Chapter 4
Persuasive Design for Improving Battery Swap Service Systems of Electric Scooters

Li-Hsing Shih and Yi-Tzu Chien

Abstract Automatic battery swap stations have been recently set widely in Taiwan while the system operators have found significant differences among the battery utilization rates of the stations. To reduce the battery idle time in the less visited stations, this study looks for effective persuasive design strategies that persuade users to choose the less visited stations. After useful persuasive strategies were collected from the related literature, eighteen feasible design strategies were proposed by considering the problem characteristics. A questionnaire survey was conducted to estimate the persuasion effects of the eighteen design strategies by using the storyboard method. The persuasive design strategies with higher persuasion effect are identified and recommended for reducing the gap of battery utilization rates. Furthermore, by using the statistical analysis like ANOVA to analyze the persuasion effect with respect to demographical variables such as gender and age, the results could help choose effective persuasive strategies for different target customer groups.

Keywords Persuasive design · Battery swap · Service design · Electric scooters

4.1 Introduction

Since battery charging time is still longer than expected, battery swap service with significant shorter time has been welcome to users of electric scooters. Recently, automatic battery swap stations have been set in various sites such as convenient stores, parking lots, and sidewalks to provide better services in Taiwan by two competing private companies. The battery swap service systems are major drivers for the fast growth of eclectic scooter sales in Taiwan. However, system operators have found that there are significant gaps among the battery utilization rates of the stations. The phenomenon implies several disadvantages. For those less visited stations, the battery utilization rates are low, incurring idle cost that should be avoided. For those more visited stations, users often complain about no fully charged battery available,

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incurring low customer satisfaction. From the sustainability point of view, too many idle batteries also mean that the society does not get the environmental benefit of the battery sharing systems, since the benefit of a PSS is increasing the utilization rate of products.

This study tries to solve the problem by looking for effective persuasive design strategy that persuade users to use the less visited stations. The work was conducted in three stages:

(1) Candidate persuasive design strategies are collected from practical cases and related literature on persuasive technology and persuasive design. By considering the problem characteristics of the current servive systems, eighteen feasible design strategies were screened and suggested.
(2) The eighteen feasible design strategies are presented in a questionnaire that aims to estimate the persuasion effects of the eighteen design strategies. In the questionnaire, each strategy is presented by using a storyboard that illustrates the expected use experience assuming the design strategy is implemented. Questions measuring to what extent the respondents are persuaded by each design strategy were presented soon after each storyboard.
(3) By going through statistical analysis, the persuasive design strategies with higher persuasion effect are identified and recommended for reducing the gap of battery utilization rates and raising the customer satisfaction. Furthermore, by using the statistical analysis like ANOVA to analyze the persuasion effects with respect to demographical variables such as gender and age, significant difference of persuasion effects among different groups of users can be identified.

4.2 Literature Review

To find candidate persuasive design strategies before conducting the questionnaire design, related literature are reviewed. Major searching keywords include persuasive technology, persuasive design, and persuasive system design. To explain how a persuasion is successful, Fogg (2009) proposed a behavior model that includes three major elements: motive, ability and trigger (prompt). He mentioned three motives including sensation, anticipation and belonging. Six types of abilities are often required for behavior changes including time, money, physical effort, brain cycle, social deviance, and non-routine while three types of trigger can be utilized for persuasion, including spark, facilitator, and signal. The model has been widely used in many areas for persuading people for behavior change. For example, Lee et al. (2014) used the model to raise the rate of women doing health examination. Ackermann et al. (2018) studied consumers' purchase behavior and overconsumption based on this behavior model. This study uses this model to check whether design strategies are feasible for persuading people for behavior change.

