Individual Differences and Human Computer Interaction

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Abstract

This paper reports on a study of the significance of individual differences in human computer interaction (HCI). The study examined three aspects of individual differences and their impact on people's preferences for different types of user interfaces. The hypothesis for the study was that, preferred interface style, preferred operating system and individual work style are expected to be influenced by culture, personal style and other individual attributes. The results of this study demonstrate the complexity of the relationship between individual differences and interface preference. There are considerable differences between the results from this study and those from a similar study by Evers and Day (1997). This indicates that conclusions about interface preferences should not be based on studies with a small sample size. It confirms the need for the collaborative International Study, (being organised by Evers, Turk and others), which will involve a large number of subjects from different countries. This study will contribute its data to the international study and thereby assist in the development of an improved understanding of the role of individual differences in HCI.

1. Introduction

This research project investigates the preferences and difficulties of individuals when using a computer. Individuals differ in their culture and their personal style. This can be expected to result in varying preferences towards different types of user interfaces. However, individuals also differ in other individual attributes, such as: age, computer experience and disabilities. In order to make allowance for individual differences in the design process for user interfaces we need to understand much more about the nature of these factors and how they impact on HCI.

With the advent of advanced, affordable technology, computer usage has become more widespread. Almost every sector of today's modern society uses computers in its operations. As a result, nearly every individual in a developed or emerging society will use a computer at some stage of their life, be it in school, at home or at work. This highlights the need to look into the difficulties faced by individuals when using computers and the importance of cultural factors.

2. Review of Key Related Research

HCI plays an important role in design of computer-based systems - *"in information systems design, the primary activity is the design and creation of computer systems for use by others (the "users")"* (Beardon, Gollifer, Rose and Worden, 1997, p. 27). Design processes for HCI aspects of computer systems need to be simple and effective - *"it is desirable to have user interface system which allows application programmers and interface designers to create interfaces without programming and without having to painfully learn tedious details of underlying toolkits"* (Sukaviriya, Foley and Griffith, 1993, p. 375). Without effective procedures and tools, vast amounts of time and effort are needed to be competent in any particular programming language in order for a good, working interface to be produced. The impact of individual differences on HCI needs to be modelled. Parameters can then be incorporated in procedures and tools to facilitate efficient and effective user interface design.

To achieve effective HCI it is important that prototype systems be evaluated. Usability of the system is a key consideration - *"the most widely identified general orientation towards system evaluation is to be found within design for usability or usability engineering ... characterised by an emphasis on criterial*

assessment, experimental testing with users, and inclusion of these in an iterative design process" (Wilson and Clarke, 1993, p. 380/381). Modelling individual differences aids in the evaluation of usability by identifying factors which vary between (and within) individuals. An appropriate evaluation strategy can then be devised, usually including particular tests involving specified types of users.

The major article used in the design of this research project was that by Evers and Day (1997). Their study *"supports the supposition that human-computer interface acceptance is indeed influenced by culture"* (Evers and Day, 1997, p. 266). Their research findings indicate significant HCI preference differences between subjects from different cultures. The study had several limitations, which were recognised by Evers and Day - *"future research will include alternate data collection modes such as interviews, direct observation of user behaviour, and focus groups…questionnaires will be administered to overseas subjects in their home cultures, to minimise potential cultural contamination problems"* (Evers and Day, 1997, p. 266). Evers has subsequently commenced her PhD, involving confirmatory research on interface acceptance and the design of information systems. Her research design (Evers, 1999, p33) includes an international study, which is in collaboration with other researchers from various countries, including Andrew Turk from Australia.

For the international collaborative study, a questionnaire has been developed to assess users' understanding and preferences in interface design across the several cultures in each country. The authors assisted with the design of the international questionnaire. It is intended that each participant from the respective countries will administer 80-100 questionnaires to subjects. Vanessa Evers herself, Andrew Turk, Donald Day and Adrie Stander will do the evaluation and analysis.

