theory. After group discussion, the following 4 design principles and 12 design techniques are proposed to promote green behavior. The principles of “Design for Green Behavior of Attitude” refers to a design principle that starts from understanding the individual’s attitude towards green behavior, and improves the positive attitude of green by presupposing design skills such as functionality, knowledge education and environmental benefit relevance. “Presupposition functional design skills”: the design that enhances a positive attitude towards green behavior by performing preset functions. For example, Change Lamp that obtains power in coin mode (preset function). “Knowledge educational design skills”: the design that promotes a positive attitude towards green behavior through knowledge or education. For example, when toilet paper is extracted, it can lead to forest loss in South America (Werner et al., 2012). “Environmental benefit relevance design technique”: a design to increase the design of positive attitude towards green behavior through the correlation between use behavior and environmental benefit. For example, the Poor Little Fish Basin, which can reduce the amount of water when washing hands, affect the survival conditions of fish.

“Design for Green Behavior of Subjective Norm” refers to a design principle that starts from understanding individuals’ subjective norms of green behavior, and improves green subjective norms through design skills such as social support, social prohibition and personal standardization. “Social Supportive Design Skills”: design that provides users with the perception that most people support and
engage in green behavior. For example, it shows the number of people whose lights turn off when others leave the conference room (Tetlow et al., 2014). “Social Prohibitive Design Techniques”: provide users with a sense that most people do not approve of the design of their own behavior on the environment. For example, it shows that most people do not approve of the design of littering behavior (De Kort et al., 2008). “Personal Normative Design Skills”: the design that causes users to judge their own integrity and approve or disapprove of green behavior. For example, it shows that littering is an environmentally unfriendly behavior, which leads individuals to reflect on the right or wrong of their own behavior (De Kort et al., 2008).

“Design for Green Behavior of Perceived Behavioral Control” refers to a design principle to improve the control ability of perceptual green behavior by means of sensory feedback, cognitive learning and physical action, starting from the understanding of individual’s perceptual behavior control ability. “Sensory Feedback Design Skills”: the design to increase the control ability of green behavior through visualization, hearing, taste, touch and smell. For example, real-time visual feedback of gasoline and electricity consumption during driving (Stillwater & Kurani, 2013). “Cognitive Learning Design Skills”: to increase the ability to control green behaviors through cognitive processes. For example, Mito, which is easy to control power consumption in the process of water heating, can be realized by simple modeling. “Body Movement Design Skills” : the design of the ability to control green behavior through body movements. For example, a product called RevOlve can generate electricity with a simple limb control capability (Lobos & Babbitt, 2013).

“Design for Green Behavior of Emotion” refers to a design principle that starts from understanding the positive and negative emotions of individuals for green behavior, and provides green behavior design skills with aesthetic impression, semantic interpretation and symbolic association, so as to generate positive green emotion. “Aesthetic impression design skills”: the aesthetic impression design of products that trigger green behavior by causing positive emotional reactions. For example, flower lamp products that cause pleasure such as blooming (low power consumption) and flower fading (high power consumption) are used. “Semantic interpretative design techniques”: product semantic design that triggers green behavior by eliciting positive emotional reactions. For example, the TAWARE Puzzle Switch product, in which the user can turn off the power switch after completing the puzzle. “Symbolic Association Design Skills”: the symbolic associative design of products that cause positive emotions and trigger green behaviors. For example, Piano Staircase products, which can evoke the emotional reaction of users when playing, through piano modeling (symbolism).

Secondly, this study will be the design principles and skills, compiled into the form of Analytic Hierarchy Process (AHP) questionnaire, to carry out the investigation work. AHP is mainly used to solve the complex decision-making problems with multi criteria under uncertainty, which is an effective social science research method. AHP deconstructs different measurement indexes by hierarchical operation, which helps decision makers to understand the whole thing and reduce the risk of decision. Based on AHP quantitative data, decision makers can comprehensively judge the appropriate scheme and formulate the optimal strategy to solve the problem of multi criteria decision-making. Finally, according to the data from the questionnaire survey, AHP analysis is carried out to obtain the weight of the design principles and skills to promote the energy-saving behavior of household appliances, so as to facilitate the consideration of relevant designers or researchers.

This study will take household appliances as the empirical object to clarify the green behavior design framework proposed in this study, so as to facilitate designers’ consideration and application in the early stage of product development. Household appliances are products that are often used in daily life. How to design household appliances to arouse personal reflection on the relationship between their own behavior and environmental greenness, so as to promote the willingness to engage in green behavior, may be one of the ways to practice green life. This research questionnaire is divided into two parts: the first part is the basic information of the respondents; the respondents are mainly 16 green product designers in Taiwan region, the gender ratio of male and female is 69% and 31%, the ratio of social personage to student is 57% and 44%. The second part is the AHP scale to promote the energy-saving behavior of household appliances. The survey date is from October 9 to October 15, 2020.
3. Results & Discussion

In this study, the data collected by the questionnaire must first pass the consistency test; AHP is based on Consistency Index (CI), Consistency Ratio (CR) and Consistency Ratio the Hierarchy (CRH). When CI, CR and CRH are all less than 0.1, it indicates that the results of the study meet the requirements of reliability. The consistency test values of this study were 0.012 for CI, 0.020 for CR and 0.007 for CRH.

