Interface Design for Older Adults with Varying Cultural Attitudes toward Uncertainty

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ABSTRACT
This work reports on the design and evaluation of culturally appropriate technology for older adults. Our design context was Cognitive Testing on a Computer (C-TOC): a self-administered computerized test under development, intended to screen older adults for cognitive impairments. Using theory triangulation of cultural attitudes toward uncertainty, we designed two interfaces (one minimal and one rich) for one C-TOC subtest and hypothesized they would be culturally appropriate for older adult Caucasians and East Asians respectively. We ran an experiment with 36 participants to investigate cultural differences in performance, preference and anxiety. We found that Caucasians preferred the interface with minimal elements (i.e. those essential for the primary task) or had no preference. By contrast, East Asians preferred the rich interface augmented with security and learning support and felt less anxious with it than the minimal.

Author Keywords
Cultural design; uncertainty avoidance; experiment; computerized cognitive assessment; older adults

ACM Classification Keywords
H.5.2 [Information interfaces and presentation]: User Interfaces - Evaluation/methodology.

General Terms
Experimentation, Human Factors, Design.

INTRODUCTION
Despite the multitude of software technologies that span the globe, interface design has largely remained framed in a western-centric perspective. Linguistic translation is not enough to provide cross-cultural flavor; it offers only a superficial solution where western culture remains deeply engrained in the design of international technology [18]. To truly design cross-cultural interfaces, we need to look beyond translation and restructure design to manufacture holistic, culturally appropriate user experiences. Cross-cultural usability, or "culturability" as suggested by Barber and Badre [1], rejects the dominant one-size-fits-all approach of international technology design in favor of one that promotes culturally adapted interfaces. Culturability delivers a culturally customized user experience to international consumers, and should hence be incorporated in the design vision of technology spanning multicultural user populations.

Investigating culturally informed design is an important step for developing Cognitive Testing on a Computer (C-TOC) – a computerized self-administered screening test for cognitive impairments intended for older individuals (55+) [2]. It is being designed initially for a clinic setting, with the goal of it eventually being taken at home. Canada is very multi-cultural; hence C-TOC's design must accommodate users' different cultural needs. Moreover, cultural differences should not create serious variations in user experience or skew test results. C-TOC can become an essential tool for all older adults as it will triage at-risk individuals to professionals quickly, and eliminate wait time for a comprehensive cognitive consultation in a clinic, which in Canada currently ranges from 6 to 24 months.

We are interested in the interplay between culture and older users' attitude to the uncertain interaction context of C-TOC. Cognitive testing intrinsically causes uncertainty as it raises health concerns in test-takers and possibly cultural stigma about cognitive competence and aging. Furthermore, the demands of self-administration or doubts about computer proficiency may contribute additional uncertainty, especially if cognitive impairment is already present. C-TOC users might feel uncertain as well about the protection of their data online. While our intention is not to tease apart the various contributors of uncertainty in the context of C-TOC, we feel it would induce anxiety. Experiencing some anxiety is expected in the context of cognitive testing, but excessive levels can reduce the size of working memory and distract from the primary task [9]. This could degrade performance and increase the likelihood of false positives. We speculate that cultural differences in attitudes toward uncertainty might produce varying user needs for anxiety appeasement and security reassurance for C-TOC users.

The contributions of this research include the design of two interfaces for one C-TOC subtest (the Symbol-Digit

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Matching test – Fig. 1), by using variation in information richness to accommodate two varying cultural attitudes toward uncertainty. In addition, we contribute an evaluation of our designs with older Western Caucasian and East Asian users where we observe cross-cultural usability differences. Finally, we provide guidelines for cross-cultural design for older adults in interaction contexts characterized by uncertainty.

RELATED WORK

We begin by describing prior research in cross-cultural differences in psychology and HCI. Next we cover three models related to cultural attitudes toward uncertainty: Hofstede's uncertainty avoidance, the theory of uncertainty orientation, and the theory of behavioral inhibition. Through triangulation of these theories, we hypothesized cultural profiles for Eastern and Western C-TOC users. We used Hofstede's uncertainty avoidance to guide cross-cultural design of two interfaces for a C-TOC subtest.

Prior to starting our discussion of culture, it is important to clarify that any cultural observations we present do not intend to generalize to all in the observed cultures, or pigeonhole people in rigid cultural categories. Instead, they should be viewed as observed cultural tendencies, similar to how gender differences in behavior also describe general tendencies, without implying that all women or all men behave the same way.

East is Not West: From Psychology to HCI

Research has found cultural differences in a myriad of social and cognitive phenomena [12]. The field of cultural psychology claims that the connection between mind and culture is bidirectional and intertwined, since cultures arise from the participation of minds in them and the mind develops from participating in a cultural context [12]. Cultures differ from one another in belief systems, social structure, heritage, and other measures that are tangible to culture observers. Cultural differences even persist at the level of basic cognitive and psychological processes. For example, Japanese have been found to perceive contextual information more readily than Americans [15]. Japanese have also been found to focus more on background items and reason holistically compared to Americans who focus on foreground items and reason analytically [19]. Other inter-cultural differences have been found in perception, low-level processing, reasoning, self-concept, concept of others and emotional responses [12]. Such strong evidence of the effect of culture on psychology implies a similar effect on human computer interaction, as some HCI literature had also found. For instance, Frandsen-Thorlacius et al. (2009) found that Danish and Chinese users differ in their perceptions of usability [11]. Similarly, Clemmensen et al. (2009) found that Easterners and Westerners differ in usability evaluations using the think-aloud method [6].

Most other HCI literature in cultural differences however is limited to detecting cultural differences or identifying cultural dimensions related to user experience, rather than designing culturally adapted interfaces and evaluating them. For example, one study investigated different cultural attitudes to electronic products and identified 10 cultural dimensions relevant to user experience [16]. Another surveyed cross-cultural differences in four countries regarding loyalty, trust, and satisfaction with existing local and foreign websites [8]. Yet another study evaluated attitudes toward mobile data services in three countries and found that users in a shared cultural context tend to like/dislike the same features [5]. Similar work has been done on preferences for mobile phone design where cultural differences were also identified [14, 27].

