Correlation Between Cognitive Style and Structure and Flow in Mobile Phone Interface: Comparing Performance and Preference of Korean and Dutch Users

Ji Hye Kim, Kun-Pyo Lee, and Im Kyeong You

HCIDL, Dept. of Industrial Design KAIST
373-1, Kusong-dong, Yusung-gu, Daejon, 305-701, South Korea
gimjee@gmail.com, kplee@kaist.ac.kr, cursa@naver.com

Abstract. This paper presents experiments conducted to determine the correlation between culturally different cognitive styles and issues of information architecture and flow, specifically in mobile phone interface. Korean and Dutch participants participated in on-screen prototype test and cognitive style test. In Experiment 1, each cultural group showed a different preference on the function/theme-related menus and individuals’ categorization styles had correlation with their preferences. Overall, the findings indicated that performance and preferences in a certain menu structure are associated with cognitive styles and it eventually helps to design culturally adapted interface. In Experiment 2, both groups showed more favorable attitude toward a Parallel approach and no significant correlation between cognitive styles and performance or preference were found. The correlation between prior experience and preference was not found to be significant in any tests.

Keywords: User interface Design, Mobile Phone, Cognitive Style, Cultural Difference.

1 Introduction

Interest in the influence of culture on user interface design has been growing as the world market is globalized. However, products and services have been localized at the superficial level through checking elements like text, symbol and functionalities without reflecting any unconscious cultural effects. Moreover, interface studies with cognitive and implicit viewpoints are rare, so mobile phones seem to keep consistent interfaces relatively independent of culture.

Most of studies on cultural interfaces are based on cultural dimensions suggested by Hall(1981) and Hofstede(1980). However the frameworks seem to be outdated and still ambiguous since those are focusing on general values or norms in human society.

It is, therefore, essential that we understand the cultural impact on the mobile interface independently and examine how the mobile interface can be culturally adapted. This study limits the field of cultural differences to culturally influenced cognitive differences and aims to illustrate how culturally different cognitive styles...
influence information structure in the mobile phone interface by examining users’ performance and attitude toward the interface.

2 Theoretical Background

Anthropological and psychological studies continue to suggest that cognitive style is culturally different. Richard Nisbett(2004)’s studies report actual proves of such cultural difference. A central idea to his research is ‘Holistic versus Analytic thought’. Holistic thought engages in context-dependent and holistic perceptual processes by attending to the relationship between a focal object and the field. On the other hand, Analytic thought engages in context-independent and analytic processes by focusing on a salient object independently from the context in which it is embedded.

Richard Nisbett and his colleagues have found cognitive differences between East Asian and Westerners. According to his investigation, East Asians attend more to the field and the relationship between an object and the field than Westerners (Masuda, Nisbett, 2001) and East Asians are inclined to explain events with reference to interaction between the object and the field, while Westerners are more inclined to explain the same events with reference to properties of the object. About ways of organizing the world, East Asians tend to group objects on the basis of similarities and relationship among the objects whereas Westerners tend to group the objects on the basis of categories and rules(Chiu, 1972; Unsworth, 2005). These researches indicate that thinking styles of East Asians are different from those of Westerners. In other word, East Asians relatively engage in holistic thoughts while Westerners engage in more analytic thought and approach.

A number of studies linking the cognitive distinctions with (hypermedia) interface styles have been carried out. Rau(2004) examined the cultural difference in the computer performance of Chinese and American users. The results indicated that a concrete representation with thematic structure was advantageous to the Chinese users, who are known to be more context-dependent and classify things on the basis of their relationships. Ford and Chen(2000) examined the effect of cognitive styles on hypermedia learning and found significant differences in navigation strategies used by Field-independent and Field-dependent learners. They found that Field-independent learners use the more analytical approach and Field-dependent learners use the more holistic approach.

