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Design Framework of Household Appliance for Users' Sustainable Behaviors

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ABSTRACT Residential sectors consume one-fifth of global energy that all sectors have actively invested in the enhancement of residential energy efficiency. User behaviors could affect residential energy efficiency that it is regarded as a foresighted research to change unsustainable behaviors with product design. This study aims to discuss the psycho-social determinants in individual energy-saving behaviors and ensure the product design strategies and methods of the mapping determinants to reduce the difference between sustainable design intention and real product operation. With the mode for goal-directed behaviors to study the determinants in household appliance energy-saving behaviors, personal desire could directly affect energy-saving Behavioral Intention and individual Perceived Behavioral Control, Positive Anticipated Emotion, Attitude, and Frequency of Past Behavior would indirectly affect energy-saving behavioral intention through personal desire. The design strategies of ego-information, ego-feedback, and ego-selectivity are the best household appliance intervention design strategies in energy-saving behaviors. Based on the research results, a product designer could establish the mapping relation matrix between product design intervention strategy as the tactic, and psycho-social determinants in energy-saving behaviors as the objective to design the more practicable household appliance for sustainable behaviors.

INTRODUCTION

In face of enhancing the contribution to the sustainability, introducing environment factors to modern product design has become an essential thinking (Wee et al. 2011). It is primary to study the issue of residences consuming one-fifth of global energy (Brounen et al. 2013). The residential energy efficiency mostly depends on the mode of human behaviors, and the usage behaviors of household appliance is the key factor (Gill et al. 2010).

The usage behaviors of household appliance are the key in residential energy efficiency. Since the energy crisis in 1970, residential energy-saving has been an important research issue (Abrahamse et al. 2005). As residential sectors consuming one-fifth of global energy, all sectors has actively invested in the research on the enhancement of residential energy efficiency (Brounen et al. 2013). Increasing highly efficient energy-saving household appliance to reduce energy consumption has been encouraged and adopted in the past years. Nevertheless, highly efficient energy-saving household appliance would be cancelled out the green product design intention because of user behaviors (Yilmaz et al. 2013). For instance, it was expected to reduce energy consumption by promoting energy-saving technology for the residential power consumption, but it was not actualized (Wang et al. 2014; Yu et al. 2013). For various consumer products, the use phase would affect the contribution of product service to the environmental load, user behaviors could influence the effectiveness of energy consumption, and the development of green technology would not automatically result in users' green actions (Wever et al. 2008).

Aiming at environmental problems, some design researchers have started to develop the affordance research on DfSB. DfSB aims to intentionally affect or result in the design for certain sustainable behaviors. It allows users instinctively realizing product functions and purposes through the strategies and methods of Design Intervention to potentially change unsustainable usage behaviors (Lockton et al.

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2010). Lilley (2009) proposed that DfSB designers could generate more suitable design approaches according to the intervention strategies of eco-feedback, behavior steering, and persuasive technology.

Understanding the mode of human behaviors could assist in enhancing the DfSB effectiveness (Lilley and Wilson 2013). Human behaviors are the coordinated reaction to internal or external stimuli, and the mode of human behavior is the framework after analyzing human behaviors that it could help interpret, predict, and change behaviors. Environmental quality mostly depends on the mode of human behavior (Steg and Vlek 2009) that understanding personal psycho-social determinants could help predict and facilitate sustainable behaviors (Bamberg and Möser 2007). TPB is used for analyzing the factors in the rational psychological decision process of sustainable behaviors; and, effective behavior intervention strategies could be formulated through TPB. However, MGB, which is better for the mode of human behavior, is little applied to the research on sustainable behaviors (Carrus et al. 2008). This study would like to discuss the decision factors in household appliance sustainable behaviors through MGB for the design direction of green products.

Literature Review

Design for Sustainable Behaviors

DfSB, aims to intentionally affect or result in the design for certain user sustainable behaviors (Lockton et al. 2010). DfSB aims to trigger user awareness and action of sustainable behaviors through appropriately designed products or services in order to reduce the effects on the environment. Instead of simply producing an object, a designer indeed establishes a persuasive theory with products as the tactic to change people's attitudes and behaviors, which have been presented on various products. It therefore has become the focus to restrict or change unsustainable behaviors that designers have to endeavor to design products which could effectively facilitate sustainability.