Little work exists that extends such surveys to provide heuristics for cross-cultural interface design. In one study, Aaron Marcus surveyed global websites and provided a set of heuristics for altering design components in response to cultural preference [17]. For instance, regarding the mental model of user interfaces, Marcus suggests that individualistic societies (e.g., Canada) prefer task-oriented models that highlight personal achievement, while collective societies (e.g., China) prefer role-oriented models that highlight connectedness and harmony. In a follow-up survey of 57 UI design experts from 21 countries, Marcus concluded that five cultural dimensions are most relevant to cross-cultural design: *Context, technological development, time perception*, *authority conception*, and *uncertainty avoidance* [17]. We focus on uncertainty avoidance in our work due to the relevance of uncertainty in the context C-TOC usability. While Marcus provided some guidelines for culturability beyond surveying, he did not discuss how it affects user preference or performance, nor did he evaluate cross-cultural designs.

Reinecke and Bernstein (2011) carried out an evaluation of cross-cultural design [22]. They designed Mocca, a task management application, and evaluated two interfaces for it: a fixed culturally neutral interface and an adapted one based on a cultural screening questionnaire. The neutral interface was created using the guidelines of American design since American designers and companies provide a large portion of websites and software solutions globally. The culturally adapted interface was generated by creating a cultural user profile, and then using it to modify the neutral interface. To create the cultural user profile, the system calculated weighted user scores of the Hofstede cultural dimensions based on the countries a user had lived in and the duration of residence in each. Next, and using design heuristics similar to Marcus' [17], the system modified the neutral interface to align with the cultural user profile. The findings showed that users preferred the culturally adaptive interface to the neutral one and performed better on it. Their results point to the importance of culturability when designing interfaces for multicultural user populations, as it does have an impact on user experience.

Hofstede's Uncertainty Avoidance

Uncertainty avoidance is one of the dimensions of the Hofstede cultural model [13]. This dimension describes society's attitude to uncertainty and tolerance of ambiguity. This is one of several cultural dimensions in the Hofstede model, the others being *Power Distance, Individualism versus Collectivism, Masculinity versus Femininity, Long-Term Orientation* and *Indulgence versus Restraint*. These dimensions were identified from a survey of cultural influences on workplace values that was run between 1967 and 1972. During that time, Hofstede worked at IBM and collected data from about 116,000 IBM employees from 40 countries in one of the most comprehensive cultural studies.

Hofstede found a cultural contrast in uncertainty avoidance between the East and West. Countries like the USA and Canada were found to be relatively less uncertainty avoidant, and more tolerant of new untraditional contexts. By contrast, countries like Japan and Korea were found to be more uncertainty avoidant, as they maintain more rigid behavioral codes and feel less comfortable with novelty.

The Theory of Uncertainty Orientation

The theory of uncertainty orientation by Shuper et al. asserts that people differ in how they feel in uncertain circumstances and how they resolve uncertainty [23]. It is similar to Hofstede's uncertainty avoidance. The theory stipulates that individuals fall on a spectrum between being *certainty-oriented* and *uncertainty-oriented*. Certainty-oriented individuals tend to react more apprehensively in uncertainty and seem to depend on others to resolve it. Uncertainty-oriented individuals, by contrast, feel fairly comfortable and oriented when confronted with uncertainty and tend to seek out information independently to resolve it.

There is evidence of an East-West cultural dichotomy in uncertainty orientation. Shuper et al. found that Canadians are significantly more uncertainty-oriented than Japanese [23]. Western cultures tend to be uncertainty-oriented since they are more individualistic, and tend to promote independence in resolving uncertainty. In contrast, Eastern cultures tend to be certainty-oriented because they are more collective in nature, promoting interdependence to deal with uncertain circumstances. These findings resonate with Hofstede's findings about the East-West contrast in uncertainty avoidance, as Japanese are significantly more uncertainty avoidant than Canadians.

The Theory of Behavioral Inhibition and Activation

The theory of behavioral inhibition and activation, by Carver and White, postulates that there are two separate neurological systems that regulate behavior [3]. The first system, the *Behavioral Inhibition System* (BIS), promotes inhibitive behavior to steer away from undesired situations. The BIS is triggered by cues of punishment, non-reward or novelty. It regulates experiences of anxiety, fear or frustration as a result of such cues. Individuals who possess a heightened BIS are more prone to anxiety and more inclined to be conservative in unfamiliar contexts. The second system, the *Behavioral Activation System* (BAS), motivates the individual toward coveted goals. The BAS is triggered by signals of reward and non-punishment, and generates positive feelings of hope and happiness. Those with a heightened BAS are consequently more willing to engage in unfamiliar or ambiguous contexts.

Once again, research in cultural psychology found evidence of a contrast between the East and West in behavioral inhibition. Tanaka and Yamauchi found that collectivism is associated with high behavioral inhibition [25]. This implies that collective cultures (e.g., China) tend to have more activated BIS, and are more vulnerable to anxiety in novel or uncertain situations. In comparison, individualistic cultures (e.g., Canada) possess less active BIS, and tend to feel less aversion and anxiety in uncertain situations.

DESIGN FOR ATTITUDE TOWARD UNCERTAINTY

Given the importance of culturability for the design of C-TOC, we ventured into the design of two cultural interfaces for one of its subtests (Fig. 1). We wanted one design to cater to the cultural needs of East Asian users (from Japan, China, and Korea), and the second to address those of Western Caucasian users of European descent. We chose these two cultural groups because they have been investigated extensively in cultural psychology literature, and because they constitute the largest two cultural groups in the major Canadian city where the study was carried out.

First, we created cultural user profiles for East Asians and Western Caucasians through triangulation of the three cultural theories above. We hypothesized that individualistic Western Caucasian users would generally be less uncertainty avoidant according to Hofstede's model, uncertainty oriented, and less behaviorally inhibited. By contrast, collective East Asian users would be more uncertainty avoidant, certainty oriented, and more behaviorally inhibited.

