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Interacting with Computers 9 (1998) 417–430

Interacting with Computers

Design of icons for use by Chinese in mainland China

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Abstract

The objective of this study was to investigate the impacts of cultural differences in cognitive abilities between the American and Chinese users on their performance with icon displays. The goal was to provide insight for software developers whose products might have potential Chinese users. The key factor in this study was the presentation mode of icon displays, which could be alphanumeric elements only, pictorial elements only, or a combined mode (both elements). An experiment was conducted with 30 American and 30 Chinese subjects. The subjects performed recognition tasks using different presentation modes. Results indicate that for the American subjects there were advantages to alphanumeric and combined modes, compared to the pictorial mode, in terms of performance time and errors. For Chinese subjects, there were advantages to pictorial and combined modes, compared with alphanumeric mode; their initial error rate also was lower using a combined mode than when using an alphanumeric one. © 1998 Elsevier Science B.V.

Keywords: Internationalization; HCI; GUI; Icon design; Chinese users

1. Introduction

In the realm of human–computer interaction (HCI), icons have predominated, especially since graphical user interfaces (GUIs) have become common. Usually, an icon consists of two elements: a figural image and a textual label. Over the past decades, research on icon usage has been conducted and published in various fields such as computer science, human factors engineering and cognitive and experimental psychology. Some of this research has focused on comparison among presentation modalities (verbal vs visual) in different system settings.

It has been reported that subjects processing only icons were slower than those using texts only or icons plus text, in a navigation task [1]. Mixed modality icons have been rated as more meaningful than icons which utilize verbal or pictorial elements only, and verbal

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0953-5438/98/$17.00
PII S0953-5438(97)00026-X

elements have been preferred over pictorial elements when mixed modality was not available [2]. In an exploratory experiment, it was found that there was no evidence of an advantage of visually enriched icons over verbally enriched icons in an information-retrieval task [3]. In another study that assessed the usability of menu items constructed of text, icons, and text-and-icons, results indicated that use of mixed formats and text-only formats resulted in fewer errors than use of icon-only formats [4]. No advantages were associated with the use of iconic representations vs text representations in the performance of casual users, with an electronic mail system [5].

However, most of these studies have not addressed cultural diversity among users. As reviewed in a paper on issues influencing icon design, this can be problematic in the designing of icons for international users (since there are cultural differences in the comprehension of icons) [6]. As the use of computers becomes widespread throughout the world, it is important for HCI researchers to think about user interface design in more international terms. Most computer operating systems and applications are developed by American vendors. Many of these vendors are approaching a situation in which half their sales are outside the United States. Meanwhile, companies in smaller countries often make a much larger proportion of sales outside their own countries than they do domestically. This indicates that software sales will increasingly depend on the international usability of products (rather than just domestic usability).

The most obvious and necessary task for international marketing seems to be translation. However, the task of translating an interface into a suitable representation for users in other countries involves more than mere text translation. It is important to consider other cultural issues such as date, time and number formats, symbols, images, colors, and functionality [7–10].

However, cultures differ not only in their languages, orthography, symbols, images and number formats. People from different cultures also vary in their appearance, perception, cognition, and style of thinking. They may hold different cultural assumptions and values, may view the world differently, and they may have quite different customs. These elements make people of a specific culture unique (distinctive from people of other cultures). Thus, to consider designing computer interfaces for international users, it is important to study cultural traits in a more profound fashion other than by the mere consideration of language or symbol translation.

2. Cultural differences and their implications for GUIs

It is essential to examine carefully the impacts of cultural diversity on human–computer performance, in order to develop or design user interfaces which are effective and easy to use for international users. Past research has documented the cognitive and cultural differences between American and Chinese populations. These differences in cognitive styles, cognitive (verbal and visual) abilities, digit span, color association, personality and cultural patterns are summarized in Table 1.

The main concern of this study is to investigate the cultural differences in cognitive abilities between the American and Chinese populations and to discern how those differences may affect users' computer performance.

