EFFECTS OF CULTURALLY ADAPTED INTERFACES ON LEARNING AND ATTITUDES: FINDINGS FROM THE HOMENETTOO PROJECT

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ABSTRACT
In the HomeNetToo project we designed user interfaces adapted to culturally influenced cognitive style and examined whether information presentations with adapted interfaces resulted in better learning and more favorable attitudes toward the information source and the interface. Participants were 161 low-income African Americans who resided in urban areas in the mid-western United States. Findings indicated that culturally adapted interfaces resulted in more favorable attitudes than the typical "magazine-style" (control) interface. Learning was enhanced when interface adaptation matched the users' cognitive style. Specifically, a 3-D spatial interface was more effective with visual/spatial learners, and an interpersonal interface was more effective with interpersonal learners. Implications for the design of technology to improve learning are discussed, the context of the paper.

KEYWORDS
Culture, cognitive style, interface design, learning

1. INTRODUCTION
HomeNetToo is a research project designed to examine the antecedents and consequences of home Internet use by low-income families in the United States (www.HomeNetToo.org; e.g., Jackson, von Eye, Biocca, Barbatis, Fitzgerald & Zhao, in press, a & b). One objective of the project is to determine whether culturally adapted user interfaces can facilitate learning in virtual environments. This report focuses on the relative efficacy of two culturally adapted interfaces - a 3-D spatial interface and an interpersonal interface, compared to a standard "magazine-style" interface on learning and attitudes toward the information source and the interface.

Researchers have begun to focus on cultural factors in the design of user interfaces (Kersten, Kersten, & Rawkowski, 2002; Okazaki & Rivas, 2002). Prompted by recognition that the globalization of the information society means greater diversity in the population of users, more attention has been turned to developing technology that can accommodate this diversity. Of particular concern is the increasing number of less educated, less technologically sophisticated individuals who will be using complex technology to perform routine tasks, such as banking and completing forms online. The design of interfaces that allow these tasks to be performed "seamlessly" has become an important goal within the design community...
How can user interfaces be designed to accommodate cultural characteristics? According to Pea (1985) and others (e.g., Biocca, 1996; Honold, 2000; Kersten, et al., 2002; Nielsen, 1990; Nielsen & Del Galdo, 1996; Norman, 1986, 1988), computer interfaces are themselves cultural artifacts that provide structures to organize users’ activity and thinking about a domain. Adapting the user interface to cultural characteristics involves transforming these structures to accommodate cultural schema. Computer interfaces offer a variety of structures that can be so adapted, namely: (1) perceptual and motor affordances; (2) semiotic and representational systems; (3) metaphors and representations linked to semantic associations; and (4) human-computer social interaction cues.

Research on adapting computer interfaces to cultural characteristics has focused on adapting semiotic and representational systems (2, above), and on modifying metaphors and representations linked to semantic associations (3, above). Most obvious among the former adaptations are adaptations to language and alphabet (Becker, 1985). Among the latter adaptations, representational conventions of pictorial and other iconic systems have been adapted to accommodate cultural differences (Nielsen, 1990; Nielsen & Del Galdo, 1996). For example, iconic representations used to symbolize function (e.g. mailboxes, wastebaskets) vary in interpretation from culture to culture, and have been readily adapted to local cultural contexts.

In the HomeNetToo project we focused on adaptations to perceptual affordances (1, above) and social interaction cues (4, above) in designing interfaces to take into account cultural influences on cognitive style. Cognitive style is defined as an individual’s preferred mode of processing information, and includes the following dimensions: sensorimotor preferences (e.g., visual, auditory, kinesthetic), semiotic (symbol system) preferences (e.g., verbal-linguistic, logico-mathematical), information manipulation preferences (e.g., convergent, divergent, assimilating and accommodating thinkers) and interpersonal and affective preferences (e.g., extraverted, introverted; Kinsella, 1995; Kolb, 1984, 1985; Reeves & Nass, 1996; Riding & Watts, 1997; Sadler-Smith, 2001; Sternberg & Grigorenko, 1997). Research suggests that individuals perform better and/or more comfortably on computer-based tasks when information presentations are compatible with their cognitive styles than when they are not (Reeves, & Nass, 1996; Turkle & Papert, 1993). Cognitive style has also been related to the extent of computer usage (Jih & Reeves, 1992), user satisfaction (Reeves & Nass, 1996), access to information databases (Tan & Lo, 1991), and the learning of spatial cognitive skills (McClurg & Chaille, 1987) and mathematics (Dugdale, 1994).