Second, we employed Hofstede's uncertainty avoidance to guide our design of the two cultural interfaces. Previous survey work in uncertainty showed that users who are less tolerant of it prefer efficient layouts of large amounts of information on the screen, clear labeling and secondary information about content [5] whereas those more tolerant of uncertainty prefer less information. Marcus had similarly found that web design in high uncertainty avoidance cultures is characterized by redundant cues to reduce ambiguity, and help systems that reduce user error [17]. In addition, Hofstede found a strong correlation between uncertainty avoidance and anxiety where high uncertainty avoidant cultures tend to be more susceptible to stress [13]. This shows that user preference for different levels of information richness might be due to culture, and has been linked to uncertainty avoidance. Similarly, one survey found Cypriots (high uncertainty avoidance) to be more nervous about e-commerce, and more demanding of security reassurance than Britons (low uncertainty avoidance) [10]. As a result, we postulated that it was important to provide high uncertainty avoidance users with further reassurance by enriching the interface with elements of learning support and security.

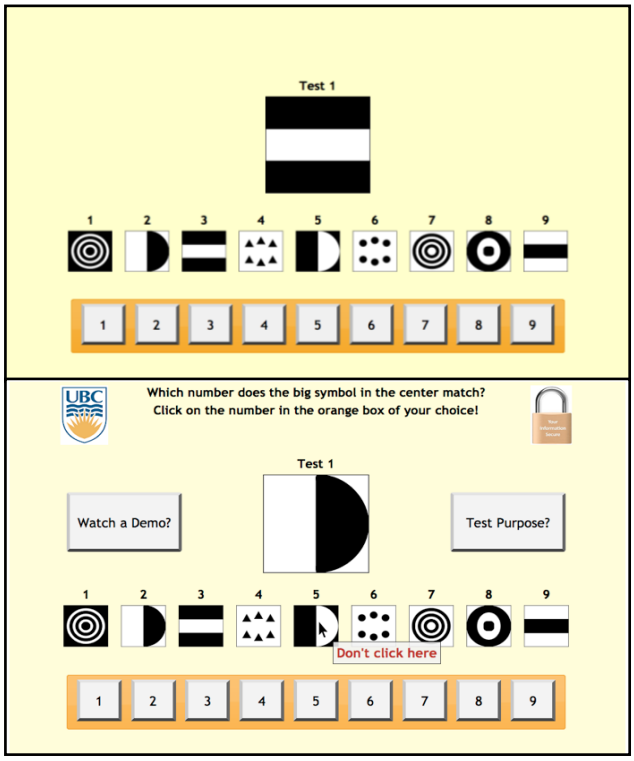

Figure 1. Minimal (top) and Rich (bottom) interfaces for the Symbol-Digit Matching test. In this test, the user clicks on the numbered button in the bottom row that corresponds to the image that matches the large central symbol. The instruction does appear initially in the Minimal interface, but disappears after the first trial.

We designed a *Minimal* interface (Fig. 1 top) for Caucasian users, who are more tolerant of uncertainty. In this interface, we included only the task elements necessary for the primary task (central figure, nine small figures, nine numbered buttons, and instructions). The instruction does appear for the first trial, but disappears for all subsequent trials to reduce information richness further. We hypothesized that this interface would be a better fit for Caucasians who are more comfortable with uncertainty. By contrast, it might seem information-deficient in a manner that could induce anxiety for East Asians.

For East Asian users, who are less comfortable with uncertainty, we designed a *Rich* interface (Fig. 1 bottom). This is a Minimal interface augmented in four ways: (1) *Instruction repetition* – instructions continue to appear in each trial of the task; (2) *Security elements* – a university logo and an information security icon are added in the top left and right corners respectively; (3) *Background information* – a test purpose button that when clicked produces a popup containing background information including test justification, description, and scoring scheme; (4) *Learning support elements* – hovering popups for the central figure, the small nine figures, and the nine numbered buttons. These popups reinforce the instructions by clarifying what the task elements are and how users should interact with them (e.g., "*do not click on small figures*", "*click on the numbered buttons*"). The interface also contains a demo button that links to a video showing how to do the task. We postulated that this interface would provide East Asians a higher sense of control over the environment, soothing anxiety about uncertainty. By contrast, its richness might feel like a distraction from the task to Caucasians.

We presented both prototypes to the C-TOC neurologists. They reassured us that the cognitive test integrity was preserved since both designs contain the primary task elements with identical dimensions and in the same layout.

EXPERIMENT

We conducted an experiment to investigate the effects of user attitude toward uncertainty for Caucasians and East Asians while taking a self-administered cognitive test. We evaluated our two interface designs of a C-TOC subtest with the two cultural user groups.

Methodology

Primary Task

The primary task was the Symbol-Digit Matching test (Fig. 1). This is one of the 15 tasks that together form the C-TOC testing battery under development. In this task, the user needs to look at a central large figure, and search for its match out of nine smaller figures arranged in a row below it. The user then submits his/her answer by clicking on the number that corresponds to the matching small figure. This task targets the cognitive functions of attention and information processing speed, and intentionally requires the user to click on a numbered button instead of the matching figure directly.

Distractor Task

We used a within-subject design in order to expose each user to both the Rich and Minimal interfaces. Given that the task was identical for both interfaces, we sandwiched a distractor task in between conditions to reduce carryover effects. We used a 2-back working memory task [21]. This task was a good distractor because: (1) it imposes a significant demand on (wipes) working memory, providing a considerable distraction between the two conditions, and (2) it has a fixed duration so that time spent between conditions is held constant across participants, avoiding a confounding effect.

Dependent Measures

We collected data for ten measures related to anxiety, preference, performance, use of support buttons and dimensions related to uncertainty.

For **anxiety**, we measured:

(1) *General anxiety* using the State Trait Anxiety Inventory [24], a 20-item questionnaire through which users self-report their current state by indicating their dis/agreement on a 4-point Likert scale with short statements such as "*I feel at ease*", and "*I feel indecisive*".