Table 1
Cultural differences between the Americans and the Chinese

Variables	References	Subjects	Tasks	Outcomes	
				Americans	Chinese
Cognitive style	[11]	60 Americans; 60 Chinese	3 Piagetian formal-operated tasks	More differentiated functioning	Less differentiated functioning
	[12]	316 Americans; 221 Chinese	28-item cognitive style test	Inferential-categorical	Relational-contextual
	[13]	Americans; Chinese	Rorschach test	More detailed respponses	More whole response
Verbal and ideational fluency	[14]	170 Caucasian British; 197 Chinese	Word fluency test	Significantly higher	Significantly lower
	[15]	Caucasian infants; Chinese infants	Response to visual and auditory displays	More vocalization	Less vocalization
	[16]	Chinese vs American norms	Torrance test for idea fluency, originality and flexibility	Scores above the Chinese norms	Scores below the American norms
Visual ability	[17]	73 Anglo-Americans; 155 Chinese-Americans	Raven's standard progressive matrices	Significantly lower	Significantly higher
	[18]	5108 Chinese vs American norms	Chinese standardized progressive matrices	Significantly lower	Significantly higher
	[14]	170 Caucasian British; 197 Chinese	Raven's standard progressive matrices	Significantly lower	Significantly higher
	[19]	60 Americans; 60 Chinese	Culture-free Torrance test and park mazes	Higher on elaboration and originality	Higher on fluency
Digit span in STM	[20]	19 Americans; 13 Chinese (college students)	Digit span task	Mean digit span: 7.2	Mean digit span: 9.2
		240 Americans; 240 Chinese (fifth graders)	Digit span task	Mean digit span: 5.9	Mean digit span: 6.9
		240 Americans; 240 Chinese (first graders)	Digit span task	Mean digit span: 5.1	Mean digit span: 6.4
		288 Americans; 288 Chinese (kindergartners)	Digit span task	Mean digit span: 4.6	Mean digit span: 5.9
Color association	[21,22]	127 Americans; 784 Chinese	Paper and pencil test	Red for on	Green for on
Personality	[23]	Literature review		More impulsive, excitable, natural and spontaneous	More restrained, cautious, patient and self-contained
Cultural patterns	[24–28]	Literature review		Individualism	Collectivism

2.1. Differences in cognitive abilities of American and Chinese populations

Chinese tend to be less fluent both verbally and ideationally than Americans [15,16,29]. It was shown in a study [14] that Chinese children scored lower than their Caucasian counterparts on a verbal fluency test. Partly, this result was due to the 'respect superiors' rule internalised during childhood by Chinese [30]. From childhood, Chinese are taught to respect and to be obedient to their superiors, under all circumstances. However, in the non-verbal (figural) test of creative thinking, Chinese subjects scored higher on the fluency measure than did Americans [19]. (It is clear that the 'respect superiors' rule is not incompatible with non-verbal figural tests which invite subjects to express ideas by drawing.)

The differences between the English and Chinese languages could have implications for some cognitive abilities. English is an alphabetic language in which the graphic unit represents *phonemes*; Chinese is a morphemic language in which the graphical unit (a character) almost always represents a *morpheme*. In Chinese, each character is pronounced as a syllable [31]. The Chinese have practiced reading and writing Chinese characters extensively since childhood. The learning experience in Chinese orthography is related to significant visual processing, and Chinese subjects' memories of Chinese characters are more related to visual codes. Chinese tend to have superior visual form discrimination abilities. Chinese subjects consistently show higher functioning than their American counterparts when concepts or abilities involving space, form, or shape are assessed [29,32,33]. Evidence showing that Chinese score higher than Caucasian populations on non-verbal IQ test has been discussed in several studies [14,17,18]. The ability to discriminate visual patterns seems to be facilitated by learning and using the Chinese language.

2.2. Implications of cultural differences for GUIs

Computer systems often use icons to represent objects of interest within a system; the most common presentation modes for icons are pictorial and verbal. Icons composed of both pictorial and verbal elements are more meaningful than icons composed of verbal or pictorial elements only, and verbal icons are preferred over pictorial icons when mixed modes are not available [2,4]. However, due to the relatively lower verbal abilities and superior visual discrimination abilities of Chinese, Chinese novice users can be expected to prefer pictorial presentation over alphanumeric presentation in interfaces. By contrast, American novice users are expected to prefer alphanumeric presentation mode over pictorial.

