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Cultural differences between designers and users is an important aspect to consider when designing products for other countries. However, many prominent authors in the human factors engineering field have failed to specifically address how to identify and utilize cultural differences in user interface (UI) design. This research evaluated if design guidelines based upon Hofstede's cultural dimension model led to valid UI requirements. The two dimensions this study focused on were Power Distance and Uncertainty Avoidance. The researcher interpreted the related literature to create a set of guidelines for each dimension. These guidelines centered on how information was communicated between the UI and the user. The guidelines were then applied to the case study of a medical diagnostic application to create four sets of UI component pairs. An online survey was used to test for correlations between the usability of the UI component pairs and variations in the cultural dimension scores for the participants. Overall, it was found that the usability of the UI component pairs did not significantly correlate with the cultural dimension scores. This suggested that UI design guidelines, based on Hofstede's cultural dimension model, did not produce valid UI requirements for communication of information between the UI and the user. However, the results of the study did provide evidence for when and how product designers should incorporate culturally localized design features. Additionally, the results suggested several avenues for future research.

Evaluating Cultural Dimensions to Design Better User Interfaces

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Robert Miller, Author

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1 Introduction

1.1 Background

One of the challenges of designing products for consumers has been characterizing and understanding the consumers' needs, expectations, and perspectives. Understanding this worldview, and how it affects the consumers' interaction with a product, is a key principle in the User-Centered Design philosophy. Part of the job of human factors engineers is to understand how to characterize the user-needs and worldviews. They can then use this knowledge to bridge the gap between what technology can deliver and what the user needs at a given point in time (Wickens, Lee, Liu, & Becker, 2004, p. 387). When designers and users come from different nationalities, the gap created by cultural differences can lead to poor product design and low consumer adoption of the product.

Culture is a term used extensively in the human factors engineering field as a catchall for a variety of uncategorized behaviors and expectations by the user (Vinken, Soeters, & Ester, 2004, p. 6). It is an important aspect to consider and analyze as part of the user characterization process.

Unfortunately, current methods for analyzing culture necessitate extensive observation and analysis of users. Such methods can take anywhere from 30 days to two years to complete (Handwerker, 2001, pp. 4–6). Devoting the time, money, and resources necessary to perform such analysis can be difficult to justify.

One method, explored in the last 15 years, is the use of cultural dimension models to determine culturally influenced system design trends. Aaron Marcus, an interface and visual design consultant, has published several analyses suggesting how Hofstede's cultural dimension model (Hofstede, 2001) might be applied to design culturally localized user interfaces (UIs) (Marcus, 2006; Marcus et al., 2000; Marcus & Alexander, 2007; Marcus & Gould, 2000). Other researchers in the field have done exploratory studies to assess correlations between cultural dimensions and UI design preferences (Cyr & Head, 2013; Jhangiani, 2006; Recabarren & Nussbaum, 2010; Zaharias & Papargyris, 2009). Very little research has been done to determine if these guidelines can be used to create valid UI requirements for new products. This research serves as a first step to fill this gap in the research.

1.2 Motivation

The motivation for this research came from multiple levels. It was initially derived from challenges encountered while designing a medical diagnostic system for use in Sierra Leone, a country in West Africa. This led to a recognition of the greater need to develop quick and effective ways to assess cultural differences and their impact on a product's design.

1.2.1 Initial Motivation

The initial motivation came from a project involving Dr. Kenneth Funk, Bauer Labs LLC, and Willamette International to adapt the Healthcare Toolkit project (HTK) (discussed in Appendix A) to help increase medical access in the impoverish nation of Sierra Leone. During the development of the diagnostic aid, the researcher realized that cultural factors might influence the UI requirements. This led to the realization that the researcher did not have the knowledge or tools to assess how culture would influence the UI design. This motivated the researcher to further explore this topic.

1.2.2 Research Motivation

The use of cultural dimensions to inform UI design has only been researched for the last 15 to 20 years. Much of the work has been exploratory in nature and dispersed across fields and goals. The next step in validating the guidelines produced by these studies was to test them in a new product context. This was necessary to determine if the guidelines could be used in industry.

The small biomass cookstove industry is one that recognizes the need for this work. One study concluded that laboratory analysis of cookstoves did not provide accurate predictions of real world decreases in greenhouse gas emissions because of significantly different environmental variables (Roden et al., 2009). Another study found that the low adoption of nontraditional cookstoves was highly dependent upon cultural differences between the users and designers (Mobarak, Dwivedi, Bailis, Hildemann, & Miller, 2012). The study found that while designers focused heavily on reducing fuel usage, improving the health of users, and reducing emissions; users valued low usage/maintenance costs over improved health effects (Mobarak et al., 2012). A study by MacCarty and Bryden (2015) found that current cookstove models do not address the variability of operator cooking strategies and that most designers rely on experience and unevaluated standards. Testing tools that allow cookstove designers to quickly identify cultural differences between them and their user populations would help them overcome these challenges.

Additionally, researchers have discovered evidence to suggest that cultural localization of products can lead to improvements in usability. A study by Li, Hess, McNab, and Yu (2009) found that differences in cultural dimension scores correlated with perceived usefulness and ease of use of websites. Another study by Zaharias and Papargyris (2009) also found that culture and perceived usability of systems were correlated for players of mass-multiplayer online games. A study by Cyr and Head (2013) found differences in culture significantly correlated with differences in website trust and satisfaction between men and women in different countries.

1.3 Objectives

The objective of this research was to evaluate a quick method to derive culturally localized UI requirements. This research assessed if cultural dimension based guidelines led to valid UI requirements. Valid guidelines were determined to be ones that a user's usability assessment of UI components, based on the guidelines, correlated with the user's cultural dimension scores. The research questions this study attempted to answer were:

1. Do UI guidelines derived from research related to Hofstede's cultural dimensions model produce valid computer UI requirements for a given country?
2. Do user-group usability ratings of UI components vary in relation to the difference between their nationalities' Hofstede cultural dimension scores?

a. Do user-group usability ratings of UI components vary in relation to the difference between their nationalities' Power Distance scores?

b. Do user-group usability ratings of UI components vary in relation to the difference between their nationalities' Uncertainty Avoidance scores?

1.4 Methodology

Since the objective of this research was to determine whether valid UI requirements could be generated for a new product, a case study was selected (discussed further in section 3.2) to apply the guidelines to. The design of an upper respiratory disease diagnostic application was chosen as the design context. This case study provided a framework to generate prototype UIs for usability testing. The project this case study was based on had no funding to support extensive in-person user characterization studies.

Two dimensions of Hofstede's cultural dimension model were chosen as the scope of this research study (discussed further in section 2.8.5): Power Distance (PD) and Uncertainty Avoidance (UA). The PD and UA dimensions were chosen because they were referenced in the UI design literature and the interpreted design guidelines were applicable to the design of a medical diagnostic aid.

The researcher undertook a two-fold approach to developing guidelines from the selected dimensions. A "top-down" approach was used to interpret design guidelines from the definitions and measurement of the two selected cultural dimensions described in Hofstede's publications. A "bottom-up" approach was used to find guidelines related to the two selected dimensions from research studies and journal articles. Both analyses allowed the researcher to interpret a pair of guidelines representing the low and high pole for each of the two dimensions. These guidelines focused on the topic of how information was communicated between the UI and the user.

Next, the guidelines were evaluated in the context of the case study to develop prototype UI components for the case study. Four sets of low-pole/high-pole UI component pairs were created to represent the guidelines for the two dimensions.

A survey system was used to measure the usability ratings of each UI component pair by a population of participants representing different nationalities. Participants were asked to take a slightly modified version of Hofstede's Value System Module (VSM) 2013 (Hofstede & Minkov, 2013b) to measure their cultural dimension scores. Next, the participants evaluated each of the four UI component pairs. Usability metrics, such as speed and preference, were collected for each UI component. Participants were also asked to rate the usability of each UI component using a modified version of a standard usability questionnaire, the End-User Computing Satisfaction survey (EUCS) (Doll & Torkzadeh, 1988).

1.5 Results

A total 65 people, representing 14 different nationalities, participated in the study. Most of the participants were between the ages of 18 and 34 years old, were a student or worked as academic professionals, and had more than 16 years of education. Most of the foreign (non-United States) participants had lived over 21 years in their home country and had lived outside their home country for less than 4 years.

PD and UA scores were gathered from Hofstede's published dataset (Hofstede, 2015) and calculated based on the participants' survey responses. The published and calculated dimension scores were not found to correlate. This was likely a result of the significant variation in participant demographic distributions between the nationalities. Differences in gender, age, education, and career have been found to influence the VSM cultural dimension scores, which is why it is recommended that scores only be compared directly for samples with similar demographic distributions (Hofstede, 2001, p. 50; Hofstede & Minkov, 2013a).

Kendall's Tau correlation analyses were performed to determine if there were significant correlations between the difference in usability metrics for the UI component pairs and the published/calculated cultural dimension scores they represented.

Overall, only a few significant correlations were found to be consistent for the PD-based UI component pairs. Conversely, no significant correlations were found to be consistent for the UA-based UI component pairs.

The results also suggested that calculated PD scores, which may have been more reflective of the variations in demographics between the nationalities, correlated better with the usability metrics than the published PD scores.

1.6 Conclusions

Based upon the results of this study, it was determined that cultural dimension based design guidelines were not found to produce valid UI requirements. This was primarily because very few correlations were found between the usability of the UI component pairs and the cultural dimension scores. This seemed to indicate that cultural differences might not affect a user's preference for how information is communicated between the UI and the user.

The limited number of participants and variations in demographic distributions between the nationality groups make these results difficult to generalize beyond the study's participant pool. However, the results did suggest methods for when and how designers should assess cultural differences in UI design. The results also brought up a number of questions and directions for future research on this topic.

2 Literature Review

This literature review covers a wide range of topics that helped guide this work. It starts with an overview of user-centered system design. Next, a definition of culture is analyzed. This includes the current methods to examine cross-cultural differences. Then a review of the design literature related to cross-cultural design preferences is detailed. Finally, this chapter concludes with an analysis of the literature that led to the identification of the research questions examined in this study.

2.1 User-Centered System Design

This investigation is grounded in the field of user-centered system design (UCSD). It is the most applicable field to this research because of its focus on designing systems that meet the users' needs.

2.1.1 Brief History of User-Centered System Design

The term "user-centered design" first appeared in the literature in 1986 with the publication of Donald Norman and Stephen Draper's book, *User-Centered System Design: New Perspectives on Human-Computer Interaction* (Keinonen, 2008). The methodology centers on using a variety of tools and approaches to characterize the user of a system (Abras, Maloney-Krichmar, & Preece, 2004; Giacomin, 2014; Keinonen, 2008). This information can then be used to increase the system's usability, efficiency, and user satisfaction (Abras et al., 2004; Giacomin, 2014; Keinonen, 2008).

This methodology sprung out of the field of human factors engineering. Wickens et al. (2004, p. 2) defines the goal of human factors engineering as enhancing the performance, safety, and satisfaction of human-machine interactions. This goal-focused definition of the field makes it unique versus the typical content-based boundaries which define most research fields (Wickens et al., 2004, p. 5).

This approach to system design is an evolution of the functionality design philosophy. Typically, designers and engineers focus on manipulating the form and features of a system to best fulfill some intended purpose, without considering the point-of-view of the user (Wickens et al., 2004, pp. 31–32). In these cases, the user is not taken into account in the design until the product has been all but finalized (Wickens et al., 2004, p. 32). Mistakes made by the user are often dismissed as "user-error" (Chapanis, 1996, pp. 8–10). UCSD brings the perspective of the user earlier into the design process to understand and prevent mistakes or other points of conflict between the system and the user (Chapanis, 1996, p. 10).

2.1.2 User-Centered Human-Machine System Engineering Process

A model that documents the UCSD process is the user-centered Human-Machine System Engineering Process (HMSE) (Funk, 2014). This model is a modification of the Waterfall model developed by Royce (1987) that was generalized into the Systems-Engineering Process model by Chapanis (1996, p. 39). This cyclical process model involves a set of four stages (Funk, 2014): analysis; design; implementation; and operation, test, and evaluation.

The full diagram of this process is shown in Figure 2.1. The diagram shows the iterative nature of this process as well as how engineers, users, and managers are involved.

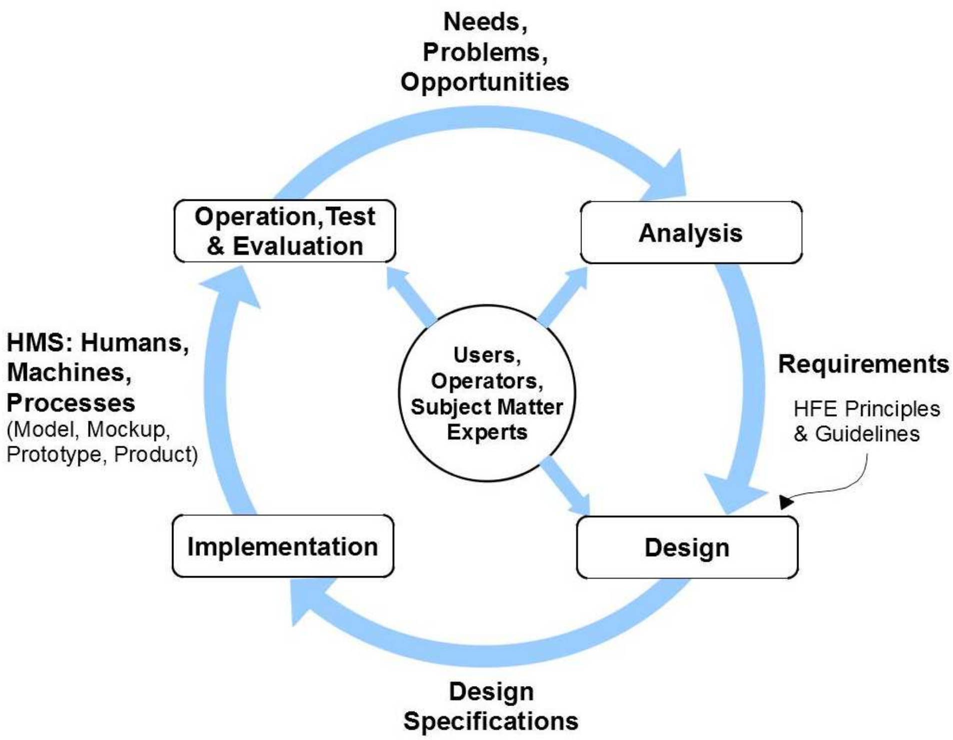


Figure 2.1. HMSE Process Model (Funk, 2014)

The analysis stage is where most of the investigation of the user and the associated task is accomplished (Chapanis, 1996, p. 43). The purpose of this stage is to comprehensively analyze the task the system needs to perform and characterize the behaviors, mental models, and preferences of the users (Wickens et al., 2004, p. 37). It is guided by the user-needs and the goal of the task (Chapanis, 1996, p. 39).

To analyze the task the system must accomplish, several forms of data collection methods are used including: observation, interviews, and even surveys (Wickens et al., 2004, pp. 42–44). After the data has been collected, a documentation process is used to summarize the task, sub-tasks, and factors that interact with or control the task (Wickens et al., 2004, p. 44). This documentation can include a functional analysis and/or task analysis (Wickens et al., 2004, p. 38). The output of this stage is a set of system requirements that guides the design of the system (Chapanis, 1996, p. 39; Wickens et al., 2004, p. 51). It is important that these requirements are as complete as possible and address the physical/environmental constraints as well as the functional and operational needs of the users (Chapanis, 1996, p. 40).

The second stage in this process is the design stage. It is a complex and iterative stage where the designers identify technological or human systems that can fulfill the system needs and requirements (Wickens et al., 2004, p. 24). An important part of this process is deciding what functions of the system should be allocated to either the human or the machine and identifying where the two must interface together (Chapanis, 1996, p. 45). As technology and systems are identified to fulfill the system's functions, a set of alternate designs are developed and evaluated. These designs are then iteratively improved (Wickens et al., 2004, p. 50) through the various design review stages until a workable system is developed (Chapanis, 1996, pp. 30–40). The output of this stage is a set of design specifications which detail how the system should look, perform, and be configured (Chapanis, 1996, p. 51).

The next stage in this process is the implementation stage. The purpose of this stage is to develop prototypes or mock-ups of the system based on the design specifications (Chapanis, 1996, p. 51). Often only technicians are a part of this process and it typically does not involve users or engineers (Chapanis, 1996, p. 51). These prototypes can be either crude paper/cardboard models, part-functional systems, or full-working prototypes (Wickens et al., 2004, p. 57). These prototypes are the output of this stage.

The prototypes from the previous stage serve as tools in the last stage of the design process, the operation, test, and evaluation stage. In this stage the prototypes are evaluated to determine if they meet the requirements and are usable for the intended task (Chapanis, 1996, pp. 51–52; Wickens et al., 2004, pp. 57–60).

Heuristic evaluations are often used to quickly determine if the prototype meets the documented system requirements (Wickens et al., 2004, p. 58). This can be done with a simple check list based on established standards and guidelines (Wickens et al., 2004, p. 58). It is best performed by multiple evaluators (Wickens et al., 2004, p. 58).

More extensive usability testing can also performed to quantitatively evaluate if the prototype meets the system requirements (Wickens et al., 2004, pp. 58–59). Tools such as experiments, simulations, and even role-playing activities can be used to evaluate if the system is functional and "user friendly" (Chapanis, 1996, pp. 50–51; Wickens et al., 2004, p. 59).

The output of this stage is an additional set of needs or problems with the system (Chapanis, 1996, p. 51; Wickens et al., 2004, p. 58). These problems then filter back into the analysis stage as the process repeats itself until a final system is developed.

Since the analysis stage is the first and primary stage where the user is characterized, it is also the stage where culture and cultural differences are identified. The next set of sections will go into detail about some of the methods used in the analysis stage.

2.1.2.1 User Characterization Methods

A number of different methods can be employed to characterize the user. This section will briefly detail a few of these methods that include meta-analysis of the user population or direct observation (Wickens et al., 2004, pp. 24–29).

A meta-analysis of a group of users can be used to understand the basic characteristics of a user including age, gender, education, relevant skills, as well as physical size and abilities (Wickens et al., 2004, p. 37). This data can be gathered from websites or databases that contain information about various population groups (Wickens et al., 2004, p. 36).

A good example of this is the use of anthropometric information by human factors engineers. Anthropometry is the study of human dimensions (Chapanis, 1996, p. 158). Data from anthropometry studies help engineers determine the body size and dimension range for potential users of the system (Chapanis, 1996, pp. 161–163).

In some cases user characteristics can also be gathered from critical incident documents, such as those that document medical accidents (Chapanis, 1996, p. 89). Additionally, some characteristics may already be determined by the designers of a system, who are looking to target a specific type of user (Chapanis, 1996, p. 68).

Direct observation methods may also be used to help build personas of potential users. Often this starts with informal or unstructured interviews with key informants to get a general picture of the user (Handwerker, 2001, p. 79). This can lead to more detailed observation plans, structured interviews, or surveys (Handwerker, 2001, p. 79; Wickens et al., 2004, pp. 24–25). Designers can sometimes completely immerse themselves in a potential user's work or life to gain a visceral understanding of them (IDEO.org, 2009, pp. 46–47).

In addition to the user characteristics, the task the users will perform with the system must be analyzed in this stage.

2.1.2.2 Task Analysis through IDEF0

IDEF0 is an analysis tool to help decompose the tasks a system and its user must perform. It was established as a standard by the National Institute for Standards and Technology in 1993 (National Institute of Standards and Technology, 1993). The acronym IDEF0 stands for Integration Definition Function Modeling (National Institute of Standards and Technology, 1993). IDEF0 and other forms of task analysis are often used in the very early stages of the system design process (Chapanis, 1996, p. 82). This is because they provide a high level overview of the scenarios and functions a system must perform without specifying how they should be accomplished (Chapanis, 1996, p. 82).

An IDEF0 diagram provides a decomposition of a task, sometimes referred to as a functional decomposition, through a series of parent and child diagrams (Greeff, 2004, pp. 119–122). Within the diagrams, boxes are used to represent individual tasks, while arrows are used to show the inputs, controls, mechanisms, and outputs of a task (Greeff, 2004, p. 122). Figure 2.2 shows the A-0, or first level diagram of an IDEF0 model, that documents the process to conduct an infectious disease medical exam. The diagram shows the task's inputs, controls, mechanisms, and outputs. Tasks can represent functions, activities, or processes. Inputs are anything that are changed by the task in some manner. Outputs are anything that are produced by the task. They can include inputs that are changed by the task. Controls are anything that modify or regulate the task. Mechanisms are people, objects, or systems that are used to perform the task.

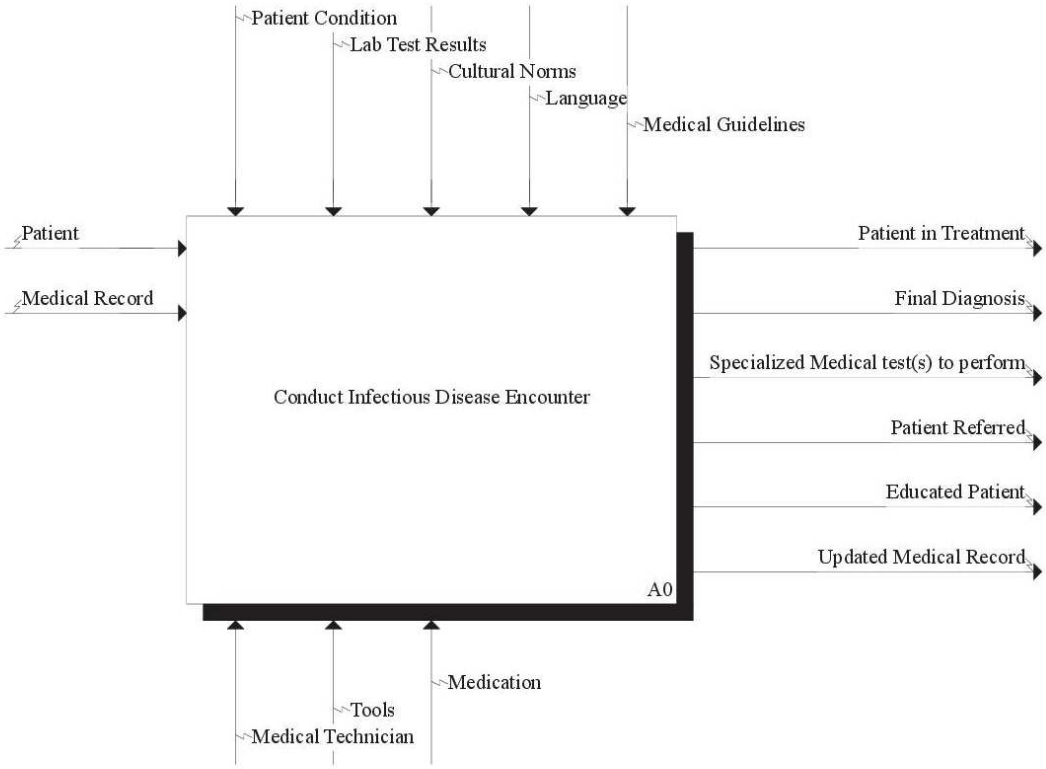


Figure 2.2. IDEF0 Syntax

The A-0 diagram contains just a single task box (Greeff, 2004, p. 121). The task box, or node, of this diagram is labeled as "A0," as is shown in Figure 2.2. This node label, which is in the bottom right hand corner of the node box, helps to uniquely identify the task, identify its parent/ child diagrams, as well as its show its location within the model (Greeff, 2004, p. 121). Child diagrams further decompose a task into its discrete sub-tasks. Figure 2.3 depicts the decomposition of the "A0" node in Figure 2.2.

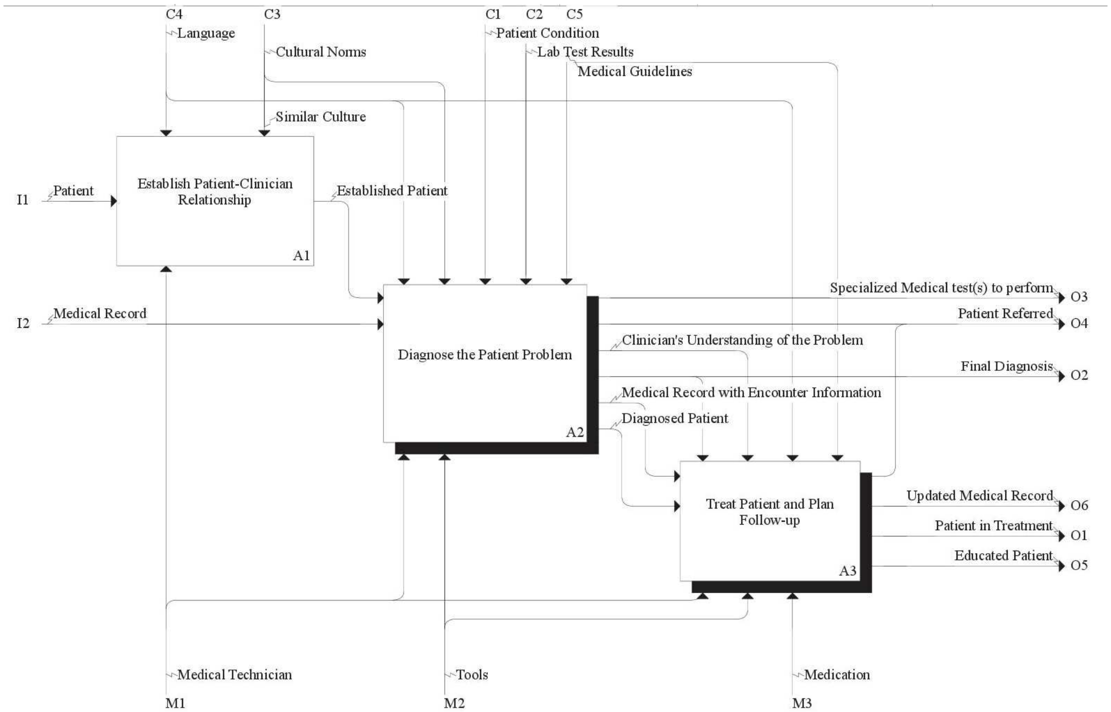


Figure 2.3. IDEF0 A0 Sub-Diagram

The nodes in this diagram are labeled “A1,” “A2,” and “A3.” In subsequent decompositions, nodes add an additional digit to the label indicating them as sub-tasks. If node “A2” could be decomposed into three sub-tasks, these sub-task nodes would be labeled “A21,” “A22,” “A23,” etc. Additional diagrams are created until no further decomposition is required to describe the process.

IDEF0 models are capable of detailing the tasks, tools, materials, and people that are involved in a process. The relatively simple syntax allows non-technical users to aid designers and engineers in the development and validation of an IDEF0 model.

One of IDEF0’s weaknesses is its inability to display time and sequence information related to the tasks (Greeff, 2004, pp. 122–123). The left to right order of tasks within a diagram, like in Figure 2.3, only shows the dependency of one task on another, if the two tasks are connected. While this can be interpreted as sequence, that is not explicitly shown and cannot be determined based on the diagram (Greeff, 2004, p. 123).

2.1.2.3 Describing Mental Models through Concept Maps

Not only do designers need to understand the mechanics of the task that must be performed, but they must also understand the user’s psychology while performing the task (Wickens, Hollands, Banbury, & Parasuraman, 2013, pp. 1–3). Understanding the mental processes involved in the task can help engineers design more usable human-machine systems (Wickens et al., 2013, p. 3).

Cognitive task analysis (CTA) is a set of tools that allow engineers and researchers to understand the cognitive tasks, models, and processes that enable users to accomplish a goal (Crandall, Klein, & Hoffman, 2006, p. 2). CTA is, in essence, a hybrid of conventional task analysis and user characterization as it is used to describe the user's cognitive characteristics in the context of a specific task (Crandall et al., 2006, pp. 3–4).

One of the methods in CTA to help elicit this information is concept mapping (Crandall et al., 2006, p. 43). The method was originally developed by Joseph Novak in the 1970s and 1980s to describe students' knowledge of science (Crandall et al., 2006, p. 43). Concept mapping involves an iterative two-step procedure that starts with an interview where knowledge is elicited from a subject matter expert(s) (SME) which is then documented in a diagram (Crandall et al., 2006, pp. 51–56). The diagram is further refined by interviewing additional SMEs, reviewing interview transcripts/notes, or reviewing the diagram with SMEs (Crandall et al., 2006, pp. 60–61).

The interview process starts with a single "focus question" that provides a scope to the discussion (Crandall et al., 2006, p. 56). The focus question should be simple, but broad enough to cover the entire scope of interest (Crandall et al., 2006, p. 56). An example of a focus question is "how do you diagnose tropical diseases?" Next the interviewer guides the SME to identify the key concepts in this domain and how they relate to each other (Crandall et al., 2006, pp. 56–59). As questions are answered, the interviewer probes the SME about their answers or further investigates specific topics (Crandall et al., 2006, p. 55). The idea is to build a set of node-link-node propositions that will be used to create the diagram (Crandall et al., 2006, p. 58).

The diagram consists of a set of boxed concepts, or nodes, that are linked together with lines, or arcs, to show connections between these nodes (Crandall et al., 2006, p. 51). The nodes are labeled with short noun phrases or words, while the links are labeled with short verb phrases that describe how the two nodes are linked (Crandall et al., 2006, p. 51). Figure 2.4 shows an example of a concept map that describes an infectious disease expert's mental model of Ebola diagnosis. The shape of the diagram itself can be either free-form or an ordered shape to meet the needs of the specific research (Crandall et al., 2006, pp. 52–54).

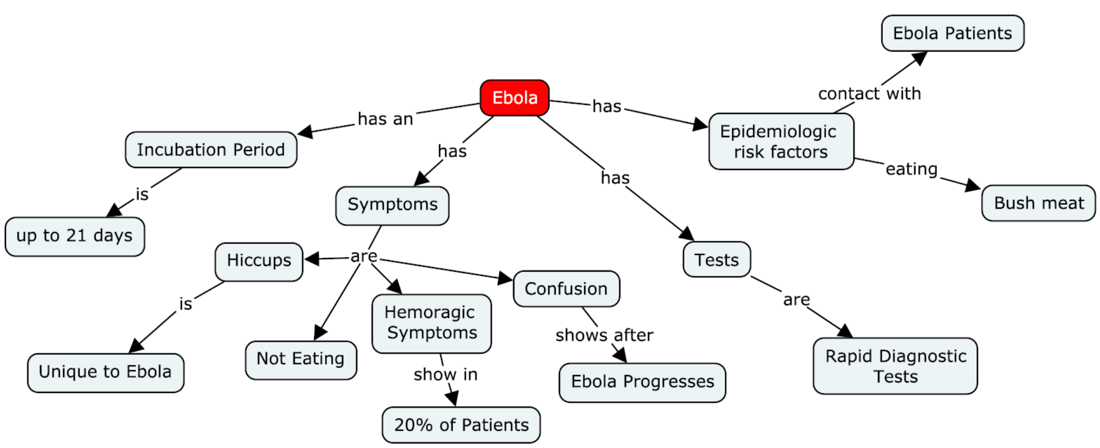


Figure 2.4. Concept map of Ebola diagnosis from an infectious disease expert

Concept mapping is useful in a number of applications including: documenting knowledge, understanding the organization of knowledge, training personnel, documenting best practices, and developing decision aids (Crandall et al., 2006, pp. 41–50).

These methods allow designers and engineers to develop product requirements for a given system. This process becomes even more complex when designers of one country are attempting to design products or systems for users in another country. Designers need to not only understand the task and users, but also need an understanding of the culture within which the users live.

2.2 Garrett's Elements of User Experiences

Since the case study used in this study (see Chapter 3 for more details) involved the design of a software UI, this section details a model developed by the website designer Jesse James Garrett (2011). This model was developed to not only detail the elements of UI design, but also provide an overview of the process by which UIs are developed (Garrett, 2011, pp. 19–24). The model was designed especially to reflect software UIs rather than UIs in general (Garrett, 2011, pp. 19–24).

The high-level version of his model is shown in Figure 2.5. The model consists of five layers which go from the most abstract layer, strategy, to the most detailed layer, surface (Garrett, 2011, p. 21).

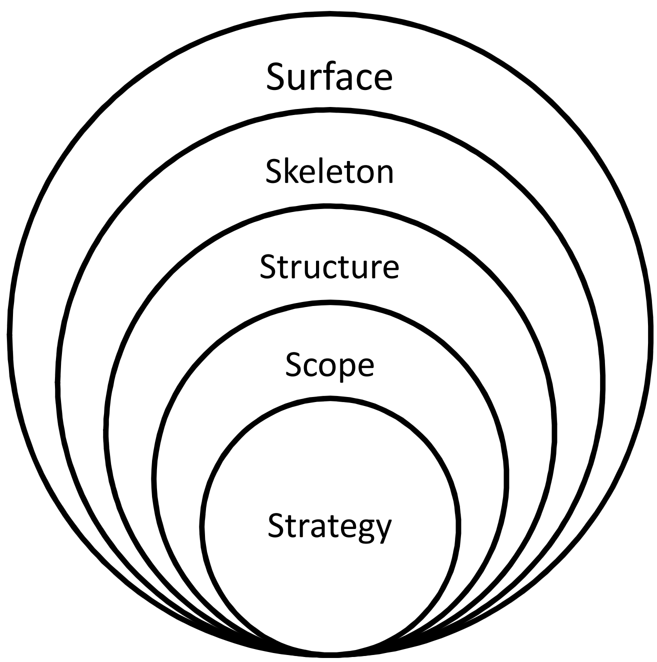


Figure 2.5. Garrett's Elements of User Experience (adapted from Garrett, 2011, p. 22)

Starting at the strategy layer, this layer is the most abstract of the UI. The decisions in this layer focus on identifying the user-needs and objectives of the product (Garrett, 2011, p. 28).

The scope layer is where the user-needs and product objectives defined in the strategy layer get focused and refined (Garrett, 2011, p. 29). This is where the functional and content requirements are developed (Garrett, 2011, p. 29).

The structure layer is where the interface requirements are translated into interface components (Garrett, 2011, p. 30). It is in this stage that the interaction design is defined, or how the UI responds to user inputs or interactions (Garrett, 2011, p. 30). It is also where the information architecture of the UI is defined, or how the information should be structured in the system (Garrett, 2011, p. 30).

The skeleton layer is where the UI begins to take shape. This layer consists of three components: information design, interface design, and navigation design (Garrett, 2011, p. 134). This layer is primarily concerned with detailing how the information, interface, and navigation is laid out on the screen, or series of screens (Garrett, 2011, p. 30).

The last layer is the surface layer. In this layer the specific attributes of the UI are determined such as the colors, icons, images, and specific controls (Garrett, 2011, p. 30).

This model provides a framework from which software components can be classified into discrete layers. It also serves as foundation to help identify the specific layers of a UI that are affected by culture differences. The next section details the definition of culture this study uses.

2.3 Culture Definition

Evaluating a user's culture is a necessary step during the analysis stage of the UI design process. Differences in culture have been found to correlate with the perceived ease of use of UIs (Li et al., 2009; Zaharias & Papargyris, 2009).

However, the concept of culture is often used as an ambiguous term to describe a number of social phenomena (Minkov & Hofstede, 2011). The dictionary has a myriad of definitions for culture, from an expression of fine aesthetic tastes of the social arts, the act of procuring living material, to the definition relevant to this discussion, a set of values, beliefs, and behavior that distinguishes a social group ("Definition of CULTURE," n.d.).

Within the field of anthropology, culture is described as a complex, amorphous, and continuously changing social construct (Vinken et al., 2004, p. 6). A commonly accepted definition of culture in anthropology by Kluckhohn (1951, p. 86) is:

> *Culture consists in patterned ways of thinking, feeling and reacting, acquired and transmitted mainly by symbols, constituting the distinctive achievements of human groups, including their embodiments in artifacts; the essential core of culture consists of traditional (i.e. historically derived and selected) ideas and especially their attached values* (as cited by Hofstede, 2001, p. 9).

This definition of culture highlights some of the key characteristics of the concept. These include that it is a pattern of behaviors, it manifests itself in numerous ways, and that it depends the history of a people.

The first part of the definition specifies that culture is a pattern of behaviors (Vinken et al., 2004, p. 6). This pattern of behaviors can also be thought of as shared being amongst members of a community (Handwerker, 2001; Rapport, 2007). Cultural behaviors are unique as they are learned from others rather than being innate or physiological in source (Hurtienne & Blessing, 2007).

Additionally, culture manifests itself in many different ways. Harry Triandis (1995, p. 4), a researcher in cross-cultural psychology, stated that culture is composed of both subjective mental models or values that manifest themselves as objective behaviors, objects, and artifacts. It is the subjective aspect of culture that Hofstede (2001, p. 9) calls "mental programs" and defines as "the collective programming of the mind that distinguishes the members of one group or category from people of another" (Hofstede, 2001, p. 9).

Lastly, culture depends on the history of a group of people. It is one's experiences over time that help to shape and define culture (Handwerker, 2001). The passage of time and events, i.e. history, helps to shape and change a community's culture. As a community's history changes and evolves with the passage of time, so does a community's culture.

To summarize, the definition of culture can also be stated as being a learned set of values, mental models, or ways of thinking that manifest itself as physical artifacts, or behaviors, that are shared amongst a social group and can evolve over time.

2.4 Methods to Elicit Cultural Requirements

This section briefly goes over the methods used in anthropology to elicit cultural information. These methods include the use of cultural databases as well as various forms of primary data collection.

Databases can be used to determine some differences between cultures. The Central Intelligence Agency of the United States publishes a website, entitled "The World Factbook," that details a set of statistics and historical information about the world's nations ("The World Factbook," n.d.). This includes information about a nation's history, climate, people, language, education, government, economy, etc. ("The World Factbook," n.d.). Such databases can be used to quickly identify defining characteristics of a nation or group of people. However, translating these differences into usable design requirements can be difficult and sometimes misleading as was discovered in a study by Honold (2000).

Primary data collection measures can also be used to analyze cultural aspects of society. These methods come from the field of ethnography and include interviews (informal and structured), surveys, times-series data collection, and observation (Handwerker, 2001). Interviews with key informants, or "cultural experts," can be an effective method to quickly gather information about the cultural of interest (Handwerker, 2001, p. 90).

A qualitative approach to analyzing culture can be done using cultural probes (Gaver, 2007). Cultural probes are different than traditional methods as the individuals being examined are the ones that collect the data with minimal to no interference by the researchers (Gaver, 2007). Cultural probes are objects which the research participant takes and interacts with on their own time based on the instructions included in the cultural probe packet (Van Leeuwen, Karnik, & Keane, 2011). In a study of home technologies, Gaver (2007) used a set of cultural probes that included a disposable camera with instructions to take pictures of things or places that represented “a spiritual center,” “a collection,” “something red,” etc. Cultural probes are designed to be somewhat ambiguous to collect a broad set of data (Gaver, 2007). Because of this, the data they generate often requires additional methods, such as interviews, to provide usable interpretations (Van Leeuwen et al., 2011).

The problem with the primary data collection methods (observation, interviews, cultural probes etc.) is that they can take many months, to even years, to complete (Handwerker, 2001, p. 4). The time and money to devote to this can be difficult to justify in industrial settings.

2.5 Anthropologic Perspectives on Culture

Key to cross-cultural research is the ability to assess similarities and differences across populations. Since research into culture has largely been in the field of anthropology, the anthropological literature was explored to determine frameworks on which to make these comparisons. Within the field of anthropology, there are three basic views of how to analyze, or think about culture: the postmodernist, particularist, and dimensionalist view (Vinken et al., 2004, p. 7).

The postmodernist view of culture in anthropology is one that views individuals as the source of culture who create ever-changing forms of it to meet their needs (Vinken et al., 2004, p. 7). This view holds that generalizations of cultural aspects of a social group are limited in their explanatory value (Vinken et al., 2004, p. 7).

The particularist view of culture states that cultures can be described as consisting of a shared set of structures and patterns (Vinken et al., 2004, p. 7). A nearly endless list of attributes can be used to describe a particular culture from values, political structures, family structures, gender roles, etc. (Vinken et al., 2004, p. 7). This view is differentiated from the postmodernist view by a belief that culture is a homogenous concept within a defined social group (Vinken et al., 2004, pp. 7–8). However, the particularist view does not recognize an overarching pattern of the structure of culture between various social groups (Vinken et al., 2004, pp. 7–8).

The dimensionalist view contends that a set of overarching qualities can be used to describe the range of diversity across all cultures (Vinken et al., 2004, p. 7). The point is not to discover some underlying and inherent aspects of culture, but instead to create a theoretical construct to turn the seemingly intractable range of cultural diversity into an understandable concept (Hofstede, 2001, Chapter 1). This was, and still is, a controversial view of culture that was largely given validity with Hofstede’s empirical cross-cultural analyses of worldwide survey performed in the 1970s and 1980s (Minkov & Hofstede, 2011).

It is the dimensionalist view that provides a usable foundation from which we can make comparisons across numerous cultures. A number of researchers have developed dimensionalist models of culture. The next section will describe three of the most accepted models within the research community.

2.6 Cultural Dimension Models

Research into cross-cultural comparison flourished after large-scale multi-country survey data became available in the 1970s (Minkov & Hofstede, 2011; Vinken et al., 2004, p. 5). This allowed researchers to elicit and validate their cross-cultural dimension models (Vinken et al., 2004, p. 5). During this time, countries across the globe were becoming more interconnected because of technological innovations, such as commercial airlines and the internet. This push for globalization led researchers to examine cultural differences and how culture changes as a result of the globalization process (Vinken et al., 2004, p. 5). The next section describes three accepted dimensional models.

2.6.1 Hofstede's Cultural Dimensions

Geert Hofstede's model of cultural dimensions is considered one of the seminal dimensional models (Minkov & Hofstede, 2011; Vinken et al., 2004, p. 6). Hofstede generated his initial model of cultural dimensions based upon IBM employee attitude surveys conducted in 1967 and 1973 (Hofstede, 2001, p. 41). A total of 71 countries, in which IBM operated, were surveyed (Hofstede, 2001, p. 48) in two stages from 1967 to 1969 and 1971 to 1973 (Hofstede, 2001, p. 51). The analysis of these data resulted in quantitative dimension scores for 50 individual countries and three geographical regions (Hofstede, 2001, p. 52).

Hofstede's model hinges on the idea that values are the core of culture. Figure 2.6 provides a picture of the model Hofstede (2001, pp. 10–11) uses to describes culture. Values form the core of culture, but are not visible or directly observable. Observable practices serve as the outside layer of culture with rituals, heroes, and symbols forming the key components of the layer (Hofstede, 2001, pp. 10–11). The meaning and understanding of these observable practices are shaped by the core values of a group (Hofstede, 2001, p. 10). Additionally, Hofstede (2001, p. 10) states that it is these invisible values that provide a bridge to compare cultures.

Hofstede focused his analysis of value differences at the national level. He did this based upon the presupposition that nationality itself is a divider of cultures. Nations are politically separate entities with different histories and identities (Hofstede, 1983). The choice to analyze the survey data on a national level was largely inspired when Hofstede realized the results of the IBM survey did not make sense on the individual level (Minkov & Hofstede, 2011). However, Hofstede does not dismiss the idea that meaningful dimensional models could exist for other levels of society (Minkov & Hofstede, 2011).

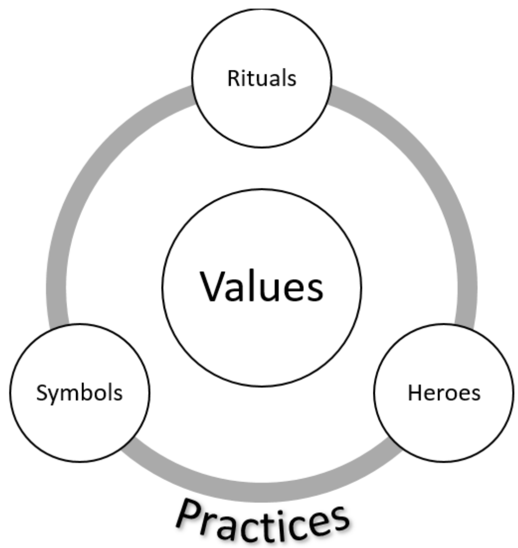


Figure 2.6. Hofstede's Levels of Culture (adapted from Hofstede, 2001, p. 11)

The concept of nationality also manifests itself as sociological and psychological differences in people (Hofstede, 1983). Nationality is part of one's social identity. It is how people describe and identify differences between each other. Hofstede (1983) states that since individuals internally feel the difference of nationality, then this feeling manifests itself as a real difference.

The influence of the political and sociological differences creates the psychological differences in people of various nationalities (Hofstede, 1983). As stated previously, culture is based upon learned behaviors and ways of thinking. Hofstede (1983) argued that this is developed based upon early life experiences influenced by community, education, and organizations. The political differences, combined with the social identity created by nation, result in early life experiences that vary country to country. It is these psychological differences, or differences in values, that Hofstede attempts to analyze on a national level (Hofstede, 1983).

His analysis of the survey data and identification of dimensions occurred via two methods: a theory based approach and a data based approach (Hofstede, 2001, p. 55). The combination of these analyses allowed statistically valid relationships to be identified, while avoiding the risks of ignoring contextual influences and the identification of trivial factors that may not be generalizable outside of the context (Hofstede, 2001, pp. 55–56). This first set of analyses identified four dimensions of culture (Hofstede, 2001, p. 58). Over the years, as replications of Hofstede's survey were done and new values surveys conducted, two additional dimensions of culture were added to Hofstede's model (Minkov & Hofstede, 2011). The six dimensions of Hofstede's model are as follows (Hofstede, 2001; Minkov & Hofstede, 2011):

- Power distance: a measure of the autonomy of individuals in a hierarchical structure; specifically related to the allocation of power in a supervisor/subordinate relationship.

- Uncertainty avoidance: the extent to which a people are not tolerant of uncertainty.
- Individualism: the extent to which an individual's priorities, concerns, and relationships are focused on either themselves or the larger group; cultures where people are focused more on the larger group are described as collective.
- Masculinity: the extent to which the male and female roles in society are either different or similar.
- Long-term orientation: the extent to which a society is focused on long-term or short-term goals.
- Indulgence: a measure of how much a society is focused on fulfilling needs vs wants.

Through Hofstede's research, he was able to generate quantitative scores for the countries involved in the original IBM study (Hofstede, 2001). His survey tool and country scores have been updated over the years, as his model has been further refined and as additional replications of the study have produced dimension scores for countries not included in the original IBM study (Hofstede, 2001). The survey is titled the Value Survey Module (VSM) and was most recently revised and published in May of 2013 (Hofstede & Minkov, 2013a).

While Hofstede's model is widely accepted, it has received extensive criticism. Many criticize Hofstede's presupposition that nationality itself is a cultural differentiator (Vinken et al., 2004, p. 9). The reasons and arguments behind this presupposition have already been reviewed, but additionally Hofstede does not dismiss the existence of cultural models at other levels of society (Minkov & Hofstede, 2011). Hofstede himself in the 1980s researched cross-cultural differences at the organizational which led to the discovery of a six dimension model very different from the national level (Minkov & Hofstede, 2011).

Additionally, because Hofstede's survey tool was originally developed for use in IBM, the questions use aspects of the work environment to assess more all-encompassing cultural values (Hofstede, 2001). There is debate on whether the assumption that work values are proper gauges for these dimensions is valid (Peterson, 2003).

2.6.2 Triandis's Individualism/Collectivism Model

Triandis's alternative model focuses on comparing cultures based upon the individualism/collectivism construct (Vinken et al., 2004, p. 10). Triandis (1995, pp. 1–2) states that the individualism/collectivism concept can be used to explain a wide variety of different cultural behaviors. Similar to Hofstede, Triandis's individualism/collectivism dimension focuses on the extent to which an individual is dependent upon the larger community (Triandis, 1995, p. 2; Vinken et al., 2004, p. 10). Unlike Hofstede, Triandis views cultures as independent of nations and largely dependent upon time, geography, and social interactions (Triandis, 1995, pp. 3–4).

Additionally, Triandis's concept of individualism/collectivism encompasses a greater number of traits beyond simple values (Vinken et al., 2004, p. 10). This is because he views individualism, collectivism, and other generalizable cultural dimensions as "cultural syndromes" (Vinken et al., 2004,

p. 31). Cultural syndromes are shared sets of symbols, roles, behavioral norms, values, etc. that focus around some central theme (Triandis, 1995, p. 6; Vinken et al., 2004, p. 31). Cultural syndromes are not a single-level concept, but instead are multi-layered and can be further decomposed and described by other cultural syndromes (Triandis, 1995, p. 43).

Additionally, Triandis's model contends that individualism can vary along a second dimension, horizontal versus vertical (Triandis, 1995, p. 44; Vinken et al., 2004, p. 11). The horizontal versus vertical dimension relates to how homologous individuals are in status within society (Vinken et al., 2004, p. 11). Horizontal societies value equality and cohesion across members of the community (Triandis, 1995, p. 44). Vertical societies value greater differences in social status, and more hierarchical structures of society (Triandis, 1995, p. 44).

Cultures can vary independently along both the individualism versus collectivism and horizontal versus vertical scales (Vinken et al., 2004, p. 11). However, more often individualist cultures tend to be horizontal in structure while collectivist cultures tend to be more vertical in nature (Vinken et al., 2004, p. 11).

Triandis contends that two aspects, or additional cultural syndromes, of a community determine whether a culture is more individualist or collective, complexity versus simplicity and looseness versus tightness (Vinken et al., 2004, p. 10).

The tight versus loose dimension relates to how homogenous a group is in their views and interconnectedness (Vinken et al., 2004, p. 10). Thus, a tight culture would be one in which individuals must conform closely to the community rules, norms, and views. Individuals who deviate from the prevailing norm are often subject to corrective or disciplinary actions (Triandis, 1995, p. 52). A loose culture would be one with a more heterogeneous set of views, rules, and norms (Triandis, 1995, p. 53).

The complex versus simple cultural syndrome relates to the complexity of the rules and roles of members in a culture (Vinken et al., 2004, pp. 10–11). Most modern societies, like the United States, are an example of a very complex culture (Triandis, 1995, p. 56). Within this type of community, there are an extensive number of rules to comply with as well as a countless number of roles. Conversely, simple cultures have very few rules and a small number of roles within the community. Examples of these cultures include primitive tribal groups and intentionally isolated groups like the Amish (Triandis, 1995, p. 57; Vinken et al., 2004, p. 11).

The combination of these two syndromes result in either more individualist or collective cultures. Collectivism is maximal in tight and simple cultures, while loose and complex cultures are the most individualistic (Vinken et al., 2004, p. 11).

A number of methods have been developed by Triandis, his associates, and other researchers to measure the individualism/collectivism and horizontal/vertical dimensions of the model (Triandis, 1995, pp. 189–206). Through this work Triandis and his colleagues (1995, pp. 202–217) recommend using a two instruments: a questionnaire called the “Subjective Individualism and Collectivism” (SINCOL) and another that measures horizontal/vertical individualism and collectivism.

The SINCOL instrument is a 24-item, self-scored questionnaire that asks participants to rate how individualistic and collectivistic they are in a set of scenarios (Triandis, 1995, pp. 213–217). The participant is first introduced to the concepts of individualism and collectivism (Triandis, 1995, p. 213). Then each item in the questionnaire presents a scenario that represents either an individualistic ideal or a collectivist ideal and the participant is asked to rate on a 0-10 scale either how collectivist or individualistic they are in relation to this scenario (Triandis, 1995, pp. 214–217). At the end, the participant adds up the total scores for the individualism and collectivism items and compares the two to determine if they are more individualistic or collectivist (Triandis, 1995, p. 217).