The aim of this study was to compare its results with those from the Evers and Day (1997) study to determine whether reasonable inferences concerning interface preferences can be made from studies with a limited number of subjects. This study will also contribute its results towards the international collaborative study. To support this objective, this study uses the international questionnaire but complements it with another questionnaire specific to this study. These additional questions allow some of the constructs to be strengthened and also the inclusion of some new individual difference and HCI preference dimensions.

3. Research Design

This research project aims to examine how individual differences can impact on people's preferences for different types of user interfaces. These individual differences can be categorised into three areas, namely, culture, personal style and other individual attributes. Not all aspects of these constructs could be evaluated within this study because of time and resource limitations. The principal research constructs have been broken down into specific dimensions, which are examined via particular questions in the international (I) questionnaire and the extra questionnaire specific to this study (L). The relationships among the constructs, dimensions and questions are displayed in Figure 1.

This study has a number of research hypotheses, at differing levels of detail. They address the general relationships between individual differences and HCI preferences and also allow comparison with specific reported findings from the Evers and Day (1997) study.

A) General Hypotheses:
- H1: Preferred Interface Style is influenced by culture, personal style and other individual attributes.
- H2: Preferred Operating System is influenced by culture, personal style and other individual attributes.
- H3: Individual Work Style is influenced by culture, personal style and other individual attributes.

B) Specific hypotheses to test some of Evers and Day's findings, e.g.:
- H4: Chinese prefer a lot of different colours.
- H5: Chinese like graphical user interface.
- H6: Chinese like pull-down menus.