3 Hypothesis

As the related studies indicate, we predicted that users’ performance and favorable attitude would be enhanced when an interface is compatible with a cognitive style (in matched condition). To grasp which cognitive style has a correlation with which element in mobile phone interface, interface elements of mobile phone were conceptually divided into three different layers; Representation, Menu structure and Interaction flow. And then, the corresponding cognitive process in each interface layer and analytic/holistic characteristics in the cognitive process were listed as follows.
Table 1. Interface layers and related cognitive styles

<table>
<thead>
<tr>
<th>Interface Layer</th>
<th>Cognitive process</th>
<th>Analytic</th>
<th>Holistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Representation</td>
<td>Perception</td>
<td>Field independent</td>
<td>Field dependent</td>
</tr>
<tr>
<td>(component and template)</td>
<td></td>
<td>Verbal</td>
<td>Visual</td>
</tr>
<tr>
<td>Menu structure</td>
<td>Categorization</td>
<td>Taxonomic</td>
<td>Relational</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inferential</td>
<td>Contextual</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rule-based</td>
<td>Family resemblance</td>
</tr>
<tr>
<td>Interaction flow</td>
<td>Task handling</td>
<td>Planned</td>
<td>Flexible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Organized</td>
<td>Spontaneous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sequential</td>
<td>Random</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear</td>
<td>Parallel</td>
</tr>
</tbody>
</table>

In this paper, we focused on ‘Menu structure’ and ‘Interaction flow’ layers and the cognitive styles related to the layers. So to speak, we hypothesized that taxonomic or relational tendency in categorization would have a correlation with a type of menu structure in mobile phone interface and linear or parallel tendency in task handling would have a correlation with a type of interaction flow in mobile phone interface.

3.1 Menu Structure and Categorization Style

An option(menu) for setting certain content in a mobile phone is classified as a ‘setting’ because of its function and also contextually attached to a menu containing the content itself because it is one of operations conducted with the content. For instance, to perform a task of setting(changing) a ringtone, you may go through a ‘setting’ menu or a ‘sound’ menu in the main screen. A ‘setting’ menu is functionally grouped by the common function of setting, whereas a ‘sound’ menu is thematically grouped by the shared context(or theme) of sound. Considering cultural cognitive difference, we predicted that they would show different performance and attitude toward certain menu structures. Specifically,

**Hypothesis 1.** East Asians would associate the task of ‘setting content’ more with a thematically grouped menu than a functionally grouped menu and show more favorable attitude toward the approach. On the other hand, Westerners would associate the task more with a functionally grouped menu and prefer the approach.

3.2 Interaction Flow and Task Handling Style

Mobile phones have a limitation on displaying information in parallel due to small-sized screens so it is important to properly organize and display the information in a page. Especially, for tasks constructed with a series of actions like sending SMS, the information flow should be carefully considered. Considering the cognitive difference, we predicted that they would show different performance and attitude toward certain interaction flows because of such cognitive difference. Specifically,

**Hypothesis 2.** East Asians would show enhanced performance and attitude in parallel flow than Westerners, while Westerners would have performance and preference enhanced in sequential flow than East Asians.
4 Experiment

For comparative experiment, Korea and the Netherlands were chosen for representative Eastern and Western cultures. This selection meets Nisbett’s division of Eastern and Western cultures. Moreover, according to Hostede(1980)’s Index on national cultural difference, Korea and the Netherlands were proved to be relatively different in terms of IDV(Individualism vs. Collectivism index) and PDI(Power distance Index), which means that they belong to quite different cultural areas.

4.1 Procedure

Cultural Background Questionnaire was conducted to collect demographic data and eventually extract participants with relatively strong cultural identity. It aimed to collect 30 available data from each country by controlling external variables such as age and educational background. And then, Experiment 1 for verifying the hypothesis 1 was followed by Experiment 2 for the hypothesis 2. The entire experiment took 30 min. approximately.

All materials in the experiment were made in Korean language for Korean participants and English for Dutch participants. Korean participants were mostly students at KAIST and Dutch participants were students or faculty staffs at TU Eindhoven. They were randomly involved in the experiment through WWW.

