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User experience: A review of methodology and the creation of an evaluation instrument

by

Ryan Williams

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of
MASTER OF FINE ARTS

Major: Graphic Design

Program of Study Committee:
Debra Satterfield, Co-Major Professor
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Ames, Iowa
2014
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ABSTRACT

Understanding human interaction with a machine is a complicated task. Humans are creatures of nature and have spontaneous and irrational behaviors while machines are logical and process oriented. It is easy to see why interactions between humans and machines are a challenge for designers, developers, and engineers. Advances in technology have increased the capacity of machines to respond to humans in natural dialogue and everyday environments. This study hopes to contribute in understanding effective communication strategies between users and machines with the development of an instrument that incorporates best practices in user evaluation in human factors, cognitive response, and post evaluation surveys. This study will also evaluate participatory and cognitive computing metrics to understand their effectiveness and opportunities to increase efficient communication between a user and a machine.

CHAPTER 1. INTRODUCTION

1.1. Introduction

The purpose of this thesis is to create a better user experience evaluation instrument that can be applied to any existing technology or future technology to develop an appropriate user experience. Technology is advancing rapidly and evolving the ability to exist in environments that have not been previously possible. For example, wearable technology such as glasses and smart watches provide the ability to respond to users in natural environments. Designers are often the creators of the visual display system that helps the user communicate with the technology. A user experience evaluation instrument will provide the designer with criteria to help create a desired user experience.

Understanding a human interaction with a machine is a complicated task. Humans are creatures of nature and have spontaneous behaviors, while machines are logical and process oriented. It is easy to see why interactions between humans and machines are a challenge for designers, developers, and engineers. Advances in technology have increased the ability for machines to respond to humans in more natural dialogs and environments. This technology has been referred to as cognitive computing, or natural language. An exploration into the cognitive computing process will help identify user experience design opportunities to consider in the user experience instrument.

An analysis of current user experience evaluation models will be conducted to form principles based in statistics that contribute to evaluating user experiences. A pilot study will be conducted to test a proposed evaluation instrument looking for opportunities of improvement. The proposed instrument will be an early stage prototype, not a finalized instrument.

1.2. Purpose of Research

The purpose of this study is to create an instrument that evaluates a user's experience. The resulting instrument will provide a framework that can be used to provide an evaluation of an existing user experience and/or applied to develop a new user experience.

1) Is it possible to create a better instrument that will measure user experience?

What items must appear on such an instrument?

How can these items be defined as relative to the value of user experience?

2) Can an instrument be applied to evaluate existing experiences to determine opportunities for an improved experience?

1.3. Definitions of key terminology

Cognitive Computing the science of developing computer systems that are able to adapt to people's natural language and environmental factors such as hearing, sight, taste, smell, and touch. (Smart Machines : IBM's Watson and the era of cognitive computing)

Cognitive Design is translating cognitive science into design experiences that offer transformation by guiding behavior

Ethnography is a research method based on observing people in their natural environment rather than in a formal research setting as a way to gain a deep understanding of people and how they make sense of their world

Human-centered design (HCD) is the process that ensures that the designs match the needs and capabilities of the people for whom they are intended.

Likert Scale is a methodology used to measure attitudes by asking people to respond to a series of statements about a topic, in terms of the extent of which they agree with them, which brings insight into the cognitive and affective components of attitudes.

Operating System is the software that controls user inputs and machine operations. It also contains the visual display of the user interface.

Participatory Design is incorporating a user into the creative development process usually through a set of specific tools.

Personas are hypothetical archetypes of actual users used to help communicate human needs.

User is a person who interacts with a product and experiences the results of those interactions.

User Experience is the embodiment of a user's environment, emotions, and interactions with any given product.

User Interface is the visual display of a machine's operating system or procedure that enables a person to respond or provide input into a machine.

CHAPTER 2. REVIEW OF LITERATURE

2.1. Introduction

New technologies have increased the capability of users and machines to interact with increased efficiency and in new environments. This presents a challenge to designers, engineers, and users to create new guidelines to help build effective user experiences. The review of literature will discuss the background of user experiences (2.2), cognitive design (2.3) and statistical evaluation methodologies as they relate to user experience (2.4). The literature will discuss how methodologies from cognitive design and cognitive computing could be combined with a foundational user experience model to create a new evaluation instrument to measure and create user experiences.

2.2. User expereince

The term “user experience” seems to evolve with advances in technology as computers are able to communicate with humans in new capacities and environments. Simone Borsci states in his book, *Computer Systems Experiences of Users with and without Disabilities,* that there are at least 27 definitions of user experience with the most referenced definition coming from Donald Norman (Borsci p. 49). A current definition found on Neilsen Norman Group’s website states that user experience is encompassing all aspects of the end-user’s interaction with the company, its services, and its products (Nielsen and Norman). Another definition authored by the User Experience Professionals’ Association states,

> “Every aspect of the user’s interaction with a product, service, or company that make up the user’s perceptions of the whole. User experience design as a discipline is concerned with all the elements that together make up that interface, including layout, visual

design, text, brand, sound, and interaction. UE (user experience) works to coordinate these elements to allow for the best possible interaction by users." (User Experience Professionals' Association).

Borsci states that in 2010, the International Organization for Standardization defined user experience as a person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service (Borsci p. 49). The ISO includes three subsequent notes,

"**Note 1** User experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments that occur before, during and after use.

Note 2 User experience is a consequence of brand image, presentation, functionality, system performance, interactive behavior and assistive capabilities of the interactive systems, the user's internal and physical state resulting from prior experiences, attitudes, skills and personality, and the context of use.

Note 3 Usability, when interpreted from the perspective of the user's personal goals, can include the kind of perceptual and emotional aspects typically associated with the user experience. Usability criteria can be used to assess aspects of user experience." (Borsci p. 50).

These definitions provide a set of fundamental characteristics that contribute to creating user experiences. These characteristics include the entire end-user's interaction process the perceptions and emotions both before and after a product interaction. In order to better understand what specific qualities contribute to this process, a further analysis on human perception, emotions, and interaction will be conducted and opportunities will be identified.

2.2.1 Defining users

A user, as defined in the term user experience, is anyone that engages in the process of interaction and the results before and after that interaction with a product. Determining specific qualities of a user helps inform the final design solution for a product's interaction experience. There are different strategies used to help define who a user is for a product or system. Most strategies involve some type of user research to be conducted. As described by Hoa Loranger in the article *UX Without User Research Is Not UX*, where user experience cannot exist without users. Loranger states, "Even the most well thought out designs are assumptions until they are tested by real users. Know the tools and apply them accordingly. Leaving the user out is not an option." (Loranger).

Defining a user can help determine what problems and potential solutions exist in a system. Lukas Mathis describes, in the book *Designed for Use*, the goal of user research is to find problems and solutions, and not to let the users tell us what they do or do not want (Mathis p. 8).

Table 2.1 *User researching techniques described in Designed for Use, Lukas Mathis, 2011.*

Find Problems	Find Solutions
Find out what people are currently doing.	Find a way of making what they are already doing easier and more efficient.
Find out what people have to do but really dislike doing.	Find a way of making the things they dislike obsolete, or at least more fun.
Find out what they would like to be doing.	Find a way of making what they want to be doing possible.

Mathis describes the problem of focus group style user research tends to present users with a specific problem to solve. As opposed to realizing the full potential of possibilities for a solution, a focus group will solve a specific problem (Mathis p. 7).

2.2.1.1 Personas

A strategy that can help make the user identification process more human is the creation of personas. Personas can be a working sketch of a perceived user for a product. Personas can help communicate user needs to different development groups on a project. They also help build a user-centered approach to finding design problems and solutions. However, as described by Mathis, personas do not replace user research (Mathis p. 21). Mathis explains that personas are a communication tool in the design process and not a replacement for actual user testing with real people (p. 21).

Loranger states that it is important to ensure that user testing does not include stakeholders or colleagues (Loranger). A true user will not have an invested interest in the success of the product or experience. The idea is that a user will be able to provide feedback without biases.

2.2.1.2 Ethnography

Ethnography is a research method based on observing people in their natural environment rather than in a formal research setting as a way to gain a deep understanding of people and how they make sense of their world (American Institute of Graphic Arts). Ethnographic research can assist in identifying user groups and the possible problems that those groups may have through a true understanding of cultural influences and their day-to-day experiences.

According to the American Institute of Graphic Arts, in the publication *An Ethnography Primer*, an ethnographic design process consists of six steps: define the problem, find the people, plan an approach, collect data, analyze data and interpret opportunities, and share insights (AIGA). An ethnographic research method can be considered an expanded breakout of Mathis' Table 2.1 of persona development. Ethnography starts to develop a framework for defining user groups and understanding their true problems which will help inform meaningful solutions.

2.2.1.3 Human-centered-design

Once a good understanding of the user is established, Human-centered design can be applied as one philosophy to help ensure that a user's requirements are being met. Donald Norman describes Human-centered design, in the book *The Design of Everyday Things: Revised and Expanded Edition*, as an approach that puts human needs, capabilities, and behavior first, then designs to accommodate those needs, capabilities, and ways of behaving (Norman p. 8). Norman describes the Human-centered design (HCD) process as having four steps, observation, ideation, prototyping, and testing each performed in sequence and repeated until satisfied. The key is that each iteration throughout the HCD process should present some type of progress (Norman p. 222).

A HCD process would works well to produce solutions that have a deep understanding of the user. Another approach, discussed by Mathis, is that of activity-centered design, where the solutions are based on activities or goals (Mathis p. 25). An activity-centered design process will place the emphases of the outcome on tasks and make an assumption that users will adapt to the solution. It is important to determine when to use HCD or ACD early on in the development process (Mathis p. 27).

2.2.2 User interface

Users that interact with a computer system are often presented with a visualization of operations that can receive input data from the user. An example of this is the operating system for a desktop computer. The operating system visualizes available operations for the user to select. The user interface, according to the International Standards Organization, is one component of an overall user experience. Norman describers three conceptual models of operation in his book, *Emotional Design: why we love (or hate) everyday things*. The system image is described as the actual operations of the machine. The designer's model is described as the visualization of the system image, and it does not always visualize all of the system operations. The user's model is described as the user's perception of how the system image should operate (Norman p. 75).

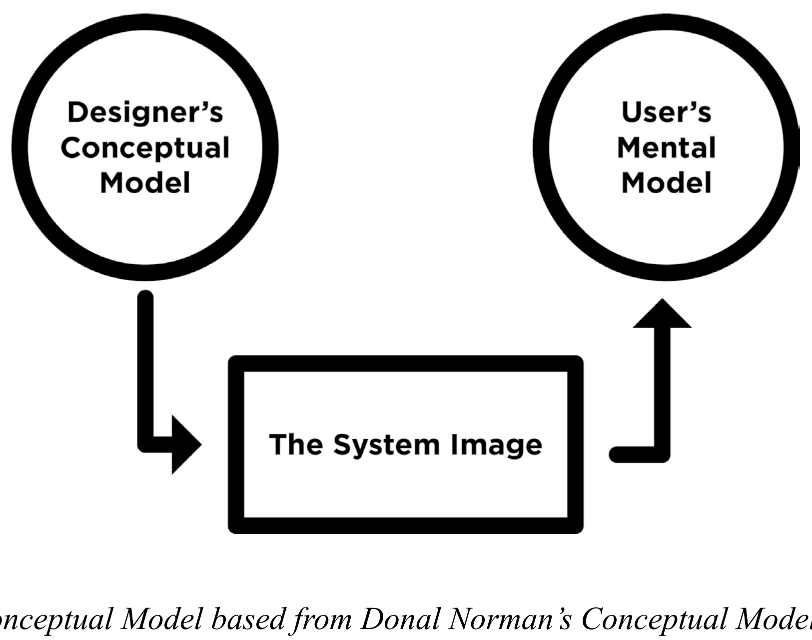


Figure 2.1 *Conceptual Model based from Donal Norman's Conceptual Model in Emotional design : why we love (or hate) everyday things, 2006.*

Notice how the designer's model and user's model do not directly communicate in Figure 2.1. The communication channel for a designer and user is through the system image. Not having direct communication with the user is a challenge for designers as they attempt to understand the user's mental model on how the system image should operate. This is why strong user research is needed before designers construct a final model.

2.2.3 Human factors

Human factors are characteristics that relate to human senses, emotions, and perceptions. These traits are qualities that contribute to how humans process information. It would be easy if humans could interpret data from computers literally. However, the power in understanding and processing computer data lies in the ability of humans to interpret data based on human factors. This section will consider what specific characteristics contribute to human factors and how these contribute to a user's interaction experience. The UEEI will have to be able to measure some form of human factors to help understand how the experience is being interpreted through a user's sensory inputs and perception.

2.2.3.1 Sensory

Sensory processing is the human ability to process multiple sensory channel inputs at once without sacrificing their cognitive load or working memory. David Rose describes, in his book *Enchanted Objects: Design, Human Desire, and the Internet of Things*, the sensory abilities of an Apache helicopter pilot. The pilot has a heads-up display in the visor of the helmet, along with a dashboard full of buttons. Pilots fly the aircraft with their hands and feet, receive communications through their headsets and sit on a bumper seat that vibrates signaling areas of potential danger. The pilot is relying on sight, hearing, and touch to fly the helicopter (p. 164).

This extraordinary ability to multi-task with sensory inputs demonstrates the processing power of the human brain over a computer system. A modern circuit, in a computer system, is able to process information one piece at a time. Regardless how fast it is able to perform the calculation, it is still limited. This is referred to as the von Neumann bottleneck (Hamm and Kelly p. 84). The human sensory input channels can be processed simultaneously in the human brain, providing an opportunity to utilize sensory input channels to increase communication abilities between humans and machines. These qualities contribute to environmental and human perception and all contribute to the overall user experience.

2.2.3.2 Emotion

Norman describes emotion, in the book *Emotional design : why we love (or hate) everyday things*, as a reflective quality in a user. At the reflective level consciousness and the highest levels of feeling, emotions, and cognition reside (Norman p. 38). Emotion is a powerful influence over a user's perceived interaction with a product. Norman describes three levels that demonstrate how a user interacts with a product: visceral which is equal to the appearance, behavioral which is equal to the pleasure and effectiveness of use, and reflection which is equal to the self-image, personal satisfaction, and memories (Norman p. 39). Norman has identified a quality of satisfaction as relating to emotional qualities. Norman describes a universal aspect of self as a desire to be well-thought-of by others, even if behavior others praise differs across cultures. This can be stylized to state that users regard the importance of other people's opinion very highly (Norman p. 54).

Emotion also shares a quality defined in the International Standards Organization's definition of a user experience as the interaction, both before and after with a product or services (ISO). Norman states that reflective qualities can extend past the current moment in time where a user can remember the past and contemplate the future (Norman p. 38). Visceral and behavioral qualities exist in the current time and do not transcend over time. It would seem that emotion is a key influencer to a user's experience.

2.2.3.3 Perception

Users who participate in interacting with a system enter with a set of goals. They have an expectation that they will be able to accomplish their goals by using the system before them. These users also come with an individualized set of experiences that contribute to how they perceive the system to function. As Norman's conceptual model, (Figure 2.1), states, the user's mental model consists of a perceived interpretation for how a system should function.

Jeff Johnson defines three qualities of perception that influence users in the book *Designing with the Mind in Mind*, as experience, context, and goals. Johnson categorizes these by time with the past equal experiences, the present equal to the current context, and the future equal to our goals (Johnson p. 1). Experience relates to the variables that contribute to our current understanding of a message. These could be any number of cultural, ethical, and personal events that contribute to the current status of the user. Norman describes a users perception of experience as the feeling of self (Norman p. 54).

Context can be influenced by how content is presented to the user. Information such as placement, surrounding content, and past experiences can all influence context. Context can also be influenced by sensory items such as sounds and touch (Johnson p.5). When interacting with a keyboard, an individual key is depressed causing a feeling of soft resistance as the key is pushed down combined with a sound of movement. All of these senses contribute the user's perception that a button is pushed.

Goals can act as filters to a user's perception. When a user enters a system with a pre-determined set of initiatives, they tend to filter out what is not important to achieving those goals (Johnson p. 8). Johnson refers to this as perceptual filtering — and claims that it is especially apparent in adults who are keen to being focused and driven compared to children who are more susceptible to stimulus (Johnson p. 7).

2.2.4 Evaluation methods

Methods of evaluating user interfaces have been developed in an attempt to provide foundational measures for designers and developers. Each new method attempts to address issues around new technology and ease of usability in the interaction process. Two popular evaluation methods from the late 1980s and early 1990s are from Schneiderman and Nielsen as seen in the comparison table from Jeff Johnson's Designing with the Mind in Mind (p. xiii).

Table 2.2 *Two best-known lists of User Interface Design Guidelines based from Designing with the Mind in Mind, Jeff Johnson, 2010.*

Shneiderman (1987); Shneiderman and Plaisant (2009)	**Nielsen and Molich (1990)**
• Strive for consistency • Cater to universal usability • Offer informative feedback • Design task flows to yield closure • Prevent errors • Permit easy reversal of actions • Make users feel they are in control • Minimize short-term memory load	• Consistency and standards • Visibility of system status • Match between system and real world • User control freedom • Error prevention • Recognition rather than recall • Flexibility and efficiency of use • Aesthetic and minimalist design • Help users recognize, diagnose, and recover from errors • Provide online documentation and help

Table 2.2 highlights key areas of emphasis in error processing and system responses. The idea that a human can control a system requires that the human understands the system. Imagine if a conversation with another person was all one-sided and no feedback was presented. Frustration would ensue because there would be no way to measure a response or know if ideas were being processed appropriately. The same frustration would be felt if the only response received was "error". Humans need contextual feedback as a point of reference when navigating the unfamiliar spaces of a computer system.