Oinas-Kukkonnen and Harjumaa (2009) proposed a complete model/procedure for persuasive design and called the model "persuasive system design (PSD)". The procedure include three stages: (1) understanding key issues behind persuasive

systems, (2) analyzing the persuasion context, and (3) proposing design strategies for use. The procedure is basically adopted in this study. They also suggested twenty eight useful design strategies that are divided into four categories: primary task support, dialogue support, system credibility support and social support. Each category contains seven useful strategies for use. Many literature adopted the PSD model for finding appropriate persuasive design. Chou (2010) used the model to persuade women to ride bicycles. Lehto and Kukkonen (2011) used the 28 strategies to find the best strategies for quitting smoking and alcohol. Kluchner et al. (2013) studied the persuasive strategy for home energy saving. Karppinen et al. (2016) developed a "health behavior change support system" for more healthy behavior based on the PSD model. Since many of the example literature found the twenty eight design strategies useful in persuasive design, they are considered as candidate strategies in this study for further screening.

To find more candidate design strategies other than the 28 strategies suggested in PSD, more literature were examined. For example, Dayan et al. (2011) suggested a "nudges" strategy for changing dining pattern against obesity. Lu et al. (2014) tried to find useful design for persuading college students to conduct more exercise and sports instead of being addicted to the internet. Coombes and Jones (2016) studied how to persuade children to walk and ride bicycles instead of taking automobiles. Oh et al. (2018) used persuasive design on website interface to persuade people to take action against obesity. Eisenbeiss et al. (2015) studied the real effects of using strategies like discount and time constraint in marketing. Whillans et al. (2018) proposed useful persuasive strategies using reminder strategy for persuading busy people to make purchase plan in advance. Payne et al. (2018) suggested some useful persuasive strategies for buying daily necessities. Chen et al. (2012) suggested a virtual object like a virtual aquarium to provide feedback on users' energy use. Lu et al. (2016) suggested several feedback strategies like using different colors to reduce energy use. Zhong and Huang (2016) suggested a "point reward system" to encourage users' recycling behavior. All the persuasive strategies in these literature were considered for screening out feasible design strategies in this study.

4.3 Selecting Feasible Persuasive Design Strategies

In this section, feasible persuasive design strategies are selected in two steps: (1) identifying candidate design strategies mentioned in the literature and (2) screening out feasible ones considering the problem characteristics of behavior changes for users taking the battery swap service. The second step is similar to the suggestion of Oinas-Kukkonnen and Harjumaa (2009) about analyzing the persuasion context before determining the design strategy. The candidate design strategies are adopted from the literature mentioned in Sect. 2 while the 28 design strategies in PSD model are adopted as a basis. Some strategies are deleted and some from other literature are added in based on the consideration of whether the strategies are feasible to be applied in the battery swap service system. In Sect. 3.1, the current user behavior/experience

for swapping batteries are discussed and divided into five stages. The analysis result is used to help the authors see the feasibility of each candidate design strategy. In Sect. 3.2, eighteen feasible design strategies are selected based on the feasibility and then ready for use in the questionnaire design.

4.3.1 Behavior Analysis for Battery Swap

The current battery swap service systems in Taiwan contain several components: (1) battery, (2) automatic charging station that provides charged batteries ready for swap, (3) cloud system providing data storage, information processing and computing, and (4) scooter. Users use their cell phones to connect with the four. To find useful and feasible persuasive design strategies, this study analyzes the user experience and related behaviors in the current swap service systems. The results can help identify whether a candidate strategy could be implemented and current users' behavior could be changed and lead to the less visited stations. If the answer of the question is positive, the candidate design strategy is called a 'feasible' one. A typical battery swap process contains five stages, including:

(a) Being aware of battery status: Users check the battery status by inspecting the control panel of the scooters. The panel shows how much electricity power is left by using ten blocks where each block represents one tenth of electricity left.
(b) Finding out nearby charging stations: Users find nearby charging stations from the map using the app provided by service providers. The locations of the charging stations are highlighted on the map noting how many fully charged batteries are available in each station.
(c) Selecting stations: Users select an intended charging station among the ones shown on the map based on users' need and other personal consideration.
(d) Checking detail information of the selected station: Users look into the detail of the selected station including the route and additional information of the surroundings of that station.
(e) Swapping battery on the station: Users interact with the unmanned charging station and physically swap the batteries inside the scooter and the station. If the station is very popular and users take some time to reach the spot, users may find there is a waiting line or no fully charged battery available and then need to find another station.