(2) *Interface-specific anxiety* using a 4-item block in the usability questionnaire (described below), adapted from the

Unified Theory of Acceptance and Use of Technology (UTAUT) questionnaire [26] such as "*The interface was intimidating to me*" or "*I hesitated while doing the task for fear of making mistakes that I could not correct.*"

For **preference**, we measured:

(3) *Overall interface preference* via a question comparing the two interfaces at the conclusion of the study.

(4) *Usability preferences* using an 8-item usability questionnaire administered after completion of the task on each interface. This was partially adapted from the UTAUT questionnaire [26], and targeted the usability areas of effort expectancy, information richness, trust/confidence and security using 4-point Likert scale questions.

For **performance**, we measured:

(5) *Completion time*, the mean trial completion time on each interface averaged over 12 out of 15 trials. The first 3 trials were excluded as practice trials.

(6) *Response accuracy*: the correct selection of the small figure number that matches the central figure.

(7) *Error clicks* on interface elements that should not be clicked, such as the central figure or the small figures. Correct clicks include only the number buttons, the demo button or test purpose button in the Rich interface.

For **use of support buttons**, we measured:

(8) *Clicks on support buttons* (test purpose and demo buttons) in the Rich interface. (Fig. 1 bottom)

For **dimensions related to uncertainty of**, we measured:

(9) *Hofstede's uncertainty avoidance score*, calculated using the uncertainty avoidance portion of the Hofstede 2008 Values Survey Module, which solicits user opinion about statements such as "*Children must be taught to be organized and avoid ambiguity*".

(10) *Behavioral inhibition score*, measured using the behavioral inhibition part of the BIS/BAS scale [3], where users evaluate items such as "*I worry about making mistakes*".

Participants

After piloting the study with 6 young HCI research colleagues and 1 adult over 55, we recruited 20 Caucasian participants (mean age = 64.7 yrs., 14 female). They were from Canada (10), the USA (4), the UK (4) and Germany (2), and had lived in Canada an average of 51 years. We recruited 16 East Asian participants (mean age = 64.4 yrs., 10 female). One participant came from Japan, the rest from China. They had been living in Canada for an average of 40 years, and all had lived the first 18 years of their lives in East Asia. Research in cultural psychology suggests that our East Asian participants would identify more with Eastern culture despite living in the West for a long time since they had spent their formative years (pre-adulthood) in the East. For example, Cheung et al. found that Canadian immigrants from Hong Kong did identify with western culture the longer they were exposed to it, but only if exposure occurred during formative years [4].

All participants culturally self-identified as Caucasian or East Asian. They were all over 55 years old, free of diagnosed cognitive impairments, and comfortable with English. We recruited 20 Caucasian participants through flyers posted through the city, Craigslist advertising, and information booths setup in senior or community centers. These means were not sufficient to recruit our target of 20 East Asian participants over 55, which led us to rely on the personal networks of our research colleagues. Half of the East Asian sample (8/16) in the end consisted of individuals recruited through our research network. The difference in familiarity with the researcher in this sample proved to have some repercussions on our results, as we explain later.

Design

We used a 2x2 design with a single exposure to each interface condition. Our factors were *ethnicity* (between subject: Caucasian or East Asian), and *interface* (within subject: Rich or Minimal). Order of presentation of interface was fully counterbalanced.

Procedure

We met participants at a place of their choosing such as public libraries, coffee shops, community centers, and private homes. We told them that they would go through a self-administered computer application for about 30 minutes. We encouraged them to go through the application independently and to only ask for assistance as a last resort.

We began the prototype with instructions for interaction alongside an overview of the various components. Next, we administered the uncertainty avoidance and behavioral inhibition questionnaires. After that, we showed a 20-second video of a beach at sunset in order to calm users before exposure to the first interface condition.

We then presented the Rich or Minimal interface where users did a block of 15 trials with each interface. We administered the State Trait Anxiety Inventory immediately after exposure to the interface in order to get the most accurate measure of anxiety as a result of interaction. Next, we administered the usability questionnaire for the first interface condition. Next we presented the distractor cognitive task (users were not told it was a distractor). Users did two trials of this task. Next, we showed a relaxing video before presenting the second interface condition, followed by the anxiety inventory and the usability questionnaire. At the end of the prototype, we administered the interface comparison questionnaire.

A short open structure interview was conducted at the conclusion of the study to discuss user experience and comments. After that, participants were provided with a small monetary sum as compensation. The study administrator was a young male Middle Eastern researcher.

Apparatus

We used a MacBook Pro laptop with Mac OS X Lion 10.7.5 operating system. The experiment prototype was developed in HTML and JavaScript and was run on Mozilla Firefox 16.0.2. Participants interacted with the prototype using the laptop keyboard and a Logitech optical scroll mouse. Videos were hosted on YouTube.

Both the Rich and Minimal interfaces were implemented on an 800x600 pixel layout so no scrolling was needed. The primary task elements (central figure, nine small figures and nine numbered buttons) occupied identical positions on both interfaces and matched in size, color and resolution. The four additional elements in the Rich interface were placed in between the primary task elements so that spatial relationships were preserved in both interfaces.

Hypotheses

Our main hypotheses can be summarized as follows:

H1-Anxiety: East Asians will experience less anxiety with the Rich than the Minimal. Caucasians will experience less anxiety with the Minimal than the Rich, or no difference.

H2-Preference: East Asians will prefer using the Rich interface and Caucasians will prefer the Minimal interface.

H3-Performance: East Asians will perform better on the Rich than the Minimal. Caucasians will perform better on the Minimal than the Rich.

H4-Use of support buttons: On the Rich interface, East Asians will use support buttons more than Caucasians.

H5-Attitude toward uncertainty: East Asians will have higher uncertainty avoidance and behavioral inhibition scores than Caucasians.

RESULTS

After performing a preliminary ANOVA analysis, we surprisingly found that East Asians as whole experienced less general anxiety than Caucasians across interfaces ($p < .05$), contradicting the cultural theories. We suspected that differences in familiarity with the researcher for East Asians affected experience of anxiety, and possibly other measures of interest. As mentioned earlier, we had to resort to personal networks of our research colleagues to build our East Asian sample, as public recruitment had proved insufficient. Consequently, our East Asian sample consisted of two equal-sized subgroups differing in level of familiarity with the researcher administering the study: *East Asian Strangers* (recruited through public ads, n=8, 6 female, mean age=64.1 yrs, mean time in Canada=38.2 yrs.) and *East Asian Acquaintances* (recruited through networking, n=8, 4 female, mean age = 64.7 yrs, mean time in Canada=41.8 yrs.). On the other hand, Caucasians were all strangers to the researcher and none were recruited through personal networks.