Borsci presents an International Standards Organization (ISO) Quality in use figure to demonstrate five variables of effectiveness, efficiency, satisfaction, freedom from risk, and context coverage (p. 44). The ISO also released a separate evaluation measure specific for computer systems called System/software product quality. It appears that the ISO has identified two separate evaluation measures. One for a user experience and one for a user interaction with a computer system. The Quality in use chart starts to address a human specific variable of

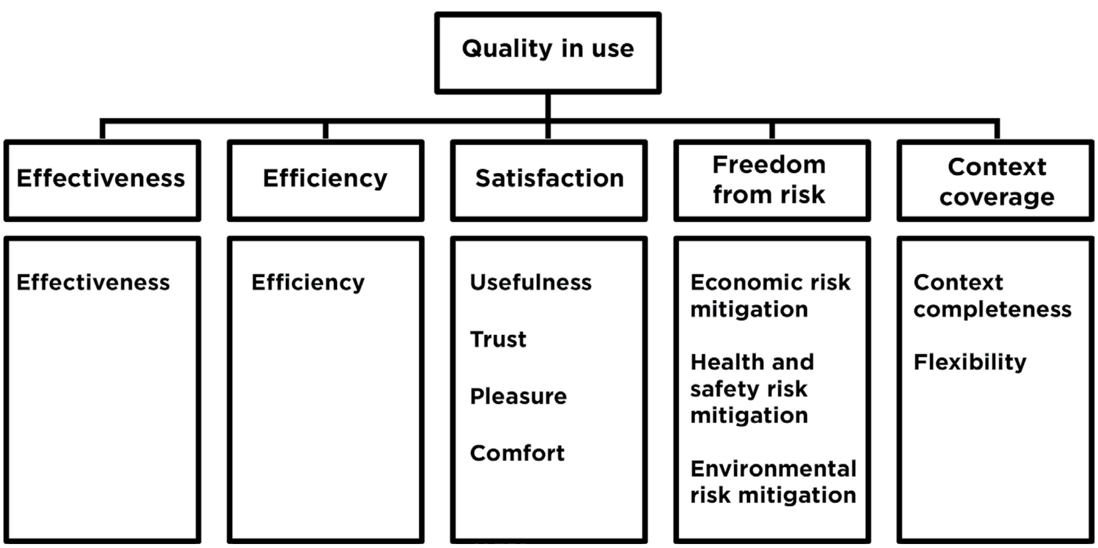


Figure 2.2 *Quality in use evaluation fro the ISO and based from Borsci's Computer Systems Experiences of Users with and without Disabilities, 2014.*

and Nielsen user interface guidelines, it becomes apparent that each one of the items contributes to human satisfaction on some level.

Norman describes fundamental principles of interaction in the book *The Design of Everyday Things*. He describes five items that should be present in an interaction with a system. These items are affordances, signifies, mapping, feedback, and a conceptual model (p. 13). Affordances are described as anything that builds a relationship between the properties of an object and the capabilities of the agent that determine how the object could be used (Norman p.11). A relational term is a signifier, which Norman describes as communicating where an action should take place. Both affordances and signifiers are used to describe what actions are possible and where they should occur (Norman p. 14).

Consider a keyboard for a computer. The raised design of the keys from the surface suggest that an action button pressing can occur. The arrangement of separate buttons are signifiers, suggesting that separate actions will occur with each button. The placement of letters on each button is reference to the term mapping. Mapping, as Norman suggests, is the relationship between the elements of two sets of things (p. 20). In the keyboard example, that would be the relationship of a button to a particular letter. Mapping is also demonstrated in the navigational elements of website design, providing a visual reference of structure and organization of a particular website directory.

When pressing a key on a keyboard, the physical feeling of the button depressing along with the visual display of the letter on the screen are both examples of feedback, one tactile and the other visual. Norman describes feedback as communicating the results of an action (p. 23). Norman suggests that feedback should be immediate and a delay of feedback will cause people to leave the system. The idea of feedback is present in the Scheiderman principles and contributes to the ISO Quality in use table of satisfaction. Feedback does not always have to be positive as long as it is communicated to the user.

The last of Norman's fundamental principles of interaction is the conceptual model. Norman describes the conceptual model as an explanation, usually highly simplified, of how something works. It does not have to be complete or even accurate as long as it is useful (p. 25). This is an interesting concept. How could an incomplete and inaccurate model be useful to a user of a computer system? Computers are machines that perform complicated calculations. If an average person were presented with a complete working model of a laptop computer as a guide for operation, they could easily become overwhelmed. An operating system on a PC or mac computer is an example of a visualized conceptual model. Users are not presented with a command line screen to programmatically enter desired tasks to complete. Instead they are presented with a visualized map with affordances and signifiers that provide the user with a simplified set of basic operations to select from. It provides the user with an opportunity to specify how they want to interact with the system while at the same time providing a Schneiderman principle of a feeling of control.

2.3. Cognitive design

The future of a machine's ability to interact with humans will increase in efficiency and natural language responses. This increased ability will come from the area of cognitive sciences where innovations in the areas of cognitive computing, where machines will learn how to communicate with humans using sensory inputs and natural reasoning. Designers will be tasked with translating cognitive science into design experiences that offer transformation by guiding behavior. Cognitive computing offers advancements in machine functionality, but designers will be in charge of translating that functionality into effective dialogue between machine and users. Just like designers have been tasked with creating visual user interfaces, they will now be creating holistic experiences. Environments, sensory inputs, and large sets of user provided context will all have to be considered in designing these experiences. Cognitive computing will allow the user to more effectively communicate with the machine and now the designer must also provide a way for the machine to communicate back to the user.

2.3.1 Cognitive computing

Steve Hamm and John Kelly, in the book *Smart Machines: IBM's Watson and the era of cognitive computing*, state,

> "It's vital to develop systems that can recognize images and sounds more like humans do. As the world becomes more complex and as its complexity becomes increasingly decipherable via analytics, we will need machines that can comprehend what's going on in the physical world and provide an expansion of human senses." (Hamm and Kelly p. 70).

Hamm and Kelly are demonstrating the need to create computers that can communicate to humans and their environments using communication channels that respond to human and environmental conditions. Norman and Johnson demonstrated the desire for humans to communicate in sensory and emotional channels.

However, computers have not had the available technology to process responses from humans on these types of channels until recently. Dynamic learning machines have been used to mine information from a variety of sources, textual, numerical, visual, sensory, across economic, business, and social science industries (Hamm and Kelly p. 26). Analyzing existing data systems to interpret appropriate human responses can help facilitate the engagement between humans and computers.

Along with responding to sensory input, computers will need to learn how to adapt to random human response. Computers are naturally logical and process information in sequence. However, humans tend to be naturally illogical in their communication responses; this is where humans harness creativity. Hamm and Kelly explain the concept of stochastic optimization as the use of probability theory or random phenomena to analyze complex problems which can be used to help understand a human's natural random responses (Hamm and Kelly p. 52).

2.3.1.1 Natural language

Norman describes, in the book *Emotional design: why we love (or hate) everyday things*, the concept of the emotion chip that could be added to data that would be responsible for interrupting emotional inputs (Norman p. 165). Norman was looking to science fiction concepts to help frame what an emotional machine might respond to. He described machines with facial features that can interpret emotions with visual expressions. Hamm and Kelly have demonstrated the ability for computer systems to analyze data systems as a way to interpret and provide natural responses tailored to the user.

Figure 2.3 demonstrates Norman's Seven Stages of Action when a user interacts with a system. Norman's principles of visceral, behavioral, and reflective interaction are displayed corresponding to a system interaction cycle. Real world experiences influence goal decision making and goal outcomes influence the real world. This cycle demonstrates the role of human sensory inputs in vision, emotion, and memory recall have in a communication process for the

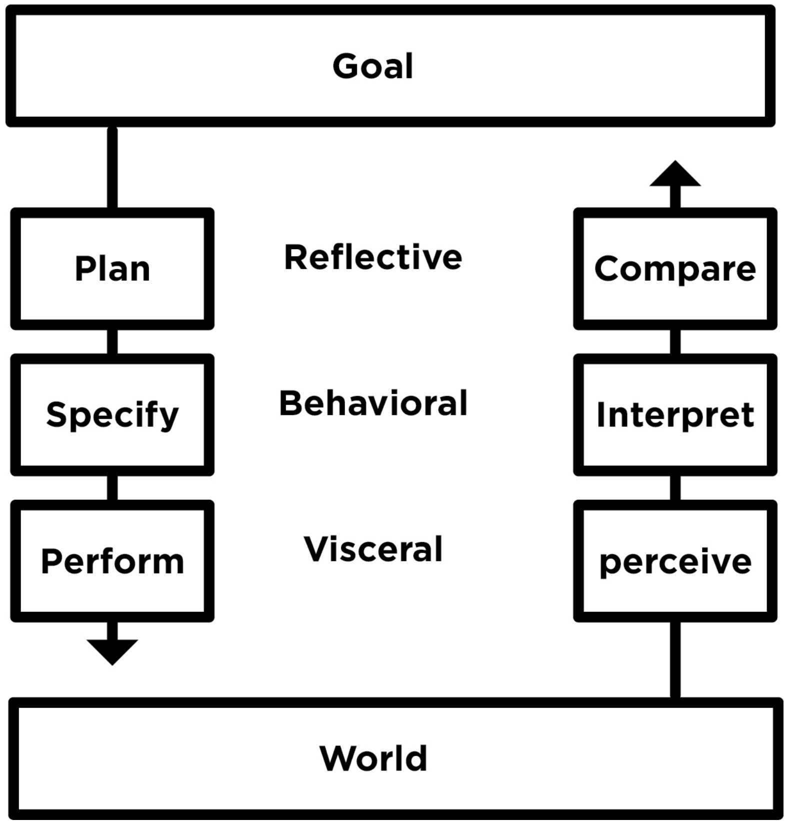


Figure 2.3 *The Seven Stages of Action based from Donald Norman's book The Design of Everyday Things: Revised and Expanded Edition 2013.*

user. A computer system attempting to respond to a user in a similar fashion might also have to follow a similar information response process to reflect a user's natural communication process.

2.3.2 Communication channels

David Rose's example of the Apache helicopter pilot demonstrates the ability of a human brain to process multiple sensory input channels at one time. Compared to a commuter system's von Neumann bottleneck effect, a human brain is far more capable at processing multiple sensory inputs at one time. As Rose demonstrates, humans are able to receive and process information with multiple sensory channels. The challenge is up to machines to learn how to harness that human ability and communicate on similar levels.

The Apache helicopter is made up of several systems that handle many different processes. The radio is a controlled communication system separate from the rumble seat. Each system has its own ability to process and communicate data. This separate system allows the Apache helicopter to avoid the von Neumann bottleneck. However, this system is not smart enough to be able to understand how each separate system affect the complete operation of the machine. That is where the pilots utilizes their skill sets.

Consumer grade machines will have to harness other processing resources to help negate the von Neumann bottleneck. Hamm and Kelly discuss the need for dynamic learning machines that will continually mine information from a variety of sources such as textual, numerical, visual, and sensory (p. 8). These dynamic learning machines will access cloud based databases that will allow for processing of this information to happen in multiple locations and report back to the dynamic learning machine on the results for the machine to process the appropriate natural human response. While this process is technically theoretical, there is some level of application that already exists in modern technology.

2.3.2.1 Guided behavior

Rose identifies seven abilities of enchantment that he claims contributes to a machine's ability to earn a user's trust and attention. These are glanceability, gestureability, affordability, wearability, indestructibility, usability, and lovability (p. 173). The topics of affordability, wearability, indestructibility and usability are not new concepts, but when presented in this group of enchainment, these concepts provide information on how technology products find their way into everyday lives of users.

Three of the topics — glanceability, gestureability, and lovability — are newer concepts and deserve further discussion. Glanceability focuses on the ability for a machine to help users make almost subconsciously precision timing and focused information (Rose p. 173). It is the ability for the machine to synthesize and simplify information so it is enjoyable to view and not overwhelming with increased demand on the user's active memory (Rose p. 179).

Gestureability is an object that humans naturally know how to interact with. They are able to sense and to respond to our natural movements (Rose p. 181). Typically technology that takes advantage of human's natural interactions sense motion of the user or objects that the user is controlling making for an efficient way to leverage communication.

Lovability is not that dissimilar from Norman's concept of emotion. Rose describes lovability as emotional engagements that could be informal cues — visual, or gestural — that suggest anthropomorphism. Rose uses the example of a sound emulating the purring of a cat, suggesting that these cues intensify a user's desire and bond with those objects (p. 190).

A designer could leverage Rose's topics to find opportunities to create connections with users. These connections could be used to inform behavioral guides. For example, a designer could create a purring kitten sound to signal a user to glance at a photo of their child that appeared on their smart watch. Users could customize and provide access to data that allows the designer and technology to further customize these experiences for an even more refined experience.

2.5. Measuring user experience

Applying best practice statistical methodologies will inform the development of the final user experience instrument for accuracy and statistical comprehension. The Single Usability Metric will be reviewed for use in summarizing category sections within the user experience instrument. A foundational understanding of survey ability and application will show the limits and opportunities for applying a survey structure to the final user experience instrument. A review of existing usability surveys, Usability Metric for User Experience in section 2.5.2. and the Post-study Usability Questionnaire, in section 2.5.3, will be reviewed and appropriate applications identified for application in the user experience instrument.

2.5.1 Survey data

Surveys can be used for gathering user requirements and post user system interaction information. Surveys can include some combination of open-ended comments, yes/no responses, and rating scales as Jeff Sauro and James R. Lewis state in their book, *Quantifying the user experience: practical statistics for user research* (p. 15). User requirements for a system may use a survey in a matrix format to associate users to behavior types (Figure 2.4).

	User 1	**User 2**	**User 3**
Behavior 1	X	X	
Behavior 2	X		
Behavior 3	X		X

Figure 2.4 *UI Behavior Matrix based from Quantifying the user experience: practical statistics for user research 2012.*

Rating scales are a form of surveys that contain close-ended responses that can be converted into numbers that can be computed for the mean and standard deviation to generate confidence levels of the user with their interaction with the system (Sauro and Lewis p. 15).

Surveys can also be used to gather open-ended questions. These questions can be categorized and quantified and added to a confidence interval to understand what percentage of users will likely feel this way (Sauro and Lewis p. 16).

2.5.2 Usability metric for user experience (UMUX)

Suaro and Lewis describe the Usability Metric for User Experience (UMUX) as having a primary goal to get a measurement of perceived usability which is closely conformed to the International Standards Organization's (ISO) definition of usability (p. 227). The ISO's usability definition focuses on the categories of effective, efficient, and satisfying. The three main concepts that make up the UMUX are:

1. This system's capabilities meet my requirements.
2. Using this system is a frustrating experience.
3. I have to spend too much time correcting things with this system.

These questions are on a rating scale from 1, strongly disagree, to 7, strongly agree (Sauro and Lewis p. 227).

Incorporating the three UMUX rating scale concepts into the UEEI will provide a quantified variable for post system interaction with a user interacting with a system.

2.5.3 Post-study System Usability Questionnaire (PSSUQ)

A post-study should be included in some format in measuring a user's experience. The Post-study System Usability Questionnaire (PSSUQ) is designed to assess a users' perceived satisfaction with computer systems or applications (Sauro and Lewis p. 192). According to Sauro and Lewis, the PSSUQ produces four usability scores: (1) Overall which is calculated by the average responses for items 1 through 16. (2) System Quality which is calculated by averaging

1 = Strongly Agree 7 = Strongly Disagree

		1	2	3	4	5	6	7	NA
1	Overall, I am satisfied with how easy it is to use this system.								
2	It was simple to use this system.								
3	I was able to complete the tasks and scenarios quickly using this system.								
4	I felt comfortable using this system.								
5	It was easy to learn to use this system.								
6	I believe I could become productive quickly using this system.								
7	The system gave error messages that clearly told me how to fix problems.								
8	Whenever I made a mistake using the system, I could recover easily and quickly								
9	The information (such as online help, on-screen messages and other documentation) provided with this system was clear.								
10	It was easy to find the information I needed.								
11	The information was effective in helping me complete the tasks and scenarios.								
12	The organization of information on the system screens was clear.								
13	The interface of this system was pleasant.								
14	I liked using the interface of this system.								
15	This system has all the functions and capabilities I expect it to have.								
16	Overall, I am satisfied with this system.								

Figure 2.5 *Post-study System Usability Questionnaire based from Quantifying the user experience: practical statistics for user research 2012.*

items 1 through 6. (3) Information Quality which is calculated by averaging items 7 through 12; and (4) Interface Quality which is calculated by averaging items 13 through 15 (p. 192). The PSSUQ survey is intended for laboratory use, meaning that the users will have recently interacted with a system before completing the survey. If evaluation of the user is conducted at another location, or significant time has passed since the user has completed their interaction with the system, a Computer System Usability Questionnaire (CSUQ) should be used (Sauro and Lewis p. 224). The CSUQ is almost identical to the PSSUQ, with a few wording changes in the questions to reflect lapsed time and past events.

2.5.4 The single usability metric (SUM)

As described by Sauro and Lewis, The Single Usability Metric (SUM) is a standardized, summated, and single usability metric developed to represent the majority of variation in four common usability metrics used in summative usability tests: task completion rates, task time, error counts, and satisfaction (p. 255). The combination of related data into one score can help provide further insight into the interoperation of the usability data. The challenge when using a statistical methodology to combine data into one score is the possibility of combining independent variables that are drastically different and the combination of data will provide a statistically uninterpretable result (Sauro and Lewis p. 255).

The SUM is an interpretable statistical methodology of combining different usability metrics into one score (Sauro and Lewis p. 256). Meaning that applying the SUM methodology will allow for interpretable statistical data that can help provide insight into system usability metrics. Applying the SUM methodology to the proposed instrument will help yield insight into metric categories. For example, a human sensory category in the UEEI could have a SUM value that provides one score from the group of data metrics in that category.

While a SUM score will be beneficial data to provide in a report after the UEEI is applied, it will also be important to provide the raw data along with the SUM score. Providing a standard deviation or confidence interval when reporting a mean will help prevent the loss of information from combining measures (Suaro and Lewis p. 255). It could be considered as showing your work or process for how the SUM score was calculated. While the SUM score will be a valued metric, it will not be the only metric used to derive conclusions. Providing raw data will yield other insights for application.