The goal is to persuade users to choose and use the charging stations that are less visited. The persuasive design could be implemented in the five stages as mentioned above. Although those popular charging stations have the advantages like near popular spots, easy to reach, on the road of good traffic flow, or near important public facilities, users may face the risk of finding no battery available. The authors keep the three elements of the behavioral model (Fogg 2009) in mind and consider the characteristics of the current swapping behavior as presented above to

find the feasible design strategies from the candidate design strategies suggested in the literature.

Whether the design strategies obtained from literature are suitable for changing the behavior of choosing charging stations was checked one by one by figuring out if the strategy can be implemented in the five stages of swapping battery behaviors. Eighteen feasible design strategies were screened out based on the feasibility and the potential of persuading users.

4.3.2 Feasible Persuasive Strategies for Users Choosing Less Visited Stations

Whether the design strategies are feasible ones also depends on if there are ideas of how the strategies can be implemented in the swap service systems. This is important because a storyboard for each design strategy has to be drawn illustrating the hypothetical use experience assuming the design strategy is implemented. In other words, how the design strategy can actually persuade users will be presented in the story board so that the persuasion effect of each design strategy can be measured in the survey. The description of the eighteen feasible design strategies are listed in the followings, where the first 11 strategies are adopted from PSD model (Oinas-Kukkonen and Harjumaa 2009) and the last seven strategies are from other literature.

1. Rewards: Systems that reward user's target behaviors may have persuasive powers. (adopted from PSD) For example, users get gifts in the less visited stations.
2. Reminders: If a system reminds users of their target behavior, the users will more likely achieve their goals. (adopted from PSD) For example, messages are sent to users to swap battery earlier.
3. Cooperation: A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to cooperate. (adopted from PSD) For example, users are encouraged to team up to achieve target behavior.
4. Simulation: Systems that provide simulations can persuade by enabling users to observe immediately the link between cause and effect. (adopted from PSD) For example, systems simulate the situation users will face for changing swap behavior.
5. Tunneling: Using the system to guide users through a process or experience provides opportunities to persuade along the way. (adopted from PSD) For example, systems guide users to swap battery based on the users' past record and daily schedule.
6. Authority: A system that leverages roles of authority will have enhanced powers of persuasion. (adopted from PSD) For example, systems provide some experts advice for utilizing less used batteries for sustainability purpose.

7. Personalization: A system that offers personalized content or services has a greater capability for persuasion. (adopted from PSD) For example, systems suggest where and when to swap battery to save users' time based on users' daily plan.
8. Social comparison: System users will have a greater motivation to perform the target behavior if they can compare their performance with the performance of others. (adopted from PSD) For example, systems present the comparison result between users and others.
9. Praise: By offering praise, a system can make users more open to persuasion. (adopted from PSD) For example, the screen of the less visited station will praise users' behavior.
10. Self-monitoring: A system that keeps track of one's own performance or status supports the user in achieving goals. (adopted from PSD) For example, systems provide user's own records on battery swap and let user decide when and where to swap battery.
11. Liking: A system that is visually attractive to its users is likely to be more persuasive. (adopted from PSD) For example, more lovely or attractive design for the less visited stations should be applied.
12. Diversified function: The system provides more services will have a greater capability for persuasion. (adopted from (Fogg 2009)) For example, more functions could be added on the less visited stations like washing scooters for free.
13. Discount: The discount level will enhance the appeal of an offer and increase purchase likelihood. (adopted from Eisenbeiss et al. (2015)) For example, some discount may be applied for users visiting the less visited stations.
14. Data visualization and interactive narratives: The use of different website features, such as sliders, drags, or mouse-overs, for enabling content engagement, and further, increasing its persuasive intent. (adopted from Oh et al. (2018)) For example, systems allow users to know more information about the swap frequency and available batteries with additional features.
15. Media richness and interactivity: Richer media contain more communication modes and social visual cues and interactivity is defined as the extent to which media would let the designer exert an influence on the content/form. (adopted from Lu et al. (2014)) For example, systems provide more pictures or using AR (augmented reality) to attract users.
16. Color associations: Colors associations could help users to easily understand the feedback messages, and thereby, increase the persuasive effectiveness. (adopted from Lu et al. (2016)) For instance, different colors are used to show the charging status of batteries in different stations.
17. Virtual object: Users interact with the virtual object, resulting in the promotion of behavior attuned towards energy conservation by influencing emotional or rational thinking. (adopted from Chen et al. (2012)) For example, systems may illustarte a virtual vegetable growing as users visit the less visited stations.
18. Threat and coping appraisal: Presenting threat (ex: Don't speed. Don't kill your mates) and coping appraisal (ex: Better arrive late than not at all) messages

