Grouping Preferences of Americans and Koreans in Interfaces for Smart Home Control

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Abstract. The purpose of the current study was to find the grouping principle for smart home interfaces that most closely matches the thinking styles of Americans and Koreans. The independent variables were grouping method (NO: no grouping other than alphabetical order, FS: functional and then spatial grouping, SF: spatial and then functional grouping), culture and gender. 40 American and 40 Korean students' perceptions of the interfaces and their performance times with the interfaces were measured. Both female and male Koreans preferred the SF grouping, consistent with a cognitive style favoring thematic organization and field dependence. For Americans, females preferred SF grouping but males preferred FS grouping. Thus, only American males' preferences conformed to a cognitive style favoring functional organization and field independence. Cultural differences in grouping preferences need to be taken into account in design of smart home interfaces.

Keywords: Culture, grouping, interface design, smart home.

1 Introduction

The objective of the current study was to find the grouping principles that most closely match the cognitive styles of Americans and Koreans, for the purpose of designing interfaces for smart home control. This paper describes an experiment that tests hypotheses regarding cultural differences in grouping preferences. Based on the results of the experiment, design guidelines for smart home interfaces were developed.

A smart home is defined as "a home or working environment, which includes the technology to allow for devices and systems to be controlled automatically" [1]. Briere and Hurley [2] define a smart home as a harmonious home, a collection of devices and capabilities based on home networking. The terms connected home, digital home, adaptive house, and aware home are also used to represent future homes. In a smart home environment, as the number of objects having radio-frequency identification (RFID) tags increases, it will become increasingly difficult to find a specific control

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on a control-panel interface for the device or object that needs to be controlled. This problem may be resolved by grouping the objects on a control panel, remote control, or computer display in such a way that the organization matches the mental representations of smart home users. According to many studies of cultural differences, people in different cultures tend to have different thinking styles. Thus, there is a possibility that potential smart home users in different cultures, especially eastern and western cultures, may have different organizational preferences for smart home interfaces. In the current study, Americans as a representative of western cultures and Koreans as the representative of eastern cultures were compared to investigate their grouping preferences for smart home interfaces.

According to Choi et al. [3], analytic versus holistic style influences how people categorize objects. East Asians tend to perceive and reason holistically, attending to the field in which objects are embedded and attributing causality to interactions between object and the field [3, 4]. In contrast, Europeans and Americans are held to be analytic, paying attention primarily to the object, categorizing it on the basis of its attributes, and attributing causality to the object based on rules about its category memberships. Choong and Salvendy [5] showed that Chinese participants performed better with thematic organization than with functional organization, whereas American counterparts performed better with functional organization than with thematic organization, in terms of error rate. Rau et al. [6] replicated the experiment of Choong and Salvendy [5] in Taiwan and showed similar results. Since both the Koreans and Chinese can be considered as East Asians, Koreans should have a similar cognitive style and classification preference to those of Chinese people. Kim and Lee [7] provided evidence that Koreans' cognitive style can be considered the same as that of the Chinese. Hwang et al. [8], Chung and Gale [9], Yoon [10] and Kim *et al*. [11] also supported cultural pattern and cognitive style differences between Americans and Koreans.

In addition to culture, gender was considered in the current study because Witkin's theory [12] [13] [14] predicts that females are more likely to have a field-dependent cognitive style, whereas males more often have an analytical or field-independent cognitive style. Basically, the concept of field-dependence is similar to holistic style and the concept of field-independence seems analogous to analytic style. This relation suggests the possibility of involvement or interference of gender with culture and grouping of the objects.

To determine initial grouping facts for the current experiment that might influence the usability of smart home interfaces, studies of interface layout organizations were reviewed. Stone et al. [15] indicated that features users consider to be related should be grouped together on the user interface, or at least their association should be clearly indicated. That is, grouping of the features should reflect users' understanding of the domain and their expectations about how the user interface should be organized. Niemela and Saariluoma [16] recommended spatial grouping of items from the same semantic category. Salmeron et al. [17] studied semantic grouping, but they focused more on different user groups such as expert and novice users. Salmeron *et al*. found that expert users performed better than novice users in information retrieval when the items of an interface were semantically organized, but not when they were placed randomly. Mehlenbacher et al. [18] compared alphabetical ordering with functional organization across three different cues: direct match; synonym cue; iconic cue.