The goal of this study was not intended to make cross-cultural comparisons regarding computer performance between American and Chinese users. Rather, it was to address the importance of embedding cultural attributes within icon design for Chinese users, by including American users as a control group.

2.3. Hypotheses

Based upon the previous discussion, one hypothesis was formulated for novice users in both cultural groups who have little or no experience in the target computer application.

Higher performance will occur when both alphanumeric and pictorial displays are presented on icon-driven systems. When the combined mode is not available, Americans will have better performance with an alphanumeric rather than pictorial display, while Chinese will have better performance using a pictorial rather than alphanumeric display.

It usually is believed that combined modality metaphors will be more meaningful than other types. In human information processing, information perceived through two channels simultaneously speeds processing time compared to cases in which information is perceived through only one channel [34]. However, an individual may be more skilled in verbal processing than in visual processing, or vice-versa. As reviewed previously, Americans generally have better verbal ability, whereas Chinese have better visual discrimination ability. Thus, it is hypothesized that when combined modality is not available, Americans will perform better if provided with alphanumeric displays rather than pictorial displays, and Chinese will perform better if provided with pictorial displays rather than alphanumeric displays.

3. Method

3.1. Subjects

Thirty American subjects and 30 Chinese subjects participated in this experiment. Since the current study involved individuals from different cultural backgrounds, a means to select subjects from each cultural group properly was essential. To reduce confounding variations among subjects from sources other than cultural differences (such as education levels, majoring fields, gender, and age) subjects from both cultural groups were male undergraduate students majoring in engineering, with little or no prior knowledge about tasks to be performed.

American subjects were undergraduates of Caucasian background at Purdue University, majoring in engineering. The ages of American subjects ranged from 18 to 25 years ($\bar{X}$ = 20.7, s.d. = 1.37). The mean computer experience of American subjects was 8.1 years with a standard deviation of 3.47. Chinese subjects lived in Mainland China; they had never been to the United States. Experiments with Chinese subjects were conducted at the Institute of Psychology, Chinese Academy of Sciences, Beijing. All Chinese subjects were male, undergraduate engineering students from Beijing University of Aeronautics and Astronautics. The ages of Chinese subjects ranged from 19 to 21 years ($\bar{X}$ = 20.2, s.d. = 0.76). The mean computer experience of Chinese subjects was 0.8 years, with a standard deviation of 0.81.

It is notable that differences in computer experience between Chinese and American subjects were substantial. College students in China do not have easy access to computers, as is the case typically in the United States. However, the differences in computer experience are not problematic, since the purpose of this study was to detect treatment effects within a cultural group (the Chinese) rather than to compare performance between cultures.

3.2. Apparatus

An IBM-based notebook computer (a Toshiba T4700CT) was used for experiments in both the United States and China. Computer programs utilized in this experiment were written using Visual Basic 3.0, running under Windows 3.1. Each subject was required to perform tasks independently, using a mouse for pointing and for selecting. No other subjects were present. Subjects' movements through the system were timed automatically (to the nearest one-thousandth of a second) and their movements were traced by a keystroke capturing program.

3.3. Task

A set of 20 icons (consisting of pictures and texts) was designed, to emulate some commands of a word processing application. Each subject was required to learn the set of icons and their associated actions, by memorizing icons featuring both pictures and text, for a limited period (five minutes). After this familiarization session, each subject was asked to recognize target icons on the computer screen, according to task requirements. Three modes of icon presentation were used: alphanumeric; pictorial; and combined. In the alphanumeric mode, only textual elements were displayed; in the pictorial mode, only pictorial elements were displayed; in the combined mode, both textual and pictorial elements were presented. There were three consecutive trials, with 20 items in each task. Each subject was given the same sequence of three trials. Recognition tasks were the same in each trial, but items were listed in different order across trials. This experiment utilized the native languages of participants (i.e. English for American subjects and Chinese for Chinese subjects). Displays used in this study are illustrated in Figs 1 and 2 (with combined mode shown for the English and Chinese versions respectively). For alphanumeric mode, text elements in Figs 1 and 2 would disappear; while for pictorial mode, figural elements in the figures would vanish.