DfSB designers could encourage or guide users reducing the effects on the environment through appropriateness, script theory, behavior shaping, feedback intervention theory, and persuasive technology (Fogg 1999; Lockton et al. 2010).It is considered that thorough motivation, executive ability, and elements for triggering practice behaviors need to be presented for effectively driving actions with Fogg Behavior Model (FBM). Fogg (1999) proposed that, to change behaviors, present motive and ability needed to be discussed and then the behaviors being dot actions (a dot was a one-time behavior), span actions (behaviors exceeding a period of time), or path actions (new habits from the time) should be considered so as to minimized the resistance in behavior change. Lockton et al. (2010) proposed to systematically assist designers in embedding DwI toolkit for changing user behaviors into the product design. Lilley (2009) indicated that product design could affect users' sustainable behaviors through eco-feedback, behavior steering, and persuasive technology.

Model of Goal-directed Behavior

MGB, originated from TPB, can benefit the research on sustainable behavioral intention (Carrus et al. 2008). TPB has been broadly applied to various domains for discussing the psycho-social determinants in personal sustainable Behavioral Intention. TPB, constructed by Ajzen (1991), regards that human Behaviors (B) are decided by personal Intention (I), which is affected by Attitude Toward the Behavior (ATB), Subjective Norm (SN), and Perceived Behavioral Control (PBC), and an individual would decide to put into practice after comprehensively thinking and judging the previous factors (rational thinking).Intention in TPB refers to reflecting the intention of engaging in certain behaviors; ATB refers to an individual evaluating personal specific behaviors; SN refers to the opinion of an individual agreeing with or opposing to an important other putting into practice; and, PBC is the subjective evaluation of an individual being able to complete the behavior. It is pointed out in TPB that Intention is the direct factor in behaviors, while ATB, SN, and PBC could influence behaviors after considering personal intention. Besides, PBC could directly affect behaviors when such behaviors are not completely controlled by Intention.

To compensate the insufficiency of predicting Behavioral Intention with TPB, the psychosocial determinants of Positive Anticipated Emotion (PAE), Negative Anticipated Emotion (NAE), Frequency of Past Behavior (FPB), Recency of Past Behavior (RPB), and Desire are included in MGB (Perugini and Bagozzi 2001). Such additional psycho-social determinants are the key in describing and deducting sustainable Behavioral Intention (Wever et al. 2008).

RESEARCH METHOD

According to the literature review, the research model and the hypothesis relationship are established, and the questionnaire design and survey are explained.

Research Model

Personal sustainable behaviors are formed by motive, ability, and opportunity. MGB could enhance the determinant in predicting personal motive. In the research on waste handling and recycling, Ölander and Thøgersen (1995) proposed Motivation-Ability-Opportunity-Behavior Model (MAO), which could affect human behaviors, and considered personal behaviors being formed by motive and ability (intrinsic characteristics) and opportunity (extrinsic condition) (Fig. 3). Based on MGB, this study tends to explore the motive dimension affecting human behaviors so as to provide DfSB directions and objectives.

DfSB aims to influence or result in sustainable behaviors with design (Lilley 2009; Lockton et al. 2010), and MGB is provenbeing able to effectively enhance the prediction and deduction of sustainable Behavioral Intention (Wever et al. 2008). Product usage involves in user intention; it would be in vain to acquire the original design intention without fundamentally exploring the psychological decision process of users (Lilley 2009). According to previous literatures, DfSB for household appliance energy-saving behaviors would affect sustainable desire and Behavioral Intention and further enhance sustainable behaviors. The DfSB product design framework constructed in this study is shown in Figure 1.