The alphabetic menu led to faster selection time than the functional menu under the direct match condition, whereas the opposite effect occurred under the synonym and iconic conditions. Coll et al. [19] compared three organization conditions (alphabetical menu; categorical menu; unordered menu) on performance time and the number of errors. Their results yielded a significant difference among the three organization conditions but failed to yield a significant difference between alphabetical menu and categorical menu on performance time. The average number of errors did not show statistical significance among the three organization conditions. The reviewed studies of grouping suggest that the factors of alphabetical order, functional grouping and spatial grouping are promising in terms of designing smart home interfaces. Thus, in the current experiment, these three types of layout organizations were manipulated in order to develop a more adaptable interface design for smart home context.

2 Method

2.1 Participants

40 American students (20 males and 20 females) and 40 Korean students (20 males and 20 females) at Purdue University were recruited. Korean participants were restricted to students who had spent less than 2 months in the U.S, so that they had only minimal prior exposure to the U.S. culture.

2.2 Variables

Independent variables were grouping method, culture and gender. Grouping method was a within-subject variable with three levels: functional and then spatial grouping (FS); spatial and then functional grouping (SF); no grouping other than alphabetical order (NO). Culture (American and Korean) and gender (male and female) were between-subject variables.

The dependent variables were satisfaction, ease of use, perceived performance speed, actual performance time, the perception of the number of chunked items, overall evaluation, general liking, and rank-order preference. All dependent variables except actual performance time were subjective in that they measured users' perceptions of the interfaces. All subjective responses except rank-order preference were measured using a questionnaire administered immediately after performing tasks with each grouping method. The rank order was measured after participants had completed performing tasks with all three types of grouping methods. Thus, this variable provides an overall evaluation about the three types of grouping methods. The objective variable was the actual performance time, which was defined as the time between when each participant clicked the 'start button' to start a trial and when he/she successfully found and clicked a correct control button for the targeted device (object).

2.3 Experimental Test Beds

As indicated earlier, based on the existing grouping studies, alphabetical order, functional grouping and spatial grouping seemed promising in terms of designing smart home interface. Thus, these three types of layout organizations were manipulated in

order to find a more adaptable interface design for the smart home context. The first experimental test bed was NO grouping interface, for which all of the smart home devices were listed in alphabetical order. The second experimental test bed was the FS grouping, for which 'functional characteristics' was the grouping principle for the main page and 'spatial characteristics' was the grouping principle for the subordinate page. The third experimental test bed was SF grouping, for which 'spatial characteristics' was the grouping principle for the main page and 'functional characteristics' was the second grouping principle for the subordinate page.

2.4 Procedure

The experiment was conducted in the Human-Computer Interaction Lab in the School of Industrial Engineering at Purdue University. Each participant performed the experiment alone. Before starting the experiment, a brief description of what it generally involved was provided to the participant. Then, the participant was asked to fill out an informed consent form and a demographic questionnaire concerning personal characteristics.

When each participant was ready to perform the experiment, a written scenario that contained information about a situation was provided to the participant. After reading the description of the situation, the participant was told to push the 'Start' button on the computer screen to start Task 1. Once the participant pushed the 'Start' button, a short scenario of Task 1, including a device (object) to control, was presented on the computer screen. After reading the Task 1 scenario, the participant began to search for the correct control for the device (object) using one of the three grouping methods. Once the participant found the correct control for the target device, the 'ending time' was recorded by the computer. This procedure was repeated for tasks 2 and 3.

Following completion of the three tasks with the initial interface, the participant was asked to fill out a questionnaire examining satisfaction with the interface used for those tasks. After completing the questionnaire, the participant repeated the same procedure for each of the two remaining interfaces that used the other grouping methods.

Upon completion of the tasks with all three grouping methods, the participants filled out the post-experiment questionnaire. In this questionnaire, they were told to rank the interfaces from 1 to 3 (1 for most liked; 3 for east liked) based on their preferences for the three different grouping methods.

2.5 Hypotheses

The following hypotheses, based on the reviewed studies of culture and grouping, were tested in the experiment.

Hypothesis 1: Participants will prefer a smart home interface with either grouping method (either FS or SF organization) over the one with NO grouping. Overall, participants will prefer the SF organization the most, followed by the FS organization.

We examined this hypothesis to determine whether meaningful grouping that adapts to users' thinking style is better than listing items in alphabetical order on the smart home interface. We expected that SF organization would be preferred because items in a home are located spatially. Each room in a home is usually designed for a functional purpose such as sleeping and eating.

Hypothesis 2: Korean participants perceive SF organization as providing faster selection than FS organization, whereas American participants will judge FS organization as providing faster selection than SF organization.