Evidence suggests that culture influences cognitive style. Within the U.S., research has focused on the cognitive styles of racial and ethnic groups, including African Americans, a focal group in the HomeNetToo project. Findings suggest that African Americans differ from White Americans on at least three of the four dimensions of cognitive style (Jackson, et. al., in press; b; Reid, 1995; Shade Kelly, & Oberg, 1997). African Americans are more visual and kinesthetic (sensorimotor preferences), prefer concrete perceptual experience to abstract experience, and prefer information embedded in an interpersonal context rather than an impersonal context (interpersonal and affective preferences), consistent with the socio-centric perspective of African Americans (Helms & Parham, 1990; Reid, 1995; Shade, 1982, 1994; Shade et al., 1997).

To create culturally adapted interfaces the HomeNetToo project design team (Media Interface and Networking Design laboratory at Michigan State University, www.MINDLAB.org) used an iterative formative evaluation approach. Culturally adapted interface was defined as an interface that: (1) makes use of the semiotic systems of the culture, including language, iconic conventions, and common genres; (2) depicts scenes that are recognizable within the culture; (3) depicts demographic and attitudinal features of characters recognizable within the culture; (4) depicts actions and dilemmas that are similar to those experienced by members of the culture. The first culturally adapted interface was the "spatial interface." It consisted of a 3-D virtual city in which health information was provided inside of five buildings. The second culturally adapted interface was the "interpersonal interface." In it an agent/avatar provided the same information as in the spatial interface. The "control" interface was a standard "magazine-style" interface. It presented the same information as in the spatial and interpersonal interfaces, but using the typical Web-page format. Details and screen captures of the three interfaces are provided in the Methods section.

Our major hypothesis was that learning would be enhanced when information was presented using a culturally adapted interface compared to a standard magazine-style interface. We also hypothesized that individual differences in cognitive style within culture would influence the efficacy of culturally adapted interfaces. Specifically, we predicted that individuals with a stronger spatial learning preference would learn better with the spatial interface, and that individuals with a stronger interpersonal learning preference would learn better with the interpersonal interface.
2. METHODS

2.1 Overview

A between-subjects experimental design was used to test the major hypothesis that culturally adapted interfaces would enhance learning and attitudes toward the information source and interface. Three levels of the independent variable, interface type, were created: a standard magazine-style (control) interface; a 3-D spatial environment interface, and an interpersonal interface. Dependent variables were how well participants learned health information and attitudes toward the information source (i.e., American Heart Institute) and the interface. Also measured were two dimensions of participants' cognitive style: spatial learning preference and interpersonal learning preference. The health topic was high-blood pressure, selected because of its importance to the African Americans community. African Americans are at high risk for high blood pressure and related diseases.

2.2 Participants

Participants were 161 African Americans (73% females) recruited from low-income neighborhoods in Detroit, Michigan (n=91) and Lansing, Michigan (n=70). Recruiting and participation took place in local community centers (e.g., Black Child and Family Institute, Lansing, MI, n=55) and churches (e.g., Generation Ministries, Detroit, MI, n=90). In addition, 15 participants were recruited from phase one of the HomeNetToo project, all from Lansing, MI. Community centers and churches were financially compensated for provided facilities and assisting with recruiting. Participants received a $25 gift certificate for their one-hour of participation.

2.3 Procedures

Research sessions began with an overview of the experiment. The participant then completed the first part of the survey (see Measures, below). Next, the participant was escorted to an adjacent room and seated on an elevated platform about 4 feet from a large rear-projection screen (3m X 2m) and at eye-level with the randomly assigned stimulus interface. The participant's facial expression was videotaped throughout the 30 minute-interaction with the interface. The participant also wore noise-cancellation headphones to filter out extraneous noise. After viewing the stimulus interface participants completed the second part of the survey (see Measures, below).

2.4 Stimulus interfaces

Three stimulus interfaces were designed to present identical textual and graphic information about high blood pressure, but using different organizational metaphors, navigation methods and adaptations to cognitive style (i.e., spatial, interpersonal or no adaptation interfaces). A summary of organization and navigation differences is presented in Table 1.

<table>
<thead>
<tr>
<th>Interface design</th>
<th>Organization and navigation</th>
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<tbody>
<tr>
<td>Magazine-style interface (control)</td>
<td>Hierarchical menu list. User clicks on a page link in the menu.</td>
</tr>
<tr>
<td>Spatial interface</td>
<td>3-D joystick navigation through thematic buildings “housing” the information. User clicks on a wall poster to open a page.</td>
</tr>
<tr>
<td>Interpersonal interface</td>
<td>Oral interaction with an agent. User verbally request information from the agent.</td>
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Information about high blood pressure was obtained from the American Heart Association Web page (2002) and divided into five sections: (1) effects; (2) consequences; (3) risks; (4) prevention through behavior change; and (5) prevention through dietary change. For all three interfaces, icons were used to represent each of these sections, as follows: (1) a book; (2) a red cross; (3) a lightning bolt; (4) a man exercising; and (5) a fork and knife. According to previous research, icons assist users in comprehension of and memory for medical and medicinal information (McDougall, de Brujin, & Curry, 2000; Morrow, Hier, Menard, & Leirer, 1998).
2.4.1 Magazine-style (control) interface

Information in the control interface was presented in standard magazine-style format. All information was presented as text or images. Participants navigated through the three layers of information by clicking on hyperlinks. Each main heading, which consisted of one or two sentences, was followed by bullet points of supplementary information. A two-dimensional picture related to each main heading was displayed adjacent to it. An illustration of the control interface is presented in Figure 1.