The second instrument is a 63-item survey that measures both the horizontal/vertical and the individualism/collectivism dimensions (Triandis, 1995, pp. 206–213). It has two sections of questions.

The first section consists of 32 statements representing either horizontal individualism (HI), horizontal collectivism (HC), vertical individualism (VI), or vertical collectivism (VC) (Triandis, 1995, pp. 206–207). The participant rates their level of agreement with these statements on a 1 to 9 scale (Triandis, 1995, pp. 206–207). To score this section, the responses that are labeled as HI, HC, VI, and VC are added up to obtain four scores (Triandis, 1995, p. 205).

The second section consists of 31 scenarios, each with a set of four responses representing either HI, HC, VI, or VC (Triandis, 1995, pp. 208–213). The participant is then asked to mark the top two most “appropriate” responses with a 1, the most appropriate response, and a 2, the next most appropriate response (Triandis, 1995, pp. 207–208). This section is scored by calculating the percentage of responses that are marked 1 or 2 for each type of response (HI, HC, VI, or VC), which gives a total of either percentages (Triandis, 1995, p. 205).

2.6.3 Schwartz Dimensional Model

Schwartz, like Hofstede, views values as the core component of culture. They represent the essential shared ideals of society and help shape the observable behaviors of members of that society (Schwartz, 2006). Schwartz sees these value ideals, or cultural value orientations (CVOs), as the most stable aspect of culture that can change, but over a very long time (Schwartz, 2006, 2014). Schwartz developed his model in an a priori fashion and performed studies to validate his theory (Schwartz, 2006). His model is multi-dimensional and more complex than the other two models reviewed, but it aims to provide a comprehensive model that explains cultural diversity more extensively than other models (Schwartz, 2006).

In Schwartz’s model, the evolution of CVOs come as society grapples with polar issues to maintain order within society (Schwartz, 2006; Vinken et al., 2004, p. 14).

1. Autonomy versus embeddedness on others: the conflict between acting as an individual versus depending on relationships within a community

2. Egalitarianism versus hierarchy: the conflict between viewing oneself as the same as others, in status or resource allocation, versus ranking oneself amongst others along some scale
3. Harmony versus mastery: the conflict between fitting in as an integral and equal component of the larger ecological world versus attempting to control and regulate the ecological systems

Schwartz concluded that societies respond to these three conflicting issues along seven CVOs (Schwartz, 2006; Vinken et al., 2004, pp. 13–14) (Vinken et al., 2004, pp. 13–14).

Societies respond to issue number one, autonomy versus embeddness, along three CVOs. Autonomy has two different forms, intellectual and affective. Intellectual autonomy values independent thought and intellectual pursuits (Schwartz, 2006). Affective autonomy, on the other hand, values independent direction for stimulative or hedonistic experiences (Schwartz, 2006). Counter to autonomy is the embeddedness CVO in which members of society are viewed as integrated components of a larger collective (Schwartz, 2006). Each member must contribute their part to the collective (Schwartz, 2006).

To the second issue, egalitarianism versus hierarchy, societies respond along two CVOs. Societies can value egalitarianism, where members view each other as equals (Schwartz, 2006). This is counter to the hierarchy CVO in which members are not viewed as equal, but instead are ranked in hierarchical system in terms of power, roles, or resources (Schwartz, 2006).

To the third issue, harmony versus mastery, societies respond along two CVOs. Societies that value harmony, view themselves and their members as components within the larger ecological system (Schwartz, 2006). They value working with nature and other societies in a peaceful and cooperative manner (Schwartz, 2006). Counter to this is the mastery CVO which sees society as above the ecological world and must instead regulate and exert control over these systems (Schwartz, 2006).

Schwartz views these CVOs as interrelated to each other (Schwartz, 2006; Vinken et al., 2004, p. 13). Some CVOs like the harmony and embeddedness are similar in their assumption that members of society are interconnected components of larger systems (Schwartz, 2006). Naturally some CVOs are polar in nature, such as egalitarianism and hierarchy (Schwartz, 2006). Schwartz uses a circular model of these seven CVOs to demonstrate how they are interrelated to each other, as shown in Figure 2.7 (Schwartz, 2006).

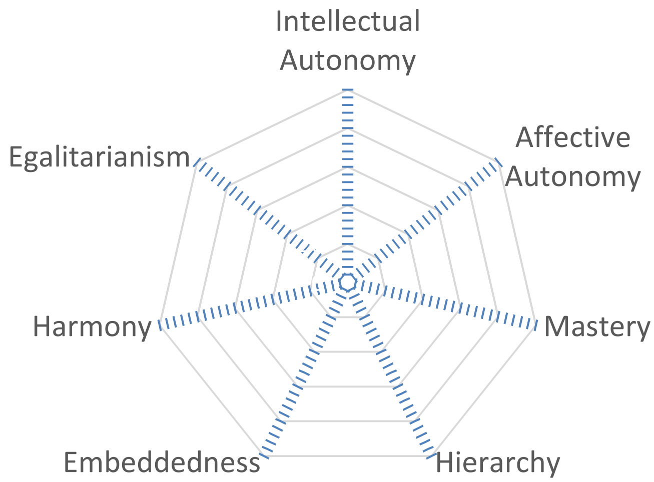


Figure 2.7. Schwartz model of cultural value orientations (adapted from Schwartz, 2006)

To validate his proposed model Schwartz and his colleagues administered two survey tools in studies performed in the 1990s and 2000s (Schwartz, 2006, 2009, 2014). One set studies used a 56 to 57 item survey called the Schwartz Value Survey (Schwartz, 2006). Each survey item listed a generic value, like pleasure or social justice, followed by a sentence or two that further explained the concept (Schwartz, 2006). The survey then asked the participant to rate how important each value was in their lives (Schwartz, 2006).

The next set of studies involved a different tool called the European Value Survey (Schwartz, 2006). The 21 item survey was a modified version of the Portrait Value Survey (Schwartz, 2006). Each item described an individual along with their goals and aspirations which represented a value (Schwartz, 2006). The participant was then asked to rate how much they related to each "person" (Schwartz, 2006).

The studies involving these two tools indicated that within country similarities along the value dimensions created distinct between-country differences (Schwartz, 2006). From these studies Schwartz (2006) was also able to identify distinct cultural world regions that corresponded to results of other dimensional models (Hofstede, 2001; Schwartz, 2006).

While there are many more cultural dimensional models, these represent a few of the seminal and most recent validated models in the field (Vinken et al., 2004).

2.7 Research Analyzing Cultural Dimension and User Interface Design

This section details some of the research studies that have been done analyzing the relationship between culture and UI design preference. The focus of the literature review was to find studies that had used cultural dimension models as a framework from which to analyze cross-cultural UI design preferences. The studies have been split into two sections: studies that examine UI design in terms of cultural dimensions and one study that attempted to apply cultural guidelines to the design of a new UI.

2.7.1 Exploratory Studies of Cultural Dimensions and Interface System Preferences

The following section provides a brief overview of studies that performed an exploratory assessment of the relationship between cultural dimensions and UI preferences. The descriptions of these studies have been ordered by publication date, with the earliest publications listed first.

An often referenced publication by Marcus and Gould (2000) provided an extensive exploration of website design characteristics that varied by culture to provide a list of design guidelines for Hofstede's five dimensions (indulgence had not incorporated into the model at this time). In the paper, the researchers hypothesized a series of design guidelines for each of Hofstede's cultural dimensions and provided examples of these guidelines from a series of websites (Marcus & Gould, 2000). The guidelines contained within this publication are too numerous to detail in this document, however they have served as a testable foundation utilized and referenced by other studies (Choi, Lee, Kim, & Jeon, 2005; Cyr, Bonanni, Bowes, & Ilsever, 2005; Cyr & Head, 2013; Jhangiani, 2006).

A study by Simon (2001) examined how perception, defined as perceived cultural appropriateness, and satisfaction of websites differed based on a person's culture and gender. The study used 160 students from a southwestern United States university representing the cultural regions of Asia, Europe, Latin America, and South America (Simon, 2001). The subjects were asked to explore four brand websites in a random order (Simon, 2001). After each website the participant then completed surveys measuring their perception and satisfaction using the website (Simon, 2001). The results of the study indicated that perception varied significantly for gender and culture (Simon, 2001).

Overall, the study found that perception and satisfaction differences were split with participants from the western regions, Europe and North America, displaying distinct differences than the participants from Asia and South/Latin America (Simon, 2001). This difference aligned with the fact that Europe and North America are more individualistic and feminine than the more collectivist and masculine Asia and South/Latin America (Simon, 2001). Additionally the results suggested that there was little difference in perception and satisfaction between the genders in the more collectivist and masculine regions, Asia and South/Latin America, while there were in the more feminine and individualistic regions, Europe and North America (Simon, 2001).

A study Cyr, Bonanni, Bowes, and Ilsever (2005) examined local versus foreign website design preferences related to trust, satisfaction, and brand loyalty across cultures. The study specifically examined if countries categorized as individualistic trusted foreign websites more than collectivist cultures (Cyr et al., 2005). The study involved 114 participants from four countries (U.S., Canada, Germany, and Japan) with approximately 25 participants representing each country (Cyr et al., 2005). Each participant was asked to navigate both their local version of the Samsung company website and a foreign version (Hong Kong) to choose a cell phone they would hypothetically purchase

(Cyr et al., 2005). After each website navigation session, the participate was asked to fill out a survey and then was interviewed to investigate their responses to the survey (Cyr et al., 2005).

The results from the exploratory study indicated that that there was no statistically significant difference in trust in the local versus foreign websites (Cyr et al., 2005). They also found that participants from all countries viewed vendor familiarity and security symbols as important factors in their trust of a website (Cyr et al., 2005). Counter to conventional thinking, the study found that the Japanese participants tended to trust their local website version less than the foreign version (Cyr et al., 2005). It appears that this may have been influenced by the design choices of the website as the Japanese participants stated in the interviews that they preferred the brighter colors and greater amount of animation in the Hong Kong website (Cyr et al., 2005).

A study by Choi, Lee, Kim, and Jeon (2005) examined cross-cultural influences on the UI design of cell phones. The researchers used a combination of the individualism and uncertainty avoidance dimensions from Hofstede’s model as well as two other dimension from another model as a framework to compare the cultural differences between the participants in Korea, Japan, and Finland (Choi et al., 2005). For this study, the researchers interviewed eight participants from each country (Choi et al., 2005). During the interview, the participant was asked to watch a video clip of an individual interacting with a phone from their own country, as well as phones from the other two countries (Choi et al., 2005). The participant was asked to verbalize what they thought or felt during each of the videos and were additionally asked some general questions between the video clips (Choi et al., 2005).

The results of the study indicated that participants from the same country demonstrated similar preferences with mobile services compared to other countries (Choi et al., 2005). In respect to uncertainty avoidance, it was found that the participants from high uncertainty avoidance nations (Japan and Korea) tended to reject ambiguous interface designs, while participants from the low uncertainty avoidance nation (Finland) were more tolerant of such designs (Choi et al., 2005). They also found that the Japanese and Korean participants preferred a greater amount of information within the screen, clear menu labeling, and additional meta-information about menus and ring-tone options (Choi et al., 2005). The participants from the low uncertainty avoidance nation, Finland, tended to preferred a streamlined interface with minimal information about ring-tone options and menus as they considered additional information useless (Choi et al., 2005). Concerning the individualism dimension, the study found that the more collectivist Korean participants preferred features that enhanced their awareness of other user preferences, such as a popularity rating of a ringtone (Choi et al., 2005). The more individualistic participants from Finland and Japan preferred design elements that enhanced their ability to achieve their own goals, such as extensive filter options when searching for a ring-tone (Choi et al., 2005).

A master’s thesis study by Jhangiani (2006) conducted a cross-cultural analysis of how cell phone UI design preferences varied by nationality and disability. The study used Hofstede’s five dimension model as a basis to identify the cultural differences between the two countries included in the study, India and the United States (Jhangiani, 2006). This study was unique from the other studies reviewed as it used participatory focus groups which asked participants to perform a series of tasks (call a number, store a phone number, send a text message, and set the ringer sound) with the cell phone and then were interviewed to determine their design preferences for the cell phone UI (Jhangiani, 2006).

The results indicated that on a national level there were significant differences in cell phone usability between the Indian and American participants (Jhangiani, 2006). The results indicated that the more collectivist Indian participants rated the importance of text messaging as greater than the individualist American participants (Jhangiani, 2006). Additionally, the study found that while American participants were concerned about security, this did not come up with the Indian participants (Jhangiani, 2006).

A study by De Angeli and Kyriakoullis (2006) focused on empirically evaluating e-commerce website attributes that contributed to “trust” and how they related to Hofstede’s model dimensions of uncertainty avoidance and individualism. This study solicited 595 participants from three countries (the UK, Greece, and Cyprus) representing two different cultural groups (the UK as one and Greece/Cyprus as the other) (De Angeli & Kyriakoullis, 2006). These two cultural groups had differences in uncertainty avoidance and individualism of greater than 40 points (De Angeli & Kyriakoullis, 2006). Participants were asked to fill out an online survey containing four sections (De Angeli & Kyriakoullis, 2006).

The first section asked the participants to evaluate the importance of five trust attributes (such as brand, recommendations by friends, etc.) in their willingness to make a purchase online using a 7-point Likert scale (De Angeli & Kyriakoullis, 2006). Additionally, they were asked to rate their overall level of anxiety making online purchases (De Angeli & Kyriakoullis, 2006). The next section consisted of eight survey items addressing the uncertainty avoidance and individualism dimensions from Hofstede’s VSM 1994 (De Angeli & Kyriakoullis, 2006). The third section asked the participant to evaluate pairs of website screenshots which showcased different variations of interface trust attributes (De Angeli & Kyriakoullis, 2006). The last section collected demographic information from the participants (De Angeli & Kyriakoullis, 2006).

The results of this study indicated that the more collective Greece and Cyprus valued recommendations by friends and customers referrals as more important in making online purchases than the more individualistic UK participants (De Angeli & Kyriakoullis, 2006). Additionally, they found that Greek and Cyprus participants trusted websites that displayed prominent local brands and a better UI aesthetic, while UK participants relied on UI components representing security to determine the trustworthiness of a website (De Angeli & Kyriakoullis, 2006). Overall, they found that the higher uncertainty avoidant Greek/Cyprus participants were more anxious about making purchases online than the UK participants (De Angeli & Kyriakoullis, 2006). This led them to conclude that adoption of new products and technology could be more difficult in collectivist and high uncertainty avoidance cultures as they tend to be avoidant of new and unknown technology along with the tendency to follow the patterns of others within their community (De Angeli & Kyriakoullis, 2006).

A study by Cyr (2008) investigated the cross-cultural design factors that influenced trust and satisfaction for online e-commerce sites that led to brand loyalty. The researchers had a particular interest in how variations in Hofstede’s uncertainty avoidance and individualism dimensions affected these variables (Cyr, 2008). The study involved 571 participants from Canada, Germany, and China (Cyr, 2008). Participants were asked to interact with the localized version of the SonyStyle website and navigate through the website to select a phone they would hypothetically purchase (Cyr, 2008). Afterwards, the participant filled out a survey evaluating the website and their experience (Cyr, 2008).

The results of the study confirmed that different design aspects influenced trust and satisfaction with the online purchase differently between cultures (Cyr, 2008). Furthermore, differences in information design, visual design, and navigational design increased trust and satisfaction for the three countries (Cyr, 2008). In relation to the uncertainty avoidance dimension, the study results indicated that the participant’s trust of a website led to greater brand loyalty for the high uncertainty avoidance countries, Germany and China (Cyr, 2008). Website satisfaction, on the other hand, had a greater influence on brand loyalty for the low uncertainty avoidance country, Canada (Cyr, 2008). Additionally, it was found that a focus on the proper display of information in a website improved website trust and satisfaction for low uncertainty avoidance countries more than high uncertainty avoidance countries (Cyr, 2008). The results also show that visual design of a website had a greater influence on a participant’s trust in a website for the collectivist country, China (Cyr, 2008). Lastly, this study found that navigational design aspects of a website appeared to improve trust and satisfaction for all countries except Germany, where only satisfaction was improved (Cyr, 2008).

Zaharias and Papargyris (2009) performed a study that looked at the perceived usability differences between cultures of a massively multiplayer online game (MMOG), EVE Online. The study used Hofstede’s dimensions as theoretical foundation to compare the perceived usability of 307 gamers from 19 countries, most of whom came from the Netherlands, Canada, Greece, Sweden, and France (Zaharias & Papargyris, 2009). Only the four original Hofstede dimensions (power distance, individualism, masculinity, and uncertainty avoidance) were investigated (Zaharias & Papargyris, 2009).

The results of the study indicated that there were significant correlations between usability and all four cultural dimensions (Zaharias & Papargyris, 2009). The results were used by the researchers to suggest design guidelines for the power distance, uncertainty avoidance, and masculine dimensions (Zaharias & Papargyris, 2009). It was found that gamers from low power distance nations tended to problem solve on their own and did not often seek feedback and guidance from the game’s authorities (Zaharias & Papargyris, 2009). Gamers from higher power distance nations tended to seek greater feedback and guidance from the game’s developers and authorities (Zaharias & Papargyris, 2009). Concerning uncertainty avoidance, it was found that gamers from low uncertainty avoidance cultures were tolerant of the varied and sometimes ambiguous UI systems within the game (Zaharias & Papargyris, 2009). Gamers from high uncertainty avoidance nations, on the other hand, desired better game guides and less ambiguous UI systems (Zaharias & Papargyris, 2009). Lastly, the results indicated that gamers from feminine nations preferred the collaborative and social features more than gamers from more masculine nations (Zaharias & Papargyris, 2009).

Cyr and Head conducted another study in 2013 further examined Cyr’s e-loyalty model, this time investigating how gender differences affected e-loyalty in more masculine and feminine cultures. This study used a survey with a total of 955 participants from six different countries (Cyr & Head, 2013). The study used Garrett’s software model as framework to classify interface differences (Cyr & Head, 2013). This study used the same method as Cyr’s 2008 study, with participants using their local version of the SonyStyle website to navigate through and find a phone they would hypothetically purchase (Cyr & Head, 2013). Afterwards the participant filled out a survey investigating their experience (Cyr & Head, 2013).

Results of the study found that there were more significant differences in information content, navigation design, trust, and satisfaction of the website between men and women in higher masculine countries than lower masculine countries (Cyr & Head, 2013). The results suggested that when websites are designed for higher masculine countries, greater attention should be focused on meeting the different design needs of men versus women (Cyr & Head, 2013).

2.7.2 Studies that Apply Cultural Dimension Models to New Design

The only study that was found that attempted to use cultural dimension guidelines to adapt a UI to a culture was done by Recabarren and Nussbaum (2010). This publication described two studies used to develop and validate a method to adapt a website to meet the cultural needs of an individual (Recabarren & Nussbaum, 2010). The researchers analyzed the literature to gather a series of website design guidelines based on variations in Hofstede’s cultural dimensions (Recabarren & Nussbaum, 2010). Contrary to Hofstede’s (2001, p. 463) guidance on the use of his model, the two studies examined cultural differences on an individual level to identify and adapt a website to a person’s unique scores on Hofstede’s cultural dimensions (Recabarren & Nussbaum, 2010). The first study examined the behavior of 41 participants, of the same nationality, on an online web-form designed by the researchers (Recabarren & Nussbaum, 2010). Usability metrics such as errors made, help requests, focus changes between fields, and page changes were recorded and compared with a participant’s cultural dimension scores (Recabarren & Nussbaum, 2010).

The second used the results of the first study to create an adaptive web-form where 114 individuals were first asked to take the Hofstede VSM (Recabarren & Nussbaum, 2010). Next, the participant was randomly shown one of four possible web-forms that varied based upon two design characteristics: help provision (always visible versus activated by user) and indication of errors (immediately indicated versus indicated upon form completion) (Recabarren & Nussbaum, 2010).

These two design characteristics were selected as they exhibited significant correlations to the individualism, power distance, and uncertainty avoidance dimensions (Recabarren & Nussbaum, 2010). The same usability metrics were also recorded as the participants interacted with the form (Recabarren & Nussbaum, 2010).

Based upon the results of the two studies the researchers found that the time to complete a web-form could be reduced by adapting the display-of-errors method based on a user's uncertainty avoidance score (Recabarren & Nussbaum, 2010). Specifically they found that individuals with very high uncertainty avoidance scores performed better when errors were displayed immediately while individuals with very low uncertainty avoidance scores performed better when errors were displayed after they completed the form (Recabarren & Nussbaum, 2010).

2.8 Literature Synthesis

This section goes over an analysis of the literature that led to the research questions that were investigated in this research.

2.8.1 Use of Culture in UI Design

The goal of this research was to examine how a user's culture could be utilized to design more usable software UIs. The fields of UCSD and human factors engineering focus on bridging the gap between the machine, or the designer of the machine, and the user to prevent incompatibilities typically dismissed as "human error" (Chapanis, 1996, pp. 8–10; Wickens et al., 2004, p. 2). These user-focused fields provided a foundation from which to explore the issue of culture in UI design.

Two models of the process to develop user-focused systems were found in the literature. The HMSE model provides an overarching view of the process by which user-center machine interfaces are developed (Chapanis, 1996, p. 39; Funk, 2014). Garrett's model of User Experience provides a software UI specific model of this generalized process (Garrett, 2011, pp. 19–24). One of the common threads between these two models is a focus on identifying and characterizing the user in order to develop product requirements that enhance the user's ability to understand and manipulate the interface (Garrett, 2011, p. 28; Wickens et al., 2004, p. 37).

While much of the field of human factors engineering focuses on characterizing innate behaviors of users (Chapanis, 1996; Wickens et al., 2004), to fully understand how users think and respond their culture must also be taken into account (Hofstede, 2001, p. 9). Culture is a term that describes learned ways of thinking and behaving that are shared amongst a group of people for a particular time period (Handwerker, 2001; Hofstede, 2001, p. 9; Rapport, 2007).

However, one of the challenging aspects of analyzing a user's culture is that the process requires extensive time and resources (Handwerker, 2001, p. 4). Both the fields of human factors engineering and anthropology use similar methods to analyze the characteristics of a group of people including the use of databases, observation, interviews, surveys, and cultural probes (Handwerker, 2001). These methods require months to years to complete and often generate a large amount of ambiguous data that requires extensive analysis to generate usable design guidance (Handwerker, 2001, p. 4; Van Leeuwen et al., 2011).

2.8.2 Guidelines as a Means to Cultural Requirements

Guidelines provide human factors engineers with a tool to solve design problems where standards do not exist and there is minimal time to perform extensive analysis (Chapanis, 1996, p. 64; Wickens et al., 2004, p. 36).

Guidelines are general in nature, but are very easy to use and can be applied to a wide variety of scenarios and problems (Wickens et al., 2004, p. 36). They can be useful in identifying design aspects to consider, summarizing research, and as a starting point to develop design solutions (Wickens et al., 2004, p. 64).

Unfortunately, established cultural design guidelines are very few and only provide a list of system design aspects to evaluate for cultural influences (Cyr & Trevor-Smith, 2004), or provide solutions based upon on professional experience with little scientific validation (Marcus & Alexander, 2007; Marcus & Gould, 2000). This is one of the drawbacks of guidelines as they do not necessarily represent a consensus of scientific research, but can simply reflect one person's perspective (Chapanis, 1996, p. 64).

The other difficulty to culturally based guidelines is that utilizing them requires an extra step. Guidelines require designers to interpret if the guideline applies to their scenario, then evaluate the implications of the solutions the guideline implies (Wickens et al., 2004, p. 36). However, cross-cultural comparisons require a method to distinguish the differences between two or more cultures (Vinken et al., 2004, p. 5). Cultural dimension models provide a method to distinguish differences across many cultures (Vinken et al., 2004, p. 8).

2.8.3 Comparing Cultural Dimension Models

For this research, a cultural dimension model was selected to provide a framework and a focus for the research. In this case, Hofstede's model was selected based upon its ability to provide simple quantitative comparisons between cultures; it is applicable at the nation level of society; and it has been more extensively cited and used in UI preference research than the other models. Overall, Hofstede's model, and the research that utilizes it, provided greater utility to help answer the primary question of this research: can dimensional models be used to identify UI design differences between countries?

This choice was based upon utility rather than model validity because all three models have been empirically validated and identify similar dimensions (Hofstede, 2001; Schwartz, 2006; Triandis, 1995). Hofstede's power distance dimension is very similar to Triandis's horizontal vs vertical individualism and Schwartz's egalitarianism versus hierarchy dimensions (Hofstede, 2001, p. 79; Schwartz, 2006; Triandis, 1995, p. 44; Vinken et al., 2004, p. 16). Additionally, the nature of cultural dimensional models themselves lend to comparison by utility rather than validity as dimensions are not real entities in themselves, but instead provide a framework from which to make tractable the problem of comparing different cultures (Minkov & Hofstede, 2011).

Table 2.1 provides an overview of the utility comparisons used to evaluate each of the three models.

Table 2.1. Comparison of the three dimensional models

Creator	Hofstede, Geert	Triandis, Harry	Schwartz, Shalom
Seminal Work	"Cultures Consequences" 1984	"Individualism & Collectivism" 1995	"A Theory of Cultural Value Orientations" 2006
Number of Seminal Work Literature References (Google Scholar)	41,901	8,849	752
Number of References per year	1,309	421	75
Has been applied to UI Design	Yes	No	No
Cultural Data is Easily Accessible	Yes	No	No

Based upon results gathered from Google scholar, it was found that Hofstede's seminal work had been the most referenced work per year out of the three authors. This could be attributed to the fact that Hofstede's work has been around the longest. However, even with the controversy and criticism surrounding the model, it is considered within the cross-cultural research field as the gold standard to which other dimensional models are compared (Cyr & Head, 2013; Peterson, 2003; Vinken et al., 2004, pp. 20–25).

Additionally, after a review of the literature applying cultural dimensions to the design of UIs, it was found that Hofstede's model had been consistently used in this field, while the others had not. Because of this, Hofstede's model provided a base of research from which design guidelines could be elicited.

Lastly, the decision to use a dimensional model as framework, from which to base cultural guidelines, required that differences between two or more culture could be identified. While Hofstede, Triandis, and Schwartz have all developed tools to quantify and compare groups based upon their dimensional models, Hofstede was the only one that provided readily accessible dimension score datasets (Hofstede, 2015). Dimensional data could be downloaded for a number of countries right from his website, which made initial comparisons between nations feasible for industries and companies that would not have the time or resources to conduct multi-national surveys.

2.8.4 Research Gap in Cultural Dimension Guideline Literature

An observation of the studies that had applied cultural dimensions to the field of interface design was that they were exploratory in nature. These studies used example interfaces such as websites, phones, and games as a tool to discover differences in UI preferences between nations and how these correlated with cultural dimensions.

The studies also focused primarily on the field of website design, with only a few studies examining mobile phone and game UIs. The power of guidelines is that they can provide potential solutions and guidance in fields where standards do not necessarily exist (Wickens et al., 2004, p. 36). The one study that attempted to do this by Recabarren and Nussbaum (2010), unfortunately misapplied Hofstede's model as a cultural personality test to adapt a web-form UI to an individual's unique culture, contrary to Hofstede's guidance (Hofstede, 2001, p. 463). While the results of the study suggested that cultural adaptation based upon Hofstede's dimension led to increases in the usability of a UI, further research is required to validate these results (Recabarren & Nussbaum, 2010).

In light of this, the next step in this field of research was to validate cultural-dimension-based-guidelines by applying them to the design of a new product to determine if they produced valid solutions. This research serves as a first step towards filling this gap.

2.8.5 Focusing on Just Two Dimensions

To limit the scope of the research the researcher chose to focus on just two of Hofstede's dimensions: power distance and uncertainty avoidance. These dimensions were chosen as they had been identified in the literature as influencing UI design (De Angeli & Kyriakoullis, 2006; Marcus & Gould, 2000; Zaharias & Papargyris, 2009), as well provided suitable constructs from which guidelines and UIs could be built for the selected case study (see Chapter 3 for more details on the case study).

Table 2.2 provides a list of the number of reviewed studies that found evidence for variations in UI design preferences for each of Hofstede's cultural dimensions. No studies were found that analyzed Hofstede's indulgence dimension, likely because it was only recently added to the model in 2011 (Minkov & Hofstede, 2011).

Table 2.2. Number of reviewed studies that found design guidelines for Hofstede's dimensions

	Number of Studies
Individualism	7
Uncertainty Avoidance	6
Masculinity	4
Power Distance	2
Long Term Orientation	1
Indulgence	0

From these data, the individualism and collectivism dimension was found to be the most researched dimension with uncertainty avoidance coming in as a close second. Much of the research concerning individualism and collectivism found that individuals from collectivist nations tend to prefer features that enhance their awareness of society such as text messages and popularity ratings (Choi et al., 2005; De Angeli & Kyriakoullis, 2006; Jhangiani, 2006). The uncertainty avoidance dimension appeared to cover issues more broadly applicable to all UIs.

The research concerning uncertainty avoidance has found that individuals from high uncertainty avoidance nations tend to prefer more information, clear labels in navigation, less ambiguous or new interface design, and in general have greater anxiety when using interfaces (Choi et al., 2005; De Angeli & Kyriakoullis, 2006; Zaharias & Papargyris, 2009). Individuals from low uncertainty avoidance nations tend to be more tolerant of new and ambiguous interface designs, prefer more streamlined navigational systems, and tend to explore interfaces rather than relying on guides or up-front information (Choi et al., 2005; De Angeli & Kyriakoullis, 2006; Recabarren & Nussbaum, 2010; Zaharias & Papargyris, 2009). Guidelines from these results could be applied to a greater number of core features of a UI including navigational systems, information display, and help/tutorial responses.

While power distance was only researched by two of the reviewed studies, the guidance from these studies could be more broadly applied to UI design and had an interesting application to the case study examined by this research. The research has indicated that individuals from high power distance nations prefer hierarchical structures for information and system design and often refer to authorities for guidance in making decisions (Marcus & Gould, 2000; Zaharias & Papargyris, 2009). Individuals from lower power distance nations tend to prefer more flat or egalitarian systems and information architecture and also feel more empowered to make decisions/solve problems on their own (Marcus & Gould, 2000; Zaharias & Papargyris, 2009). These aspects can again be applied to many different types of UIs. Additionally, since the case study used in this research is focused on the development of a decision aid, the aspect of whether or not an individual feels more empowered to make decisions on their own had a particular relevance to this application.

Based upon this Hofstede’s uncertainty avoidance and power distance dimensions were chosen as the two dimensions of focus for this research.

2.8.6 Research Questions

In summary, this research study focused on the following research questions to help bridge the gap in the current research and fulfill the goal of evaluating the use of cultural dimension models to create more usable UIs.

1. Do UI guidelines derived from research related to Hofstede's cultural dimensions model produce valid computer UI requirements for a given country?
2. Do user-group usability ratings of UI components vary in relation to the difference between their nationalities' Hofstede cultural dimension scores?

a. Do user-group usability ratings of UI components vary in relation to the difference between their nationalities' Power Distance scores?
b. Do user-group usability ratings of UI components vary in relation to the difference between their nationalities' Uncertainty Avoidance scores?

3 Methods

3.1 Introduction

This chapter details the methodology used to answer the research questions. First, a case study was identified as a new context in which the cultural guidelines derived from the literature could be applied. A series of task analysis activities provided background on the process and functions that the software UI would have to accomplish. Next, guidelines were derived from the literature and applied to the case study to develop four pairs of UI components. Lastly, an online survey was developed and distributed to assess whether a user's usability of the UI components varied with their nationality's Hofstede dimension scores, as predicted by the cultural guidelines.

3.2 Motivational Case Study

A case study approach was adopted to help answer the research questions. The studies examining cultural dimensions and UI design had been mostly exploratory in nature with very few attempts to apply the derived guidelines to new fields. Case study research focuses on examining a phenomenon within a set of contextual conditions, as the context and the phenomenon are meaningless without the other (Yin, 2009, p. 18). The method has traditionally been used in the social sciences, with case studies allowing the examination of theories within real-life conditions (Yin, 2009, pp. 4–20).

The case study in this research was used as a context in which the guidelines could be applied to develop software UIs. These UIs could then be tested using usability analysis methods. Since the purpose of guidelines is to design systems, it is difficult to assess whether guidelines lead to more usable systems without a context in which to apply them. This makes the context and phenomenon indistinguishable from each other in this type of research conforming to Yin's (2009, p. 18) definition of a case study. However, unlike Yin's (2009, pp. 17–20) description of the case study methodology, this research tested the outputs of the case study using more traditional survey and usability methodologies.

A project that inspired the case study used in this research was the development of an infectious disease diagnostic version of the Healthcare Toolkit (HTK-ID). The Healthcare Toolkit (HTK) is collaboration between Dr. Kenneth Funk and Bauer Labs LLC. The goal of the project is to create a portable system that integrates the data organization and diagnostic support of an electronic health records system with physiological examination equipment such as stethoscopes and blood pressure cuffs ("Healthcare Toolkit « Bauer Labs," n.d.).

A version of the HTK system focused on the diagnosis of infectious diseases is currently in development to improve medical access in impoverish nations such as Sierra Leone. A non-profit group called Willamette International, which provides medical services in Sierra Leone ("Willamette International," n.d.), has provided help with the HTK-ID project.

The purpose of this research was to determine if cultural-dimension-based design guidelines could lead to more usable culturally localized UIs. This meant that the study would need to determine if a UI based upon these guidelines would lead to greater measured usability in one culture versus the other.

Since a research team at Oregon State University, located in the United States, intended to design the HTK-ID UI for Sierra Leoneans at least these two nationalities would need to participate in such a study.

The problem with the case study was that while equatorial infectious diseases, such as malaria, are common in countries like Sierra Leone, people here in the United States (as well as other non-equatorial nations) do not encounter these diseases on a regular basis. Participants from these countries would not relate to software UIs concerning these diseases. This could affect the validity of their responses. Because of this, it was decided to modify the case study to focus on infectious upper respiratory diseases such as the flu and common cold.

Like the equatorial diseases, upper respiratory diseases often start with a common symptom such as cough or fever. Additionally, because of the range of severity and treatment options they can often require a visit to the doctor to diagnose. After examining the differential diagnosis sections of a series of medical case studies (Carey, 2007, pp. 115–122, 2007, pp. 99–114; Neal-Boylan, 2011, pp. 387–398) the following four diseases were chosen: influenza (flu), viral pneumonia, bacterial pneumonia, and viral syndrome (common cold) as the diseases of focus for the case study medical application.

Before any UIs could be designed, a thorough task analysis needed to be performed to decompose the tasks the system must perform and identify the UIs that must be developed (Wickens et al., 2004, pp. 37–38). For this study, a task analysis was performed on the diagnostic process of the equatorial infectious diseases via an IDEF0 model and a knowledge model.

The task analysis was done for the equatorial infectious diseases rather than the upper respiratory diseases of the case study, as one of the goals of the research program, of which this study was a part, was to produce requirements for the HTK-ID system. Since this process only provided some basic background and inspiration for the case study, only the findings are discussed in this section. A detailed description of the HTK-ID project and task analysis process is provided in Appendix A.

The resulting diagrams of the task analysis activities provided the researcher with the background information needed to develop culturally relevant UI systems. Specifically the IDEF0 model and the knowledge model allowed the researcher to identify and allocate tasks to the UI systems. The diagrams also provided background on the types of information that would need to be collected and displayed by the HTK-ID and similar diagnostic systems.

The IDEF0 model provided the task decomposition needed to identify the tasks that would need to be allocated between the software system and user. Since the case study medical application was intended to be a diagnostic aid, the IDEF0 model provided the primary tasks that would need to be performed in this process. These tasks were to collect information, analyze it, and generate a list of hypotheses. It was determined that the last task, finalizing the diagnosis, would be left up to the medical personnel. Discussions with the SMEs revealed that the final diagnostic decision, which was sometimes a matter of life or death, was ultimately up to the medical professional who needed to evaluate all aspects of the case including the patient history, age, risk factors, as well as the reliability/availability of resources in the facility. Some of this information would not necessarily be documented in a medical record and would need to be assessed immediately.

The knowledge model was used to help identify the types of information utilized by physicians and infectious disease experts when diagnosing infectious diseases. The most critical piece of information appeared to be the epidemiological information. This was used by the SMEs to mentally calculate a likelihood probably for each candidate condition. Symptomatic information was primarily used to assess the severity of the condition.

All of this information was utilized in the next phase of the research that focused on developing the cultural guidelines from the literature to be used to create UI components for the case study.

3.3 Guideline and UI Component Pair Development

The next step of the research study was to develop cultural guidelines based upon the research studies found during the literature review. A pair of guidelines was developed for each of the two Hofstede cultural dimensions that were the focus of the research: power distance and uncertainty avoidance. Each guideline pair consisted of one guideline to provide guidance for the low pole of the dimension and one for the high pole. After the guidelines were developed, two UI components of the case study medical application UI were identified as being relevant to each of the two cultural dimensions. Four different UI components were identified in total. A pair of alternate versions of these UI components were created to represent the associated pair of guidelines. The rest of this section is devoted to detailing this process.

3.3.1 Development of Guidelines

The development of the cultural guidelines began with an assessment of how specific or abstract the guidelines should be. Garrett’s (2011) Elements of User Experience model (refer to section 2.2 for more information) was used as the basis of this analysis to determine what layers of a UI the guidelines should apply to.

The literature suggests that the design of the structure, skeleton, and surface layers of a software UI should be modified to make a culturally localized design (Cyr, 2008). However, because cultural dimensions represent broad values it is proposed that guidelines derived from cultural dimensions have a greater applicability on the design of the structure and skeleton layers.

This is because symbols and colors, in some cases, can depend more upon history and technology than upon cultural values. The “save” icon used Microsoft Windows applications is one such example. The “save” icon is a picture of a 3.5 inch floppy disk that used to be a common medium to save files on. Because it was commonly used, software designers adopted the symbol to represent the “save” action. It is still used today because of its long history in use. The use of such an icon is unlikely to be derived from a guideline based solely upon a cultural dimension construct.

Because of this, the current research focused on generating and analyzing cultural-dimension-based guidelines that affected the structure and skeleton layers of a software UI. However, this does not dismiss the idea that useful guidelines could be generated for the surface layer. In fact, Marcus and Gould (2000) suggest some such guidelines in their article that have yet to be further validated.

Next, the literature was reviewed to identify themes and UI preferences to develop a guideline pair for each of the two dimensions. Only one guideline pair was identified per dimension to limit the scope of the research project and make testing/analysis feasible.

Two types of literature were reviewed in this process. Hofstede’s publications and analysis tools were reviewed to identify the issues and concepts that were measured by each dimension. The exploratory studies detailed in the Literature Review that examined the UI preferences in terms of Hofstede’s cultural dimensions were also reviewed. The researcher then developed a general guideline pair that represented the common themes between the “top-down” and “bottom-up” reviews of the literature.

3.3.1.1 Power Distance Guideline

Hofstede (2001, p. 79) states that the power distance (PD) dimension on the most basic level measures inequality in a society. The value itself is a measure of how much society values inequality versus equality (Hofstede, 2001, p. 83). It focuses on the term “power,” which is defined as the ability to direct or control (“Definition of POWER,” n.d.).

A nation’s PD score is measured in Hofstede and Minkov’s VSM (2013a) based upon the responses to four questions. The first question asks the participant to rate how important it is to “have a boss (direct superior) you can respect” (Hofstede & Minkov, 2013b). The next question asks the participant to rate how important it is to “be consulted by your boss in decisions involving your work” (Hofstede & Minkov, 2013b). The third question asks the participant about how often “are subordinates afraid to contradict their boss…” (Hofstede & Minkov, 2013b). The last question asks the participant if they agree with the statement “an organization structure in which certain subordinates have two bosses should be avoided at all cost” (Hofstede & Minkov, 2013b).

The themes these questions explore are the value of respect in a relationship, the ability to make decisions, the ability to question a superior, and the value of strict hierarchies. At least two of these questions directly concern how empowered an individual feels to make their own decisions and question the decisions/guidance of their superiors. This idea should logically extend to any guidance document or decision aids provided by an authority as well.

From the studies exploring UI design preferences that correlate with Hofstede’s PD dimension, a few key insights were apparent. The study by Zaharias and Papargyris (2009) found that players of massively multiplayer online (MMO) games from lower PD nations tended to solve problems within the game on their own. Contrary to that, players from high PD nations preferred to seek guidance from game developers and game authorities to solve problems (Zaharias & Papargyris, 2009). This theme was also echoed by Marcus and Gould (2000) who identified that PD might influence how information access is structured and the prevalence of strict rules within a website.

A common theme in the literature was that the PD dimension appears to influence how empowered an individual is to make decisions. Since individuals from high PD nations do not feel as empowered to make decisions, then a high PD UI should be adapted to minimize the number and extent of decisions to be made by the user. A UI for users from a low PD nation should instead enhance the ability of the user to make their own decisions. Thus, the guideline pair for the PD dimension is:

- High PD: provide the user with guidance, information, and tools so that users do not have to make as many decisions.
- Low PD: provide the user with the tools and information to make decisions on their own.

3.3.1.2 Uncertainty Avoidance Guideline

The uncertainty avoidance (UA) dimension is defined by Hofstede (2001, pp. 145–148) as how a culture handles and copes with the unknown. The “unknown” is often a source of anxiety for individuals (Hofstede, 2001, p. 146). Some cultures have adapted to tolerate and accept uncertainty, while others are intolerant of uncertainty and try to avoid it (Hofstede, 2001, p. 146).

Hofstede (2001, pp. 160–161) also states that UA correlates with a culture’s acceptance of new experiences and information. People from high UA nations tend to reject changes, while people from low UA nations tend to more accepting of changes and new experiences (Hofstede, 2001, pp. 160–161).

A nation’s PD score is measured in Hofstede and Minkov’s VSM (2013a) based, like the PD dimension, on the responses to four questions. The first question asks the participant “how often do you feel nervous or tense” (Hofstede & Minkov, 2013b). The next question asks the participant to “describe your state of health these days” (Hofstede & Minkov, 2013b). The third question asks the participant’s level of agreement with the statement, “one can be a good manager without having a precise answer to every question that a subordinate may raise about his or her work” (Hofstede & Minkov, 2013b). The last question asks the participant’s level of agreement with the statement, “a company’s or organization’s rules should not be broken – not even when the employee thinks breaking the rule would be in the organization’s best interest” (Hofstede & Minkov, 2013b).

The first two questions are a measure of a person’s subjective health and well-being, which has been found to correlate with the UA dimension (Hofstede, 2001, p. 160). The last two questions pertain more directly to the UA dimension itself by gauging how accepting the participant is of ambiguous situations. Does the participant require information in advance to avoid the unknown? On the other hand, are they more accepting of the unknown and willing to wait for such situations to be cleared up in the future? This suggests that people from high UA nations must have information in advance to avoid the unknown, while people from low UA nations require less information in advance as they are more accepting of the unknown.

This theme was also found in the research studies examining the UA dimension and UI preferences. Zaharias and Papargyris's (2009) study results suggested that players of MMO games from high UA nations desired more extensive game guides that helped them understand the UI better. Choi et al. (2005) also found that cell-phone users from high UA nations tended to not like ambiguous UIs, preferring UIs that displayed greater amounts of information to describe menus and options. On the other hand, cell-phone users from low UA nations preferred simpler UIs with less information as this facilitated quick exploration (Choi et al., 2005). Such users considered anything more than the bare minimum of labeling and information as useless (Choi et al., 2005).

The common theme conveyed by the literature is that users from high UA nations tend to prefer more information about a UI before they interact with it. Users from low UA nations tend to prefer more streamlined UIs that facilitate quicker exploration. Thus, the guideline pair for the UA dimension is:

- High UA: provide users with more information in advance to enhance their understanding of actions and their consequences within a UI before an action is initiated.
- Low UA: provide users with minimal information cues to aid their ability to quickly and safely explore and discover actions and their consequences within a UI.

3.3.2 Development of the UI Component Pairs

After developing the guidelines for each cultural dimension, the next step was to identify UI components that the guidelines influenced. This section details the general process by which the UI components were identified and created.

During this process, the IDEF0 and knowledge model developed during the task analysis provided the background information needed to identify the appropriate components of the case study UI.

Since the PD dimension guideline was related to decision making, two UI components were identified that involved decisions: the data entry options and results display. The entry of patient symptoms and risk factors was identified as a component that required the user to make a decision. These types of UIs often require a user to select one of a set number of responses to describe or classify a patient's symptoms. The case study UI also needed to display the results of the differential diagnosis to help the medical technician decide which disease(s) was the likely cause and required further investigation.

The UA dimension guideline focused on how structural and interaction information concerning a UI should be conveyed. It specifically identified a dichotomy between displaying information about the UI in advance to a user versus presenting less information to allow the user to learn about the UI on their own. The two most relevant UI components in the case study medical application UI were the navigational menu and the location of the results in the system UI. The preference for navigational menu designs has been shown to vary by nationality in other studies (Choi et al., 2005). Navigational menus can vary in the amount of information included in the design to facilitate user understanding or exploration. The other component deals with when and where the results of the case study medical application tool should be presented to the user. Should it be presented immediately so that there is less uncertainty while using the tool? Alternatively, should the results be shown after the user has completed the data entry activities?

After the four UI components were identified, drafts of the alternate versions were created. In cases where medical information was to be displayed to the user, such as the case study UI results display, medical case scenarios of upper respiratory diseases were consulted (Carey, 2007, pp. 115–122, 2007, pp. 99–114; Neal-Boylan, 2011, pp. 387–398). A popular online symptom matching tool was also utilized to make the information appear realistic ("Symptom Checker," n.d.).

Drafts of these UI components were reviewed by the researcher's faculty advisor and colleagues within their research group. Based on the received feedback, the UI components were modified to improve the information clarity in the UI and fix any identified mistakes. The final versions of the UI component pairs are described in the next section.

3.3.3 Finalized UI Component Pairs

For users from high PD nations the guideline developed in this research suggested that number and extent of decisions should be minimized. To represent this the high PD version, shown in Figure 3.1, provided the user with very specific and detailed options. The reasoning for this was that specific options reduced the need for users to interpret the meaning of each of the options to ease the decision making process. The disadvantage to this design was that the responses to these questions only captured one aspect of a symptom. For example, while the temperature of a fever was important in determining its severity, the length of time a fever has been present was another indication of its severity that could not be captured in one of these detailed question responses ("Fever: First aid - Mayo Clinic," 2015).

In contrast, the low PD version of the data entry options, shown in Figure 3.2, were more general and abstract. These abstract options allowed more information to be captured within a single response. In this version, the user could consider the temperature and timeline of a fever to decide if it was either mild, moderate, or severe. These abstract levels of severity have been found to be effective in describing and diagnosing symptoms (Van Zanten et al., 2006). The disadvantage to this design was that user was required to process more information and make more decisions as to the meaning of these options, but this reflects the low PD guideline.

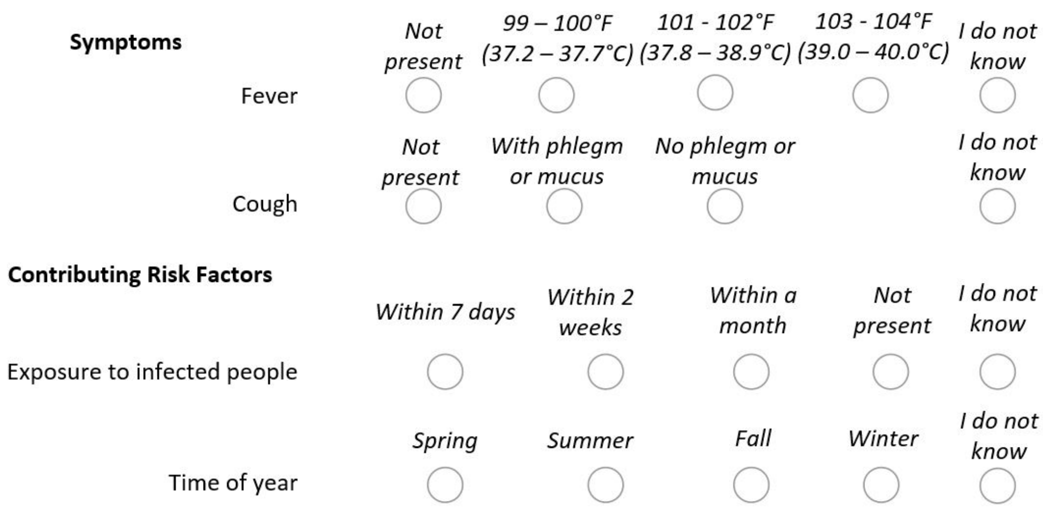


Figure 3.1. High PD Data Entry Options

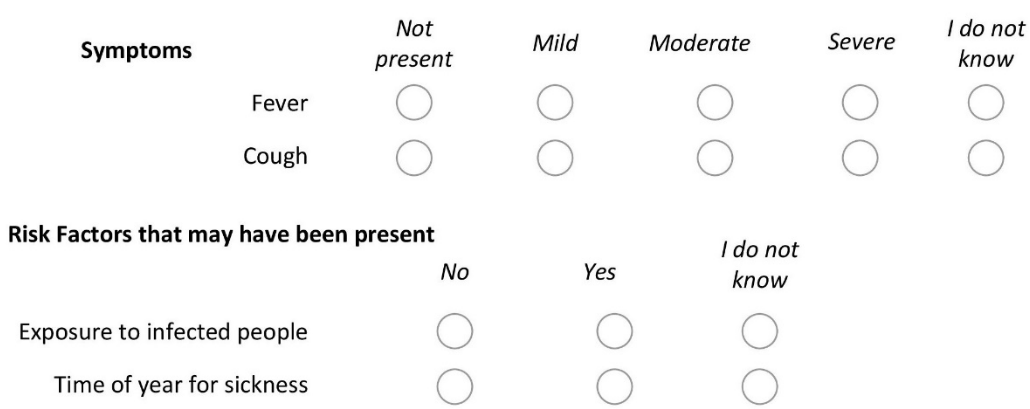


Figure 3.2. Low PD Data Entry Options

The PD guideline was also suspected to influence the results display of the case study. To represent this the results display shown in Figure 3.3 was created. It consisted of a list of the possible upper respiratory diseases as well as single decision variable that showed which disease was most likely in the form of a percentage. The percentage was meant to indicate a percentage of the symptoms and risk factors that matched each disease. The amount of supporting evidence that would need to be evaluated by the user was reduced to a single decision variable in this display. While it did reduce the number of decisions that must be made comparing information, it required the user to trust a "black-box" algorithm that user may not understand or trust.

	Percent Likely
Influenza (Flu)	90%
Viral Syndrome (Common Cold)	60%
Viral Pneumonia	70%
Bacterial Pneumonia	85%

Figure 3.3. High PD Results Display

In contrast to this, the low PD guideline suggested that users from low PD countries would prefer interfaces that did not reduce the number of decisions that should be made, but instead showed all the information needed to make the decision on their own. To represent the guideline an alternate case study UI results display was created, shown in Figure 3.4. This version showed the same list of diseases as the other display, but instead showed detailed information about the symptoms and risk factors that match each disease. There was purposefully no summarizing decision variable like in the high PD results display as the guideline suggested that low PD users preferred to make their own decisions. Instead, the detailed information could be analyzed by the user so they could come to their own conclusion about which disease(s) required further investigation. The disadvantage to this design was that it required more cognitive processing than the high PD version.