2.6 Summary

The definition of user experience according to the International Standards Organization can be summarized as including all the user's interactions, emotions, and environmental conditions pre, post, and during a system interaction. Norman provides qualities and characteristics for defining a user and how emotions can be interpreted from interactions through his seven stages of action relating to visceral, behavioral, and reflective. The challenge is understanding how to capture an evaluation measure from the user. Determining how to evaluate emotion and perception is difficult because these values can change from user to user. Both Norman and Rose provide frameworks for how user's perception can be guided and how users make decisions based on these behaviors in the areas of glanceability, gestureability, affordability, wearability, indestructibility, usability, and lovability.

Sauro and Lewis provide best practice principles on how to work with evaluation surveys and Likert ratings scales as they relate to user experience. The Usability Metric for User Experience (UMUX) is a series of three questions with specific intention to understand effective, efficient, and satisfying experiences. The Post-study System Usability Questionnaire (PSSUQ) is a series of 16 questions focused on evaluating the quality of a system, interface, and information experienced by a user during an interaction. The Single Usability Metric (SUM) can be used as a methodology to combine quantified variables sets into a single metric for further evaluation.

CHAPTER 3. METHODOLOGY

3.1. Overview

Norman's conceptual model, (Figure 2.1), highlights communication limitations between users, designers, and the system image. The proposed model looks for opportunities to improve communication between the three groups by incorporating channels of communication between the user, the designer, and the system. The ultimate problem is that users would like to interact with a system that they do not have the ability or desire to design. The designers are not true users of the system and are not able to design for every available user. Cognitive design and cognitive computing present communication channel opportunities that can increase the potential that the user and designer models match as close as possible and the system image matches the user's expectations.

The methodology will propose an instrument that can be tested for effectiveness, reliability, and consistency. The proposed instrument is an early stage prototype and not a final product. A pilot study will demonstrate areas that require further research.

3.1.1 Purpose

A modern circuit is able to process information one at a time, regardless of how fast it is able to perform the calculation, it is still limited. This is referred to as the von Neumann bottleneck (Hamm and Kelly p. 84). If we consider the current workflow of the designer and evaluation model, they occur at separate times. The designer completes their model then releases it to the user. After which point the model is evaluated. The current model seems to represent a von Neumann design bottleneck. Designers are only able to respond to one evaluation at a time.

Adding communication challenges between the designer, user, and system that allow for

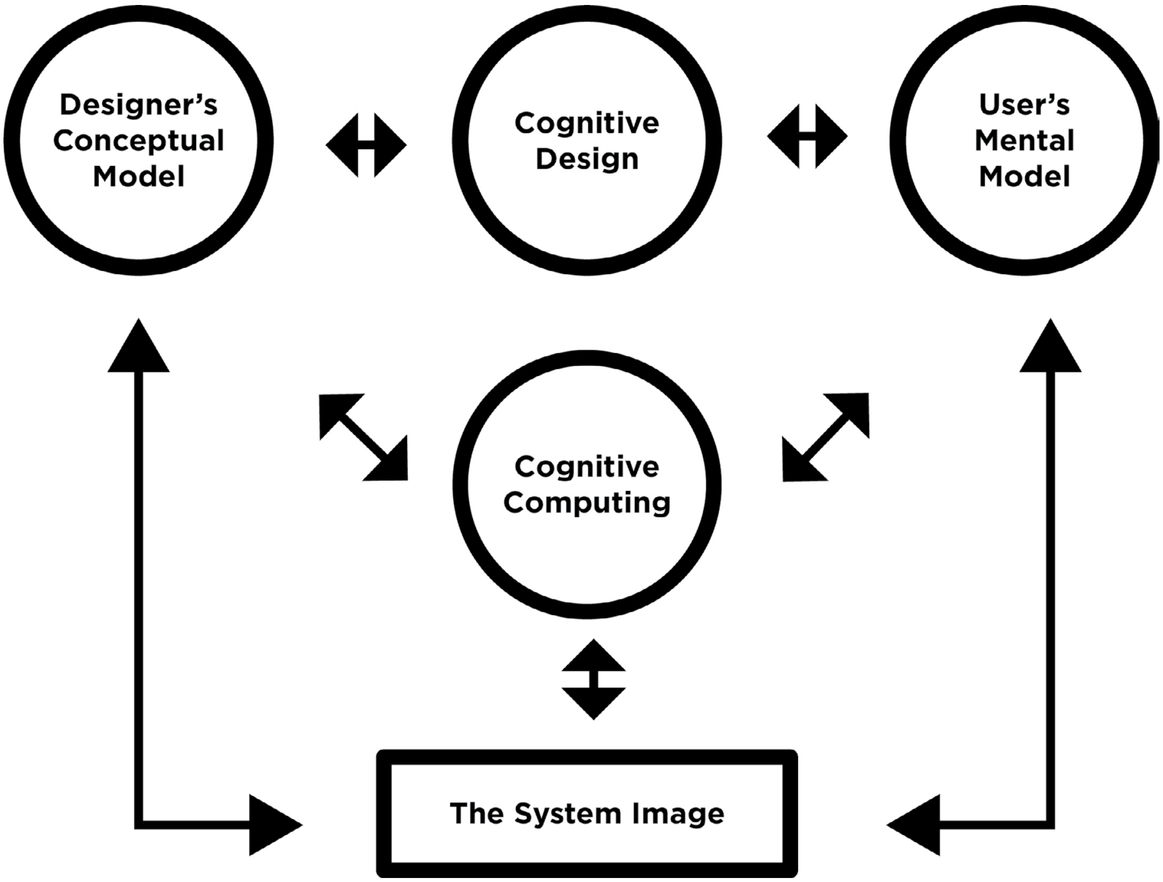


Figure 3.1 *Proposed communication workflow model using cognitive design and cognitive computing to increase communication channel inputs between the design, user, and system.*

direction communication between each group and the ability to respond to each other should increase the potential for matching a user's mental model with the design of the system image as the designer and cognitive computing facilitates information processing. Increasing the match of the user's mental model to the system will in turn increase the satisfaction of the user experience as a whole.

The proposed workflow model demonstrates how the design, user, and system image would communicate with each other through the additional channels. The proposed instrument will provide opportunities for the designer and system to evaluate the user experience at different

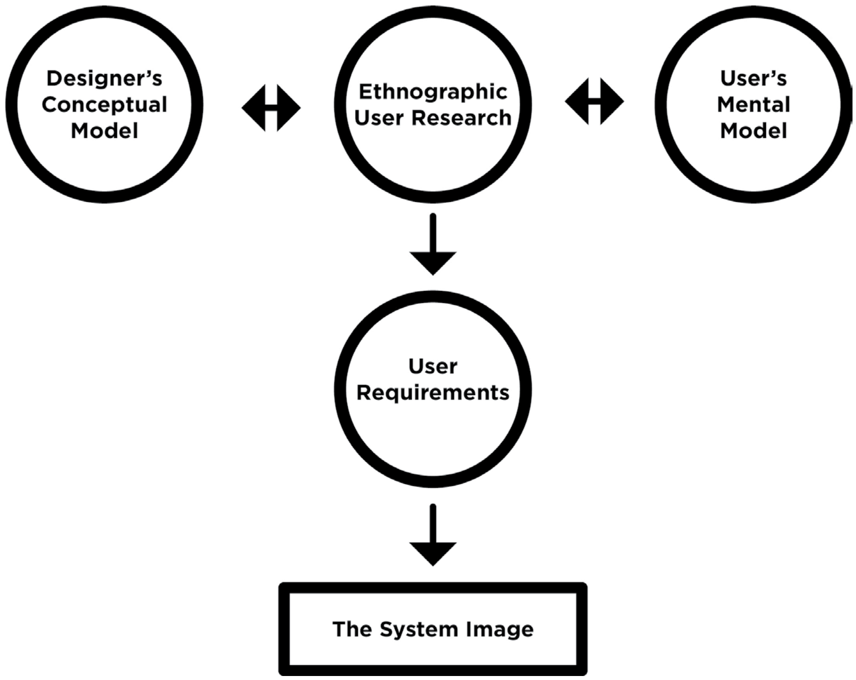


Figure 3.3 *Proposed User Research Methodology using Ethnographic Research to define user requirements before a user beings interacting with a system.*

points in the model.

The proposed workflow operates under the user interface for all design philosophy (UIA). The UIA was developed in order to solve the problems and overcome the criticism and shortcomings for the universal design philosophy included in a user-centered-design approach. The user-centered-design (UCD) approach is the first pioneering design philosophy that tried to drive the designer to fulfill the two ideal conditions (Brosci p. 29). The two ideal conditions being the designer and the user's model of the system image. UCD operates on the idea that the designer can perform appropriate user research to understand as much as possible about the user. The challenge with the UCD is that it did not provide the ability for the designer to adjust to the user's needs after the model was constructed.

A UIA workflow model, (Figure 3.6), shows that a designer can reach the goal of design

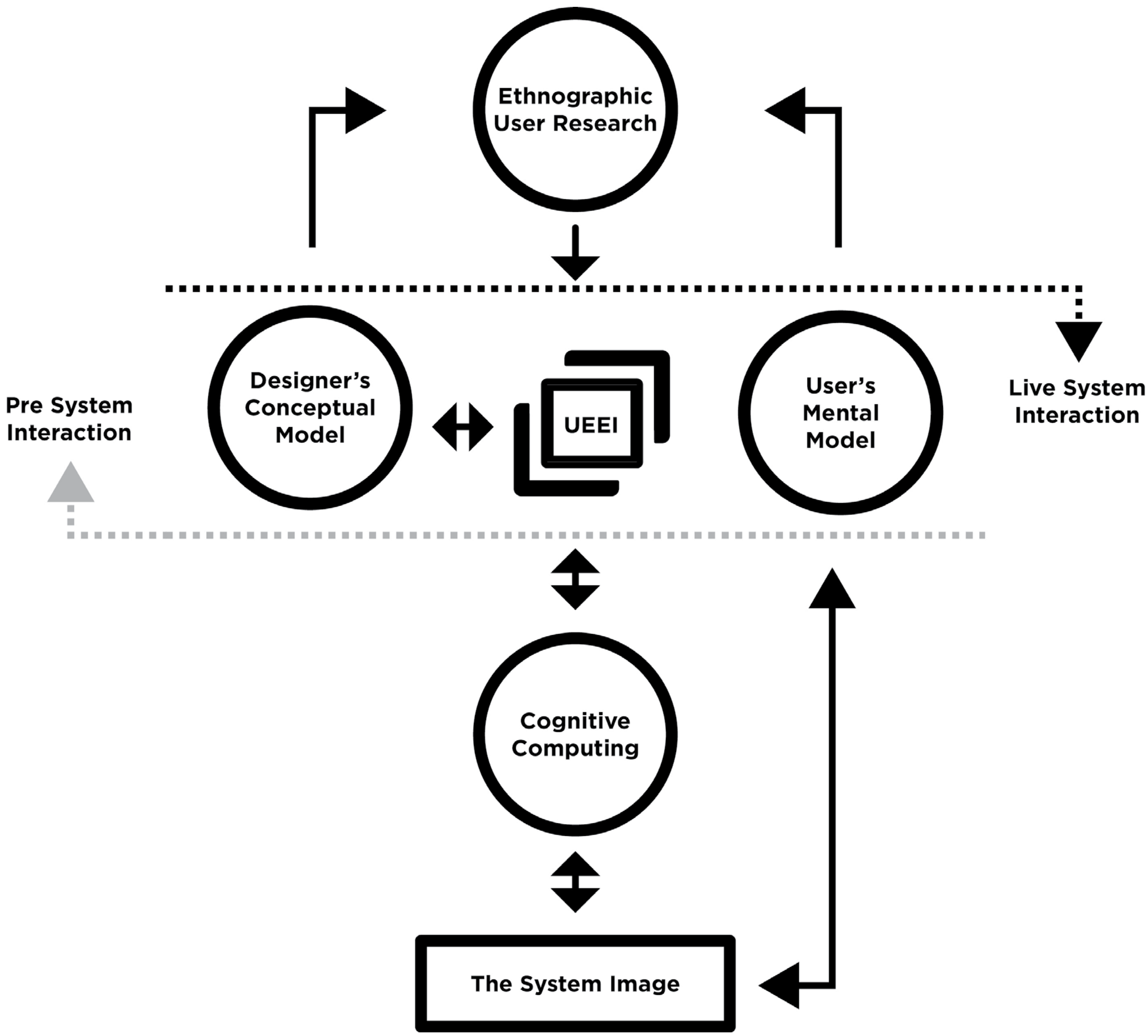


Figure 3.4 *Designer and User's Mental Modal Cognitive Computing Evaluation Communication Process.*

1 = Strongly Agree   7 = Strongly Disagree

		1	2	3	4	5	6	7	NA
1.	This systems capabilities meet my requirements.								
2.	Using this system is a frustrating experience.								
3.	I have to spend too much time correcting things with this system.								
SUM	**Usability Quality** **Single Usability Metric (SUM) Score** **Total of scale from 1-6**								

Figure 3.5 *Usability Metric for User Experience (UMUX) with a Liket Rating Scale and The Single Usability Metric (SUM) total score.*

for all if they take into account the user's requirements, abilities, and preferences align with the accessibility and quality of the interaction (Borsci p. 33).

The proposed communication workflow model equalizes the design and evaluation perspectives into a user-driven approach. The UIA design philosophy still relies on a designer developing to a user model and evaluators trying to rethink the model from a user point of view (Borsci p. 34). Creating a user-driven model, (Figure 3.1), equalizes the design and evaluation

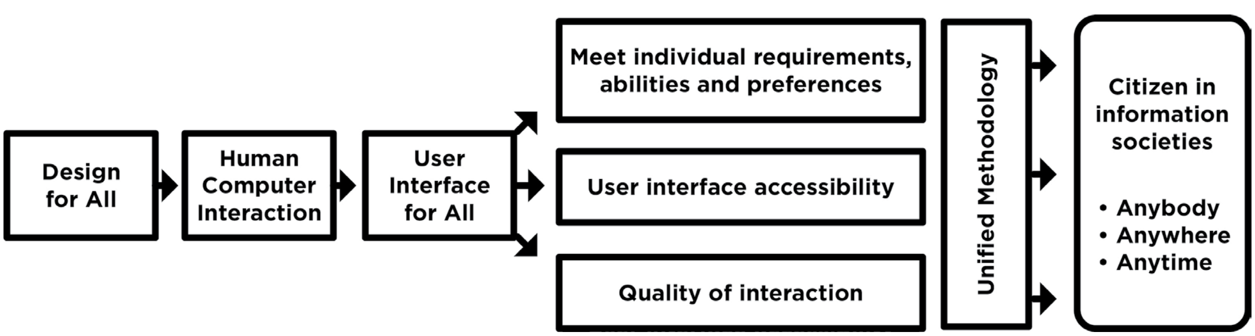


Figure 3.6 *Conceptual application of the UIA aim in the design process based on Computer Systems Experiences of Users with and without Disabilities, 2014.*

perspectives. The model becomes adaptive to the user as they are experiencing the interaction. It allows for designers to respond to evaluations directly from the user as they are engaging with the interface.

3.2. Instrument development

The UEEI will consider evaluation methodologies for pre, during, and post user system interaction. In order to quantify the results, a Likert rating scale will be used to measure the level of agreement with closed ended comments. One will serve as the highest agreement value while seven will serve as a lowest agreement value. Sauro and Lewis discuss the physiological methodology around a Likert rating scale with a positive low value and a negative high value, stating that there are varying approaches but the original intention of the Post-study System Usability Questionnaire (PSSUQ) showed that low quantified values were successful for accurate user evaluations (p. 192). Not applicable will be an available option to remove the question from evaluation, meaning that if ten items existed in a survey, a not applicable indication would reduce the items to nine, thereby reducing the total. A qualitative evaluation was not conducted in the pilot study. However, a NA qualitative follow up study is reviewed in future directions (6.3).

3.2.1 User requirements

This component of the user evaluation will be conducted before the user begins his or her interaction with the system. The user researcher should conduct an evaluation of the user and understand the user’s behaviors and requirements as they relate to the system. An ethnographic methodology can be utilized to understand the user or user groups with a focus on observing cultural, social, and personal behaviors, constraints and opportunities. These observations should be presented in a survey table resembling Figure 2.4. This survey will be documented and applied to the system before interaction.

Cognitive computing could be used to populate all or some of the user requirements information into the system without input from a researcher or user. For example, a user could choose to identify the use of existing personalized data sets such as social media or other existing personal and social data context. Cognitive design could be used to interpret the data and provide a framework for user interface signifiers.

3.2.2 System interaction

The Usability Metric for User Experience (UMUX) will be used to determine a live user interaction evaluation. Applying UMUX during a live user interaction will increase the communication effectiveness of interactions between the user and machine by allowing for live performance adjustments. The idea is that that system would have access to a user requirements survey before system interaction to make a best judgement on how the initial experience should be conducted. During the interaction the system can utilize input variables from the UMUX for experience adjustments.

Cognitive computing can also play a role in live user evaluation. The system could make an analysis based on the inputs from the user to rank the variables and adjust the experience appropriately. Manual entry can be used by an observer other than the user. Observation can be conducted in a live interaction environment and variables determined and entered into the system for a live system response to the user's interaction.

3.2.3 System interaction post evaluation

The Post-study System Usability Questionnaire (PSSUQ) has been tested in application and proven useful in providing post evaluation metrics in the areas of quality in the system, system interface, and information as it retaliates to the user's experience. Utilizing 15 items from the PSSUQ will bring added insight to the UEEI. Item 16 will be omitted due to the addition of Usability Metric for User Experience (UMUX), which is more focused on capturing user experience metrics. Adding a Single Usability Metric (SUM) for each section of system quality, interface, and information will provide another metic to compare overall user experience.

This survey can be filled by the user after a system's interaction for the user experience designer to evaluate the experience. The SUM scores can be totaled and averaged for an overall metric the user's experience during the interaction.