3.4. Experimental design

A single factor design was used for the experiment. The independent variable was the presentation mode, with three levels: alphanumeric, pictorial and combined. There were 10 subjects assigned to each of the three treatment cells. The experimental design was the same for each cultural group.

The dependent variables were overall performance time in seconds for each of 20 trials, and number of errors.

3.5. Procedure

For this experiment, which took American subjects approximately 20 minutes and Chinese subjects approximately 30 minutes, all subjects began by completing a questionnaire concerning individual differences (such as age, major, year in school, ethnic background, and past computer experience). For each cultural group, subjects were assigned randomly to one of three presentation conditions (alphanumeric, pictorial, and combined).

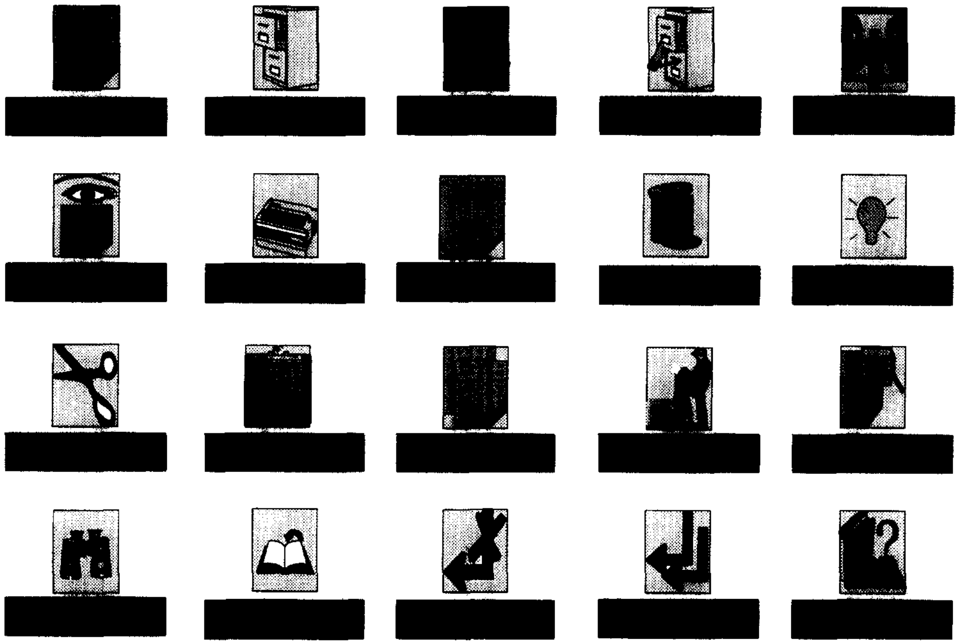

Fig. 1. Icons utilized by the American subjects in the Experiments.

Before tasks were administered, a brief practice session was conducted to help subjects understand operation of the system and tasks to be performed. (The purpose of this practice session was to help subjects understand mouse operation and the system itself, without interfering with real tasks to be performed.)

Following the practice sessions, each subject was given a learning set containing 20 icons featuring both images and text and corresponding descriptions of functionality associated with the icons. Subjects did not know in advance which mode they would be assigned to.

All 20 icons were displayed for each subject for each mode of presentation (alphanumeric, pictorial or combined mode, see Figs 1 and 2). Each subject was asked to perform an identical set of three consecutive trials, in the same sequence. Each trial required subjects to recognize target icons according to the task requirement. Subjects were instructed to perform recognition tasks as quickly as possible without sacrificing accuracy.

Each subject performed the tasks alone and was instructed not to discuss the content of the experiment with other participants.