This hypothesis was formulated to examine whether smart home interfaces should be designed differently for Americans and Koreans. To test this hypothesis, the interaction effect of grouping method and culture was examined in male and female data sets, respectively.

Hypothesis 3: A three-way interaction of grouping method, culture, and gender will exist in perception of performance speed.

This hypothesis was designed to examine whether gender differences exist within a culture. Because American culture consists of diverse sub-populations (ethnic groups), gender differences seem more likely to play a role for U.S. users than for Korean users.

3 Results and Discussion

An analysis of variance (ANOVA) was conducted on the preference and performance measures as a function of grouping method, culture, and gender. Follow-up ANOVAs were performed on the male and female data sets.

3.1 Internal Consistency

The internal consistency was measured using Cronbach's coefficient alpha. The higher the alpha is, the more consistent the measure is. Usually 0.7 and above is considered to be acceptable [21]. The internal consistency of the combined data set was 0.91. The internal consistency of American and Korean participants was 0.90 and 0.91, respectively.

3.2 Testing of Hypotheses

The means and standard deviations (SDs) of the dependent measures for each grouping method are presented in Table 1. Hypothesis 1 was statistically supported. Grouping using either FS or SF organization was preferred over NO organization on all of the satisfaction questionnaire items, the post-experiment question, and average performance time, with statistical significance ($p < .001$) and practical significance (with more than 10% difference). These results are consistent with previous findings [15, 16, 17]. Although Mehlenbacher et al. [18] and Coll et al. [19] failed to show a significant difference between alphabetical ordering and other semantic groupings such as functional or categorical, the current experiment clearly showed users' preferences toward either FS or SF organization over alphabetical ordering. Therefore, our results imply that a smart home interface should be designed using grouping that reflects users' understanding of the domain and their expectations about how the interface should be organized. In comparison to the FS grouping, the SF grouping was preferred, $F(1, 76) = 3.575$, $p = .062$, and tended to show higher agreement on perceived performance speed, $F(1, 76) = 3.059$, $p = .084$. The mean ranking for the FS grouping was worse than that for the SF grouping, and the mean rated performance speed was

less for the FS grouping than for the SF grouping. These results imply that, in the context of smart home interfaces, users' general thinking style is closer to thematic organization and field dependence than to functional organization and field independence.

Table 1. Descriptive statistics for each item as a function of grouping method

Item	Grouping					
	NO		FS		SF	
	Mean	SD	Mean	SD	Mean	SD
Perceive Satisfaction	4.68	1.49	5.38	1.10	5.46	1.24
Perceived Number of Items Chunked	3.44	1.65	5.81	0.87	5.75	1.00
Perceived Performance Speed	4.68	1.52	5.28	1.10	5.58	1.18
Overall Evaluation	3.59	1.44	4.40	1.51	4.31	1.47
Overall Liking	4.16	1.50	5.23	1.26	5.35	1.39
Ease of Use	4.63	1.44	5.38	1.07	5.40	1.29
Paired Question of Perceived Satisfaction	4.35	1.52	5.38	1.12	5.35	1.30
Rank	2.68	0.63	1.79	0.71	1.54	0.64
Performance Time (seconds)	41.03	25.71	19.36	6.69	19.65	7.98

Table 2 contains the means and standard deviations for perceived performance speed as a function of grouping method, culture and gender, which are relevant to hypotheses 2 and 3. Hypothesis 2 was supported with statistical significance, $F(1, 38) = 6.001$, $p = .019$, for the male participants but not for the female participants. According to the results, American male participants thought that FS grouping was faster than SF grouping, whereas Korean male participants thought that SF grouping was faster than FS grouping. That is, American male users tended to consider functional characteristics of a target device or item first, whereas Korean male users tended to first consider spatial characteristics of the room in the house in which a target device or item is located. These results imply that for male users the cognitive style of Americans follows functional organization and field independence, whereas that of Koreans follows thematic organization and field dependence. The female groups did not show statistical significance in the interaction effect of grouping method and culture, but they showed statistical significance in the main effect of grouping method for perceived performance speed, $F(1, 38) = 5.282$, $p = .027$, and rank order, $F(1, 38) = 5.918$, $p = .020$. Both American and Korean females thought that SF grouping was faster than FS grouping and gave higher preference ranking to SF grouping than to FS grouping. The results from the female data set for perceived performance speed and general preference ranking imply field dependency of females. That is, female smart home interface users tend to first consider spatial/context characteristics which a target device or item belongs to, rather than the target's or item's own functional characteristics.