Analysis on the East Asian sample showed that East Asian Strangers experienced significantly more anxiety on the Minimal than the Rich ($F_{1,14} = 3.99$, $p < .05$), whereas Acquaintances felt relatively no anxiety on either interface. This difference in experience of anxiety confirmed the confounding effect of familiarity with the researcher on anxiety between East Asian Acquaintances on one hand (knew researcher indirectly) and the Caucasians or East Asian Strangers on the other (did not know researcher at all), so we decided to exclude the former from the analysis. In the primary analysis, which we describe next, we compare Caucasians to only those East Asians who shared the same level of familiarity with the researcher. Luckily, order of presentation of interfaces was counterbalanced for the East Asian Stranger subgroup.

Primary analysis: Caucasians vs. East Asian Strangers

We performed a 2x2 mixed model ANOVA using *ethnicity* (20 Caucasian and 8 East Asian) and *interface* (Rich and Minimal). All results reported here are effects of ethnicity and/or interface. Order of presentation had no significant effect on any of the results reported here.

All measures were checked for normality. Completion time and overall anxiety were positively skewed, so we performed a log transform prior to the ANOVA in order to normalize the data. Data of self-reported Likert-scale measures, such as usability questions, were also not normal. For those measures, we performed the Align Transform Rank (ART) procedure prior to the ANOVA in order to normalize the data and enable interaction analysis [28]. Since the data was transformed prior to analysis, the graphs of our raw data results do not show error bars.

Pairwise comparisons on significant interactions were performed using a Bonferroni correction to protect against type I error. We report on measures that were significant ($p < .05$). Additionally, we report observed power and partial eta-squared (η^2), a measure of effect size, where 0.01 is a small effect size, 0.06 is medium, and 0.14 is large [7].

General anxiety: East Asian Strangers were less anxious on the Rich than the Minimal, and were less anxious on the Rich than Caucasians. Scores on the State Trait Anxiety Inventory showed an interaction of ethnicity and interface ($F_{1,26} = 7.831$, $p < .01$, $\eta^2 = .231$, power = .768). Pairwise comparisons showed that East Asian Strangers were less anxious on the Rich than the Minimal ($p < .05$), and that they were less anxious than Caucasians on the Rich ($p < .05$) (Fig. 2). This partially supported H1; no difference was found in interface-specific anxiety.

As mentioned earlier, East Asian Acquaintances showed no significant difference in general anxiety between interfaces (Mean/Std on Rich=3.8/1.8; Mean/Std on Minimal=4.7/1.3).

Overall interface preference: East Asian Strangers preferred the Rich interface, and Caucasians preferred the Minimal interface or had no preference. Responses to the overall preference question on the interface comparison questionnaire showed a significant main effect of ethnicity ($F_{1,26} = 4.31$, $p < .05$, $\eta^2 = .142$, power = .516). 5 out of 8 East Asian Strangers preferred the Rich to the Minimal. By

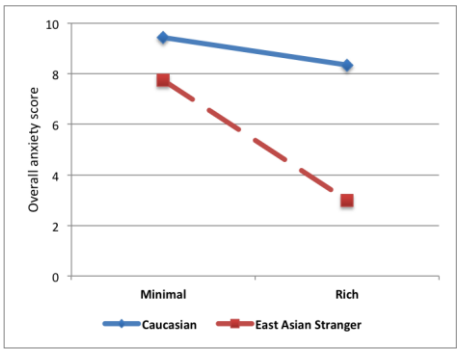

Figure 2. General anxiety score for Caucasians and East Asian Strangers. (*N* = 28)

contrast, 16 out of 20 Caucasians preferred the Minimal interface or had no preference. (Fig. 3a)

Qualitative comments revealed that 4 out of 8 East Asian Strangers weighed security elements in their preference for the Rich interface, explaining that they rendered it more "*legitimate*" and "*professional*". By contrast, only 3 out of 20 Caucasians mentioned security as a factor influencing interface preference. Almost half (9 out of 20) specifically mentioned lack of perceived "clutter" as one of the reasons for their preference. Altogether, this partially supported H2. In order to understand these preferences, we looked at user feedback on the usability areas of effort expectancy, information richness, trust/confidence and security.

Usability preference (effort expectancy): East Asian Strangers found the Rich easier to use than the Minimal. In terms of the Minimal interface, Caucasians found it easier to use than East Asian Strangers. Responses to the question "*I found the test interface easy to use*" showed a significant interaction of interface and ethnicity ($F_{1,26}$ = 18.129, p < .01, η^2 = .393, power = .984). Pairwise comparisons showed that East Asian Strangers found the Rich interface easier to use than the Minimal (p < .01), and that Caucasians found the Minimal interface easier to use than East Asian Strangers (p < .01). (Fig. 3b) Thus effort expectancy might be one factor that explains the overall preference finding above.

Usability preference (trust/confidence): Caucasians were more trusting of the research than East Asian Strangers, and trust was higher on the Rich interface. Responses to the question "*I have confidence in the legitimacy of the research team which designed the interface*" showed a main effect of ethnicity ($F_{1,26}$ = 7.501, p < .05, η^2 = .211, power = .753), and a main effect of interface ($F_{1,26}$ = 7.158, p < .05, η^2 = .204, power = .733) (Fig. 3c). This result proved important in understanding recruitment problems we had faced with East Asians and the variation in attitudes toward uncertainty between the two cultural groups, but cannot be used directly to explain the overall preference finding.

Usability preference (security and information richness): no effect of ethnicity on either. No quantitative difference was found in these two usability areas.

Performance: No effects of ethnicity on performance. Mean completion time showed no effect of ethnicity or interface. Data for response accuracy and error clicks showed a ceiling effect, where participants performed well on both interfaces with very few incorrect answer choices and few error clicks. H3 was not supported.