1 = Strongly Agree   7 = Strongly Disagree

		1	2	3	4	5	6	7	NA
1.	Overall, I am satisfied with how easy it is to use this system.								
2.	It was simple to use this system.								
3.	I was able to complete the tasks and scenarios quickly using this system.								
4.	I felt comfortable using this system.								
5.	It was easy to learn to use this system.								
6.	I believe I could become productive quickly using this system.								
SUM1	**System Quality** **Single Usability Metric (SUM) Score** **Total of scale from 1-6**								

Figure 3.7 *System Quality section The Post-study System Usability Questionnaire (PSSUQ) with Likert Rating Scale and Single Usability Metric (SUM).*

1 = Strongly Agree   7 = Strongly Disagree

		1	2	3	4	5	6	7	NA
7.	The system gave error messages that clearly told me how to fix problems.								
8.	Whenever I made a mistake using the system, I could recover easily and quickly								
9.	The information (such as online help, on-screen messages and other documentation) provided with this system was clear.								
10.	It was easy to find the information I needed.								
11.	The information was effective in helping me complete the tasks and scenarios.								
12.	The organization of information on the system screens was clear.								
SUM2	**Information Quality Single Usability Metric (SUM) Score Total of scale from 7-12**								

Figure 3.8 *Information Quality section The Post-study System Usability Questionnaire (PSSUQ) with Likert Rating Scale and Single Usability Metric (SUM).*

1 = Strongly Agree 7 = Strongly Disagree

		1	2	3	4	5	6	7	NA
13.	The interface of this system was pleasant.								
14.	I liked using the interface of this system.								
15.	This system has all the functions and capabilities I expect it to have.								
SUM3	**Interface Quality** **Single Usability Metric (SUM) Score** **Total of scale from 13-15**								

Figure 3.9 *Interface Quality section The Post-study System Usability Questionnaire (PSSUQ) with Likert Rating Scale and Single Usability Metric (SUM).*

1 = Strongly Agree 7 = Strongly Disagree

		1	2	3	4	5	6	7	NA
16.	This systems capabilities meet my requirements.								
17.	Using this system is a frustrating experience.								
18.	I have to spend too much time correcting things with this system.								
SUM4	**Usability Quality** **Single Usability Metric (SUM) Score** **Total of scale from 16-18**								

Figure 3.10 *Usability Metric for User Experience (UMUX) with Likert Rating Scale and Single Usability Metric (SUM).*

3.2.4 Future system

Understanding how a system's user experience conforms to the user requires an evaluation of human qualities that the system may contain. Donald Norman and David Rose gave frameworks for analyzing how objects can communicate to humans through emotion, humans senses and natural language. Item one is derived from affordability which allows the system to financially accessible to the user. Items two and three are considering the indestructibility of a system. Measuring if the system is able to keep up and withstand a normal day-to-day set of operations with the user. Is the user required to operate the system under special conditions because the system is not operable under normal user? Item four is considering how information

1 = Strongly Agree 7 = Strongly Disagree

		1	2	3	4	5	6	7	NA
1.	Is this system affordable?								
2.	Does this system integrate with your lifestyle?								
3.	Is this system reliable for your day-to-day use?								
4.	Does this system present information in an enjoyable manner?								
5.	Does this system respond to your natural movements and inputs?								
6.	Does this system relate to your emotional considerations.								
SUM	**Future Quality** **Single Usability Metric (SUM) Score** **Total of scale from 1-6**								

Figure 3.11 *Future System Quality Metrics Version One.*

is communicated to the user under the principle of glanceability. The information could be presented in a variety of mediums but how is clear, efficient, accessable, and enjoyable is it to digest by the user? Item five is considering guesterability, how the system incorporates natural human movement in user input and responses. Item six is considering lovability, the emotional connection that a user has with the system.

This section of the evaluation quantifies with closed ended questions: the ability for the system to communicate to the user with human factors. These questions are subject and depended on individual users, which creates the user a variable. The evaluation of future systems can be included in the post evaluation. It could also be incorporated by the cognitive system during the user interaction and adjustments made accordingly as values are interpreted.

3.2.5 Compilation and revision

A compilation of all the evaluation metrics into one instrument is presented in this section. Language had to be adjusted to speak to the evaluator referencing the user of the system. Language was also adjusted to use less jargon and added clarity. The UEEI works as a compilation decided into categories. Each category contains questions that relate to different aspects of the system and user's perceived perception.

Figures 3.11, 3.12, 3.13, and 3.14 contain changes the language of the questions to reference a user for added clarity for an evaluator that will use the UEEI. Figure 3.15's wording was changed to make common sense to an evaluator. Figure 3.15 is asking questions that are not necessarily evident without some understanding of the user and their emotional, interaction, and style preferences.

Figure 3.17 changes the Human Quality items into statements, instead of questions, to match the wording format for the preview 18 items. This change brings consistency into the wording of each item which will allow for less participant confusion when the survey instrument is used. Topic words are still used for each item, styled in a bold format and titled at the top of each statement. This helps direct the user to understand what topic is referred to in the statement. The human quality metrics will probably contain the most NA results in the survey because participants may not understand how to properly interpret these items. The topic titles bring added clarity.

UX Questionnaire / System Quality **1 = Strongly Agree** **7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
1.	Overall, the user seems satisfied with how easy it is to use this system.								
2.	It was simple for the user to use this system.								
3.	The user was able to complete the tasks and scenarios quickly using this system.								
4.	The user felt comfortable using this system.								
5.	It was easy for the user to learn to use this system.								
6.	I believe the user could become productive quickly using this system.								
SUM1	**P.I. Use Only System Quality Single Usability Metric (SUM) Score Total of scale from 1-6**	**n Total**			**Total Amt**			**Mean**	

Figure 3.12 *System Quality Metrics Version Two.*

UX Questionnaire / Information Quality **1 = Strongly Agree** **7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
7.	The system gave error messages that clearly told the user how to fix problems.								
8.	Whenever the user made a mistake using the system, they could recover easily and quickly								
9.	The information (such as online help, on-screen messages and other documentation) provided with this system was clear to the user.								
10.	It was easy to find the information the user needed.								
11.	The information was effective in helping the user complete the tasks and scenarios.								
12.	The organization of information on the system screens was clear.								
SUM2	**P.I. Use Only** **Information Quality** **Single Usability Metric (SUM) Score** **Total of scale from 7-12**	**n Total**			**Total Amt**			**Mean**	

Figure 3.13 *Information Quality Metrics Version Two.*

UX Questionnaire / Interface Quality **1 = Strongly Agree** **7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
13.	The interface of this system was pleasant. to the user.								
14.	The user liked using the interface of this system.								
15.	This system has all the functions and capabilities the user expected it to have.								
SUM3	**P.I. Use Only** **Interface Quality** **Single Usability Metric (SUM) Score** **Total of scale from 13-15**	**n Total**			**Total Amt**			**Mean**	

Figure 3.14 *Interface Quality Metrics Version Two.*

UX Questionnaire / Usability Quality **1 = Strongly Agree** **7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
16.	This system's capabilities meet the user's requirements.								
17.	Using this system is a positive experience to the user.								
18.	The user has to spend too much time correcting things with this system.								
SUM4	**P.I. Use Only** **Usability Quality** **Single Usability Metric (SUM) Score** **Total of scale from 16-18**	**n Total**			**Total Amt**			**Mean**	

Figure 3.15 *Usability Quality Metrics Version Two.*

UX Questionnaire / Human Quality **1 = Strongly Agree 7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
19.	Affordable - Is this system affordable to the user?								
20.	Wearable/Integration - Does this system integrate with the user's lifestyle?								
21.	Durable - Is this system reliable for the user's day-to-day use?								
22.	Glanceable - Does this system present information in an enjoyable manner to the user?								
23.	Gesture - Does this system respond to the user's natural movements and inputs?								
24.	Emotion - Does this system invoke an emotional response to the user?								
SUM5	**P.I. Use Only** **Human Quality** **Single Usability Metric (SUM) Score** **Total of scale from 19-24**								

Figure 3.16 *Human Quality Metrics Version Two.*

UX Questionnaire / Human Quality **1 = Strongly Agree 7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
19.	**Affordable** The system is affordable to the user.								
20.	**Wearable/Integration** The system integrates with the user's lifestyle.								
21.	**Durable** The system is reliable for the user's day-to-day use.								
22.	**Glanceable** The system presents information in an enjoyable manner to the user.								
23.	**Gesture** The system responds to the user's natural movements and inputs.								
24.	**Emotion** The system invokes an emotional response to the user.								
SUM5	**P.I. Use Only** **Human Quality** **Single Usability Metric (SUM) Score** **Total of scale from 19-24**	**n Total**			**Total Amt**			**Mean**	

Figure 3.17 *Human Quality Metrics Version Three.*

3.3. Demonstration of use

An applied example of a perfect score for the User Experience Evaluation Instrument (UEEI) is demonstrated in Figure 3.18. Figure 3.18 combines the SUM values from each of the five sections in the UEEI into a table format for an overall perspective on each category. The n total is the total amount of all variables in a section. The total amount is the total quantified sum of each item and the mean is the total amount divided by the n total.

Figure 3.18 is a perfect score total and can be presented in an overview table format without a need to see how each section item scored because each item received a perfect rating value of one and each item variable was included. A score of one for an item represents a qualitative response of strongly agree which is seen as a positive rating in the UEEI. A total amount value of 24 represents that each variable item received a score of one. A n total value of 24 represents that each variable item was measured in the system. A mean value of one represents that every variable measured averaged a quantified score of one, or a qualified measure of strongly agree.

A SUM score is intended to provide another statistical perspective. It is not intended to be used as an overall statistical representation of the evaluated system. This is because the variable items being quantified do not all necessarily relate to each other. This means that the Human Qualities category represents a different quantified perspective than the interface quality section.

Figure 3.19 represents the UEEI's worst possible score. Each item is quantified with a value of 7, or a qualified value of strongly disagree which is a poor score in the UEEI. The n total has a value of 24 meaning that each item variable received a quantified score. The total amount has a value of 168 with a mean value of seven. These values state that each of the 24 item variables received a value of seven.

Figure 3.20 represents varied results which should be paired with the original raw data for further evaluation on specific item variable scores. Notice the n total values are not all complete. The total of n is 21, meaning that three item variables were not scored and removed from the UEEI. The item variables that receive a score of NA are removed to provide an accurate representation of the actual capabilities of the system. The items did not provided a quantified score of zero because that would negatively influence the results. Not all item variables are expected to exists in all systems. For example, item nine states: the information (such as online help, on-screen messages and other documentation) provided with this system was clear to the user. A system may not have help or support documentation to assist the user in their interaction. Instead, a system might operate with an errorless interaction process where the user is redirected to a starting point instead of viewing support documentation.

Figure 3.21 is the Human Quality section for the UEEI of Figure 3.20. Figure 3.21 provides the raw item scores to allow for further specific evaluation on the system. For example, it was marked that the stem did not have any emotional influences on the user so it received a score of NA and was removed from the SUM scores. It can also be determined that the system was affordable to the user but did not integrate with their lifestyle. The raw metrics from a section help inform specific areas of strength and weakness in a system as demonstrated by the UEEI.

A limitation to the demonstration of use in the pilot study is that the UEEI is used as a post evaluation instrument when it’s true intention is to be used as an evaluation instrument during a user’s experience. Future consideration should look at how to reword the UEEI to relate to a live user experience.

UX Questionnaire / SUM Totals / Perfect Score

		n Total	Total Amt	Mean
SUM1	System Quality Single Usability Metric (SUM) Score Total of scale from 1-6	6	6	1
SUM2	Information Quality Single Usability Metric (SUM) Score Total of scale from 7-12	6	6	1
SUM3	Interface Quality Single Usability Metric (SUM) Score Total of scale from 13-15	3	3	1
SUM4	Usability Quality Single Usability Metric (SUM) Score Total of scale from 16-18	3	3	1
SUM5	Human Quality Single Usability Metric (SUM) Score Total of scale from 19-24	6	6	1
Total		24	24	1

Figure 3.18 *User Experience Evaluation Instrument Perfect Score Demonstration.*

UX Questionnaire / SUM Totals / Wost Possible Score

		n Total	Total Amt	Mean
SUM1	System Quality Single Usability Metric (SUM) Score Total of scale from 1-6	6	42	7
SUM2	Information Quality Single Usability Metric (SUM) Score Total of scale from 7-12	6	42	7
SUM3	Interface Quality Single Usability Metric (SUM) Score Total of scale from 13-15	3	21	7
SUM4	Usability Quality Single Usability Metric (SUM) Score Total of scale from 16-18	3	21	7
SUM5	Human Quality Single Usability Metric (SUM) Score Total of scale from 19-24	6	42	7
Total		24	168	7

Figure 3.19 *User Experience Evaluation Instrument Worst Possible Score Demonstration.*

UX Questionnaire / SUM Totals / Varied Score

		n Total	Total Amt	Mean
SUM1	System Quality Single Usability Metric (SUM) Score Total of scale from 1-6	6	25	4.2
SUM2	Information Quality Single Usability Metric (SUM) Score Total of scale from 7-12	5	16	3.2
SUM3	Interface Quality Single Usability Metric (SUM) Score Total of scale from 13-15	3	7	2.3
SUM4	Usability Quality Single Usability Metric (SUM) Score Total of scale from 16-18	2	7	3.5
SUM5	Human Quality Single Usability Metric (SUM) Score Total of scale from 19-24	5	20	4
Total		21	75	3.6

Figure 3.20 *User Experience Evaluation Instrument Varied Score Demonstration.*

UX Questionnaire / Human Quality **1 = Strongly Agree** **7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
19.	**Affordable** The system is affordable to the user.	X							
20.	**Wearable/Integration** The system integrates with the user's lifestyle.							X	
21.	**Durable** The system is reliable for the user's day-to-day use.		X						
22.	**Glanceable** The system presents information in an enjoyable manner to the user.				X				
23.	**Gesture** The system responds to the user's natural movements and inputs.						X		
24.	**Emotion** The system invokes an emotional response to the user.								X
SUM5	**P.I. Use Only** **Human Quality** **Single Usability Metric (SUM) Score** **Total of scale from 19-24**	**n Total**			**Total Amt**			**Mean**	
		5			**20**			**4**	

Figure 3.21 *User Experience Evaluation Instrument Human Quality Demonstration.*

3.4. Summary

The User Experience Evaluation Instrument (UEEI) will provide 39 total metrics, 24 closed ended questions and four Scale and Single Usability Metric (SUM) totals. The UEEI is categorized into five sections of quality for the system, information, interface, usability and human quality for which a user's experience can be evaluated. Cognitive computing can allow the usability category to be evaluated live by the system for immediate response to the user's experience. Low scores are positive indicators and high scores are poor indicators.

The SUM scores contain a n total which is the total of each item measured. A total amount which is the total sum of each item measured and a mean which is the n total divided by the total. The SUM score is intended to provide another statistical perspective and should not be used as a summary or overall score of the UEEI. Including the raw data metrics is important for specific item evaluations on the system.

In order to quantify future potential for a system's users experience, human factors are quantified over Likert Rating Scale. The rating scale uses the same low value positive and high value negative as the previous scales. The metrics that are being measured are affordability, lifestyle, reliability, information presentation, natural response, and emotion. Some of the metrics may not be present or measurable on the system so they can be removed with a not applicable selection.

The pilot study produced statistical results that demonstrate the need to refine the UEEI statements. The UEEI's statements groups, systems, information, interaction, usability, and human qualities were analyzed for correlations and reliability. The correlation analysis demonstrated that the UEEI groups of system information, and interaction statements correlated well as a group. While the UEEI groups of usability and human quality did not work well as a group and have a few statements that could be considered sub topics. 5.3.4. Correlation Analysis.

The reliability tests suggest that UEEI group of usability did not cover the topic of usability well and perhaps more statements or details in the statements are needed. The UEEI topics of systems, information, interaction, and human quality all produced favorable reliability results suggesting that they cover their topics well. A full review of the correlation and reliability analysis can be found in 5.3.3. Reliability Analysis.

The correlation and reliability analysis suggest that the UEEI has opportunity for improvement and further investigation as an early stage prototype. Further investigation can help inform and develop a more complete model in the future.

CHAPTER 4. USER EXPERIENCE OBSERVATION TESTING & MEASURES

A study was conducted to test the reliability, effectiveness, and consistency of the User Experience Evaluation Instrument (UEEI). The study asked participants to use the UEEI to evaluate a user experience of the principle investigator (P.I.) completing a usability task list using a computer and smartphone. The P.I. completed the task list so the participants could observe a user experience and complete the UEEI to test its effectiveness as a user experience evaluation instrument. The task list, computer, or smartphone are not being evaluated individuality. Instead the entire experience of interaction is being evaluated with the UEEI to see if the UEEI is usable and can produce data that is reliable and consistent.

4.1. Testing set-up

Participants were recruited by word of mouth to test the effectiveness of the UEEI through an observed user experience interaction. The participants were provided an informed consent document informing them that their participation was completely voluntary, that they could withdraw their participation at any time and that their participation would be anonymous (Figure 6.3 in Appendix A). The informed consent also described the purpose of the study to test the UEEI's effectiveness, reliability, and consistency for measuring a user's interaction experience. Instructions informed the participants that they should complete the UEEI survey during the observation as much as they could. Participants were allowed ten minutes to review the items on the UEEI and ask for clarification. Participants were also informed on the Likert scale's value ratios to level of agreement and that the value NA should be marked if the participants felt the item could not be rated.

The participants were given an entrance survey to complete (Figure 6.5 in Appendix A) before the observation began. The UEEI was then distributed to the participants for their review (Figure 6.7 in Appendix A). The principle investigator (P.I.) then completed the P.I. task list during which the participants completed the UEEI (Figure 6.6 in Appendix A).

4.1.1 Participants

In order to test the effectiveness of the User Experience Evaluation Instrument (UEEI), participants were recruited to use the UEEI during a user experience observation. The participants were randomly selected through the use of a word of mouth script. 20 participants were selected to use the UEEI. The participants varied in their association with Iowa State University as students or staff members of the university. Other participants had no association with Iowa State University. Participants varied in their experience levels of using technology. The participants were recruited with approval by the Iowa State University's Institutional Review Board (IRB ID#14-561).