4. Results and discussion

The intention of this study was to examine how different graphical presentation modes might affect the computer performance of American vs Chinese users. The hypothesis that a difference would be detected was tested by running planned comparisons (contrasts) using the SAS General Linear Model (GLM) to examine differences in performance across

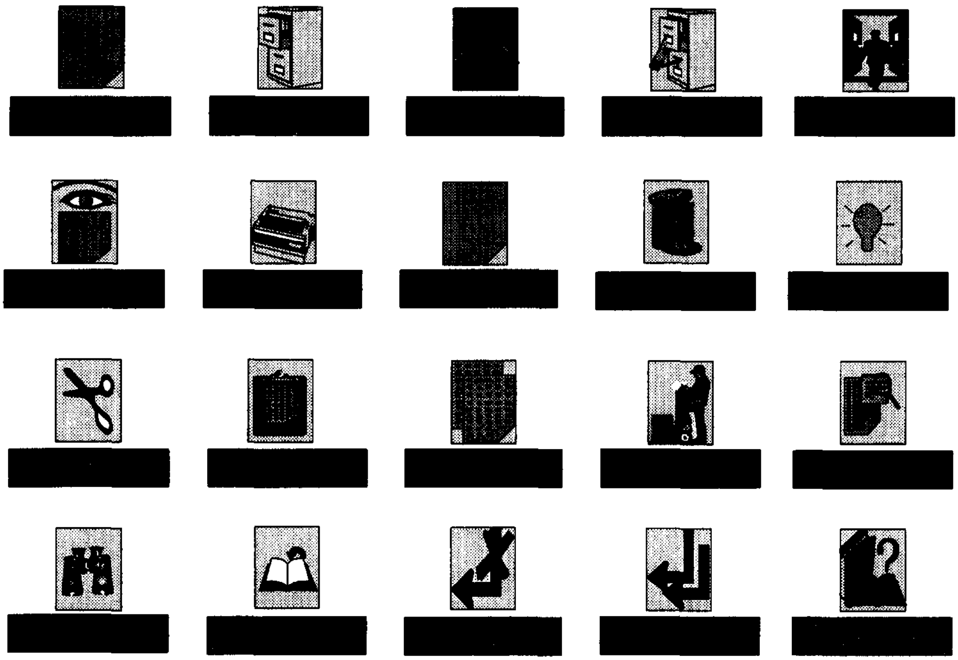

Fig. 2. Icons utilized by the Chinese subjects in the Experiments.

different presentation modes, for each cultural group. The statistical significance level (α) was 0.05 for all tests reported.

Before testing the hypothesis, all data collected were checked for model adequacy. (Normality and homogeneity of variance are basic assumptions of model adequacy.) The data in violation of these assumptions were transformed, which satisfied most relevant assumptions. One exception was error measures, for which nonparametric tests were used.

4.1. Testing of hypothesis for American subjects

It was hypothesized that American subjects would perform better when using alphanumeric displays than when using pictorial ones, when combined modes were not available.

Planned comparisons (contrasts) of time and error were used to assess the hypothesis. Data from these planned comparisons are presented in Appendix A (Table 2), for American subjects. Performance time results between alphanumeric and combined modes showed no significant differences across all three trials. An examination of performance time planned comparison results between pictorial and combined modes found significant differences in the first trial ($F_{(1,27)} = 6.55$, $P = 0.02$). Subjects using combined mode ($\bar{X} = 96.4$, s.d. = 20.86) were 23.54% faster than subjects using pictorial mode ($\bar{X} =$ 126.1, s.d. = 35.38). There also were significant differences in mean performance time between the alphanumeric and pictorial modes in the first trial ($F_{(1,27)} = 12.82$, $P = 0.001$).

Subjects using alphanumeric mode ($\bar{X}$ = 86.2, s.d. = 13.04) were 46.23% faster than subjects using pictorial mode ($\bar{X}$ = 126.1, s.d. = 35.38). However, there were no statistically significant differences in subsequent trials among any of the comparisons made for performance times.

Nonparametric Wilcoxon Rank Sum tests were performed for planned comparisons of mean errors. An examination of the error results for American subjects (Appendix A) indicated that there were significant differences between pictorial and combined modes in terms of errors in the first trail ($Z = -2.03$, $P = 0.04$). Errors committed by subjects using combined mode ($\bar{X}$ = 2.3, s.d. = 2.26) were 58.2% smaller than those when using pictorial mode ($\bar{X}$ = 5.5, s.d. = 3.87). Results also indicate that significant differences were found between alphanumeric and pictorial modes in the first trial ($Z = -3.36$, $P = 0.001$). The error rate for the alphanumeric mode ($\bar{X}$ = 0.4, s.d. = 0.70) weas 1275% lower than for pictorial mode ($\bar{X}$ = 5.5, s.d. = 3.87). However, there were no statistically significant differences in subsequent trials among any comparisons made for errors.