sequentially might increase the likelihood that they will be committed to memory. (adopted from Cathcart and Glendon (2016)) For example, systems send messages to users about the risk of visiting the crowded stations.

4.4 Questionnaire Design and the Survey

With the eighteen feasible persuasive strategies, a questionnaire is designed for estimating the persuasion effect of each strategy. The questionnaire survey was conducted to collect responses from the potential users in Taiwan.

4.4.1 Questionnaire Design

To estimate the persuasive effects of the feasible design strategies, eighteen storyboards were drawn to let respondents understand how each design strategy works and what a user can interact with the system and obtain service during the battery swapping process. Recent examples of using storyboards for studying persuasive effect include Orji et al. (2014) and Shih and Jheng (2017). According to the suggestion of Truong et al. (2006), a good storyboard design should contain presentation to a certain level of detail, verbal or graphic expression, calling the as-real feelings for the respondents, and showing the time or sequence of the use experience. In this questionnaire, three cartoons were designed to show how and what a user would experience assuming the design strategy is implemented in the battery swap service system. For instance, a storyboard designed for the strategy "rewards" is shown in the Fig. 4.1 where a gift is given to the user who goes to the less visited station.

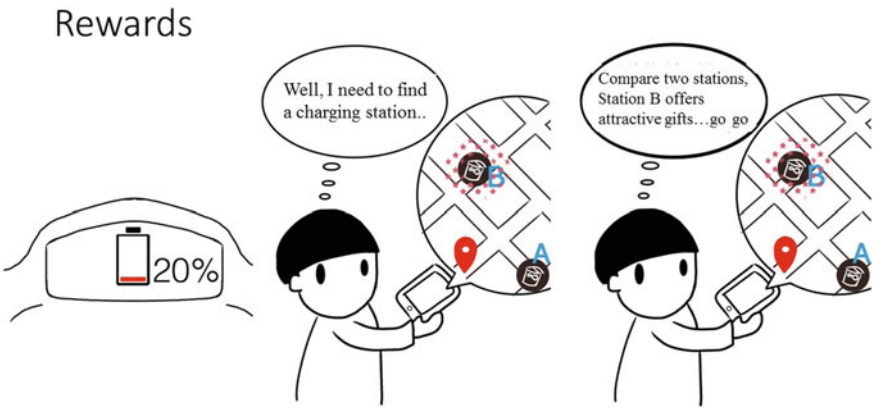

Fig. 4.1 An example storyboard for strategy "rewards"

Two questions are put under each storyboard to collect the responses about persuasion effect. The 7-point Likert scale is used to let respondents express their agreement on:

(1) I have the same feelings as that of the person in the storyboard and
(2) I will react/do the same as the person in the storyboard.

The answers to the two questions are treated as persuasion scores (estimate of persuasion effect) for the design strategy. There are eighteen storyboards as the one shown in Fig. 4.1 in the questionnaire. In other words, a respondent will read eighteen storyboards and answer 36 questions in addition to the questions collecting the respondent's demographic information.