4.1.2 Pre-survey

A pre-survey was provided to participants to complete prior to the user experience observation. The pre-survey asked for participant demographic information such as age, gender, native language, education level, and experience with technology operating systems and devices. This information will be used to see how different groups of participants interpreted the application of the User Experience Evaluation Instrument (UEEI) as it related to the participants perceived evaluation of the observed user experience.

4.1.3 Testing environment

The testing environment was located at the Iowa State University College of Design's

Main Street studios in Ames, IA. The environment allowed for a quiet and focused testing space for participants to observer and listen to the user experience interaction. The principle investigator (P.I.) set up a laptop computer and a smartphone on a table. Participants were seated around the P.I. on both the left and right side. Participants had a good view of the on screen interactions and the P.I.'s face and hands as the P.I. interacted with the computer and smartphone (Figure 4.1).

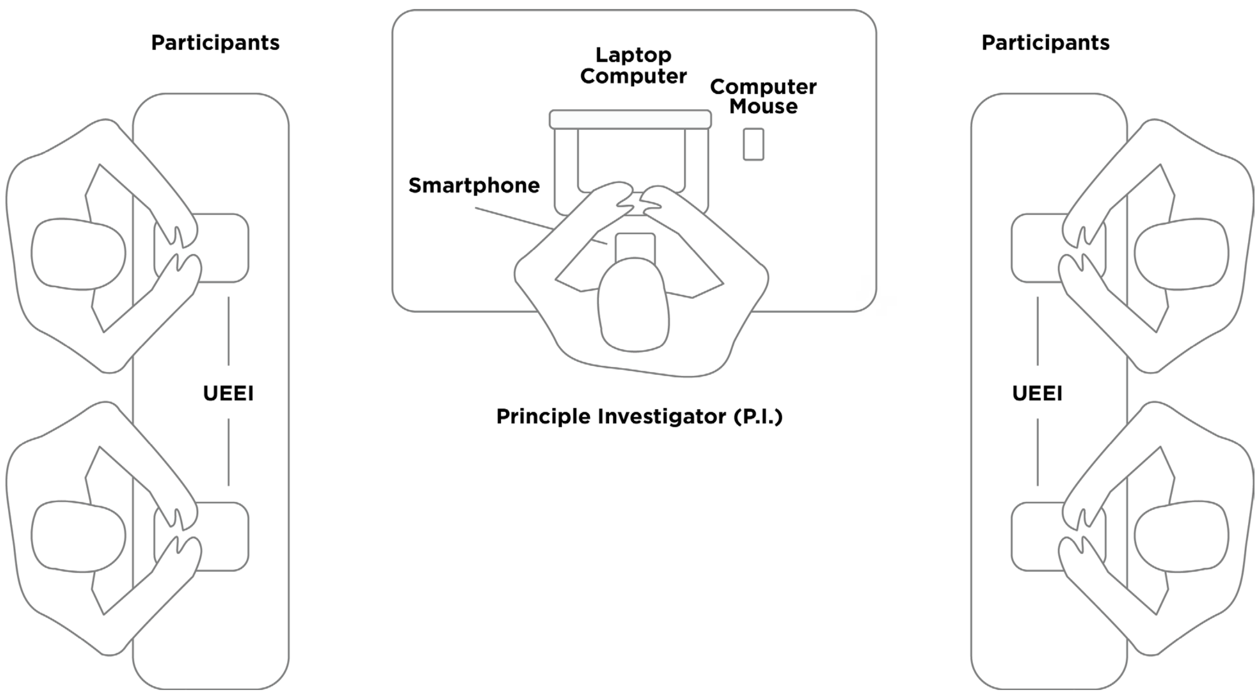


Figure 4.1 *Testing Environment (top view).*

4.1.4 Technology

Participants were asked to complete the User Experience Evaluation Instrument (UEEI) during a user experience observation. Participants were provided with a paper copy of the UEEI and a pen to complete the survey during the observation.

The principle investigator (P.I.) completed a task list using a MacBook Pro 15 inch laptop computer running the operating system OS X Yosemite 10.1 and an iPhone 5s running the operating system iOS 8.1. Both operating systems were the most currently available at the time of the observation. The P.I. also used software application Microsoft Word, Box, and Google Chrome on the laptop computer and the Box and Calendar applications on the smartphone. Calculation formulas for the UEEI's responses were found using Jeff Sauro Measuring U's website at http://www.measuringu.com/calc.php.

4.1.5 Observation scenario

The purpose of the observation is for the participants to evaluate a user's experience using the User Experience Evaluation Instrument (UEEI). A task list was created for the principle investigator to complete while interacting with a technology system, a Mac laptop and smartphone. The goal of this task list was to create an interaction experience that resembles a workflow that could be familiar to the participants observing. For example, the use of Microsoft Word is a common application that is likely to be familiar to participants. The laptop computer and smartphone also being common objects that participants have familiarity with to allow for minimal confusion with participants understand what they are observing. The task list contains seniors that are common workflow tasks such as creating a new Microsoft Word document, typing, saving the document, typing a password, and creating and sharing a calendar event. Below is the list of tasks and the associated workflow:

1. Power on the laptop computer.
    a. Touch a key on the keyboard > Type the login password for the system

2. Open Microsoft Word.
    a. Use the computer mouse to navigate the courser to the Microsoft Word application icon > Click on the icon > Select Create New Document
3. Compose a word document describing a title (Fake Event), date (11/17/2014), time (9 am), and location (Fake Location) of an event.
    a. Use the computer's keyboard to type the required information
4. Save the document to CyBox (Box Application) with the name FakeEvent.
    a. File > Save As > Box File Directory > Type document name > Save
5. Open the FakeEvent document on a smartphone.
    a. Touch smartphone to turn on > Click Box Application > Sign-in to CyBox account > Type username > Type username > Look up password on the laptop computer using Google Chrome and LastPass > Type password into CyBox log-in > Click on Fake Document
6. Create a calendar event based on the document's event information.
    a. View the FakeEvent document > Click out of the application > Select the Calendar application > Touch the plus sign to create a new event > enter in event details for title, location, time, and date.
7. Set a reminder of 1 day for the event.
    a. Select reminder > Select 1 day
8. Share the calendar even with fakeperson@email.com.
    a. Select invite > Enter fakeperson@emailcom > Select done

The P.I. spoke aloud while completing the task list so the participants could understand clearly what interactions were being accomplished. While speaking aloud, the P.I. informed the participants as to what was influencing some of the interactions. For example, task item five required the P.I. to switch back and forth from the smartphone and laptop computer. The P.I. informed the participants that this was a frustrating experience and a better solution would be to purchase a password appellation for the smartphone but the P.I. did not want to spend money to do that. This information was intended to inform the participants about items 19 and 24 on the UEEI. The P.I. also spoke aloud any errors encounter and the solutions found during the task list workflow.

4.2. Evaluation measures and statistical variables

Standardized measures were developed to evaluate the reliability, effectiveness, and consistency of the User Experience Evaluation Instrument (UEEI). The evaluation measures helped determine if the UEEI is an instrument that is understandable to be used by people and reliable to produce user experience evaluation results. Statistical variables were used to compare and evaluate the quantitative output of the UEEI's measurable items.

4.2.1 N total

The User Experience Evaluation Instrument (UEEI) is categorized by system evaluation type. Each category contains a series of statements that participants were asked to quantify over a Likert scale of one, strongly agree, to seven, strongly disagree. If a participant felt that not enough information was available to rate a statement, a value of NA could be marked for that statement resulting in the removal for the statement from evaluation. In order to determine the total number of statements that were quantified in each category, a n total was calculated by adding each statement that was evaluated with a rating. There is an n total for each category and an overall n total for the UEEI as a whole. The n total provides a measure for reliability of the UEEI. A low n total for a category suggests that the statements were not able to be evaluated by participants, having a low effectiveness. A high n total for a category suggests that statements were able to be evaluated by participants and have a high effectiveness.

4.2.2 Total amount

A total amount of the quantified value was calculated at for each category for the User Experience Evaluation Instrument (UEEI) and as a summary overview for the UEEI by adding the total values of each statement as marked on the Likert rating scale. Quantified totals will help determine the mean of each category, providing a review of the category's performance. The quantified totals help measure the effectiveness of the UEEI as an instrument.

4.2.3 Mean

A mean was calculated for each category and an overall mean for the User Experience Evaluation Instrument (UEEI). The mean was calculated by adding all of the total amount values divided by the n total $\bar{X} = \frac{\sum X}{n}$, where $\sum$ equals the sum of the total values and X equals the total value of the category and n equals the sum total of statements measured in the category, or the n total.

4.2.4 Standard deviation

Standard deviation is used to compare the quantified value ranges for each statement to measure the statements consistency, or spread in variability, in evaluation output by each participant. Standard deviation is measured by the root mean square of the values from their means $S = \sqrt{\frac{\Sigma(X-M)^2}{n-1}}$. Where $\sum$ equals the sum of the total values for each statement, X equals the values, M equals the mean, and n equals the total number of statements. A standard deviation is in the same units as the raw data, meaning it is a comparable value A low value for the standard deviation means a high level of consistency in the evaluation values. A high value for the standard deviation means a low level of consistency in the evaluation values.

4.2.5 Bivariate correlation

A bivariate correlation analysis will be conducted to determine how the statement groups of the User Experience Evaluation Instrument (UEEI) work individually as a group. Possible outliers will be identified and considered for a sub group based on the correlation analysis. A correlation analysis will also be conducted on the five groups as a whole to see how each group works together as a complete instrument.

CHAPTER 5. RESULTS AND FINDINGS

5.1. Introduction

The User Experience Evaluation Instrument (UEEI) was tested for its effectiveness, reliability, and consistency as an instrument to measure a user's interaction experience. The purpose of the test is to determine if the UEEI can be used and understood to evaluate a user's experience. A pre-survey was given to each participant to obtain demographic information (5.2) and then the UEEI was given o each participant to evaluate a user's experience (5.3).

5.2. Pre-survey demographic analysis

Participants were asked to complete a demographic survey before using the user experience evaluation using the User Experience Evaluation Instrument (UEEI). Demographic swere measured in age, gender, education level, and native language. The demographic survey assists in defining human variables that could influence the use of the UEEI. For example, the demographic survey found that the participants had a varied native language. The UEEI is written in English. Overall the UEEI was able to be completed even by those whose native language was not English. However, analyzing specific UEEI items that were marked NA by the participants might reveal that the intent of the wording may not be clear.

Age range of the participants was varied with at least one participant from each age group. The largest age range was 24-29. Females made up 65 percent of the participants and 85 percent of the participants had at least a college a degree.

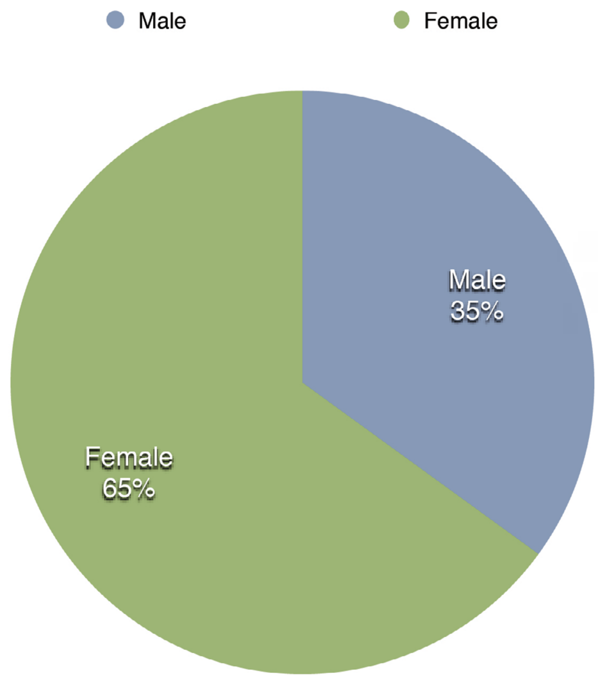


Figure 5.1 *Participant Gender (n=20).*

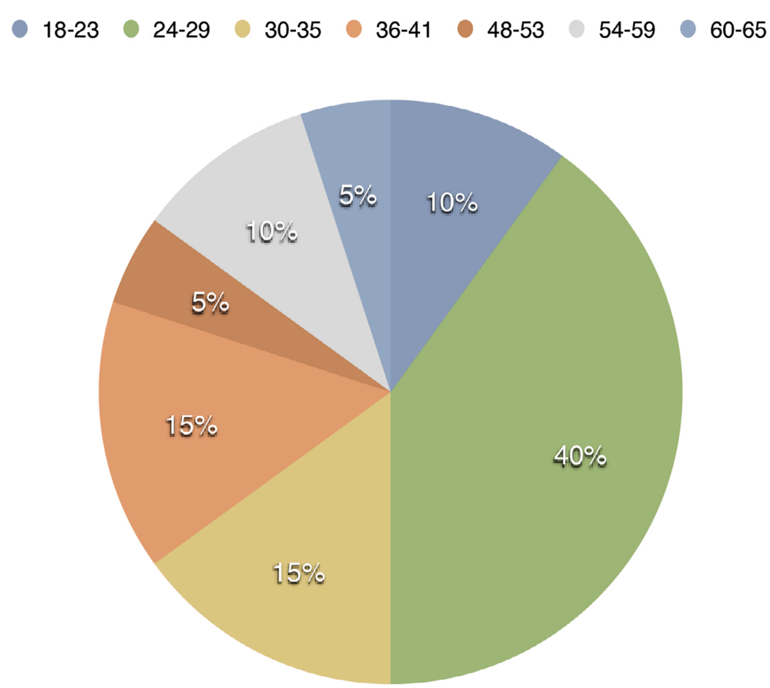


Figure 5.2 *Participant Age Range (n=20).*

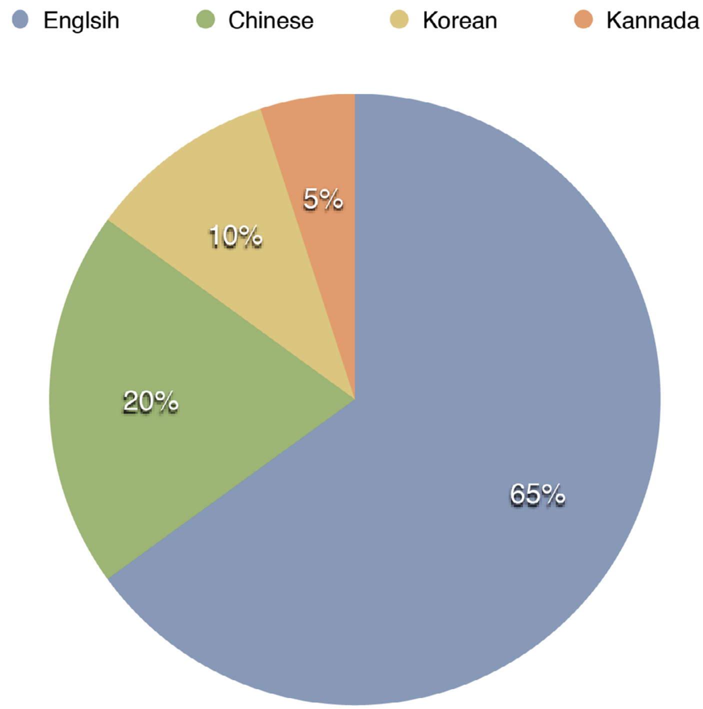


Figure 5.3 *Participant Native Language (n=20).*

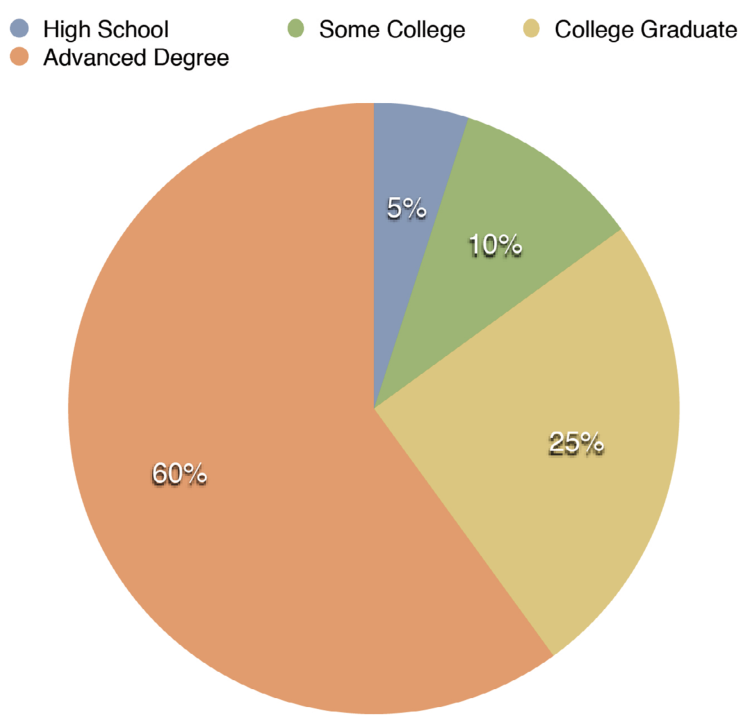


Figure 5.4 *Participant Education (n=20).*

5.3. User experience evaluation instrument test data analysis

The User Experience Evaluation Instrument (UEEI) was evaluated for effectiveness, reliability, and consistency during the participant user experience evaluation. The raw data from the test is presented with charts and graphs (5.3.4). Effectiveness is analyzed in (5.3.1), reliability in (5.3.2) and consistency in (5.3.3).

5.3.1 Effectiveness analysis

The User Experience Evaluation Instrument (UEEI) can be evaluated for effectiveness with the analysis of how many statements the participants marked as NA (Figure 5.7). Values 20 percent and above will be considered ineffective, meaning that participants felt they were not able to rate those statements 20 percent of the time. Four statements received a 20 percent or higher NA mark and those are 7, 9, 19, and 24. Statement seven states, “The system gave error messages that clearly told the user how to fix problems.” One theory as to why this statement received a high NA mark could be because the participants felt they did not have an appropriate view of the system’s visualization either on the laptop computer or the smartphone. Statement nine states, “The information (such as online help, on-screen messages and other documentation) provided with this systems was clear to the user.” This could also be attributed to the participants not having a direct viewing angle of the information on the screen. The participant’s could be correct in their determination that no information on screen error messages or documentation was presented during the interaction. The system did provide on screen help documentation; however, the task list did not require access to the content.