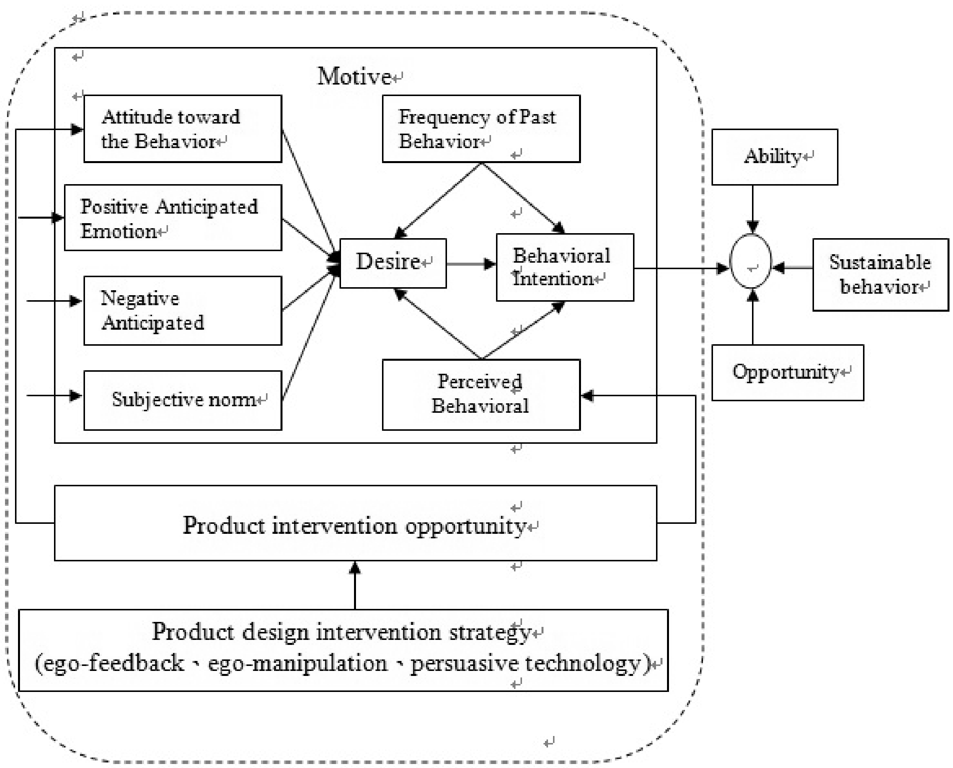

Fig. 1. Product design framework for sustainable behaviors

Hypothesis Relation

Regard the relations between Attitude and Desire (H1), ATB refers to an individual evaluating personal specific behaviors (Ajzen 1991), that is, personal evaluation of household appliance sustainable behaviors. Hirose (1995) indicated that environment-friendly behaviors relied on Objective Intention (general attitude) and Behavioral Intention (tending to apply specific actions), in which the former depended on perceived environmental risks (risk of environment pollution), perceived responsibility (being aware of the responsibility for the environment from pollution or damaged environments), and perceived measure effectiveness (perceiving the application of appropriate measures being able to solve environmental problems), and the latter relied on feasibility evaluation (people with sufficient knowledge or skills to evaluate environment-friendliness), social norm evaluation, and profit and cost evaluation. According to MGB, ATB of household appliance energy-saving behaviors would significantly affect Desire. The hypothesis H1, ATB of household appliance energy-saving behaviors would remarkably, directly, and positively affect Desire, is proposed in this study. Three dimensions for measuring ATB contain "I regard household appliance energy-saving behaviors as an (1) essential, (2) valuable, and (3) useful thing".

In regard to the relations between Positive Anticipated Emotion, Negative Anticipated Emotion, and Desire (H2, H3), PAE and NAE are the positive and negative psychological reactions of an individual anticipating the success of personal objective (Perugini and Bagozzi 2001), that is, individual positive/negative psychological reactions to the anticipated success of household appliance sustainable behaviors. PAE and NAE could benefit the prediction of environmental Behavioral Intention (Carrus et al. 2008). Research indicated that increasing personal positive emotion and reducing negative emotion were the best strategies for driving sustainable intention. Such a problem is attracting more concerns. MGB measures personal effects on Desire with PAE and NAE so as to enhance the prediction of Behavioral Intention. According to MGB, PAE and NAE of household appliance energy-saving behaviors would appear notable effects on Desire. In this case, the hypotheses H2, PAE of household appliance energy-saving behaviors present notably and directly positive effects on Desire, and H3, NAE of household appliance energy-saving behaviors show remarkably and positively positive effects on Desire are proposed in this study. Six dimensions for measuring PAE and NAE cover "I am (1) proud, (2) delighted, (3) satisfied, (4) guilty, (5) disappointed, and (6) discouraged of household appliance energy-saving behaviors".