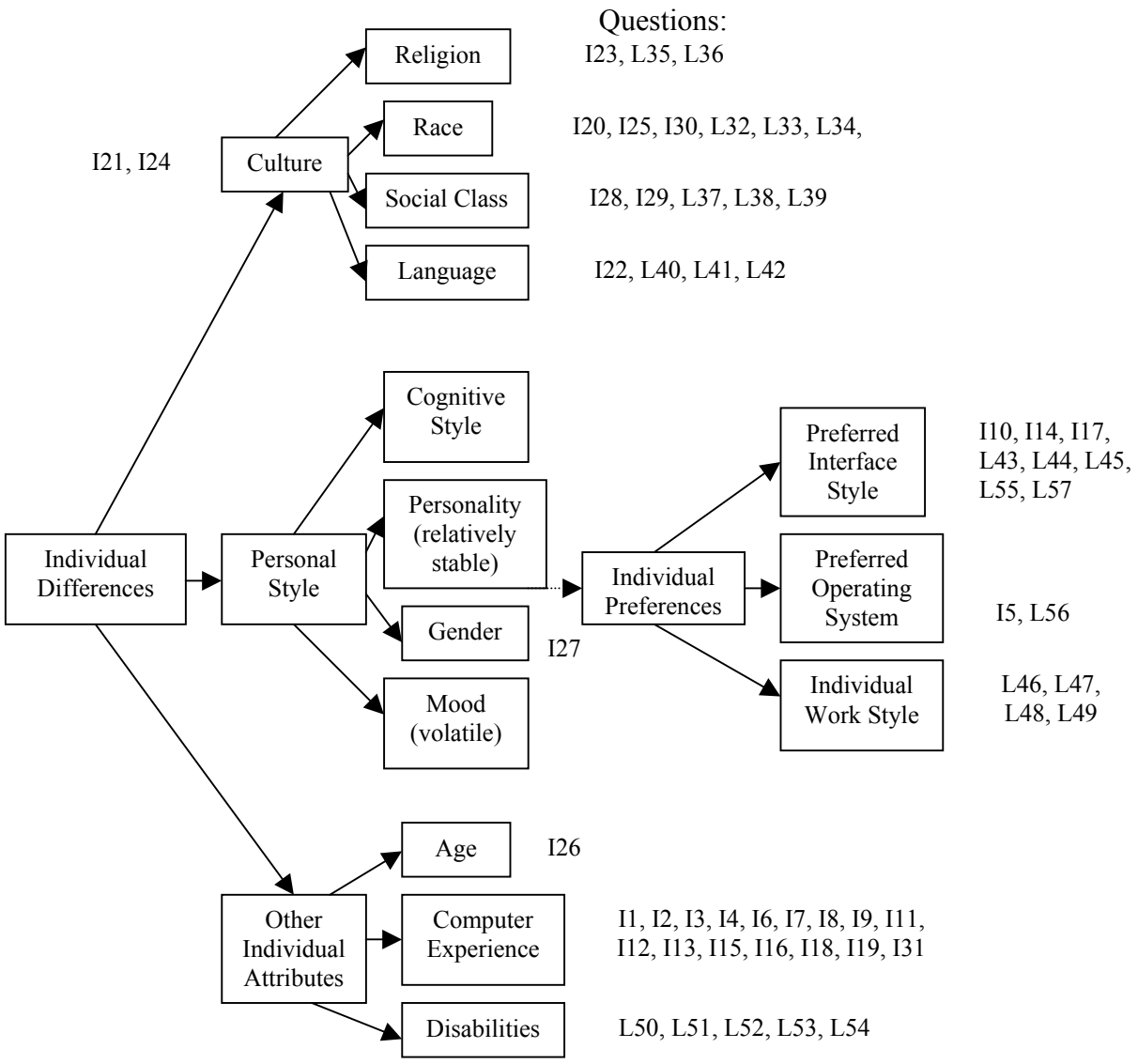

Figure 1 - Research Framework

4. Definition of Constructs

For this research project, definitions were required for the following constructs:

a) Individual Differences (Independent Variables): Culture; Personal Style; Other Individual Attributes.
b) Individual Preferences (Dependent Variables): Preferred Interface Style; Preferred Operating System; Individual Work Style.

The discussion below justifies the use of specific dimensions of the constructs and discusses how they are operationalised in the questionnaire.

Individual Differences

Individual differences can be defined as the aspects that distinguish one person from another. There are several such areas but for the sake of this study, only some aspects relevant to HCI will be considered, i.e.: culture; personal style; and other individual attributes. Culture can be defined as: religion; race; social class; and language. Personal style can be broken down into: cognitive style; personality; gender; and

mood. Other individual attributes (for this study) consists of: age; computer experience; and disabilities. Discussion of each of these constructs and dimensions follows.

Culture

In a general sense, culture shapes social life and vice versa. This is evident in the way people's actions reflect their cultural backgrounds, including use of computers (Turk & Trees, in press). *"Each culture has its own beliefs, behaviours and perceptions. Members of the same culture are likely to have the same "knowledge" of certain things, and would think and act similarly in certain situations"* (Yeo, 1996, p. 3). The complex construct "culture" needs to be broken down into a set of dimensions so that it can be operationalised for experimental study by designing questions which address each of the dimensions. These dimensions are religion, race, social class and language. A discussion of these dimensions follows.

Religion

Awareness of the religions of computer users is of great importance when it comes to designing interfaces so as not to unintentionally alienate certain groups of people, e.g. by using inappropriate icons. Religion is a matter of choice for each individual, although not entirely so, due to the pressures from family or religious congregations. Apart from conventional 'organised' religion, another aspect of religion can be said to be in the form of individual beliefs or biases. Individuals may hold personal convictions that even people of similar religions are not able to comprehend. As a result, detailed information about a person's religion is impossible to obtain from the questionnaire and only general religious categories are used.

Race

Individuals differ in their genetic background and this influences their behaviour and preferences. Where a group of people have similar genetic background they may be classified as belonging to the same 'race'. However, this does not mean that an individual will necessarily identify with one specific race. For instance, some individuals have mixed parentage. For example, one parent may be English while the other may be German. The child of this couple may identify more with either being English or being German. Hence, in the questionnaire subjects are asked to nominate which race they most identify with.