American subjects performed better using the Alphanumeric presentation mode compared to the pictorial mode, on performance time and errors (in the first trial). However, it should be noted that since the alphanumeric presentation mode utilized the dominant abilities of American subjects, providing extra information by use of the combined mode did not enhance their performance in terms of performance time. (It caused more errors at the beginning of the trials.) On the other hand, since visual discrimination ability was not the dominant for American subjects, the provision of extra information via the combined mode (rather than the use of pictorial elements only) did improve performance. After they had learned through the trials, provision of different presentation modes did not affect later performance by American subjects.

4.2. Testing of the hypothesis for Chinese subjects

Contrary to American subjects, it was hypothesized that Chinese subjects would perform better using pictorial displays compared to alphanumeric ones, when combined modes were not available.

Planned comparisons (contrasts) of the time and error response variables were used to assess the hypothesis. These data (for Chinese subjects) are presented in Appendix B (Table 3).

Performance time results comparing the alphanumeric and combined modes showed significant differences in the first and the third trials (1st trial: $F_{(1,27)} = 5.24$, $P = 0.03$; 3rd trial: $F_{(1,27)} = 4.80$, $P = 0.04$). The subjects with combined assignment in the Chinese version were always faster than they were with alphanumeric assignment, throughout all three trials. At the first trial, the combined group ($\bar{X}$ = 167.4, s.d. = 31.96) was 20.76% faster than the alphanumeric group ($\bar{X}$ = 211.3, s.d. = 47.05). At the third trial, the combined group ($\bar{X}$ = 103.4, s.d. = 37.75) was 27.88% faster than the alphanumeric group ($\bar{X}$ = 143.4, s.d. = 52.30). There were no significant differences found throughout all three trials in the performance time planned comparison between pictorial and combined modes. An examination of performance time planned comparison results between the alphanumeric and pictorial modes indicated that significant differences were found at the first and the third trials (1st trial: $F_{(1,27)} = 4.65$, $P = 0.04$; 3rd trial: $F_{(1,27)} = 4.89$,

$P = 0.04$). At the first trial, the pictorial group ($\bar{X} = 169.9$, s.d. $= 47.62$) was 19.56% faster than the alphanumeric group ($\bar{X} = 211.3$, s.d. $= 47.05$). At the third trial, the pictorial group ($\bar{X} = 103.06$, s.d. $= 28.86$) was 28.14% faster than the alphanumeric group ($\bar{X} = 143.4$, s.d. $= 52.30$).

As discussed previously, nonparametric Wilcoxon Rank Sum tests were performed for planned comparisons of mean errors. An examination of the errors planned comparison results between the alphanumeric and combined modes for Chinese subjects in Table 3 indicates that a significant difference was found at the first trial ($Z = 1.97$, $P = 0.05$). At the first trial, subjects with combined assignment ($\bar{X} = 5.1$, s.d. $= 3.84$) made 51.4% fewer errors than those with alphanumeric assignment ($\bar{X} = 10.5$, s.d. $= 6.36$). There was no significant difference found between the pictorial and combined modes in the errors planned comparison except at the third trial ($Z = -2.00$, $P = 0.05$). The errors committed by subjects with combined mode ($\bar{X} = 2.0$, s.d. $= 2.00$) were 59.18% fewer than those by subjects with pictorial mode ($\bar{X} = 4.9$, s.d. $= 4.28$), at the third trial. There were no significant differences found between the alphanumeric and pictorial modes in the errors planned comparison throughout all three trials.

The Chinese subjects performed better with pictorial presentation mode vs alphanumeric mode in terms of performance times, on the first and third trials. It should be noted that since the pictorial presentation mode utilized the dominant ability of Chinese subjects, providing extra information with the combined mode did not enhance their performance in terms of performance time and errors. On the other hand, since verbal ability was not the dominant ability of Chinese subjects, the provision of extra information with the combined mode rather than providing alphanumeric elements only did improve their performance in reducing performance time and errors.