SN reflecting external social pressure could effectively enhance energy-saving behaviors (Wang et al. 2011). Social pressure might come from family members (internal consideration) or individuals or groups beyond family (external consideration) (Bortoleto et al. 2012). Influential relatives, friends, or others could play the role in encouraging sustainability or stopping unsustainable behaviors. Perugini and Bagozzi proved that Desire could enhance the prediction of future Behavioral Intention. According to MGB, SN using household appliance energy-saving behaviors would appear significant effects on Desire. For this reason, the hypothesis H4, SN of household appliance energy-saving behaviors present remarkably and directly positive effects on Desire, is proposed in this study. Three dimensions are applied to measuring SN, as "Relatives' and friends' (1) emphasis, (2) affirmation, and (3) support would affect my opinions and intention of household appliance energy-saving behaviors".

In terms of the relations between Frequency of Past Behavior, Desire and Behavioral Intention (H5, H7), FPB refers to the number of times executing specific behaviors in the past (Perugini and Bagozzi 2001), that is, the number of times an individual practicing household appliance sustainable behaviors in the past. Carrus et al. (2008) indicated that FPB, as the key factors in predicting sustainable Behavioral Intention, would notably affect the intention of engaging in recycling and taking public transportation. Increasing FPB as the antecedent of Desire in MGB aims to measure the information of individual auto-behaviors, in order to fill up the effectiveness of behavior prediction with TPB (Perugini and Bagozzi 2001). According to MGB, FPB of household appliance energy-saving behaviors would reveal significant effects on Desire and Behavioral Intention. Consequently, the hypotheses H5, FPB of household appliance energy-saving behaviors show notably and directly positive effects on Desire, and H7, FPB of household appliance energy-saving behaviors present remarkably and directly positive effects on BI, are proposed in this study. Two dimensions for measuring FPB include. "The frequency of household appliance energy-saving behaviors in the past (1)week and (2)month".

Regarding the relations between Perceived Behavioral Control, Desire and Behavioral Intention (H6, H8), understanding PBC being able to benefit predicting sustainable behaviors has been proven in various literatures to be related to sustainable Behavioral Intention. Litvine and Wüstenhagen (2011) pointed out personal control belief leading sustainable behaviors that understating the reason could change unsustainable behaviors. MGB considers that PBC could result in intention, but could not analyze the factors in Behavioral Intention, which could merely be effectively predicted through Desire. According to MGB, PBC of household appliance energy-saving behaviors would notably affect Desire and Behavioral Intention. As a result, the hypotheses H6, PBC of household appliance energy-saving behaviors would significantly, directly, and positively affect Desire, and H8, PBC of household appliance energy-saving behaviors present remarkably and directly positive effect on BI, are proposed in this study. Three dimensions are used for measuring PBC, as "I (1)am capable of, (2) would insist on, and (3)would overcome household appliance energy-saving behaviors.

In regard to the relations between Desire and Behavioral Intention (H9), Desire, as the antecedent of BI, is the mediator of ATB, PAE, NAE, SN, PBC, and FPB affecting BI. BI is the image of an individual deciding to put into practice after comprehensively considering and judging the previous factors (Ajzen 1991). In other words, BI is the image when an individual decides to practice household appliance sustainable behaviors after comprehensively considering and judging the previous factors. Desire has been proven being able to effectively predict sustainable BI (Carrus et al. 2008). It is regarded in this study that Desire for household appliance energy-saving behaviors would remarkably affect BI. As a consequence, the hypothesis H9, Desire for household appliance energy-saving behaviors show significantly and directly positive effects on BI, is proposed in this study. The dimension of "I have the desire for household appliance energy-saving behaviors in the future" is used for measuring Desire. Two dimensions of "(1)I am willing to continue household appliance energy-saving behaviors in the future" and "(2)I would endeavor to practice household appliance energy-saving behaviors" are included in BI.

Furthermore, the correlations between sustainable behavior design and Behavioral Intention present the major objective of DfSB being influencing or resulting in the design intention of sustainable behaviors through design (Lilley 2009), and MGB has been proven being able to effectively enhance the prediction and deduction of sustainable Behavioral Intention (Wever et al. 2008). Product usage would involve in user intention that it would be in vain to acquire the original intention of a design without fundamentally exploring the psychological decision process of users (Lilley 2009). Based on previous literatures, DfSB of household appliance energy-saving behaviors would affect BI. The measuring items in DfSB questionnaire are referred to seven DfSB strategies and design approaches proposed by Lilley and Lofthouse (2009), where clever design strategy is removed as it tends not to call or change user behaviors.