4.2 Experiment 1

Prototype Test. A mobile phone prototype is an interactive prototype running in desktop environment which allows participants to perform tasks by simple mouse-clicking. It was built with basic interface elements which are closely related to the research questions.

In the mobile phone prototype, the main screen was consisted of six menus (Call history, Messaging, Phonebook, Sound, Display, and Settings) and setting content was possible through not only thematic menus like ‘Sound’ and ‘Display’ and but also a ‘Setting’ menu.

Participants were asked to change the ringtone(Task 1) and wallpaper(Task 2). After completing the two tasks, they were asked to perform the same tasks again in the other way(4 tasks in total). It was to let the subjects experience and compare two different ways so that a preferred approach could be asked at the end of the test.

Cognitive Style Test. Cognitive Style Test is to find out whether an individual cognitive style is taxonomic or relational and a methodology similar to Unsworth(2005)’s experiments were used. 26 sets were selected which were judged to have relatively high image-quality and clarity. One target picture and two alternative pictures were presented together and participants were asked to pick one alternative which goes the best with the given target picture as quickly as possible. The two alternatives were composed of one belonging to the same taxonomy as the target picture and the other one sharing a relationship with the target picture.
Fig. 1. Two approaches of setting wallpaper (Top: ‘Setting’ menu, Bottom: ‘Display’ menu)

Result. The collected data were analyzed by using SPSS and the significance level was p<.05.

Menus which they selected. Fisher’s exact test was conducted with a 2 x 2 crosstable of cultural factor (Korean, Dutch) and selected menu (Setting/Sound, Display). As shown in Fig. 2, over 70% of both cultural groups set ringtone by using a ‘Sound’ menu and the results indicated that there were no significant difference in selected menus between the two groups (p=1.00). For the task of setting wallpaper, most of the participants changed wallpaper by using a ‘Display’ menu and no significant differences were found between the groups (p=.52). As a result, there were no cultural differences in menus they started with to perform the tasks.

Menus which they preferred. 53% of Dutch participants (n=16) preferred the ‘Setting’ menu and 77% of Korean participants (n=23) preferred the ‘Sound’ menu. Preferred menus in changing the ringtone were different between the groups (p=.03). In changing wallpaper, 53% of the Dutch participants (n=16) preferred ‘Setting’ menu and 73% of the Korean participants (n=22) preferred the ‘Display’ menu. The cultural difference did not appear statistically significant (p=.06) but, it was almost the same tendencies as national tendencies found in the former task.

Fig. 2. Selected menus in setting ringtone(Left) and wallpaper(Right)
Fig. 3. Preferred menus in setting ringtone(left) and wallpaper(right)

**Categorization style of each cultural group.** Data taking longer than mean value of completion time (2.39s) were excluded since they were not thought to be unconscious and instant responses. After that, the percentage of each response type (relational grouping or taxonomical grouping) was counted so that an individual categorization tendency was yielded in a relative index ([100]: strong taxonomic ~ [1]: strong relational tendency).

To see if there are any differences in the categorization tendency between cultural groups or selected menus, 2-way ANOVA was conducted. An interaction effect between national groups and selected menus were not found. Korea group (M=35.73, SD=26.45) had more relational tendency than Dutch group (M=42.32, SD=30.70) but, the difference was not significant [F(1,56)=.74, p=.39].