Use of support buttons: No quantitative evidence of ethnicity effect on use of support buttons. On the Rich interface, no participant clicked on the test purpose button, and only 1 East Asian Stranger clicked on the demo button, resulting in no significant difference with regard to use of support buttons. H4 was not supported quantitatively.

Qualitatively however, 5 out of 8 East Asian Strangers indicated they weighed support buttons in their interface preference, whereas only 2 out of 20 Caucasians indicated appreciation for this additional support.

Attitude toward uncertainty: no cultural difference found in uncertainty avoidance or behavioural inhibition scores, but the two scores were correlated. Contrary to H5, no significant difference was found between the two cultural groups in uncertainty avoidance score ($F_{1,26}$ = .860, p = .36, η^2 = .035, power = .145) or behavioural inhibition score ($F_{1,26}$ = 2.319, p = .14, η^2 = .088, power = .310), although East Asian Strangers scored higher on both. We reflect on the low observed power of these tests later. We computed the Pearson product-moment correlation coefficient for the two

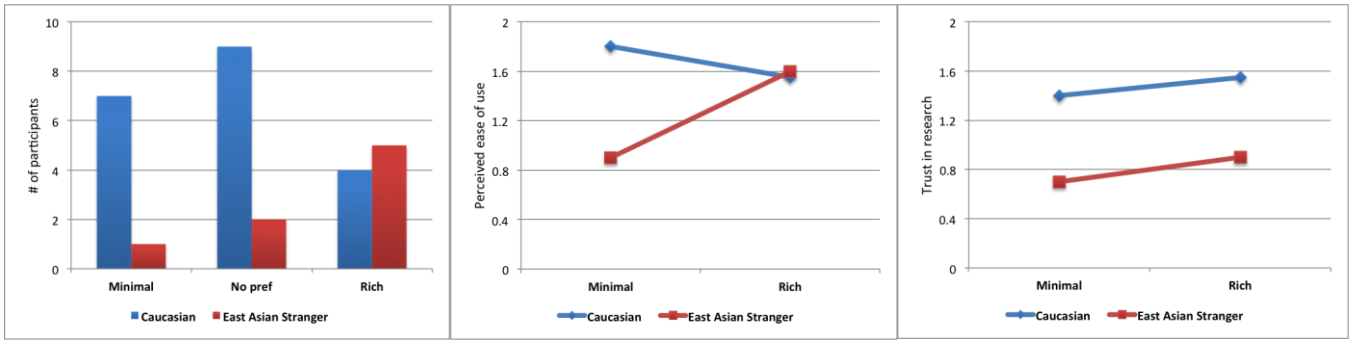

Figure 3. Caucasian and East Asian Stranger results for (a) overall interface preference (b) perceived effort expectancy (c) trust in research. (*N* = 28)

scores and found they were positively correlated ($r = .468$, $n = 28$, $p < .05$).

Summary of Hypotheses

H1-Anxiety: East Asians will experience less anxiety with the Rich than the Minimal. Caucasians will experience less anxiety with the Minimal than the Rich, or no difference. Partially supported. East Asians did have less general anxiety using the Rich than the Minimal. No differences in interface specific anxiety were found however. Caucasians experienced no difference in anxiety for the two interfaces.

H2-Preference: East Asians will prefer using the Rich interface and Caucasians will prefer the Minimal interface. Partially supported. East Asians preferred the Rich interface. However, Caucasians preferred the Minimal or had no preference.

H3-Performance: East Asians will perform better on the Rich than the Minimal. Caucasians will perform better on the Minimal than the Rich. Not supported; participants performed well on both interfaces.

H4-Use of support buttons: On the Rich interface, East Asians will use support buttons elements more than Caucasians. Not supported quantitatively; only one participant clicked on one button.

H5-Attitude toward uncertainty: East Asians will have higher uncertainty avoidance and behavioral inhibition scores than Caucasians. Not supported quantitatively, but low statistical power makes this result questionable.

Secondary Analysis using Uncertainty Avoidance Score

Since we did not get the expected mapping between ethnicity and Hofstede's uncertainty avoidance, we wanted to explore whether uncertainty avoidance had any effect on our primary dependent measures of anxiety and preference. We performed a secondary analysis using uncertainty avoidance (UA) grouping, ignoring ethnic group. The full sample was divided into groups based on their uncertainty avoidance score resulting in 3 groups for Low, Med and High UA. The average UA score was -4.2 for Low ($n = 10$), 0.9 for Med ($n = 12$) and 4.1 for High ($n = 14$). We chose this division over equal-sized groups since the latter would have resulted in individuals with the same UA score being placed in different groups. We performed a 2x2 mixed model ANOVA on the dependent measures of the primary analysis using *UA groups* (Low, Med and High) and *interface* (Rich and Minimal). We report on the same parameters as the primary analysis, with the addition of the Scheffé post hoc test when a main effect of UA groups is found. We report only on the measures that showed significant differences. These results should be seen as preliminary given that UA grouping was not a controlled factor in our experimental design.

Usability preference (security): High UA users noticed the university logo more than low UA users. Responses to the question "*I noticed the logo of the University on the webpage (of the Rich interface)*" showed a main effect of UA grouping ($F_{1,33} = 4.52$, $p < .05$, $\eta^2 = .215$). Post hoc analysis showed that high UA users noticed the university logo more readily than the low UA users ($p < .05$). Most high UA users (11 out of 14) indicated they noticed the university logo, whereas most low UA users (7 out of 10) indicated they were either not sure or that they did not notice it at all.

Usability preference (information richness): Low UA users found interfaces to have unnecessary information more so than high UA users did. Responses to the fill-in-the-blank question "*The information provided in the interface was {not enough, just right, too much} to do the task*" showed a main effect of UA grouping ($F_{1,33} = 3.23$, $p < .05$, $\eta^2 = .155$). Post hoc analysis showed that low UA users felt interfaces had "*too much information*" more than high UA users ($p < .05$).