Questionnaire Design and Survey

Based on the research of Perugini and Bagozzi (2001) and Song et al. (2012)and the understanding of DfSB influencing individual household appliance energy-saving behaviors, computer-based and paper-based questionnaire survey are utilized in this study, and paper-based questionnaires are randomly distributed in southern areas.

DATA ANALYSIS AND DISCUSSION

The Cronbach α of the sub-dimensions in the measurement model appears in 0.818-0.929, showing the favorable reliability (Table 1). The discriminant validity and the convergent validity of the questionnaire are tested with composite reliability (CR) in CFA and Average Variance Extracted (AVE). From Table 1, the diagonal square root of AVE is larger than non-diagonal values (relative coefficients in lines and row), corresponding to the requirement for discriminant validity (Fornell and Larcker 1981). The CR of sub-dimensions reveals in 0.815-0.930, which is larger than the requirement for 0.6; and, AVE appears in 0.615-0.866, larger than the requirement for 0.5.

Table 1: Test of measurement model

Dimension	*BI*	*DE*	*ATB*	*PAE*	*NAE*	*SN*	*PBC*	*FPB*
BI	0.884							
DE	0.870	0.903						
ATB	0.507	0.539	0.784					
PAE	0.387	0.429	0.345	0.805				
NAE	0.126	0.168	0.191	0.280	0.857			
SN	0.211	0.247	0.177	0.278	0.212	0.814		
PBC	0.399	0.369	0.247	0.001	0.022	0.053	0.904	
FPB	0.521	0.542	0.433	0.212	0.126	0.273	0.378	0.930
CR	0.877	0.815	0.826	0.844	0.892	0.853	0.930	0.928
AVE	0.781	0.815	0.615	0.648	0.735	0.663	0.817	0.866

*Note 1:*DE(Desire), DfSB(design for sustainable behavior), ATB(Attitude Toward the Behavior), PAE(positive anticipated emotion), NAE(negative anticipated emotion), SN(subjective norm), PBC(perceived behavioral control), BI(Behavioral Intention), FPB(frequency of past behavior), CR(composite reliability), AVE(average variance extracted)
Note 2: Diagonal value is the square root of AVE.

In regard to the test of overall model fit, χ^2 =314.161, DF(degree of freedom)=161, and χ^2/DF=1.951 correspond to the standard of less than 3;CFI (comparative fit index)=0.94, TLI (Tucker-Lewis index)=0.934, and IFI (incremental fit index) correspond to the standard of larger than 0.9; and, RMSEA (root mean square error of approximation)=0.068, less than the standard of 0.08, revealing the favorable model fit of this study (Bagozzi and Yi 1988).

Hypothesis Testing and Discussion

The hypothesis testing of this measurement model is shown in Table 2. Four predictor variables of Desire and attitude ($\beta_{AT'\rightarrow DE}$ = 0.328, t =4.177, $p < 0.05$), Positive Anticipated Emotion ($\beta_{PAE'\rightarrow DE}$=0.365, t =5.104, $p < 0.05$), Frequency of Past Behavior ($\beta_{PFB\rightarrow DE}$=0.232, t =3.485, $p < 0.05$), and Perceived Behavioral Control ($\beta_{PBC\rightarrow DE}$ =0.3622, t =4.887, $p < 0.05$) present significantly positive correlations, Figure 2, demonstrating the direct effects of AT, PAE, FPB, and PBC on DE of household applianceenergy-saving behaviors that H1, H2, H5, and H6 are agreed, consistent with other research conclusions (Perugini and Bagozzi, 2001).

DE and NAE ($\beta_{NAE'\rightarrow DE}$ =0.011, t =0.171, $p > 0.05$) reveal negative correlations with SN ($\beta_{SN'\rightarrow DE}$ =0.018, t =0.263, $p > 0.05$), showing that NAE and SN do not directly affect DE of household appliance energy-saving behaviors thatH3 and H4 are refused. DE and NAE do not show correlations that complicated contradiction might appear on the ambivalence (an object presents mutually contradictory emotions) of sustainable Behavioral Intention and reduce the correlations with other measuring indicators. To solve such a problem, the positive and negative emotion could be separately measured for the best results (Carrus et al. 2008). The reason for DE and SN being not correlated might be the participants considering the desire for energy-saving household appliance being personal that the pressure of Behavioral Intention is not from external identification. SN of personal sustainable behaviors is possibly related to the collective requirements of participants. Research indicated that group norm, policy, and social norm presented better functions on sustainable behaviors (Knussen et al. 2004; Wang et al. 2011).