Table 2. Descriptive statistics of grouping, culture and gender on perceived performance speed

Culture	Gender	Grouping			
		FS		SF	
		Mean	SD	Mean	SD
American	**Female**	5.00	1.26	5.70	1.08
	Male	5.55	1.15	5.00	1.59
	Total	5.28	1.22	5.35	1.39
Korean	**Female**	5.25	0.97	5.70	1.03
	Male	5.30	1.03	5.90	0.72
	Total	5.28	0.99	5.80	0.88

Overall, in the context of interface design for smart home control, these results imply that Koreans' cognitive style tends to follow thematic organization and field dependence, regardless of gender. But, Americans' cognitive style follows functional organization and field independence only for males, possibly because females tend to be field-dependent even in the American culture.

Hypothesis 3 was also statistically supported, $F(1, 76) = 4.163$, $p = .045$, in perceived performance speed. Perceived satisfaction tended toward significance, $F(1, 76) = 3.156$, $p = .08$. All subject groups except American males showed higher agreement on SF grouping being faster than FS grouping. This outcome implies that, for Koreans, SF grouping is highly recommended for the design of smart home interfaces. For Americans, though, interface designers need to take into account the gender of the smart home user. That is, for Americans, some sort of gender adaptable interface that can change its organization of the items based on the different genders' grouping preferences is recommended because females showed preferences for SF grouping whereas males preferred FS grouping. Gender involvement can be considered as a part of a culture effect because Americans' high individualism and masculinity [22] can explain the gender differentiation of American participants.

3.3 Performance Time Measurement

As shown in Table 1, the interfaces with FS or SF grouping showed much shorter actual performance time than the interface with NO grouping. However, performance time was similar for the FS and SF groupings, which did not differ significantly. This result is consistent with the results from similar studies that measured performance time between East Asians and European Americans, even though those studies showed performance differences on recall or error rate [5] [6]. In the current experiment, recall or error rate was not measured because a popup window was continuously displayed to provide feedback to the participants when they chose a wrong category, and performance time was continuously measured until they chose the right category. We thought that the current experimental procedure might detect differences in performance in time in part due to errors increasing the time required to operate the correct control. However, the results still showed an inability to detect statistical significance on performance time. Some possible reasons for the lack of ability to detect

an influence of interface organization on actual performance time include the limited number of items or objects presented on the interfaces and the limited number of participants. The inability to detect a performance time difference may be caused by the semantic groupings for the FS and SF arrangements being too similar, since these two groupings had almost the same organization except for the presentation order of the main- and sub-menus on the interface. This latter interpretation may suggest that even though the amount of time required to perform with the SF and FS interfaces was not reliably different, participants actually perceived a small difference on the interfaces and felt the impact of it.

The experiment was able to successfully capture statistical significance between alphabetical arrangement (no grouping other than alphabetical order) and semantic grouping using either FS or SF organization with more than 50% difference. That is, semantic grouping using either FS or SF grouping showed shorter performance time compared to alphabetical arrangement. This result was somewhat expected based on some of the results from Mehlenbacher et al. [18]. Since the task descriptions used in the current experiment can be considered as synonym cues, shorter performance time of semantic grouping using either FS or SF grouping seems reasonable. The statistical significance appeared between alphabetical arrangement and semantic grouping using either of FS or SF organization can extend the literature on grouping since closely related previous studies such as those of Mehlenbacher et al. [18] and Coll et al. [19] failed to find a statistical difference in performance time between alphabetical and functional or categorical arrangements. However, at the same time, there is also a possibility that this significant effect might be caused by learning because alphabetical arrangement was always showed first to the participants in the current experiment. In this regard, there is a need to conduct further research that rules out a learning effect. A traditional experimental procedure about reaction time measurement with many trial blocks might be used to further examine potential learning effect. But, any learning effect in the current experiment is likely small because alphabetical arrangement is distinct from the other two layout organizations.

4 Conclusions

None of the grouping-related studies except Chen et al.'s [23] quantitatively measured people's perceptions of the usability of the interfaces. The current experiment measured both users' perceptions and performance times with different organizations of smart home interfaces. Through the current study, more tangible ideas of how to design a smart home interface for different cultural groups (Americans and Koreans) were provided. The current study also supports the view that grouping principles should closely match users' thinking styles and mental representations. Designers of smart home control interfaces need to take cultural differences into account.

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