Interface-specific anxiety: High and Medium UA users felt more anxious during the task than low UA users. Responses to the question "*I felt anxious while doing the task*" showed a main effect of UA grouping ($F_{1,33} = 3.71$, $p < .05$, $\eta^2 = .184$). Post hoc analysis showed that on both interfaces, low UA users felt less anxious than both high and med UA ($p < .05$ for both). No difference was found in general anxiety.

DISCUSSION

Reflection on results

Preference: We detected a cultural difference in preference that partially met our hypothesis. In terms of usability areas, we detected a cultural difference in effort expectancy and trust, but not in information richness or security. Perhaps having only one item in the usability questionnaire for each of these areas limited our power to detect a quantitative difference. Qualitatively, however, we found evidence of a cultural contrast. East Asians indicated weighing security elements in their preference for the Rich interface, even though they were iconic of security and not functional. On the other hand, Caucasians indicated that the lack of perceived clutter tipped their preference toward the Minimal interface. This implies that varying information richness to align with cultural attitude toward uncertainty likely has merit.

Performance: Our performance hypothesis was not supported, as we found no significant difference in performance between ethnicities or interfaces. This is actually good news for C-TOC as having cultural variations in performance could have serious implications on its integrity as a cognitive test. On the other hand, doing 30 trials of a cognitive task may not have provided enough time to allow for variations in performance; going through the full cognitive test battery would be more taxing and might create a larger variation in performance, especially with other C-TOC subtests that have a richer answer space. Moreover, our participants were likely less preoccupied with the implications of cognitive testing than "real" C-TOC test-takers will be, as we focused on usability in our study rather than the cognitive aspects of C-TOC.

Use of support buttons: Our hypothesis about use of support buttons did not receive quantitative support either, as we witnessed only one East Asian participant clicking on the demo button, and no one clicked on the test purpose button. In retrospect this is not surprising, as participants may have thought that their time "off task" would count towards their performance. Our qualitative findings do show that a greater proportion of East Asians than Caucasians appreciated such elements and weighed them in their preference of the Rich interface. This implies that these elements provided a sort of cognitive cushion [20], reassuring users by their presence. This aligns with our design vision that the richness of the interface provides East Asians with a sense of control over the interaction environment through support elements, soothing anxiety about uncertainty.

Anxiety: We detected a cultural difference in general anxiety that matched our hypothesis. While Caucasians exhibited no difference in anxiety on the two interfaces, East Asians were less anxious on the Rich interface than the Minimal. Again, it is possible that security and support elements appeased their anxiety on the Rich interface, as qualitative comments showed that East Asians weighed those elements in their preference for the Rich interface. On the other hand, these elements seemed less valuable to Caucasians, and did little to alter their anxiety experience on the two interfaces.

Reflection on cultural attitude toward uncertainty

Our hypothesis about differences in uncertainty avoidance score between Caucasians and East Asian Strangers was not met. This was surprising, but could be explained partially by the low observed power of our statistical test (.145). It may also be a result of our participants belonging to the subculture of East Asians who had spent their formative years in Asia, but lived in Canada afterwards (compared to those who lived in Asia all their lives). However, we gleaned from our informal conversations with participants that East Asians are less comfortable with uncertainty. First, we learned that East Asians in general have less affinity to participate in research given our findings on confidence in research (Fig. 3c). Second, we noticed that East Asian participants were generally more apprehensive of the study context than Caucasians. For instance, 3 of the East Asian Strangers in the study asked for proof of identity before meeting the researcher, while no Caucasian asked for any such information. This implies a stronger aversion to uncertainty among East Asians than Caucasians.

Our struggle in recruiting East Asian participants over a long period of time indicates that they might indeed avoid participating in research. We began recruiting from both cultural groups simultaneously using public advertisements. While we succeeded in reaching our Caucasian quota of 20 after only about 1.5 months, it took 3 months to recruit 8 East Asian participants in a city where they constitute about 25% of the population. Expanding our public recruitment artillery, by setting information tables or participating in activities with seniors to build rapport, did little to help. The futility of public recruitment with East Asians led us to consider contacting acquaintances of our research network. We still could not reach our East Asian quota of 20 within a reasonable timeframe. This struggle to reach our East Asian recruitment target further implies relative discomfort in unfamiliar contexts.

As with all research, we faced the problem of self-selection to participate, but this had a larger impact on East Asian recruitment, as this group was relatively less accessible in our cultural investigation. The reason we suspect Hofstede managed to detect a difference in uncertainty avoidance scores between the East and West was that he had the rare opportunity of avoiding the problem of self-selection; he was an IBM researcher requesting international IBM employees to participate in work-mandated research. By contrast, we lacked that privilege.

In sum, this suggests that our findings related to Hofstede's uncertainty avoidance are conservative. This is due in part to the intrinsically challenging dilemma of studying uncertainty avoidance: how can we investigate a phenomenon whose presence in a culture discourages participation in research in the first place? The East Asian Stranger participants we recruited were probably less uncertainty avoidant than the average East Asian person whom we struggled to recruit because the latter avoids participating in research altogether.

Design implications

We provide some design guidelines for C-TOC, and similar multicultural design contexts for older adults characterized by uncertainty. For older East Asians, we recommend information rich interfaces augmented with security elements and learning support. We found that such elements are especially important when anxiety is likely during interaction. Our secondary analysis showed that high UA users are more likely to feel anxious, and are more tolerant of information richness than low UA users. For older Caucasians, minimal interfaces are more appropriate, as these users mainly attend to the primary task elements. Catering to cultural preferences may increase willingness across cultures to use C-TOC. We imagine C-TOC could develop to become a cultural adaptive interface similar to Mocca [22], where a culturally adaptive version would be presented after collecting a modest amount of cultural data.

CONCLUSION AND FUTURE WORK

Our design and evaluation of cultural interfaces show that there is some validity in culturability. Varying the information richness of an interface based on uncertainty avoidance impacted the experience of two ethnic groups with differences on 1) interface preference, 2) perceived effort expectancy, and 3) anxiety. East Asians leaned towards an information rich interface on all these measures whereas Caucasians showed no difference or leaned towards information minimal. The cultural difference in UA was not detected, but the test was underpowered. Catering to cultural preferences – in the case of C-TOC at least – may increase the likelihood to use a technological solution across cultures.