**Correlation between categorization style and selected/ preferred menu.** However, the categorization tendency was found to be different by selected menus. The categorization tendency was different [F(1,56)=5.05, p=.03] between a group selecting the ‘Setting’ menu (M=53.35, SD=34.46) and a group selecting the ‘Sound’ menu (M=34.26, SD=25.02) in changing ringtone. Such tendentious differences were also found in changing wallpaper [F(1,56)=7.87, p=.01] between a group selecting ‘Setting’ menu (M=57.59, SD=31.50) and a group selecting ‘Display’ menu (M=32.84, SD=24.99). Categorization tendency was also found to be different by preferred menus. Categorization tendency were different [F(1,56)=16.86, p=.00] between a group preferring the ‘Setting’ menu in changing ringtone (M=56.78, SD=32.90) and a group preferring the ‘Sound’ menu (M=27.99, SD=18.78). Such tendentious differences were also found in changing wallpaper [F(1,56)=9.27, p=.00] between a group preferring the ‘Setting’ menu (M=53.01, SD=34.46) and a group preferring the ‘Display’ menu (M=29.70, SD=19.38). So to speak, the group which selected/preferred the ‘Setting’ menu had a tendency to be more taxonomic than the group which selected/preferred the ‘Sound’ or ‘Display’ menu in the both tasks. Then, if we know individuals’ categorization tendency, can we find out menus that the individuals will select/prefer? A logistic regression analysis was conducted to reveal the casual relation.

A group for the ‘Setting’ menu was coded as 0 and groups for the ‘Sound’ or ‘Display’ menu were coded. The classification accuracy of a regression model with selected menu in changing ringtone and categorization tendency was 76.7% [chi-square=4.92, df=1, p=.03] and 76.7% [chi-square=8.32, df=1, p=.04] for selected menu in changing wallpaper and categorization tendency. In Table 2, B values were
shown to be (-). This means, the higher taxonomic person s/he is, the more possibility to select a ‘Setting’ menu in changing ringtone or wallpaper. Consequently, the higher taxonomic person s/he is, the more possibility to prefer a ‘Setting’ menu in changing a ringtone or wallpaper.

**Table 2. Result of logistic regression analysis**

<table>
<thead>
<tr>
<th>Cognitive style</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selected menu: Ringtone</td>
<td>-.023</td>
<td>-.023</td>
<td>-.023</td>
<td>-.023</td>
<td>-.023</td>
<td>-.023</td>
</tr>
<tr>
<td>Selected menu: Wallpaper</td>
<td>-.030</td>
<td>-.030</td>
<td>-.030</td>
<td>-.030</td>
<td>-.030</td>
<td>-.030</td>
</tr>
<tr>
<td>Preferred menu: Ringtone</td>
<td>-.040</td>
<td>-.040</td>
<td>-.040</td>
<td>-.040</td>
<td>-.040</td>
<td>-.040</td>
</tr>
<tr>
<td>Preferred menu: wallpaper</td>
<td>-.031</td>
<td>-.031</td>
<td>-.031</td>
<td>-.031</td>
<td>-.031</td>
<td>-.031</td>
</tr>
</tbody>
</table>

**Impact of prior experience.** As a result of Fisher’s exact test, no correlation was found between the ways their current mobile phones offer for ringtone setting and their selected menu during the test (p=1.00). There was also no difference between the ways of setting wallpaper in their current mobile phones and the ways they performed in the test (p=.73).

4.3 Experiment 2

**Prototype Test.** Two approaches (Linear and Parallel) were built for the ‘Message’ and ‘Phone book’ menus. A linear approach was a step-by-step process. On the other hand, in a parallel approach, all the items were shown in one scrollable page (Fig. 4).

The participants were asked to send SMS (Task 1) and save a contact (Task 2) in two approaches (4 tasks in total) and the two approaches were presented in different order for the two tasks to minimize a learning effect. Task completion time and a number of mouse clicks were measured and a preferred approach was asked after completing the 4 tasks.

![Fig. 4. Two approaches of sending SMS (Top: Linear, Bottom: Parallel)](image-url)
Cognitive Style Test. To examine their cognitive styles which are especially related to task handling, a questionnaire with 16 statements was made by extracting statements on a Sequential-Global distinction from Felder’s Learning Style Index and statements from Kaufman(1999)’s Polychronic Attitude Index and converting them into 5 point Likert scale.

Result. The collected data were analyzed by using SPSS and the significance level was p<.05.

Completion time. 2-way ANOVA showed that no interaction effect between cultural groups and approach types (T1: [F(1,116)=.35, p=.56], T2: [F(1,116)=1.52, p=.22]). It means that two cultural groups showed the same tendency across the two approaches. Korean participants performed faster in all tasks than did Dutch participants.