Symptoms and Risk Factors You Have Entered That Match Each Disease

	Influenza (Flu)	Viral Syndrome (Common Cold)	Viral Pneumonia	Bacterial Pneumonia
Risk Factors	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Place of Residence - Age - Time of Year
Symptoms	- Joint Aches - Cough - Headache - Chills - Fever - Body aches	- Body Aches - Fever	- Body Aches - Fever - Cough	- Joint Aches - Cough - Headache - Chills - Fever - Body aches

Figure 3.4. Low PD Results Display

It was determined that the UA guidelines could be applied to the design of the navigational menus of the case study UI. The high UA guideline suggested that more information should be displayed to facilitate the understanding of a UI before an action is initiated. Using this as a guideline the navigational menu for the case study UI, shown in Figure 3.5, was developed. This menu used multiple modes to relay to the user what would display when each button was clicked. This included the use of icons, labels, as well as detailed descriptions that would show up when the mouse hovered over the button. While this provided an extensive amount of information, it came at a cost of using more space than a simpler menu system.

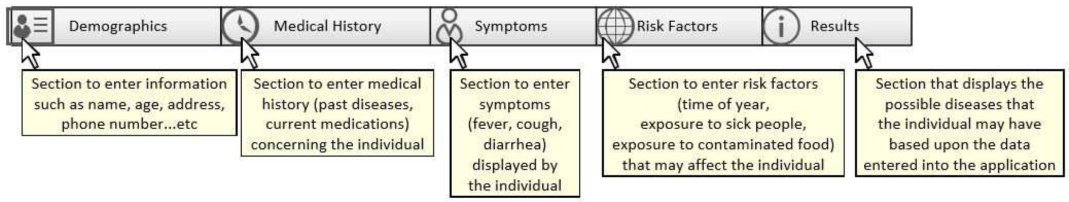


Figure 3.5. High UA Navigation Menu

The low UA guideline on the other hand, suggested that a UI should be streamlined to support exploration. As a counterpoint to the high UA navigational menu, the low UA navigational menu, shown in Figure 3.6, displayed considerably less information in a more compact menu. This menu system had less information to process, which the research suggested was useless to users from low UA nations (Choi et al., 2005). This allowed the user to quickly explore and learn about the navigational menu on their own.

Figure 3.6. Low UA Navigation Menu

The other UI component of the case study UI that the UA guidelines appeared to apply to was the location of the results in the system. Since users from a high UA nation desired more information in advance, the high UA results location UI, shown in Figure 3.7, displayed the results at the bottom of the screen in red text at all times. The idea was that the results at the bottom of the screen would update as the user entered information into the tool, as demonstrated in Figure 3.7. Since the user was always aware of the results, this reduced the uncertainty while using the tool. There was a tradeoff with this design as the results display reduced the available screen space for the rest of the tool.

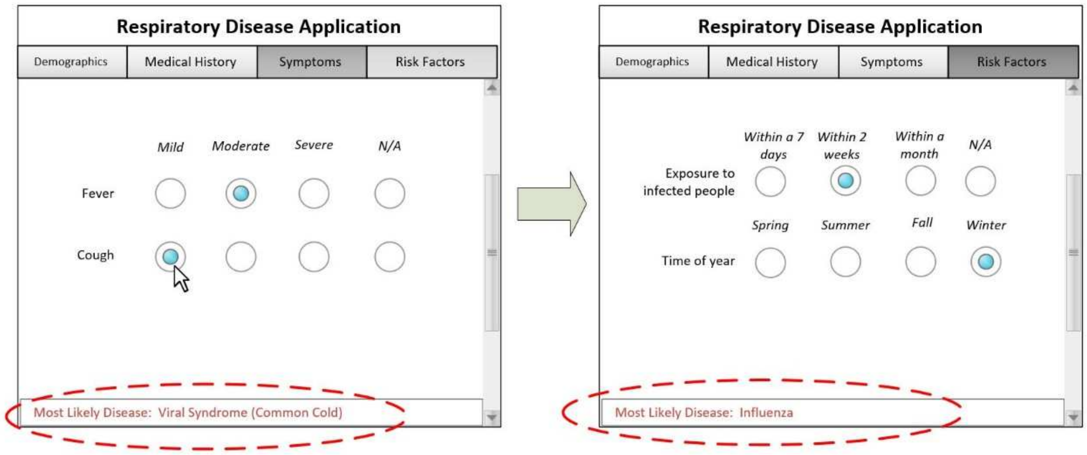


Figure 3.7. High UA Results Location with the results circled in red

For the low UA version, shown in Figure 3.8, the results were placed in a separate tab to be viewed after the data was entered into the other portions of the tool. This design was meant to increase the usable screen space for the data entry tasks, as users from low UA nations would not require the results while they were performing the data entry tasks. The tradeoff in this design was that the user must wait until the end to review the results and they had no feedback on how the results changed as more data was entered.

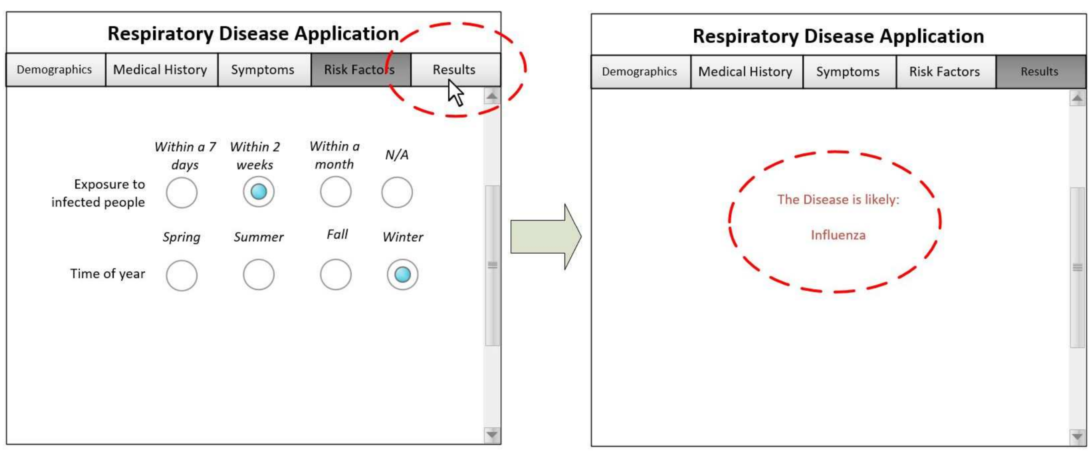


Figure 3.8. Low UA Results Location with the results circled in red

It should be noted that unlike the other UI components, the demonstration of the results location UI solution required that a more complete UI be shown. This was quite different from the isolated components developed for the other UI component pairs. To minimize the salience of the other UI aspects (the results, navigation menu, and data entry) it was decided that minimalistic versions of the other UI components would be used in both the high and low UA versions of the results placement.

These four UI component pairs were not meant to be a complete list of all aspects of the case study medical application UI that the PD and UA guidelines would apply to. Neither were they meant to represent the most usable or ideal versions of these UI components. They were developed to be similar representations of the same components that varied just in the manner spelled out by the cultural-dimension-based guidelines to facilitate usability comparisons.

3.4 Validation

Again, the goal of this research was to determine if cultural-dimension-based guidelines could lead to more usable UIs. To answer this question, the usability of the UI pairs developed needed to be assessed.

Usability is defined by Wickens (2004, p. 59) as how easy a system is to use. Nielson (1993) stated that usability consists of five variables: learnability, efficiency, memorability, errors, and satisfaction (Wickens et al., 2004, p. 59).

It should be understood that Hofstede's cultural dimensions represent continuums and as such, nations cannot be classified as just "high PD" or just "low PD" (Hofstede, 2001, p. 96). Since the UI components detailed in the previous section represented the poles of the cultural guideline, it was hypothesized that if the cultural guidelines were valid, then the difference in usability with the UI component pairs would vary on average with the participant group's nationality scores. Based upon this the researcher generated the following hypotheses:

- *Hypothesis A*: A participant's national score in the PD dimension **will** correlate with their difference in usability between the UI components labeled "high PD" versus the UI components labeled "low PD."
- *Hypothesis A.null*: A participant's national score in the PD dimension **will not** correlate with their difference in usability between the UI components labeled "high PD" versus the UI components labeled "low PD."
- *Hypothesis B*: A participant's national score in the uncertainty avoidance dimension **will** correlate with their difference in usability between the UI components labeled "high uncertainty avoidance" versus the UI components labeled "low uncertainty avoidance."
- *Hypothesis B.null*: A participant's national score in the uncertainty avoidance dimension **will not** correlate with their difference in usability between the UI components labeled "high uncertainty avoidance" versus the UI components labeled "low uncertainty avoidance."

It was these hypotheses that that guided the researcher to use the test methodology described in the next section.

3.4.1 Validation Method

The difficulty with cross-cultural research is that it often requires participants from a number of cultures, with this research study not being an exemption. Hofstede recommends that replications of his research should involve a homogenous sample of no less than 20 participants (at least 50 is ideal) per country from at least ten countries (Hofstede, 2001, p. 463; Hofstede & Minkov, 2013a). This is considerably more than the five to six participants necessary for a basic system usability assessment

(Wickens et al., 2004, p. 409). A survey was chosen as the test vehicle as it offered an efficient method to gather data from a large number of participants.

An online survey software called Qualtrics, provided by Oregon State University, was used to create the survey in this study ("Qualtrics | Oregon State University | Oregon State University," n.d.). The online system allowed the survey to be easily distributed and accessed by participants. Additionally, the software had the ability to track how long a user spent on a page of the survey. This allowed the researcher to collect quantitative usability data that would not be possible using a paper version.

It was also decided to conduct the usability assessments of the UI components in isolation and not as part of a completely formed UI system. Having the participants assess the UI components without any other distractions allowed the participants to focus on just the UI component of interest. This allowed the researcher the opportunity to derive clear correlations between the UI component design and the usability results. The cross-cultural design studies that used fully functional websites or games often could only derive self-reported design preferences, as the raw data itself could not pinpoint which features made the difference (Choi et al., 2005; Cyr et al., 2005; Simon, 2001).

To test the usability of these components a combination of metrics were used. The time to interact with the component in a fictional scenario, a participant's confidence in their answers to the scenario, a modified standard usability questionnaire, and an overall preference question were used to assess the different aspects of usability.

Initial drafts of the survey were reviewed by the researcher's advisor and members of their research group. The feedback was used to revise and enhance the survey. In addition, all of the survey text and questions developed by the researcher, which did not come from a standard tool, were assessed for reading grade level using the Flesch-Kincaid reading grade level equation. The standard for general readability is anywhere from 5th to 8th grade (Paasche - Orlow, Taylor, & Brancati, 2003). However, with the target audience being at least 18 years or older and the content involving medical terminology it was determined that a 10th grade reading level maximum was more achievable. While every effort was made to reduce the reading grade level to 10 or below, exceptions were made if the changes required to reduce the grade level did not allow a question to be efficiently asked or would hinder clarity. This is because the Flesch-Kincaid reading grade level equation is largely influenced by the number of words in a sentence and the number of syllables in a word (Paasche - Orlow et al., 2003). In this case, large words such as "nationality" and "identify" are counted as extremely complex even if their meaning is relatively simple and known.

A description of the final survey is provided in the section 3.4.3 and a copy of the survey is provided in Appendix D. The next section discusses the survey population that was solicited to participate.

3.4.2 Survey Population

When doing cross-cultural research it is important to establish matched samples of participants between countries (Schwartz, 2006). In this study, the researchers attempted to balance the needs of matching the study population to the intended user population of the case study as well as ensuring that populations representing different nationalities were similar enough to be compared directly.

To meet these needs the researcher asked representatives from Willamette International to describe some key characteristics of the potential user population for the case study. From these meetings a list of user characteristics were developed.

- Must read, write, and speak English
- Have little or no medical training
- Have moral integrity
- Be willing and eager to learn

From this list, the key characteristics of being able to communicate in English and having no formal medical training were selected as reasonable inclusion criteria for the study.

The researchers also made the decision to focus on participants currently living in the United States, either temporarily or permanently. This was done in an effort to ensure that participants representing the different nationalities were currently living in similar environments. United States universities and colleges provided a unique assembly of individuals from many different nations all facing similar living and working environments. This provided a viable population of sufficient size and diversity to make the study possible.

Based upon this ideal population of participants living in the United States, the researchers set the following inclusion criteria to ensure that the participant was sufficiently knowledgeable and representative of the nationality they identified with.

- 18 years of age or older
- Currently living in the United States, either permanently or temporarily
- Read and write in English
- Identify with only one nationality
- Spent approximately 15 years living in the country associated with the nationality they identify with
- If they are currently not living in the country associated with their nationality, they have spent no more than the last 5 years living outside of the country associated with their nationality (ignoring absences of 3 months or less)
- Does not have medical training beyond basic first-aid, CPR, and AED training that would qualify them for a medical profession

3.4.3 Survey Protocol

A full copy of the survey is attached in Appendix D. This section describes the survey protocol and examination procedures that were followed for this study.

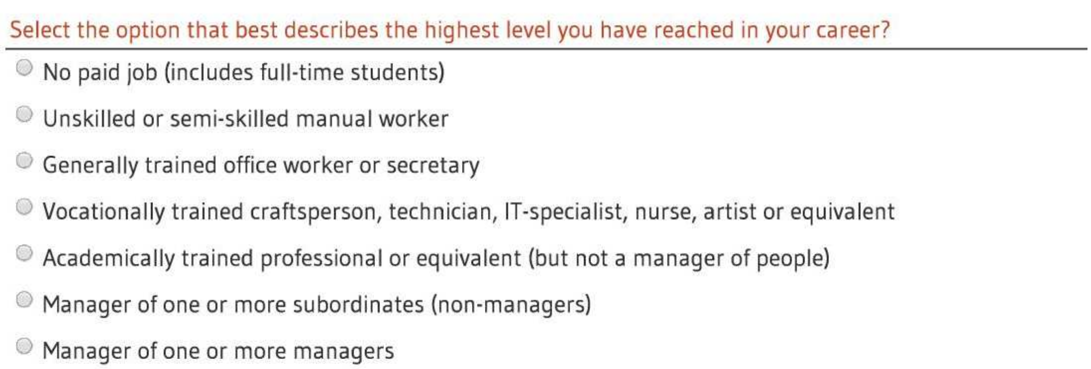
Individuals that wished to participate in the study accessed the survey by clicking on a link or entering the website address into their browser.

Participants were then presented with the informed consent documentation. Individuals that wished to participate checked a box indicating that they understood the information in the informed consent document. They then checked a box to indicate that they consented to proceed with the survey. They then clicked the “Next Page” button to proceed.

Next, the participant was asked to answer a series of screening questions related to their eligibility to participate in the study. While these questions were not mandatory, if the participant failed to answer one of the questions then they were prompted by the system if they wished to continue without answering the question or if they wished to answer the question before proceeding. This helped ensure that only eligible individuals completed the rest of the survey.

If the participant met the eligibility criteria, they were then asked to provide some demographic information including gender, age, number of years of formal education, and highest level of managerial status they have achieved in their career. All of these questions were derived from the VSM survey (Hofstede & Minkov, 2013b). Variations in these demographics have been found to influence the Hofstede dimension scores (Hofstede, 2001, p. 50; Hofstede & Minkov, 2013a). Modifications were made to the gender question responses to comply with Oregon State University (OSU) Institutional Review Board (IRB) policies.

The career question text was also modified to clarify how participants who have had multiple jobs should respond. The original question asked a participant to identify what kind of paid job they have or had. This was found to be confusing to the researcher’s colleagues who were currently students, but previously had been managers or other types of workers. The question was modified to final version shown in Figure 3.9.


Select the option that best describes the highest level you have reached in your career?

- No paid job (includes full-time students)
- Unskilled or semi-skilled manual worker
- Generally trained office worker or secretary
- Vocationally trained craftsperson, technician, IT-specialist, nurse, artist or equivalent
- Academically trained professional or equivalent (but not a manager of people)
- Manager of one or more subordinates (non-managers)
- Manager of one or more managers

Figure 3.9. High Managerial Level Question

On the next page, the participant was asked to indicate what nationality they identified with by selecting the country associated with that nationality from a drop-down list. An “other” option was provided along with an associated text box if their country did not appear on the list. They were asked how long they lived in that country and how many years have passed since they lived in that country. They were also asked questions about the country they were born in, if it was different from the country associated with their nationality.

After the demographics and nationality information had been collected, the participant was asked to fill out the VSM survey developed by Hofstede and Minkov (2013b). This was done so that the Hofstede cultural dimension scores could be calculated for each of the nationalities that participated and compared to Hofstede’s published scores. The questions concerned what the participant valued in terms of a job, values that were important in their private life (fun time, moderation, service, and thrift), their general health and happiness, and if they were proud to be a citizen of their country. Response options were added to the original VSM so that participants could indicate if they did not wish to respond to any or all of the questions. An example of a few of these questions are shown in Figure 3.10.

Please think of an ideal job, disregarding your present job, if you have one. In choosing an ideal job, how important would it be to you to...

	Of utmost importance	Very important	Of moderate importance	Of little importance	Of very little or no importance	*Do not wish to answer*
Have sufficient time for your personal or home life	○	○	○	○	○	○
Have a boss (direct superior) you can respect	○	○	○	○	○	○
Get recognition for good performance	○	○	○	○	○	○
Have security of employment	○	○	○	○	○	○
Have pleasant people to work with	○	○	○	○	○	○
Do work that is interesting	○	○	○	○	○	○
Be consulted by your boss in decisions involving your work	○	○	○	○	○	○
Live in a desirable area	○	○	○	○	○	○
Have a job respected by your family and friends	○	○	○	○	○	○

Figure 3.10. Section of the VSM Questionnaire used in the Survey

After the participant completed the VSM, a page was displayed that informed them that the next set of questions would ask them to evaluate a series of UI components, shown in Figure 3.11. They were also informed that they would be asked to respond to timed fictitious medical scenarios, and that all information/scenarios presented in the survey were fictitious and should not be used outside the survey context.

The next set of questions will ask you to evaluate parts of a medical application to help someone determine what disease they might have such as the flu, common cold, or pneumonia. Except where noted, software parts will be shown as screenshots that you will not be able to interact with. You will be timed during some of the questions.

The researchers have made up all of the information and situations in the following questions. Do not use any of the information in these questions outside the survey.

Figure 3.11. Survey Introduction to Component Usability Message

Next, the participant was asked to evaluate the UI component pairs developed by the researcher. Each participant evaluated all four UI component pairs. The order the pairs were presented to the participant was randomized between participants. The presentation order of the two UI components in a pair were randomized between participants as well.

For each UI component, the participant was asked to interact with it in a timed fictitious medical scenario. For example, in the PD dimension/Results display scenario the participant was first shown a page detailing the scenario and informing them that their time to complete the scenario on the next page would be recorded. The scenario in this case asked the participant to imagine that their friend was sick and that they had decided to use a medical application to determine what disease was affecting their friend. They were told they had already entered all the requested data into the application. They were then presented on the next page with the results display and were asked to determine what disease their friend had based upon the information presented in the results display, as shown in Figure 3.12. Only the participant's response to the question, time until first mouse click on the page, time until last mouse click on the page, and time until page submittal were recorded for these scenarios. A similar scenario was used for the PD data entry UI pair.

Since the UA guidelines were more focused on information expectation, an alternate timed scenario type was used. For the UA navigation component pair, the participant was asked to click on an image of the navigational menu to identify the button they would click to record their symptoms, shown in Figure 3.13. Again the participant's response, the location of the click on the image, time until first mouse click, time until last mouse click, and time until page submittal were recorded for these scenarios. A similar image click scenario was used for the UA results placement pair.

Scenario repeated from last page:
Imagine your friend is sick. You decide to use a medical application to determine what disease is affecting them. You have already entered all of the requested data into the application including their symptoms and any risk factors.

The results of the medical application are shown as:

Symptoms and Risk Factors You Have Entered That Match Each Disease

	Influenza (Flu)	Viral Syndrome (Common Cold)	Viral Pneumonia	Bacterial Pneumonia
Risk Factors	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Place of Residence - Age - Time of Year
Symptoms	- Joint Aches - Cough - Headache - Chills - Fever - Body aches	- Body Aches - Fever	- Body Aches - Fever - Cough	- Joint Aches - Cough - Headache - Chills - Fever - Body aches

Based purely on the data shown in the results above, what disease do you think your friend has?

- Bacterial Pneumonia
- Influenza (Flu)
- Viral Pneumonia
- Viral Syndrome (Common Cold)
- Other
- I do not know
- None of the diseases above

Figure 3.12. Survey - PD Results Display Timed Scenario

Scenario repeated from last page:
Imagine that you are using a medical application to determine what disease your friend has. You need to enter into the application that your friend has a sore throat, body aches, and feels weak.

Click on the navigation bar where you might enter this information.

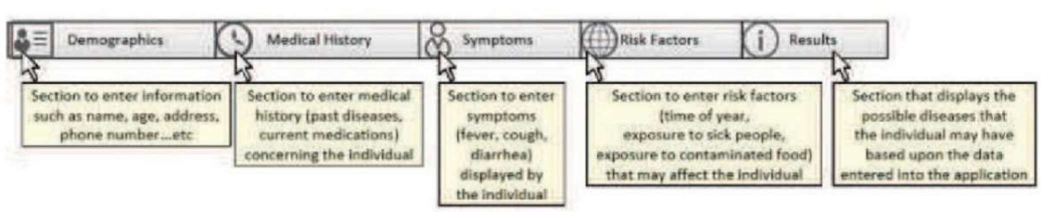
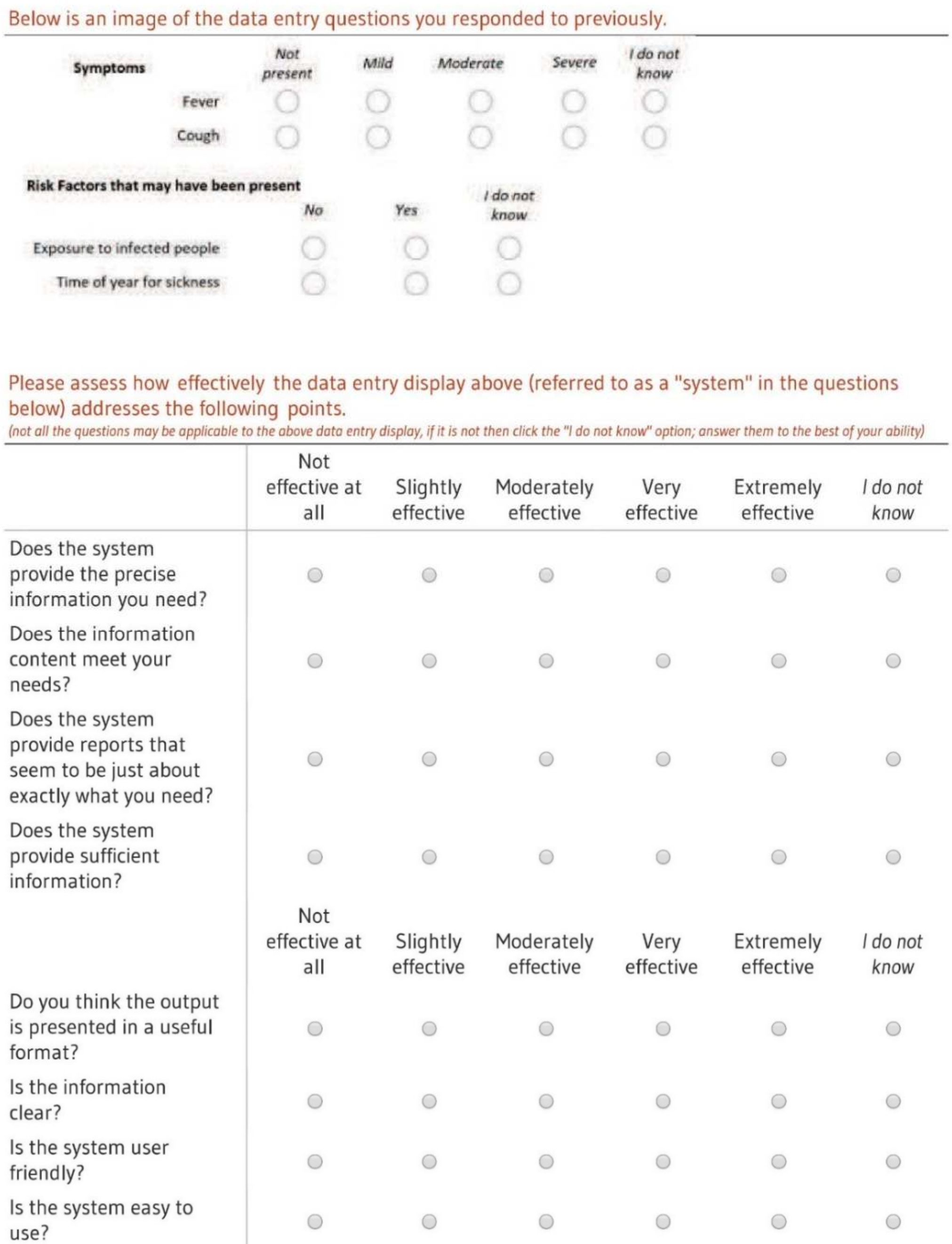


Figure 3.13. Survey - UA Navigation Timed Scenario

On the page after the scenario, the participant was asked to rate their confidence (along a 0% to 100% scale) in their answer(s) to the previous scenario and what influenced their confidence rating via a free text response.

Then the participant was presented with an image of the UI component they just interacted with, and were asked to fill out a modified version of a standard usability questionnaire called the End-User Computing Satisfaction (EUCS) survey developed by Doll and Torkzadeh (1988). An example of the modified questionnaire used in the survey is shown in Figure 3.14.


Below is an image of the data entry questions you responded to previously.

Symptoms	Not present	Mild	Moderate	Severe	I do not know
Fever					
Cough					

Risk Factors that may have been present	No	Yes	I do not know
Exposure to infected people			
Time of year for sickness			

Please assess how effectively the data entry display above (referred to as a "system" in the questions below) addresses the following points.

(not all the questions may be applicable to the above data entry display, if it is not then click the "I do not know" option; answer them to the best of your ability)

	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	I do not know
Does the system provide the precise information you need?						
Does the information content meet your needs?						
Does the system provide reports that seem to be just about exactly what you need?						
Does the system provide sufficient information?						
	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	I do not know
Do you think the output is presented in a useful format?						
Is the information clear?						
Is the system user friendly?						
Is the system easy to use?						

Figure 3.14. Modified EUCS Questionnaire

A standard usability questionnaire allows for the qualitative aspects of usability to be assessed (Lewis, 2002). While the System Usability Scale (SUS) and Post-Study Usability Questionnaire (PSSUQ) are other viable usability questionnaires (Lewis, 2002), the EUCS was selected as it has been shown to provide comparable responses between cultures in cross-cultural research studies (Deng et al., 2008; Igbaria & Zviran, 1991).

Additionally, the questions in standard usability questionnaires, like most usability evaluations, are designed to be used with interactive and at least semi-functional prototypes (Chapanis, 1996, p. 126; Lewis, 2002). While the researcher understood that since this study involved the assessment of isolated UI components and the tool was being misapplied, a validated standard usability questionnaire appropriate for this scenario could not be found. The EUCS offered the benefit that the questions in the instrument evaluated different aspects of usability including content, accuracy, format, ease of use, and timeliness (Doll & Torkzadeh, 1988). The questions associated with these different aspects are also independent of each other (Doll & Torkzadeh, 1988) which allowed the researcher to remove questions that could not be evaluated by the participant (e.g. accuracy and timeliness).

Lastly, the Likert scale for the EUCS was changed from time-based responses that ranged from “almost never” to “almost always” to effective assessment responses that ranged from “not effective at all” to “extremely effective.” This was changed, as the time-based responses did not make sense when the participants were asked to evaluate a static display they could not interact with. While this change could have affected the validity of the instrument, the sacrifice was made so that EUCS questions made sense to the participant and would ensure that more meaningful results could be obtained.

Next, the participant was presented with the other UI component in the UI component pair and asked to respond to the same scenario, confidence question, and fill out the usability questionnaire for the other UI component.

Lastly, after the participant had evaluated both UI components in the pair they were asked their overall preference between the two versions on a nearly continuous scale with seven milestones, as shown in Figure 3.15.

After completing the evaluation of the UI component pair, a participant was randomly presented with another pair until they had evaluated all four UI component pairs.

Below are the two result displays you have been shown previously.

Results Display 1

Symptoms and Risk Factors You Have Entered That Match Each Disease

	Influenza (Flu)	Viral Syndrome (Common Cold)	Viral Pneumonia	Bacterial Pneumonia
Risk Factors	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Place of Residence - Age - Time of Year
Symptoms	- Joint Aches - Cough - Headache - Chills - Fever - Body aches	- Body Aches - Fever	- Body Aches - Fever - Cough	- Joint Aches - Cough - Headache - Chills - Fever - Body aches

Results Display 2

	Percent Likely
Influenza (Flu)	90%
Viral Syndrome (Common Cold)	60%
Viral Pneumonia	70%
Bacterial Pneumonia	85%

Use the slider below to rate your preference between the two result displays.

Strongly prefer *Results Display 1*	Prefer *Results Display 1*	Somewhat prefer *Results Display 1*	Neutral	Somewhat prefer *Results Display 2*	Prefer *Results Display 2*	Strongly prefer *Results Display 2*

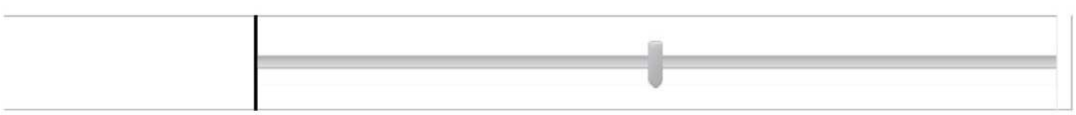


Figure 3.15. UI Component Comparison Question

The final section of the survey asked them to rate their level of agreement (on a 5 point Likert scale) with four statements representing the key ideas behind the cultural dimension guidelines. The statements and the guidelines they represented were as follows:

- I prefer the software to make decisions/suggestions rather than make them myself – High Power Distance
- I prefer to make decisions myself rather than have the software make decisions/suggestions for me – Low Power Distance

- I prefer more information in an interface so that I understand what my interaction with an interface will do before I interact with the interface – High Uncertainty Avoidance
- I prefer minimal designs that allow me to quickly explore a software system – Low Uncertainty Avoidance

These questions served as a more direct method to evaluate if the guidelines were valid.

Lastly, to incentivize participation in the survey the participant was offered an opportunity to enter a raffle for one of three $25 Amazon gift cards. A link to a separate survey was provided to the participant after they finished the survey (completely or partially). Participation was not required to enter. However, to enter the raffle the participant had to confirm that they were 18 years old or older and to provide their name, valid email address, and valid US phone number so the prize could be distributed. This was collected in a separate survey to ensure that the personally identifiable information could not be connected to the research survey responses.

3.4.4 Survey Distribution

After receiving Oregon State University (OSU) Institutional Review Board (IRB) approval to conduct the study, shown in Appendix E, the researcher began soliciting for participants.

A number of methods were used to advertise the survey. The researcher posted advertisements on social networking sites, such as Facebook. Emails were sent out on email lists the researcher had access to including an OSU graduate assistant labor union list that had been previously used by other researchers to advertise for study participants. To target international students the researcher contacted OSU's International Student Services and INTO program,[1] that provide support for international students. Additionally, OSU clubs were contacted.

The researcher also contacted organizations at other universities around the US. Before contacting any organizations at a university, their IRB was contacted to ensure that the researcher had permission to solicit participants. After receiving approval, the research contacted international student organizations and clubs at the university.

A full list of organizations solicited for participants is provided in Appendix F.

3.5 Summary

To answer the researcher questions, the researcher first identified a suitable case study. Next, a task analysis was performed to determine tasks the case study medical application UI needed to accomplish and the information types that were critical during these tasks. Cultural guideline pairs were derived from the literature and then used with this information to develop UI component pairs that represented these guidelines. A survey was then developed to assess the usability of these UI component pairs for matched populations representing a number of nationalities.

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[1] INTO OSU is a pathway program, associated with the larger INTO University partnership ("INTO Study > Home," n.d.), that provides international students an opportunity and support for admission into OSU's undergraduate and graduate programs.

4 Results

4.1 Introduction

This chapter details the results of the usability survey described in the previous chapter. The first section describes the survey population, the nationalities the participants represented, and how the nationalities were mapped to nations/nation regions to compare the data with Hofstede's published dimension scores. The second section reports the results of the UI-component-pair usability analysis. The third section reports the results of the guideline statement analysis. The last section describes the results of the extraneous variable effects analysis.

4.2 Participant Population

Survey data was collected over a period of a month and a half between March 14 and April 30 of 2016. In that time, 85 people accessed the survey. Out of the 85 people that accessed the survey, 67 participants were found to be eligible to participate based upon the inclusion criteria and their willingness to report their nationality. This was further reduced to 65 as two participants identified with nationalities that did not have data for the PD and UA dimensions in Hofstede's published dataset. This is discussed further in the next section. Overall, the survey had a 23% dropout rate.

All 65 participants reported their gender for the survey. Figure 4.1 presents the gender distribution of the participants. The gender distribution consisted of 44 (68%) female participants, 20 (31%) male participants, and 1 (1%) trans male/trans man participant.

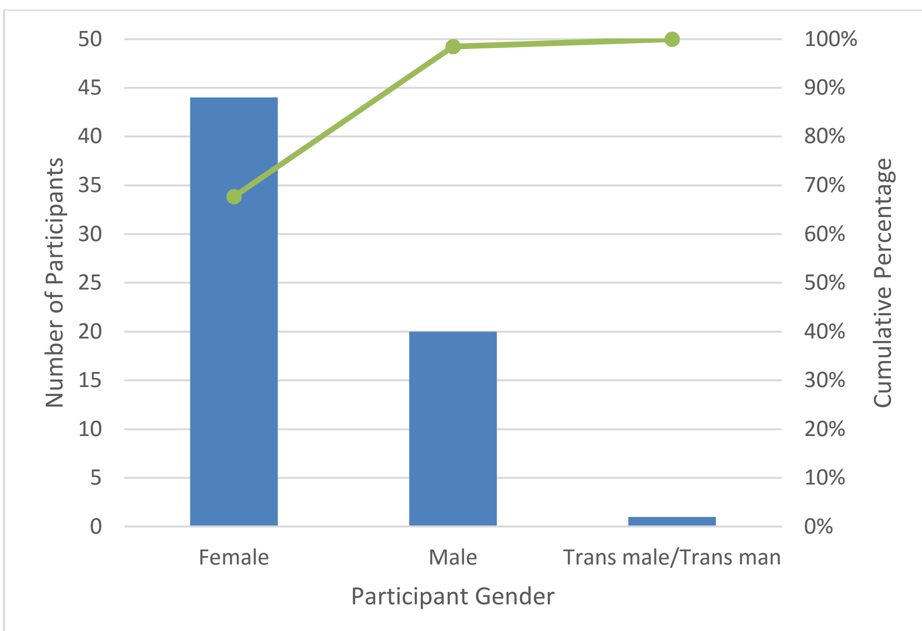


Figure 4.1. Participants by Gender

All 65 participants reported their age for the survey. Figure 4.2 presents the age range distribution of the participants. Most of the participants (80%) were between the ages of 18 and 34 years old.

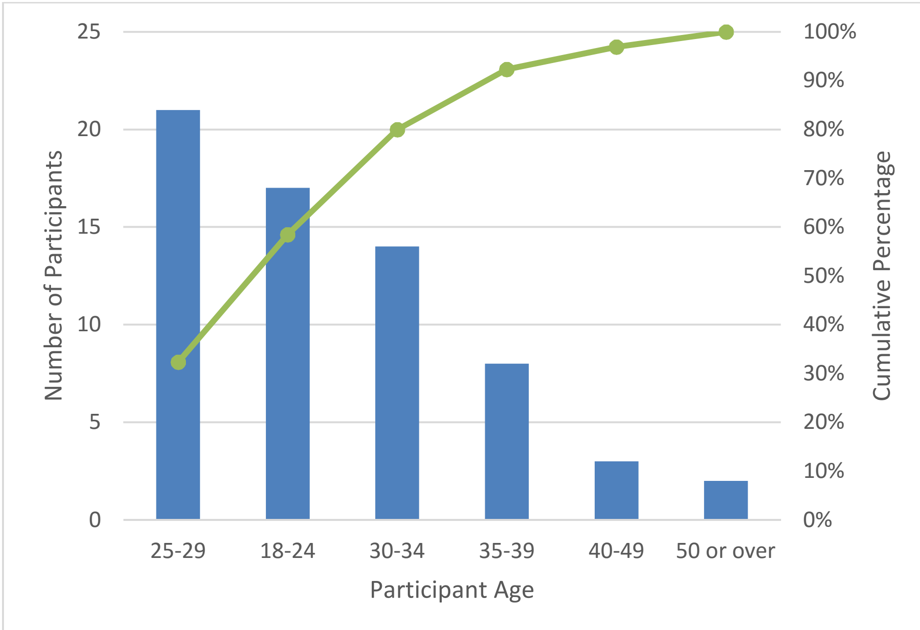


Figure 4.2. Participants by Age

All 65 participants reported their number of years of education. Figure 4.3 presents the years of education distribution for the participants. In the United States educational system, students typically complete high school after 12 years, a four-year college after 16 years, and any additional education is typically towards a graduate degree. Based upon this, most (95%) of the participants had at least 16 years of education. This means that most of participants were likely near the end of their undergraduate education, in a graduate degree program, or were working towards/had completed a graduate degree program.

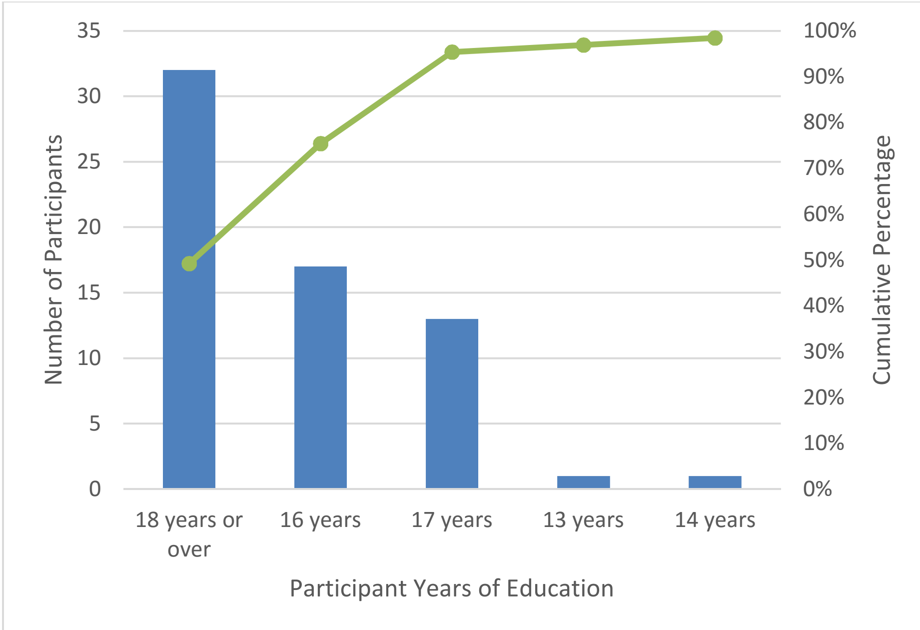


Figure 4.3. Participants by Years of Education

All 65 participants reported the highest managerial position they had achieved in their career. The distribution of this is shown in Figure 4.4. Students and academically trained professionals that did not manage others made up 71% of the participants. Managers of one or more subordinates made up 18% of the participants. None of the participants reported being manual workers or managers of managers.

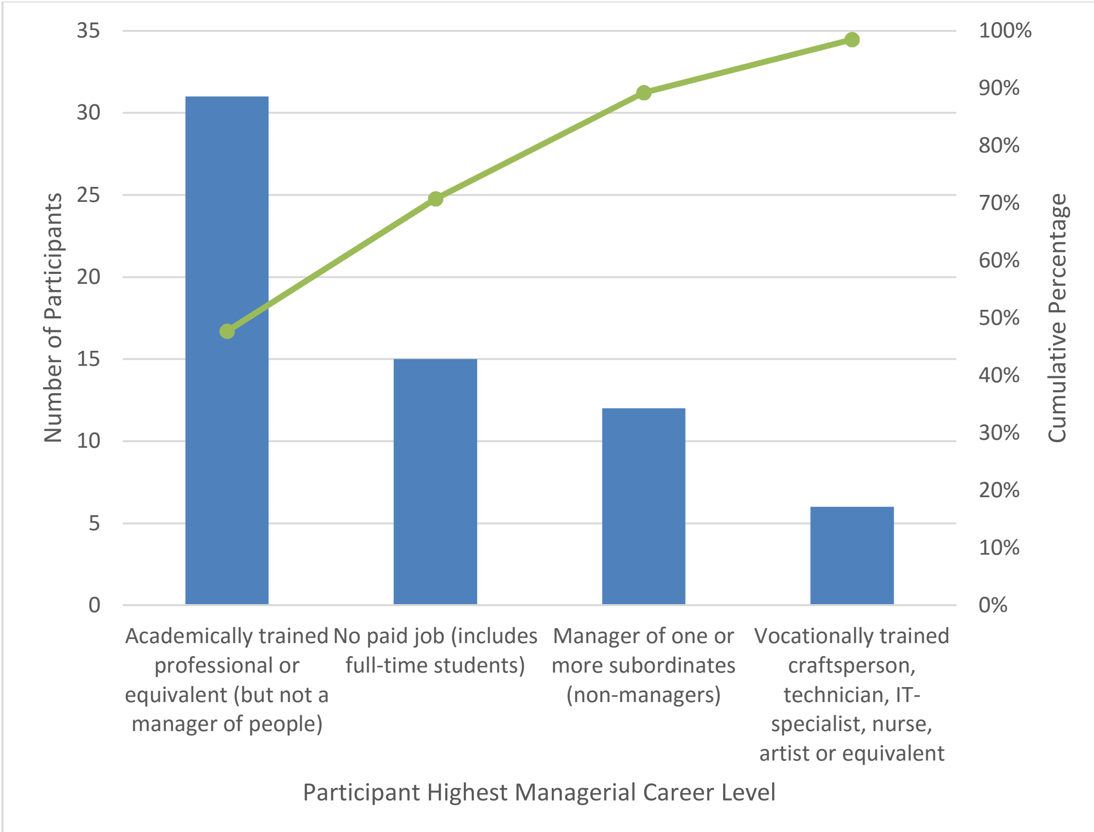


Figure 4.4. Participants by Highest Achieved Managerial Career Level

Figure 4.5 shows the nationality breakdown of the participants. Since nationality information was critical to the study, all 65 participants had to provide this information to be included as a participant. The participants represented 17 different nationalities. A total of 37 (57%) of the participants identified the United States as their nationality. The other countries had significantly fewer participants. Four countries had between 3 and 4 participants that identified with the nationality including Senegal, India, Iran, and Nigeria. The other 12 countries had two or fewer participants that identified with the nationality. The one participant that indicated “other” as their nationality noted that they identified as an ethnic group within Russia. For analysis purposes, this participant was labeled as Russian because this study focused on national level comparisons.

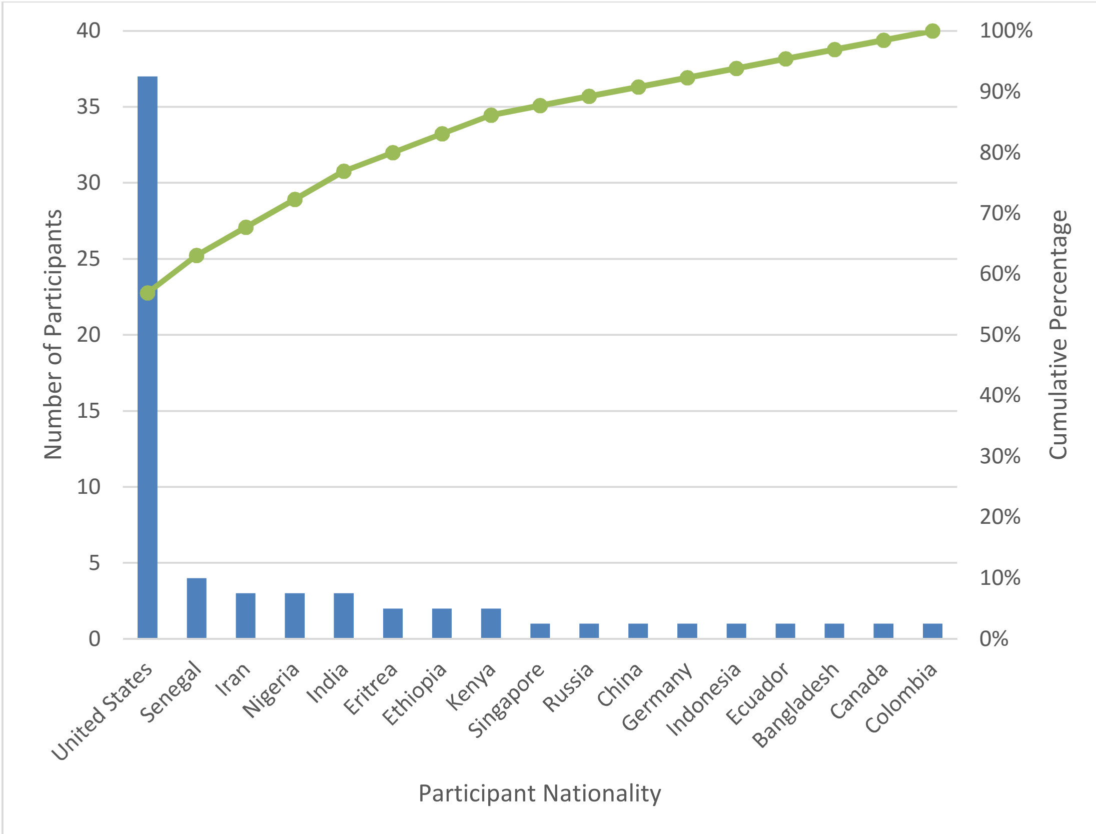


Figure 4.5. Participants by Nationality

All 65 participants reported the total number of years they spent living in the country associated with their nationality. Figure 4.6 shows the distribution of participants based upon five-year groupings. The question asked for a free-text response where participants recorded exactly how many years they had spent living in their home country. The researcher coded the responses into five-year groupings to aid in the results analysis.

Most (80%) of the participants had spent between 21 and 35 years living in the country associated with their identified nationality. Three participants had even spent 41 to 45 years living in their home country.

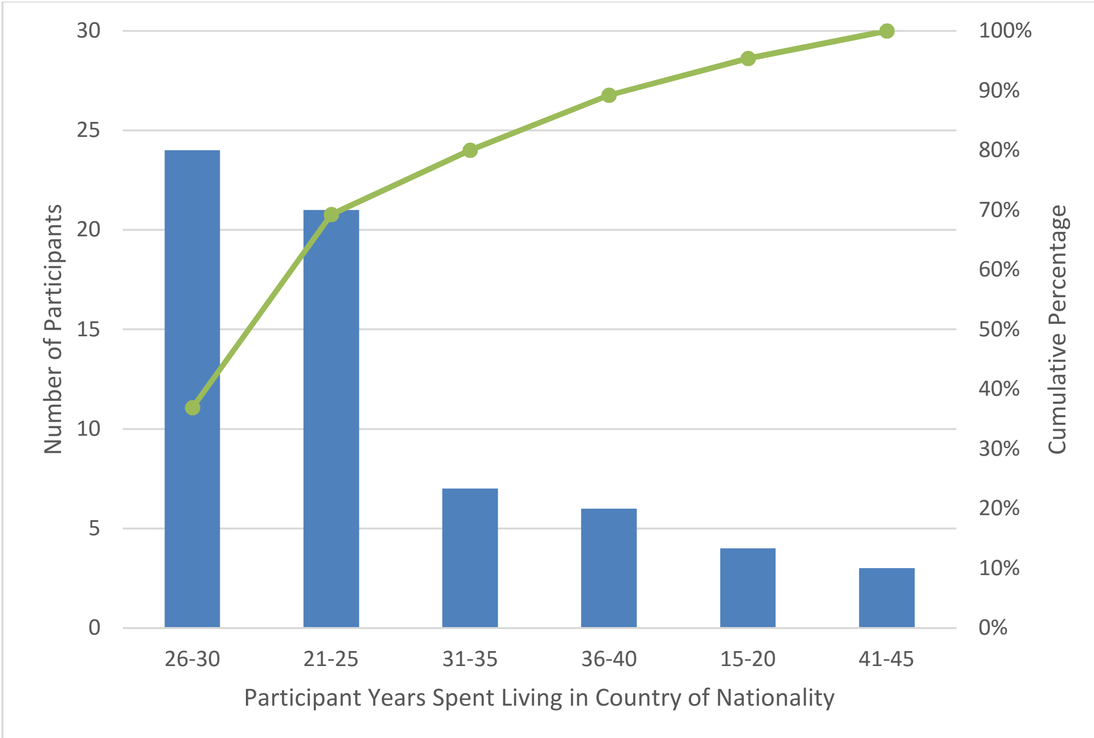


Figure 4.6. Participants by Years Spent Living in Country of Nationality

The 28 participants that did not currently live in the country associated with their identified nationality (i.e. anyone that did not identify as American) were asked to report how long they had lived outside their home country. All 28 participants responded to the question and the distribution of these participants is shown in Figure 4.7. Most (96%) of these participants had lived 4 years or less outside of their home country.

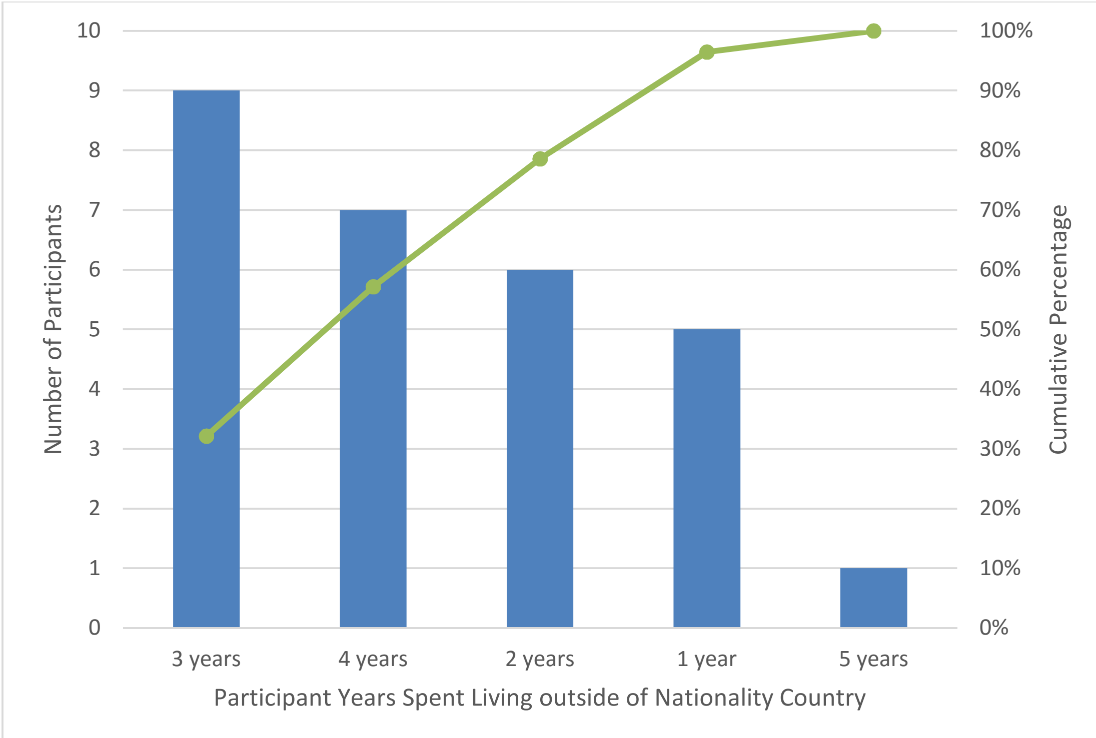


Figure 4.7. Participants by Years Spent Living outside Nationality Country

It should also be noted that three of the 65 participants (5%) reported being born in a country other than their identified nationality. These participants reported living in the other country for 2 years or less. They also reported that they had not lived in the country they were born in for over 10 years.