BI and DE ($\beta_{DE'\rightarrow BI}$ =0.903, t =10.635, $p < 0.05$) show significantly positive correlations that DE directly affects BI of household appliance energy-saving behaviors; H9 is agreed. Such a result is also supported by other research (Carrus et al. 2008; Perugini and Bagozzi 2001).

BI and FPB ($\beta_{FPB'\rightarrow BI}$ =0.082, t =1.644, $p < 0.05$) and PBC ($\beta_{PBC'\rightarrow BI}$ =0.017, t =0.256, $p < 0.05$) show negative correlations that FPB and PBC do not directly affect BI of household appliance energy-saving behaviors; H7 and H8 are refused. BI and FPB being not correlated is consistent with the research of Song et al. (2012) on sustainable behaviors. In the research on recycling behaviors, Knussen et al. (2004) indicated that personal habits were generally easier to predict future BI. The correlations between FPB and BI reflect on temporal stability (Ajzen 1991) that the past behaviors would continuously affect intention,

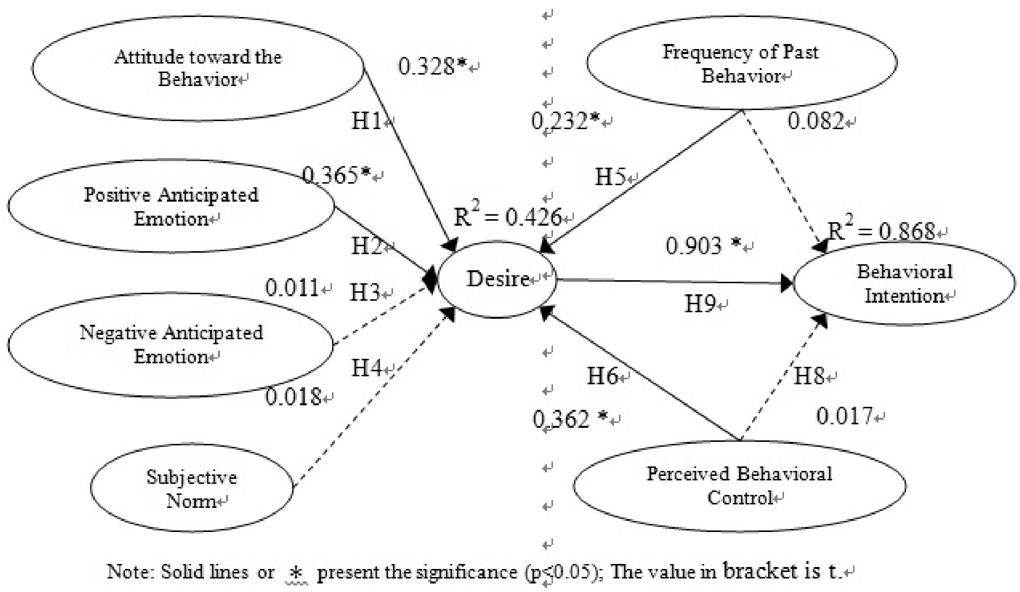

Fig. 2. Hypothesis testing and standardized path coefficient of the research model

but do not show direct relations with future behaviors. When behaviors become habits, people are likely to form intention identical to past behaviors (Ouellette and Wood 1998), such as washing face before leaving home in the morning. Habits are the process of automatic cognition, rather than complex decision process (that is, decisions based on attitudes and intention) (Steg and Vlek 2009). To predict the factors in BI of household appliance, it is necessary to understand the habitual environmental behaviors of an individual. Moreover, the irrelevance between BI and FPB shows that PBC could indirectly affect BI through DE. Aiming at the research on sustainable behaviors, Song et al. (2012) also acquired the same result. PBC could not directly affect BI, possibly because the dimensions for measuring PBC are restricted in personal control. Actually, household appliance energy-saving behaviors in daily life could involve in external (residential members or the relative personnel) intervention. Besides, when practicing specific sustainable behaviors, the measurement of financial cost, power, or time could be the factors (Wang et al. 2011) that various or broader definitions could be applied to measuring PBC (Song et al. 2012).