Statement 19 states, “Affordable: The system is affordable to the user.” Participants marked NA at the highest rate for statement 19 at 30 percent. This could be attributed to the fact that human participants completed the UEEI and from a social context finances are generally not discussed or shared with groups of recent acquaintance. However, during the user experience interaction, the principle investigator explicitly stated that they did not want to pay for a particular application that would make the interaction a better experience. Participants could have felt this was not enough information to evaluate the system as a whole or they did not fully understand the statement.

Statement 24 states, “Emotion: The system evokes an emotional response to the user.” This statement received a NA mark 20 percent of the time. Human participants might have trouble evaluating the emotion of someone they just met. Emotions are difficult to measure and evaluate from a brief interaction sample. However, during the interaction, the P.I. did verbally state moments of frustration and positive affirmation. The participants had trouble picking up on those verbal clues or felt they could not evaluate the information.

Figure 5.5 *Mean and Standard Deviation for the UEEI participant results 1 through 12.*

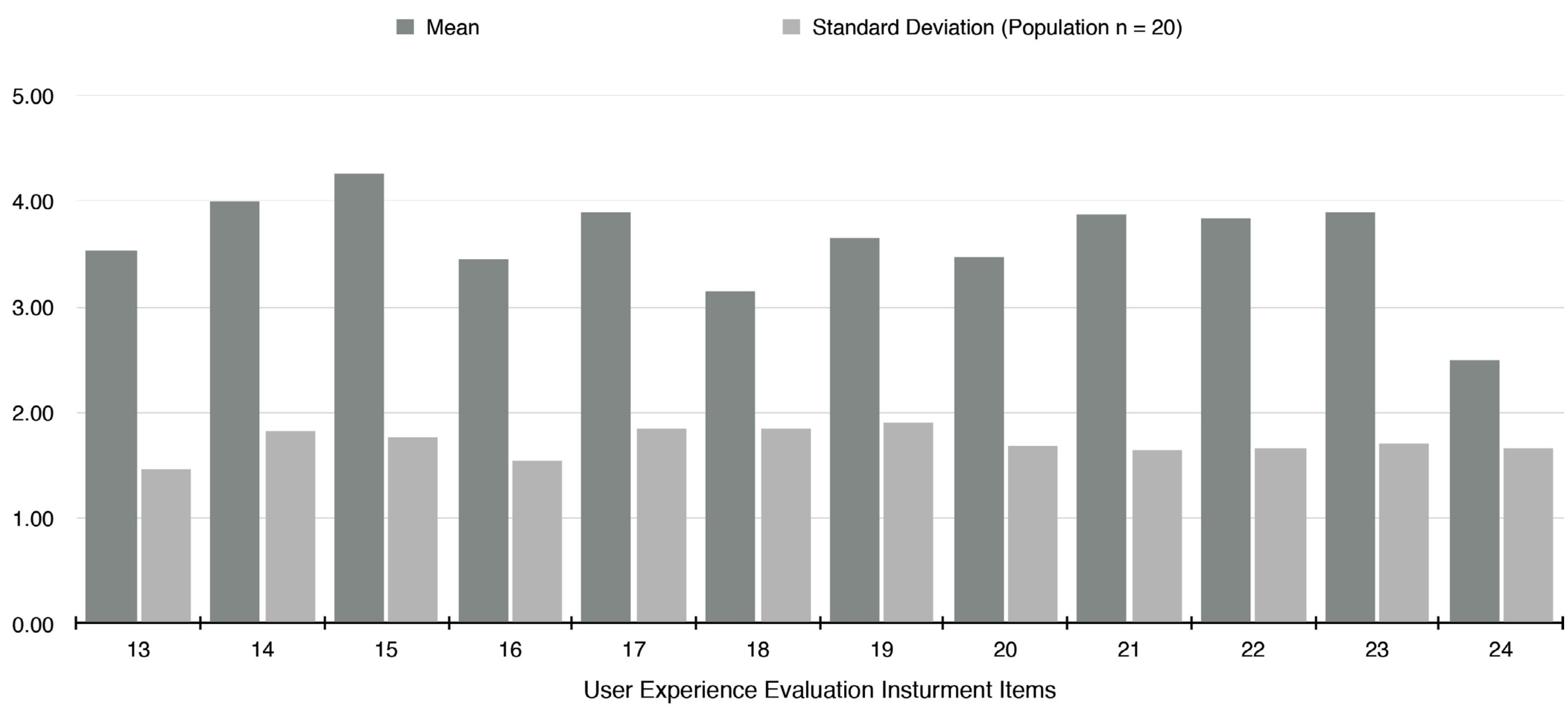
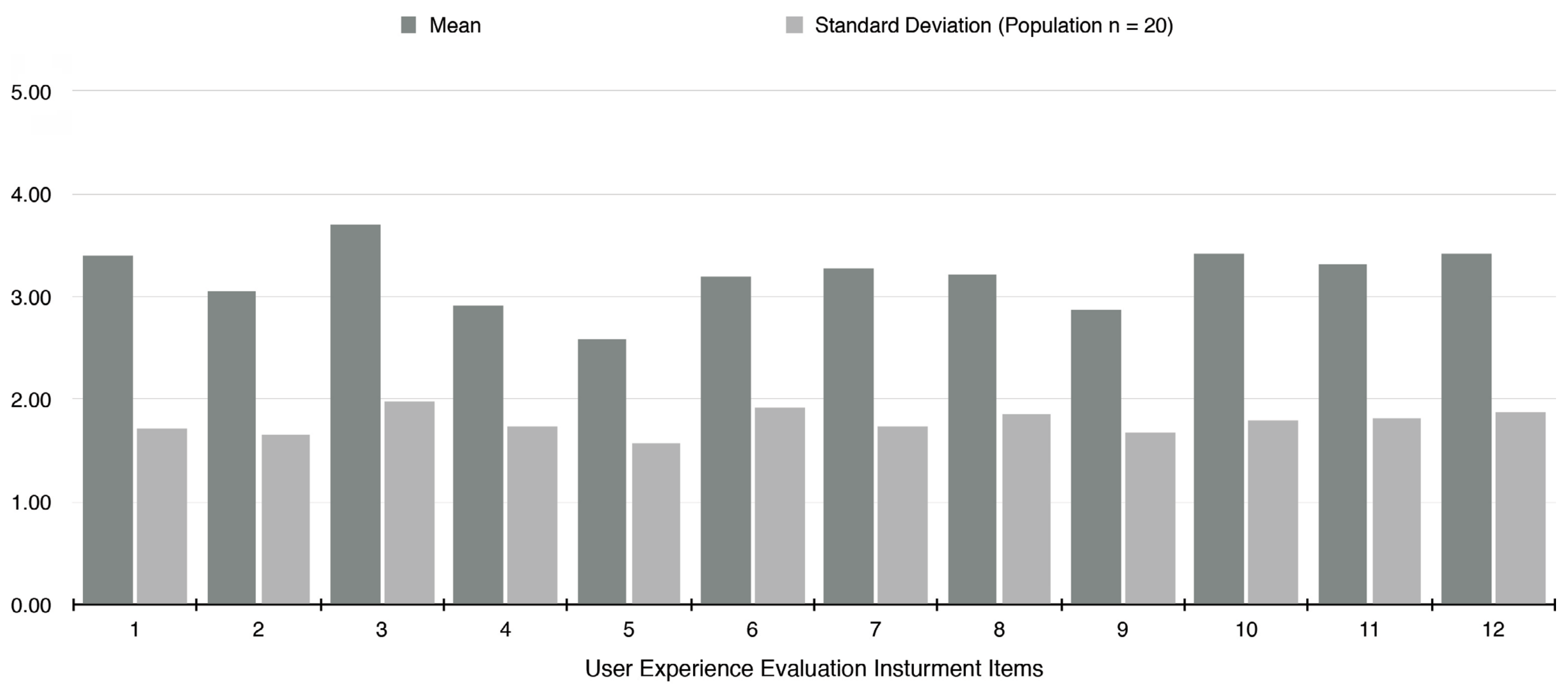


Figure 5.6 *Mean and Standard Deviation for the UEEI participant results 13 through 24.*



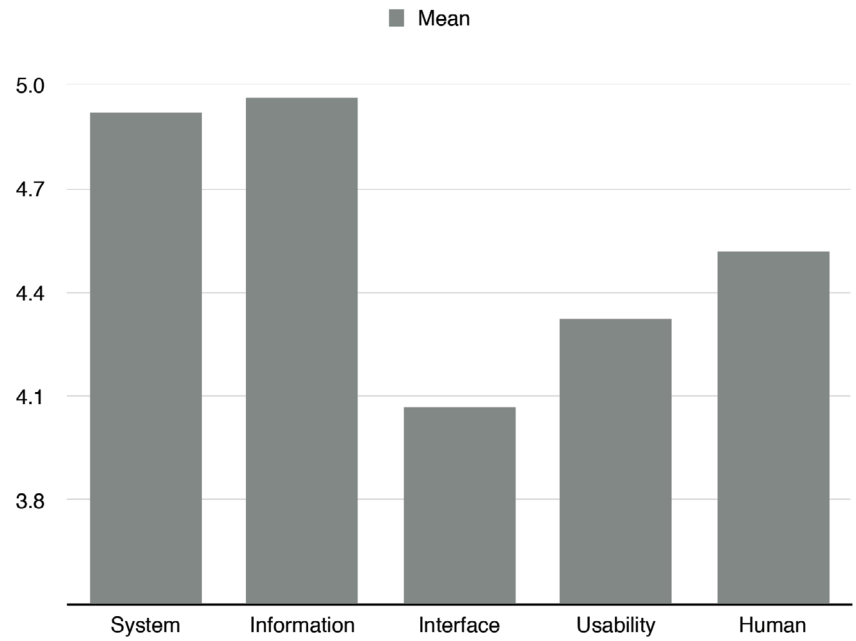


Figure 5.7 *Mean for UEEI data categories.*

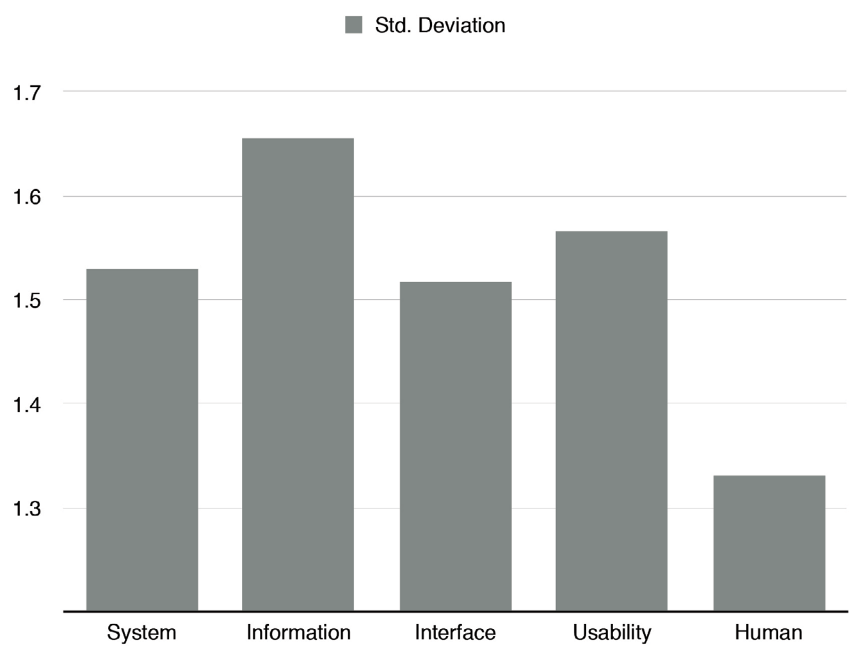


Figure 5.8 *Standard Deviation for UEEI data categories.*

5.3.2 Reliability analysis

A statistical reliability analysis was conducted on each statement group – system, information, interface, usability, and human quality – from the User Experience Evaluation Instrument (UEEI). Cronbach's alpha was used to determine if the individual groups represented their data category positively. A Cronbach's alpha score of .75 and above is considered to demonstrate that the statement variables represent their data category effectively. A scale statistic of variance was calculated to determine how much of the data group the statement variables covered. The statistical data was transposed to reflect higher numbers to be positive. 7 as strongly agree and 1 as strongly disagree along a scale.

System, information, interface, and human quality groups all received Cronbach's alpha scores above.75 which are positive indications demonstrating that the statement variables in those group represent their data topics favorably. The data group of usability received a low Cronbach's alpha below .75 suggesting that the usability statements did not represent the data category of usability well. One possible explanation is the low number of statements in that category of three. One bad statement variable could easily ruin it for the group. Statement variable 18 was the only variable to have a reversed positive scale. Perhaps participants were confused by the switch and failed to mark statement 18 accurately.

The scale statistic of variance was calculated to determine how much of the data group the statement variables covered. System, information, and human quality groups were measured to have a high value for variance suggesting the data groups covered their topics well. Interface and usability received low variance values suggesting they did not cover their topics with enough detail as individual groups. Human received a low variance score but a positive reliability score suggesting that the statical variables work well together as a group but do not cover the data topic completely. Which is to be expected from the human group because only six statement variables try to cover the data topic of human qualities leaving opportunity for additional statement variables to help cover the topic in greater detail.

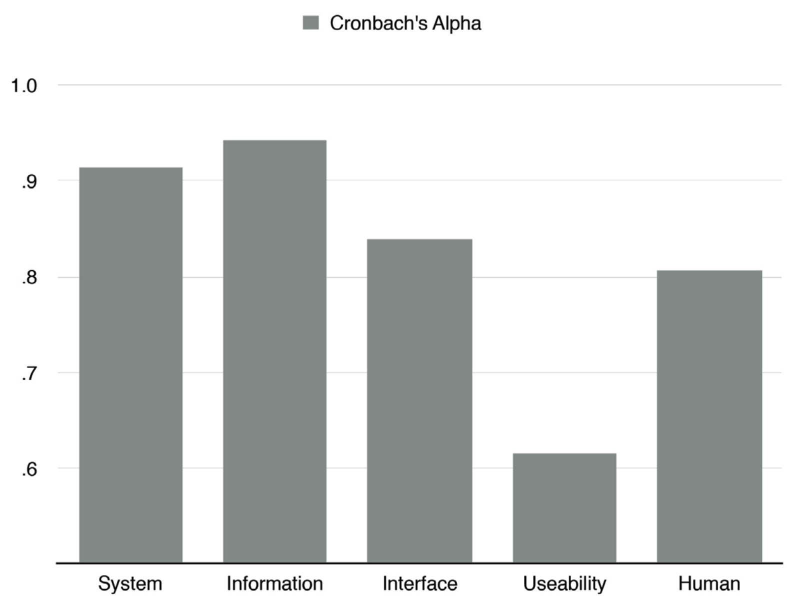


Figure 5.9 *Cronbach's Alpha for UEEI data categories.*

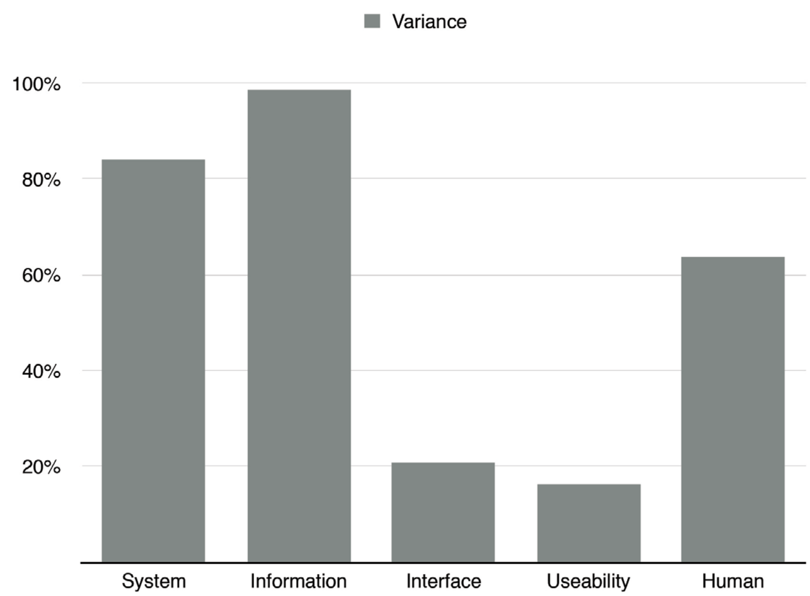


Figure 5.10 *Variance for UEEI data categories.*

5.3.3 Consistency analysis

Consistency can be measured with mean and standard deviation scores of each statement on the User Experience Evaluation Instrument. Figure 5.5 and 5.6 show the mean and standard deviations for each statement. The standard deviations are calculated for the same size of n=20 and are in the same numerical values as the UEEI so the results are comparable. The ranges for the standard deviations stay between one and two. The maximum value in the UEEI is seven which means the standard deviation range is below the medium value suggesting a low level of standard deviation. A low level of standard deviation suggests a positive score for the UEEI's consistency.

Statement 19 received the highest standard deviation score of 1.91. Statement 19 also received the highest mark of NA. This suggests that participants felt statement 19 is not clear and not able to measured accurately.

5.3.4 Correlation analysis

Bivariate correlation analysis was conducted on each data group – system, information, interface, usability, and human quality – from the User Experience Evaluation Instrument (UEEI). All statement variables worked well as individual groups for the groups system and interface quality. Each statement variable in the group worked well with the others and no outliers were identified. The statistical data was transposed to reflect higher numbers to be positive. 7 as strongly agree and 1 as strongly disagree along a scale.