4.2.1 Nationality Mapping Process

The next step in the process was to map the identified nationalities to the countries/regions in Hofstede's (2015) published dataset of cultural dimension scores. This was a necessary step to validate if the published usability scores could be used with the design guidelines to interpret culturally relevant UIs.

To accomplish this the researcher compared the list of participant nationalities to Hofstede's (2015) dataset of cultural dimension scores, published on his website. During this process, it was found that two participants identified with nations that did not have PD and UA scores in the Hofstede dataset. These countries were Nepal and Puerto Rico and the two participants representing these countries were not included in the analysis.

Not including these two countries brought the original 67-participant pool down to the 65 participants addressed in the results analysis. It also brought the number of represented countries down to the 17. While 12 of the 17 countries had PD and UA dimension in Hofstede's data set, five of the 17 had to be grouped into geographical regions to get comparable dimension scores. The mapping of these five countries is shown in Table 4.1.

Table 4.1. Participant Nationality Countries Mapped to Geographical Regions

Country	Mapped Geographical Region
Eritrea	Africa East
Ethiopia	Africa East
Kenya	Africa East
Senegal	Africa West
Nigeria	Africa West

This mapping followed the same geographical grouping procedure as Hofstede had used in his original analysis (Hofstede, 2001, p. 52). Hofstede grouped the countries into the Africa East and West regions in order to gather a demographically comparable sample of participants (Hofstede, 2001, p. 52).

As a result of this process, the 17 individual countries were reduced to 12 individual countries and 2 geographical regions. The distribution of the participants representing these countries and geographical region is shown in Figure 4.8. The United States still represents the majority (57%) of the participants. However, the Africa West and Africa East regions, with 7 (11%) and 6 (9%) participants respectively, represented the next largest groups of participants.

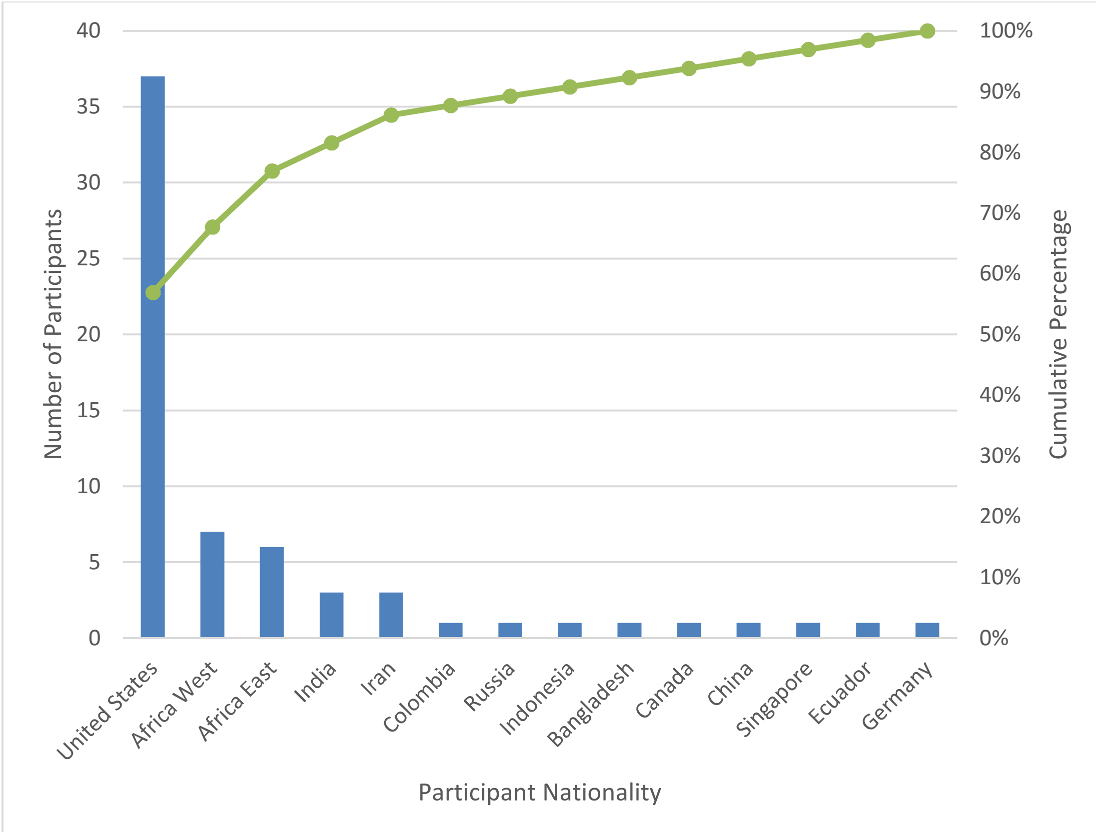


Figure 4.8. Participants by Nationality Country/Geographical Region

The next section compares the demographic distributions of the participants between nationalities.

4.2.2 Demographics by Nationality

Cross-cultural research requires that the populations being compared are matched samples (Schwartz, 2006). Hofstede and Minkov (2013a) state that cross-cultural comparison populations must match in gender, age, education, and career to calculate comparable cultural dimension scores using Hofstede's VSM. This is because these factors have been found to influence the Hofstede cultural dimension scores (Hofstede, 2001, p. 50). This section displays the demographic distributions of the participants by nationality[2].

Figure 4.9 displays the participant gender percentage by nationality. The gender distribution was found to vary between the nationalities. The United States participants (N = 37) had a 76% female, 22% male, and 3% trans male/trans man distribution. At the opposite end of the spectrum India (N = 3) and Iran participants (N = 3) both had a 33% female and 64% male distribution.

[2] Since nine of the nationalities in this study were each represented by only one participant, these countries' demographic data was grouped together and displayed as "Other" in the following section. This was done in the demographic section only to maintain the anonymity of the participants as required by the OSU IRB. These participants were categorized per their identified nationality in all other analyses performed in this study.

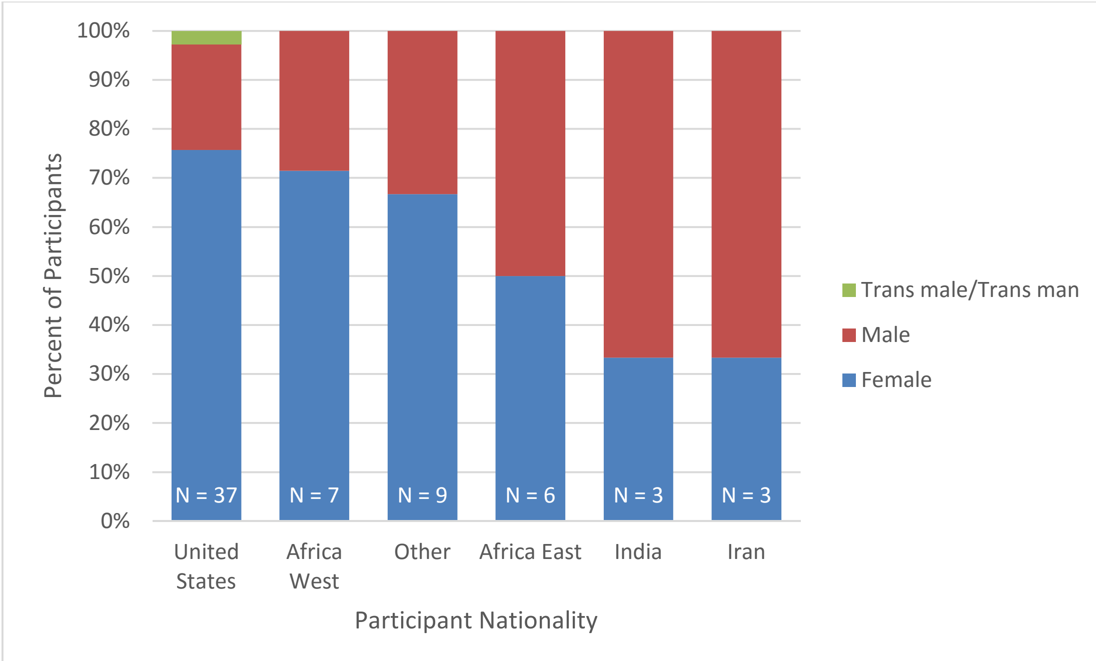
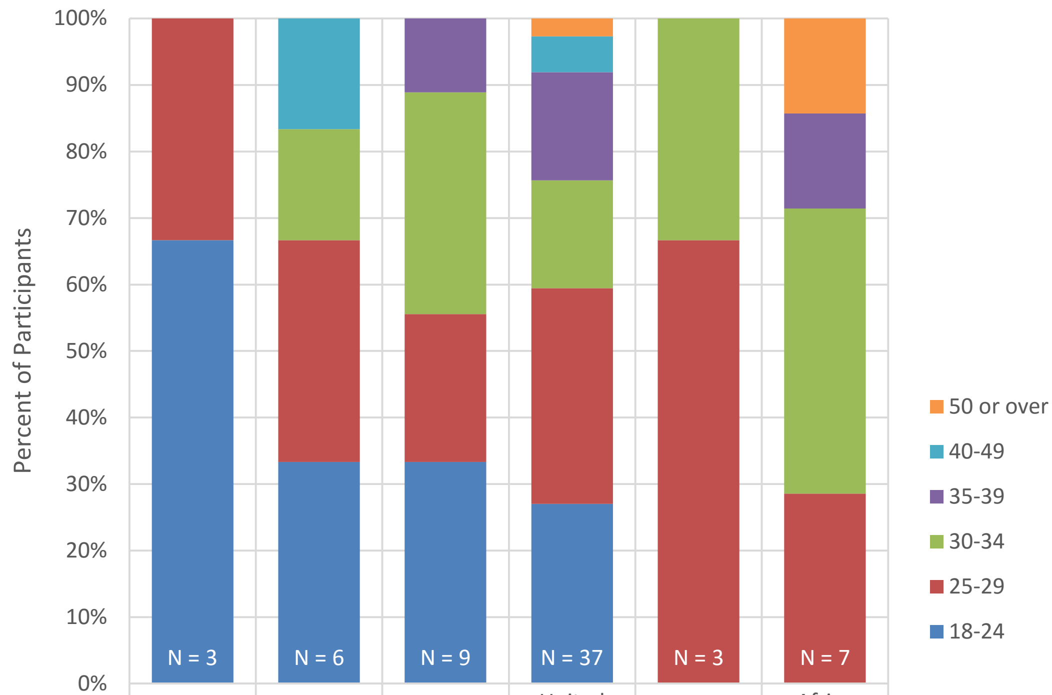


Figure 4.9. Participant Gender Percentage by Nationality

Figure 4.10 displays the participant age-range distribution by nationality. The age-range distribution of the participants also varied between the nationalities. Out of the nationalities that were represented by more than three participants, the Africa East region's participants were mostly (66%) between the ages of 18 and 29 years old. Conversely, the African West region's participants were mostly (57%) between the ages of 30 and 39 years old.



	India	Africa East	Other	United States	Iran	Africa West
50 or over	0%	0%	0%	3%	0%	14%
40-49	0%	17%	0%	5%	0%	0%
35-39	0%	0%	11%	16%	0%	14%
30-34	0%	17%	33%	16%	33%	43%
25-29	33%	33%	22%	32%	67%	29%
18-24	67%	33%	33%	27%	0%	0%

Participant Nationality

Figure 4.10. Participant Age-Range by Nationality

Figure 4.11 shows the participant highest-managerial-career-level distribution by nationality. All of the nationalities had participants that had been academically trained professionals, with no managerial responsibilities. This ranged from as high as 71% of the Africa West participants to as low as 17% of the Africa East participants. No participants had been a manager of managers. The highest managerial level represented in six of the 14 nationalities was a manager of one or more subordinates.

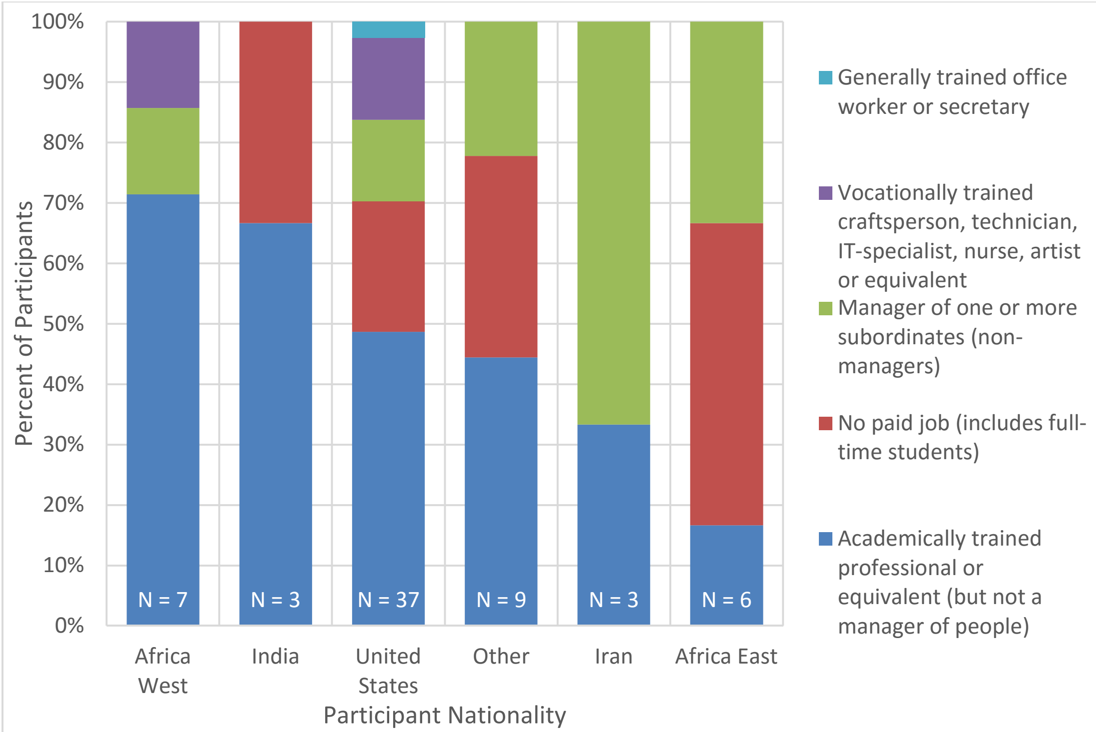
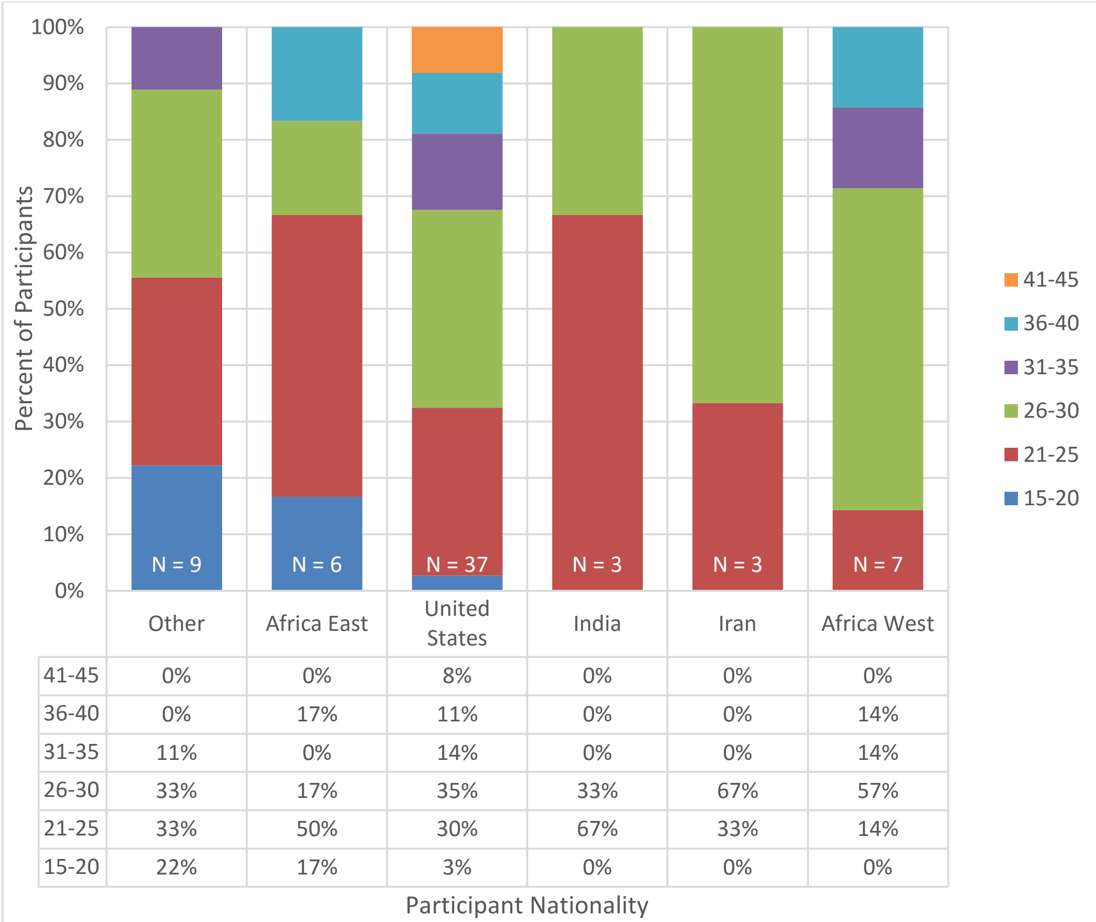


Figure 4.11. Participant Highest Managerial Career Level by Nationality

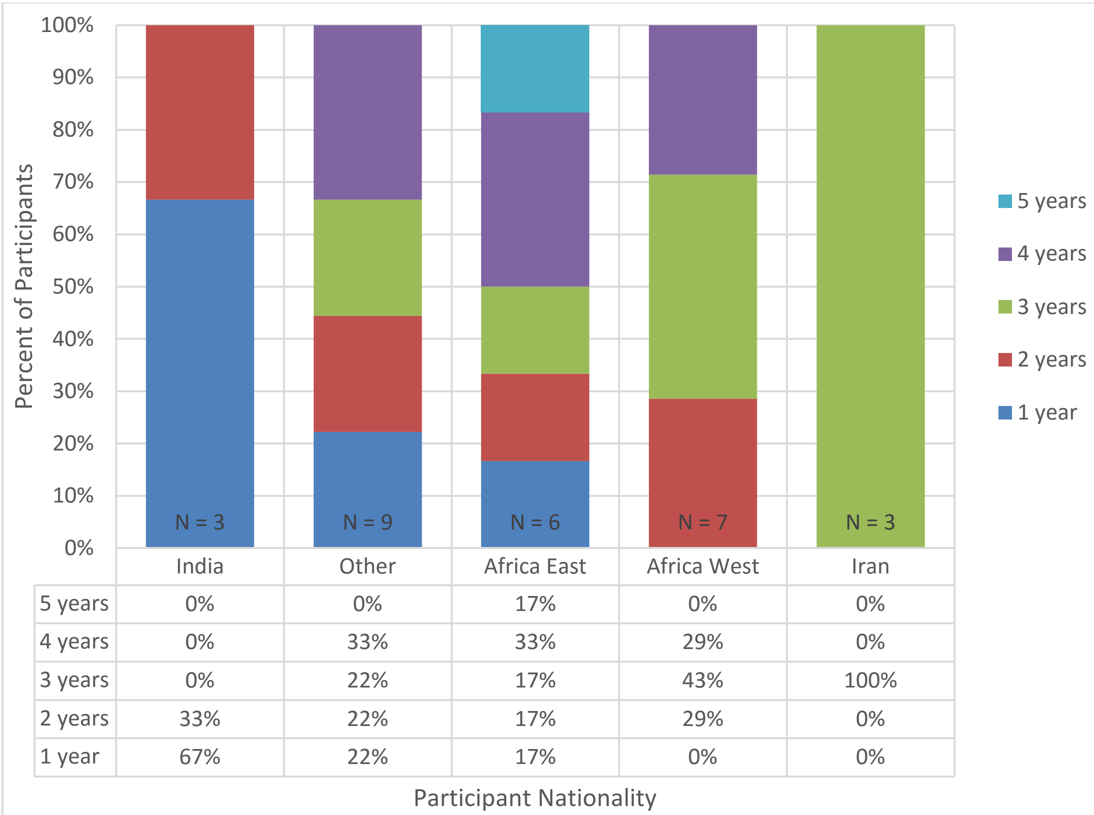
Figure 4.12 shows the participant time spent in the country of their identified nationality distribution by nationality. With the exception of three of the countries grouped in the “Other” grouping, most of the participants from the different nationalities had lived in their home country between 21 and 33 years. This ranged from as low as 65% of United States participants to as high as 100% of Iran and India participants.



	Other	Africa East	United States	India	Iran	Africa West
41-45	0%	0%	8%	0%	0%	0%
36-40	0%	17%	11%	0%	0%	14%
31-35	11%	0%	14%	0%	0%	14%
26-30	33%	17%	35%	33%	67%	57%
21-25	33%	50%	30%	67%	33%	14%
15-20	22%	17%	3%	0%	0%	0%

Figure 4.12. Participant Time Spent in Country of Identified Nationality by Nationality

For the participants that were not currently living in the country associated with their nationality, Figure 4.13 displays the participant years spent living outside of their home country by nationality. At least 50% of all participants that identified with these nationalities spent less than three years living outside of their home countries at the time of the survey.



	India	Other	Africa East	Africa West	Iran
5 years	0%	0%	17%	0%	0%
4 years	0%	33%	33%	29%	0%
3 years	0%	22%	17%	43%	100%
2 years	33%	22%	17%	29%	0%
1 year	67%	22%	17%	0%	0%

Figure 4.13. Participant Years Spent Living outside Nationality Country by Nationality

4.3 Statistical Analysis Methods

The focus of the analysis was to analyze the relationships between the usability metrics/survey responses for the UI component pairs versus the cultural dimension scores. Statistical analysis methods were chosen to assess whether correlations, or relationships, existed and if they were significant.

Two characteristics of the study and the participants limited the types of analysis that could be applied. First, the study relied on survey responses that were ordinal in nature, meaning that the responses could be ranked but the intervals between the responses were unknown or inconsistent (Davis, 2013). While the Hofstede dimension scores may initially appear continuous, they are calculated based upon Likert scales items, which are ordinal instead of continuous. This combined with the fact that the nationalities were represented by very few participants meant that a normally distributed result set could not be assumed. Non-parametric tests do not require the data to be normally distributed (Corder, 2014). This made them appropriate to use in this context.

The majority of the analysis focused on determining if relationships existed between the usability metrics and the cultural dimension scores. Regression tests can be used in hypothesis testing procedures to determine if statistically significant relationships exist between the independent and response variables (Montgomery, 2013). Non-parametric regression methods were particularly applicable to this study because the ordinal nature of the variables made it unlikely that if a relationship existed it would be linear. Non-parametric regression methods can detect nonlinear relationships as they analyze the ranking of the data, not the values of the data (Hayslett & Murphy, 2014, p. 180)

There are various non-parametric regression methods including Shapiro-Wilk, Kolmogorov-Smirnov, Spearman, and Kendall's Tau (Davis, 2013). For this study, the Kendell's Tau method was used because of its ability to handle ties within the datasets (Kraska-Miller, 2014). This method, like other regression methods, produces a correlation coefficient that varies between 1.0 and -1.0. This correlation can be tested for significance by the p-value method. This method is also referred to as Kendall's Tau correlation analysis.

The researcher also attempted to assess if extraneous variables may have affected the responses and influenced the results. The Kruskal-Wallis one-way analysis of variance by ranks method (Kruskal-Wallis) was selected as the non-parametric test for these analyses. The method can be applied to measure the differences in the medians between two or more independent samples (Kraska-Miller, 2014). It can be used when the assumptions of normality and equal variances in a typical ANOVA are in question (Kraska-Miller, 2014). The Kruskal-Wallis test does require that the shape of the distributions, or skew, be similar to determine if the medians are different (Kraska-Miller, 2014).

All statistical tests were performed in StatGraphics Centurion XVII provided by Oregon State University ("STATGRAPHICS," n.d.). For this study, a p-value of 0.05 or less was considered significant.

4.4 Calculated versus Published PD and UA Scores

Hofstede's cultural dimension model was originally selected for use in this study because dimensions scores for quite a few nations are accessible right from his website. This makes it possible for a company or organization to compare nation dimension scores for a project without expending the time and resources to administer the VSM and calculate the scores themselves. Furthermore, since Hofstede dimensions measure deeply held values, the relative scores between nations have been found to remain stable over time (Hofstede, 2001, p. 36; Minkov & Hofstede, 2011). To check if the published dimension scores were representative for the survey population, the researcher calculated the PD and UA dimension scores for nationalities represented in the survey.

Participants' responses to the VSM 2013 (Hofstede & Minkov, 2013b) survey questions were used to calculate the PD and UA scores by nationality. The general formula to calculate the PD score, as specified by Hofstede and Minkov (2013a), is:

$$PD\ score = 35(\overline{Q_{07}} - \overline{Q_{02}}) + 25(\overline{Q_{20}} - \overline{Q_{23}}) + C_{PD}$$

In this formula, C_{PD} is a constant used to shift the PD scores to values between 0 and 100 or used to "anchor" the scores to published results, which is discussed later. The variables $\overline{Q_{07}}$, $\overline{Q_{02}}$, $\overline{Q_{20}}$, and $\overline{Q_{23}}$ refer to the mean scores of the questions for the participants of a nationality group. The question numbers are derived from Hofstede and Minkov's VSM (2013b).

The general formula to calculate the PD score, as specified by Hofstede and Minkov (2013a), is:

$$UA\ score = 40(\overline{Q_{18}} - \overline{Q_{15}}) + 25(\overline{Q_{21}} - \overline{Q_{24}}) + C_{UA}$$

In this formula, C_{UA} is also a constant used to shift the UA scores to values between 0 and 100 or used to anchor the scores to published results. This constant can be different from the C_{PD} constant.

Because replication studies of Hofstede's original IBM survey typically do not include matched samples of sufficient size and can be difficult to match the original IBM population demographics or time in which it was conducted, calculated scores cannot easily be compared to published results (Hofstede, 2001, pp. 463–464, 2001, pp. 66–67; Hofstede & Minkov, 2013a). Hofstede's cultural dimensions are used to compare the values of two or more countries. This makes the absolute scores relatively meaningless. Rather than the absolute values, the differences between the different nationality scores should be compared instead (Hofstede, 2001, p. 66).

To aid in the comparison of the calculated PD scores to the published scores, the constants in the formulas were modified to "anchor" the calculated scores to the published scores. Anchoring refers to the process of calculating the difference, or average difference, between the calculated and published dimension scores for the common country(s) between two studies (Hofstede & Minkov, 2013a). The process is used for VSM extension studies attempting to gather dimension scores for countries or regions not included in the original IBM survey (Hofstede, 2001, pp. 464–465; Hofstede & Minkov, 2013a). While gathering new nationality scores was not a goal of this study, the process of anchoring did facilitate the comparison of the calculated and published scores.

Since the United States nationality group had a population of sufficient size to accurately calculate the dimension scores, its scores were used to calculate the anchor constants. The difference between calculated and published United States scores (ΔPD and ΔUA) were then used as the constants in the dimension score formulas to shift the two scores so that they matched. The addition of these constants then shifted all of the other nationality scores by the same amount. The ΔPD used for the C_{PD} was 9 and the ΔUA used for the C_{UA} was 111.

The calculated PD and UA scores together with their published counter-parts for the different nationalities are shown in Table 4.2 and Table 4.3. The nations represented by more than three participants (Africa East, Africa West, and the United States) show a similar trend between the calculated and published PD scores. The calculated PD scores of the Africa West and East regions are both higher than the United States scores. The Africa East calculated PD score (61) is only three units less than the published score (64). However, the Africa West calculated PD score is less than the Africa East calculated PD scores, which is not consistent with the published scores.

Table 4.2. Calculated versus Published Power Distance Scores

		Power Distance		
Nationality	N	Calculated	Published	Difference
Africa East	6	61	64	3
Africa West	7	58	77	19
Germany	1	54	35	-19
United States	37	40	40	0
Iran	3	39	58	19
Bangladesh	1	34	80	46
China	1	34	80	46
India	3	21	77	56
Russia	1	-1	93	94
Canada	1	-16	39	55
Singapore	1	-16	74	90
Colombia	1	-51	67	118
Ecuador	1	-61	78	139
Indonesia	1	-86	78	164

A graph of the published PD scores versus their associated calculated PD scores is shown in Figure 4.14. While, visually there appears to be slight correlation between the published and calculated PD scores, this was not found to be statistically significant based upon a Kendall's Tau correlation analysis (p-value = 0.2503).

Figure 4.14. Published versus Calculated PD Scores

The published versus calculated UA scores, shown in Table 4.3, did not show any similar trends for the United States, Africa West, and Africa East nationalities. Based upon the published UA scores, the Africa West and East calculated UA scores should be close to, but greater than the United States calculated UA score. In this case, the scores are less than the United States score.

Table 4.3. Calculated versus Published Uncertainty Avoidance Scores

		Uncertainty Avoidance		
Nationality	N	Calculated	Published	Difference
India	3	114	40	-74
Colombia	1	86	80	-6
Iran	3	54	59	5
United States	37	46	46	0
Russia	1	46	95	49
Indonesia	1	46	48	2
Africa West	7	39	54	15
Africa East	6	23	52	29
Bangladesh	1	21	20	-1
Canada	1	-4	48	52
China	1	-9	30	39
Ecuador	1	-19	67	86
Singapore	1	-19	8	27
Germany	1	-44	65	109

A graph of the published UA scores versus their associated calculated UA scores is shown in Figure 4.15. Visual inspection of this graph showed no correlation between the published and calculated UA scores. A Kendall's Tau correlation analysis confirmed that there was no significant correlation (p-value = 0.5182).

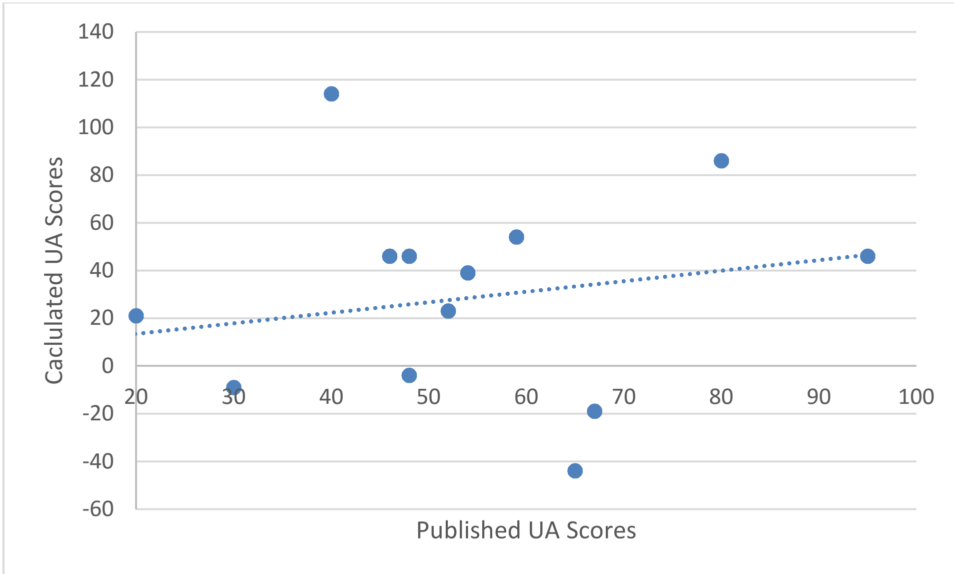


Figure 4.15. Published versus Calculated UA Scores

The next step in the analysis process involved determining if there were significant correlations between difference in usability of the UI component pairs and the published/calculated dimension scores.

4.5 UI Component Usability Analysis

This section details the analysis method and the results of the usability-dimension score correlation analysis.

4.5.1 Usability Metric Calculations

For each UI component pair a series of usability metrics were calculated. The metrics focused on calculating the differences in usability between the UI component pairs to determine if they correlated with the dimension scores. Four different metrics were calculated and analyzed for each UI component pair.

The first metric was the difference in the time to complete the timed usability scenarios. One measure of the usability of a UI is to determine if time to complete an action is less than an alternative UI (Wickens et al., 2004, p. 408). The time until the page submittal, or the time until the participant completed the scenario and moved on to the next survey question, was used as the total time to complete the scenario. Since the participant was introduced to the scenario on the survey page prior to the time tracking page, this variable only represented the time the participant took to evaluate and interact with the UI component.

The difference between the scenario times for the high pole UI component and low pole UI component provided a measure of which version of the UI component took longer. Since a smaller completion time of the scenario was the desirable condition, the formula was multiplied by -1 to produce a positive correlation with the cultural dimension if the expected condition was found, as shown in the formula below.

$$Difference\ in\ Timed\ Scenario = -(t_H - t_L)$$

The t_H variable in this formula represents the time to complete the high pole UI component scenario, while t_L represents the time to complete the low pole UI component scenario.

Because of this formulation, a smaller t_H value versus t_L value creates a positive overall difference, while the opposite creates a negative difference. If a positive correlation is found between this metric and the cultural dimension, then higher dimension values correlate with reduced t_H values versus t_L values and vice versa. The rest of the metrics, except where noted, were formulated to correspond with this logic of a positive correlation being the expected result.

The second usability metric was the difference in interaction confidence between the UI component pair. In this case, a high degree of confidence interacting with the UI component is desirable. As such, the metric was calculated using the following formula:

$$Interaction\ Confidence\ Difference = c_H - c_L$$

The variable c_H represents the interaction confidence rating for the high pole UI component, while c_L represents the interaction confidence rating for the low pole UI component.

The third usability metric was the difference in EUCS scores for the UI component pair. The modified EUCS score for each UI component was calculated by summing the numerical Likert scale ratings for all of the EUCS questions. The study results of Deng et al. (2008) suggest this method of scoring is comparable across nationalities. Since a higher EUCS score indicates a more usable UI the difference formula was calculated as follows:

$$EUCS\ Score\ Difference = s_H - s_L$$

The variable s_H represents the EUCS score for the high pole UI component, while s_L represents the EUCS score for the low pole UI component.

The fourth metric of the usability analysis was the response to the survey question that asked the participant to assess their overall preference between the pair of UI components. The response to this question could vary between -100 to 100 with a positive value response corresponding to a preference for the high pole UI component and vice versa. The nature of this question allowed it to be used in the regression analysis without any further modification.

The correlation analysis for these four metrics were conducted twice for each UI component. The first batch of analyses was done using data from all of the study participants. A second round of correlation analysis was done on all the participants that did not identify with the United States nationality. This was done because cross-cultural studies that involved university student populations from a single country often exclude students who are going to school in their home country (Simon, 2001). This is because foreign students[3] face unique challenges adapting to life in a new country that the native students do not face. This makes direct comparisons between native and foreign students difficult.

The researcher still chose to include the native United States participants in the first batch of correlation analysis, even with this known limitation, because the case study that inspired research was interested in cultural usability differences between the United States and other nationalities. However, the analysis on just the foreign participants served as a check to ensure that correlations found in the first analysis were indeed valid.

The next section details the results of the correlation analyses for the four UI component pairs.

4.5.2 Power Distance – Data Entry Options Analysis

Table 4.4 shows the Kendall's Tau correlation results for the four PD – Data Entry Options usability metrics versus the published and calculated PD scores. These results were derived from the full participant pool. Between 52 and 56 participants completed questions associated with these metrics. The only statistically significant correlation was found between the interaction confidence difference and the calculated PD scores (p-value = 0.0044). This correlation had a negative coefficient of -0.3384, meaning the effect was counter to what was expected.

Table 4.4. Full Participant Results for the PD-Data Entry Usability Metrics and PD scores

Kendall's Tau Correlation Analysis

		Published PD		Calculated PD	
Usability Metric	n	Correlation	P-Value	Correlation	P-Value
Timed Scenario Difference	56	-0.1088	0.3365	0.0341	0.7612
Interaction Confidence Difference	56	-0.1654	0.1682	-0.3384	0.0044
EUCS Score Difference	55	-0.1360	0.2454	-0.1337	0.2484
Preference	52	-0.1411	0.2659	-0.1550	0.2183

Table 4.5 shows the Kendall's Tau correlation results for the four PD – Data Entry Options usability metrics versus the published and calculated PD scores for the foreign participants. Between 22 and 25 participants completed questions associated with these metrics. The only statistically significant correlation was found between the interaction confidence difference and the calculated PD scores (p-value = 0.0161). This correlation had a negative coefficient of -0.3939.

[3] The term "foreign" is used in this document to describe participants that were living in the United States, but identified with a nationality other than the United States. It is not meant as a description of the participant's legal resident status within the United States as this was not known by the researcher.

Table 4.5. Foreign Participant Results for the PD-Data Entry Usability Metrics and PD scores

		Kendall's Tau Correlation Analysis			
		Published PD		Calculated PD	
Usability Metric	n	Correlation	P-Value	Correlation	P-Value
Timed Scenario Difference	25	-0.2278	0.1543	0.0716	0.6404
Interaction Confidence Difference	25	0.1715	0.3153	-0.3939	0.0161
EUCS Score Difference	24	-0.0890	0.6024	-0.1294	0.4273
Preference	22	0.0297	0.8656	-0.0814	0.6317

4.5.3 Power Distance – Results Display Analysis

Table 4.6 shows the Kendall’s Tau correlation results for the four PD – Results Display usability metrics versus the published and calculated PD scores for the full participant pool. Between 53 and 58 participants completed questions associated with these metrics. Five of the eight correlations were found to be statistically significant. Two of these correlations were with published PD scores, while the other three were with the calculated PD scores. The timed scenario difference was found to be negatively correlated with both the published PD scores (Coef = -0.3456) and the calculated PD scores (Coef = -0.2813).

Table 4.6. Full Participant Results for the PD-Results Display Usability Metrics and PD scores

		Kendall's Tau Correlation Analysis			
		Published PD		Calculated PD	
Usability Metric	n	Correlation	P-Value	Correlation	P-Value
Timed Scenario Difference	58	-0.3456	0.0018	-0.2813	0.0104
Interaction Confidence Difference	57	0.1033	0.3820	0.3826	0.0011
EUCS Score Difference	56	0.0898	0.4411	0.3115	0.0069
Preference	53	0.2361	0.0487	0.2098	0.0764

Table 4.7 shows the Kendall’s Tau correlation results for the four PD – Results Display usability metrics versus the published and calculated PD scores for the foreign participants. Between 23 and 26 participants completed questions associated with these metrics. Four of the eight correlations were found to be statistically significant. Two of these correlations were found for the published PD scores and two for the calculated PD scores. The correlation coefficients for the interaction confidence difference were found to be of opposite polarity between the published PD scores (Coef = -0.4236, p-value = 0.0117) and the calculated PD scores (Coef = 0.4888, p-value = 0.0024).

Table 4.7. Foreign Participant Results for the PD-Results Display Usability Metrics and PD scores

		Kendall's Tau Correlation Analysis			
		Published PD		Calculated PD	
Usability Metric	n	Correlation	P-Value	Correlation	P-Value
Timed Scenario Difference	26	-0.0581	0.7079	-0.4279	0.0042
Interaction Confidence Difference	25	-0.4236	0.0117	0.4888	0.0024
EUCS Score Difference	24	-0.4056	0.0161	0.2874	0.0741
Preference	23	-0.1998	0.2561	0.2256	0.1780

4.5.4 Uncertainty Avoidance – Navigation Display Analysis

Table 4.8 shows the Kendall's Tau correlation results for the four UA – Navigation Display usability metrics versus the published and calculated UA scores for the full participant pool. Between 53 and 58 participants completed questions associated with these metrics. Only one correlation between the direct comparison responses and the published UA scores was found to be significant (Coef = 0.2384, p-value = 0.0397).

Table 4.8. Full Participant Results for the UA-Navigation Display Usability Metrics and UA scores

		Kendall's Tau Correlation Analysis			
		Published UA		Calculated UA	
Usability Metric	n	Correlation	P-Value	Correlation	P-Value
Timed Scenario Difference	58	0.0890	0.4170	-0.0197	0.8615
Interaction Confidence Difference	57	0.0811	0.5439	0.1340	0.3158
EUCS Score Difference	53	0.0843	0.4852	-0.0132	0.9145
Preference	56	0.2384	0.0397	-0.1217	0.3088

Table 4.9 shows the Kendall's Tau correlation results for the four UA – Navigation Display usability metrics versus the published and calculated UA scores for the foreign participants. Between 24 and 26 participants completed questions associated with these metrics. None of the correlations in this analysis were found to be significant.

Table 4.9. Foreign Participant Results for the UA-Navigation Display Usability Metrics and UA scores

Kendall's Tau Correlation Analysis

		Published UA		Calculated UA	
Usability Metric	n	Correlation	P-Value	Correlation	P-Value
Timed Scenario Difference	26	-0.0361	0.8084	0.0461	0.7576
Interaction Confidence Difference	26	0.1505	0.5518	0.3405	0.1788
EUCS Score Difference	24	0.0716	0.6733	0.0506	0.7660
Preference	25	0.1794	0.2723	-0.0153	0.9256

4.5.5 Uncertainty Avoidance – Results Location Analysis

Table 4.10 shows the Kendall's Tau correlation results for the four UA – Results Location usability metrics versus the published and calculated UA scores for the full participant pool. Between 53 and 56 participants completed questions associated with these metrics. None of the correlations in this analysis were found to be significant.

Table 4.10. Full Participant Results for the UA – Results Location Usability Metrics and UA scores

Kendall's Tau Correlation Analysis

		Published UA		Calculated UA	
Usability Metric	n	Correlation	P-Value	Correlation	P-Value
Timed Scenario Difference	56	0.1117	0.3190	-0.1079	0.3509
Interaction Confidence Difference	55	-0.0138	0.9133	0.1547	0.2367
EUCS Score Difference	53	0.0843	0.4852	-0.0132	0.9145
Preference	53	-0.0419	0.7627	0.1181	0.3945

Table 4.11 shows the Kendall's Tau correlation results for the four UA – Results Location usability metrics versus the published and calculated UA scores for the foreign participants. Between 24 and 25 participants completed questions associated with these metrics. None of the correlations in this analysis were found to be significant.

Table 4.11. Foreign Participant Results for the UA – Results Location Display Usability Metrics and UA scores

		Kendall's Tau Correlation Analysis			
		Published UA		Calculated UA	
Usability Metric	n	Correlation	P-Value	Correlation	P-Value
Timed Scenario Difference	25	0.0143	0.9256	0.0538	0.7261
Interaction Confidence Difference	24	-0.0687	0.7098	0.2800	0.1303
EUCS Score Difference	24	0.0716	0.6733	0.0506	0.7660
Preference	24	-0.0519	0.7471	0.0080	0.9604

The next section details the correlation analyses that were performed on the guideline statement survey questions.

4.6 Guideline Statement Survey Question Analysis

The next set of correlation analyses were performed on the final survey question that asked the participant to rate their level of agreement, on a 5-point Likert scale, with a series of statements that represented the key ideas of the cultural dimension guidelines. The four statements corresponded with the low and high poles for both the PD and UA guidelines and were as follows.

- I prefer the software to make decisions/suggestions rather than make them myself – High Power Distance
- I prefer to make decisions myself rather than have the software make decisions/suggestions for me – Low Power Distance
- I prefer more information in an interface so that I understand what my interaction with an interface will do before I interact with the interface – High Uncertainty Avoidance
- I prefer minimal designs that allow me to quickly explore a software system – Low Uncertainty Avoidance

While the usability analyses served as an indirect measure of the guideline validity, these questions were designed to serve as a more direct method of validation.

Like the usability analysis, a Kendall's Tau correlation analysis was performed on responses of both the full participant pool as well as the subset of foreign participants. Because of the wording of the statements, it was expected that the statement representing the low pole guideline would result in a negative correlation coefficient, while the statement representing high pole guideline would result in a positive correlation.

Table 4.12 shows the Kendall's Tau correlation results for the PD guideline statements versus the published and calculated PD scores for the full participant pool. A total of 55 participants completed these survey questions. The LPD and HPD guideline statements (Coef = -0.3038, p-value =

0.0263 and Coef = 0.3338, p-value = 0.0173 respectively) were both found to be significantly correlated with the calculated PD scores.

Table 4.12. Full Participant Results for the PD Statements versus Published and Calculated PD scores

Kendall's Tau Correlation Analysis

		Published PD		Calculated PD	
Statement	n	Correlation	P-Value	Correlation	P-Value
LPD Guideline	55	-0.1064	0.4416	-0.3038	0.0263
HPD Guideline	55	0.1677	0.2367	0.3338	0.0173

Table 4.13 shows the Kendall's Tau correlation results for the PD guideline statements versus the published and calculated PD scores for the foreign participants. A total of 24 participants completed these survey questions. The only significant correlation was found between the HPD guideline statement and the calculated PD scores (Coef = 0.5460, p-value = 0.0064). The other three correlations were close to the 0.05 p-value significance cutoff.

Table 4.13. Foreign Participant Results for the PD Statements versus Published and Calculated PD scores

Kendall's Tau Correlation Analysis

		Published PD		Calculated PD	
Statement	n	Correlation	P-Value	Correlation	P-Value
LPD Guideline	24	0.3952	0.0594	-0.3871	0.0530
HPD Guideline	24	-0.4004	0.0561	0.5460	0.0064

Table 4.14 shows the Kendall's Tau correlation results for the UA guideline statements versus the published and calculated UA scores for the full participant pool. A total of 55 participants completed these survey questions. Only one correlation was found to be significant between the LUA guideline statement and the calculated UA scores (Coef = 0.2757, p-value = 0.0467).

Table 4.14. Full Participant Results for the UA Statements versus Published and Calculated UA scores

Kendall's Tau Correlation Analysis

		Published UA		Calculated UA	
Statement	n	Correlation	P-Value	Correlation	P-Value
LUA Guideline	55	-0.2248	0.0936	0.2757	0.0467
HUA Guideline	55	0.0709	0.6063	-0.1063	0.4546

Table 4.15 shows the Kendall's Tau correlation results for the UA guideline statements versus the published and calculated UA scores for the foreign participants. A total of 24 participants completed these survey questions. No significant correlations were found in this analysis.

Table 4.15. Foreign Participant Results for the UA Statements versus Published and Calculated UA scores

Kendall's Tau Correlation Analysis

		Published UA		Calculated UA	
Statement	n	Correlation	P-Value	Correlation	P-Value
LUA Guideline	24	-0.0144	0.9407	0.1736	0.3719
HUA Guideline	24	-0.2430	0.1971	-0.0984	0.6024

To validate whether the display order of the UI component pairs influenced the results, the researcher conducted an analysis of this known extraneous factor. This analysis is detailed in the next section.

4.7 Analysis of Ordering Effects

Controlling for extraneous factors is a major challenge in experiment design. While researchers attempt to control the influence of known extraneous factors, they can sometimes still affect the results.

One of the factors the researcher attempted to control for in this study was ordering effects caused by the presentation order of the UI component pairs. To prevent this the display order of the UI component pairs was randomized between participants. Figure 4.16 shows the display order distribution for all of the UI component pairs. While the presentation order frequencies in this graph appeared relatively balanced, the low number of participants within the nationality groups meant that a balanced set of display orders was unlikely.

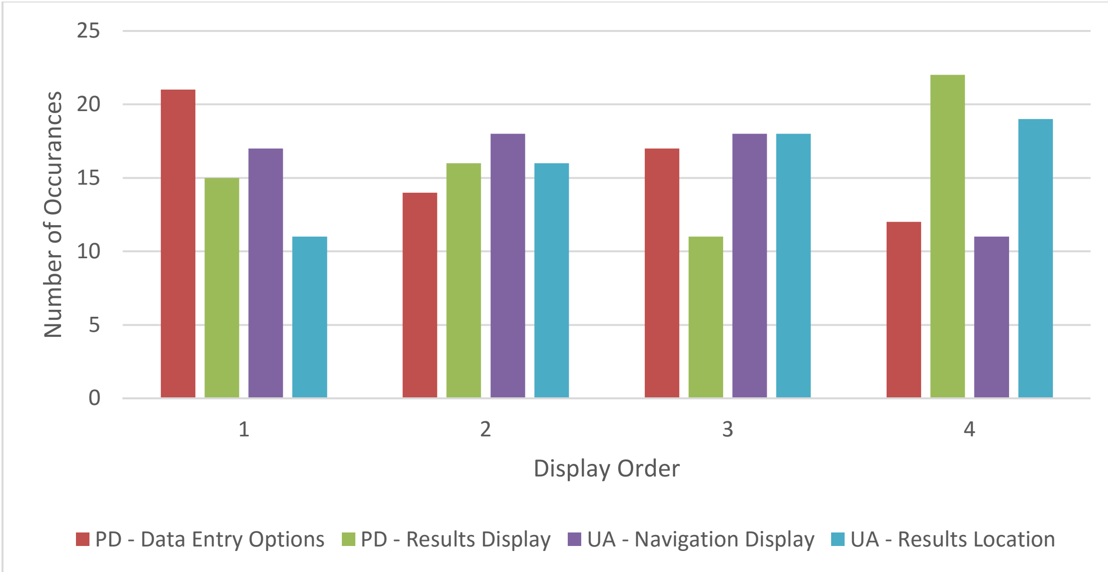


Figure 4.16. Distribution of UI Component Pair Display Order

Time and resource constraints limited the scope of analysis the researcher could perform to determine the extent of the order effects on the response variables measured in this study. As such, the researcher chose to perform an analysis on the interaction confidence difference metric for the PD – Results Display UI-component-pair. This response variable was found to be significantly correlated with the calculated PD scores in both the full participant pool analysis and the foreign participant subset analysis.

To test for ordering effects a Kruskal-Wallis analysis was performed to determine if the display order for the PD-Results Display UI-component-pair had any effect on the results of the interaction-confidence-difference response variable. The results of the test found that display order was not significant (p-value = 0.0685).

Because the p-value of the Kruskal-Wallis analysis was close to the 0.05 significance cutoff, a Kendall's Tau correlation analysis was performed to check for any significant correlations between the display order, the calculated PD, and the response variable (interaction confidence difference).

Table 4.16 shows the correlation matrix for this analysis, which included the full participant pool. Table 4.17 shows the same correlation matrix, except this time only including the foreign participants.

Both the full participant pool and foreign participant analyses indicated significant correlations (p-value = 0.0011 and p-value = 0.0024 respectively) between the calculated PD scores and the interaction confidence difference responses. However, no significant correlations were indicated between the display order and the calculated PD scores or between the display order and the interaction confidence difference responses.