Social Class

Social class reflects an individual's status in society. This can often be explained in relation to wealth. If an individual belongs to the high income-bracket group, he or she is seen as someone with a higher social class. With this view, individuals may be inclined to perceive things differently when it concerns their status, especially in associating particular objects or symbols with high social class. The non-economic issues of social class that may be considered to include hereditary titles and educational level. Hereditary titles are bestowed upon individuals through birth into a royal or 'noble' family. Such individuals are classified as having a high social class. The questionnaire addresses only the economic aspects.

Language

Language plays an important role in different cultures. It can be used to distinguish between cultures, however, not with very much success. For example, take the proposition that *"members of the same culture understand the same language"* (Rey, 1998). More often than not, this is true only to a certain extent. Although people may have the same cultural background, they may not necessarily understand the same language. This can be due to the environment in which they were brought up. For example, a Chinese family may speak English most of the time and the children in this family naturally pick it up as their mother tongue rather than Mandarin, which is culturally their mother tongue. There is also a possibility of multiple languages in one culture, including the slangs, jargons etc - e.g. in the Chinese culture, there are what one may call multiple languages (or 'dialects'), i.e.: Hokkien; Teochew; Hakka; Hainan; Fuchou; and Cantonese. Hence, complex questions are needed to identify a person's language.

Personal Style

Personal style has a direct relationship to an individual's use of HCI. Cognitive style, personality, gender and mood are dimensions that can be considered in the study of individual differences in HCI. However, because of time and resource limitations, only gender was considered in this study.

Gender

Gender represents whether individuals are male or female. Individuals of different genders are usually considered to differ in the way they perceive computer tasks, however, this may be based merely on myths and biases. Making assumptions of this nature, without research evidence, is not a good basis for inferences about how design of computers should reflect the gender of users - *"the mythic and political biases of computer technology influence but do not completely determine the specific relationships established at the human-computer interface"* (Sofia, 1993, p. 89). Computers are machines and as such are often associated with males rather than females. This conventional perspective does not, however, fit well with contemporary schools of thought, which demand a more sophisticated approach. This involves looking at computer use in more depth. The questionnaire asks the subject's gender.

Other Individual Attributes

Other individual attributes considered in this study of individual differences in HCI are age, computer experience and disabilities, which are discussed below.

Age

As people grow older, they will be less agile in their physical movement. Thinking speed and memory power will also deteriorate. *"Both middle aged and older adults take more time to process each item in short term memory"* (Hawthorn, 1998, p. 271). Their ability to mentally grasp things will slow down significantly. The learning process is thereby made more tedious. This can be a problem when learning to use software. Subjects were asked their age.

Computer Experience

Computer experience is usually seen as the exposure that one has had to the use of computers. This could be expressed as the number of years one has used the computer, the current level of competency in various computer-based tasks or the number of software packages one knows how to use. Each of these aspects is covered by questions in the questionnaire.

Disabilities

There are different types of disabilities. Physical disabilities can involve sight, hearing, speech, movement and control. This applies more to the aged but it does not mean that the young are spared from these physical problems. Certain cases of disabilities may be either from birth or through accidents. Other (non-physical) disabilities include language, intellectual ability and location. In this study, the consideration of disabilities is limited to those associated with vision.

Individual Preferences

The individual preference constructs used in this study are: preferred interface style; preferred operating system; and individual work style. These dependent variables are perceived as being influenced by the individual differences mentioned above. Hence there is also a need to define the dependent variable constructs, as follows.

Preferred Interface Style

Generally, preferred interface style would mean the design of a user interface one is inclined to use rather than another. At a more specific level, things like colour, icons, sounds, or even animated graphics may be what computer users are looking for in a user interface. Of course, there will be variations of preferences such as for brighter colours or softer colours and command line or graphical user interfaces. A set of complex questions covers all these aspects in the questionnaire.