In summary, the first part of the hypothesis was not supported for either American subjects or Chinese subjects, in that the combined mode did not always result in advantage over alphanumeric or pictorial modes in terms of performance (performance time and errors). The advantage of combined mode was noted only when it was compared to a presentation mode requiring an ability which was not dominant for the users (because the Combined mode provided supplementary information). For American subjects, the advantage of combined mode was evident, since it provided extra alphanumeric information in comparison to the pictorial mode (which requires the visual discrimination ability). For Chinese subjects, the advantage of combined mode was seen, since it provided extra pictorial information in comparison to the alphanumeric mode (which requires the verbal ability).

The second part of the hypothesis was supported for American subjects. The American subjects performed better with alphanumeric assignment vs pictorial assignment, both on performance time and errors, in the first trial. In accordance with past studies [14–16] which also reported superiority in verbal ability for American subjects, the support of the hypothesis for the American subjects indicates that it is more beneficial for such subjects to use alphanumeric vs pictorial elements, when the combined mode is not available.

The third part of the hypothesis was partially supported in terms of performance time in the first and third trials, for Chinese subjects. It took these subjects less time to perform the required tasks with a pictorial assignment vs an alphanumeric one. No significant difference was found in errors made by these subjects. In accordance with past studies [17–19] which reported superiority in visual-discrimination ability for Chinese subjects, the result seen here indicates that Chinese subjects will perform more efficiently with pictorial rather than alphanumeric elements of icon displays, when the combined mode is not available.

5. Conclusions

The purpose of this study was to investigate the impacts of different cultural attributes between American and Chinese users in terms of their performance interacting with GUIs. From the results presented in the previous section, the impacts of cultural differences on performance time and error rate were especially apparent in the initial performances of American and the Chinese subjects they interacted with.

For American subjects, initial performance time was shorter if users were provided with an alphanumeric rather than a pictorial presentation mode. And, initial performance time for Americans was shorter with combined mode vs the pictorial mode. For these subjects, the initial error rate was lower with an alphanumeric presentation mode than with a pictorial one. It also was lower with a combined mode vs a pictorial one.

For Chinese subjects, providing a pictorial presentation mode for icon displays helped decrease initial performance time vs that while using an alphanumeric mode. The performance time also was shorter if users were provided with a combined mode rather than an alphanumeric mode. The initial error rate was lower for Chinese subjects when using a combined presentation mode, vs an alphanumeric one.

From the results of this study, it is clear that it is preferable to provide a combined presentation mode when designing GUIs, especially to facilitate better initial performance. Performance with a combined mode can be at least as good as or better than performance with either an alphanumeric or a pictorial mode. However, if providing a combined mode is not possible due to certain constraints, it will be beneficial to provide icons with textual elements for American users, and icons with figural elements for Chinese users.

As stated in previous sections, most computer applications were developed by American vendors. The recommendations for icon design generated by this study will be especially useful for developers whose products have Chinese as potential users.

It is imperative that GUIs are designed to consider quick and accurate recognition by users, to ensure better usability for interfaces. This consideration is especially important at early stages of human–computer interaction, since the assurance of better performance will encourage novice users to learn the system and will enable them to perform tasks effectively.

Acknowledgements

This research was made possible by support from the technology transfer initiative and the NEC professorship at Purdue University. We gratefully acknowledge Dr. Kan Zhang, Director, Institute of Psychology, Chinese Academy of Sciences, Mainland China, for his great assistance and cooperation in making the experimentation in Mainland China possible.

Appendix A.

Table 2 shows data for testing the hypothesis, for American subjects.