The results of data analysis show that the weight values of the criteria layer are “Designed for Green Behavior of Perceived Behavioral Control” of 0.289, “Design for Green Behavior of Emotion” of 0.274, “Design for Green Behavior of Subjective Norm” of 0.228 and “Design for Green Behavior of Attention” of 0.209, which means that in order to effectively promote sustainable behavior, home appliance designers should first focus on the “Planning of Perceptual Behavior Control Design Principle of Sustainable Behavior”, as shown in Tab.1. This design principle first emphasizes the “Design Skills of Sensory Feedback”, with the weight value of 0.380, followed by “cognitive learning” of 0.321 and “Body Movement” of 0.299. “Sensory Feedback” energy-saving behavior design technique is to increase the user’s perceptual behavior control ability by visual, auditory, tactile and olfactory designs. For example, the electric kettle with a whistle device can make the user feel that the water is boiling through hearing, so as to prevent the electricity consumption behavior of overheating (Sensory Feedback). The electric iron can first consider the color change of LED light, and then feedback the energy consumption information (Sensory Feedback) in real time through visual feedback, and then display the correlation between clothing material and electric energy (Cognitive Learning), so that users can clearly understand that their own behavior is the main factor controlling the power consumption (Physical Mobility).

Secondly, in “Design for Green Behavior of Emotion”, the most important design technique is “Aesthetic Impression”, with the weight value of 0.383, followed by “Symbolic Association” of 0.344 and “Semantic Interpretation” of 0.273. “Aesthetic Impression” energy-saving behavior design technique is designed to trigger the user’s willingness to engage in green behavior by arousing positive emotional response of users. For example, the flower shaped electric lamp with its flower blooming when the power consumption is low, fading when the power consumption is high can remind users of the energy-saving behavior of turning off the lights. Furthermore, for the “Design for Green Behavior of Subjective Norm”, the most important design skill is “Social Support”, with the weight value of 0.384, followed by “Social Prohibition” of 0.335 and “Personal Normative” of 0.281. “Social Support” household appliances energy-saving behavior design technique is to enhance the user’s motivation to perform energy-saving behavior by displaying the socially recognized energy-saving behavior design. For example, a design that displays the average energy consumption of the concerned groups on the air conditioner, or shows that when you leave the room, turn off the air conditioner to achieve the energy saving goal. In the aspect of “Design for Green Behavior of Attitude”, the design skill of “Causal Correlation of Environmental Benefits” is the most important, with the weight value of 0.392, followed by “Default Functionality” of 0.333 and knowledge education of 0.275. “Environmental Benefit Relevance” is a design technique for energy-saving behavior of household appliances by showing the correlation between their own behaviors and environmental benefits, so as to enable them to reflect on the environmental impact of their own behaviors when using household appliances.
using an electric furnace, the carbon dioxide equivalent of electricity consumption is displayed synchronously. In terms of the overall weight value of household appliances energy-saving behavior design skills, “Sensory Feedback” of 10.976, “Aesthetic Impression” of 10.490, “Symbolic Association” of 9.412, “Cognitive Learning” of 9.296, “Social Support” of 8.749, “Operation Procedure” of 8.648 and “Environmental Benefit Relevance” of 8.198 account for a relatively high proportion. According to the results of data analysis, the designer of household appliances can evaluate the weight and order of design skills of energy-saving behavior of household appliances, and work out the design scheme to effectively promote the energy-saving behavior of household appliances.

**Tab.1 AHP Weight Value of Promoting Household Appliances Energy Saving Behavior**

| Design Goal                  | Design Principles          | DP            | Design Skills                         | DS     | OW %   |
|------------------------------|----------------------------|---------------|---------------------------------------|--------|--------|
| Effectively Design Products to Promote Behavior of Attitude | Design for Green 0.209     | Preset Functionality | Knowledge Education                  | 0.333  | 6.960  |
|                              |                           |               | Relevance of Environmental Benefits   | 0.392  | 8.198  |
|                              | Design for Green 0.228     | Social Support |                         | 0.384  | 8.749  |
|                              | Social Support            |               | Knowledge Education                  | 0.335  | 7.626  |
|                              | Personal norms            |               | Social Prohibition                   | 0.281  | 6.413  |
| Energy Saving Behavior of Subjective Norm | Design for Green 0.289 | Sensory Feedback | Cognitive Learning                  | 0.380  | 10.976 |
|                              | Behavioral Control        |               | Limb Mobility                        | 0.299  | 8.648  |
|                              | Design for Green 0.274     | Aesthetic Impression | Semantic Interpretation              | 0.383  | 10.490 |
|                              | Behavioral Control        |               | Symbolic association                 | 0.344  | 9.412  |

DP: Weight Value of Design Principle; DS: Weight Value of Design Skill; OW: Overall Weight Value.

4. Conclusions
For many consumer products, user behavior influences the effect of energy consumption and the contribution of the whole product life cycle to the environmental load. The development of green technology alone does not necessarily lead to green behavior (Wever et al., 2008). Green product designers often ignore the impact of the use stage on sustainability, resulting in a gap between design intent and actual operation (Lilley, 2009; Lopes et al., 2012). However, product use behavior involves complex internal and external psychological factors. It is obviously a difficult task for designers to curb or change unsustainable behaviors and practice green design intention through product design.

Based on the theory of DfSB and behavior, the purpose of this study is to put forward the design principles and techniques to effectively promote green behavior, so as to facilitate the relevant designers to consider in the product planning stage. This study first combs the relevant literature of DfSB and behavior theory, and after group discussion, puts forward 4 design principles and 12 design techniques to promote green behavior. In this study, household appliances are taken as the empirical object and a questionnaire survey is conducted. The purpose of this study is to solve the multi criteria decision-making problem which needs to choose the best design principles and techniques under limited resources. According to the analysis of survey data, the “Design for Green Behavior of Enforced Behavioral Control” is the key to promote the energy-saving behavior of household appliances, while the design skills focus on sensory feedback, aesthetic impression, symbolic association, cognitive learning, social support, operation procedure and environmental benefit relevance. Relevant designers can consider the design principles and skills to promote the energy-saving behavior of household appliances, evaluate its weight and order, and design more effective products to promote green behavior.

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