Preferred Operating System

There are many types of operating systems for computers. Some examples of systems are Windows 3.1, Windows 95 or 98, Unix or Linux or Solaris and Mac OS. Preference depends on which one individuals find easiest to use. The questionnaire asks subjects which operating system they prefer.

Individual Work Style
Individuals have different work styles. Some prefer to work in a quiet environment while others may be comfortable working in a busy environment. Group work may be favourable to some, but less palatable to others. These issues are addressed in the questionnaire.

5. Research Method

The experimental study consisted of the administering of questionnaires to students at Murdoch University, during May 1999. The questionnaire used is that for the international study by Evers, Turk and others, which, in turn was based on the Evers and Day (1997) questionnaire. The international questionnaire was used in its complete form and was followed by another set of questions specific to this study.

The subjects consisted of 46 third year students doing the unit B325 Human Computer Interaction as well as Honours students in Information Systems and Computer Science at Murdoch University. This group is made up of people from different nationalities and ethnic backgrounds. It is recognised that the sample size is small and that students are not necessarily typical users. Therefore, on its own, the external validity of this study is low. However, the collaboration with the international study gives this study more substance and increases its validity when its results are ultimately combined with those of similar studies.

The statistical software used to analyse the outcome of the survey was SPSS. However, because of the large number of questions in the survey and the small number of subjects, it was decided that the data sets should be rationalised prior to the use of SPSS. Of course, the full, detailed data will be used for the collaborative international study. The analysis of the observed data involved two stages, as follows.

A) Reduction of the complexity of the analysis by combining responses from questions into integrated categories (via spreadsheets);
B) A statistical analysis of reduced complexity (integrated) constructs, i.e. use of chi-square analysis via SPSS. Chi-square analysis was also performed on the separate dimensions of the ‘culture’ construct.

The steps involved in the data analysis, were as follows:

The coding of response options:
The response options in the questions were coded to facilitate the data entry and analysis. This was accomplished by representing the actual options in each question by numbers and/or letters.

Identify subjects and data entry:
Subjects’ names were not included in the questionnaire. Each completed questionnaire was numbered to enable the responses to different questions by the same subject to be related. The data for each subject was entered into spreadsheets for each question related to each dimension of each construct (see Fig. 1).

Complexity reduction:
Graphs were generated summarising the responses for each question. After going through each question pertaining to a respective dimension (of each construct), reasons were determined to justify the inclusion or exclusion of individual questions in the subsequent analysis phase. An appropriate ‘rule’ was generated for this complexity reduction process for each dimension (of each construct).

Derive integrated category for each dimension:
The questions to be included in the analysis were used to derive the 'integrated category' (in the spreadsheet for each dimension), according to the 'rule' generated in the previous step.

Integration at construct level:
After all the dimensions of each construct have been categorised (first order integration), reasons and 'rules' were determined to derive the (second order) 'integrated category' for each whole construct, based on the (first order) 'integrated category' for each of its dimensions.

Data entry in SPSS:
The integrated category data for culture (second order), gender (first order), computer experience (second order), preferred interface style (first order), preferred operating system (first order) and

individual work style (first order) were entered into SPSS. Computer experience was considered the most useful dimension for analysis from the construct "other individual attributes".

Chi-square tests:

A chi-square test was run on culture with preferred interface style, preferred operating system and individual work style. Similarly, chi-square tests were run on gender and computer experience with the dependent variables. There were no significant associations between the independent variables and the dependent variables, since the calculated chi-square values were less than the table values at a significance level of 0.05. Because there were no significant relationships found for the integrated construct of culture, the separate dimensions of culture were tested with the dependent variables. No significant associations were found.

6. Results

The nature of the data collected from the survey consists of open-ended questions, 6-point Likert scale questions, closed questions, category questions and checklist questions. The raw results were processed through a sequence of spreadsheet steps (described above) to yield integrated data categories. Because of the sample size of 46, it was only possible to utilise 3 categories of culture, i.e. the Australians (16 subjects), the Chinese (14 subjects) and other cultures (16 subjects). Selected key aspects of user interface preferences for the three culture groups were summarised and compared with some specific findings from the Evers and Day (1997) study - see Tables 1, 2 and 3.