Table 2
Data for testing the hypothesis, for American subjects

Variables	Trials	Alphanumeric ($N = 10$)		Combined ($N = 10$)		$F_{(1,27)}$	P
		$\bar{X}$	s.d.	$\bar{X}$	s.d.		
Time (sec)	1	86.202	13.043	96.373	20.860	1.04	0.3163
	2	63.334	7.425	62.254	19.448	0.10	0.7517
	3	49.982	12.753	60.513	18.034	2.53	0.1231
Errors	1	0.4	0.70	2.3	2.26	$Z = -1.906$[a]	0.0567
	2	0.6	0.97	0.5	1.27	$Z = 0.750$[a]	0.4533
	3	0.5	1.08	0.6	1.08	$Z = -0.348$[a]	0.7277
Variables	Trials	Pictorial ($N = 10$)		Combined ($N = 10$)		$F_{(1,27)}$	P
		$\bar{X}$	s.d.	$\bar{X}$	s.d.		
Time (sec)	1	126.051	35.375	96.373	20.860	6.55	0.0164[b]
	2	69.244	20.125	62.254	19.448	0.98	0.3319
	3	57.814	12.992	60.513	18.034	0.17	0.6866
Errors	1	5.5	3.87	2.3	2.26	$Z = -2.031$[a]	0.0423[b]
	2	0.3	0.95	0.5	1.27	$Z = 0.547$[a]	0.5842
	3	0.4	0.97	0.6	1.08	$Z = 0.448$[a]	0.6544
Variables	Trials	Alphanumeric ($N = 10$)		Pictorial ($N = 10$)		$F_{(1,27)}$	P
		$\bar{X}$	s.d.	$\bar{X}$	s.d.		
Time (sec)	1	86.202	13.043	126.051	35.375	12.82	0.0013[b]
	2	63.334	7.425	69.244	20.125	0.45	0.5095
	3	49.982	12.753	57.814	12.992	1.40	0.2468
Errors	1	0.4	0.70	5.5	3.87	$Z = -3.362$[a]	0.0008[b]
	2	0.6	0.97	0.3	0.95	$Z = 1.296$[a]	0.1951
	3	0.5	1.08	0.4	0.97	$Z = 0.000$[a]	0.9999

[a]wilcoxon rank sum tests.
[b]Significant at 0.05 level.

Appendix B.

Table 3 shows data for testing the hypothesis, for Chinese subjects.

Table 3
Data for testing the hypothesis for Chinese subjects

Variables	Trials	Alphanumeric ($N = 10$)		Combined ($N = 10$)		$F_{(1,27)}$	P
		$\bar{X}$	s.d.	$\bar{X}$	s.d.		
Time (sec)	1	211.256	47.054	167.398	31.963	5.24	0.0301[b]
	2	150.035	69.376	129.064	54.616	0.73	0.3991
	3	143.411	52.299	103.433	37.748	4.80	0.0372[b]
Errors	1	10.5	6.36	5.1	3.84	$Z = 1.971$[a]	0.0487[b]
	2	5.9	7.39	4.1	4.20	$Z = 0.305$[a]	0.7606
	3	5.7	4.32	2.0	2.00	$Z = 1.685$[a]	0.0919
Variables	Trials	Pictorial ($N = 10$)		Combined ($N = 10$)		$F_{(1,27)}$	P
		$\bar{X}$	s.d.	$\bar{X}$	s.d.		
Time (sec)	1	169.930	47.624	167.398	31.963	0.02	0.8958
	2	126.896	54.443	129.064	54.616	0.00	0.9569
	3	103.055	28.862	103.433	37.748	0.00	0.9836
Errors	1	7.6	5.56	5.1	3.84	$Z = -0.874$[a]	0.3820
	2	4.5	6.04	4.1	4.20	$Z = 0.382$[a]	0.7022
	3	4.9	4.28	2.0	2.00	$Z = -2.004$[a]	0.0450[b]
Variables	Trials	Alphanumeric ($N = 10$)		Pictorial ($N = 10$)		$F_{(1,27)}$	P
		$\bar{X}$	s.d.	$\bar{X}$	s.d.		
Time (sec)	1	211.256	47.054	169.930	47.624	4.65	0.0400[b]
	2	150.035	69.376	126.896	54.443	0.83	0.3702
	3	143.411	52.299	103.055	28.862	4.89	0.0356[b]
Errors	1	10.5	6.36	7.6	5.56	$Z = 1.022$[a]	0.3069
	2	5.9	7.39	4.5	6.04	$Z = 0.612$[a]	0.5406
	3	5.7	4.32	4.9	4.28	$Z = 0.304$[a]	0.7614

[a]wilcoxon rank sum tests.
[b]Significant at 0.05 level.

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