Table 4.16. Kendall's Tau Correlation Matrix for Ordering Effects of All Participants

		Calculated PD		Display Order	
Correlation with	n	Correlation	P-Value	Correlation	P-Value
Display Order	57	-0.0231	0.8579		
Interaction Confidence Difference	57	0.3826	0.0011	0.2035	0.0651

Table 4.17. Kendall's Tau Correlation Matrix for Ordering Effects of Foreign Participants

		Calculated PD		Display Order	
Correlation with	n	Correlation	P-Value	Correlation	P-Value
Display Order	25	-0.0459	0.7972		
Interaction Confidence Difference	25	0.4888	0.0024	-0.0367	0.8335

4.8 Summary

To summarize, out of the 85 individuals that accessed the survey, 65 were found to be suitable participants to include in the analysis. The participants were mostly between the ages of 18 and 34 years old, were a student or worked as academic professionals, and had more than 16 years of education.

A total of 14 different nationalities were represented by the participants. Most of the foreign (non-US participants) participants had spent over 21 years in their home country and had been living outside their home country for less than 4 years.

Next, PD and UA scores were gathered from Hofstede's published dataset and calculated based upon participant survey responses. Participants from the African countries were grouped into Africa West and East geographical regions following Hofstede's method, because published PD and UA dimension scores were not available for the individual countries. The published and calculated dimension scores were not found to correlate. This was likely a result of the significant variation in participant demographic distributions between the nationalities.

Kendall's Tau correlation analysis was then performed to determine if there were significant correlations between the difference in usability metrics of PD/UA UI component pairs and the associated dimension scores. The correlation analysis was repeated for the full participant pool as well as the subset of foreign participants.

Table 4.18 shows the number of significant correlations that were found for the published and calculated dimensions scores by UI component pair for all participants. More correlations that were significant and positive were found for the UI components based upon the PD guidelines rather than the UA guideline based UI component pairs. The greatest number of significant correlations were found for the PD-Results Display UI-component-pair than any of the others. More correlations were also found to be significant for the calculated dimension scores than for the published dimension scores.

Table 4.18. Number of Significant Correlations for All Participants by UI Component Pair

	Published		Calculated	
UI Component Pair	All	Positive	All	Positive
PD - Data Entry Options	0	0	1	0
PD - Results Display	2	1	3	2
UA - Navigation Display	1	1	0	0
UA - Results Location	0	0	0	0

A similar distribution of significant correlations was found when the analysis was repeated for the foreign participants, as shown in Table 4.19. In this analysis, the only significant correlations were found for the PD-based UI component pairs. Again, the greatest number of significant correlations were found for the PD – Results display UI-component-pair.

Table 4.19. Number of Significant Correlations for Foreign Participants by UI Component Pair

	Published		Calculated	
UI Component Pair	All	Positive	All	Positive
PD - Data Entry Options	0	0	1	0
PD - Results Display	2	0	2	1
UA - Navigation Display	0	0	0	0
UA - Results Location	0	0	0	0

Kendall's Tau correlation analysis was also performed on the participant responses to the survey questions that asked them to rate their level of agreement, on a 5-point Likert scale, with a series of statements that represented the key ideas of the cultural dimension guidelines. Like the usability analysis, the regression for these questions was performed on both the full participant pool as well as the subset of foreign participants.

Overall, significant correlations were only found between the guideline statement responses and the calculated dimension scores. More correlations that were significant were found for the PD guideline statements than the UA guideline statements.

Lastly, the researcher performed an analysis to determine if the presentation order of the UI component pairs had an effect on the usability metric correlations. Because of time and resource constraints, the analysis was performed only on the usability metric that produced the most significant correlation, the interaction confidence difference for the PD – Results Display UI-component-pair.

A Kruskal-Wallis test showed that the display order had no significant effect on the response variable (p-value = 0.0685). However, because the p-value of the Kruskal-Wallis test was close to 0.05, a set of Kendall's Tau correlation analysis was performed to determine if significant correlations existed between the display order, calculated PD score, and the response variable. No significant correlations were found.

5 Discussion

The purpose of this chapter is to examine the results of the study, presented in chapter 4, to help answer the research questions proposed at the end of chapter 2. This chapter begins with a discussion of the participant population's demographics. The section specifically addresses how the demographics may have influenced the interpretations of the survey results. Next, research question number two is assessed based upon the usability results of the survey. Following that, research question number one is answered based upon the answer to research number two and the overall results of the survey. Lastly, this chapter concludes with a detailing of the factors that limited the interpretation and generalizability of the results of this study.

5.1 Demographics of the Participant Population

This section examines the characteristics of the survey population, how they may have affected the cultural dimension scores, and the impact this had on the interpretation of the results of this study.

5.1.1 General Participant Demographics

One of the first things that should be noted before examining the participant demographics is that the nature of participant recruitment method (detailed in section 3.4.4) meant that the participant population was not random.

To advertise for participants the researcher primarily used electronic advertisement methods such as email and social media to recruit potential participants. As such, the demographic distribution of the participants was heavily influenced by the pool of participants the researcher had access to. This is reflected in the fact that most of the participants were between the between the ages of 18 and 34, were students or worked as academic professionals, and had more than 16 years of education.

Additionally, while the researcher originally viewed university students as ideal population pool from which to draw, being a university student was not a part of the inclusion criteria. Drawing solely from university students was deemed to be too limiting to generate generalizable results. Thus, while much of the advertising was done through university connections and channels, individuals from the general population were recruited into the participant pool through social media and personal referrals from individuals that saw the advertisements.

These factors perhaps contributed to the skewing of the participant demographics. This means that the results of this study may not be significant outside this pool of participants and, more importantly, may not apply to the intended populations.

Lastly, it appeared that the foreign participants were similar and representative of their identified nationalities. This was based upon the results in Figure 4.6 and Figure 4.7, which showed that most of the foreign participants had spent at least 21 years living in their home country. They had also spent 4 years or less living outside of their home country. It should be noted that other studies have typically used more restrictive inclusion criteria. One such study by Simon (2001) restricted the participants to those that had lived less than 6 months outside their home country.

Living as much as four years outside of one's home country likely resulted in the participants displaying some adaption to the United States culture. However, with the requirement that participants be able to read and write English it was felt that stricter inclusion criteria would have adversely limited the researcher's ability to recruit foreign participants. At the time of this study, the researcher was not aware of any studies that had examined the effect emigration had on the cultural value scores. As such, the results may not be generalizable to the general populations of the nationalities represented in this study.

5.1.2 Demographics between Nationalities

As discussed in section 4.2.2 the participants of this study represented a total of 12 countries and 2 geographical regions. The number of participants and their demographic distributions varied greatly between the 14 different nationalities.

In terms of number of participants, the greatest number of participants represented the United States, with 37 participants. Between the foreign nationalities, or the nationalities that were not the United States, the numbers of representative participants were as high as seven to as low as one participant. In fact, all but four of the 13 foreign nationalities were represented by just one participant. This fact alone meant that achieving matched demographic distributions across the nationalities was not possible. This suspicion was confirmed and shown in Figure 4.9, Figure 4.10, and Figure 4.11. However, this mismatch of demographic distributions between the nationalities had an unexpected benefit for this study, discussed in the next section.

5.1.3 Impact on the Hofstede Cultural Dimension Scores

The Hofstede PD and UA dimension scores for the nationalities represented in this study were gathered from two main sources. Published and validated scores were gathered from a dataset made available on Hofstede's own website (Hofstede, 2015). PD and UA scores were also calculated from the participants' responses to the VSM 2013 (Hofstede & Minkov, 2013b) included in the study survey.

As detailed in section 4.4, comparisons of the published and calculated scores showed very little similarity. This was not unexpected as Hofstede and his colleagues (2001, p. 50; 2013a) have noted that demographics such as age, gender, education, and career can affect the dimension scores. While the VSM instrument has been shown to be reliable (Hofstede, 2001, p. 65; Hofstede & Minkov, 2013a; Hoppe, 1990), it is not a very robust tool to measure cultural values. A reliable test, in this case, is one that produces similar results under a similar set of conditions. A robust test is one that produces similar results under a range of conditions. This is something Hofstede (2001, pp. 66–67) does note about the VSM, that it is reliable but not robust.

Interestingly enough, since the calculated PD and UA scores appeared to account for the mismatched demographics between the nationalities, the researcher was able to use them to determine if this affected the results. The lack of robustness in the VSM tool actually allowed the researcher to generate results that were more meaningful.

However, it should be noted that since it was unknown how and to what extent the demographics affected the PD and UA dimension scores the researcher could not conclusively prove that this was the only factor that affected them. The differences may have been a product of the low number of participants, cultural contamination, or some other combination of unknown factors. Many of the exploratory studies detailed in section 2.7 did not calculate their own values for Hofstede's cultural dimensions. Without further comparable research, it is unknown if the results of this research are applicable outside this particular set of participants.

5.2 Research Question 2

The first research question asked if computer UI guidelines derived from research related to Hofstede's cultural dimensions model produced valid UI requirements for a given country. If a design guideline is valid, then it should produce a more usable system than if it was not applied. In this case, it was hypothesized that if the guidelines were valid then the usability of the UI component pairs based on the guidelines would correlate with the associated dimension scores.

This means that the answer to the first researcher question depends upon the results and conclusion to the second research question, which is why it is addressed first. The second research question asked if user-group usability ratings of UI components varied in relation to the difference between their nationalities' Hofstede cultural dimension scores. Specifically the researcher was interested if user-group usability ratings of UI components varied in relation to the scores of two of the six cultural dimensions, Power Distance (research question 2a) and Uncertainty Avoidance (research question 2b).

This section first details the answer to research questions 2a and 2b by examining the results of the usability assessments for each of the four UI component pairs. This section then concludes with an answer to research question 2.

5.2.1 Usability Correlations with Power Distance Scores

5.2.1.1 PD – Data Entry Options Pair

From the assessment of difference in usability between the pair of PD – Data Entry Options detailed in section 4.5.2, the Kendall's Tau correlation analyses found that the only significant correlation was between the interaction confidence difference and the calculated PD scores. For the full participant pool analysis, this was found to have a correlation coefficient of -0.3384 and a p-value of 0.0044. When the analysis focused on just the foreign participants, the correlation was found to have a correlation coefficient of -0.3929 and a p-value of 0.0161.

The fact that the correlation had a negative coefficient was counter to the researcher's expectation. The negative correlation coefficient indicated that the users with higher calculated PD scores were less confident with the HPD – Data Entry Options than they were with the LPD – Data Entry Options and vice versa. This was the exact opposite of what the researcher thought would happen based upon the PD guideline.

The free-text responses associated with the interaction confidence questions were examined by the researcher for some reasoning behind this negative correlation, but the responses did not provide any additional insight.

Related to the LPD – Data Entry Options, participants specifically commented that options were too vague and subjective. Participants commented that they had difficulty with the “imagine your friend is sick” scenario used for both the LPD and HPD versions. Participants also commented that they were confused why so few questions were displayed in the UI component examples.

Barring that the correlation was a result of chance or unknown factors, the researcher speculated that the negative correlation could be a result of a misinterpretation of the guideline. If the guidelines are assumed accurate, it could be that the more discrete data options in the HPD – Data Options display require the users to make definitive decisions. Participants with lower PD scores, who are more comfortable making discrete decisions, feel more confident in their answers. Conversely, the more vague and subjective options allow participants with higher PD scores to make decisions that are not as definitive, making them feel more confident in their answers i.e., non-definitive answers can be reconciled with a wider range of data. This is purely the researcher’s speculation and is not backed up by any other research or data.

5.2.1.2 PD – Results Display Pair

From the Kendall’s Tau correlation analysis of the PD – Results Display pair, shown in Table 4.6 and Table 4.7, two of the eight correlations that were examined were found to be significant for both the full participant pool and the foreign participants. One of the two correlations was between the calculated PD scores and the time scenario difference. The second correlation was between the calculated PD scores and the interaction confidence difference.

Correlations between the published PD scores and all four usability metrics were found to be significant in the two analyses. However, as shown in Table 5.1, each of the correlations was found in only one or the other of the two analyses. This makes it likely that the significance was due to chance, low participant number, or some other factor.

Table 5.1. PD-Results Display Correlation P-Values between Published PD scores and Usability metrics

	Correlation P-Values	
Usability Metric	All	Foreign
Timed Scenario Difference	0.0180	0.7079
Interaction Confidence Difference	0.3820	0.0117
EUCS Score Difference	0.4411	0.0161
UI Preference	0.0487	0.2561

Two significant correlations were found with the calculated PD scores for both analysis. The correlation coefficient for the interaction confidence difference was found to be positive in polarity. This was expected by the researcher and indicated that the participants with high-calculated PD scores were more confidence in their interactions with HPD – Results Display and vice versa.

It was unexpected to find a negative correlation between the calculated PD scores and the completion time difference. This is because a more usable interface is one that typically takes less time to complete an action. To gain insight into this result the researcher looked through the free-text responses associated with the interaction confidence and the EUCS questions for each version of the PD-Results Display.

What was found is that there appeared to be two different reactions to the displays. Some participants appeared to be confused by the information that was displayed. For the LPD - Results Display, some participants appeared confused by the sheer amount and type of information displayed. Some participants commented that many of the symptoms and risk factors overlapped, while others commented that they had no decision variable to reference. For the HPD - Results Display, some participants commented that they were unsure about the algorithm that generated the percentage. Other participants commented that since some of the percentages were close to each other, they were unsure about which disease was most likely.

Other participants appeared to react very differently to the displays and were able to reason out a meaning behind the results. For the LPD – Results Display, some participants commented that they were able to compare the number and types of symptoms to conclude which disease was most likely. For the HPD – Results Display some participants commented that percentages provided a clear answer to which disease was most likely.

While it is difficult to determine from these few and self-reported comments, it is suspected that the negative correlation may be related to the concepts of user expectancy and top-down processing. Users tend to focus more on portions of a UI where they expect things to occur or where they might find useful information (Wickens et al., 2013, p. 52, 2004, p. 123). Contextual cues and past experience play a big role in this process (Wickens et al., 2004, pp. 123–125).

It may be that the participants with higher calculated PD scores expected the display to have a clear decision variable. When they could not find one in the LPD – Results Display they gave up quickly. Conversely, the HPD – Display did have this expected feature, resulting in them engaging and spending more time with this version. Meanwhile, the participants with lower calculated PD scores may not have expected a clear decision variable to be in the display. As a result, they were more likely to spend more time engaging and analyzing the LPD – Results Display.

5.2.1.3 Summary of PD Score Usability Correlations

Overall, it appears that in some specific cases the calculated PD scores positively correlated with the usability metrics for the two UI component pair. However, only one of the four metrics were found to be significantly correlated for the PD – Data Entry Options and only two of the four metrics were found to be significantly correlated for the PD – Results Display.

It is interesting to note that none of the published PD scores, which represented the overall cross-national PD differences, were found to significantly correlate with the usability ratings and preferences of the users. Only a couple of the metrics were found to correlate with the calculated PD scores, which represented the PD value differences between these specific participant nationality groups. This suggests that while overall the usability ratings did not correlate well with the PD scores, it appears that with this group of participants the calculated PD scores correlated better with the usability ratings than the published PD scores. This is not surprising given the fact that the nationality groups were not demographically similar to each other, which likely influenced the calculated dimension scores as stated in section 5.1.3.

However, based upon the results it appears that the answer to question 2a is that there is not enough evidence to indicate that user-group usability ratings of UI components are correlated with PD scores

5.2.2 Usability Correlations with Uncertainty Avoidance Scores

5.2.2.1 UA – Navigation Display Pair

From the Kendall's Tau correlation analysis of the UA – Navigation Display pair, shown in Table 4.8 and Table 4.9, none of the usability metrics were found to be significantly correlated with either the published and calculated UA scores in both sets of analysis.

The only significant correlation was found in the full participant pool analysis between UI preference and the published UA score. (Coef = 0.2384, p-value = 0.0397). This correlation had a positive coefficient value, indicating that it corresponded with the researcher's expectation. This meant that a participant with a lower published UA score tended to prefer the LUA – Navigation Display more than a participant with a higher published UA score. This correlation was not significant when the analysis was repeated for just the foreign participants (Coef = 0.1794, p-value = 0.2723), but the coefficient did remain positive. The correlation not continuing to be significant in the second analysis indicates that the United States participant responses may have produced a false positive significance.

Even though none of the other correlations were found to be significant there was an interesting pattern with the positive versus negative correlation coefficients between the two analyses, shown in Table 5.2. The calculated UA scores showed no consistency in the number of positive versus negative correlations found between the two analyses. Conversely, the published UA scores did show a consistent trend towards positive correlations. This could mean one of two things. Since the correlations were not statistically significant this could, and likely does, mean the pattern represents nothing. However, since other studies have shown that UA scores do correlate with the extent that users prefer information in advance (Choi et al., 2005; Zaharias & Papargyris, 2009), it could indicate that the published UA scores predicted the usability and preferences of the participants better than the calculated UA scores.

Table 5.2. Count of Positive and Negative Correlation Coefficients by Score and Analysis Population for the UA – Navigation Display

	Published		Calculated	
Participant Pool	Positive	Negative	Positive	Negative
All Participants	4	0	1	3
Foreign Participants	3	1	3	1

5.2.2.2 UA – Results Location Pair

From the Kendall's Tau correlation analysis of the UA – Results Location pair, shown in Table 4.10 and Table 4.11, none of the usability metrics were found to be significantly correlated with either the published or calculated UA scores in both sets of analysis. Even though none of correlations were significantly correlated, an interesting pattern appeared with the number of positive and negative correlation coefficients between the two analyses. As shown in Table 5.3, while the number of positive and negative correlations were very different for the calculated UA scores, they remained the same for the published PD scores. More so, Table 4.10 and 4.11 show that the correlation coefficient polarities of all four metrics remained constant for the published UA scores.

Table 5.3. Count of Positive and Negative Correlation Coefficients by Score and Analysis Population for the UA – Results Location

	Published		Calculated	
Participant Pool	Positive	Negative	Positive	Negative
All Participants	2	2	2	2
Foreign Participants	2	2	4	0

Unfortunately, this observation is likely a product of some factor other than the UA score. After examining the free-text responses associated with the interaction confidence and the EUCS questions for the UA – Results Location, the researcher found a mix of comments indicating that some users found the location of the results easily, while others did not. Additionally, the results may have been inconclusive for this display due to a different aspect of the uncertainty avoidance value.

Uncertainty avoidance does not only play a part in the preference for information in advance (Choi et al., 2005; Zaharias & Papargyris, 2009), but also plays a role in whether new people, things, and tools are accepted or rejected (Hofstede, 2001, pp. 160–161). Individuals from higher UA nations tend to view change or anything new as bad, while individuals from lower UA nations tend to be more accepting of anything new (Hofstede, 2001, pp. 160–161). The fact that the participants were not medically trained and had never used the UI presented in this study before could have meant that the participants from higher UA nations found both UIs in the pair equally unusable. Since this was not within the scope of this study, further research is required to validate this conclusion.

5.2.2.3 Summary of UA Score Usability Correlations

The results of the analysis of the two UA related UI component pairs found no consistently significant correlations between the usability differences and the UA scores, either published or calculated. The single significant correlation found between the UI preference and the published UA score was only found significant for the full participant pool and not when the analysis was repeated just with the foreign participants.

What this indicates is that, at least for this case study, the answer to research question 2b is that there is not enough evidence to indicate that user-group usability ratings of UI components are correlated with UA scores.

5.2.3 Summary of Research Question 2

Based upon the analysis so far it appears that for these two dimensions, Power Distance and Uncertainty Avoidance, there is not enough evidence to indicate that user group usability ratings correlate with their dimensional scores.

The analysis of the PD-based UI component pairs only revealed two consistently significant correlations, while no significant correlations were found for the UA-based UI component pairs. It suggests that the application of these guidelines to new UI designs may not lead to gains in usability. However, there are several limitations to generalizability of these conclusions, discussed later in section 5.4. The results of this study contrast with those of others that have found that cultural dimensions do correlate with increased UI performance and usability (Recabarren & Nussbaum, 2010). This indicates that further research is necessary to determine which combination of cultural dimensions and UI aspects create robust increases in usability of UIs based upon a user's culture.

5.3 Research Question 1

Research question 1 asked if UI guidelines derived from research related to Hofstede's cultural dimensions model produce valid computer UI requirements for a given country. Based upon this question the researcher determined that valid requirements are those that produce an increase in usability. Wickens et al. (2004, p. 59) states that a system is usable if it is easy for a user to use. Since the goal of many industries is to make their products or systems easy to use by consumers, this appeared to be valid measure of whether or not the UIs produced by guidelines derived from research of Hofstede's cultural dimensions were valid. This led the researcher to focus this study on answering research question 2.

However, research question number 2 relied heavily on the measurement of the usability of the UI component pairs, which is an indirect measurement of the guidelines. As stated in section 3.2, this was necessary as measuring the validity of design guidelines directly can be difficult. In an attempt to determine if the key ideas behind the guidelines were valid, the researcher asked participants their level of agreement with a series of statements representing each of the four guidelines. These statements and their corresponding cultural dimension poles were as follows:

- I prefer the software to make decisions/suggestions rather than make them myself – High Power Distance
- I prefer to make decisions myself rather than have the software make decisions/suggestions for me – Low Power Distance
- I prefer more information in an interface so that I understand what my interaction with an interface will do before I interact with the interface – High Uncertainty Avoidance
- I prefer minimal designs that allow me to quickly explore a software system – Low Uncertainty Avoidance

It should be noted that the reliability or effectiveness of these questions were not evaluated. As such, the statistical analyses and results of these questions should not be taken at face value. The fact that the UA statements involved more complex words and concepts than the PD statements may have biased these results. Since these results are used in context with this fact and the results of the usability analysis, the conclusions to research question number one does not solely rely on these results.

5.3.1 PD Guideline Statements

The Kendall's Tau correlation analyses of the participant responses to the PD statements, as shown in Table 4.13 and Table 4.14, revealed that only one correlation was found to be consistently significant for both the full participant pool and the foreign participants. This correlation was between the calculated PD scores and the HPD guideline statement. This correlation had a positive coefficient meaning that the relationship was as expected by the researcher. This means that participants from higher calculated-PD-score nations agreed more with this statement than participants from lower calculated-PD nations.

In line with this, the participant responses to the LPD guideline statement was found to be significant for the full participant pool (Coef = -0.3038, p-value = 0.0253), but just barely not significant for the foreign participant pool (Coef = -0.03871, p-value = 0.0530). The p-value for the second analysis was only 0.003 away from significance. Also interesting about the results is that the correlation coefficient remained negative, which was in line with the researcher's expectation and consistent with the HPD guidelines results. This suggests that the LPD guideline may have been valid.

It was found that the published PD dimension scores showed no significant correlations with the guideline statements. It should be noted that the polarity of the published PD correlation coefficients switched between the full participant pool analysis and the foreign participant analysis. This indicates that for this group of participants, the calculated PD scores correlated better with the participants' responses to the PD guideline statements than the published PD scores. This is consistent with the observation made in section 5.2.1.3 describing conclusions from the PD UI-component-pair usability results. It is also consistent with the Hofstede's (2001, p. 50) finding that demographics can influence the dimension scores for the VSM. However because the limitations of this study discussed in section 5.4, this conclusion may not apply outside this specific group of participants.

5.3.2 UA Guideline Statements

The analyses of the UA guideline statement did not reveal any consistent, statistically significant correlations between the published or calculated UA scores and the responses to the UA guideline statements.

The only statistically significant correlation was found between the calculated UA scores and the LUA guideline statement responses (Coef = 0.2757, p-value = 0.0467). The positive correlation coefficient was unexpected by the researcher. This combined with the observation that the p-value for this correlation was much higher (p-value = 0.3719) when the analysis was repeated for the foreign participants indicates this relationship may not have been significant.

As noted in section 5.3, the inconclusiveness of these results might have been unduly influenced by the wording and content of these two statements and less by the UA values of the participants. The concept of "system exploration" was likely a more familiar concept to the participants than "information that informed interaction." Additionally, because most of the population was highly educated they may have been more accustomed to critically analyzing and exploring systems themselves, leading to further bias in the results. While this was clearly an oversight by the researcher, it also demonstrates the difficulty that sometimes comes into play when trying to measure such preferences directly.

5.3.3 Summary of Research Question 1

Based upon all of the analyses conducted in this study, it appears that the answer to research question 1 is that there is not enough evidence to indicate that cultural guidelines based on the research related to Hofstede's cultural dimension model lead to valid UI requirements.

As discussed in section 5.2.3 the results of the usability correlation analyses were largely inconclusive. This was consistent with the UA guideline statement analysis, discussed in section 5.3.2. As discussed in section 5.3.1, the results of the PD guideline statement analyses indicated that the guidelines were valid for the calculated PD scores. This corresponded to some of the correlation results in the PD – Results Display analyses, discussed in section 5.2.1.2. However, these limited results were inconsistent with the rest of the conclusions made in this study. This led the researcher to conclude that while the calculated PD scores might have led to good design requirements in some cases, overall the results do not indicate that the sets of guidelines used in this research study lead to good design requirements. In some cases, they led to misleading design requirements. This makes these cultural dimension guidelines similar to the use of cultural databases, discussed in section 2.4, which a research study by Honold (2000) found to provide misleading design information about Indian society.

This conclusion is further backed up by the observation that much of the research examining UI design and cultural dimension has found a mix of results. Two studies that both examined the effect of culture on cell phone interface preference, conducted within years of each other, found a mix of results (Choi et al., 2005; Jhangiani, 2006). A Master's thesis research study by Jhangiani (2006) found none of the same statistically significant relationships that were found in a study by Choi et al. (2005).

Additionally problematic is that it appears, in some cases, that the calculated scores were a better predictor of the results for the PD guidelines and UI-component-pairs than the published scores. This was not unexpected as the calculated scores likely were affected by the mismatched demographics between the participant nationality groups. However, it does indicate that for smaller populations of users, demographic influences on values may play a bigger role than cross-cultural value differences. Thus, the use of published cultural dimension scores may in some cases lead to poor design decisions. Since this was the only example of this type of conclusion that the researcher was aware of, additional research is necessary to determine if this conclusion is generalizable to the broader world population.

What the results of this study and others indicate is that Hofstede's cultural dimension model may not be appropriate for analyzing detailed culturally influenced UI preferences. While Hofstede's model seemed to be appropriate, based upon the extent of research that had utilized his model and the accessibility of dimension score datasets, it could be that a more complex model, such as Schwartz's (2006), might be more suitable.

One of the problems that could affect the explanatory value of Hofstede's model within the UI design field is the fact that Hofstede's cultural dimensions are viewed as largely independent of each other (Hofstede, 2001). Practitioners within the human factors engineering field recognize that the usability of UIs are influenced by a number of interacting factors including cognition, perception, past experience, the task that must be performed, etc. (Wickens et al., 2013, 2004). Even with the accepted use of design guidelines within the human factors engineering field, it may be naïve to suspect that a model that does not incorporate these interactive effects could apply. While it was outside of the scope of this research, it could have been that interactions between two or more Hofstede dimension scores would have better correlated with the results of this study. However, this is merely a speculation that would require additional research to validate.

5.4 Limitations

Recognizing the limitations of a study is important in research to help ensure that incorrect or misleading conclusions are not drawn from the results (Montgomery, 2013, p. 2). It is also important to recognize the limitations of a study so that researchers can identify additional topics and questions that need further analyses. Like any experiment, this study had a number of limitations that affected the generalizability and conclusiveness of the results. These limitations are grouped into limitations of the methodology, the survey, and the participant population.

5.4.1 Methodology Limitations

One of the main limitations to the generalizability of this study's results is use of a case study approach. As stated in section 3.2, the case study approach was utilized because without some form of usability test results, it was nearly impossible to assess if the guidelines were valid. This is the power of the case study approach as it allows phenomena that are meaningless outside of given context to be studied (Yin, 2009, p. 18).

However, this fact makes the results of such studies limited in their generalizability, as it is unknown if the similar results would be found in a different set of contextual conditions. The results of case studies are particularly difficult to generalize to wider populations or a universal group of situations (Yin, 2009, p. 15). As such, the results of this study may only be applicable for this set of participants, design guidelines, and UIs. Further research is required to determine if different case studies produce similar results.

Related to this limitation is that the guidelines and UI components were both interpreted by the researcher based on the available literature. The guidelines were not sourced directly from a source. They were based on themes interpreted by the researcher from both Hofstede's publications and the results of other studies reviewed in Chapter 2. As such the guidelines, the UI components, and the usability results of the study were heavily influenced by the researcher's ability to synthesize meaning from the literature. The inconclusive nature of the results suggests that the researcher may not have been successful at this.

Another limitation to this was that this study examined the usability of isolated components of a UI system. As described in section 3.4.1, the researcher chose to study UI components that were not a part of a complete UI system. This was done to minimize the effects of extraneous UI components on the usability results, allowing the participant to focus on the UI component of interest. It also allowed the researcher to conduct a simpler designed research survey and examine more UI component pairs than using a complete UI system with random combinations of components. However, this experimental simplification was not reflective of the actual industrial use of these UI components, which would be just one component in a larger system. It is unknown if similar usability correlations would be found if these UI component pairs were incorporated into full UI systems. As such, further research is required to validate the usability trends found in this study.

5.4.2 Survey Limitations

All survey methods have some inherent limitations. Surveys themselves are a form of self-reported data collection methods that do not require a researcher to be present to collect the data (Crandall et al., 2006, p. 14). This means that the only information collected is that which the participant is willing to provide. There is less control over the quality of information provided by the participant than compared with other methods (Crandall et al., 2006, p. 14). In contrast, a researcher using an interview method can question and explore topics that have not been fully answered (Crandall et al., 2006, p. 13). The self-reporting nature of the survey did not allow the researcher to verify the demographic information provided by the participants. Additionally the environment in which the survey was taken could not be controlled by the researcher. Distractions or other extraneous factors from the environment could have influenced the results of this study.

Surveys also depend heavily on the validity and reliability of the rating scales and questionnaires used. The researcher attempted to use validated and reliable questionnaires when possible, such as the VSM 2013 (Hofstede & Minkov, 2013b) and the EUCS questionnaire (Doll & Torkzadeh, 1988). However, in some cases, unevaluated questions and scales were used that were created by the researcher. These included the UI interaction confidence question, the overall preference question, and the cultural dimension guideline statements. Also, while the EUCS is a validated and reliable tool (Deng et al., 2008; Doll & Torkzadeh, 1988), a modified version was used in this survey that had a different, and unevaluated, response scale from the original (this is described in further detail in section 3.4.3). As such, the statistical significance and conclusions drawn from these scales are subject to interpretation and require additional research to validate.

5.4.3 Participant Population Limitations

The other limitation to this study was related to the participants included in this study. The possible survey participants were heavily influenced by recruitment methods the researcher had access to. This fact is reflected by the observation that many of the participants were similar in age, education, and managerial career status to the researcher. This means that generalizability of these results to populations of different demographics is limited.

Additionally, the size of the participant population makes the generalizability of these results to populations outside of this research study limited. A rough estimate of a proper sample size for the 95% confidence level used in this survey, based upon an actual population size of over 100,000 individuals is at least 383 participants (“Sample Size for Survey,” n.d.). This survey only had 65 participants in total, which were further broken down into smaller groups based upon their identified nationality. In some cases, only one participant represented a whole nationality group. Even though the researcher made no claim about the results representing individual nationality groups, the generalizability of the observations and the statistical significance from results to individuals or groups outside this specific study population is limited.

Related to this is the fact that the participants for this study were not randomly selected. Many statistical methods are predicated on the assumption that participants are randomly selected from a population (Montgomery, 2013, p. 30). This includes the p-value test for significance used in the results analysis. As such, the statistical significance values were reported as additional information used by the researcher to interpret the results of this study. Further research is required to determine if these findings are applicable to populations outside of this study’s participant pool.

It should also be noted that PD and UA dimension scores calculated in this survey only reflect this study’s participant pool. This is because the nationalities in this study, other than the United States, were represented by less than 20 participants and they do not represent samples matched across age, gender, education, and career. This is a limitation to the study as the calculated scores, and the subsequent correlations, were likely influenced by the different age, gender, education, and career levels of the participants. Determining the exact nature of the influence was deemed to be outside the scope of this study by the researcher.

6 Conclusion

This research continued efforts to make tractable the concept of culture and its relation to system design. Before the adoption of dimension models, culture was largely viewed as an intractable concept that was too complex to deconstruct into its basic elements (Minkov & Hofstede, 2011).

In line with this, the purpose of this research study focused on analyzing if cultural dimension models could be used to elicit valid UI design guidelines. Such guidelines could help designers create products for use in different countries. This was found to be a very challenging task that required the researcher to integrate two complex fields, cross-cultural research with human factors engineering.

This section provides a summary of the research findings from this study. This is followed by the implications this research has for system designers. It concludes with a series of recommendations for future research in this field.

6.1 Summary of Findings

Based on the results of this research, there was not enough evidence to indicate that UI design guidelines based upon Hofstede's cultural dimension model lead to valid UI requirements. This conclusion was made not only from the results of this study's survey but also based upon the observation that many of the studies in this field consist of mixed and sometimes contradictory results (De Angeli & Kyriakoullis, 2006; Jhangiani, 2006; Recabarren & Nussbaum, 2010).

Specifically examining the usability of UI systems, the results of this study suggested that, for this case study and these specific UI component pairs, there was not enough evidence to suggest that usability metrics of UI components correlate with a user group's cultural dimension scores. This study specifically examined if usability of UI components correlated with Hofstede's Power Distance and Uncertainty Avoidance dimensions.

For the Power Distance dimension, only a couple of significant correlations were found to be consistent in the analyses. However, it appeared that the results might have been influenced by demographic differences between the participant groups, not by broad cultural differences.

For the Uncertainty Avoidance dimension, no significant correlations were found to be consistent in the analyses. However, it appeared that results may have been influenced by the observation that users from higher UA nations tended to reject new technology (De Angeli & Kyriakoullis, 2006). Since the participants were not medically trained, they may have found all of the UA-based UI component pairs equally unusable.

While the results of this case study, with its limitations, were difficult to generalize outside of this group of participants, it did not mean that the results did not contribute to the overarching theories involved (Yin, 2009, p. 15). Theories are meant to be generalizable to all applicable situations, which means that case studies, such as this one, help provide evidence for the validity of a theory. As such, the results demonstrated that more research is necessary to determine how cultural dimension models can properly be used by designers to create culturally localized designs.

Based upon the results of this study and others, the researcher has compiled a list of recommendations for designers attempting to create products for use in other countries.

6.2 Recommendations for System Designers

The results of this study pointed out that product designers should use caution when applying cultural design guidelines. Guidelines are subject to interpretation, and as such, interpretations of the same guideline may vary by individual (Chapanis, 1996, pp. 62–64). As was found in this study, misinterpretations of a guideline can lead to unexpected results, sometimes resulting in systems that were less usable than other alternatives.

This was also found in a case-study detailed by Honold (2000) while German designers were trying to design a clothes washer for use in India. Germans working in India noticed that time and punctuality was not as important in India as it was in Germany (Honold, 2000). This led German designers to conclude that a more efficient wash cycle, even if it were longer, would be preferable (Honold, 2000). However, upon further investigation it was found that clothes washing was done every day, in the morning, for all members of the household (Honold, 2000). As such, a wash cycle of more than an hour was considered less desirable (Honold, 2000).

Thus, designers should be careful when trying to interpret cultural design considerations, as the designers' own bias can easily lead to misinterpretations. Beyond this point, the results of this research study suggested four things that designers consider when creating products for another country: number of potential users; observing the user when possible; what technology is currently in use; and what aspects of a system are affected by or facilitate social interaction. These suggestions can be remembered by the acronym NOTS, pronounced as "knots," since culture can be thought of as a tangle of interacting and intertwining aspects.

6.2.1 Number of Potential Users

The results of this study did not indicate that global cross-cultural differences have an effect on the usability of systems for smaller groups of users within a given nation. Demographic differences between the participant groups that affected the calculated PD scores appeared to correlate better than cross-cultural value differences. This suggested that if designers are looking to examine cross-cultural differences for design solutions that they should first determine the size and demographic characteristics of their potential user pool.

If designers expect their system to be utilized by a smaller subset of a national population, then it is best to focus less on cross-cultural differences and more on the individual needs of the specific group.

However, studies that involved larger number of participants found more conclusive links between system design and cultural differences (Cyr, 2008; Li et al., 2009). This suggests that systems intended to be used by a large portion of a nation's population would likely benefit from examining cross-cultural differences.

6.2.2 Observe and Interview When Possible

Both the anthropology and human factors engineering fields recognized the benefit of directly observing a population to gain an understanding about them (Handwerker, 2001; Wickens et al., 2004). Even if a formal study could not be conducted, simply engaging with potential users and observing the task a system would be involved with could provide much needed information for design (IDEO.org, 2009).

The United States has a lower PD score than other countries including those in China (Hofstede, 2015). Since hierarchical social structures are typically avoided in lower PD scoring nations (Hofstede, 2001, p. 107), one might assume that systems should be designed with flat structures. However, in some cases this is not true. The United States military emphasizes a strict hierarchical system known as the “chain of command.” This results in much of their social and technological systems following a hierarchical system structure. Simple observations of this group would quickly reveal such a fact that would have not been known by strictly examining the PD dimension scores.

6.2.3 Technology in Use

It is also recommended that when trying to develop technology for use in other countries it is best to examine the technology that is currently in use. A study by De Angeli and Kyriakoullis (2006) found that Greek participants, who were not as used to online shopping as the British participants in the study, were more anxious while making online purchases. This helped to point out that designers can benefit from examining the technology that is currently in use. This could help designers take advantage of transfer of training and develop interfaces that are more intuitive. Both of these concepts hinged upon a person or group’s past experiences with technology (Cairns, 2015; Wickens et al., 2004, p. 486)

Additionally of note was that designers should assess if the technology they were wishing to introduce to a group of users was appropriate. Since the motivation for this research came in part to help designers create products for use in impoverish nations, such as countries in Africa, the topic of appropriate technology should be mentioned. Developing appropriate technology was the process of evaluating if a new system was compatible with the local culture and did not disrupt, or at worse destroy, their lives (Hazeltine, 2003). Since there is plenty of literature on this topic, the researcher specifically advises designers to consider this aspect if they are creating systems for use in impoverish nations.

6.2.4 Social Interactions

Lastly, the researcher suggests that designers should examine the social interaction aspects of their product, as cross-cultural differences will likely influence these features. The UI components examined in this study focused primarily on the communication of information between the software system and the user. The results of this study did not indicate that usability of these UI components were significantly influenced by cross-cultural differences.

On the other hand, other studies have found that features that facilitate or interact with social communication appear to be influenced by cross-cultural differences (Choi et al., 2005; Jhangiani, 2006). While further research is needed to confirm this, it does suggest that designers should focus more effort on trying to adapt these types of features to the needs of a specific culture.

6.3 Recommendations for Future Research

The results of this research brought up several suggestions and questions for future research. One of these was that further research should be conducted to determine if the guidelines developed in this research, or other cultural dimension based guidelines could lead to better culturally localized UIs for other case studies. This research study examined the application of the cultural guidelines to the design of a medical diagnostic application. Since guidelines were developed to be broadly applicable to all types of UIs, additional research is necessary to determine if similar results are found when these guidelines applied to other types of UIs.

An issue that was encountered during the analysis phase of this study was that the calculated dimension scores did not match the published results. While this was expected, and likely resulted from the low number of participants, mismatched demographics, and cultural contamination, it did bring up a question that the researcher had not encountered in any of the reviewed literature, exactly how cultural values are affected by demographic variations. It was briefly mentioned by Hofstede (2001, p. 50) that demographics had an effect on the dimension scores, but further research is recommended to determine the extent of these effects.

Additionally, the researcher found that the literature suggested cultural value based dimensions may have a greater influence on the usability of social interaction features of a software (Choi et al., 2005; Jhangiani, 2006; Marcus & Gould, 2000; Zaharias & Papargyris, 2009). The case study in this research focused on the communication of information between one user and the software, a critical process for a diagnostic aid. However, since the results were largely inconclusive, it was suspected cultural dimension based guidelines applied to social interaction features might lead to greater correlations between usability and cultural dimension scores. As such, future research examining these types of guidelines is suggested.

Lastly, the results of this study suggested that Hofstede's cultural dimension model may be too broad to effectively predict detailed UI guidelines. As stated previously, Hofstede's model was predicated on the idea that his dimensions were largely independent of each other. However, human-computer interaction and usability are affected by many different interacting variables (Chapanis, 1996; Wickens et al., 2004). While the simplicity and accessibility of Hofstede's model appeared to be attractive to many researchers (Zaharias & Papargyris, 2009), including this one, it may be that a more complex model is better suited for UI designers.

Related to this was the fact that Hofstede's model was only useful in comparing cultures on the national level (Hofstede, 2001, pp. 28–29; Minkov & Hofstede, 2011). While this was certainly useful in some design cases, such as the designer and users being from two different countries, it did not help when trying to design for smaller populations or populations from multiple countries that were demographically different. A more comprehensive values model, like Schwartz's model (2006), could provide a more flexible foundation for UI design guidelines. As such, additional research is needed to determine what models and guidelines are the most useful for UI designers. Luckily, the overlapping value concepts between Hofstede, Triandis, Schwartz, and other models (Vinken et al., 2004, p. 16) mean that research concerning one model could possibly be applied to the others with only minor modifications.

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APPENDICES

Appendix A Case Study and Task Analysis Detail

This appendix provides additional detail and background on both the HTK-ID system and the task analysis performed on the infectious disease process. The system and task analysis provided the inspiration and background information for the case study used in this research. However, since the development of the HTK-ID only provided inspiration for this research and not content, the details of this project are included in this appendix for interested readers.

Healthcare Toolkit

The Healthcare Toolkit (HTK) is a project that has been a collaboration between Dr. Kenneth Funk and Bauer Labs LLC. The overall goal of the device is to fuse the data collection power of electronic health records systems with wireless medical equipment, such as stethoscopes and blood pressure cuffs, to create a portable medical examination kit that facilitates data collection and diagnostic support (“Healthcare Toolkit « Bauer Labs,” n.d.).

Originally envisioned as applicable to the arenas of primary-care and mobile healthcare screenings (“Healthcare Toolkit « Bauer Labs,” n.d.), a collaboration with the non-profit Willamette International revealed that such a system might help expand healthcare access in impoverished countries such as Sierra Leone.

Willamette International is a Christian non-profit organization that provides medical, infrastructure, and faith-based support in West Africa and South America, with current efforts aiding the country of Sierra Leone (“Willamette International,” n.d.). Representatives from this organization helped the researchers with background research and helped guide the scope of this project.

Sierra Leone – Country Profile and Medical Infrastructure

Sierra Leone is country located on the western coast of the African continent, in a region called West Africa. Since the country gained independence from the United Kingdom in 1961, it has faced decades of governmental coups and civil war (“Sierra Leone History,” n.d.). In 2002, a nearly six year war ended with the help of United Nation peacekeepers (“Sierra Leone History,” n.d.). From 2002 to present, the country has remained relatively stable, but decades of war have left the country in ruin. English is the official language of the nation, but a number of other languages are spoken including Mende, Temne, and an English-based Creole language called Krio (“The World Factbook: Africa: Sierra Leone,” 2014).

Most of the population of approximately 6 million (“The World Factbook: Africa: Sierra Leone,” 2014) have very little access to clean water, modern sanitation facilities, and medical care (National Malaria Control Programme (NMCP) [Sierra Leone], Statistics Sierra Leone, University of Sierra Leone, Catholic Relief Services, and ICF International, 2013). There is approximately one physician for every 5,000 people in the country (“The World Factbook: Africa: Sierra Leone,” 2014). Infectious diseases, such as malaria, are a major cause of death in the country (National Malaria Control Programme (NMCP) [Sierra Leone], Statistics Sierra Leone, University of Sierra Leone, Catholic Relief Services, and ICF International, 2013).

The current structure of Sierra Leone's medical infrastructure is managed at the national level by the Ministry of Health and Sanitation (MoHS) ("Sierra Leone:Leadership and governance - The Health System - AHO," n.d.). Local management of medical infrastructure at the district level is provided by District Medical Officers that manage the local primary care health units ("Sierra Leone:Leadership and governance - The Health System - AHO," n.d.). The local healthcare systems are supported by non-governmental organization (NGOs) that use community health volunteers to provide direct medical care in rural and underserved communities (Scott, McMahon, Yumkella, Diaz, & George, 2014).

Patients in Sierra Leone use a variety of methods to seek care depending upon their income level and access to traditional medical facilities (Scott et al., 2014). A combination of in-home treatments, traditional healers, pharmaceutical sellers, and modern medicine appear to be used by most of the population (Scott et al., 2014). The extensive use of non-professional medical services appears to result from a variety of factors including superstitious beliefs of disease etiology, difficulty of travel to reach facilities, limited hours of facilities, the prohibitive cost of such treatments, and in some cases to avoid ridicule from medical staff for not seeking treatment sooner (Scott et al., 2014). This last situation is especially common in the case of parents seeking treatment for their children (Scott et al., 2014).

There is a need for more extensive access to modern medical assistance, especially in the rural portions of the country. Representatives from Willamette International looked to fulfill this need with an adaptation of the HTK system. Based upon their target population and training requirements, they intended the system to be used by native Sierra Leoneans who could read, write, and speak English and had minimal or no formal medical training.

Healthcare Toolkit – Infectious Disease Variant

For this first iteration of the HTK system in Sierra Leone, it was decided to focus on infectious disease diagnosis. Malaria is endemic to the area and the recent outbreak of the Ebola virus had wreaked havoc across the country.

Based upon discussion with representatives of Willamette International, the system would focus on the diagnosis of four diseases that all present with fever and often require laboratory tests and/or treatment to diagnosis. These diseases include malaria, Lassa fever, typhoid, and yellow fever. This system was called the Healthcare Toolkit – Infectious Disease variant or HTK-ID.

Task Analysis

As part of the development of the HTK-ID system, a task analysis was done producing both an IDEF0 task model and a knowledge model. Subject matter experts (SMEs) including representatives of Willamette International and an infectious disease expert in Corvallis, Oregon were consulted in the development of the models. It should also be noted that the task analysis was a collaborative effort that not only included the researcher of this study, but also other graduate and undergraduate students at Oregon State University.

IDEF0 Model

The IDEF0 model of the medical diagnostic process developed by Zolfaghari (2014) served as base to develop a model representing the equatorial infectious disease diagnostic process. The model was originally developed by Zolfaghari to reflect the general medical diagnostic process. A thorough literature review as well as interviews of physicians were used to develop the IDEF0 model (Zolfaghari, 2014, pp. 30–31). Further reviews by the SMEs allowed Zolfaghari to create the final version of the model presented in his thesis.

Since the model did not reflect the specific tasks required to diagnose infectious diseases in Sierra Leone, SMEs were consulted to help refine the model. To do this the researcher had discussions with representatives from Willamette International who had experience conducting medical examinations in Sierra Leone. An infectious disease expert from Corvallis, Oregon, who also had medical experience in Sierra Leone, was consulted to provide additional feedback and review of the model.

The full model is shown in Appendix B. As Zolfaghari (2014, pp. 30–39) provided a thorough explanation of the theory and logic behind his original model, the rest of this section will be devoted to highlighting the key portions of model which guided the rest of this research.

The A-0 diagram for this model, shown in Figure A.1, contains one task box "Conduct Infectious Disease Encounter." This model was limited to the diagnosis of infectious diseases. The process is initiated and controlled by the patient condition, any available lab test results, as well as cultural components such as norms and language. Broad cultural terms were integrated in this model to document how cultural aspects influenced different aspects of the encounter based upon discussions with the SMEs. The patient and medical record are inputs into the process, as the patient is examined and the medical record is added to during the encounter. Outputs of this process included the patient in treatment, sometimes a final diagnosis, and/or orders for additional tests or treatments that may not have occurred during the encounter. The medical technician, their tools, and any available medications are the mechanisms that allowed the encounter to occur.

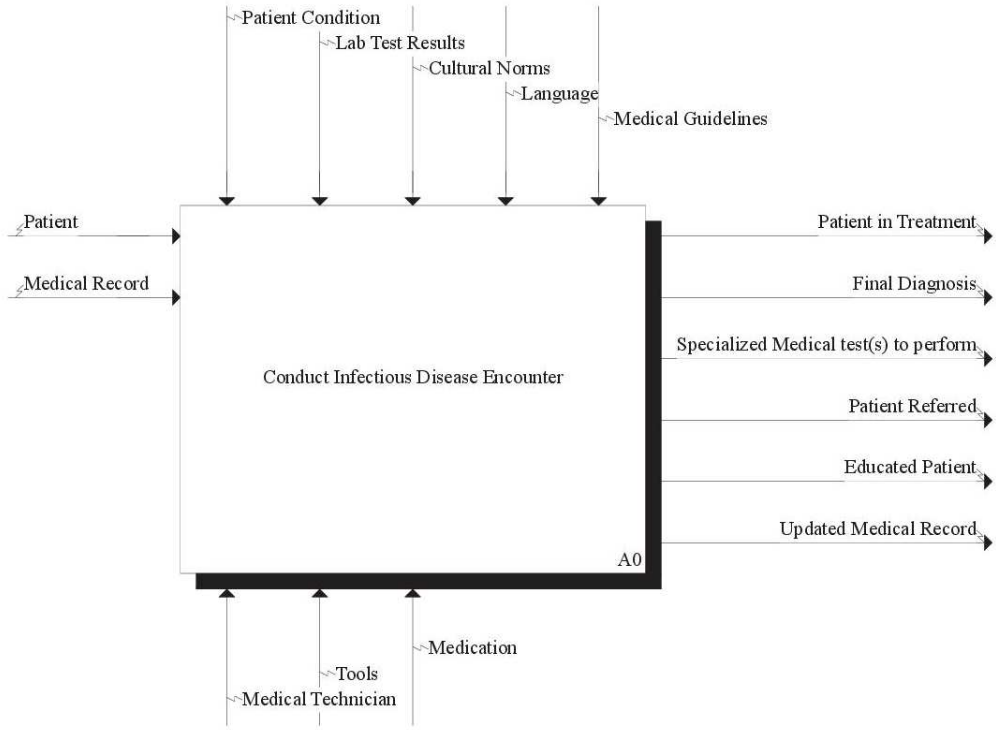


Figure A.1. A-0 Diagram

This task was broken down further into the A0 diagram, shown in Figure A.2. The encounter involved three primary tasks: establishing a relationship, diagnosing the patient, and then administering treatment/developing a follow-up plan (Zolfaghari, 2014, pp. 31–32). In Zolfahari's (2014) original model the treatment and developing a follow-up plan tasks are modeled as separate tasks, but they were combined in this model as the discussions with the SMEs revealed that they are often an integrated process with follow-up being a critical part of the treatment plan itself.

It was also noted by a representative of Willamette International that physician/patient cultural differences between themselves and the patient appear to influence the relationship building process. This is sometimes negative in nature, as a Sierra Leonean patient does not feel that an American can relate to or understand their situation. Sometimes it is positive, with the patient giving greater respect to the American physician as they are perceived as giving higher quality medical care than locally available resources.