The indirect and total effects of the measurement model are shown in Table 3. Indirect effects refer to indirectly affecting the objective through at least one variable; total effects, the sum of direct effects and indirect effects, could be used for explaining the total effects of dependent variables on the objective. The total effects on DE appear PAE (0.365), PBC (0.362), ATB (0.328), and FPB (0.232), where the high value shows the larger effects. The total effects on BI present DE (0.903), PBC (0.344), PAE (0.330), ATB (0.296), and FPB (0.291), revealing the highest effect of PBC on BI, except DE (mediator). Household appliance developers could plan the DfSB product design based on such results.

DfSB Design Strategies for Household Appliance

Green designers should focus on the design of dependent variables for affecting BI effects and introduce mapping DfSB strategies for the optimal DfSB of household appliance. Firstly, according to the questionnaire survey, Table 4, the product design for affecting the participants' household appliance energy-saving behaviors contains design of real-time displaying energy consumption (ego-information strategy,

Table 2: Hypothesis testing of the research model

Hypothesis	*Hypothesis correlation*	*Agreed or refused*
H1	ATB of using energy-saving household appliance presents significantly and positively direct effects on DE.	Agreed
H2	PAE of using energy-saving household appliance presents significantly and positively direct effects on DE.	Agreed
H3	NAE of using energy-saving household appliance presents significantly and positively direct effects on DE.	Refused
H4	SN of using energy-saving household appliance presents significantly and positively direct effects on DE.	Refused
H5	FPB of using energy-saving household appliance presents significantly and positively direct effects on DE.	Agreed
H6	PBC of using energy-saving household appliance presents significantly and positively direct effects on DE.	Agreed
H7	FPB of using energy-saving household appliance presents significantly and positively direct effects on BI.	Refused
H8	PBC of using energy-saving household appliance presents significantly and positively direct effects on BI.	Refused
H9	DI of using energy-saving household appliance presents significantly and positively direct effects on BI.	Agreed

Table 3: Effects among dimensions

	Direct effect		*Indirect effect*		*Total effect*	
Dimension	*Desire*	*Behavioral Intention*	*Desire*	*Behavioral Intention*	*Desire*	*Behavioral Intention*
Desire	-	0.903**	-	-	-	0.903*
Attitude toward the behavior	0.328*	-	-	0.296*	0.328*	0.296*
Positive Anticipated Emotion	0.365*	-	-	0.330*	0.365*	0.330*
Negative Anticipated Emotion	0.011	-	-	0.010	0.011	0.010
Subjective norm	0.018	-	-	0.016	0.018	0.016
Frequency of past Behavior	0.232*	0.082	-	0.209*	0.232*	0.291*
Perceived Behavioral control	0.362*	0.017	-	0.327*	0.362*	0.344*

Table 4: DfSB design strategy and method of sustainable household appliance

Sequence	*DfSB method*	*Mean*	*DfSB strategy*
1	Design of real-time displaying energy consumption	5.908*	Ego-information
2	Design of visual energy-saving reminder	5.806*	Eco-feedback
3	Optional energy-saving function setting	5.801*	Ego-selectivity
4	Design of energy consumption display	5.733*	Ego-information
5	Design of multiple choice of energy-saving operation procedure	5.689*	Ego-selectivity
6	Automatic control of energy consumption	5.641*	Ego-technique intervention
7	Design of encouraging energy-saving behaviors	5.597*	Ego-stimulus
8	Design of average energy consumption display of household appliance	5.466*	Eco-feedback
9	Design of audio energy-saving reminder	5.383*	Eco-feedback
10	Design of energy consumption restriction	4.976*	Ego-manipulation
11	Design of appealing people concerning to energy-saving behaviors	4.893*	Ego-manipulation
12	Design of touch energy-saving reminder	4.830*	Eco-feedback
13	Design of energy-saving behavior punishment	4.029*	Ego-stimulus