4.4.2 A Questionnaire Survey

The questionnaire survey was conducted via internet in January, 2019 and had 330 effective responses out of 368 responses. The background information of the sample are as follow.

(a) Gender: female: 51.8%, male: 48.2%
(b) Age: 21–30: 51.5%, 31–40: 32.1%, 40 and above 16.4%.
(c) Education: College 56.1%, graduate school 35.8%, others 8.1%.
(d) Vocation: students 24.8%, manufacturing 18.5%, commerce 13.6%, service industry 12.4%, government employee 10.3%, others 20.4%.

Since the survey was conducted via internet, social network platform, and portal websites, the respondents tend to be younger. This should be noted in the result interpretation.

4.5 Statistical Results & Recommended Design Strategies

In this section, statistical results of the questionnaire survey are presented. Design strategies are ranked according to the persuaion scores (persuasion effects) that collected from the responses. The strategies with higher pesuasion scores are recommended for use. Section 5.1 presents the results from overall respondents while Sect. 5.2 presents the ANOVA results that show whether the persuasion scores are affected by demographic variables like gender and age of the respondents.

4.5.1 Design Strategies Recommended

Table 4.1 shows the recommended design strategies with the rankings based on persuasion scores. Figure 4.2 contains an error bar chart of the results of the first ten design strategies. The 'color association' strategy that uses different colors to show the availability of batteries in the charging stations has the highest persuasion score. The users can know not only the number of fully charged batteries but also the

Table 4.1 Persuasion effect of 18 design strategies

Strategy	Average	Stand dev	Rank
Color	6.02	0.96	1
Threat	5.82	1.02	2
Diversified functions	5.77	1.07	3
Reminder	5.77	1.22	4
Tunnel	5.73	1.08	5
Simulation	5.72	1.09	6
Discount	5.65	1.15	7
Data visual	5.62	1.05	8
Self-monitor	5.53	1.09	9
Personalize	5.48	1.18	10
Authority	5.21	1.20	11
Media richness	5.16	1.28	12
Reward	5.12	1.37	13
Cooperation	4.63	1.56	14
Praise	4.46	1.55	15
Virtual object	4.36	1.49	16
Social comparison	4.28	1.50	17
Liking	4.08	1.49	18

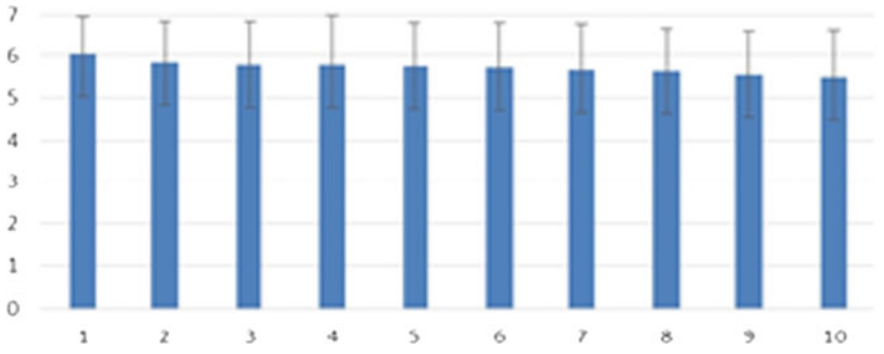

Fig. 4.2 Average and standard deviation of persuasion effect of the first ten strategies

Table 4.2 Recommended strategies in five stages

Behavioral stages	Strategy (rank)
I. Being aware of battery status	Threat (2)
	Reminder (4)
II. Finding information of charging stations	Tunnel (5)
	Simulation (6)
	Data Visualization (8)
	Self monitor (9)
III. Selecting stations	Color (1)
	Diversified function (3)
	Discount (7)
IV. Checking detail information of the selected station	Media richness and interactivity (12)
V. Swapping battery	Color (1)

number of partially charged batteries so that users could be aware of the likelihood of getting a partially charged battery in the crowded station. The 'threat and coping appraisal' strategy has the second highest persuasion score. The users consider the type of message like 'you should swap the battery earlier to avoid the risk of not finding available charged battery' is persuasive.