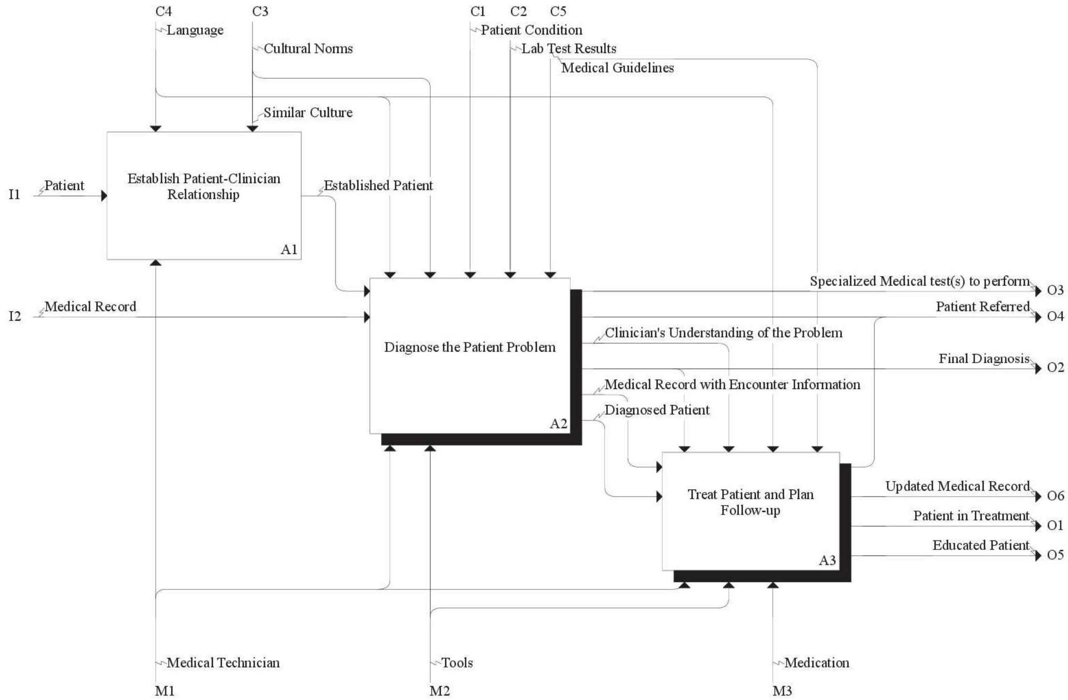


Figure A.2. A0 Diagram - Conduct Infectious Disease Encounter

Since the HTK-ID system was focused on aiding the diagnostic process, the A2 task "Diagnose the Patient Problem" was further decomposed in the A2 diagram, shown in Figure A.3. This diagram displayed the tasks that must occur to diagnose infectious diseases. First information about the patient, their symptoms, and their current physical conditions are gathered. This information is then used to generate a list of hypothetical diseases that could be causing the problems. This list is then processed to generate a final diagnosis.

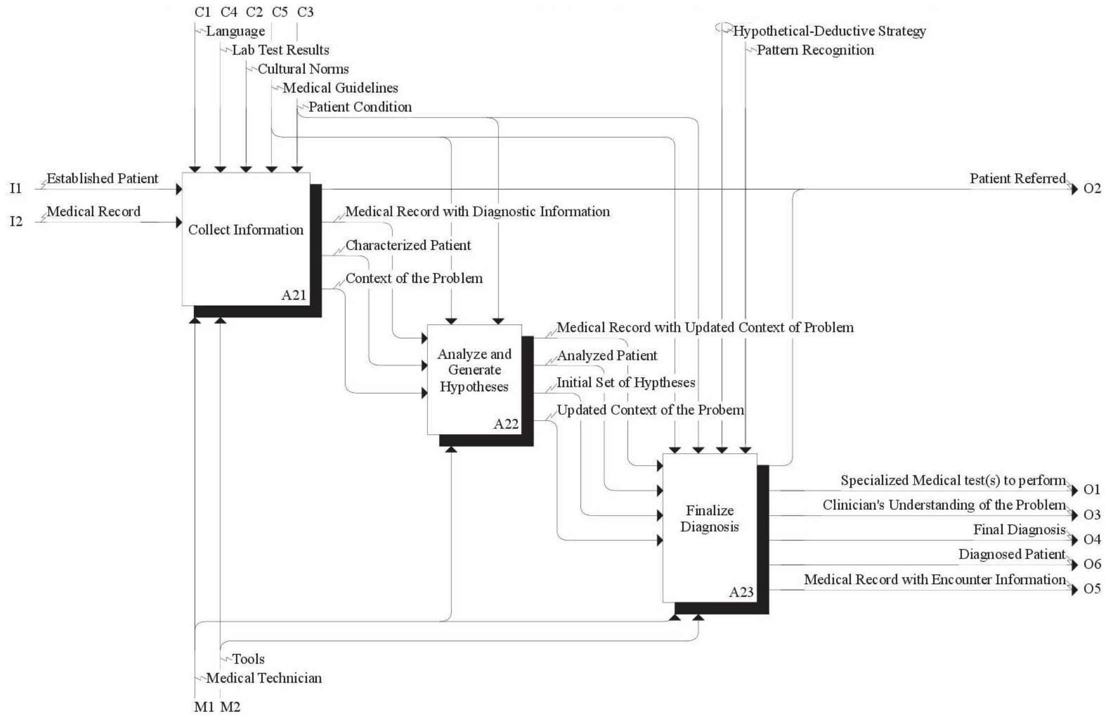


Figure A.3. A2 Diagram – Diagnose the Patient Problem

The A21 – Collect Information task was decomposed in the A21 diagram, shown in Figure A.4. Information is collected by the medical technician in three main ways to gain information relevant to infectious disease: reviewing the current medical record, collecting epidemiologic data, and lastly by collecting diagnostic information. Epidemiology is the study of the characteristics and distribution of diseases within a population (Killewo, 2010, p. 2). Clinical epidemiology is the use of these methods and data to identify risk factors or characteristics of patients that might make them more susceptible to a disease (Killewo, 2010, p. 228). Discussions with the SMEs revealed that since the equatorial diseases of interest typically present with similar symptoms, the epidemiological information such as access to clean water, use of mosquito nets, and time of year help to narrow which disease has a higher likelihood of being the cause of their illness. The last task “Collect Diagnostic Information” refers to the collection of both physical and symptomatic information.

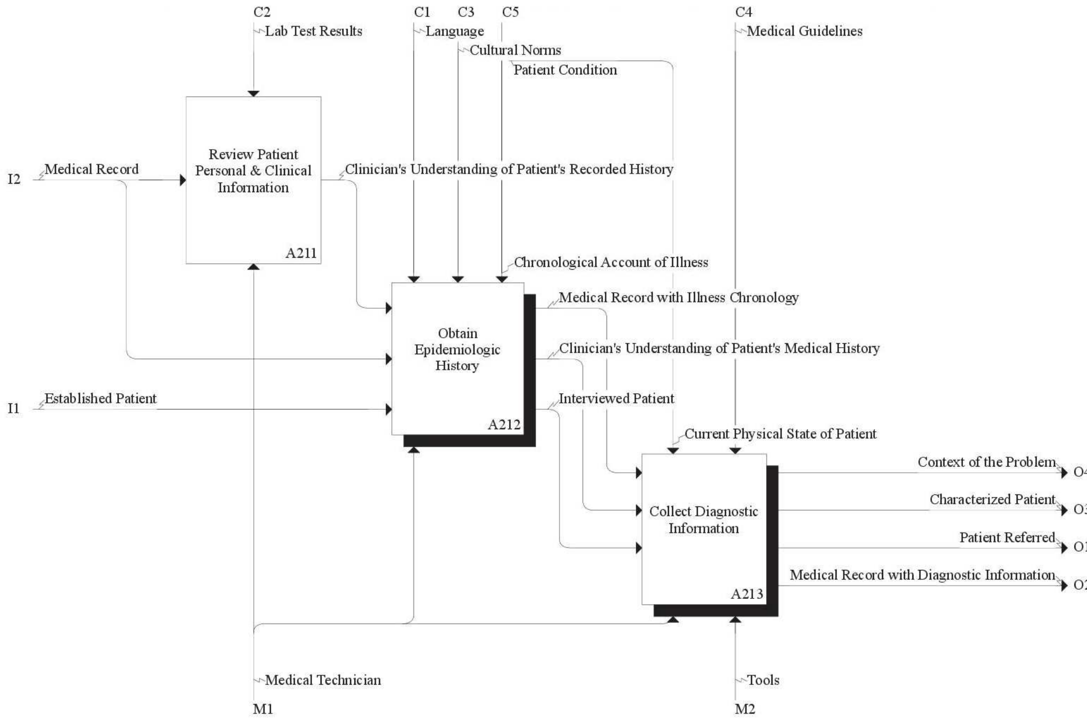


Figure A.4. A21 Diagram – Collect Information

The "Collect Diagnostic Information" was decomposed in the A213 diagram, shown in Figure A.5. This diagram helped identify the critical steps that were completed in the physical exam process. First, the medical technician analyzes the information collected from the medical records as well as the epidemiologic history to determine what physical exams they need to perform. With Ebola being a highly contagious disease transferred by physical contact that was prevalent in Sierra Leone when the model was developed, the medical technician needed to conduct a hands-free Ebola screening before proceeding with the examination ("Viral Hemorrhagic Fevers - Chapter 3 - 2016 Yellow Book | Travelers' Health | CDC," n.d.). Afterwards, the medical technician conducts a visual as well as physical examination looking for signs or symptoms that might point to cause for the patient's illness. During this process, the medical technician reviews the observations and obtains any additional diagnostic information by asking the patient questions or performing further examinations. This iterative data collection process helps the medical technician develop an understanding of the patient's problem (Zolfaghari, 2014, pp. 35–36).

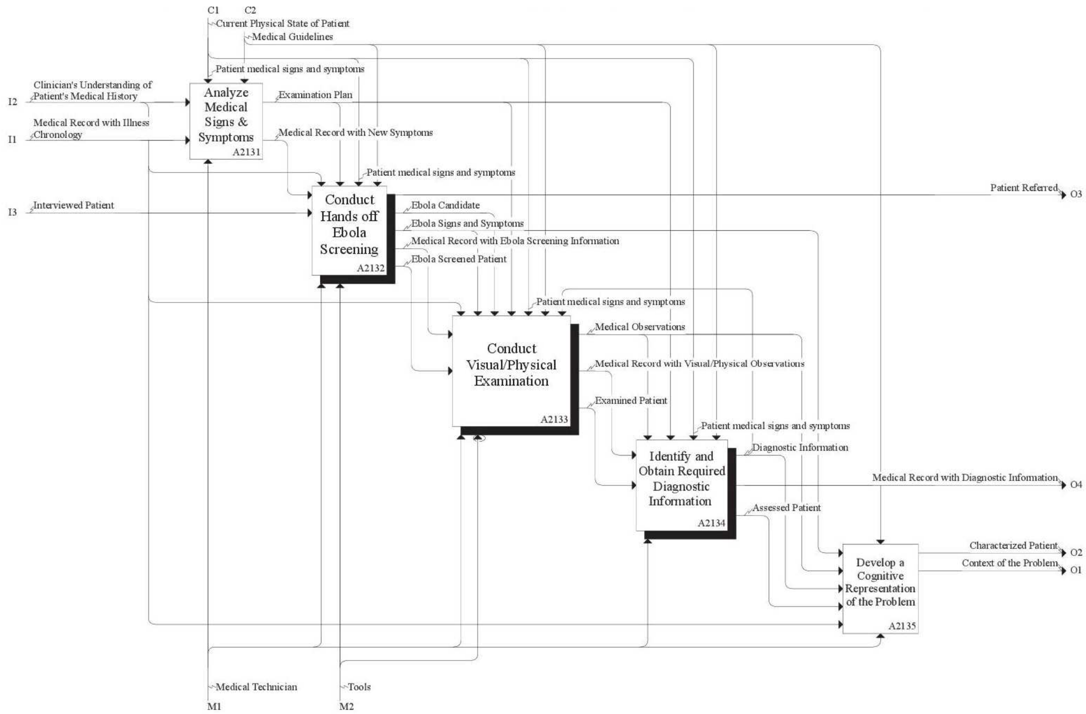


Figure A.5. A213 Diagram - Collect Diagnostic Information

Backing out of these sub-diagrams the task A22, "Analyze and Generate Hypotheses" shown in Figure A.3, was decomposed in the A22 diagram, shown in Figure A.6. This diagram demonstrated one of the critical steps of the differential diagnosis process where a set of candidate conditions are generated that matches the symptoms and risk factors. This leads the medical technician to identify the information that is necessary to rule out candidate conditions to get closer to a final diagnosis.

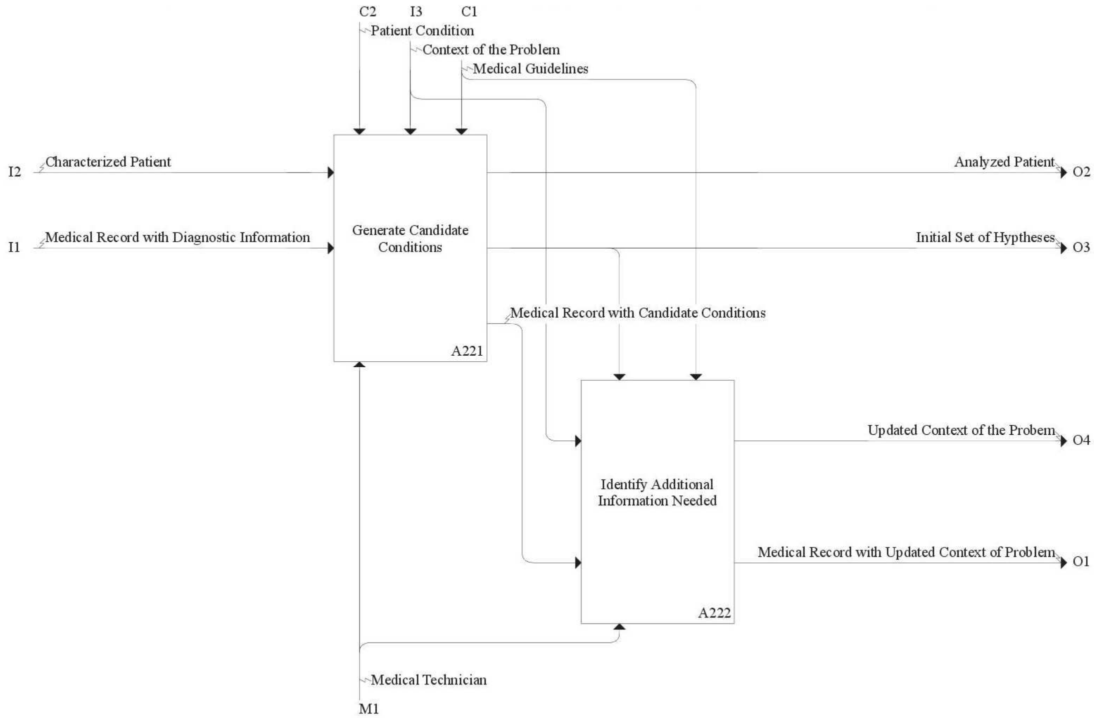


Figure A.6. A22 Diagram - Analyze and Generate Hypotheses

The last step in this process is the A23 task, "Finalize Diagnosis." This process was decomposed into the A23 diagram shown in Figure A.7. In this task, the candidate conditions are prioritized and additional information is obtained to help rule in or out conditions. This is done by conducting or ordering medical tests. An example of this would be the use of microscopy to diagnose malaria by examining the patient's blood under a microscope (T. Makler C. J. Palmer A. L. Ager, 1998). The results are ultimately used to rule out candidate conditions until a final diagnosis or treatment is established.

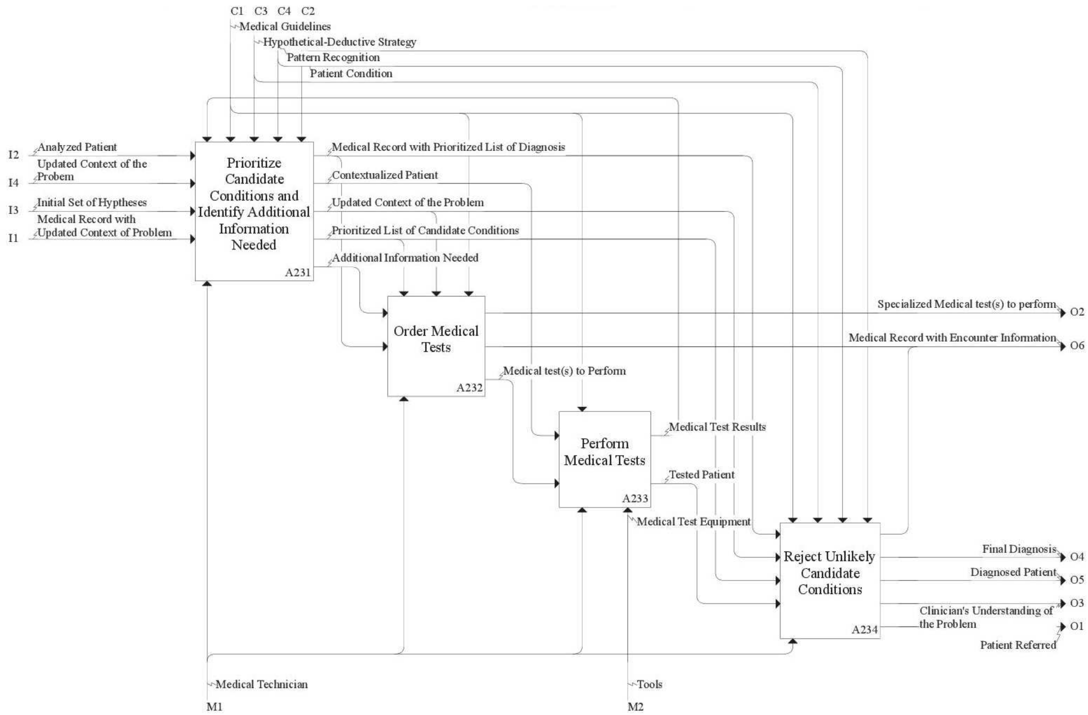


Figure A.7. A23 Diagram - Finalize Diagnosis

This model helped to identify the major tasks that must be performed during an infectious disease encounter. It also provided a diagram to display the ways in which tools, information, and medical personal all interacted in the process to get the task done. This enabled the researcher to understand how the HTK-ID might help support the medical technician in these tasks.

Concept Map

To help further understand the mental model of a clinician who is diagnosing a patient, a concept map was developed based upon discussions with the Willamette International representatives and the infectious disease expert. A software tool call CmapTools was used to create to all of the diagrams (“Cmap | CmapTools,” n.d.).

The first initial concept map was developed starting with the question “how do you diagnose an infectious disease?” To represent this domain, the concept map was developed to represent the relationships between the different factors that influenced the risk of each disease, tools used to examine the different parts of human body, and lab tests that aided in the diagnostic process. The initial concept map, shown in Figure A.8 shows how the factors and tools influenced a western-trained clinician during the diagnostic process and how to come up with the final diagnosis. One of the major insights from this concept map is that the expert largely relied on their conceptual probability of each of the suspect diseases based upon symptoms, lab tests, and environmental risk factors. It showed that these clinicians seem to utilize some innate form of Bayesian statistics.

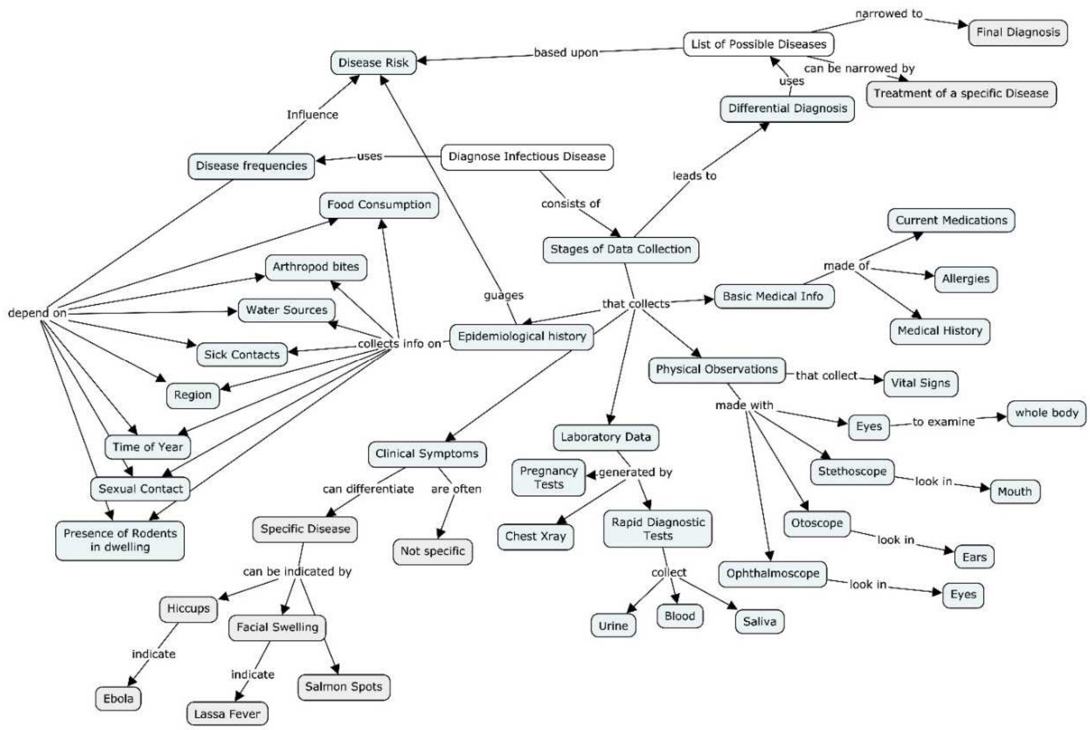


Figure A.8. Initial Concept Map of Infectious Disease Diagnosis

One of the limitations with this initial concept map was that it did not provide much granularity into the cues associated with the individual diseases. As such, it did not sufficiently represent the knowledge and mental models used in the diagnosis of these diseases. With further review by the SMEs, a second multi-layer concept map, called a knowledge model (Crandall et al., 2006, p. 47), was developed to illustrate the detailed knowledge required in the diagnosis of each of the specific diseases. The full knowledge model is shown in Appendix C.

To develop the new model additional discussions were conducted with the SMEs. A discussion for each of the individual diseases was prompted with the question, “what cues, symptoms, risk factors, and procedures would you look for or perform to diagnosis disease x?” Ebola was included in the model, in addition to the original four diseases, as one of the SMEs wished to discuss the disease after learning that that HTK-ID was being designed for use in Sierra Leone.

The top-level concept of the knowledge model, shown in Figure A.9, provided the connection between the individual disease concept maps. It also showed the commonalities and links between the diseases. Icons on the disease concepts provided links within the CmapTools program to the sub-concept maps.

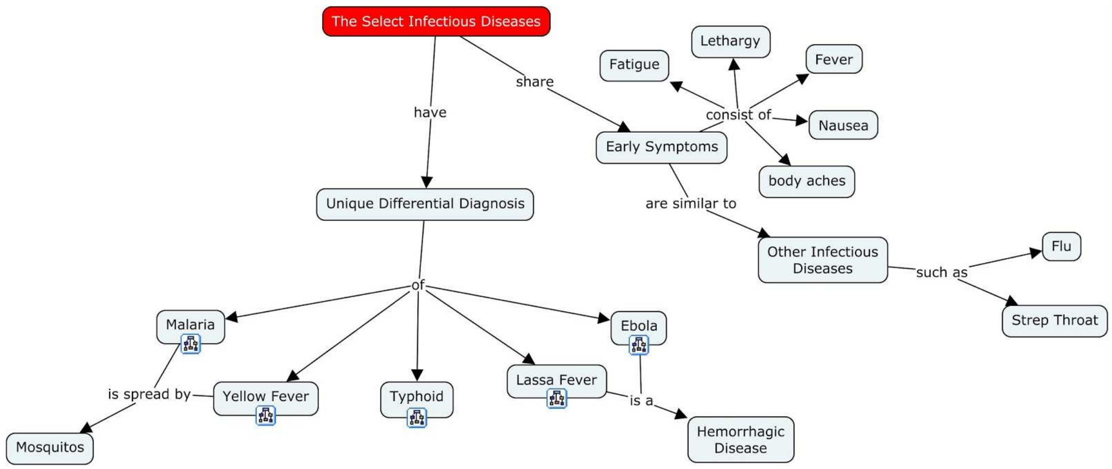


Figure A.9. Top-level of Knowledge Model

The knowledge model was then broken out into concept maps describing the individual diseases. The concept map for malaria is shown in Figure A.10 below. These concept maps further decomposed the diagnostic process. It also showed the specific information a physician would evaluate if they suspected a patient had the respective diseases.

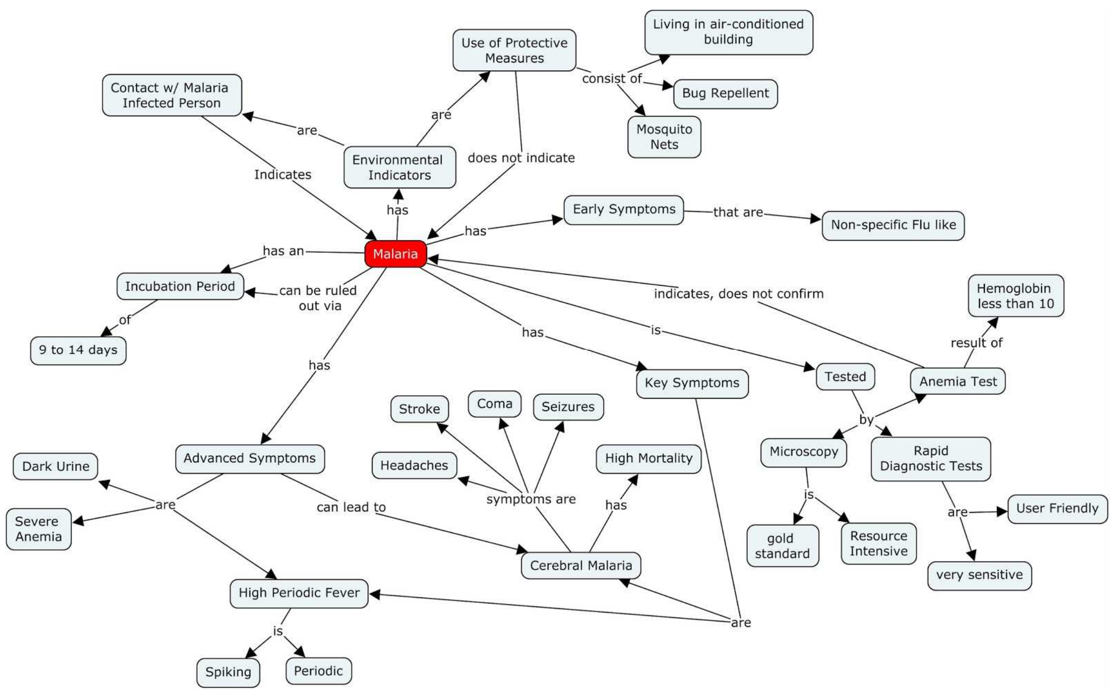


Figure A.10. Malaria Sub-concept map

The malaria concept map showed that a physician considers a number of factors if the disease is suspected including environmental factors as well as the incubation period. Some symptoms such as dark urine and anemia could indicate to the physician that the patient had an advanced case of malaria. This could lead to cerebral malaria, which has a high mortality rate. The diagram also showed the tests a physician considered using including microscopy, which was stated as the most accurate but is very resource intensive of the tests. Rapid diagnostic tests were noted as a very user-friendly alternative that could still provide a high degree of sensitivity.

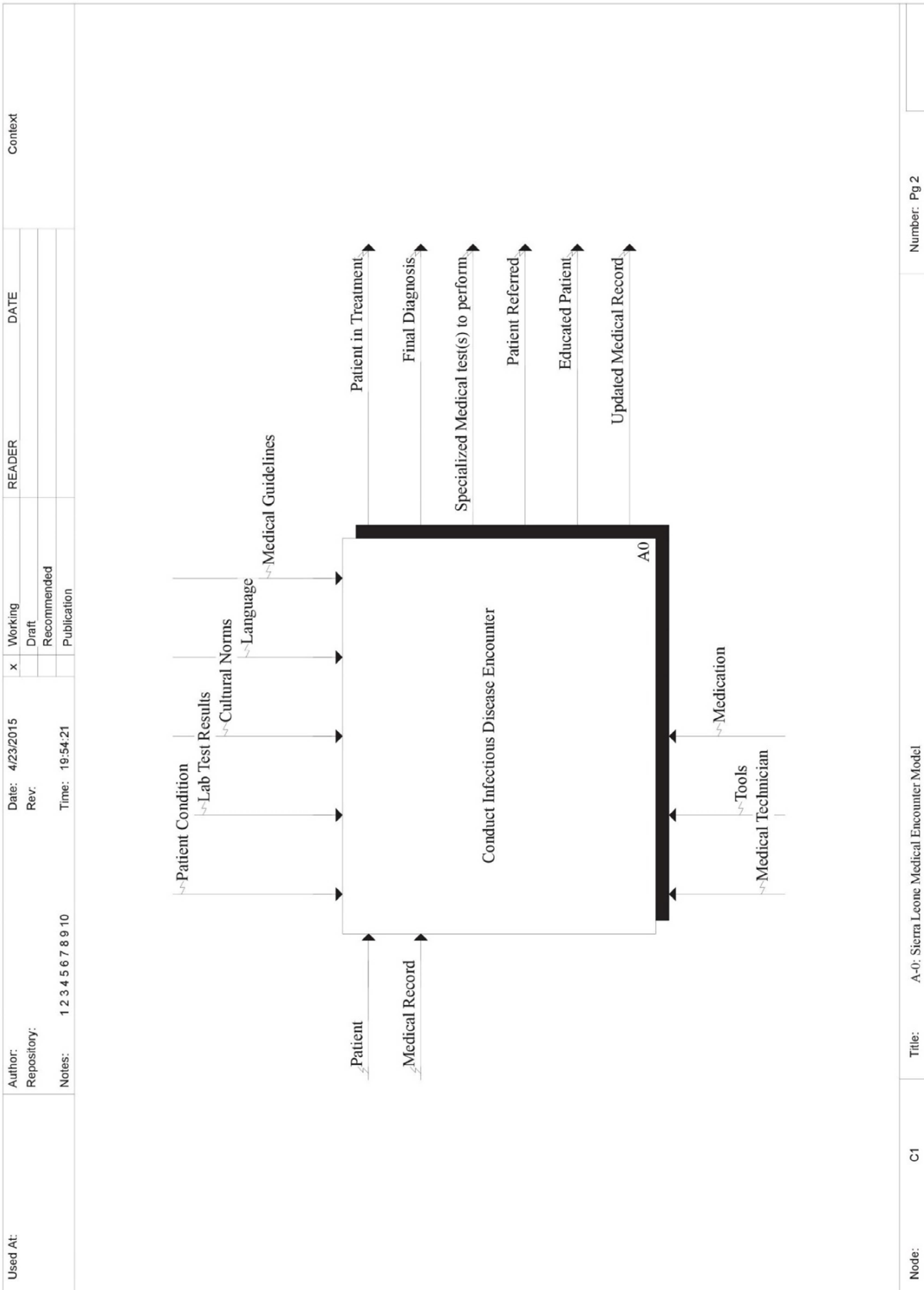
Task Analysis to Requirements

The resulting models from the task analysis were used to generate product requirements for the HTK-ID system. Such requirements included being able to collect various types of diagnostic information, provide a list of list of tests to diagnose each disease, be able to function in certain environments, etc.

It was during the development of the requirements that the researcher wondered if the differences in culture between the users of the HTK-ID and designers would affect these requirements and resulting UIs. As such, the HTK-ID and the task analysis models from the project provided the inspiration and background information for the upper respiratory diagnostic tool used as a case study for this research.

Appendix B IDEF0 Model of Infectious Disease Diagnostic Process

- **A-0: Sierra Leone Medical Encounter Model**
  - A0: Conduct Infectious Disease Encounter
    - A1: Establish Patient-Clinician Relationship
    - A2: Diagnose the Patient Problem
      - A21: Collect Information
        - A211: Review Patient Personal & Clinical Information
        - A212: Obtain Epidemiologic History
          - A2121: Obtain Patient's Chronology of Symptoms
          - A2122: Obtain Patient's Recent Contact with Sickness
          - A2123: Obtain Information about Patient's Access to Clean Water
          - A2124: Obtain Information about any recent Authropod bites
          - A2125: Obtain Information about Patient's recent Food Consumption
          - A2126: Obtain Information about recent sexual contact
          - A2127: Obtain Information about Presence of Rats or Mice in Patient's Home
        - A213: Collect Diagnostic Information
          - A2131: Analyze Medical Signs & Symptoms
          - A2132: Conduct Hands off Ebola Screening
            - A21321: Take Temperature
            - A21322: Obtain Diagnostic Information
            - A21323: Perform Rapid Diagnostic Test
          - A2133: Conduct Visual/Physical Examination
            - A21331: Analyze Observations and Refine Examination Plan
            - A21332: Look for Malaria Specific Symptoms/Signs
            - A21333: Look for Yellow Fever Specific Symptoms/Signs
            - A21334: Look for Typhoid Specific Symptoms/Signs
            - A21335: Look for General/Other Symptoms/Signs
          - A2134: Identify and Obtain Required Diagnostic Information
            - A21341: Analyze Responses and Refine Questions
            - A21342: Obtain Malaria Specific Diagnostic Information
            - A21343: Obtain Yellow Fever Specific Diagnostic Information
            - A21344: Obtain Typhoid Specific Diagnostic Information
            - A21345: Obtain General/Other Diagnostic Information
          - A2135: Develop a Cognitive Representation of the Problem
      - A22: Analyze and Generate Hypotheses
        - A221: Generate Candidate Conditions
        - A222: Identify Additional Information Needed
      - A23: Finalize Diagnosis
        - A231: Prioritize Candidate Conditions and Identify Additional Information Needed
        - A232: Order Medical Tests
        - A233: Perform Medical Tests
        - A234: Reject Unlikely Candidate Conditions
    - A3: Treat Patient and Plan Follow-up
      - A31: Develop Treatment and Avoidance Plan
      - A32: Dicuss Treatment and Avoidance Plan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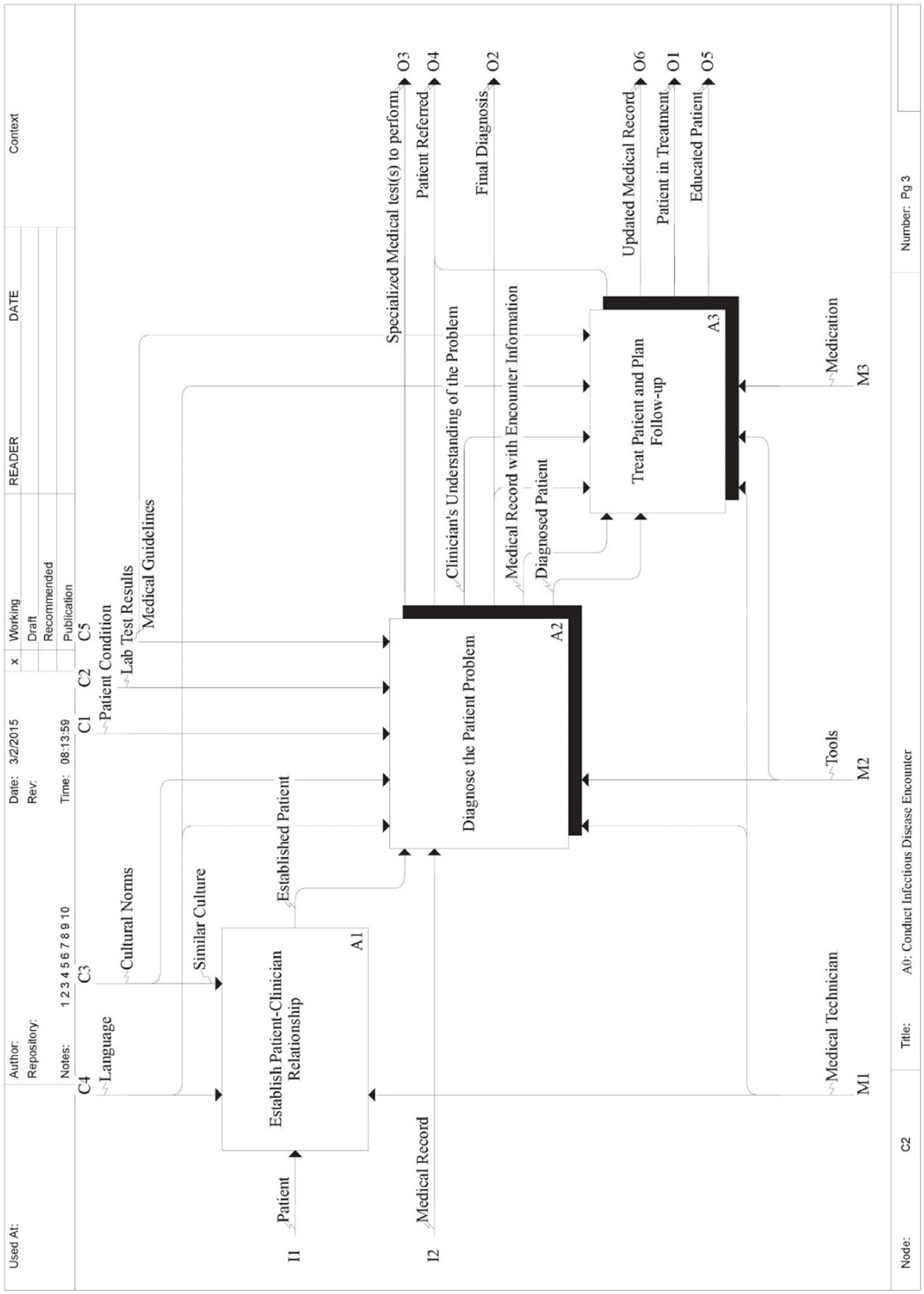
DATE
Context
Patient Condition
Lab Test Results
Cultural Norms
Language
Medical Guidelines
Patient
Medical Record
Conduct Infectious Disease Encounter
A0
Medication
Tools
Medical Technician
Patient in Treatment
Final Diagnosis
Specialized Medical test(s) to perform
Patient Referred
Educated Patient
Updated Medical Record
Node:
C1
Title:
A-0: Sierra Leone Medical Encounter Model
Number: Pg 2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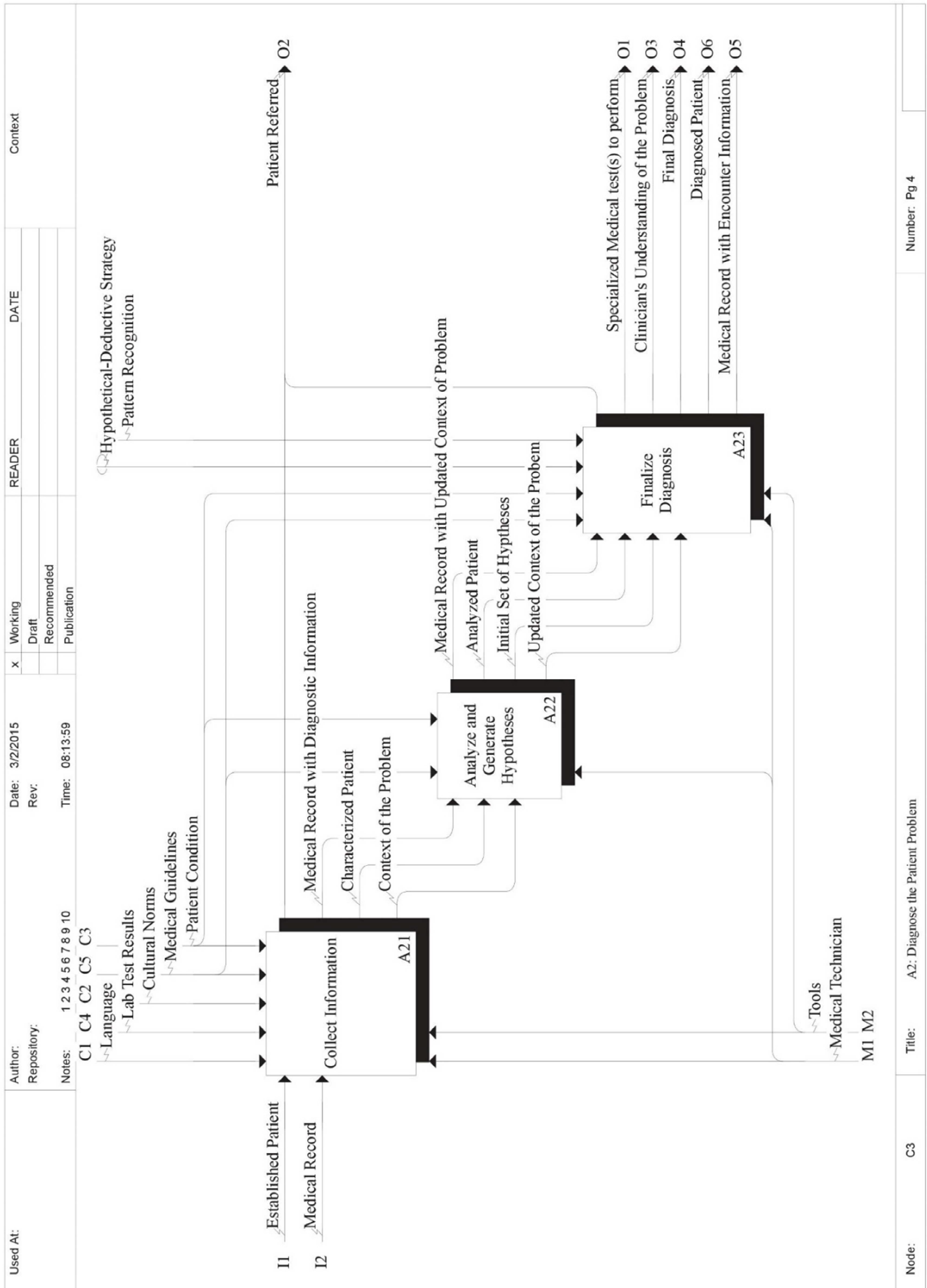
Context
C4
Language
C3
Cultural Norms
Similar Culture
C1
Patient Condition
C2
Lab Test Results
C5
Medical Guidelines
I1
Patient
I2
Medical Record
Establish Patient-Clinician Relationship
A1
Established Patient
Diagnose the Patient Problem
A2
Clinician's Understanding of the Problem
Medical Record with Encounter Information
Diagnosed Patient
Treat Patient and Plan Follow-up
A3
Specialized Medical test(s) to perform
O3
Patient Referred
O4
Final Diagnosis
O2
Updated Medical Record
O6
Patient in Treatment
O1
Educated Patient
O5
Medical Technician
M1
Tools
M2
Medication
M3
Node:
C2
Title:
A0: Conduct Infectious Disease Encounter
Number: Pg 3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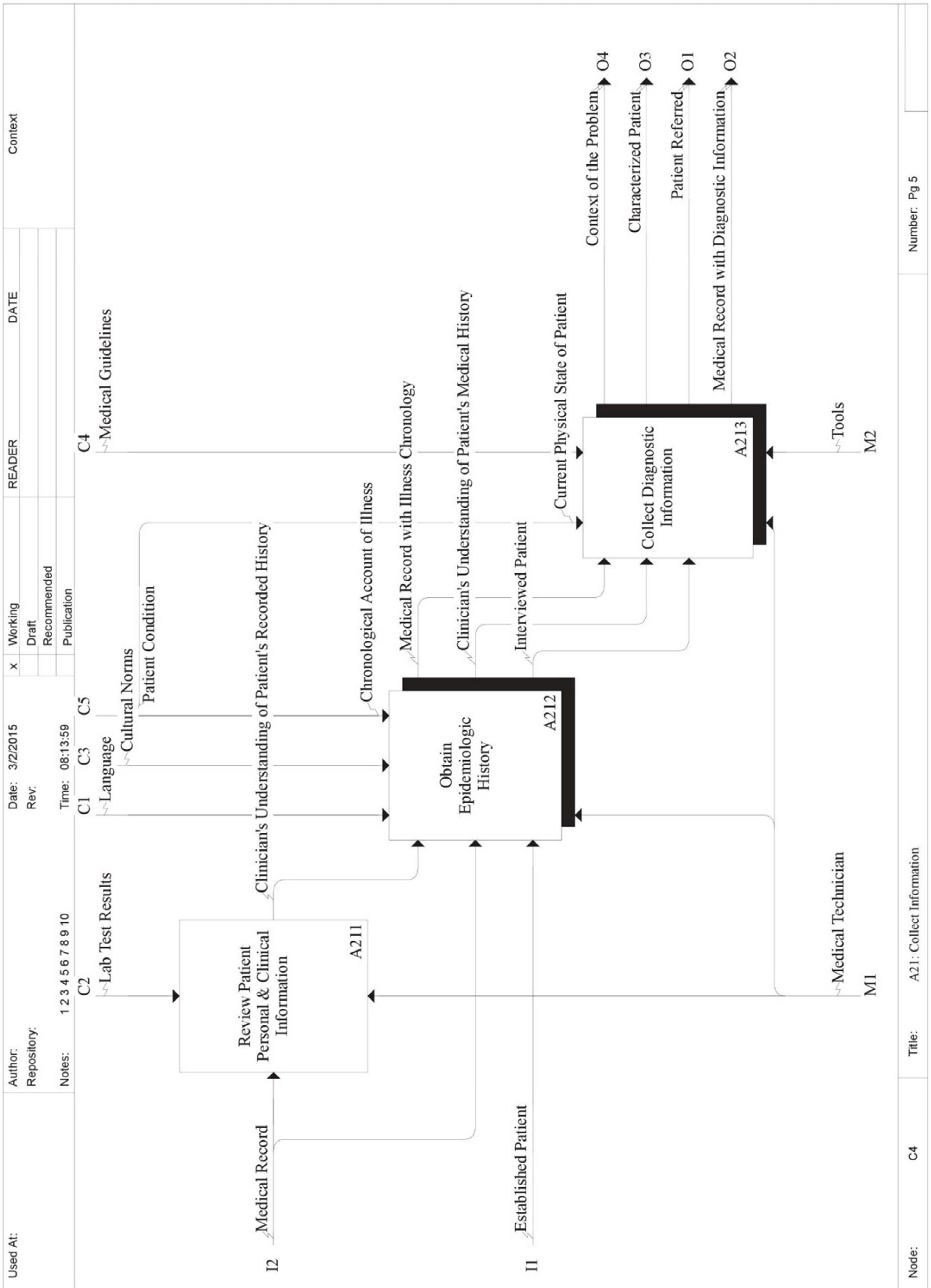
Context
C1 C4 C2 C5 C3
Language
Lab Test Results
Cultural Norms
Medical Guidelines
Patient Condition
Hypothetical-Deductive Strategy
Pattern Recognition
Patient Referred
O2
I1
Established Patient
I2
Medical Record
Collect Information
A21
Medical Record with Diagnostic Information
Characterized Patient
Context of the Problem
Analyze and Generate Hypotheses
A22
Medical Record with Updated Context of Problem
Analyzed Patient
Initial Set of Hyptheses
Updated Context of the Probem
Finalize Diagnosis
A23
Specialized Medical test(s) to perform
O1
Clinician's Understanding of the Problem
O3
Final Diagnosis
O4
Diagnosed Patient
O6
Medical Record with Encounter Information
O5
Tools
Medical Technician
M1 M2
Node: C3
Title: A2: Diagnose the Patient Problem
Number: Pg 4