However, it proved hard for us to attribute the cultural preference to one measure of attitude toward uncertainty, such as Hofstede's uncertainty avoidance, as it was deficient on its own in explaining the cultural variation.

We envision other paths to further this research. *Translating the study prototype* might expand the pool of recruitment as we found a population of older East Asians who could not manage the level of conversational English of our prototype. Finally, *running the study online remotely* could help us mitigate the recruitment challenges we faced. While it might result in a less controlled study environment, it could extend our reach to users across cultures.

REFERENCES

1. Barber, W., & Badre, A. (1998). Culturability: The merging of culture and usability. *Proc. of the 4th Conference on Human Factors and the Web*, 1–14.
2. Brehmer, M. M. (2011). Usability and the effects of interruption in C-TOC: Self-Administered Cognitive Testing on a Computer. *M.Sc thesis*. University of British Columbia.
3. Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology*, *67*(2), 319–333.
4. Cheung, B. Y., Chudek, M., & Heine, S. J. (2011). Evidence for a sensitive period for acculturation: Younger immigrants report acculturating at a faster rate. *Psychological Science*, *22*(2), 147–152.
5. Choi, B., Lee, I., Kim, J., & Jeon, Y. (2005). A qualitative cross-national study of cultural influences on mobile data service design. In *Proc. of CHI 2005* (pp. 661–670).
6. Clemmensen, T., Hertzum, M., Hornbæk, K., Shi, Q., & Yammiyavar, P. (2009). Cultural cognition in usability evaluation. *Interacting with Computers*, *21*(3), 212–220.
7. Cohen, J. (1973). Eta-squared and partial eta-squared in communication science. *Human Communication Research*, *28*, 473–490.
8. Cyr, D., Bonanni, C., & ilsever, J. (2004). Design and e-loyalty across cultures in electronic commerce. In *Proc. of 6th Int'l Conference on Electronic Commerce* (pp. 351–360).
9. Darke, S. (1988). Anxiety and working memory capacity. *Cognition & Emotion*, *2*(2), 145–154.
10. De Angeli, A., & Kyriakoullis, L. (2006). Globalisation vs. localisation in e-commerce: cultural-aware interaction design. In *Proc. of the Working Conference on Advanced Visual Interfaces* (pp. 250–253).
11. Frandsen-Thorlacius, O., Hornbæk, K., Hertzum, M., & Clemmensen, T. (2009). Non-universal usability?: A survey of how usability is understood by Chinese and Danish users. In *Proc. of CHI 2009* (pp. 41–50).
12. Heine, S. J. (2007). *Cultural Psychology* (1st ed.). W. W. Norton & Company.
13. Hofstede, G. (1980). *Cultures Consequences : International Differences in Work-Related Values* (Abridged.). SAGE Publications, Inc.
14. Jhangiani, I., & Smith-Jackson, T. (2007). Comparison of mobile phone user interface design preferences: perspectives from nationality and disability culture. In *Proc. of the 4th Int'l Conference on Mobile Technology, Applications, and Systems* (pp. 512–519).
15. Kitayama, S., Duffy, S., Kawamura, T., & Larsen, J. T. (2003). Perceiving an object and its context in different cultures: A cultural look at new look. *Psychological Science*, *14*(3), 201–206.
16. Lee, I., Choi, G. W., Kim, J., Kim, S., Lee, K., Kim, D., Han, M., Park, S., An, Y. (2008). Cultural dimensions for user experience: cross-country and cross-product analysis of users' cultural characteristics. In *Proc. of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction - Volume 1* (pp. 3–12).
17. Marcus, A. (2010). Cross-cultural user-interface design for work, ho play, and on the way. In *ACM SIGGRAPH ASIA 2010 Courses* (pp. 5:1–5:160).
18. Merritt, S., & Bardzell, S. (2011). Postcolonial language and culture theory for HCI4D. In *Proc. of CHI 2011, Extended Abstracts* (pp. 1675–1680).
19. Miyamoto, Y., Nisbett, R. E., & Masuda, T. (2006). Culture and the physical environment. *Psychological Science*, *17*(2), 113 –119.
20. Nekrasovski, D., Bodnar, A., McGrenere, J., Guimbretière, F., & Munzner, T. (2006). An evaluation of pan & zoom and rubber sheet navigation with and without an overview. In *Proc. of CHI 2006* (pp. 11–20).
21. Owen, A. M., McMillan, K. M., Laird, A. R., & Bullmore, E. (2005). N-back working memory paradigm: A meta-analysis of normative functional neuroimaging studies. *Human Brain Mapping*, *25*(1), 46–59.
22. Reinecke, K., & Bernstein, A. (2011). Improving performance, perceived usability, and aesthetics with culturally adaptive user interfaces. *ACM Trans. Comput.-Hum. Interact.*, *18*(2), 8:1–8:29.
23. Shuper, P. A., Sorrentino, R. M., Otsubo, Y., Hodson, G., & Walker, A. M. (2004). A theory of uncertainty orientation. *Journal of Cross-Cultural Psychology*, *35*(4), 460 –480.
24. Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). Manual for the state-trait anxiety inventory. Retrieved from http://ubir.buffalo.edu/xmlui/handle/10477/2895
25. Tanaka, A., & Yamauchi, H. (2004). Cultural self-construal and achievement goal. *Hellenic Journal of Psychology*, *1*, 221–237.
26. Venkatesh, V., Morris, M. G., Gordon B. Davis, & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27*(3), 425–478.
27. Walsh, T., Nurkka, P., & Walsh, R. (2010). Cultural differences in smartphone user experience evaluation. In *Proc. of the 9th International Conference on Mobile and Ubiquitous Multimedia* (pp. 24:1–24:9).
28. Wobbrock, J. O., Findlater, L., Gergle, D., & Higgins, J. J. (2011). The aligned rank transform for nonparametric factorial analyses using only anova procedures. In *Proc. of CHI 2011* (pp. 143–146).