Mouse clicks. Two cultural groups showed the same tendency in the number of mouse clicks (T1: [F(1,116)=.01, p=.92], T2: [F(1,116)=1.41, p=.24]). No significant differences were found not only between groups but also between interface types.

Preference. The result of Fisher’s exact test (two cultural groups × two approaches) showed that there was no difference in preference between groups (T1: p=1.00, T2=0.60), as Figure 7 shows. Interestingly, over 60% of each group preferred the parallel approach.

Cognitive style of each cultural group. A factor analysis yielded two factors; Random-Sequential factor and Multi Tasking–Single Tasking factor (excluding 5 statements, Cronbach $\alpha = 0.755, 0.725$ respectively). The Korean participants averagely got higher values than the Dutch participants in the Random-Sequential factor [F(1,58)=8.84, p=.004] and the Multi Tasking–Single Tasking factor [F(1,58)=12.52, p=.001]. In other words, the Korean participants had more sequential and single-tasking tendencies in task handling.

Fig. 5. Preferred approaches in sending SMS(left) and saving contact(right)

Correlation between cognitive style and performance/preference. The correlation between such individual styles and individual performances(completion time, the number of mouse clicks) was not significantly found. Between preferred menus in the task of sending SMS(e.g., between a group preferring the linear approach and a group
preferring the parallel approach), there was significant difference in the Random-Sequential factor \([F(1,58)=4.28, p=.04]\), but no difference was found in the task of saving contact. In the Multi-Single factor, no significant difference was revealed. Consequently, this finding indicated that performance and preference in the two different approaches (Linear, Parallel) hardly had a connection with cognitive styles on task handling (Random-Sequential, Multi-Single).

**Impact of prior experience.** The effect of prior experience was checked in the same way as used in Experiment 1. The ways of sending SMS and saving contact in the mobile phones participants currently use did not have any correlation with the approaches they preferred in sending SMS and saving contact \((T1: p=.52, T2=.24)\).

5 Discussion and Implication

In Experiment 1, cognitive styles in categorization (Relational or taxonomic) had a significant correlation with types of menu structure (Thematic or Functional). Relational-grouping participants (Korean) were more likely to select and prefer the thematically grouped menu, whereas taxonomic-grouping participants (Dutch) tended to select and prefer the functionally grouped menu. Correlation between prior experience and performance & preference were not found significant so that the association between cognitive style and menu structure got more supported.

In Experiment 2, no correlation between cognitive styles in task handling (Sequential or Random, Multi Tasking of Single Tasking) and types of interaction flow (Linear or Parallel) was found. We speculated that the tasks (sending SMS, saving contact) were too basic and familiar so that the types of approach could not have any influence on the performance. Considering that in other related studies they presented ‘learning’ tasks to participants and found some difference, the degree of difficulty in the tasks we presented was not appropriate to find explicit differences.

Moreover, the way of measuring cognitive styles might have had some limitations. The 5 point Likert scale statements were written in too general and direct manners, not situation-specific. So participants confuse what they want to be with what they really are.

6 Conclusion

This study shows a possibility of cognitively adapted interface by connecting cognition model and interface architecture. The participants having a taxonomic categorization style performed the tasks in the functional approach and preferred the approach in the situation where both approaches were available. Therefore, for Western users who are known to be more goal-oriented, it may be better to organize menus by goals or functions so that they feel certain of goal achievements. For example, we can organize main menus with functionally grouped menus such as ‘Setting’ and ‘Download’.

However, there were limitations in the experiment. The experiment environment was desktop-based so it might not have been realistic enough to demonstrate mobile phone interface. And the subject groups were mostly students in their early twenties who are more easily adjusting themselves to change so it might be difficult to find
clear differences between cultures or individuals. Therefore, we will need to capture a big-enough sample with diverse generations to ensure the validity of data. Other issues apart from menu structure and flow in interface will need to be also considered and so will other possible products.

References