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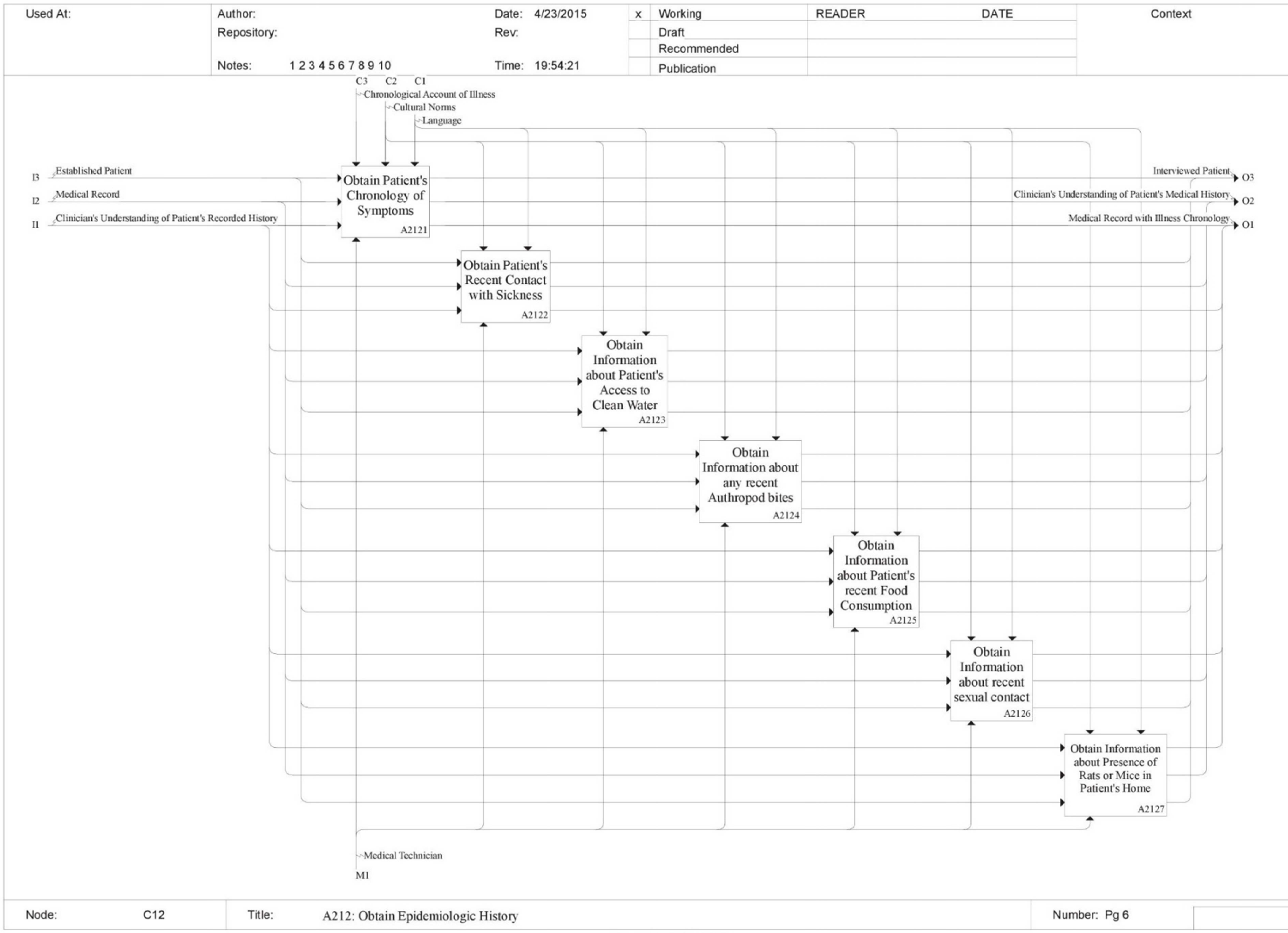
Context
C2
Lab Test Results
C1
Language
C3
Cultural Norms
C5
Patient Condition
C4
Medical Guidelines
I2
Medical Record
I1
Established Patient
Review Patient Personal & Clinical Information
A211
Clinician's Understanding of Patient's Recorded History
Obtain Epidemiologic History
A212
Chronological Account of Illness
Medical Record with Illness Chronology
Clinician's Understanding of Patient's Medical History
Interviewed Patient
Current Physical State of Patient
Collect Diagnostic Information
A213
Context of the Problem
O4
Characterized Patient
O3
Patient Referred
O1
Medical Record with Diagnostic Information
O2
Medical Technician
M1
Tools
M2
Node: C4
Title: A21: Collect Information
Number: Pg 5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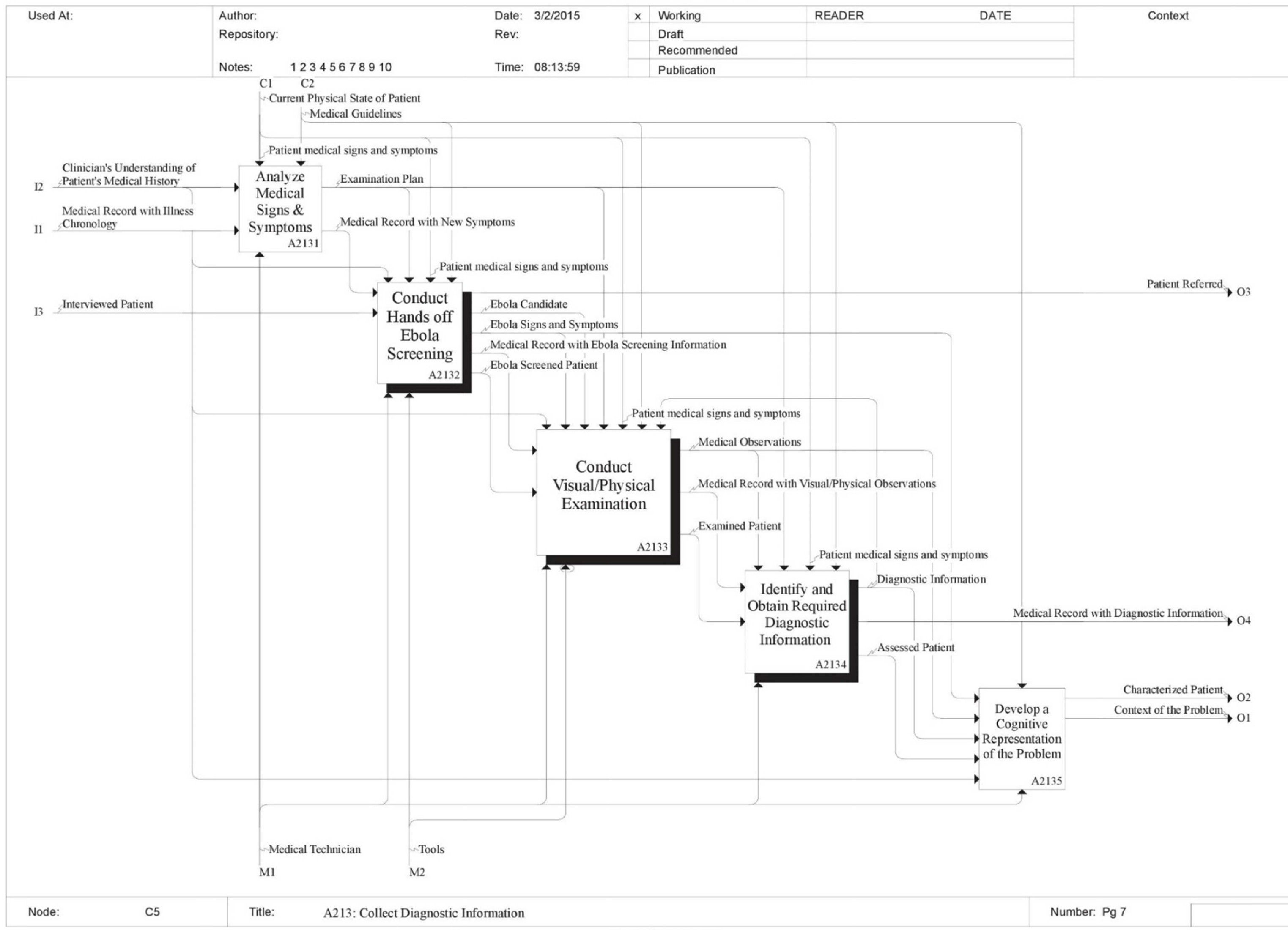
Context
C3 C2 C1
Chronological Account of Illness
Cultural Norms
Language
I3 Established Patient
I2 Medical Record
I1 Clinician's Understanding of Patient's Recorded History
Obtain Patient's Chronology of Symptoms
A2121
Obtain Patient's Recent Contact with Sickness
A2122
Obtain Information about Patient's Access to Clean Water
A2123
Obtain Information about any recent Authropod bites
A2124
Obtain Information about Patient's recent Food Consumption
A2125
Obtain Information about recent sexual contact
A2126
Obtain Information about Presence of Rats or Mice in Patient's Home
A2127
Interviewed Patient O3
Clinician's Understanding of Patient's Medical History O2
Medical Record with Illness Chronology O1
Medical Technician
M1
Node: C12
Title: A212: Obtain Epidemiologic History
Number: Pg 6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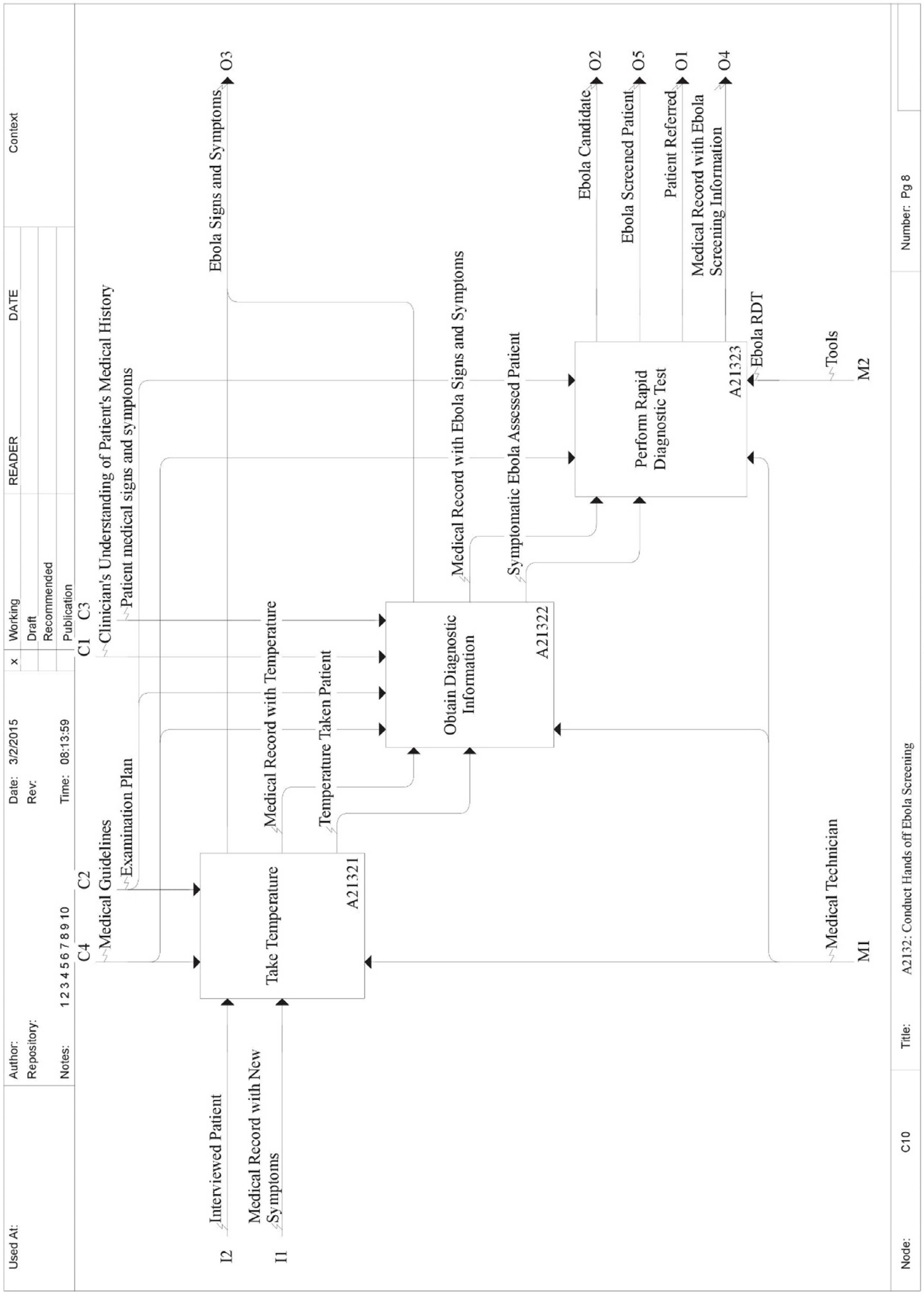
DATE
Context
C1
C2
Current Physical State of Patient
Medical Guidelines
Patient medical signs and symptoms
I2
Clinician's Understanding of Patient's Medical History
I1
Medical Record with Illness Chronology
Analyze Medical Signs & Symptoms
A2131
Examination Plan
Medical Record with New Symptoms
Patient medical signs and symptoms
I3
Interviewed Patient
Conduct Hands off Ebola Screening
A2132
Patient Referred
O3
Ebola Candidate
Ebola Signs and Symptoms
Medical Record with Ebola Screening Information
Ebola Screened Patient
Patient medical signs and symptoms
Conduct Visual/Physical Examination
A2133
Medical Observations
Medical Record with Visual/Physical Observations
Examined Patient
Patient medical signs and symptoms
Diagnostic Information
Identify and Obtain Required Diagnostic Information
A2134
Medical Record with Diagnostic Information
O4
Assessed Patient
Develop a Cognitive Representation of the Problem
A2135
Characterized Patient
O2
Context of the Problem
O1
Medical Technician
M1
Tools
M2
Node: C5
Title: A213: Collect Diagnostic Information
Number: Pg 7



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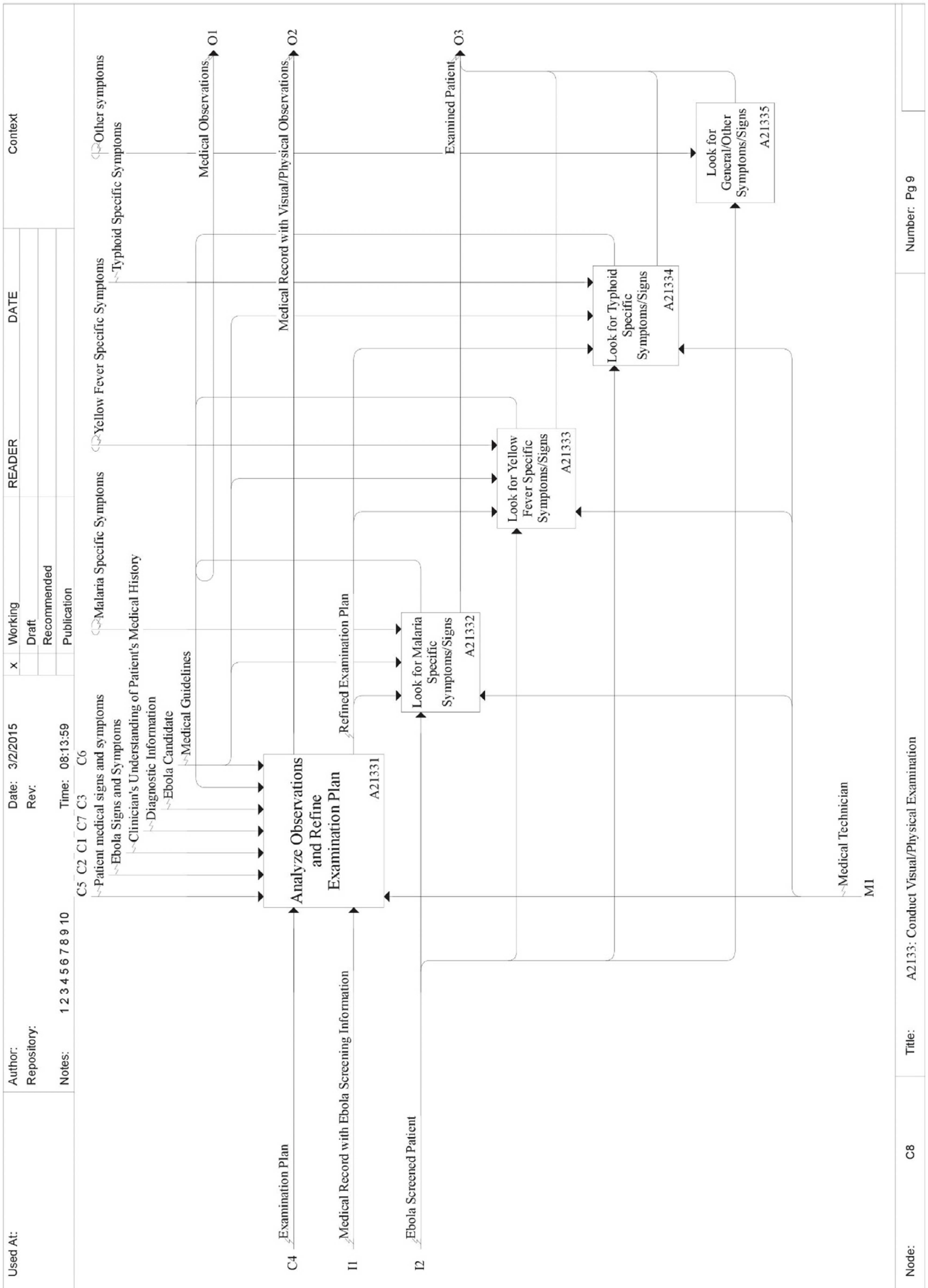
Context
Take Temperature
A21321
Obtain Diagnostic Information
A21322
Perform Rapid Diagnostic Test
A21323
I2 Interviewed Patient
I1 Medical Record with New Symptoms
C4 Medical Guidelines
C2 Examination Plan
C1 C3 Clinician's Understanding of Patient's Medical History
Patient medical signs and symptoms
Medical Record with Temperature
Temperature Taken Patient
Medical Record with Ebola Signs and Symptoms
Symptomatic Ebola Assessed Patient
Ebola Signs and Symptoms O3
Ebola Candidate O2
Ebola Screened Patient O5
Patient Referred O1
Medical Record with Ebola Screening Information O4
Ebola RDT
Tools
M2
Medical Technician
M1
Node: C10
Title: A2132: Conduct Hands off Ebola Screening
Number: Pg 8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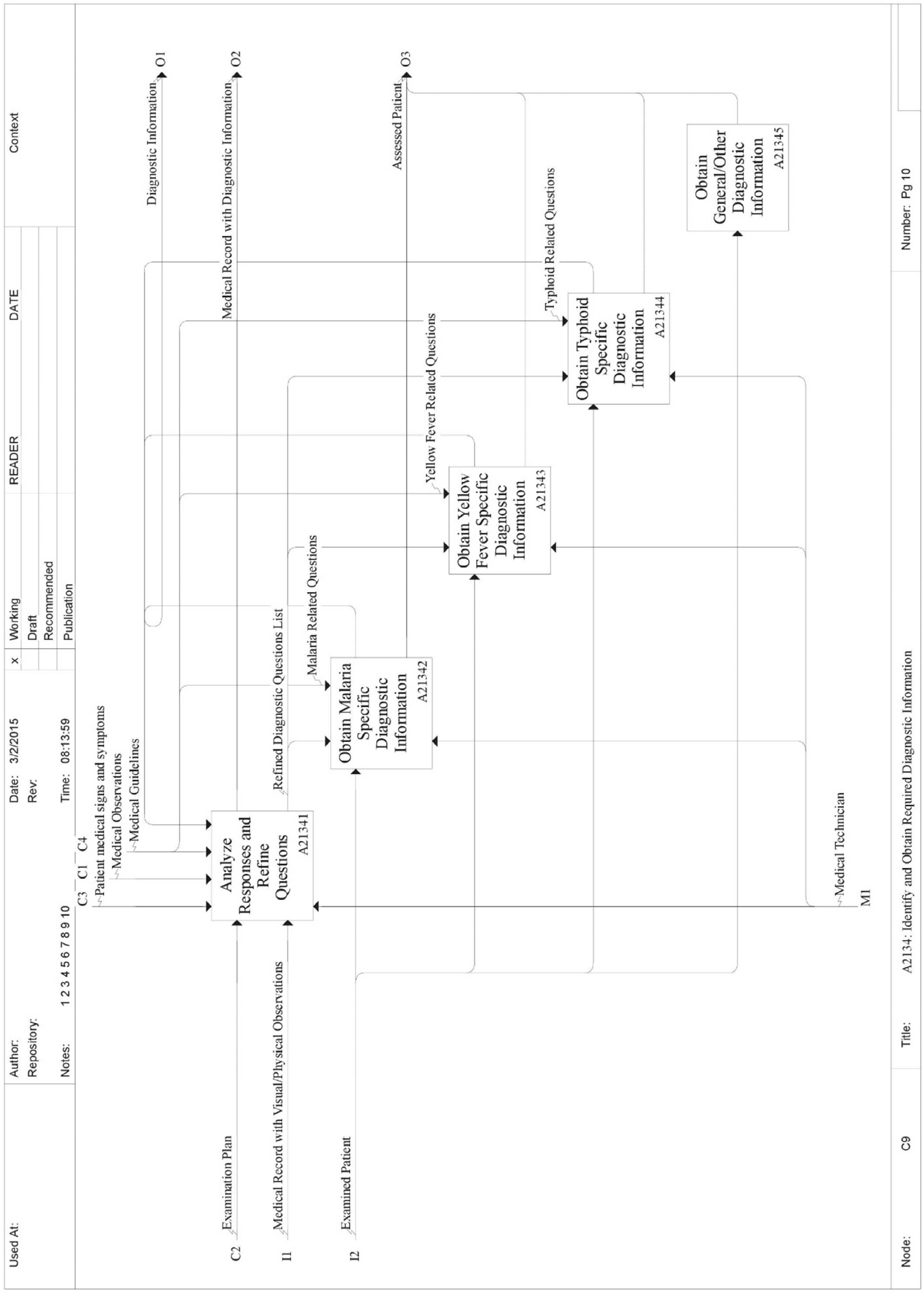
Context
C5 C2 C1 C7 C3 C6
Patient medical signs and symptoms
Ebola Signs and Symptoms
Clinician's Understanding of Patient's Medical History
Diagnostic Information
Ebola Candidate
Medical Guidelines
Malaria Specific Symptoms
Yellow Fever Specific Symptoms
Typhoid Specific Symptoms
Other symptoms
Medical Observations
O1
Medical Record with Visual/Physical Observations
O2
Examined Patient
O3
C4
Examination Plan
I1
Medical Record with Ebola Screening Information
I2
Ebola Screened Patient
Analyze Observations and Refine Examination Plan
A21331
Refined Examination Plan
Look for Malaria Specific Symptoms/Signs
A21332
Look for Yellow Fever Specific Symptoms/Signs
A21333
Look for Typhoid Specific Symptoms/Signs
A21334
Look for General/Other Symptoms/Signs
A21335
Medical Technician
M1
Node: C8
Title: A2133: Conduct Visual/Physical Examination
Number: Pg 9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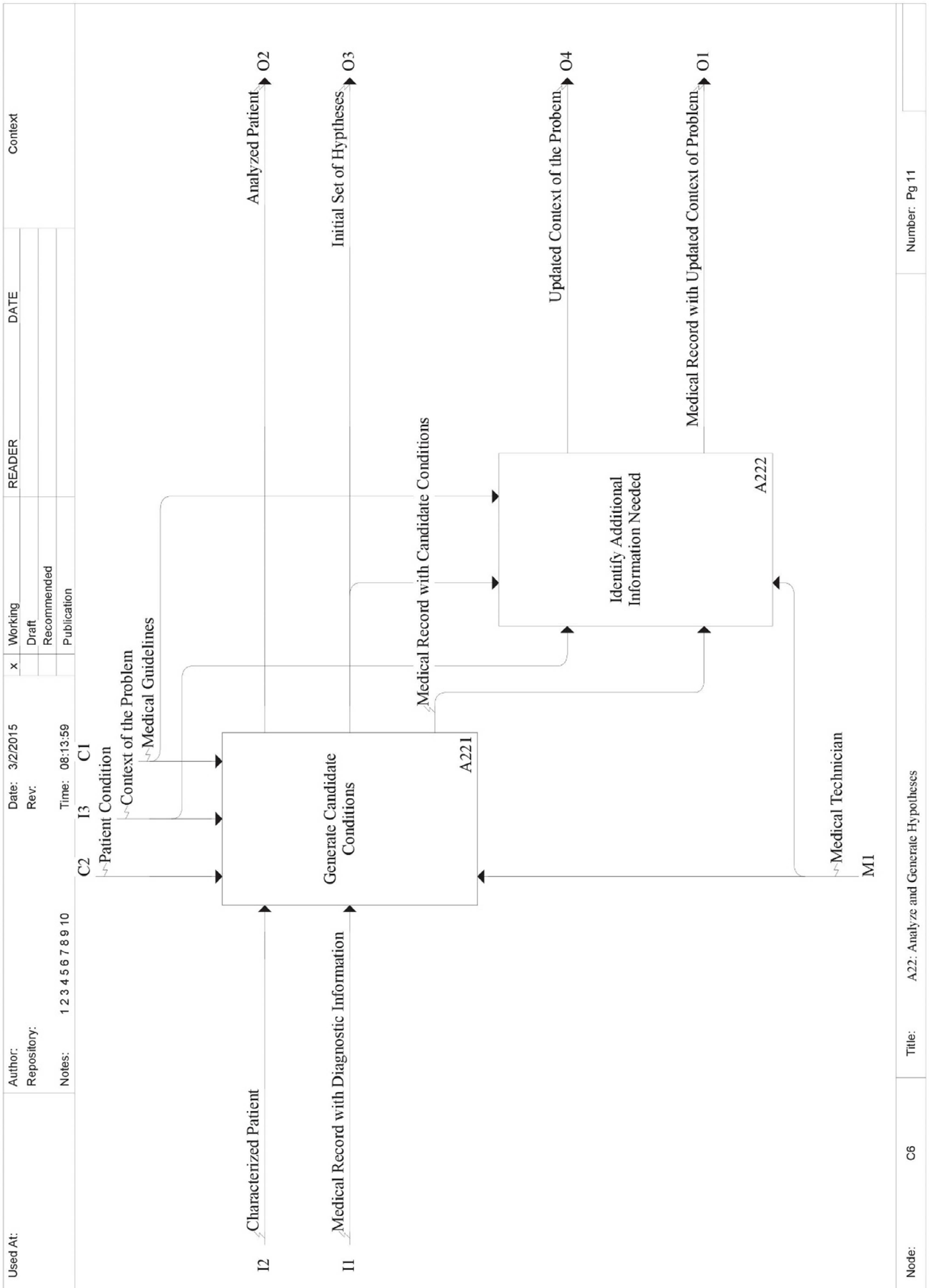
Context
Examination Plan
C2
Medical Record with Visual/Physical Observations
I1
Examined Patient
I2
C3
C1
C4
Patient medical signs and symptoms
Medical Observations
Medical Guidelines
Analyze Responses and Refine Questions
A21341
Refined Diagnostic Questions List
Malaria Related Questions
Obtain Malaria Specific Diagnostic Information
A21342
Yellow Fever Related Questions
Obtain Yellow Fever Specific Diagnostic Information
A21343
Typhoid Related Questions
Obtain Typhoid Specific Diagnostic Information
A21344
Obtain General/Other Diagnostic Information
A21345
Diagnostic Information
O1
Medical Record with Diagnostic Information
O2
Assessed Patient
O3
Medical Technician
M1
Node:
C9
Title:
A2134: Identify and Obtain Required Diagnostic Information
Number: Pg 10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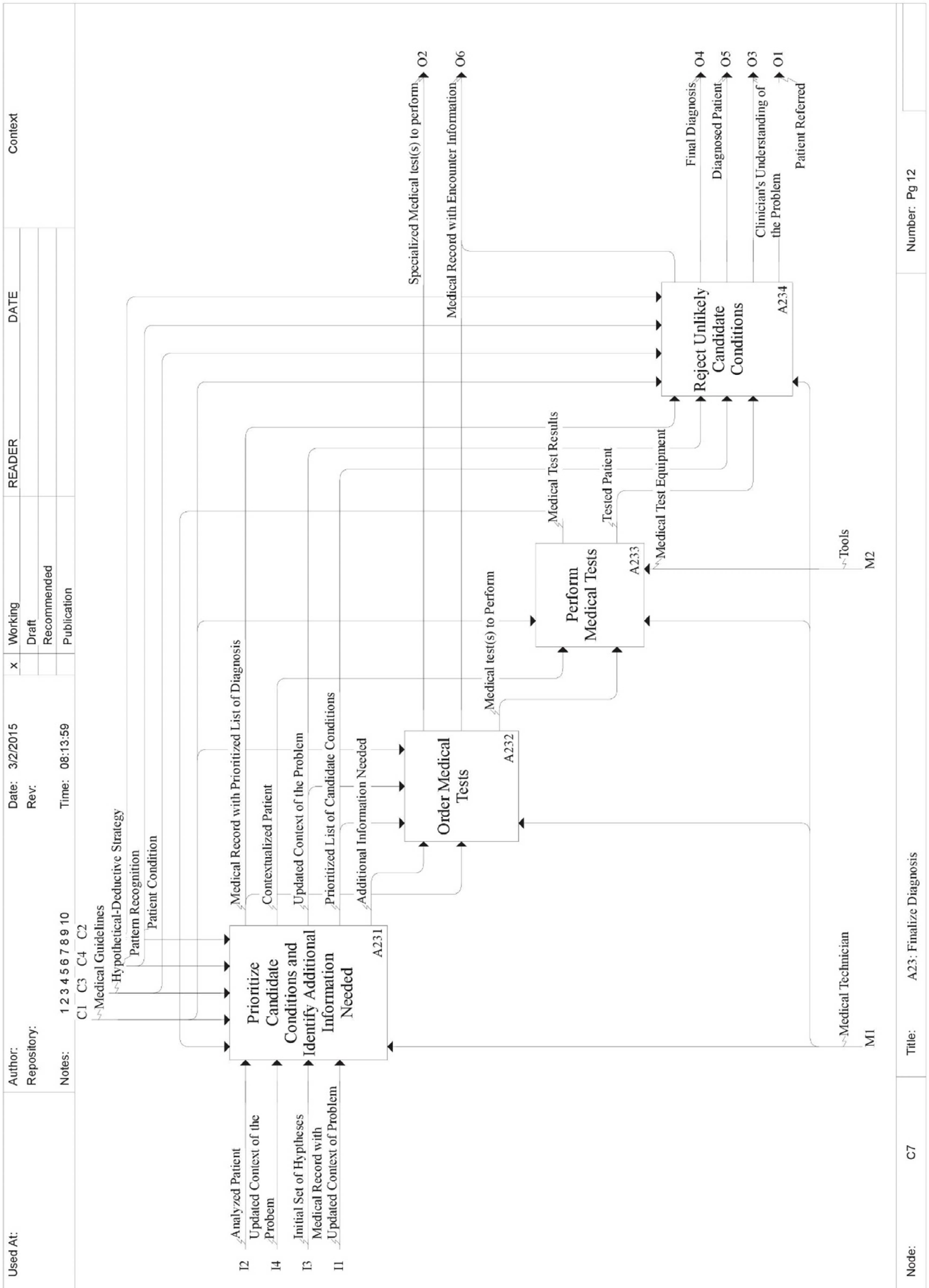
Context
C2
Patient Condition
I3
Context of the Problem
C1
Medical Guidelines
I2
Characterized Patient
I1
Medical Record with Diagnostic Information
Generate Candidate Conditions
A221
Medical Record with Candidate Conditions
Identify Additional Information Needed
A222
Analyzed Patient
O2
Initial Set of Hyptheses
O3
Updated Context of the Probem
O4
Medical Record with Updated Context of Problem
O1
Medical Technician
M1
Node: C6
Title: A22: Analyze and Generate Hypotheses
Number: Pg 11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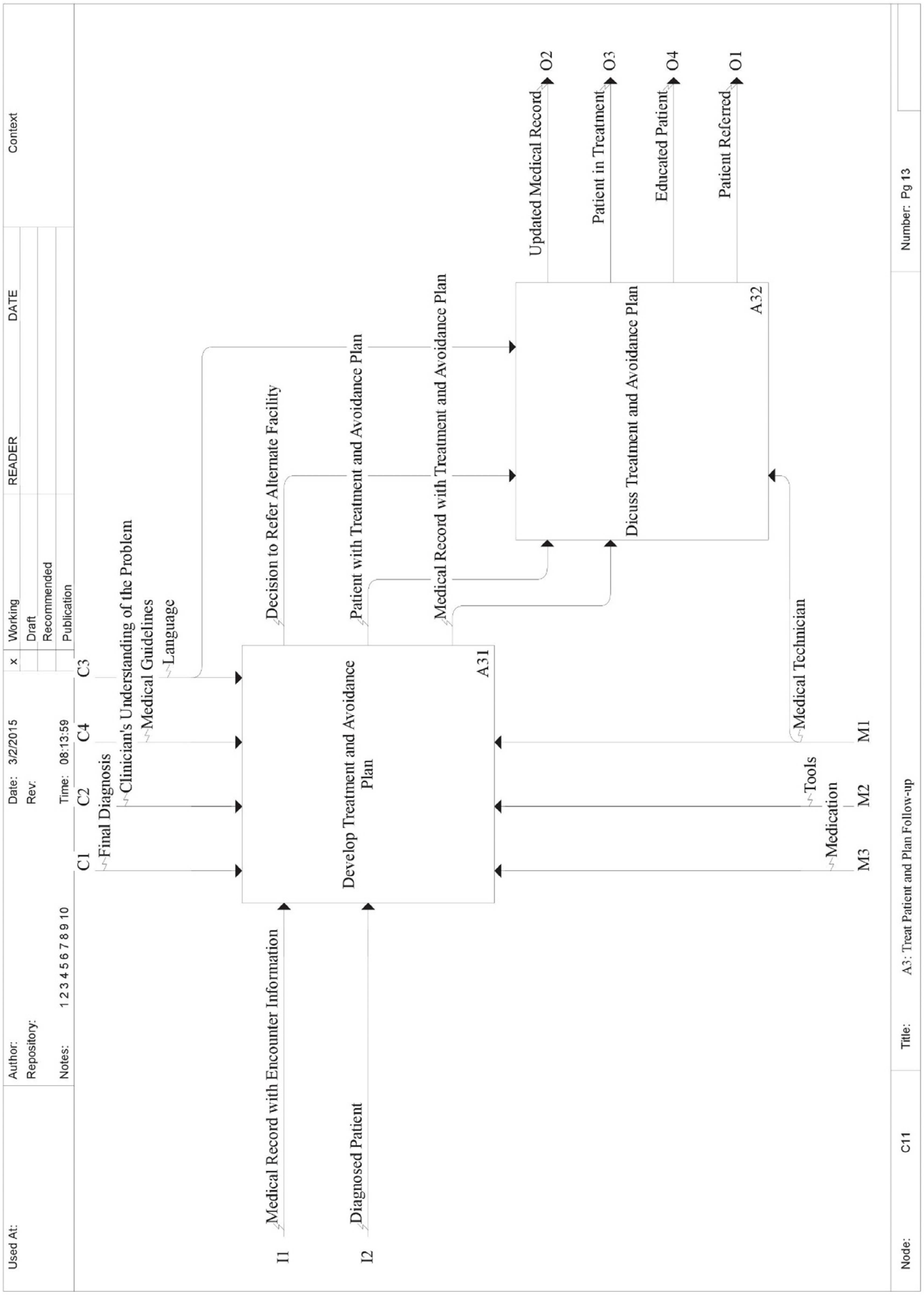
Context
C1 C3 C4 C2
Medical Guidelines
Hypothetical-Deductive Strategy
Pattern Recognition
Patient Condition
I2 Analyzed Patient
I4 Updated Context of the Probem
I3 Initial Set of Hypheses
I1 Medical Record with Updated Context of Problem
Prioritize Candidate Conditions and Identify Additional Information Needed
A231
Medical Record with Prioritized List of Diagnosis
Contextualized Patient
Updated Context of the Problem
Prioritized List of Candidate Conditions
Additional Information Needed
Order Medical Tests
A232
Medical test(s) to Perform
Specialized Medical test(s) to perform O2
Medical Record with Encounter Information O6
Perform Medical Tests
A233
Medical Test Results
Tested Patient
Medical Test Equipment
Tools
M2
Reject Unlikely Candidate Conditions
A234
Final Diagnosis O4
Diagnosed Patient O5
Clinician's Understanding of the Problem O3
Patient Referred O1
Medical Technician
M1
Node: C7
Title: A23: Finalize Diagnosis
Number: Pg 12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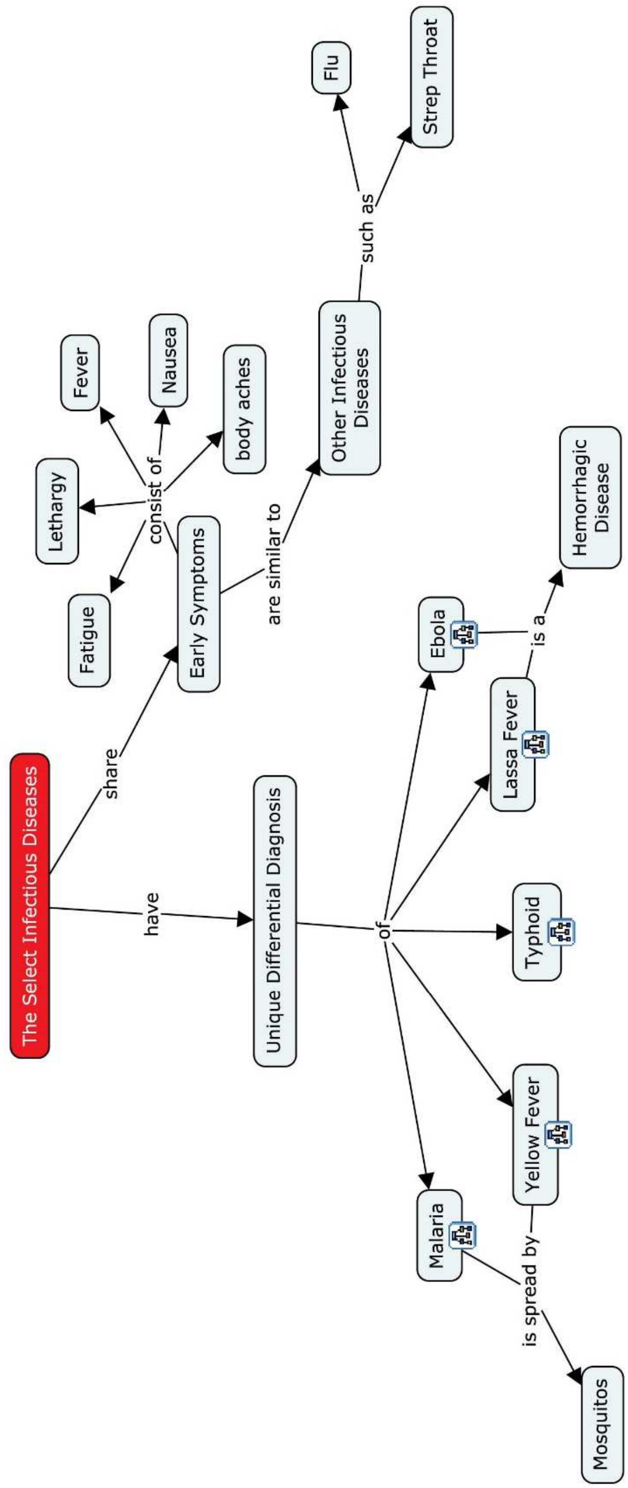
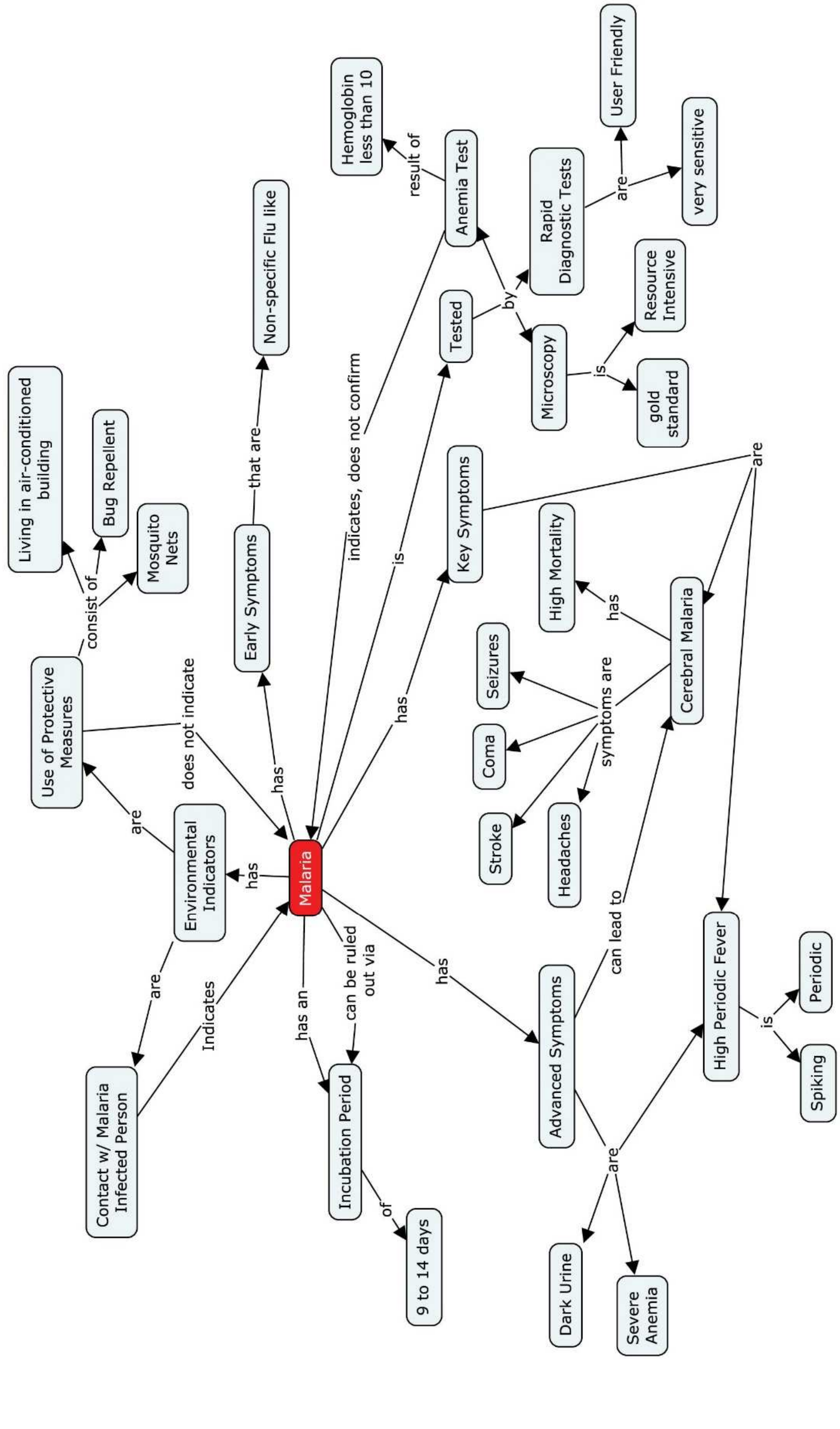
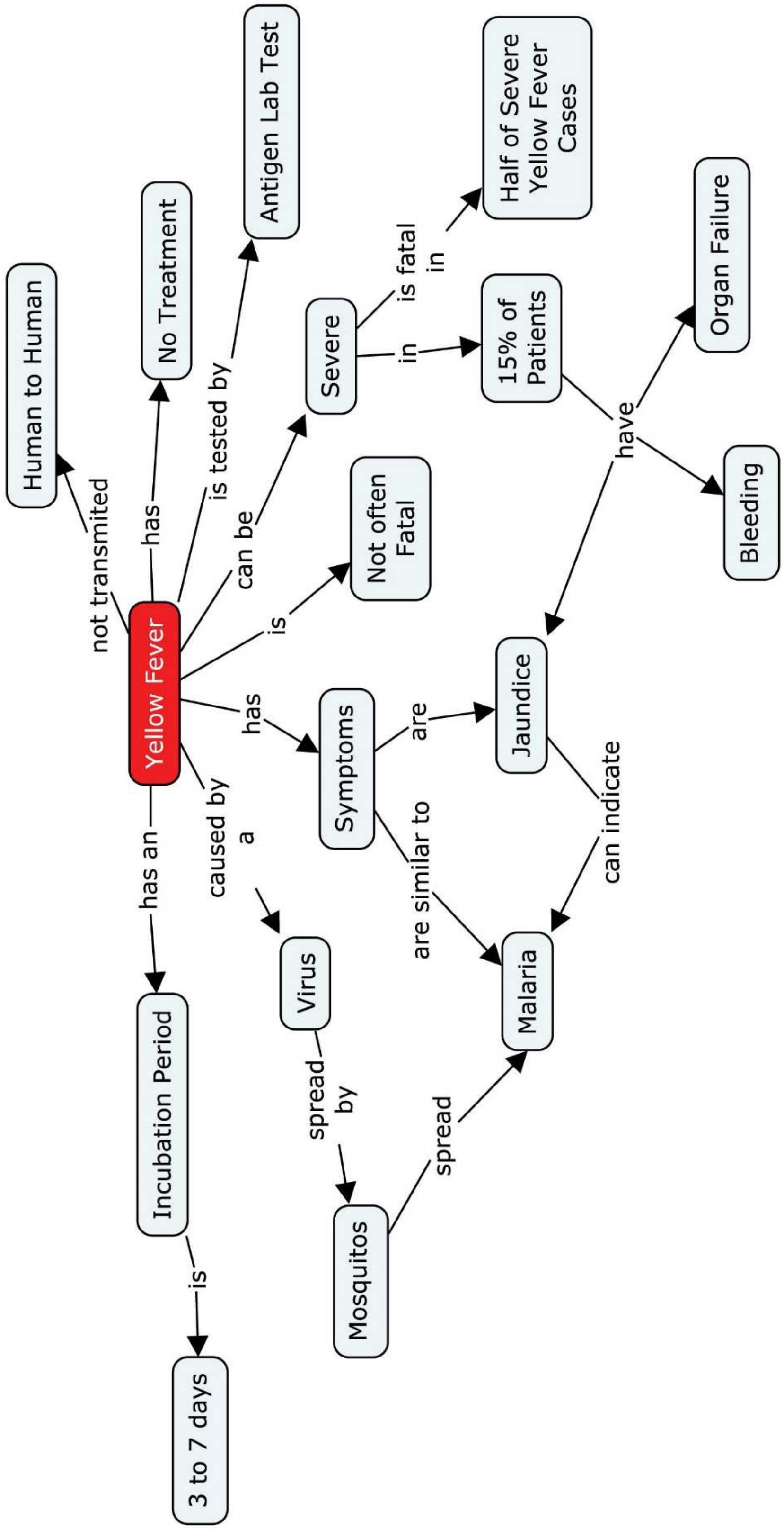
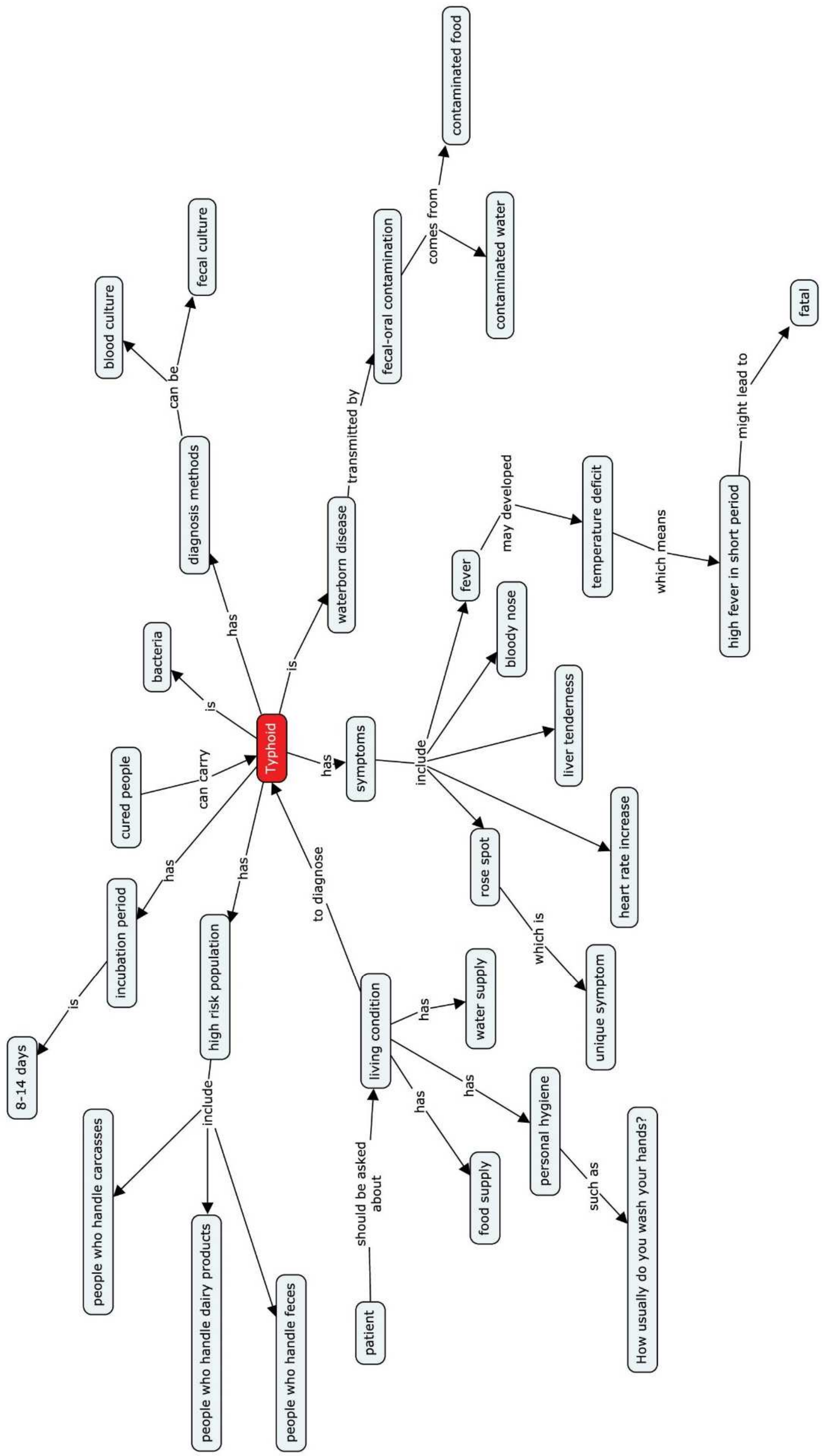
Context
C1
C2
C4
C3
Final Diagnosis
Clinician's Understanding of the Problem
Medical Guidelines
Language
I1
Medical Record with Encounter Information
I2
Diagnosed Patient
Develop Treatment and Avoidance Plan
A31
Decision to Refer Alternate Facility
Patient with Treatment and Avoidance Plan
Medical Record with Treatment and Avoidance Plan
Dicuss Treatment and Avoidance Plan
A32
Updated Medical Record
O2
Patient in Treatment
O3
Educated Patient
O4
Patient Referred
O1
Medical Technician
M1
Tools
M2
Medication
M3
Node: C11
Title: A3: Treat Patient and Plan Follow-up
Number: Pg 13

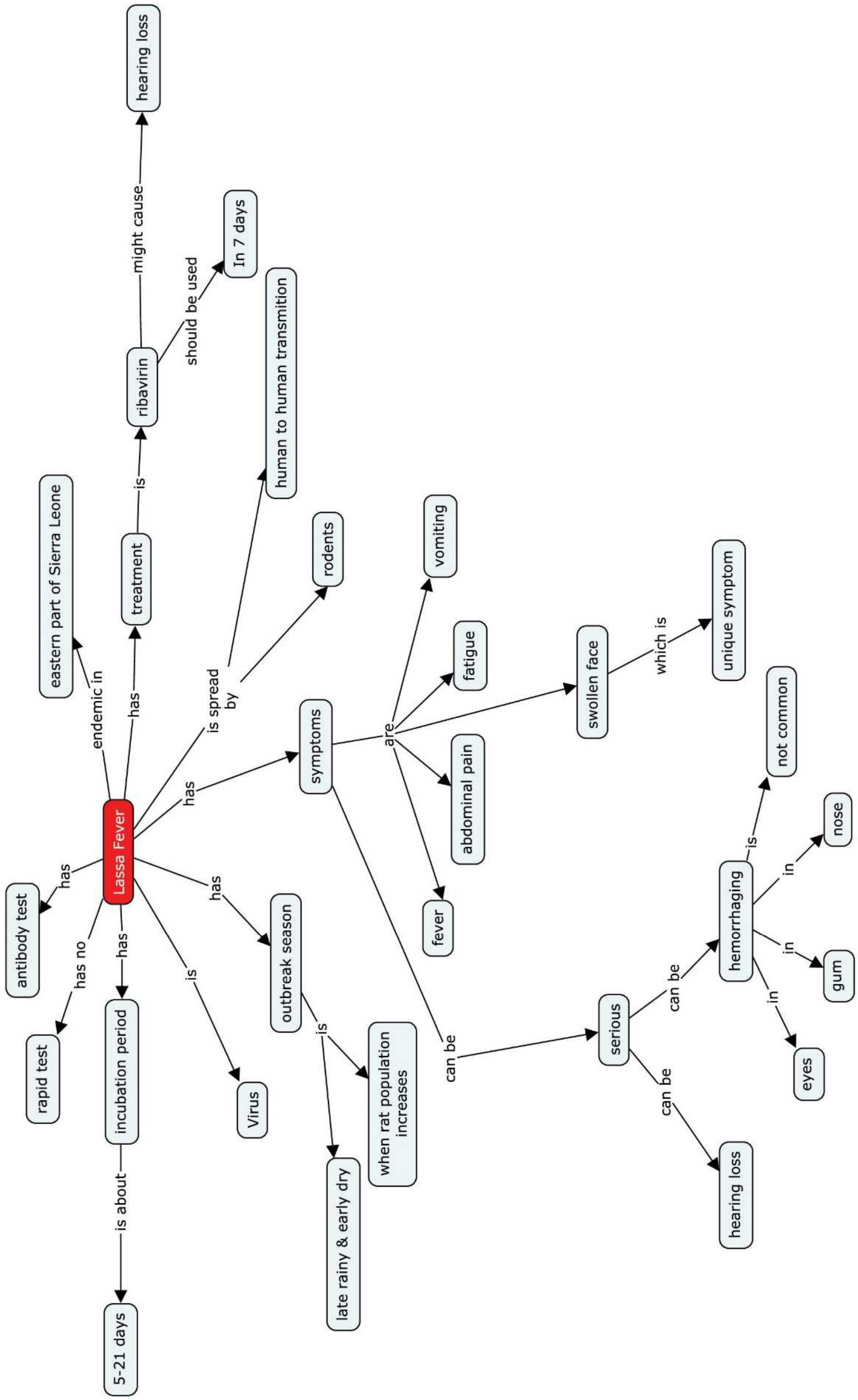
Appendix C Knowledge Model of Infectious Disease Diagnostic Process

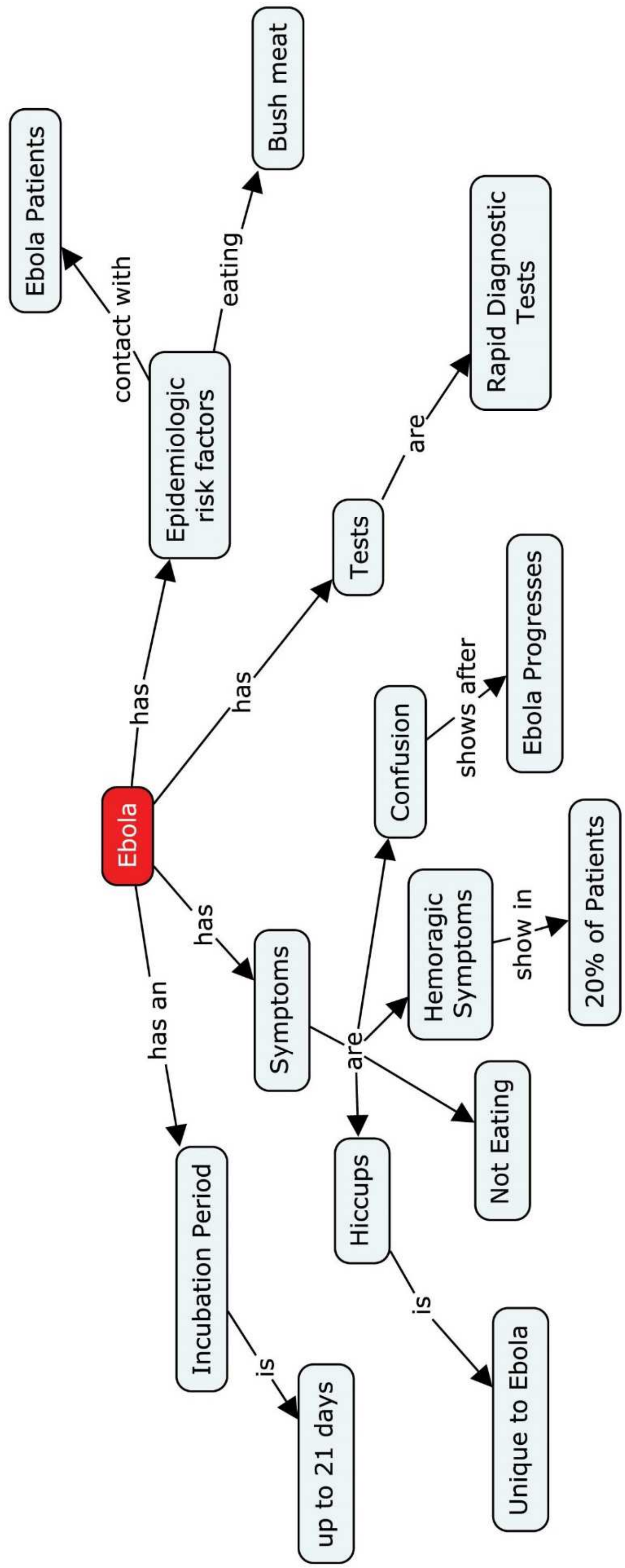



Malaria
has
Environmental Indicators
are
Use of Protective Measures
consist of
Living in air-conditioned building
Bug Repellent
Mosquito Nets
does not indicate
are
Contact w/ Malaria Infected Person
Indicates
has
Early Symptoms
that are
Non-specific Flu like
indicates, does not confirm
Anemia Test
result of
Hemoglobin less than 10
is
Tested
by
Rapid Diagnostic Tests
are
User Friendly
very sensitive
Microscopy
is
Resource Intensive
gold standard
has
Key Symptoms
are
Cerebral Malaria
has
High Mortality
symptoms are
Seizures
Coma
Stroke
Headaches
High Periodic Fever
is
Periodic
Spiking
has
Advanced Symptoms
can lead to
are
Dark Urine
Severe Anemia
has an
can be ruled out via
Incubation Period
of
9 to 14 days


Yellow Fever
not transmited
Human to Human
has
No Treatment
is tested by
Antigen Lab Test
can be
Severe
is fatal in
Half of Severe Yellow Fever Cases
in
15% of Patients
have
Organ Failure
Bleeding
is
Not often Fatal
has
Symptoms
are
Jaundice
can indicate
are similar to
Malaria
caused by a
Virus
spread by
Mosquitos
spread
has an
Incubation Period
is
3 to 7 days


Typhoid
can carry
cured people
is
bacteria
has
diagnosis methods
can be
blood culture
fecal culture
is
waterborn disease
transmitted by
fecal-oral contamination
comes from
contaminated food
contaminated water
has
symptoms
include
fever
may developed
temperature deficit
which means
high fever in short period
might lead to
fatal
bloody nose
liver tenderness
heart rate increase
rose spot
which is
unique symptom
to diagnose
living condition
has
water supply
has
food supply
has
personal hygiene
such as
How usually do you wash your hands?
should be asked about
patient
has
incubation period
is
8-14 days
has
high risk population
include
people who handle carcasses
people who handle dairy products
people who handle feces


Lassa Fever
endemic in
eastern part of Sierra Leone
has
treatment
is
ribavirin
might cause
hearing loss
should be used
In 7 days
is spread by
human to human transmition
rodents
has
symptoms
are
vomiting
fatigue
swollen face
which is
unique symptom
abdominal pain
fever
can be
serious
can be
hemorrhaging
is
not common
in
nose
in
gum
in
eyes
can be
hearing loss
has
outbreak season
is
when rat population increases
late rainy & early dry
is
Virus
has
incubation period
is about
5-21 days
has no
rapid test
has
antibody test


Ebola
has
Epidemiologic risk factors
contact with
Ebola Patients
eating
Bush meat
has
Tests
are
Rapid Diagnostic Tests
has
Symptoms
are
Confusion
shows after
Ebola Progresses
Hemoragic Symptoms
show in
20% of Patients
Not Eating
Hiccups
is
Unique to Ebola
has an
Incubation Period
is
up to 21 days

Appendix D Research Study Survey

Informed Consent

EXPLANATION OF RESEARCH

Project Title: Evaluating the Use of Cultural Dimensions to Design Better User Interfaces
Principal Investigator: Dr. Kenneth H. Funk II
Student Researcher: Robert Miller, Tucker Barnes
Version Date: 16 February 2016

Purpose: You are being asked to take part in a research study. The purpose of this research study is to assess the relationship between software component usability and a user's nationality. This research is being conducted as part of Robert Miller's Master's thesis.

