Cognitive style and interface design: findings from the HomeNetToo project

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Abstract

In the HomeNetToo project we designed alternative user interfaces and examined whether interface design and user's cognitive style independently and/or interactively influenced learning and attitudes about health information (www.HomeNetToo.org, NSF-ITR #085348). Participants were 161 low-income African Americans who resided in urban communities in the midwestern United States. Findings indicated that: (1) interface design influenced attitudes about the source of health information; (2) Cognitive style influenced intentions to use the health information presented in the interface and evaluations of the interface; (3) Gender was related to cognitive style; (4) Participants significantly increased their basic and behavioral knowledge about high blood pressure by viewing the interface presentation, regardless of interface type, cognitive style or gender. Implications for the design of technology to enhance learning are discussed.

Keywords: cognitive style, interface design, learning.

1 Introduction

Cognitive style is defined as an individual’s culturally attuned ways of perceiving, organizing, remembering and evaluating information [1]. It is the individual’s preferred mode for perceiving and processing information about the social and physical world [2]. Although some researchers argue for a distinction between cognitive style and learning style, most agree that the two constructs share the following core assumptions: (1) Individuals differ in how they seek, model, and learn information from the environment; (2) Individual differences are systematic and reflect stable differences in perceptual and processing preferences; (3) Individuals tend to selectively absorb, use, and manipulate
information presented in a manner that matches their cognitive style, and avoid or ignore information presented in a manner that does not match their cognitive style; (4) Individuals perform better at cognitive tasks when information presentations match their cognitive style than when they do not [3-14].

A growing body of evidence suggests that adapting the information technology (IT) interface to user characteristics and preferences (e.g., personality, affective preferences) affects a variety of important outcomes in computer-mediated environments (e.g., performance, affect; [15-28]). In particular, adapting the interface has been shown to influence user satisfaction and motivation for computer-mediated activities, computer usage, access to information databases, attention to information, and the learning of computer programs and spatial cognitive skills [29-35]. However, studies vary considerable with respect to the quality of research design and hence in the confidence we can place in their conclusions.

In the HomeNetToo project we designed user interfaces adapted to two dimensions of cognitive style: visual preferences and interpersonal preferences. Kolb’s Learning Styles Inventory [36] was used to measure the perceptual and processing preference dimensions of cognitive style. An experiment examined whether cognitive style and interface design, independently and interactively, would influence learning and attitudes about health information presented in the interface.

2 Methods

Three levels of interface design were created: a 3-D spatial interface, an interpersonal interface and a "magazine-style" (control) interface. Two levels of perceptual style and two levels of processing style were created by median splits on Kolb’s Learning Style Inventory. Three by two multivariate and univariate analyses of variance (ANOVAs) were used to examine main and interactive effects of perceptual/processing style preferences and interface design on the following dependent measures: changes in basic and behavioral knowledge about high blood pressure (i.e., pre-post difference scores); attitudes about the information source (i.e., American Heart Institute), intentions to use information presented in the interface, evaluations of the interface.

2.1 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 participation.
2.2 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 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 interface participants completed the second part of the survey (see Measures, below).

Table 1: Experimental interfaces.
2.3 Interface design

Three 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. Snapshots of the three interfaces are presented in Table 1.

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, respectively: (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).

2.3.1 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 (Table 1).

2.3.2 Three-dimensional spatial interface

Information in the 3-D 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. 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 (Table 1).

2.3.3 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 (Table 1).
2.4 Measures

Part I of the survey, administered before viewing the interface, 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) Kolb’s Learning Styles Inventory [36].

The Kolb inventory consists of ten items, each having four choices about preferred ways to learn. Scoring is based on Cartesian coordinates of Active Experimentation (doing) versus Reflective Observation (watching) on the x-axis, and Concrete Experience (experiencing) versus Abstract Conceptualization (thinking) on the y-axis. The coordinates yield two scores, one for the perceptual style preference dimension (y-axis, Abstract Conceptualization plus Concrete Experience) and one for the processing style preference dimension (x-axis, Active Experimentation plus Reflective Observation). High scores on the perceptual style dimension indicate a preference for perceiving by abstract conceptualization and low scores indicate a preference for perceiving by concrete experience. High scores on the processing style dimension indicate a preference for processing by reflective observation and low scores indicate a preference for processing by active experimentation.

Part II of the survey, administered after viewing the interface, reassessed basic and behavioral knowledge about high blood pressure (1 and 2, above), plus: (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); (4) intentions to use the information about high blood pressure (19 items, e.g., I will eat a healthy diet. 1=strongly disagree, 7=strongly agree); and (5) evaluations of the interface (7 items, e.g., The site I just visited is enjoyable, 1=strongly disagree, 7=strongly agree. Demographic information was also obtained (e.g., gender).