*Note:** stands for the significance ($p<0.05$)0 mean=5.91; the higher value shows the higher effects on the participant), design of visual energy-saving reminder (ego-feedback strategy, 5.81), optional energy-saving function setting (ego-information strategy, 5.80), design of energy consumption display (ego-information strategy, 5.73), design of multiple choice of energy-saving operation procedure (ego-selectivity strategy, 5.69), automatic control of energy consumption(ego-technique intervention, 5.641), design of encouraging energy-saving behaviors (ego-stimulus, 5.597), design of average energy consumption display of household appliance (ego-feedback strategy, 5.466), design of audio energy-saving reminder (ego-feedback strategy, 5.383), design of energy consumption restriction (ego-manipulation, 4.98), design of appealing people concerning to energy-saving behaviors (ego-manipulation 4.89), design of touch energy-saving reminder (ego-feedback strategy, 4.83), and design of energy-saving behavior punishment (ego-stimulus,4.03). Furthermore, aiming at influencing BI effects, the relation matrix for mapping DfSB could be introduced. Means-End Chain (MEC)could be applied to having users practice (tactic) energy-saving behaviors (purpose) (Herrmann et al. 2000). The basic structure of Means-End contains attributes, effective parts, and set of values. Attributes are divided into specific (tangible) and abstract (intangible) ones, where the former could describe physical–chemical–technical constitution in various levels, while the latter describes the match with the overall product, based on personal subjective opinions, rather than objective facts. Effective parts are divided into functionality and psycho-sociality, in which the former refers to the actual use of products, while the latter refers to the product opinions beyond the actual functions of products. Set of values is divided into useful value and terminal value. With the example of PBC (effective parts with psycho-sociality), which presents the highest total effect on BI (0.344), the previously optimal DfSB is introduced to establish the relation matrix (Fig. 3) for designing household appliance(specific attribute) so as to enhance sustainable behaviors (value).

CONCLUSION

Aiming at product usage, a product design framework for enhancing sustainable behaviors is proposed in this study to reduce the difference between the actual use of products and the green design intention. Changing unsustainable behaviors of humans is the easiest and the most practical method to increase energy efficiency. Products present influence that favorable product design could lead, trigger, or change unsustainable behaviors. With MGB and DfSB strategies and methods, a product design framework for sustainable behaviors is established in this study for green product designers practicing the psycho-social determinants insustainable behaviors and quantitatively analyzing the product design points and directions for sustainable behaviors, based on the effects among determinants and the design strategies and methods of mapping determinants.

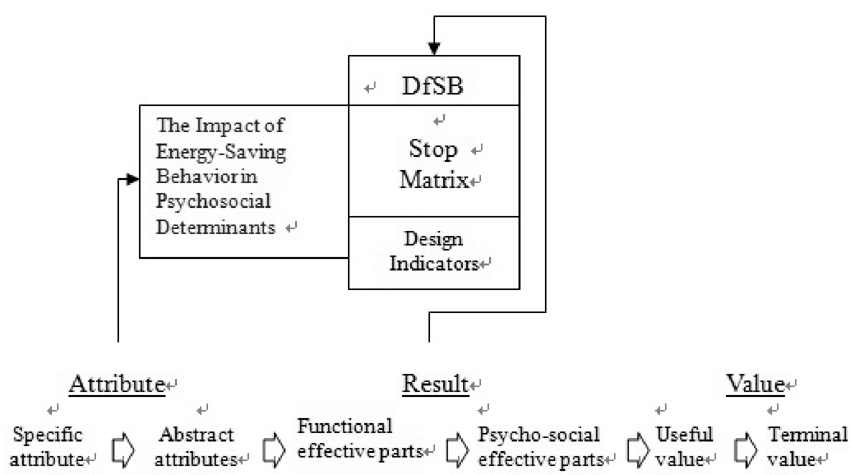

Fig. 3. Psycho-social determinantsinenergy-saving behaviors and relation matrix of DISB method

The empirical research on household appliance through the research framework reveals that Behavioral Intention of household appliance is directly affected by individual Desire; with the effect value 0.903 (the higher value shows the larger effects). Individual Attitude, Positive Anticipated Emotion, Frequency of Past Behavior, and Perceived Behavioral Control could indirectly influence Behavioral Intention of household appliance through Desire, and the total effects of Behavioral Intention show 0.296, 0.330, 0.291, and 0.344, respectively. However, Behavioral Intention is not directly affected by Frequency of Past Behavior and Perceived Behavioral Control and indirectly influenced by Negative Anticipated Emotion and Subjective Norm. On the other hand, the research data show the top five product design for household appliance energy-saving behaviors as real-time displaying energy consumption, visual energy-saving reminder, optional energy-saving function setting, energy consumption display, and multiple choice of energy-saving operation procedure, which could better facilitate the household appliance energy-saving behaviors. Based on such results and the total effects on individual Behavioral Intention, designers could establish the relation matrix of the mapping design for creating household appliance which could better enhance sustainable behaviors under limited resources.

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