Table 4.2 puts the design strategies with higher persuasion scores (rank 1 to rank 9) in the five behavior stages of battery swap process. For example, The strategies of 'threat and coping appraisal (rank 2)' and 'reminder (rank 4)' could be used in the first stage 'being aware of battery status' in order to let users start the process of battery swapping. The implementation of a strategy (e.g. color) is not limited in one behavioral stage.

4.5.2 Design Strategies for Different Users

The RM-ANOVA is conducted to test whether persuasion effect of different design strategies has interaction with demographic variables like gender and age. If there is interaction, different design strategies should be recommended for different groups of users to increase the persuasion effect. For example, the 'persuasive strategy' is taken as one factor in the RM-ANOVA with 18 levels (strategies) while 'gender' is taken as the other factor with 2 levels. The statistical software SPSS was used to conduct the ANOVA analysis using the survey responses.

For the case of gender, the F-test results of the interaction ($F = 1.563$ and $p = 0.121$) are not significant. In other words, there is no significant persuasion (interaction) effect between gender and persuasive strategies. There is no need to make

Table 4.3 Recommended strategies for two groups

	Age under 40		Age above 40	
Rank	Strategy	Average	Strategy	Average
1	Color	6.00	Color	6.18
2	Threat	5.82	Media richness*	5.84
3	Remind	5.80	Threat	5.84
4	Diversified	5.79	Tunnel	5.79
5	Simulation	5.75	Data visual	5.78
6	Tunnel	5.73	Diversified	5.63
7	Discount	5.68	Self monitor	5.54
8	Data visual	5.60	Simulation	5.51
9	Self monitor	5.52	Remind	5.51
10	Personalize	5.48	Personalize	5.44
11	Authority	5.21	Discount	5.41
12	Reward*	5.18	Authority	5.24
13	Media richness*	5.08	Cooperate	4.71
14	Cooperate	4.62	Reward*	4.59
15	Praise	4.49	Virtual object	4.35

different persuasion design for female or male customers. Other demographical variables such as education level and vocation were also tested and no significant effect was found.

For the case of age, the ANOVA results ($F = 1.866$, $p = 0.001$) show a significant interaction effect. In other words, the persuasion effects of persuasive strategies are significantly different for users in different ages. In order to make the recommendation on design strategy more practical, two groups of users (under and above the age of 40) are taken for further analysis. Table 4.3 shows the averages and standard deviations of persuasion scores for different strategies for the two groups of users. For example, the strategy "color associations" ranks the first in both groups. The strategy "threat and coping appraisal" ranks the second in the group of age under 40 while "media richness and interactivity" ranks the second for the group of age above 40. However, if strict statistical testing like ANOVA is taken, there are only two strategies: 'rewards' and 'media richness and interactivity' have significantly different persuasion effects on the two groups. This should be considered when the designers want to use the results in Table 4.3 for practical implementation.

4.6 Summary

This study focuses on choosing appropriate persuasive design strategies for improving battery swap service systems. To reduce the idle cost of battery and raise

the customers' satisfaction, the goal is to persuade users not to go to the more visited charging stations and go to the less visited stations instead. Feasible persuasive design strategies were carefully selected from literature review and considering the problem characteristics. Eighteen feasible design strategies were adopted in the questionnaire survey and the storyboard method was used to estimate the persuasion effect of each design strategy. The statistical results of persuasion effects for eighteen strategies are presented and the results recommend the strategies with higher persuasion scores like color associations, threat and coping appraisal, diversified functions, reminders, and tunnel. In addition, ANOVA method is used to find whether different strategies should be recommended for persuading specific types of users. The results show that there is no significant interaction effect on gender and persuasive strategy while there is significant interaction effect on age and persuasive strategy. By conducting further statistical analysis, appropriate persuasive strategies are recommended respectively for the groups of users under age of 40 and above 40.

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