Eligibility: To participate in this study you must meet the following criteria:
- 18 years or older
- Currently living in the United States, temporarily or permanently
- Read and write in English
- Identify with only one nationality
- Spent approximately 15 years (does not need to be continuous) in the country of your nationality
- Spent no more than the last 5 years living outside the country of your nationality (if you currently do not live in the country of your nationality)

Activities: In this study, you will be asked to provide some demographic information. You will also take a cultural values survey. Lastly, you will be asked to evaluate a series of software components. It is recommended that you use a computer, laptop, or tablet to complete this survey. The questions may not display properly on a small device such as a smartphone.

Time: It should take around 30 minutes to complete this survey.

Risks: There are no likely risks to taking part in this study. We will not request identifiable information. We ask that you do no volunteer any that is not requested. This will ensure that your responses cannot be traced back to you.

Furthermore, a secure online survey tool will collect the data. It will be kept for three years after the completion of the study in a password-protected file that will be stored on a secure OSU drive.

Benefit: This study is not designed to benefit you directly. Additionally your responses provide a first step in validating a new method to develop culturally targeted computer interfaces.

Payment: You will not be paid for being in this research study. However, you will have the opportunity to enter into a raffle for one of three $25 Amazon gift cards. A link will be provided to a separate survey that collect the necessary information. Participation is not required to enter the raffle. You must be 18 years or older to enter and must be willing to provide your name, phone number, and email address. Winners will be informed at the conclusion of this study.

Confidentiality: Your participation in this study is anonymous.

Voluntary: Participation in this study is voluntary. You are free to skip any questions that you do not wish to answer at any time.

If you have any questions about this research project, please contact: Robert Miller (Student Researcher, millerro@oregonstate.edu) or Dr. Ken Funk (Principle Investigator, funkk@engr.orst.edu). If you have questions about your rights or welfare as a participant, please contact the Oregon State University Institutional Review Board (IRB) Office, at (541) 737-8008 or by email at IRB@oregonstate.edu.

Checking the box indicates that this study has been explained to you, that your questions have been answered, and that you agree to take part in this study.

- [ ] I understand the information presented and the potential risks of participating in this study and all my questions have been answered.

I have read the information provided and consent to participate in the study.

I consent	I do not consent
○	○

Screening Questions

Are you age 18 or older?

- ○ Yes
- ○ No

Do you read and write English?

- ○ Yes
- ○ No

Do you currently live in the United States temporarily or permanently?

- ○ Yes
- ○ No

Do you identify with only one nationality?

- ○ Yes
- ○ No

Think of the country whose nationality you identify with. Have you lived in that country for a total of 15 years or more over your entire life?
(the 15 years does not need to be continuous)

- ○ Yes
- ○ No

Think of the country whose nationality you identify with. If you are currently living outside of that country, how long have you currently lived outside of that country (ignoring absences of 3 months or less)?

- Less than 5 years
- 5 years or more
- Not applicable

Do you have any formal medical training beyond basic first aid, CPR, and AED training?
(i.e. schooling/training that qualifies you for a medical profession such as a Medical Assistant, Nurse, Physician, and EMT...etc.)

- Yes
- No

Demographics

Are you:

- Male
- Female
- Trans male/Trans man
- Trans female/Trans woman
- Genderqueer/Gender non-conforming
- Different identity (please state)

How old are you?

- 18 - 20
- 20 - 24
- 25 - 29
- 30 - 34
- 35 - 39
- 40 - 49
- 50 - 59
- 60 or over

How many years of formal school education (or their equivalent) have you completed (starting with primary school)?

- 10 years or less

11 years

- 12 years (US High School diploma)
- 13 years
- 14 years
- 15 years
- 16 years (US 4 year college)
- 17 years
- 18 years or over

Select the option that best describes the highest level you have reached in your career?

- No paid job (includes full-time students)
- Unskilled or semi-skilled manual worker
- Generally trained office worker or secretary
- Vocationally trained craftsperson, technician, IT-specialist, nurse, artist or equivalent
- Academically trained professional or equivalent (but not a manager of people)
- Manager of one or more subordinates (non-managers)
- Manager of one or more managers

What is the nationality you identify with?
(This may or may not be the nation you were born in or the nation you currently live in)

If you answered "Other" to the previous question, please describe:

How long (in years) have you lived in the country associated with your nationality?

How many years have passed since you lived in the country associated with your nationality?
(If you are currently residing in that country, enter 0)

Were you born in a different country than the country associated with your nationality?

- Yes

No

What country were you born in?

If you answered "Other" to the previous question, please describe:

How long (in years) did you live in the country you were born?

How many years have passed since you lived in the country you were born?
(If you are currently residing in that country enter 0)

VSM 2013 without Demographics

Please think of an ideal job, disregarding your present job, if you have one. In choosing an ideal job, how important would it be to you to...

	Of utmost importance	Very important	Of moderate importance	Of little importance	Of very little or no importance	*Do not wish to answer*
Have sufficient time for your personal or home life	○	○	○	○	○	○
Have a boss (direct superior) you can respect	○	○	○	○	○	○
Get recognition for good performance	○	○	○	○	○	○
Have security of employment	○	○	○	○	○	○
Have pleasant people to work with	○	○	○	○	○	○
Do work that is interesting	○	○	○	○	○	○
Be consulted by your boss in decisions involving your work	○	○	○	○	○	○
Live in a desirable area	○	○	○	○	○	○
Have a job respected by your family and friends	○	○	○	○	○	○

Have chances for promotion	○	○	○	○	○	○

In your private life, how important is each of the following to you

	Of utmost importance	Very important	Of moderate importance	Of little importance	Of very little or no importance	*Do not wish to answer*
Keeping time free for fun	○	○	○	○	○	○
Moderation; having few desires	○	○	○	○	○	○
Doing service to a friend	○	○	○	○	○	○
Thrift (not spending more than needed)	○	○	○	○	○	○

How often do you feel nervous or tense?

Always	Usually	Sometimes	Seldom	Never	*Do not wish to answer*
○	○	○	○	○	○

Are you a happy person?

Always	Usually	Sometimes	Seldom	Never	*Do not wish to answer*
○	○	○	○	○	○

Do other people or circumstances ever prevent you from doing what you really want to?

Yes, always	Yes, usually	Sometimes	No, seldom	No, never	*Do not wish to answer*
○	○	○	○	○	○

All in all, how would you describe your state of health these days?

Very good	Good	Fair	Poor	Very poor	*Do not wish to answer*
○	○	○	○	○	○

How proud are you to be a citizen of your country?

Very proud	Fairly proud	Somewhat proud	Not very proud	Not proud at all	*Do not wish to answer*
○	○	○	○	○	○

How often, in your experience, are subordinates afraid to contradict their boss (or students their teacher)?

Never	Seldom	Sometimes	Usually	Always	*Do not wish to answer*

To what extent do you agree or disagree with each of the following statements?

	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	*Do not wish to answer*
One can be a good manager without having a precise answer to every question that a subordinate may raise about his or her work						
Persistent efforts are the surest way to results						
An organization structure in which certain subordinates have two bosses should be avoided at all cost						
A company's or organization's rules should not be broken - not even when the employee thinks breaking the rule would be in the organization's best interest						

Introduction to Component Analysis

The next set of questions will ask you to evaluate parts of a medical application to help someone determine what disease they might have such as the flu, common cold, or pneumonia. Except where noted, software parts will be shown as screenshots that you will not be able to interact with. You will be timed during some of the questions.

The researchers have made up all of the information and situations in the following questions. Do not use any of the information in these questions outside the survey.

LPD Results

Please answer the question on the next page based upon the following scenario:
(this is a brand new scenario and is not related to any others you have seen)

Imagine your friend is sick. You decide to use a medical application to determine what disease is affecting them. You have already entered all of the requested data into the application including their symptoms and any risk factors.

The results for the medical application will be shown on the next page. Based just on the information shown in the display of results, determine what disease you think your friend has.

Your time to complete the scenario on the next page will be recorded.

These page timer metrics will not be displayed to the recipient.

First Click: *42.885 seconds*

Last Click: *42.885 seconds*

Page Submit: *0 seconds*

Click Count: *1 clicks*

Scenario repeated from last page:
Imagine your friend is sick. You decide to use a medical application to determine what disease is affecting them. You have already entered all of the requested data into the application including their symptoms and any risk factors.

The results of the medical application are shown as:

Symptoms and Risk Factors You Have Entered That Match Each Disease

	Influenza (Flu)	Viral Syndrome (Common Cold)	Viral Pneumonia	Bacterial Pneumonia
Risk Factors	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Place of Residence - Age - Time of Year
Symptoms	- Joint Aches - Cough - Headache - Chills - Fever - Body aches	- Body Aches - Fever	- Body Aches - Fever - Cough	- Joint Aches - Cough - Headache - Chills - Fever - Body aches

Based purely on the data shown in the results above, what disease do you think your friend has?

- Bacterial Pneumonia
- Influenza (Flu)
- Viral Pneumonia
- Viral Syndrome (Common Cold)
- Other
- I do not know
- None of the diseases above

LPD Results Confidence

How confident are you that your answer to the last question is correct, just based upon the information in the display of results?
(0% meaning you are not at all confident in your answer and 100% meaning that you are completely confident in your answer)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Please explain why you are, or are not, confident in your answer.

LPD Results EUCS

Below is the display of results you were shown previously.

Symptoms and Risk Factors You Have Entered That Match Each Disease

	Influenza (Flu)	Viral Syndrome (Common Cold)	Viral Pneumonia	Bacterial Pneumonia
Risk Factors	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Place of Residence - Age - Time of Year
Symptoms	- Joint Aches - Cough - Headache - Chills - Fever - Body aches	- Body Aches - Fever	- Body Aches - Fever - Cough	- Joint Aches - Cough - Headache - Chills - Fever - Body aches

Please assess how effectively the display of results above (referred to as "the system" in the questions below) addresses the following points.
(not all the questions may be applicable to the above display of results, if it is not then click the "I do not know" option; answer them to the best of your ability)

	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Does the system provide the precise information you need?						
Does the information content meet your needs?						
Does the system provide reports that seem to be just about exactly what you need?						
Does the system provide sufficient information?						
	Not effective at	Slightly	Moderately	Very	Extremely	*I do not*

	all	effective	effective	effective	effective	*know*
Do you think the output is presented in a useful format?	○	○	○	○	○	○
Is the information clear?	○	○	○	○	○	○
Is the system user friendly?	○	○	○	○	○	○
Is the system easy to use?	○	○	○	○	○	○

If you have any other comments about this display of results please enter them below.

HPD Results

Please answer the question on the next page based upon the following scenario:
(this is a brand new scenario and is not related to any others you have seen)

Imagine your friend is sick. You decide to use a medical application to determine what disease is affecting them. You have already entered all of the requested data into the application including their symptoms and any risk factors.

The results for the medical application will be shown on the next page. Based just on the information shown in the display of results, determine what disease you think your friend has.

Your time to complete the scenario on the next page will be recorded.

These page timer metrics will not be displayed to the recipient.

First Click: *42.879 seconds*

Last Click: *42.879 seconds*

Page Submit: *0 seconds*

Click Count: *1 clicks*

Scenario repeated from last page:
Imagine your friend is sick. You decide to use a medical application to determine what disease is affecting them. You have already entered all of the requested data into the application including their symptoms and any risk factors.

The results of the medical application are shown as:

	Percent Likely
Influenza (Flu)	90%
Viral Syndrome (Common Cold)	60%
Viral Pneumonia	70%
Bacterial Pneumonia	85%

Based purely on the data shown in the results above, what disease do you think your friend has?

- Viral Pneumonia
- Bacterial Pneumonia
- Viral Syndrome (Common Cold)
- Influenza (Flu)
- Other
- None of the diseases above
- I do not know

HPD Results Confidence

How confident are you that your answer to the last question is correct, just based upon the information in the display of results?

(0% meaning you are not at all confident in your answer and 100% meaning that you are completely confident in your answer)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

Please explain why you are, or are not, confident in your answer.

HPD Results EUCS

Below is the results display you were shown previously.

	Percent Likely
Influenza (Flu)	90%
Viral Syndrome (Common Cold)	60%
Viral Pneumonia	70%
Bacterial Pneumonia	85%

Please assess how effectively the display of results above (referred to as "the system" in the questions below) addresses the following points.
(not all the questions may be applicable to the above display of results, if it is not then click the "I do not know" option; answer them to the best of your ability)

	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Does the system provide the precise information you need?	○	○	○	○	○	○
Does the information content meet your needs?	○	○	○	○	○	○
Does the system provide reports that seem to be just about exactly what you need?	○	○	○	○	○	○
Does the system provide sufficient information?	○	○	○	○	○	○
	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Do you think the output is presented in a useful format?	○	○	○	○	○	○
Is the information clear?	○	○	○	○	○	○
Is the system user friendly?	○	○	○	○	○	○
Is the system easy to use?	○	○	○	○	○	○

If you have any other comments about this display of results please enter them below.

PD Results Compare

Below are the two result displays you have been shown previously.

Results Display 1

Symptoms and Risk Factors You Have Entered That Match Each Disease

	Influenza (Flu)	Viral Syndrome (Common Cold)	Viral Pneumonia	Bacterial Pneumonia
Risk Factors	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Exposure to infected people - Place of Residence - Age - Time of Year	- Place of Residence - Age - Time of Year
Symptoms	- Joint Aches - Cough - Headache - Chills - Fever - Body aches	- Body Aches - Fever	- Body Aches - Fever - Cough	- Joint Aches - Cough - Headache - Chills - Fever - Body aches

Results Display 2

	Percent Likely
Influenza (Flu)	90%
Viral Syndrome (Common Cold)	60%
Viral Pneumonia	70%
Bacterial Pneumonia	85%

Use the slider below to rate your preference between the two result displays.

Strongly prefer *Results Display 1*	Prefer *Results Display 1*	Somewhat prefer *Results Display 1*	Neutral	Somewhat prefer *Results Display 2*	Prefer *Results Display 2*	Strongly prefer *Results Display 2*

LPD Data Entry

Please answer the question on the next page based upon the following scenario:
(this is a brand new scenario and is not related to any others you have seen)

Imagine a sick friend is sitting next to you. They are coughing, sneezing, and feeling warm. You decide to use a medical application to determine what disease they have.

The next page will display some questions the medical application displays so you can record their symptoms and any risk factors that may be present. Answer the questions to describe your imaginary friend's symptoms.
(if you are having difficulty imagining your friend's symptoms, think back to the last time you were sick with similar symptoms and use the questions to describe your symptoms)

You will be able to interact with the questions. Your time to complete the scenario on the next page will be recorded.

These page timer metrics will not be displayed to the recipient.

First Click: *42.877 seconds*

Last Click: *42.877 seconds*

Page Submit: *0 seconds*

Click Count: *1 clicks*

Scenario repeated from last page:
Imagine a sick friend is sitting next to you. They are coughing, sneezing, and feeling warm. You decide to use a medical application to determine what disease they have.
OR
If you are having difficulty imagining your friend's symptoms, think back to the last time you were sick with similar symptoms.

Answer the questions below to describe some of the symptoms the person has.

	Not present	Mild	Moderate	Severe	I do not know
Fever	○	○	○	○	○
Cough	○	○	○	○	○

Answer the questions below to describe some of the risk factors that may have put your friend at risk of getting sick.

	No	Yes	I do not know
Exposure to infected people	○	○	○
Time of year for sickness	○	○	○

LPD Data Entry Confidence

How confident are you that the available answers to the questions allowed you to accurately describe your friend's symptoms and risk factors? (do not asses how confident you were imagining your friend's symptoms)
(0% meaning you are not at all confident in the available answer and 100% meaning that you are completely confident in the available answers)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
○	○	○	○	○	○	○	○	○	○	○

Please explain why you are, or are not, confident in your answers.

LPD Data Entry EUCS

Below is an image of the data entry questions you responded to previously.

Symptoms	*Not present*	*Mild*	*Moderate*	*Severe*	*I do not know*
Fever	○	○	○	○	○
Cough	○	○	○	○	○

Risk Factors that may have been present	*No*	*Yes*	*I do not know*
Exposure to infected people	○	○	○
Time of year for sickness	○	○	○

Please assess how effectively the data entry display above (referred to as a "system" in the questions below) addresses the following points.

(not all the questions may be applicable to the above data entry display, if it is not then click the "I do not know" option; answer them to the best of your ability)

	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Does the system provide the precise information you need?	○	○	○	○	○	○
Does the information content meet your needs?	○	○	○	○	○	○
Does the system provide reports that seem to be just about exactly what you need?	○	○	○	○	○	○
Does the system provide sufficient information?	○	○	○	○	○	○
	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Do you think the output is presented in a useful format?	○	○	○	○	○	○
Is the information clear?	○	○	○	○	○	○
Is the system user friendly?	○	○	○	○	○	○
Is the system easy to use?	○	○	○	○	○	○

If you have any other comments about this data entry display please enter them below.

HPD Data Entry

Please answer the question on the next page based upon the following scenario:
(this is a brand new scenario and is not related to any others you have seen)

Imagine a sick friend is sitting next to you. They are coughing, sneezing, and feeling warm. You decide to use a medical application to determine what disease they have.

The next page will display some questions the medical application displays so you can record their symptoms and any risk factors that may be present. Answer the questions to describe your imaginary friend's symptoms.
(if you are having difficulty imagining your friend's symptoms, think back to the last time you were sick with similar symptoms and use the questions to describe your symptoms)

You will be able to interact with the questions. Your time to complete the scenario on the next page will be recorded.

These page timer metrics will not be displayed to the recipient.

First Click: *42.872 seconds*

Last Click: *42.872 seconds*

Page Submit: *0 seconds*

Click Count: *1 clicks*

Scenario repeated from last page:
Imagine a sick friend is sitting next to you. They are coughing, sneezing, and feeling warm. You decide to use a medical application to determine what disease they have.
OR
If you are having difficulty imagining your friend's symptoms, think back to the last time you were sick with similar symptoms.

Answer the questions below to describe some of the symptoms the person has.

	Not present	99-100 °F (37.2-37.7 °C)	101-102 ºF (37.8-38.9 ºC)	103-104 ºF (39.0-40.0 ºC)	I do not know
Fever	○	○	○	○	○

	Not present	With phlegm or mucus	No phlegm or mucus	I do not know
Cough	○	○	○	○

Answer the questions below to describe some of the risk factors that may have put your friend at risk of getting sick.

	Within 7 days	Within 2 weeks	Within a month	Not present	I do not know
Exposure to infected people	○	○	○	○	○

	Spring	Summer	Fall	Winter	I do not know
Time of year	○	○	○	○	○

HPD Data Entry Confidence

How confident are you that the available answers to the questions allowed you to accurately describe your friend's symptoms and risk factors? (do not asses how confident you were imagining your friend's symptoms)

(0% meaning you are not at all confident in the available answer and 100% meaning that you are completely confident in the available answers)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
○	○	○	○	○	○	○	○	○	○	○

Please explain why you are, or are not, confident in your answers.

HPD Data Entry EUCS

Below is an image of the data entry questions you responded to previously.

Symptoms	*Not present*	*99 – 100°F (37.2 – 37.7°C)*	*101 - 102°F (37.8 – 38.9°C)*	*103 - 104°F (39.0 – 40.0°C)*	*I do not know*
Fever	○	○	○	○	○

	Not present	*With phlegm or mucus*	*No phlegm or mucus*	*I do not know*
Cough	○	○	○	○

Contributing Risk Factors	*Within 7 days*	*Within 2 weeks*	*Within a month*	*Not present*	*I do not know*
Exposure to infected people	○	○	○	○	○

	Spring	*Summer*	*Fall*	*Winter*	*I do not know*
Time of year	○	○	○	○	○

Please assess how effectively the data entry display above (referred to as a "system" in the questions below) addresses the following points.
(not all the questions may be applicable to the above data entry display, if it is not then click the "I do not know" option; answer them to the best of your ability)

	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Does the system provide the precise information you need?	○	○	○	○	○	○
Does the information content meet your needs?	○	○	○	○	○	○
Does the system provide reports that seem to be just about exactly what you need?	○	○	○	○	○	○
Does the system provide sufficient information?	○	○	○	○	○	○
	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Do you think the output is presented in a useful format?	○	○	○	○	○	○
Is the information clear?	○	○	○	○	○	○
Is the system user friendly?	○	○	○	○	○	○
Is the system easy to use?	○	○	○	○	○	○

If you have any other comments about this data entry display please enter them below.

PD Data Entry Compare

Below are the two data entry displays you have been shown previously.
Data Entry 1

Symptoms	*Not present*	*Mild*	*Moderate*	*Severe*	*I do not know*
Fever	○	○	○	○	○
Cough	○	○	○	○	○

Risk Factors that may have been present	*No*	*Yes*	*I do not know*
Exposure to infected people	○	○	○
Time of year for sickness	○	○	○

Data Entry 2

Symptoms	*Not present*	*99 – 100°F (37.2 – 37.7°C)*	*101 - 102°F (37.8 – 38.9°C)*	*103 - 104°F (39.0 – 40.0°C)*	*I do not know*
Fever	○	○	○	○	○
	Not present	*With phlegm or mucus*	*No phlegm or mucus*		*I do not know*
Cough	○	○	○		○

Contributing Risk Factors	*Within 7 days*	*Within 2 weeks*	*Within a month*	*Not present*	*I do not know*
Exposure to infected people	○	○	○	○	○
	Spring	*Summer*	*Fall*	*Winter*	*I do not know*
Time of year	○	○	○	○	○

Use the slider below to rate your preference between the two data entry displays.

Strongly prefer *Data Entry 1*	Prefer *Data Entry 1*	Somewhat prefer *Data Entry 1*	Neutral	Somewhat prefer *Data Entry 2*	Prefer *Data Entry 2*	Strongly prefer Data Entry 2

LUA Results Placement

Please answer the question on the next page based upon the following scenario:
(this is a brand new scenario and is not related to any others you have seen)

Imagine that you are using a medical application to determine what disease your friend has. You have entered all of their symptoms and information and you now want to see what disease they have.

The next page will display a screen shot of the medical application. Click on the image where you expect to see the results.

Your time to complete the scenario on the next page will be recorded.

These page timer metrics will not be displayed to the recipient.

First Click: *42.87 seconds*

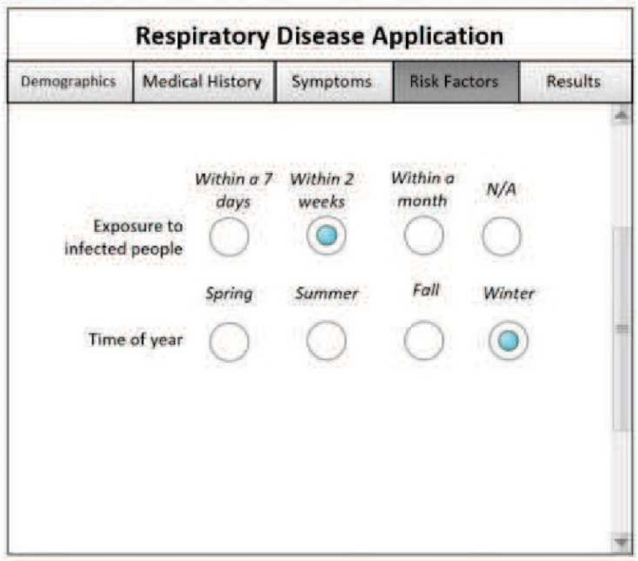
Last Click: *42.87 seconds*

Page Submit: *0 seconds*

Click Count: *1 clicks*

Scenario repeated from last page:
Imagine that you are using a medical application to determine what disease your friend has. You have entered all of their symptoms and information and you now want to see what disease they have.

Click on the screen shot below where you expect to see the results.



LUA Results Placement Confidence

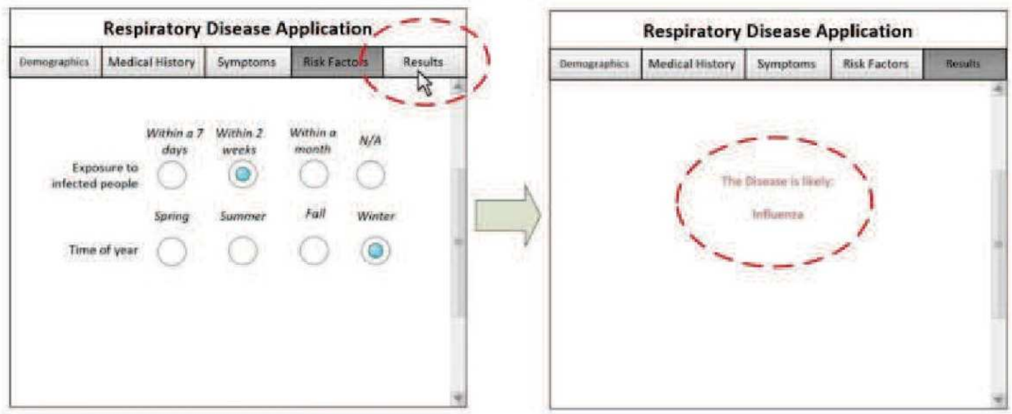
How confident are you that you have selected the correct part of the screen shot on the previous page?
(0% meaning you are not at all confident in your answer and 100% meaning that you are completely confident in your answer)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
○	○	○	○	○	○	○	○	○	○	○

Please explain why you are, or are not, confident in your answer.

LUA Results Placement EUCS

Below is a series of screen shots of the medical application you just saw. The results are shown in a separate screen after you click on the "Results" button in the navigation bar.



Please assess how effectively the placement of the results in the above screen shots (referred to as a "system" in the questions below) addresses the following points.
(not all the questions may be applicable to the above screen shots, if it is not then click the "I do not know" option; answer them to the best of your ability)

	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Does the system provide the precise information you need?						
Does the information content meet your needs?						
Does the system provide reports that seem to be just about exactly what you need?						
Does the system provide sufficient information?						
	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*

Do you think the output is presented in a useful format?	○	○	○	○	○	○
Is the information clear?	○	○	○	○	○	○
Is the system user friendly?	○	○	○	○	○	○
Is the system easy to use?	○	○	○	○	○	○

If you have any other comments about the results placement in the above screen shots please enter them below.

HUA Results Placement

Please answer the question on the next page based upon the following scenario:
(this is a brand new scenario and is not related to any others you have seen)

Imagine that you are using a medical application to determine what disease your friend has. You have entered all of their symptoms and information and you now want to see what disease they have.

The next page will display a screen shot of the medical application. Click on the image where you expect to see the results.

Your time to complete the scenario on the next page will be recorded.

These page timer metrics will not be displayed to the recipient.

First Click: *42.865 seconds*

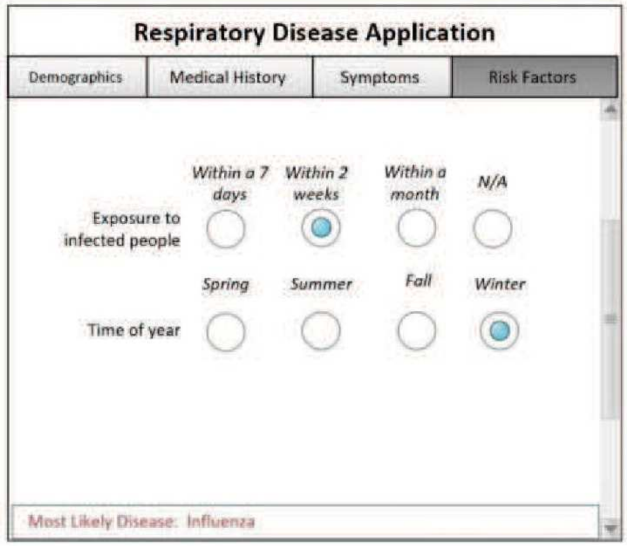
Last Click: *42.865 seconds*

Page Submit: *0 seconds*

Click Count: *1 clicks*

Scenario repeated from last page:
Imagine that you are using a medical application to determine what disease your friend has. You have entered all of their symptoms and information and you now want to see what disease they have.

Click on the screen shot below where you expect to see the results.



HUA Results Placement Confidence

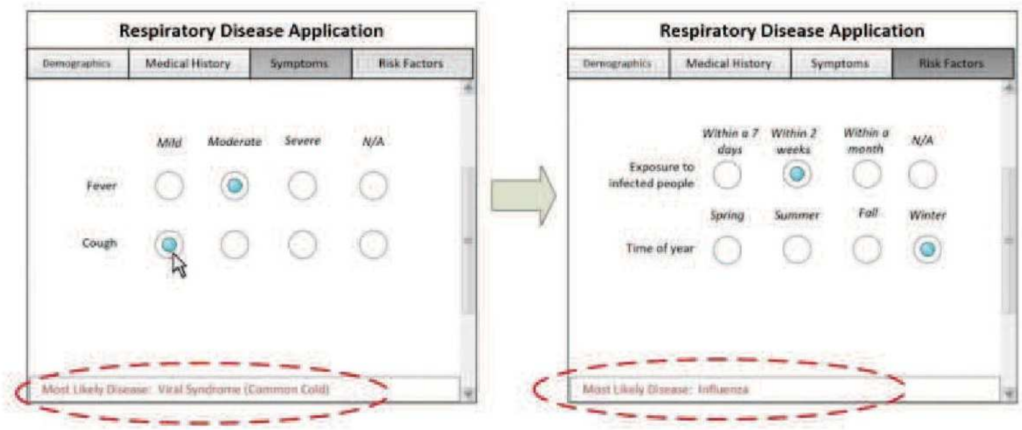
How confident are you that you have selected the correct part of the screen shot on the previous page?
(0% meaning you are not at all confident in your answer and 100% meaning that you are completely confident in your answer)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
○	○	○	○	○	○	○	○	○	○	○

Please explain why you are, or are not, confident in your answer.

HUA Results Placement EUCS

Below is a series of screen shots of the medical application you just saw. The results, or the most likely disease, is shown at the bottom of the screen at all times. The system updates and refines the results as you enter more information.



Please assess how effectively the placement of the results in the above screen shots (referred to as a "system" in the questions below) addresses the following points.

(not all the questions may be applicable to the above screen shots, if it is not then click the "I do not know" option; answer them to the best of your ability)

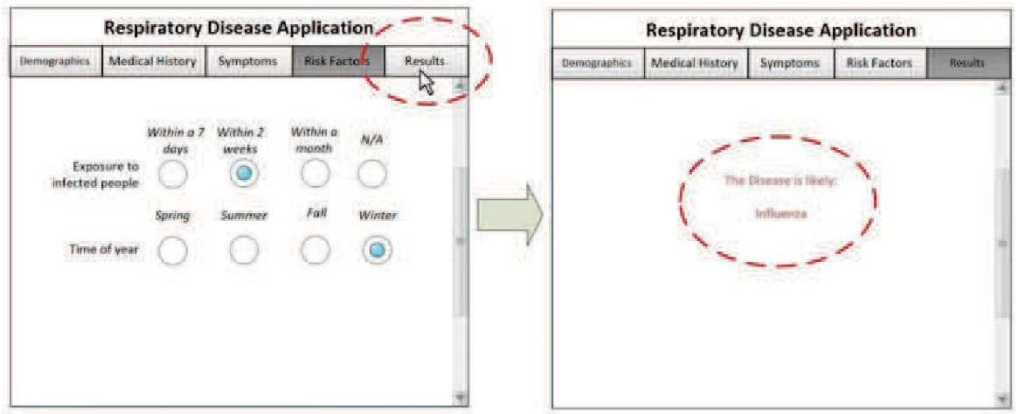
	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Does the system provide the precise information you need?						
Does the information content meet your needs?						
Does the system provide reports that seem to be just about exactly what you need?						
Does the system provide sufficient information?						
	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Do you think the output is presented in a useful format?						
Is the information clear?						
Is the system user friendly?						
Is the system easy to use?						

If you have any other comments about the results placement in the above screen shots please enter them below.

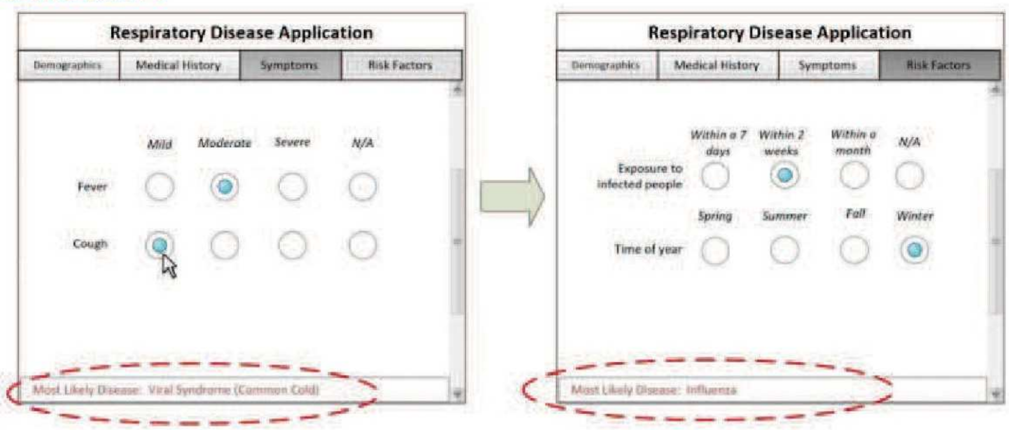
UA Results Placement Compare

Below are the two different medical application displays you have been shown previously.

Result Location 1



Result Location 2



Use the slider below to rate your preference between the two different locations for the results.

Strongly prefer *Result*	Prefer *Result*	Somewhat prefer *Result*	Somewhat prefer *Result*	Prefer *Result*	Strongly prefer Result Location

Location 1	*Location 1*	*Location 1*	Neutral	*Location 2*	*Location 2*	2

LUA Navigation

Please answer the question on the next page based upon the following scenario:
(this is a brand new scenario and is not related to any others you have seen)

Imagine that you are using a medical application to determine what disease your friend has.

The next page will display an image of the navigation bar for the application. You need to record that your friend has diarrhea, a headache, and is vomiting. Click on the navigation bar where you might enter this information.

Your time to complete the scenario on the next page will be recorded.

These page timer metrics will not be displayed to the recipient.

First Click: *42.861 seconds*

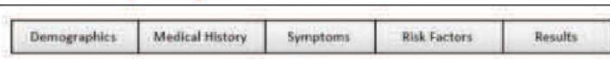
Last Click: *42.861 seconds*

Page Submit: *0 seconds*

Click Count: *1 clicks*

Scenario repeated from last page:
Imagine that you are using a medical application to determine what disease your friend has. You need to enter into the application that your friend has diarrhea, a headache, and is vomiting.

Click on the navigation bar where you might enter this information.



LUA Navigation Confidence

How confident are you that you selected the correct button to enter the information on the previous page?
(0% meaning you are not at all confident in your answer and 100% meaning that you are completely confident in your answer)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
○	○	○	○	○	○	○	○	○	○	○

Please explain why you are, or are not, confident in your answer.

LUA Navigation EUCS

Below is the navigation bar you were shown previously. The buttons link to pages to enter the different types of data.

Demographics	Medical History	Symptoms	Risk Factors	Results

Please assess how effectively the navigation bar above (referred to as a "system" in the questions below) addresses the following points.
(not all the questions may be applicable to the above navigation bar, if it is not then click the "I do not know" option; answer them to the best of your ability)

	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Does the system provide the precise information you need?	○	○	○	○	○	○
Does the information content meet your needs?	○	○	○	○	○	○
Does the system provide reports that seem to be just about exactly what you need?	○	○	○	○	○	○
Does the system provide sufficient information?	○	○	○	○	○	○
	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Do you think the output is presented in a useful format?	○	○	○	○	○	○
Is the information clear?	○	○	○	○	○	○
Is the system user friendly?	○	○	○	○	○	○
Is the system easy to use?	○	○	○	○	○	○

If you have any other comments about this navigation bar please enter them below.

HUA Navigation

Please answer the question on the next page based upon the following scenario:
(this is a brand new scenario and is not related to any others you have seen)

Imagine that you are using a medical application to determine what disease your friend has.

The next page will display an image of the navigation bar for the application. You need to enter into the application that your friend has a sore throat, body aches, and feels weak. Click on the navigation bar where you might enter this information.

Your time to complete the scenario on the next page will be recorded.

These page timer metrics will not be displayed to the recipient.

First Click: *42.859 seconds*

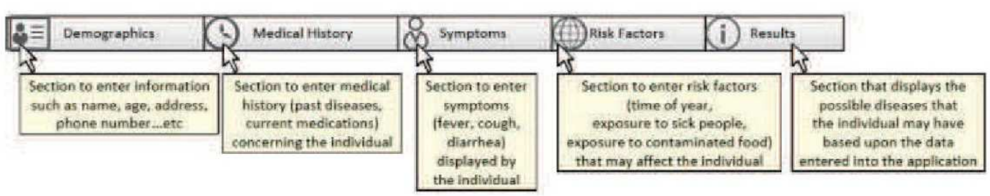
Last Click: *42.859 seconds*

Page Submit: *0 seconds*

Click Count: *1 clicks*

Scenario repeated from last page:
Imagine that you are using a medical application to determine what disease your friend has. You need to enter into the application that your friend has a sore throat, body aches, and feels weak.

Click on the navigation bar where you might enter this information.



HUA Navigation Confidence

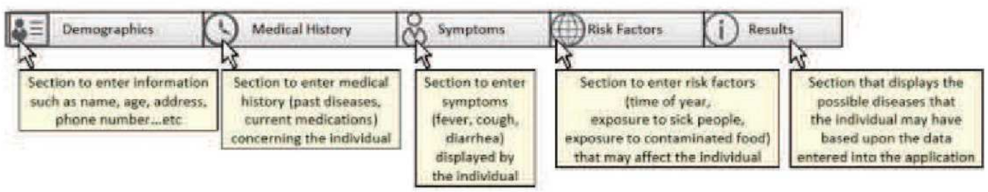
How confident are you that you selected the correct button to enter the information on the previous page?
(0% meaning you are not at all confident in your answer and 100% meaning that you are completely confident in your answer)

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
○	○	○	○	○	○	○	○	○	○	○

Please explain why you are, or are not, confident in your answer.

HUA Navigation EUCS

Below is the navigation bar you were shown previously. The buttons link to pages to enter the different types of data. All of the hover over messages are shown in the image below that would be displayed if the mouse hovered over the button.



Please assess how effectively the navigation bar above (referred to as a "system" in the questions below) addresses the following points.

(not all the questions may be applicable to the above navigation bar, if it is not then click the "I do not know" option; answer them to the best of your ability)

	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Does the system provide the precise information you need?						
Does the information content meet your needs?						
Does the system provide reports that seem to be just about exactly what you need?						
Does the system provide sufficient information?						
	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective	*I do not know*
Do you think the output is presented in a useful format?						
Is the information clear?						

Is the system user friendly?	○	○	○	○	○	○
Is the system easy to use?	○	○	○	○	○	○

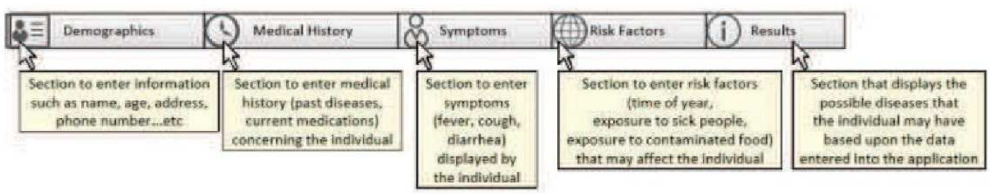
If you have any other comments about this navigation bar please enter them below.

UA Navigation Compare

Below are the two different navigational bars you have been shown previously.

Navigation Bar 1

Navigation Bar 2



Use the slider below to rate your preference between the two different navigation bars.

Strongly prefer *Navigation Bar 1*	Prefer *Navigation Bar 1*	Somewhat prefer *Navigation Bar 1*	Neutral	Somewhat prefer *Navigation Bar 2*	Prefer *Navigation Bar 2*	Strongly prefer Navigation Bar 2

General Interface Preference Questions

Please rate your level of agreement with the following statements based upon all of your experience with software systems, not just the parts of software you reviewed in this survey.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I prefer the software to					

make decisions/suggestions rather than make them myself.	○	○	○	○	○
I prefer minimal designs that allow me to quickly explore a software system.	○	○	○	○	○
I prefer more information in an interface so that I understand what my interactions with an interface will do before I interact with the interface.	○	○	○	○	○
I prefer to make decisions myself rather than have the software make decisions/suggestions for me.	○	○	○	○	○

Appendix E Institutional Review Board Approval

Institutional Review Board
Office of Research Integrity | Oregon State University
B308 Kerr Administration Building, Corvallis, OR 97331-2140
Telephone (541) 737-8008
irb@oregonstate.edu | http://research.oregonstate.edu/irb

EXEMPT DETERMINATION

Date of Notification	03/10/2016		
Study ID	7309		
Study Title	Evaluating the Use of Cultural Dimensions to Design Better User Interfaces		
Principal Investigator	Kenneth Funk		
Study Team Members	Tucker Barnes, Robert Miller		
Submission Type	Initial Application	Date Acknowledged	03/10/2016
Level	Exempt	Category(ies)	2
Funding Source	None	Proposal #	N/A
PI on Grant or Contract	N/A	Cayuse #	N/A

The above referenced study was reviewed by the OSU Institutional Review Board (IRB) and determined to be exempt from full board review.

EXPIRATION DATE: 03/09/2021
*The exemption is valid for **5 years** from the date of approval.*

Annual renewals are not required. If the research extends beyond the expiration date, the Investigator must request a new exemption. Investigators should submit a final report to the IRB if the project is completed prior to the 5 year term.

Documents included in this review:

- ☒ Protocol
- ☐ Consent forms
- ☐ Assent forms
- ☐ Alternative consent
- ☐ Letters of support
- ☒ Recruiting tools
- ☒ Test instruments
- ☐ Attachment A: Radiation
- ☐ Alternative assent
- ☐ Grant/contract
- ☐ External IRB approvals
- ☐ Translated documents
- ☐ Attachment B: Human materials
- ☐ Other:

Comments:

Principal Investigator responsibilities:

- Certain amendments to this study must be submitted to the IRB for review prior to initiating the change. These amendments may include, but are not limited to, changes in funding, , study population, study instruments, consent documents, recruitment material, sites of research, etc. For more information about the types of changes that require submission of a project revision to the IRB, please see: http://oregonstate.edu/research/irb/sites/default/files/website_guidancedocuments.pdf
- All study team members should be kept informed of the status of the research. The Principal Investigator is responsible for ensuring that all study team members have completed the online ethics training requirement, even if they do not need to be added to the study team via project revision.
- Reports of unanticipated problems involving risks to participants or others must be submitted to the IRB within three calendar days.
- The Principal Investigator is required to securely store all study related documents on the OSU campus for a minimum of three years post study termination.

Appendix F Organizations Solicited for Survey Participants

Type	**University**	**Organization Name**
Club	Oregon State University	African Student Association
Club	University of Oregon	African Student Association
Club	University of Oregon	African Student Association
Club	University of Washington	African Student Association
Club	Portland State University	Arab Persian Student Organization
Club	University of Washington	Arabic Culture Student Association
Club	University of Oregon	Asian Cultural Communication Association
Club	University of Oregon	Asian Culture Communication Association
Club	Oregon State University	Asian Pacific American Student Union
Club	Portland State University	Association of African Students
Club	Oregon State University	Association of Latin American Students
Club	University of Washington	Brazil Club
Club	Oregon State University	Chinese Association at OSU
Club	University of Washington	Chinese Student Association
Club	Portland State University	Chinese Student Scholar Association
Club	University of Washington	Chinese Taiwanese Student Organization
Club	Portland State University	Cultural and Historical Association for Israel
Club	University of Washington	Dub City Bhangra
Club	Portland State University	German Student Cultural Association
Club	Portland State University	Hong Kong Student Association
Club	University of Oregon	Hong Kong Student Association
Club	University of Washington	Hong Kong Student Association
Club	Portland State University	Indian Student Association
Club	University of Washington	Indian Student Association
Club	Oregon State University	Indian Students Association
Club	Oregon State University	Iranian Student Association
Club	Portland State University	Iranian Students Association of Portland
Club	Portland State University	Iraqi Students' Club
Club	Oregon State University	Japanese Student Association
Club	University of Washington	Japanese Student Association
Club	University of Oregon	Japanese Student Organization
Club	Portland State University	Japanese Student Society
Club	Portland State University	Organization of International Students
Club	University of Washington	Pakistani Students Association
Club	University of Oregon	Saudi Student Association
Club	Portland State University	Saudi Student Club
Club	University of Washington	Singapore Students' Association
Club	University of Washington	Taiwanese Overseas Student Association
Club	Portland State University	Taiwanese Student Association
Club	University of Washington	Taiwanese Student Association

Type	**University**	**Organization Name**
Club	Oregon State University	Thai Student Association
Club	University of Washington	Thai Student Association
Club	Portland State University	Thai Student Organization
Club	Portland State University	Vietnamese Student Association
Club	University of Oregon	Vietnamese Student Association
Club	University of Washington	Vietnamese Student Association
Department	University of Oregon	International Student and Scholar Services
Department	University of Oregon	International Student Association
Department	Oregon State University	International Student Services
Department	Portland State University	International Student Services
Department	University of Washington	International Student Services
Department	Oregon State University	INTO Program
Labor Union	Oregon State University	Coalition of Graduate Employees
Social Media		Personal Facebook Account