![Figure 1. MAGAZINE-STYLE (control) interface](image1)

2.4.2 Spatial interface

Information in the spatial interface was organized into thematic buildings similar to the top level of the hierarchical menu in the control interface. Participants navigated through a three-dimensional courtyard to select a building, which placed them within a large room inside it. Each of the five buildings in the urban setting contained posters with links equivalent to those provided at the second level of the magazine-style interface menu. Users selected a page by clicking on a poster. The page appeared in a new window, and contained the same text and images as in the other interface conditions. Figure 2 illustrates the spatial interface.

![Figure 2. SPATIAL interface](image2)
2.4.3 Interpersonal interface

The interpersonal interface contained an anthropomorphic, African-American character - an intelligent agent, "Cardie," who guided the participant through the information. The information was presented on web pages identical to those used in the control interface. At the start of the session the agent introduced herself (orally) and asked the participant to select a topic from a list of the same topics included in the other interface conditions. The participant made her/his selection with an oral request to the agent. The page containing information about that topic was then displayed, with the agent introducing the main points (but not the bulleted points) on the page. Figure 3 illustrates the interpersonal interface.

![Interpersonal Interface](image)

**Figure 3. INTERPERSONAL interface**

2.5 Measures

Part I of the survey, administered before viewing the stimulus interface (pre-measures), contained the following measures: (1) basic knowledge about blood pressure (10 items, e.g., A normal blood pressure reading is: a) 20 over 10, b) 70 over 30, c) 140 over 90, d) 200 over 100); (2) behavioral knowledge about blood pressure (10 items, e.g., Which of the following will not help to reduce high blood pressure? a) reducing sodium intake, b) eating more fruits and vegetables, c) increasing alcohol intake, d) prescribed medication from a doctor.); (3) cognitive style (i.e., spatial learning preference (20 items; Ekstrom, French, Harman & Derman, 1976) and interpersonal learning preference (5 items; e.g., I learn more when I study with a group; 1=not true of me, 5=very true of me; Kinsella, 1995).

Part II of the survey, administered after viewing the stimulus interface (post-measures), re-assessed basic and behavioral knowledge about high blood pressure (1 and 2, above), and; (3) attitudes toward the information source (American Heart Association, 3 items, e.g., I trust the American Heart Association, 1=strongly disagree, 7=strongly agree), and; (4) attitudes toward the interface (7 items, e.g., The site I just visited is enjoyable, 1=strongly disagree, 7=strongly agree).

3. RESULTS

For each participant the following measures were computed: (1) number of correct answers to basic knowledge questions and number of correct answers to behavioral knowledge questions about high blood pressure pre- and post-stimulus interface (maximum score for each measure is 10); (2) pre-post difference scores for basic and behavioral knowledge; (3) composite measure (average) of attitudes toward the
information source, and; (4) composite measure of attitudes toward the interface. All composite measures evidenced good reliability (.80<alpha<.93). Also computed were composite scores for spatial learning preference and interpersonal learning preference (M=3.34). The spatial learning preference score was computed by summing the number of correct (scored "1") and incorrect items (scored "-1") out of 160 items (i.e., maximum score is 160, minimum score is -160, M=36.88). The interpersonal learning preference score was the average of 5 items (where "5" indicates a stronger interpersonal learning preference, alpha=.70).

One-way analyses of variance (ANOVAs) were used to test the major hypothesis that participants would learn more with culturally adapted interfaces than with the control (magazine-style) interface. The hypothesis was not supported for measures of basic knowledge or behavioral knowledge about high blood pressure. Scores on both of these measures increased from pre- (Ms=5.30, 5.42, out of 10 maximum point) to post-stimulus interface presentation (Ms=6.39, 6.21, respectively), indicating significant learning, regardless of which interface was used to present information. (Note that the three stimulus interface groups were equivalent on both measures prior to the presentation, that is, there were no confounding pre-stimulus differences among groups).

However, a main effect of interface type was obtained on attitudes toward the information source (American Heart Institute), F(2,158)=6.14, p<.05. Participants in the culturally adapted interface conditions had more favorable attitudes (Ms=6.02, 6.30, for spatial and interpersonal interfaces, respectively) than did those in the control interface condition (M=5.54). There was no difference between the spatial and interpersonal interface conditions on this measure.