The information group contained statement variables five and six that did not work well with statement 1 in the information category. Information statement one is, “The system gave error messages that clearly told the user how to fix problems.” Information statement five is, “The information was effective in helping the user complete the tasks and scenarios.” And information statement six is, “The organization of information on the system screens was clear.” Statement one deals with the topic of system errors while the other two statements deal with error information and display of content. Two of the statements deals with errors suggesting that a separate error section be developed as a sub category. A factor analysis will be necessary to determine more information.

The usability group had two out of three statements that worked together. Statement one, “This system’s capabilities meet the user’s requirements.” And statement two, “Using this system is a positive experience to the user.” Statement three is, “The user has to spend too much time correcting things with this system.” Statement three is UEEI variable item 18, the only item to have a reverse positive in the UEEI. Participant error may be a factor for this result.

The human group had three items that worked relatively will together but for the most part the group was not very cohesive. Statement variable one is, “Affordable - Is this system affordable to the user?” Statement variable six is, “Emotion - Does this system invoke an emotional response to the user?” These two statements did not work will with the other variable statements in the group. These two items could each be a sub category. Human emotion is a topic that can be evaluated in more detail and accuracy. Statement one deals with the topic of accessibility but is worded for affordability. Statement clarity could have played a role in this result.

A correlation analysis was also conducted on the UEEI as a whole to see how each of the groups worked together. Human quality was found to be an outliers suggesting that the statement variables did not work well with the other statements variables. This finding makes sense because the human quality section is evaluating human characteristics where the other sections are measuring system characteristics.

Correlations

		sys1	sys2	sys3	sys4	sys5	sys6
sys1	Pearson Correlation	1	.785**	.448*	.705**	.555*	.479*
	Sig. (2-tailed)		.000	.047	.001	.014	.033
	N	20	20	20	20	19	20
sys2	Pearson Correlation	.785**	1	.645**	.665**	.717**	.612**
	Sig. (2-tailed)	.000		.002	.001	.001	.004
	N	20	20	20	20	19	20
sys3	Pearson Correlation	.448*	.645**	1	.547*	.838**	.796**
	Sig. (2-tailed)	.047	.002		.013	.000	.000
	N	20	20	20	20	19	20
sys4	Pearson Correlation	.705**	.665**	.547*	1	.617**	.520*
	Sig. (2-tailed)	.001	.001	.013		.005	.019
	N	20	20	20	20	19	20
sys5	Pearson Correlation	.555*	.717**	.838**	.617**	1	.874**
	Sig. (2-tailed)	.014	.001	.000	.005		.000
	N	19	19	19	19	19	19
sys6	Pearson Correlation	.479*	.612**	.796**	.520*	.874**	1
	Sig. (2-tailed)	.033	.004	.000	.019	.000	
	N	20	20	20	20	19	20

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Figure 5.11 *Correlations for UEEI System category.*

Correlations

		info1	info2	info3	info4	info5	info6
info1	Pearson	1	.665**	.625*	.518*	.374	.504
	Sig. (2-		.007	.022	.048	.170	.055
	N	15	15	13	15	15	15
info2	Pearson	.665**	1	.908**	.741**	.684**	.616**
	Sig. (2-	.007		.000	.000	.002	.006
	N	15	19	14	18	18	18
info3	Pearson	.625*	.908**	1	.751**	.736**	.743**
	Sig. (2-	.022	.000		.001	.002	.001
	N	13	14	15	15	15	15
info4	Pearson	.518*	.741**	.751**	1	.904**	.657**
	Sig. (2-	.048	.000	.001		.000	.003
	N	15	18	15	19	19	18
info5	Pearson	.374	.684**	.736**	.904**	1	.712**
	Sig. (2-	.170	.002	.002	.000		.001
	N	15	18	15	19	19	18
info6	Pearson	.504	.616**	.743**	.657**	.712**	1
	Sig. (2-	.055	.006	.001	.003	.001	
	N	15	18	15	18	18	19

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Figure 5.12 *Correlations for UEEI Information category.*

Correlations				
		inter1	inter2	inter3
inter1	Pearson	1	.764**	.494*
	Sig. (2-		.000	.031
	N	19	19	19
inter2	Pearson	.764**	1	.663**
	Sig. (2-tailed)	.000		.002
	N	19	19	19
inter3	Pearson Correlation	.494*	.663**	1
	Sig. (2-	.031	.002	
	N	19	19	19

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Figure 5.13 *Correlations for UEEI Interface category.*

Correlations				
		use1	use2	use3
use1	Pearson Correlation	1	.636**	.412
	Sig. (2-tailed)		.003	.071
	N	20	20	20
use2	Pearson Correlation	.636**	1	.069
	Sig. (2-tailed)	.003		.773
	N	20	20	20
use3	Pearson Correlation	.412	.069	1
	Sig. (2-tailed)	.071	.773	
	N	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 5.14 *Correlations for UEEI Usability category.*

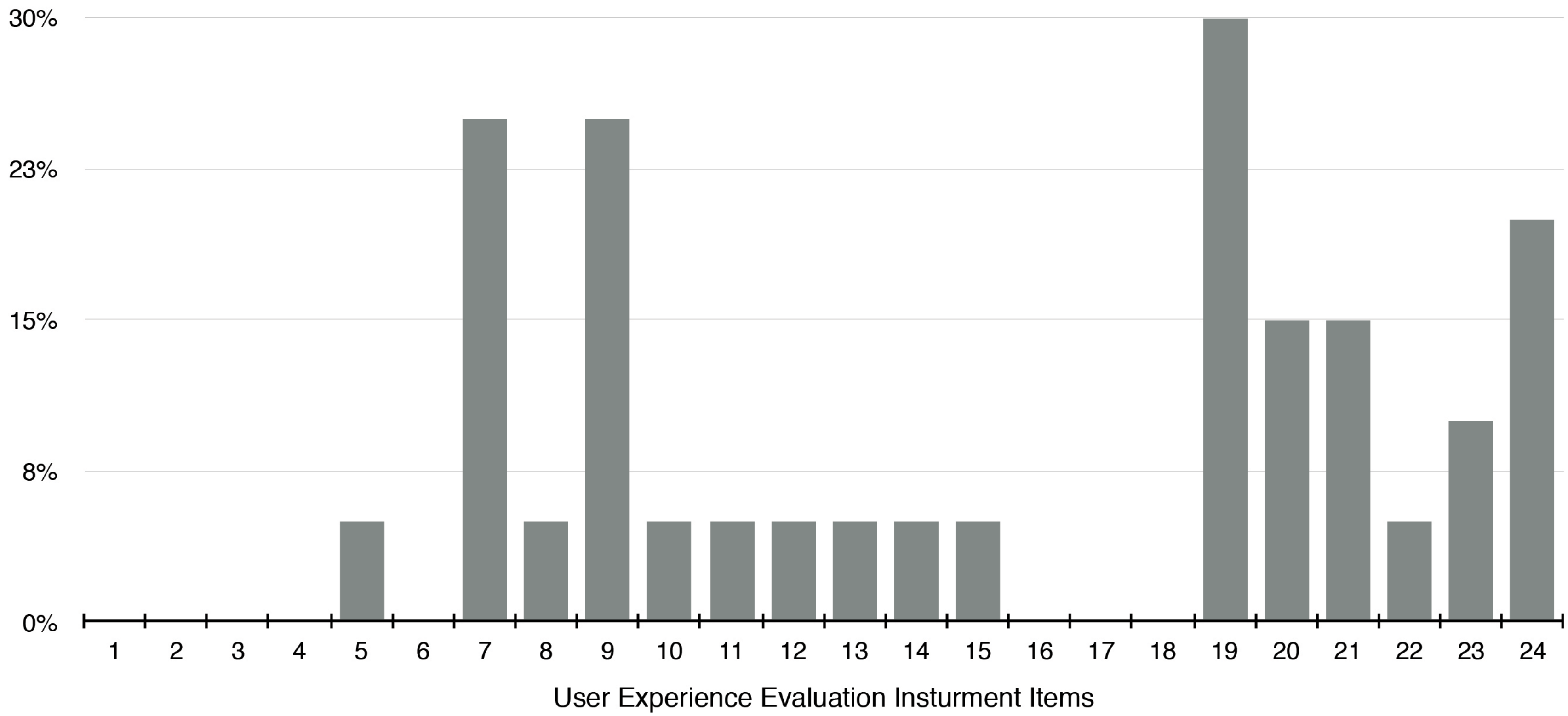
Correlations

		human1	human2	human3	human4	human5	human6
human1	Pearson	1	.179	.488	.091	.613*	.362
	Sig. (2-		.541	.076	.757	.026	.248
	N	14	14	14	14	13	12
human2	Pearson	.179	1	.659**	.730**	.359	.042
	Sig. (2-	.541		.004	.001	.172	.886
	N	14	17	17	17	16	14
human3	Pearson	.488	.659**	1	.674**	.640**	.145
	Sig. (2-	.076	.004		.003	.008	.621
	N	14	17	17	17	16	14
human4	Pearson	.091	.730**	.674**	1	.594**	.161
	Sig. (2-	.757	.001	.003		.009	.552
	N	14	17	17	19	18	16
human5	Pearson	.613*	.359	.640**	.594**	1	.377
	Sig. (2-	.026	.172	.008	.009		.167
	N	13	16	16	18	18	15
human6	Pearson	.362	.042	.145	.161	.377	1
	Sig. (2-	.248	.886	.621	.552	.167	
	N	12	14	14	16	15	16

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Figure 5.15 *Correlations for UEEI Human category.*

Figure 5.16 *Participant UEEI NA results.*



5.4. Summary

The User Experience Evaluation Instrument (UEEI) evaluation can be considered an effective instrument to measure a user's experience, with the exception of a few statements. The UEEI's reliability remains inconclusive as there is direct desired results for comparison. However, the UEEI did produce consistent results with standard deviation lower then the mean and median values. The UEEI deserves another round of tests to improve the quality and clarity of language in the statements and a control testing scenario.

CHAPTER 6. CONCLUSION

Measuring a perceived user's experience is a process that is evolving as technology changes to communicate directly with human senses and environments. Norman's conceptual model represents a starting marker for where user experience evaluation started and how it can evolve. When considering how to measure and improve a user's experience, the user should be considered first and foremost. Without the user there is no user interaction. Ethics, design, and cognitive computing approaches should all be framed around the user and their requirements.

6.1. Research questions answered

The purpose of this research started out asking two questions. The first question states:

1) Is it possible to create a better instrument that will measure user experience?

What items must appear on such an instrument?

How can these items be defined as relative to the value of user experience?

It was possible to develop an instrument to measure a user experience. The User Experience Evaluation Instrument was developed with research in the areas of user experience, user experience evaluation methodologies and the influence of new technology systems. Evaluation statements were derived from a combination of past evaluation and systems and new items were created from sensory and emotional consideration. These statements were grouped into categories the UEEI.

The second question considers the applicant of the UEEI and it states:

2) Can the User Experience Evaluation Instrument (UEEI) be applied for an evaluation of existing experiences to determine opportunities for an improved experience?

Participants were asked to use the UEEI during a user interaction cycle to evaluate the perceived experience. The UEEI was able to produce data. The data was measured to be effective and consistent. The value of the data was not able to be determined as there was no control evaluation to determine the ideal outcome of the UEEI. The UEEI was proved to be inconclusive for reliability as a whole but individual groups and variables were identified has being stronger than others.

6.2. Limitations

The User Experience Evaluation Instrument (UEEI) was evaluated in a testing scenario that asked participants to use the UEEI during a user interaction cycle. Variation in human perceptions could influence the marked values in the UEEI. Also, inconsistencies with the system in the testing produce could cause variation values on the UEEI.

6.2.1 Human participants

The intention of the user experience observation test was to have participants complete the User Experience Evaluation Instrument (UEEI) during the principle investigator's interaction process. However, a majority of the participants completed the UEEI after the interaction had finished. The value in having human participants test the UEEI demonstrated its effectiveness to be used across many different types of people and perceptions. However, controlling the timing of the evaluation would help test the differences of post and live interaction evaluations.

Ideally the UEEI would be completed by cognitive computing systems. These are newly developed systems and research access is limited. Testing the UEEI with cognitive computer systems would help determine the potential for the UEEI to be used as a live evaluation instrument.

6.2.2 Participant evaluations

Each participants observed the same principle investigator (P.I.) complete the same task list. This attempted to limit varied results from the UEEI. However, a true test of the UEEI would be to let participants use it observing different users completing different task scenarios. This would test the true application of the UEEI to evaluate different user experiences with the same system.

6.2.3 System variables

The principle investigator (P.I.) completed the same task list of each participant evaluation. However, each time different errors appeared in the system that could cause the participants to evaluate each experience different from one to the other. The errors included Microsoft Word not opening properly or timely, the iOS keyboard on the smartphone auto-correcting differently depending on the typos from the P.I., ect. While in practice the User Experience Evaluation Instrument (UEEI) is built to measure these system inconsistencies, the object of this test was to evaluate the UEEI as an effective, valid, consistence instrument. System inconsistencies can effect the consistency of the UEEI results.

6.2.4 Post evaluation

The User Experience Evaluation Instrument's (UEEI) statements are worded as if the user experience evaluation is being conducted post evaluation when the intent of the UEEI is to be used during the user's inter action. The wording of the statement could contribute to the participants using the UEEI as a post evaluation instrument instead of during the interaction cycle. The UEEI's should be reworded to reflect a live evaluation cycle in a future pilot study.

6.3. Future considerations

This thesis has discussed and explored possibilities of improving a users experience through evaluation during an interaction cycle. A test was conducting using human participants to evaluate an experience using the User Experience Evaluation Instrument (UEEI). This test has potential for further development with consideration of ethics, participatory design, and cognitive computing.

A review of the NA responses from the pilot study will consider how a future study could capture qualitative feedback for a refined analysis on why responses received an NA value. A review of using correlation data to conduct a factor analysis in a future study will also be discussed.

6.3.1 NA responses

The User Experience Evaluation Instrument (UEEI) allowed participants to record a NA value for statements that they felt they were not able to answer. As previously discussed, statements 7, 9, 19, and 24 received NA scores 20% of the time. The pilot study did not address possible issues of why participants marked a statement NA. A future study should ask participants to provide qualitative feedback that provides insight into why an NA mark was provided. This will help provide information on areas to focus on for improvement. For example, clarity could be an issues for statement 19, Affordable. Qualitative feedback could provide specific insight into how to improve clarity for statement 19.

6.3.2 Factor analysis

Bivariate correlation analysis was conducted on each of the five User Experience Evaluation Instrument (UEEI) groups. A factor analysis is a next step analysis that could be conducted in a future review of the UEEI's raw data. A factor analysis will determine specific statements that might be outliers in a group . A review of their value can be conducted to determine if the variables should be removed from the UEEI to improve it's correlation scores. For example, the human quality section did not correlate well with the other UEEI groups. A factor analysis on the human quality group will determine outliers that could be removed to help it's performance with the UEEI as a whole.

6.3.3 Ethical considerations in user data collection

Advances in system learning can come at a cost to the user. Cognitive computing requires a system to access a database of information to aide the interaction experience. This database of data could be user provided either at will or accessed without the users knowledge. For example, a database of the user's social media content could be accessed by a machine to determine language response preferences. The user may not always be aware that they have provided consent for a machine to access their information or fully understand the scope of information the machine has access to or how it will be used and stored for later use.

Cognitive computing also allows for a machine to learn new information during an interaction with a user. The system will gather response feedback from the user during the interaction. The system can learn about how a user perceives and responds sensory information. The machine may store this response information for future interactions with the user. Adam Greenfield describes the term graceful degradation, in the book *Everyware: The Dawning Age of Ubiquitous Computing*, as a term from engineering that describes how a system should fail gently with minimal harm to the user and their experience (p. 235). A system that fails should give priority to the user and their information.

A user should be made aware of how their information is being used, accessed, archived, and repurposed. A user should have the ability to provide and remove content at any given moment with their machine interaction. Greenfield describes this as the principle that engagement with an information system must be deniable. The user should always be able to have full control over the system at any time (p. 246).

6.3.4 Participatory design

Participatory design is part of a human centered design philosophy where the user is the focus of the desired solution. User research can only provide part of the model that is the user and at times user research alone is not enough to build a complete model.

Participatory design engages the user in co-operative creation of a design solution. This engagement could be early on the ideation process to identify needs and opportunities. Aaron Ganci states, in the article *Finding real problems: Using participatory design research to help students propose and design new applications*, that we know that being a designer involves much more than the artifact you create (Ganci). Ganci presents the importance of incorporating the user into decision making process for development and creation of products and design solutions.

Tradition participatory design methodologies evolved into applied user experience and research practice with the idea of a tool kit. A designer can provide a predetermined set of tools that is made available to a user or group of users to arrange and create their own product. These tool kits can contain any amount of content and or items, usually they will relate to the medium and final outcome that the designer is expecting the user to participate in.

Consider participatory design at its broadest meaning. A user participating in a creation process. This can be applied to any number of mediums and environments. Condor a human computer interaction approach to participatory design. A tool kit could be a user profile that contains user provided information to be used by a software applicant to learn user preferred content, visual layouts, and communicate methods. The user is participating in the creation process by collaborating with the software through a profile. Similar to how a cognitive computing system could access user provided databases of information.

6.3.5 Cognitive computing

Cognitive computing presents potential to improve a user's experience with systems. Cognitive computing is able to process data to determine a natural language response and deliver that to the user. The challenge with cognitive computing is determining what data sets are appropriate to allow cognitive computers to access and collect. Ethical issues surround the collection, access, and storage of user data. Especially data sets that are very personal to the user. Perhaps the most promising data sets for cognitive systems to access are those that are use large scale interaction systems, like city and population data. These macro data sets are less personalized to individual users and more generalized to system trends. John Kelly and Steve Hamm discuss macro data systems for cities in the book *Smart Machines : IBM's Watson and the era of cognitive computing*. Citizens are given access to report trends to city systems. For example, reporting potholes for the city workers to fix (p. 129). Using macro data systems to engage users will help demonstrate the potential for cognitive systems in everyday use on a micro level.