	Evers and Day Australian	This Study	Difference
Different Colours	28.9%	62.5%	33.6%
Pull-down Menus	63.2%	93.8%	30.6%
Fixed Menus	31.4%	100.0%	68.6%
Text-based Interfaces	8.3%	81.3%	73.0%
GUI Interfaces	78.4%	37.5%	40.9%
Mouse	72.2%	100.0%	27.8%
Joystick	21.1%	68.8%	47.7%
Touch Screens	47.1%	75.0%	27.9%
Sounds	64.9%	87.5%	22.6%
Culturally Adapted Interfaces	65.8%	43.8%	22.0%

Table 1 – Percentages of subjects (in culture categories) who favour particular interface features, for each study.

	Evers and Day Asian	This Study Chinese	Difference
Different Colours	72.9%	71.4%	1.5%
Pull-down Menus	54.2%	100.0%	45.8%
Fixed Menus	54.3%	85.7%	31.4%
Text-based Interfaces	43.1%	64.3%	21.2%
GUI Interfaces	63.8%	28.6%	35.2%
Mouse	88.5%	92.9%	4.4%
Joystick	66.2%	78.6%	12.4%
Touch Screens	73.1%	92.9%	19.8%
Sounds	86.5%	85.7%	0.8%
Culturally Adapted Interfaces	34.0%	28.6%	5.4%

Table 2 – Percentages of subjects (in culture categories) who favour particular interface features, for each study.

	Evers and Day		This Study			
	Chinese		Chinese		Australian	
	Mean	SD	Mean	SD	Mean	SD
Different Colours	2.00	0.9	2.20	0.63	2.50	0.85
Pull-down Menus	2.60	0.8	1.79	0.70	1.93	0.80
Fixed Menus	2.69	0.8	1.83	0.58	2.06	0.57
Text-based Interfaces	3.06	1.0	2.33	0.71	2.08	0.64
Mouse	1.74	0.8	1.23	0.44	1.69	0.87
Joystick	2.35	1.2	2.09	0.83	1.91	0.54
Touch Screens	2.13	1.1	1.92	0.86	1.92	0.79
Sounds	1.76	0.8	1.67	0.78	2.00	0.78

Table 3 – Scores (on 5-point scale) for interface preferences of different culture groups in each study (lower score indicates greater preference).

To assess the relationships between constructs, significance values were obtained from chi-square analysis using SPSS. The chi-square results showed no significant associations among the variables because the calculated values did not exceed the table value, with the corresponding degrees of freedom, at a 0.05 significance level. The significance values from the chi-square results were compared. Some of the values appeared to be more significant than other values, although none fell within the 0.05 level of significance. See Tables 4 and 5.

	Significance		
	Preferred Interface Style	Preferred Operating System	Individual Work Style
Culture	0.690	0.531	0.550
Gender	0.822	0.809	0.743
Computer Experience	0.125	0.103	0.400

Table 4 – Results of chi-square analysis of relationships for general (integrated) constructs.

	Significance		
	Preferred Interface Style	Preferred Operating System	Individual Work Style
Social Class	0.197	0.081	0.315
Religion	0.099	0.158	0.245
Race	0.472	0.711	0.238
Language	0.792	0.980	0.478

Table 5 – Results of chi-square analysis of relationships for separate dimensions of culture.

7. Discussion

Comparison with Evers and Day (1997) Study Findings:

Comparison of Percentages – Australian Students (Table 1)
For the Australian students, there were vast differences between the results for the Evers and Day study and this study. The largest difference in percentages was for the preference for text-based interfaces while the smallest difference was for the preference for culturally adapted interfaces.