3 Results

For each participant the following measures were computed: (1) number of correct answers to basic knowledge questions about high blood pressure and number of correct answers to behavioral knowledge questions about high blood pressure, both pre- and post-interface presentation; (2) pre-post difference scores for basic and behavioral knowledge about high blood pressure; (3) composite measure (average) of attitudes toward the information source; (4) composite measure (average) of intentions to use the information; and (5) composite measure (average) of evaluations of the interface. All composite measures were reliable (.80<alpha<.93). Also computed were composite scores (sums) for the perceptual and processing style dimensions, followed by median splits to
categorize participants into high and low perceptual preference groups and high and low processing preference groups.

ANOVA revealed a main effect of interface design on attitudes toward the information source (American Heart Institute), $F(2,155)=6.11$, $p<.01$. Participants in the 3-D spatial ($N=60$) and interpersonal ($N=41$) interface conditions had more favourable attitudes ($M_s=6.01, 6.35$, respectively, $SE_s$ (standard errors)$=.145, .176$, respectively) than did participants in the magazine-style ($N=60$) interface condition ($M=5.54$, $SE=.146$). There was no difference between the spatial and interpersonal interfaces on this measure. There were no differences related to interface design on measures of basic knowledge or behavioral knowledge about high blood pressure. Scores on both measures increased from pre-interface presentation ($M_s=5.30, 5.42$, out of 10 maximum points) to post-interface presentation ($M_s=6.39, 6.21$, respectively), indicating significant learning by viewing the interface, regardless of its design. Note that the three interface design groups were equivalent on both knowledge measures prior to the interface presentations (i.e., there were no pre-existing differences in knowledge about high blood pressure among the three interface design groups).

There was a marginally significant main effect of perceptual style preference on intentions to use the information about high blood pressure presented in the interface, $F(1,155)=3.08$, $p<.08$, and a significant main effect on evaluations of the site, $F(1, 155)=3.97$, $p<.05$. Participants who preferred concrete learning experiences were less likely to intend to use the information ($N=75$, M$=6.05$, SE=.103)) and had less favourable evaluations of the site ($M=5.85$, SE=.123) than did those who preferred abstract learning experiences ($N=86$, $M_s=6.30, 6.19$, respectively, $SE_s=.096, .114$, respectively). There was no interaction between interface design and perceptual style preference.

There was a marginally significant main effect of processing style preference on intentions to use the information presented at the site, $F(1, 155)=2.95$, $p<.09$, and a significant main effect on evaluations of the site, $F(1, 155)=5.30$, $p<.05$. Participants who preferred reflective observation were less likely to intend to use the information found at the site ($N=66$, $M=6.03$, SE=.108), and evaluated the site less favourably ($M=5.79$, SE=.129) than did those who preferred active experimentation ($N=95$, $M_s=6.23, 6.18$, SE$s=.092, .109$, respectively). There were no interactions between interface design and processing style preference.

Gender differences were obtained for both perceptual and processing styles preferences. Males preferred abstract conceptualization ($N=42$, $M=6.10$, $SE=.318$) whereas females preferred concrete experience ($N=112$, $M=5.30$, SE=.198; $F(1, 152)=4.39$, $p<.05$). Females preferred reflective observation ($M=4.34$, SE=.195) whereas males preferred active experimentation ($M=3.67$, SE=.295; $F(1, 152)=3.39$, $p<.068$). However, there were no gender differences in learning (basic or behavioral information), attitudes toward the source of information (i.e., American Heart Association), intentions to use the information about high blood pressure, or evaluations of the site.
4 Discussion

Findings indicated that: (1) interface design influenced attitudes about the source of health information. Participants who experienced the 3-D spatial interface or the interpersonal interface had more favourably attitudes than those who experienced the standard magazine-style interface; (2) Cognitive style influenced intentions to use the health information presented in the interface as well as evaluations of the interface. Participants who preferred concrete learning experience and reflective observation were less likely to intend to use the information, and evaluated the interfaces less favourably than did participants who preferred abstract conceptualization and active experimentation (respectively). (3) Gender was related to cognitive style. Females preferred concrete experience and reflective observation whereas males preferred to abstract conceptualization and active experimentation (respectively). (4) Participants significantly increased their basic and behavioral knowledge about high blood pressure by viewing the interface presentations, regardless of interface design, cognitive style or gender.

Our findings have implications for the design of technology to enhance learning in members of underserved groups. They suggest that 3-D spatial interfaces and interfaces that contain anthropomorphic “helping” agents produce more favourable attitudes about the information presented than do standard “magazine-style” interfaces. Although these adapted interfaces did not result in better learning, it is important to note that our participants were never explicitly instructed to learn the information presented in the interface. Had they been so instructed, then the 3-D spatial and interpersonal interfaces may have resulted in better learning as well. Our findings that cognitive style may interact with interface design to influence intentions to use the information presented in the interface suggest that more attention should be given to cognitive style and possible cultural influences on cognitive style in the design of technology for learning.

References