APPENDIX A. TEST MATERIALS

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 11/4/2014

To: Ryan Williams
156 College of Design

CC: Dr. Andrea Quam
158 College of Design

From: Office for Responsible Research

Title: User Experience Survey

IRB ID: 14-561

Study Review Date: 11/4/2014

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**

- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

Please be aware that **approval from other entities may also be needed.** For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.**

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.

Figure 6.1 *IRB Approval Letter.*

Word of Mouth Script

Participants needed to test a user experience evaluation instrument.

The purpose of this study to test the relevance, consistency, and effectiveness of a survey instrument to evaluate a user's interaction with a laptop computer, tablet, or smartphone. The data collected from the study will inform the validity of the survey instrument to evaluate a user's experience with technology.

Participants will be asked to use the survey instrument to evaluate a user interacting with a laptop computer, tablet, or smartphone. The survey instrument consists of 24 closed-ended questions and the participant will be asked to rate each question on a Likert scale 1 to 7. The participants will be evaluating myself, the P.I., complete a computer interaction task list of normal and non-offensive tasks while operating an application on a laptop computer, tablet, or smartphone. The participants will complete the survey instrument at the same time as I complete the task list. The data collected from each participant's survey instrument evaluation will be compiled and presented in a thesis. No participant identifiers will be collected.

Participation is completely voluntary. All of the information participants provide will be kept strictly confidential and reported in summary form only. No individual will be identified, nor will participants' names be attached to any data. Participants must be 18 years or older to take part in this study.

If you know someone who may be interested in participating this study, please contact Ryan Williams at rgw@iastate.edu

Figure 6.2 *Word of Mouth Recruitment Script.*

Informed Consent Document

Title of Study: **User Experience Survey**
Participants: Principle Investigator: Ryan Williams, rgw@iastate.edu BFA
Major Professor Andrea Quam aquam@iastate.edu

This is a study on user experience evaluation. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time. No items will be purchased during the session. No personal or financial information will be collected during the session. Participants will be provided with a survey and writing utensil.

INTRODUCTION
The purpose of this study to test the relevance, consistency, and effectiveness of a survey instrument to evaluate a user's interaction experience with a laptop computer, tablet, or smartphone. The data collected from the study will inform the validity and application of the survey instrument to evaluate a user's experience with technology.

Project Description: An evaluation instrument has been developed to measure the quality of a user's experience while they interact with a technology system. This study will help determine the success and failures of the evaluation instrument and its metrics.

This study will help to develop the user experience instrument for applied use on future technology systems.There is no direct benefit to the participant. However, the knowledge gained can be expected to provide significant opportunities to improve user interaction experiences for the general public.

DESCRIPTION OF PROCEDURES
If you agree to participate in this study, participation will last for approximately 30 minutes**.** During the study you may expect the following study procedures to be followed.

1) The researchers will contact prospective participants to schedule a study and will send an informed consent document.

2) On the selected date of the study, you will be given a copy of the Informed Consent Document for review and to sign prior to the start of the session. If you agree, and sign the Informed Consent Document the session will begin.

3) Information regarding the project will be read before the session.

4) The participant's observation of the P.I. and participant survey will take place at the Design on Main studios or another similar quiet area.

6) The participants will be asked to observe the P.I. complete a series of tasks using a computer, tablet, or smartphone. The participant will be asked to complete a survey during this observation. The participant may skip any questions/items that they do not wish to rate or stop the observation if they feel uncomfortable.

7) The participants will complete a brief exit survey, after the initial observation and survey, to answer brief interview questions given by a member of the research team.

RISKS
There are no foreseeable risks in this study. However, you may leave the study at any time without penalty.

BENEFITS

Figure 6.3 *Informed Consent Document.*

There is no direct benefit to the participant. However, the knowledge gained can be expected to provide significant opportunities to improve user experience evaluation methodologies.

COSTS AND COMPENSATION

You will not have any costs from participating in this study, other than your time. There will not be any compensation to participate in this study.

PARTICIPANT RIGHTS

Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide not to participate in the study or leave the study early, it will not result in any penalty or loss of benefits to which you are otherwise entitled. During the testing, if you feel uncomfortable at any time you can quit.

CONFIDENTIALITY

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy your records for quality assurance and data analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, the following measures will be taken.

No participant identifiers will be collected during this study. The participant's identity will be anonymous to outside sources throughout the study. Any field notes taken during this study will not contain the names of the participants. Questionnaires and field notes will be shredded after all the information is entered into the computer. Once the study has been concluded, all surveys may be retained for future use pertaining to this research (process).

QUESTIONS OR PROBLEMS

You are encouraged to ask questions at any time during this study. For further information about the study contact Ryan Williams, Principal Investigator, phone 712-212-1885, email rgw@iastate.edu.

If you have any questions about the rights of research subjects or research-related injury, please contact IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, Office for Responsible Research, (515) 294-3115, 1138 Pearson Hall, Ames, IA 50011.

****

SUBJECT SIGNATURE

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document and that your questions have been satisfactorily answered. You will receive a copy of the signed and dated written informed consent prior to your participation in the study.

Subject's Name (printed) ____

____ ____________________

(Subject's Signature) (Date)

Figure 6.4 *Informed Consent Document (pg. 2).*

Pre-survey

1 What is your age?
❍ 18-23
❍ 24-29
❍ 30-35
❍ 36-41
❍ 42-47
❍ 48-53
❍ 54-59
❍ 60-65
❍ 65+

2 Gender
❍ Male
❍ Female

3 Native Language
❍ English
❍ Other, please specify ____________________

4 Education
❍ High School
❍ Some College
❍ College Graduate
❍ Advanced Degree

5 How comfortable are you using the following?Rate the following (1 being least comfortable, 5 being most comfortable)

	1	2	3	4	5
Computer					
Tablets (iPads, Android Tab)					
Smart Phone					

6 What kind of computer do you use primarily?
❍ PC (any Windows computer)
❍ Macintosh
❍ Linux

Figure 6.5 *Participant Pre-Survey for Demographics and System Familiarity.*

User Experience Survey

P.I. Task List.

The P.I. will complete these tasks. The participant will be asked to observe the P.!. complete these tasks and complete a survey which asks the participant to evaluate the system for a positive experience, appropriate capabilities, and interaction time. The location of the observations and survey will be at the Design on Main Studios or similar quite setting.

1. Power on a laptop computer.
2. Open a word editing application (i.e. Microsoft Word).
3. Compose a word document describing the title, date, time, and location of an event.
    a. Title of event: Fake Event
    b. Date: 11/17/2014
    c. Time: 9 am
    d. Location: Fake Location
4. Save this document to a cloud based file manager (i.e. CyBox).
5. Open the document on a smartphone
6. Create a calendar event based on the document's event information
7. Set a reminder of 1 day for the event
8. Share the calendar event with another person
    a. Fake Person
    b. fakeperson@email.com

Figure 6.6 *Principle Investigator's System Interaction Task List.*

UX Questionnaire / System Quality **1 = Strongly Agree** **7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
1.	Overall, the user seems satisfied with how easy it is to use this system.								
2.	It was simple for the user to use this system.								
3.	The user was able to complete the tasks and scenarios quickly using this system.								
4.	The user felt comfortable using this system.								
5.	It was easy for the user to learn to use this system.								
6.	I believe the user could become productive quickly using this system.								
SUM1	**P.I. Use Only** **System Quality** **Single Usability Metric (SUM) Score** **Total of scale from 1-6**	**n Total**			**Total Amt**			**Mean**	

UX Questionnaire / Information Quality **1 = Strongly Agree** **7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
7.	The system gave error messages that clearly told the user how to fix problems.								
8.	Whenever the user made a mistake using the system, they could recover easily and quickly								
9.	The information (such as online help, on-screen messages and other documentation) provided with this system was clear to the user.								
10.	It was easy to find the information the user needed.								
11.	The information was effective in helping the user complete the tasks and scenarios.								
12.	The organization of information on the system screens was clear.								
SUM2	**P.I. Use Only** **Information Quality** **Single Usability Metric (SUM) Score** **Total of scale from 7-12**	**n Total**			**Total Amt**			**Mean**	

UX Questionnaire / Interface Quality **1 = Strongly Agree** **7 = Strongly Disagree**

		1	2	3	4	5	6	7	NA
13.	The interface of this system was pleasant. to the user.								
14.	The user liked using the interface of this system.								
15.	This system has all the functions and capabilities the user expected it to have.								
SUM3	**P.I. Use Only** **Interface Quality** **Single Usability Metric (SUM) Score** **Total of scale from 13-15**	**n Total**			**Total Amt**			**Mean**	

Figure 6.7 *Participant User Experience Evaluation Instrument Survey (pg 1).*

UX Questionnaire / Usability Quality 1 = Strongly Agree 7 = Strongly Disagree

		1	2	3	4	5	6	7	NA
16.	This system's capabilities meet the user's requirements.								
17.	Using this system is a positive experience to the user.								
18.	The user has to spend too much time correcting things with this system.								
SUM4	**P.I. Use Only Usability Quality Single Usability Metric (SUM) Score Total of scale from 16-18**	**n Total**			**Total Amt**			**Mean**	

UX Questionnaire / Human Quality 1 = Strongly Agree 7 = Strongly Disagree

		1	2	3	4	5	6	7	NA
19.	**Affordable** The system is affordable to the user.								
20.	**Wearable/Integration** The system integrates with the user's lifestyle.								
21.	**Durable** The system is reliable for the user's day-to-day use.								
22.	**Glanceable** The system presents information in an enjoyable manner to the user.								
23.	**Gesture** The system responds to the user's natural movements and inputs.								
24.	**Emotion** The system invokes an emotional response to the user.								
SUM5	**P.I. Use Only Human Quality Single Usability Metric (SUM) Score Total of scale from 19-24**	**n Total**			**Total Amt**			**Mean**	

UX Questionnaire / SUM Totals

		n Total	Total Amt	Mean
SUM1	**System Quality Single Usability Metric (SUM) Score Total of scale from 1-6**			
SUM2	**Information Quality Single Usability Metric (SUM) Score Total of scale from 7-12**			
SUM3	**Interface Quality Single Usability Metric (SUM) Score Total of scale from 13-15**			
SUM4	**Usability Quality Single Usability Metric (SUM) Score Total of scale from 16-18**			
SUM5	**Human Quality Single Usability Metric (SUM) Score Total of scale from 19-24**			
Total				

Figure 6.8 *Participant User Experience Evaluation Instrument Survey (pg. 2).*

Table 6.1 *Raw User Experience Evaluation Instrument (UEEI) Data P1-10 (part 1).*

	P 01	P 02	P 03	P 04	P 05	P 06	P 07	P 08	P 09	P 10
System Quality										
1	4	4	5	6	3	4	4	4	5	2
2	4	2	6	5	4	2	2	4	3	2
3	5	2	7	6	3	1	2	3	5	2
4	5	1	5	6	3	1	4	3	5	4
5	NA	2	6	5	2	1	1	2	2	1
6	5	2	6	5	3	2	1	3	2	2
N Total	**5**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
Total Amount	**23**	**13**	**35**	**33**	**18**	**11**	**14**	**19**	**22**	**13**
Mean	**4.60**	**2.17**	**5.83**	**5.50**	**3.00**	**1.83**	**2.33**	**3.17**	**3.67**	**2.17**
Information Quality										
7	6	4	4	NA	NA	1	1	4	NA	1
8	6	1	7	3	2	1	1	3	NA	1
9	NA	NA	7	NA	NA	2	1	3	2	2
10	5	1	5	6	3	3	1	3	4	2
11	4	2	6	6	3	3	1	2	3	1
12	6	4	7	2	NA	3	1	3	5	2
N Total	**5**	**5**	**6**	**4**	**3**	**6**	**6**	**6**	**4**	**6**
Total Amount	**27**	**12**	**36**	**17**	**8**	**13**	**6**	**18**	**14**	**9**
Mean	**5.40**	**2.40**	**6.00**	**4.25**	**2.67**	**2.17**	**1.00**	**3.00**	**3.50**	**1.50**

Table 6.2 *Raw User Experience Evaluation Instrument (UEEI) Data P1-10 (part 2).*

	P 01	P 02	P 03	P 04	P 05	P 06	P 07	P 08	P 09	P 10
Interface Quality										
13	5	4	6	6	2	3	1	3	4	5
14	3	4	7	7	2	4	1	4	5	4
15	4	6	6	7	2	5	4	4	5	1
N Total	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Total Amount	**12**	**14**	**19**	**20**	**6**	**12**	**6**	**11**	**14**	**10**
Mean	**4.00**	**4.67**	**6.33**	**6.67**	**2.00**	**4.00**	**2.00**	**3.67**	**4.67**	**3.33**
Usability Quality										
16	5	4	6	6	1	3	3	2	4	1
17	4	4	7	7	5	2	1	3	5	3
18	4	3	1	2	3	1	2	2	2	7
N Total	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Total Amount	**13**	**11**	**14**	**15**	**9**	**6**	**6**	**7**	**11**	**11**
Mean	**4.33**	**3.67**	**4.67**	**5.00**	**3.00**	**2.00**	**2.00**	**2.33**	**3.67**	**3.67**
Human Quality										
19	7	NA	2	5	1	NA	6	3	3	5
20	6	4	6	6	3	NA	2	3	2	2
21	7	4	4	6	2	NA	2	4	6	5
22	7	4	5	3	5	NA	2	3	5	3
23	7	3	NA	2	1	NA	4	4	5	6
24	6	1	2	1	1	NA	2	2	NA	1
N Total	**6**	**5**	**5**	**6**	**6**	**0**	**6**	**6**	**5**	**6**
Total Amount	**40**	**16**	**19**	**23**	**13**	**0**	**18**	**19**	**21**	**22**
Mean	**6.67**	**3.20**	**3.80**	**3.83**	**2.17**	**NA**	**3.00**	**3.17**	**4.20**	**3.67**
Overall										
N Total	**22**	**22**	**23**	**22**	**21**	**18**	**24**	**24**	**21**	**24**
Total Amount	**115**	**66**	**123**	**108**	**54**	**42**	**50**	**74**	**82**	**65**
Mean	**5.23**	**3.00**	**5.35**	**4.91**	**2.57**	**2.33**	**2.08**	**3.08**	**3.90**	**2.71**

Table 6.3 *Raw User Experience Evaluation Instrument (UEEI) Data P11-20 (part 1).*

	P 11	P 12	P 13	P 14	P 15	P 16	P 17	P 18	P 19	P 20
System Quality										
1	7	1	4	5	1	2	1	1	2	3
2	6	2	6	4	1	2	1	1	2	2
3	6	3	6	4	7	2	1	1	5	3
4	6	2	2	3	2	2	1	1	1	1
5	6	3	3	3	4	2	1	1	2	2
6	7	2	4	4	7	2	1	1	1	4
N Total	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
Total Amount	**38**	**13**	**25**	**23**	**22**	**12**	**6**	**6**	**13**	**15**
Mean	**6.33**	**2.17**	**4.17**	**3.83**	**3.67**	**2.00**	**1.00**	**1.00**	**2.17**	**2.50**
Information Quality										
7	4	1	4	6	NA	5	2	2	4	NA
8	5	2	3	5	4	5	4	2	1	5
9	5	1	4	4	3	4	3	1	1	NA
10	7	1	3	5	5	3	5	1	2	NA
11	7	2	3	3	6	3	5	1	2	NA
12	7	2	4	3	6	2	3	1	2	2
N Total	**6**	**6**	**6**	**6**	**5**	**6**	**6**	**6**	**6**	**2**
Total Amount	**35**	**9**	**21**	**26**	**24**	**22**	**22**	**8**	**12**	**7**
Mean	**5.83**	**1.50**	**3.50**	**4.33**	**4.80**	**3.67**	**3.67**	**1.33**	**2.00**	**3.50**

Table 6.4 *Raw User Experience Evaluation Instrument (UEEI) Data P11-20 (part 2).*

	P 11	P 12	P 13	P 14	P 15	P 16	P 17	P 18	P 19	P 20
Interface Quality										
13	5	4	4	3	4	2	3	1	NA	2
14	5	3	5	6	7	2	3	1	NA	3
15	7	3	5	4	7	4	2	3	NA	2
N Total	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**0**	**3**
Total Amount	**17**	**10**	**14**	**13**	**18**	**8**	**8**	**5**	**0**	**7**
Mean	**5.67**	**3.33**	**4.67**	**4.33**	**6.00**	**2.67**	**2.67**	**1.67**	**NA**	**2.33**
Usability Quality										
16	5	4	3	4	6	2	2	3	3	2
17	6	3	6	3	7	3	3	2	2	2
18	4	5	7	1	1	6	3	2	4	3
N Total	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
Total Amount	**15**	**12**	**16**	**8**	**14**	**11**	**8**	**7**	**9**	**7**
Mean	**5.00**	**4.00**	**5.33**	**2.67**	**4.67**	**3.67**	**2.67**	**2.33**	**3.00**	**2.33**
Human Quality										
19	6	3	2	5	1	2	NA	NA	NA	NA
20	5	2	2	4	6	2	3	NA	1	NA
21	5	2	2	5	5	2	3	NA	2	NA
22	6	2	2	5	7	2	4	2	2	4
23	7	4	3	5	5	2	4	2	2	4
24	NA	2	5	3	1	2	3	2	NA	6
N Total	**5**	**6**	**6**	**6**	**6**	**6**	**5**	**3**	**4**	**3**
Total Amount	**29**	**15**	**16**	**27**	**25**	**12**	**17**	**6**	**7**	**14**
Mean	**5.80**	**2.50**	**2.67**	**4.50**	**4.17**	**2.00**	**3.40**	**2.00**	**1.75**	**4.7**
Overall										
N Total	**23**	**24**	**24**	**24**	**23**	**24**	**23**	**21**	**19**	**17**
Total Amount	**134**	**59**	**92**	**97**	**103**	**65**	**61**	**32**	**41**	**50**
Mean	**5.83**	**2.46**	**3.83**	**4.04**	**4.48**	**2.71**	**2.65**	**1.52**	**2.16**	**2.9**

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