Comparison of Percentages – Asian and Chinese Students (Table 2)
There were no percentages listed for interface preferences of the Chinese students in the paper describing the Evers and Day (1997) study. Hence, to allow comparison of preference for HCI variables in percentages with the Chinese students in this study, the Asian students were the next most appropriate group of subjects for this purpose. Because there will be some differences between the Asian students and

the Chinese students in the respective studies, the basis for this comparison is weak. There is, however, an indication that there are differences between the results for the two studies.

Comparison of Means – Chinese and Australian Students (Table 3)
The preference for fixed menus had the largest difference in means between the two groups of Chinese students. The preference for sounds had the smallest difference in means between the two groups of Chinese students. In this study, there were much lesser differences between the Chinese students and the Australian students, perhaps because the students (from each background) are part of a sub-culture which is more "international".

There are very significant differences in the results from the two studies (Evers and Day (1997) and this one). This could be due to the small number of Australian students and Chinese students used for comparison in both studies. In the Evers and Day study, there were 38 Australian students and 66 Chinese students. This study had 16 Australian students and 14 Chinese students. This indicates that much more extensive research (with much larger numbers of subjects) is required before user interface preferences can be inferred from constructs of nationality or culture. Indeed, culture may be much less significant than other factors in determining interface preferences.

Relationships Between Independent and Dependent Variables In This Study:

The calculated values from the chi-square analysis for both the main constructs and the dimensions of culture were less than the table value at a significance level of 0.05. The significance values are displayed in Tables 4 and 5 above. For each dependent variable (in Table 4) the significance value for "culture" was more significant (i.e. closer to 0.05 level) than that for "gender" while the value for "computer experience" was more significant (i.e. closer to 0.05 level) than either "gender" or "culture". Hence, it appears that computer experience may be a more important factor than culture or gender in determining HCI preferences. However, a study with greater statistical power is needed to verify this supposition.

The dimensions of culture had more than one contender for the greatest level of significance, although none achieved the 0.05 level (see Table 5). Social class and religion were the most significant in the strength of association with each of preferred interface style and preferred operating system. Social class, religion and race appeared to be inclined towards the more significant end of the scale in terms of individual work style. Language was the least significant dimension of culture for all dependent variables. Although these results are interesting, they permit no valid inferences. They do, however, indicate that a multi-dimensional construct of 'culture' should be used in future studies.

Research Hypotheses:

A significant association was not found between any of the independent variables and dependent variables (to a 0.05 significance level). Hence, none of the general research hypotheses (H1; H2; H3) were supported by the results.

With respect to the specific hypotheses related to some of the specific findings from the Evers and Day (1997) study, the following were discovered:

- The use of different colours in user interfaces was fairly strongly preferred among the Chinese in this study, as indicated by 71.4% of Chinese subjects fitting this category (see Table 2). This (weakly) supports Hypothesis 4.
- Graphical user interfaces were not very popular among the Chinese in this study - 28.6% indicated this preference (see Table 2). This does not support Hypothesis 5.
- It was clear that the Chinese in this study strongly prefer using pull-down menus because 100% of subjects indicated this preference (see Table 2). This supports Hypothesis 6.

8. Conclusions and Further Research

Individual differences have a very broad scope. In this study, only some of the areas pertaining to HCI were covered. Culture, personal style and other individual attributes were the aspects investigated to show how they can impact on people's preferences for different aspects of HCI. The preferences investigated were: preferred interface style; preferred operating system; and individual work style.

The results from this study are very different from those for the Evers and Day (1997) study, although some of the specific comparative research hypotheses were supported. These results cast at least some doubt on the validity of the findings from the Evers and Day (1997) study, although this study had considerably fewer subjects than the Evers and Day study. The main research hypotheses within this study were not supported. These results show that the method used will not produce reliable results with a small sample size. This indicates that more research is needed to allow accurate inferences of user interface preferences from individual user differences, such as culture. The collaborative international study will be useful for this purpose because of the larger number of subjects, which will permit more detailed analysis and provide a much higher level of validity.

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