Next, we tested the prediction that individual differences in cognitive style would influence the efficacy of culturally adapted interfaces. Quartile splits were used to categorize participants into four spatial learning preference groups and four interpersonal learning preference groups. Two-factor ANOVAs (3 levels of stimulus interface X 4 levels of cognitive style) were used to examine main and interactive effects of cognitive style.

Main effects of spatial learning preference group indicated that participants who had a stronger spatial learning preference performed better on both basic knowledge, F(3,149)=2.62, p<.05, and behavioral knowledge tests, F(3,149)=4.62, p<.01, after the stimulus interface presentation than did participants with a lesser preference for spatial learning. However, a spatial learning preference group by stimulus interface interaction qualified this effect for behavioral knowledge, F(6,149)=1.95, p<.08. The lowest spatial learning preference group performed more poorly (M=4.61) than did the higher spatial learning preference groups (Ms=6.35, 6.81, 6.21) in the control interface condition only (p<.05). There were no differences among the spatial learning preference groups after viewing the interpersonal interface. After viewing the spatial interface, the highest spatial learning preference group performed better on the test of behavioral knowledge (M=7.06) than did the other three groups (Ms=6.09, 6.29, 6.19). Thus, learning was maximized when the interface was adapted to the learner's spatial learning preference dimension of cognitive style.

An interaction between spatial learning preference group and stimulus interface was also obtained on attitudes toward the information source, F(6,149)=2.24, p<.05. While all groups had similar and least favorable attitudes in the control interface condition (Ms=5.28, 5.55, 5.73, 5.69, lowest to highest spatial learning preference group), groups with a lower preference for spatial learning had less favorable attitudes (M=5.49, 5.78) than did higher spatial learning preference groups (Ms=6.22, 6.47) when the interface was spatial, but not when it was interpersonal (Ms=6.18, 6.88, 6.35, 6.03). Thus, participants with a lesser preference for spatial learning benefited from an interpersonal interface, but not from a spatial interface, insofar as attitudes toward the information source are concerned.

Analyses of main and interactive effects of the interpersonal learning preference groups revealed a marginally significant interaction on attitudes toward the information source, F(6,149)=2.02, p<.07. Participants in the two highest interpersonal learning preference groups had the most favorable attitudes when the stimulus interface was interpersonal (6.96, 6.32), compared to when it was spatial (5.62, 5.94) or control (5.30, 5.35). Participants with a lesser preference for interpersonal learning were equally favorable in their attitudes after viewing the spatial (6.06, 6.44) and interpersonal interfaces (6.38, 5.81), and more favorable after viewing these culturally adapted interfaces than after viewing the control interface (5.46, 6.05).
4. DISCUSSION

Findings from the HomeNetToo project indicate that culturally adapted interfaces can benefit learning in virtual environments. Interfaces adapted to culturally-influenced cognitive style resulted in more favorable attitudes toward the information source than did the standard "magazine-style" interface. Moreover, culturally adapted interfaces produced better learning when they matched the user's cognitive style than when they did not. Individuals with a strong spatial learning preference learned best when a 3-D spatial interface was used to present the information. Individuals with a strong interpersonal learning preference performed best when information was presented using an interpersonal interface.

Evidence that culturally adapted interfaces produced better learning only when they also matched the user's cognitive style suggests that both cultural and individual characteristics should be considered in designing the user interface. Within cultures individuals will vary in a variety of characteristics that may be relevant to interface design. Research has thus far focused on personality and, with our research, on cognitive style. Future research is needed to identify both individual and cultural characteristics that can be mapped to features of interface design (e.g., perceptual and motor affordances, human-computer social interaction cues) in ways that will optimize learning. Findings from such research could be used to develop a set of guidelines for user-oriented design of immeasurable benefit to education, job-training and e-commerce (Baecker, Grudin, Buxton, & Greenberg, 1996; Biocca, 1996; Green, Davies, & Gilmore, 1996; Nickerson, 1995; Norman, 1986, 1988; Rudasill, Lewis, Polson, & McKay, 1996; Schneiderman, 1992).

The somewhat limited effects of culturally adapted interfaces on learning in our research may be attributable to the limited amount of time and information available to our participants. The entire experimental session lasted only about one hour, only a portion of which was devoted to interacting with the interface. Moreover, at no time were participants explicitly instructed to "learn" the information. It may be that learning that occurs over a more extended period of time with explicit instructions to learn will benefit more culturally adapted interfaces than the "one-shot" incidental learning that occurred in our experiment. Future research using a series of learning activities presented by culturally adapted interfaces will provide a more rigorous test of their effects on learning and related outcomes (e.g., attitudes).

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